Sept. 19, 1950 R. H. GODDARD 2,523,008

TURBINE STARTING AND CONTROL APPARATUS

Filed July 26, 1946

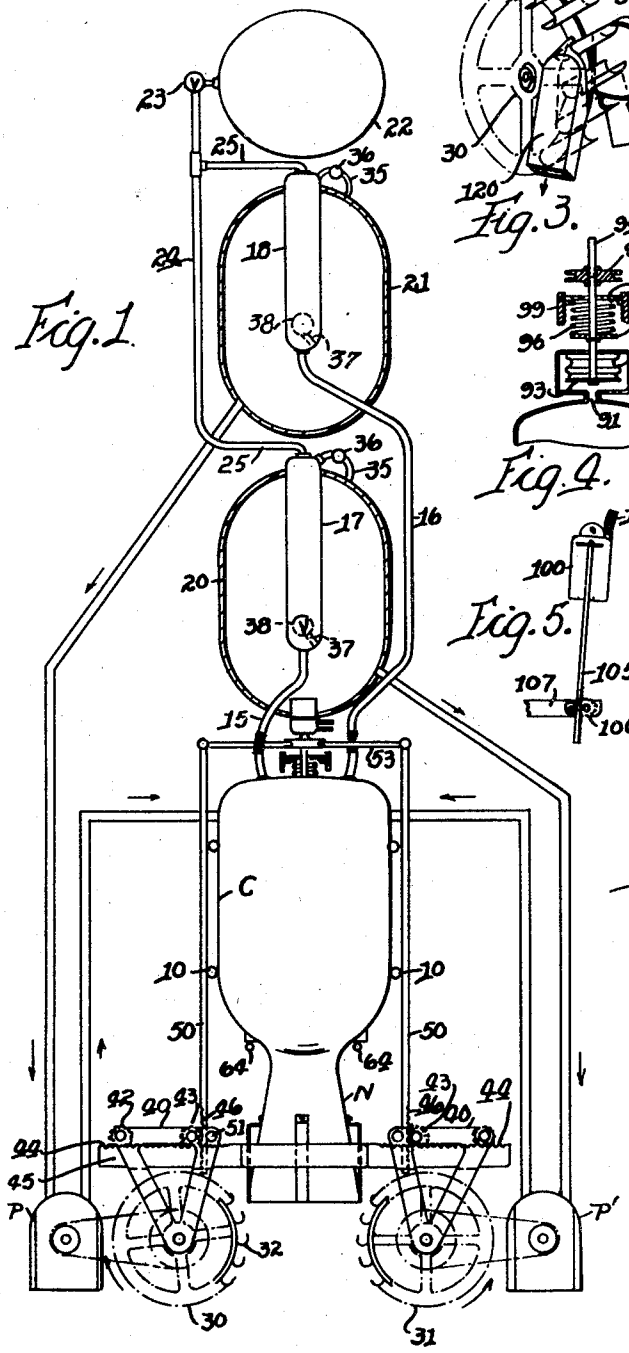

Fig. 1.

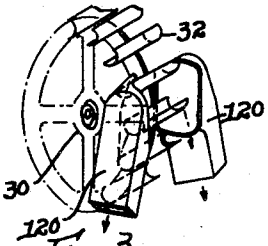

Fig. 3.

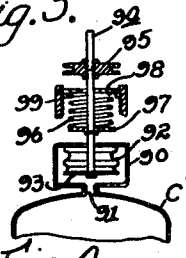

Fig. 4.

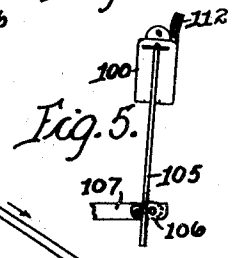

Fig. 5.

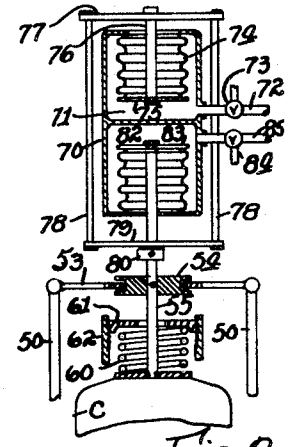

Fig. 2.

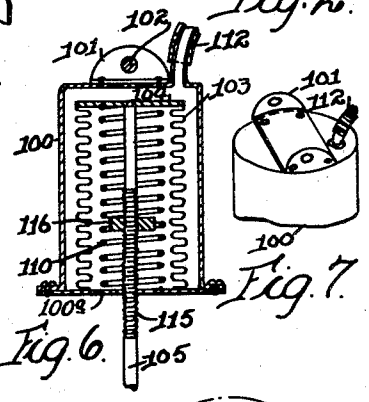

Fig. 6.

Fig. 7.

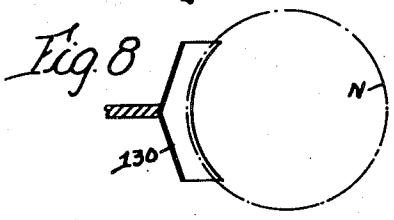

Fig. 8

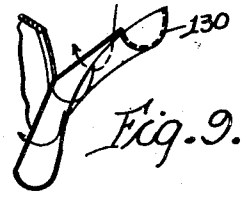

Fig. 9.

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2,523,008

TURBINE STARTING AND CONTROL APPARATUS

Robert H. Goddard, deceased, late of Annapolis, Md., by Esther C. Goddard, executrix, Paxton, Mass., assignor of one-half to The Daniel and Florence Guggenheim Foundation, New York, N. Y., a corporation of New York

Application July 26, 1946, Serial No. 686,390

8 Claims. (Cl. 60—35.6)

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This invention relates to the operation of turbines by nozzle-discharged combustion gases, and particularly to the starting and control of such turbines.

It is the general object of the invention to provide means to vary the position of the turbines with respect to the path of travel of the discharged combustion gases in such manner that a selected desired condition may be maintained. Such condition may relate to the maintenance of constant thrust, constant acceleration, constant chamber pressure, or to compensation for decreasing fuel load.

To the accomplishment of this general object, improved apparatus is provided for automatically maintaining the desired condition or adjustment and for changing the setting of the turbines in response to changes in operating conditions.

More specifically the invention relates to means for moving a pair of turbines toward or away from the stream of discharged combustion gases in response to changes in selected operating conditions.

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

Preferred forms of the invention are shown in the drawing, in which:

Fig. 1 is a front elevation of the improved turbine starting and control apparatus;

Fig. 2 is an enlarged sectional front elevation of certain parts shown in Fig. 1;

Fig. 3 is a perspective view of a portion of a turbine and associated parts;

Fig. 4 is a view similar to Fig. 2 but showing a modified construction;

Fig. 5 is a front elevation of a further modification;

Fig. 6 is an enlarged sectional view of certain parts shown in Fig. 5;

Fig. 7 is a perspective view of the upper end of the casing shown in Figs. 5 and 6;

Fig. 8 is a plan view of a modified turbine blade construction; and

Fig. 9 is a perspective view of the blade shown in Fig. 8.

Referring to the drawing, a combustion chamber C is provided with a discharge nozzle N and is mounted for limited axial movement in roller guides 10. At its upper or closed end, it is connected by telescoping pipes 15 and 16 to starting tanks 17 and 18 enclosed within low-pressure storage tanks 20 and 21 adapted to contain liquid fuel and a liquid oxidizing agent.

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A high pressure tank 22 contains an inert gas, such as nitrogen or helium, and is connected through a valve 23, pipe 24 and branch pipes 25 to the starting tanks 17 and 18. When the valve 23 is manually opened, gaseous pressure is applied to the tanks 17 and 18 and the liquid contents thereof are discharged into the combustion chamber C through the pipes 15 and 16. Any suitable ignition means (not shown) is provided for then igniting the gases from the intermingled mixture and thus starting combustion.

Turbines 30 and 31 are mounted at the rear or below the nozzle N, and the turbine buckets or vanes 32 project into the path of the discharged combustion gases. The turbine 30 is belt connected to drive a pump P by which liquid from the storage tank 21 is forced into the combustion chamber C. The turbine 31 similarly drives a pump P' connected to deliver liquid from the tank 20 to the combustion chamber C.

The starting tanks 17 and 18 are provided with vent connections 35 having check valves 36, and with filling pipes 37 provided with check valves 38. With this construction, the starting tanks 17 and 18 will be automatically refilled as soon as the valve 23 is manually or automatically closed to shut off the high pressure gas.

For a more complete description of the construction and operation of the starting and storage tanks and of the high pressure gas tank, reference is made to the prior patent of Robert H. Goddard, No. 2,397,659, issued April 2, 1946.

The turbines 30 and 31 are mounted on frames or carriers 40 which are supported by pinions 42 and 43 which engage racks 44 on a fixed supporting frame 45 through which the nozzle N is slidable. The pinions 43 are engaged by racks 46 at the lower ends of vertically extending rods 50.

The racks 46 are held in mesh with the pinions 43 by guide rolls 51 rotatably mounted in the carriages 40 and engaging the back edges of the rods 50. At their upper ends, the rods 50 are connected to a cross plate 53 which in turn is supported by a collar 54 (Fig. 2) fixed on a rod 55 mounted on the upper end of the combustion chamber C and axially movable therewith.

The angular movement of the rod 50 is very slight, with a maximum limit of 1.5°, but if considered desirable, flexible joints may be provided in the rods 50 as shown in Fig. 3 of Goddard Patent No. 2,450,950, issued October 12, 1948.

A coil spring 60 (Fig. 2) is interposed between the upper end of the combustion chamber C and a disc 61 threaded in a fixed sleeve 62. The

spring normally forces the combustion chamber down against stops 64 (Fig. 1) and resists the upward thrust of the chamber. As the thrust increases, the chamber C will be displaced upwardly relative to the disc 61 and against the resistance of the spring 60. Such upward movement raises the rods 50 and racks 46 relative to the carriers 40 and their fixed supporting frame 45.

The pinion 43 in the left-hand carrier 40 will thus be rotated anti-clockwise and will effect a controlled outward movement of the turbine 30 away from the stream of discharged combustion gases. This in turn will reduce the speed of the turbine 30 and will correspondingly reduce the amount of combustion liquid delivered to the combustion chamber by the pump P. The companion turbine 31 is similarly moved outward to reduce the delivery by the pump P'.

Consequently, the delivery of combustion liquids to the chamber C will be controlled to maintain any desired upward thrust of the combustion chamber, and this upward thrust may be selectively varied by adjusting the disc 61 (Fig. 2) in the fixed sleeve 62. The gears 43 may be of such comparative size as will give a combustion mixture of preferred proportions of fuel and oxidizer.

In order to vary the controlled upward thrust during the operation of the combustion chamber C, the structure shown in the upper part of Fig. 2 is provided. A fixed casing 70 has an upper chamber 71 to which a gas under pressure may be supplied through a pipe 72 controlled by a three-way valve 73.

A bellows operator 74 in the chamber 71 has its end disc 75 connected by a rod 76, cross arm 77, tie rods 78 and cross arm 79 to a collar 80 fixed on the upright rod 55 previously described. The collar 80 is attached to the cross arm 79 and forms a hub or bushing therefor.

The casing 70 also contains a lower chamber 82 and a disc 83 mounted at the upper end of the upright rod 55. The gas pressure in the lower chamber 82 is controlled by a three-way valve 84 in a supply pipe 85.

If the upper chamber 71 is vented and gas is admitted to apply any desired pressure in the chamber 82, this gas pressure will be added to the pressure of the spring 60 and the combustion chamber will be regulated to operate at a greater thrust than would be demanded by the spring 60 alone. The valve 84 should be manually returned to closed position as soon as the desired pressure is reached in the chamber 82

If, on the other hand, it is desired to regulate for decreased thrust, gas pressure is built up in the upper chamber 71 and the lower chamber 82 is vented. The pressure in the upper chamber 71 then acts in opposition to the spring 60 and thus reduces its resistance to upward movement of the chamber C. If both chambers 71 and 82 are vented, the spring 60 alone controls the operation as originally described.

In the modified construction shown in Fig. 4, the position of the turbines and the corresponding output of the pumps is controlled by the pressure of the gases in a fixed combustion chamber C'.

This combustion chamber C' is provided with an auxiliary casing 90 connected into the chamber by an open passage 91 at the upper end of the chamber and containing a bellows operator 92 having an end disc 93 mounted on an upright rod 94. The rod 94 carries a grooved collar 95 corresponding to the collar 54 shown in Fig. 2

and operating the cross arm 53 and upright rods 50 as previously described. A spring 96 is mounted between a disc 97 on the rod 94 and a disc 98 threaded in a fixed sleeve 99. The spring 96 corresponds in function to the spring 60 shown in Fig. 2.

With this construction, an increase in pressure in the chamber C' compresses the bellows operator 92 and the spring 96 and causes the turbines to be moved away from the path of the discharged gases as previously described. The control apparatus in this case maintains uniform chamber pressure rather than uniform thrust.

In Figs. 5, 6 and 7 a construction is shown by which the feed of the two liquids may be varied in different proportions. In this form of the invention, a separate control device is provided for varying the inward or outward adjustment of each turbine.

Each of these devices comprises a casing 100 (Fig. 6) having ears 101 pivoted on a fixed cross pin 102. The casing 100 contains a bellows operator 103 having an end disc 104 connected to the upper end of a rod 105 corresponding to the upright rod 50 in Fig. 1 and engaging a pinion 106 (Fig. 5) on a carriage 107 corresponding to one of the carriages 40.

A spring 110 at its upper end engages the disc 104 and at its lower end engages the bottom of the casing 100 which is vented at 100*a*. A pipe 112 connects the casing 100 to the interior of a combustion chamber not shown but corresponding to the chambers C and C' previously described. As the chamber pressure increases, the spring 110 is compressed and the rod 105 is pushed downward.

It will be noted from Fig. 5 that the rod 105 in this construction is outside of the pinion 106 rather than being inside as shown in Fig. 1. Consequently, downward movement of the rod 105 shifts the turbine outward, whereas in Fig. 1 upward movement of the rod 50 produces outward movement.

Each rod 105 may be threaded as indicated at 115 to receive a nut 116 which may be adjusted thereon and which acts as a stop by engagement with the vented bottom of the casing 100, thus limiting downward displacement of the rod 105 and corresponding outward movement of the turbine at any desired operating adjustment. The turbines will return to full inward positions prior to starting.

The construction shown in Figs. 5 to 7 is to be duplicated for each turbine, and the springs 110 may be selected to produce any desired feed of each combustion liquid. A change in pressure in the combustion chamber will produce a change in feed proportionate to the strength of the spring 110 in each control device.

A preferred construction of turbine blades and discharge passages is shown in Fig. 3, in which the gases engage the blades 32 and discharge endwise therefrom. The discharged gases are received in curved casings 120 by which they are diverted substantially rearward.

If the speed of the turbine blades is approximately one-half that of the combustion gases, the resultant rearward movement of the gases becomes negligible and the casings 120 may be omitted. In this case, the construction of the bucket or blade may be as shown in Figs. 8 and 9, with the blades 130 curved in plan to correspond to the periphery of the discharge end of the nozzle N, and with the blades also slightly curved

in a tangential plane to facilitate transverse discharge of the gases.

Several forms and modifications of the invention having been thus described, the invention is not to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what is claimed is:

1. In a rocket apparatus, a combustion chamber having a discharge nozzle, a pair of turbines movable into and out of the path of travel of the discharged combustion gases, feeding means for combustion liquids operated by said turbines, means to move said turbines transversely of said path of travel, and control devices for said moving means responsive to pressure changes in said combustion chamber and operative to maintain uniform chamber pressure.

2. In a rocket apparatus, a combustion chamber mounted for axial movement and having a discharge nozzle, a pair of turbines movable into and out of the path of travel of the combustion gases, low-pressure storage tanks for combustion liquids, pumps driven by said turbines and feeding said liquids at high pressure to said combustion chamber, and automatic means responsive to the axial position of said combustion chamber and effective to shift said turbines radially of said chamber on axial movement of said chamber, thereby maintaining uniform combustion chamber pressure.

3. In a rocket apparatus, a combustion chamber mounted for axial movement and having a discharge nozzle, a pair of turbines movable into and out of the path of travel of the combustion gases, low-pressure storage tanks for combustion liquids, pumps driven by said turbines and feeding said liquids at high pressure to said combustion chamber, automatic means responsive to the axial position of said combustion chamber and effective to shift said turbines radially of said chamber on axial movement of said chamber, thereby maintaining uniform combustion chamber pressure, and means to vary the resistance of said chamber to axial displacement.

4. In a rocket apparatus, a combustion chamber mounted for axial movement, a spring to resist such movement of said chamber, a pair of turbines operated by the discharged combustion gases, fuel-feeding means driven by said turbines, and means to move said turbines in and out of the gas stream in predetermined relation to the axial displacement of the chamber.

5. The combination in a rocket apparatus as set forth in claim 4, in which means is provided to vary the effective resistance of said spring to the axial displacement of said combustion chamber.

6. The combination in a rocket apparatus as set forth in claim 4, in which bellows operators are provided which are connected to increase or decrease the effective action of said spring as pressure is applied to one or the other of said operators.

7. The combination in a rocket apparatus as set forth in claim 4, in which the turbines are mounted in carriers movable radially of said combustion chamber on a frame fixed in said apparatus, and in which said frame has rack bars and said carriers have coacting pinions, and in which means is provided to rotate said pinions and thereby move said carriers in response to changes in the axial position of said chamber.

8. The combination in a rocket apparatus as set forth in claim 4, in which the turbines are mounted in carriers movable radially of said combustion chamber on a frame fixed in said apparatus, and in which said frame has rack bars and said carriers have coacting pinions, and in which additional rack bars are movable axially relative to said fixed frame and are operative to rotate said pinions and thereby move said carriers in response to changes in the axial position of said combustion chamber.

ESTHER C. GODDARD,
Executrix of the Last Will and Testament of Robert H. Goddard, Deceased.

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The following references are of record in the file of this patent:

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