Nov. 23, 1954 E. STAUFF 2,694,898

DEVICE FOR DEFLECTING A HIGH-SPEED JET OF GAS EJECTED THROUGH A NOZZLE

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Fig. 1a

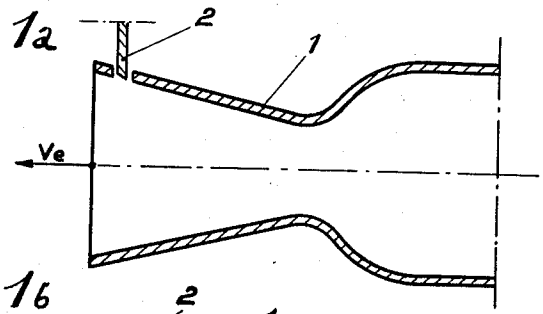


Fig. 1b

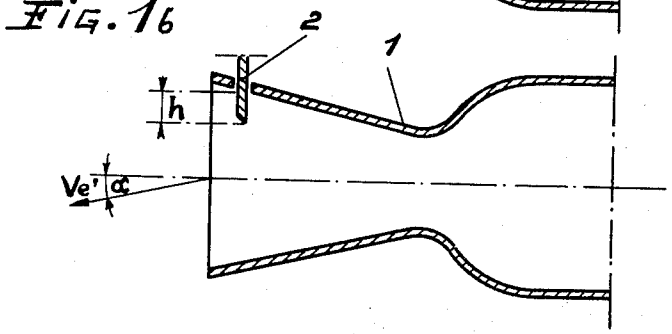


Fig. 2b

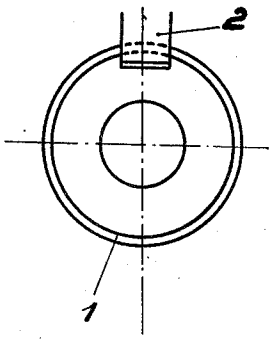


Fig. 2a

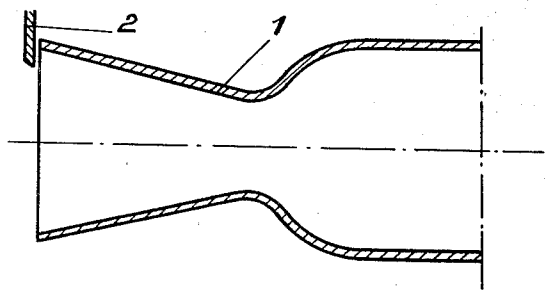


Fig. 4

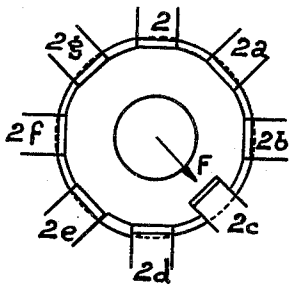
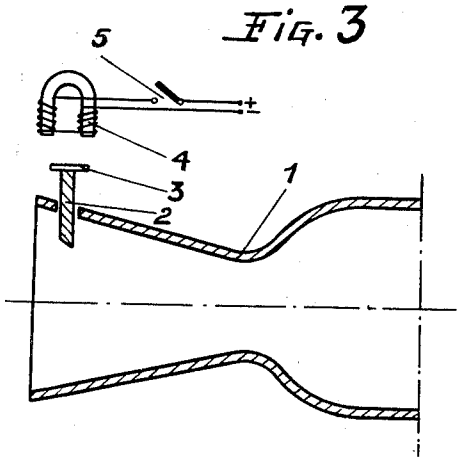


Fig. 3



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Fig. 5.

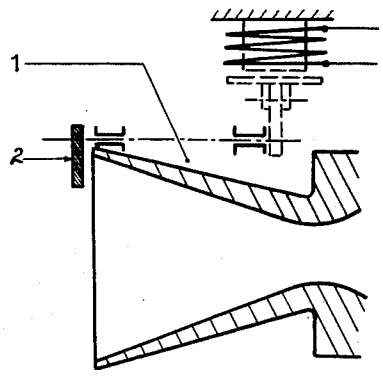


Fig. 6.

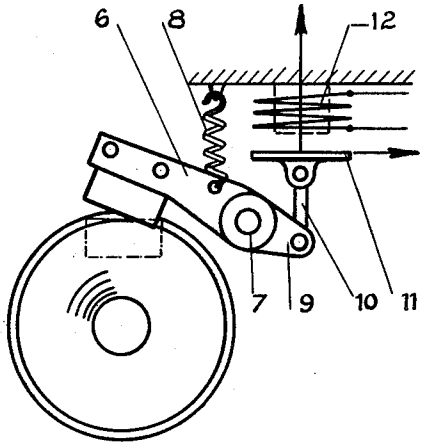


Fig. 7.

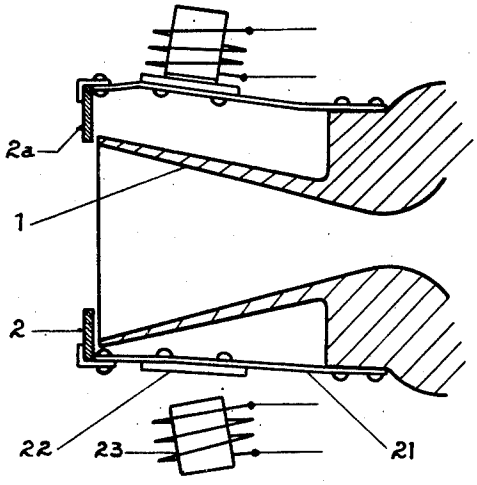
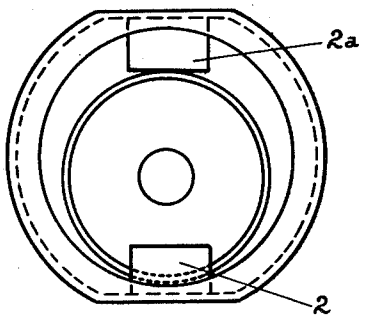


Fig. 8.



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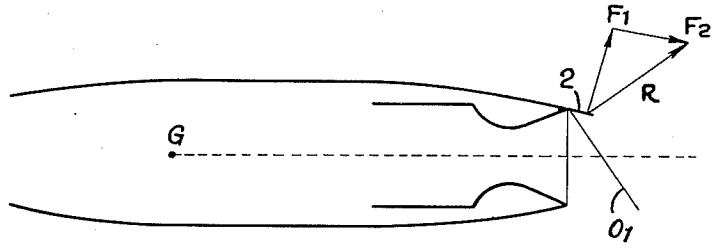


FIG. 9.

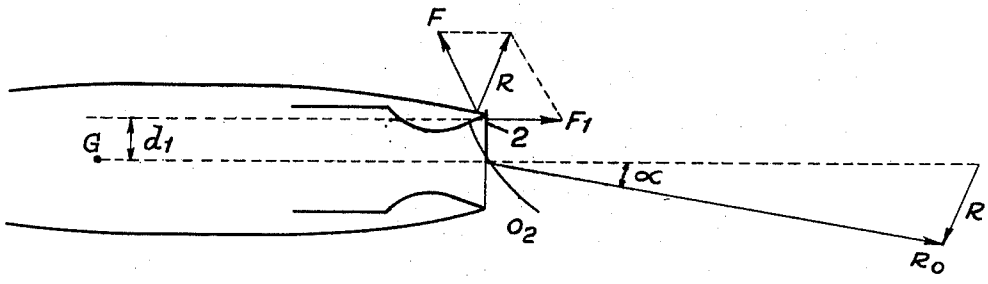


FIG. 10.

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2,694,898

DEVICE FOR DEFLECTING A HIGH-SPEED JET OF GAS EJECTED THROUGH A NOZZLE

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Application August 8, 1949, Serial No. 109,112

Claims priority, application France August 9, 1948

4 Claims. (Cl. 60—35.54)

The present invention relates to a particularly simple and economical device which is readily adaptable to any actuating member and which, owing to the rapidity with which it can change its position due to its small mass and its reduced movements, can be used for progressively deviating a jet issuing from the nozzle of a jet motor with a view to producing powerful overall torques for the piloting of an aircraft, with the minimum of power consumption and the maximum of responsiveness, by the instantaneous alteration of the pressure distribution along the walls of the nozzle.

In order to vary the direction of a high-speed jet of gas, it is in general necessary to exert a considerable force or to move considerable physical masses. This fact is a drawback in certain applications such as the use of a deflection of the propelling jet for producing an artificial moment about the centre of gravity of a jet-propelled aircraft; either the necessary mechanism becomes complicated, or the consumption of power too high.

The present invention relates to a deflecting device that obviates the above-mentioned drawbacks, since it enables considerable deflections, of the order of magnitude of several angular degrees, to be effected in a high-speed jet of gas while using movable parts of only small mass and only employing small forces compared to the result obtained.

The device according to the present invention is essentially characterized by the fact that it comprises at least one interceptor which is made to penetrate by means of a suitable actuating system into the stream of gas, either through the wall of the nozzle, or behind said nozzle, in order to vary the direction of the jet of gas.

Other features and the chief advantages of the invention will become apparent from the description thereof which will be given hereinafter with reference to the accompanying drawing which illustrates diagrammatically and merely by way of example various embodiments of the invention.

In said drawing:

Figs. 1*a* and 1*b* show longitudinal sections of a nozzle provided with a device according to the invention, for two different positions of the interceptor.

Figs. 2*a* and 2*b*, respectively, show a longitudinal section and an end view of another embodiment of the invention.

Fig. 3 shows a system for actuating the interceptor.

Fig. 4 shows another embodiment of the invention.

Figs. 5 and 6 illustrate, respectively in longitudinal section and in end view, a device for controlling the interceptor.

Figs. 7 and 8 illustrate, respectively in longitudinal section and in end view, another embodiment of the control device for the case where two interceptors are provided.

Fig. 9 illustrates diagrammatically the resultant forces where the interceptor is introduced at a small angle as heretofore proposed by others, and

Fig. 10 illustrates diagrammatically the resultant forces where the interceptor is introduced at right angles within the supersonic jet as per the present invention.

In the wall of a nozzle **1** an opening is provided through which is adapted to move an interceptor **2** of any suitable shape. The presence of this obstacle changes

the distribution of the pressures along the corresponding wall of the nozzle, thereby producing both a transverse force applied to said nozzle and a deflection of the jet issuing therefrom. These two effects are connected with one another by the laws of mechanics. Figs. 2 show a modification wherein the interceptor is located outside the nozzle.

The high speed of the jet of gas, which may be below or above the speed of sound, makes it possible to reduce considerably the response lag of aerodynamic origin, as compared with similar control surfaces which are subjected only to the wind produced by the flight of the aircraft. Furthermore, the action of the device obviously depends little on the speed of flight.

Another advantage of the arrangement proposed is that, so long as no deflection is required, the interceptor remains outside the jet of gas which may be at high temperature and be moving at very high velocity; consequently, the interceptor is less liable to damage than the known system of deflecting flaps which are adapted to move about an axis at right angles to that of the nozzle and are constantly immersed in the fluid stream.

The small size of the necessary interceptors makes it possible to place a whole series **2**, **2***a*, **2***b* . . . thereof in a ring about a nozzle of revolution (see Fig. 4), thereby making it possible to vary in a very simple manner the meridian plane in which the lateral force F or the lateral component of the speed is produced.

Tests have shown that, between certain limits, the angle of deflection (angle formed between Ve and Ve') (Fig. 1*b*) varies in the same direction as the length *h* by which the interceptor has penetrated into the stream of gas; the device according to the invention can, therefore, be used both for continuously adjusting the direction of the jet and for producing a discontinuous adjustment of said direction according to the all-or-none principle.

In the case in which the interceptor moves between two extreme positions, since *h* can only assume two values, h_1 and h_2 (see Fig. 3), this movement may advantageously be obtained by securing the interceptor **2** to the moving armature **3** of an electromagnet **4**, to which current is supplied at will or automatically by means of a switch **5**. In this case, the deflecting action, which may be very powerful, is produced by actuating the switch **5**; the current consumed by the electromagnet **4** may be small since the force to which the interceptor is subjected in the direction at right angles to the axis of the nozzle is almost zero.

Referring to Fig. 6, the intercepting surface **2**, which is located, in this example, behind the nozzle **1**, is integral with an arm **6** which may rotate about the shaft **7**. This arm is normally maintained in the retracted position of the interceptor, by means of a spring **8**.

A lever **9** at the end of the shaft **7** is engaged by the rod **10** which is unitary with an iron member **11** adapted to be attracted by the electromagnet **12**.

When a current passes through the electromagnet **12**, the iron member **11** is attracted. The rod **10** pulls on the lever **9** and causes the shaft **7** to rotate, the spring **8** to become extended and the interceptor **2** to be introduced into the jet.

When the current ceases, the attractive force of the electromagnet on the iron member is no longer exerted so that the interceptor is brought back to its retracted position by the spring **8**.

Figs. 7 and 8 show the case where two interceptors are provided. These interceptors **2** and **2***a* are secured to the ends of a resilient blade **21** secured to a member integral with the nozzle **1**.

This resilient blade **21** carries an iron member **22** which can be attracted by the electromagnet **23**.

The resilient blade returns into the jet the interceptor which has previously been retracted by the action of the electromagnet.

Both interceptors **2** and **2***a* are mechanically or electrically co-ordinated. They move in the same direction, i. e. when interceptor **2** is in the jet, interceptor **2***a* is outside the jet and vice-versa.

The device according to the invention may be used (*a*) For the piloting of an aircraft, at any speed and

at any altitude, either by a direct action of the pilot on the chosen interceptor surfaces by means of conventional mechanisms or even by an indirect action by means of a suitable pulsating device (not shown);

(*b*) For deviating a gaseous jet issuing from a nozzle, whether the purpose of this deviation be (or not) the protection of a space swept by the jet or the feeding of a rotary power machine.

It is obvious that the invention has only been described and illustrated in a purely explanatory and in no wav limitative manner and that any modification of detail may be made therein in accordance with its principle without exceeding its scope.

It has been found by experience that in the case of a supersonic gaseous jet, the method of operation of an interceptor employed to produce a controlling moment on a nozzle, as well as the results obtained are totally different depending on whether the said interceptor is introduced into the gaseous jet at a right angle or not.

According to established principles, an interceptor according to the present invention, introduced perpendicularly into a supersonic gaseous jet, gives rise to a separate shock wave inducing an over-pressure zone upstream of the interceptor, the flow being subsonic within said zone.

An interceptor introduced, on the contrary, like standard aerodynamic flaps, at a small angle within a supersonic gaseous jet gives rise to a shock-wave not detached from said interceptor, so that in that case there is no over-pressure zone upstream of the interceptor, and the flow along the latter is supersonic.

If follows from this essential difference, that:

(*a*) In the case where the interceptor **2** (see Fig. 9) is introduced at a small angle inside the supersonic jet, the pressures acting upon said interceptor exert a force F_1 giving rise to a diving moment, it being noted that the shockwave O_1 not being separate and the flow along the interceptor being as a result supersonic, considerable friction forces F_2 will occur and reduce the efficiency of the interceptor which then only operates through resultant R.

(*b*) On the contrary, in the case where the interceptor **2** (see Fig. 10) is introduced at right angles within the supersonic jet, the force F_1 acting upon the interceptor itself gives rise not to a diving moment but to a lifting moment (small in view of the short lever arm d_1).

The diving moment results from the fact that the shock wave O_2, which is separate, gives rise to overpressures exerted along F, upstream of the interceptor directly on the body of the nozzle.

The pressure and velocity changes within the gaseous jet caused by introducing the interceptor **2** at a right angle are bound to each other by the law of the quantity of motion.

The jet thrust that was axial before the introduction of the interceptor shows therefore a lateral component R, resultant of F and F_1.

If R_o is the total thrust, the jet is accordingly deflected by an angle α such that

$$\sin \alpha = \frac{R}{R_o}$$

I claim:

1. In a device for deflecting a supersonic gaseous jet, a nozzle subject to supersonic flow of a gaseous current therethrough, at least one movable jet-intercepting surface disposed at right angles to the gaseous current, said surface having relatively small dimensions in comparison with those of the nozzle and located adjacent the outlet orifice of the said nozzle and outside the nozzle when in the position of rest, the end of said intercepting surface adjacent said outlet orifice having a bevel shape so as to reduce frictional forces, and actuating means for introducing a single movable interception surface at a time into the supersonic gaseous current at right angles to said current, whereby the displacements of said movable surface result in an impact wave producing proportional changes in the distribution of pressure along the corresponding wall of the nozzle upstream of the intercepting surface and a proportional substantial deviation of the longitudinal axis of the supersonic jet without modifying the output of said nozzle.

2. In a device for deflecting a supersonic gaseous jet, a nozzle subject to supersonic flow of a gaseous current therethrough, a movable interceptor located immediately adjacent the outlet orifice of said nozzle and having a deflecting surface disposed at right angles with respect to the nozzle gas flow, and actuating means moving said interceptor into the supersonic gas stream in a direction perpendicular to the flow of gas to deflect the flow of gas, producing an impact wave and thereby causing a substantial deviation in the direction of flow of the supersonic jet stream, said deviation of the supersonic jet stream resulting in a side thrust applied to the wall of the nozzle upstream of the interceptor.

3. Device according to claim 2, wherein the movable intercepting surface is located downstream relatively to the outlet orifice of the nozzle.

4. Device according to claim 2, wherein the movable intercepting surface is located upstream relatively to outlet orifice of the nozzle.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,838,984	Berkowitz	Dec. 29, 1931
1,879,187	Goddard	Sept. 27, 1932
2,077,471	Fink	Apr. 20, 1937
2,395,809	Goddard	Mar. 5, 1946

FOREIGN PATENTS

Number	Country	Date
606,176	Great Britain	Aug. 10, 1948