March 5, 1946. R. H. GODDARD 2,395,809

ROCKET DIRECTING APPARATUS

Filed Dec. 2, 1939

Fig. 1.

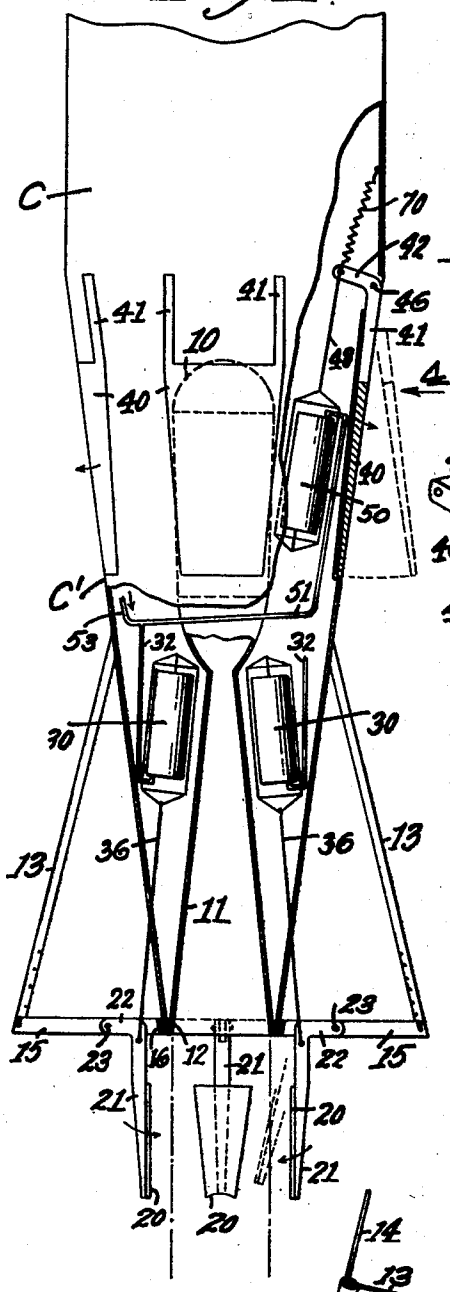


Fig. 2.

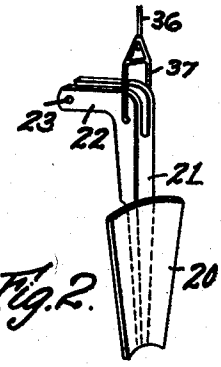


Fig. 6.

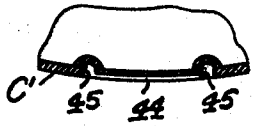




Fig. 5.

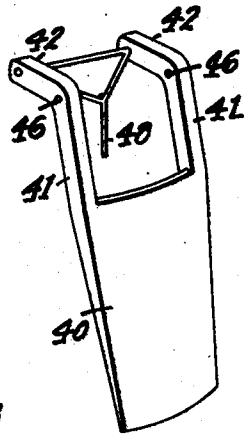


Fig. 3.

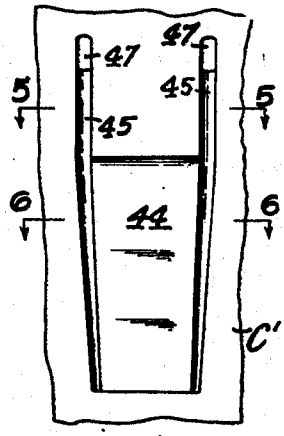


Fig. 4.

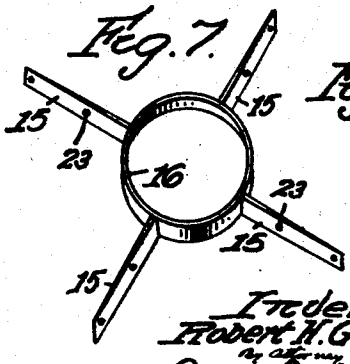


Fig. 7.

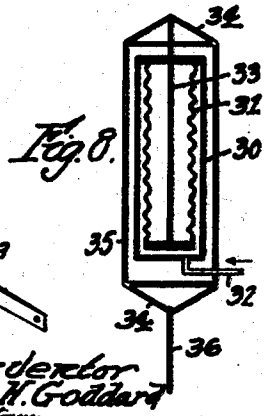


Fig. 8.

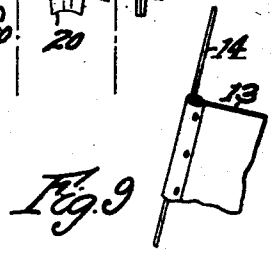


Fig. 9.

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UNITED STATES PATENT OFFICE

2,395,809

ROCKET DIRECTING APPARATUS

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Application December 2, 1939, Serial No. 307,298

3 Claims. (Cl. 244—52)

This invention relates to aircraft of the rocket type in which propulsion is produced, at least in part, by a rearwardly discharged blast from a combustion chamber within the craft. Such aircraft are designed for operation at extremely high altitudes, and both the speed of the craft and the density of the atmosphere vary widely in different parts of a flight.

It is the general object of my present invention to provide improved steering apparatus by which the flight of an aircraft of the rocket type may be effectively directed under widely varying conditions as to speed and atmospheric density.

To the attainment of this object, I provide a set of vanes coacting with the rocket blast and a second set of vanes coacting with the free air through which the craft is traveling. I also provide means for actuating certain vanes in one set simultaneously with certain vanes in the other set to produce a single steering effect, all as will be hereinafter fully described.

My invention further relates to arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

A preferred form of the invention is shown in the drawing, in which

Fig. 1 is a plan view, partly in section, of the rear portion of a rocket craft embodying my improvements;

Fig. 2 is a perspective view of one of the vanes which coact with the rocket blast;

Fig. 3 is a perspective view of one of the vanes which coact with the free air;

Fig. 4 is a side elevation of a portion of the rocket casing, looking in the direction of the arrow 4 in Fig 1;

Figs. 5 and 6 are detail sectional views, taken along the lines 5—5 and 6—6 respectively in Fig 4;

Fig. 7 is a perspective view of a supporting element to be described;

Fig. 8 is a sectional view of a vane-actuating cylinder; and

Fig. 9 is a detail perspective view to be described.

Referring to Fig. 1, I have shown a portion of an aircraft of the rocket type comprising a casing C having a readwardly tapered portion C', a combustion chamber 10 mounted within the portion C', and a nozzle 11 extending to an opening 12 at the rear end of the portion C' and through which opening the combustion gases are discharged.

I have also shown the usual fixed vanes 13, which are preferably made of thin light-weight material and which may be reenforced at their outer edges by stiffening wires 14, the lower ends of which are attached to the outer ends of arms 15 (Fig. 7). These arms project outwardly from a ring 16 secured around the opening 12 at the rear end of the tapered casing portion C', as shown in Fig. 1, and afford support for the blast vanes to be described.

The parts thus far described, with the exception of the wires 14, arms 15 and ring 16, are of the usual type and in themselves form no part of my present invention, which relates particularly to improved apparatus for steering the craft, as will now be described.

This steering apparatus comprises in part a set of blast vanes 20 (Figs. 1 and 2), preferably made of stainless or heat-resistant sheet steel. Each vane 20 is curved in transverse section, as indicated in Fig. 2, and the lower end of each vane is also upwardly arched, so that the middle portion of the end of the vane will not project too far into the middle portion of the rocket blast, which portion is at very high temperature and travels at extremely high speed.

The width of the vanes is preferably decreased toward the rear, as shown in Figs. 1 and 2, in order to avoid interference when two adjacent vanes are operated simultaneously in steering. The adjacent vanes may then engage along their side edges and form a substantially continuous surface.

Each vane 20 is mounted on a tapered supporting arm 21 having an offset end portion 22 pivoted at 23 on one of the supporting arms 15 previously described. The offset end portion 22 is preferably slotted, as indicated at Fig. 2, to embrace its arm 15. The vane is thus held more securely in axial alignment and unbalanced forces which might tend to twist the vane sidewise are avoided.

The blast vanes 20 are shown in full lines in Fig. 1 in their normal idle or inoperative position, and one of the vanes 20 is shown in dotted lines in operative position. When in normal position, the vanes 20 extend rearward parallel to the path of travel of the craft and present very slight air resistance.

The vanes 20 are selectively operated by suitable actuating devices. In the present embodiment of my invention, each vane is provided with a pressure-operated device comprising a cylinder 30 (Fig. 8) having a thin metal bellows member 31 mounted therein and secured and tightly sealed thereto at its upper end. A pipe 32 is con-

nected to the closed space between the cylinder 30 and the bellows member 31. Application of gas or other pressure through the pipe 32 will obviously compress the bellows member 31.

A rod 33 (Fig. 8) is fixed to the lower end of the member 31 and extends loosely through an opening in the upper end of the cylinder 30. The upper end of the rod 33 is connected through light frame or truss elements 34 and pull rods 35 to a wire 36, the lower end of which is connected through a yoke 37 (Fig. 2) to the arm 21 of an associated vane 20.

When pressure is applied to the pipe 32, the rod 33 and associated parts exert an upward pull on the wire 36 which then tends to advance its vane 20 toward the dotted line position shown in Fig. 1. In this advanced position, the vane 20 engages the rocket blast at one side thereof, and is thereby rendered effective to exert a directing force on the flight of the craft, as is well understood.

A separate operating cylinder is provided for each vane 20, and the vanes 20 may thus be operated selectively to direct flight in a desired direction. The selective application of pressure in the pipes 32 may be automatically controlled by a gyroscope or in any other convenient manner, such control apparatus forming no part of my present invention.

The apparatus thus far described will produce a steering effect so long as the rocket blast is in operation but will produce little effect when the blast is discontinued. For the purpose of steering the craft under these latter conditions, I provide a set of air vanes 40 (Fig. 3) which are substantially larger than the vanes 20 and which are preferably formed of some very light material, such as aluminum.

The air vanes 40 are each provided with upwardly extending arms 41 having offset end portions 42, and each vane 40 is curved transversely to correspond to the curvature of the casing portion C' at the point where the vane is mounted. The vanes 40 are normally seated in recesses 44 (Fig. 6), each formed by inwardly depressing a part of the casing portion C'. The arms 41 are similarly provided with recesses 45 in which they are nested.

The air vanes 40 are pivoted to the casing edge at 46, and their offset ends 42 extend inward through openings 47 at the upper ends of the recesses 45. Wires 48 are attached to the offset ends 42 of the arms 41 and are operated by pressure cylinders 50, similar in all respects to the cylinders 30 previously described, pressure being applied in each cylinder 50 through a pipe 51.

I commonly connect the pipe 32 of a blast vane cylinder 30 on one side of the aircraft and the pipe 51 of an air vane cylinder 50 on the opposite side of the craft to a common pressure supply pipe 53, so that a selected blast vane 20 and an oppositely disposed air vane 40 can be simultaneously moved to effect a common steering action.

The fact that tension only is applied through the vane-operating wires 36 and 48 permits the cylinders to be located at a considerable distance from the associated vanes. Springs 70 are provided for returning the air vanes 40 to inoperative position, but the blast vanes 20 will naturally assume positions parallel to the line of flight when no operating pressure is applied thereto.

The arms 21 are made of substantial length so that the blast vanes 20 will not be located too closely adjacent the outlet of the nozzle 11 and thus interfere with the discharge of gases therefrom. Similarly, the arms 41 are of substantial length, so that the air vanes 40 will be swung outward far enough to encounter free air and beyond the stream of rapidly moving air directly associated with the moving aircraft.

It is desirable that all portions exposed to the rocket blast or to the air stream be stream-lined to reduce air resistance. For the same reason, the actuating cylinders 30 and 50 are concealed in the annular space between the casing portion C' and the combustion chamber 10 or nozzle 11, as clearly shown in Fig. 1.

The arms 22 and 42 are so disposed angularly with respect to their pull wires 36 and 48 that uniform pressure in the cylinders 30 and 50 produces approximately uniform turning moments of force on the vanes 20 and 40.

If uniform pressure is maintained in the supply pipe 53, the movements of the vanes 20 and 40 will be proportioned to the resistance encountered by the vanes. At low speeds or high altitudes the air vanes will be displaced more easily by uniform pressure than they will be at higher speeds or in denser atmosphere, but greater displacement will be necessary to produce a given steering effect. The movements of the blast vanes will be inverse to the blast pressure.

The two sets of vanes, simultaneously operated, provide very effective steering of the aircraft under varying conditions of flight. When the craft is just starting and is moving slowly, the blast vanes 20 are more effective. As the speed increases, the air vanes become increasingly operative and steering is accomplished with less inward movement of the blast vanes and with correspondingly less interference with the rocket blast. As the air density decreases at higher altitudes, however, the air vanes become less effective and the action of the blast vanes must again increase. When the rocket blast ceases, however, the loss of further steering effect by the blast vanes must be offset by wider displacement of the air vanes.

My improved steering apparatus thus gives substantially the same directing impulse regardless of the speed of the aircraft, will use most effectively the force that is applied thereto, and will have a minimum of drag or air resistance.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:

1. In an aircraft propelled at least in part by a rocket blast discharging rearward from a combustion chamber through a nozzle, steering apparatus comprising a plurality of blast vanes peripherally disposed about said rocket blast and substantially rearward of said nozzle, each vane being mounted on a relatively long and narrow supporting arm pivoted at its forward end to said craft and extending rearward therefrom, each vane being bodily and permanently spaced by said arm substantially rearward from said nozzle and entirely out of engagement with the rocket blast at any time except at a locus substantially spaced rearward from the rear end of said nozzle and thereby avoiding back pressure in said nozzle, and selective means to swing each blast vane angularly from a normal inoperative outward position which is out of the rocket blast to an operative inward position in engagement with the outer portion only of said rocket blast.

2. In an aircraft propelled at least in part by a rocket blast discharging rearward from a combustion chamber through a nozzle, steering apparatus comprising a plurality of blast vanes peripherally disposed about said rocket blast and

substantially rearward of said nozzle, each vane being mounted on a relatively long and narrow supporting arm pivoted at its forward end to said craft and extending rearward therefrom, each vane being bodily and permanently spaced by said arm substantially rearward from said nozzle and entirely out of engagement with the rocket blast at any time except at a locus substantially spaced rearward from the rear end of said nozzle and thereby avoiding back pressure in said nozzle, and selective means to swing each blast vane angularly from a normal inoperative outward position which is out of the rocket blast to an operative inward position in engagement with the outer portion only of said rocket blast, said blast vanes being of segmental and frustro-conical contour and being so mounted and positioned that they engage each other along their adjacent side edges when swung inward but that their rear end edges are substantially spaced from the nozzle axis when the side edges are thus engaged, whereby a substantial axial opening is at all times left open for discharge of blast gases.

3. In an aircraft propelled at least in part by a rocket blast, steering apparatus comprising a set of blast vanes, a set of air vanes, separate and selectively controlled pressure-operated actuating devices for each air vane and for each blast vane, a common and constant fluid pressure supply for all of said devices, operative connections between said pressure supply and said separate devices, and means to selectively associate the connections between certain of said separate devices and said common and constant fluid pressure supply so that the operating device of a selected blast vane at one side of the craft and the operating device of an oppositely-disposed air vane on the other side of the craft are simultaneously made active, and said connections to said constant fluid pressure supply operating in parallel and not in series and thereby rendering the extent of displacement of each air vane and of each blast vane independent of any other, with such displacement for each vane inversely proportional to the speed and density of the atmospheric medium engaged by said vane.

ROBERT H. GODDARD.