March 20, 1962 E. FISCHOFF 3,025,669

METHODS OF AND DEVICES FOR STABILIZING TURBINE RATING, NOTABLY IN POWER MISSILES

Filed July 28, 1958 3 Sheets-Sheet 1

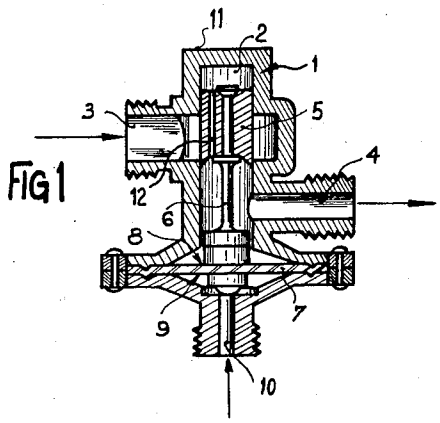


FIG 1

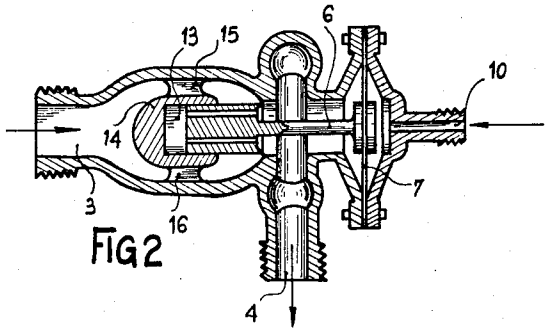


FIG 2

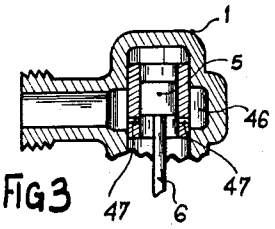


FIG 3

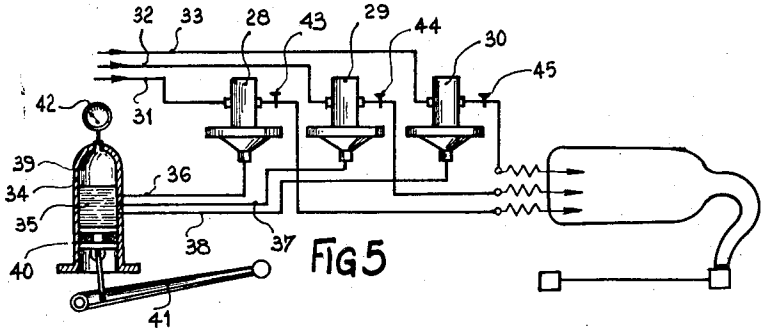


FIG 5

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METHODS OF AND DEVICES FOR STABILIZING TURBINE RATING, NOTABLY IN POWER MISSILES

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FIG 4

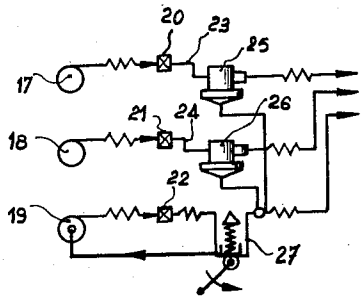


FIG 8

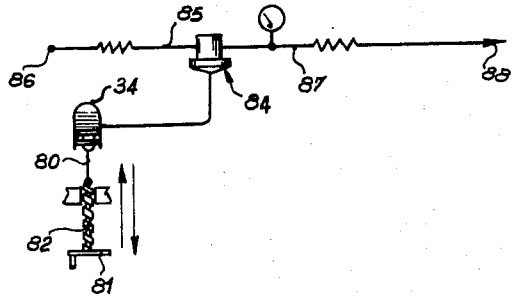
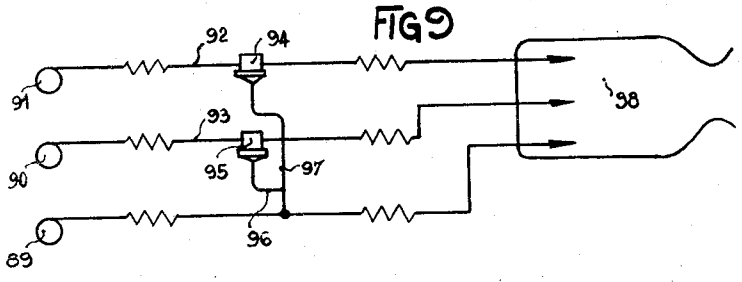


FIG 9



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METHODS OF AND DEVICES FOR STABILIZING TURBINE RATING, NOTABLY IN POWER MISSILES

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FIG6

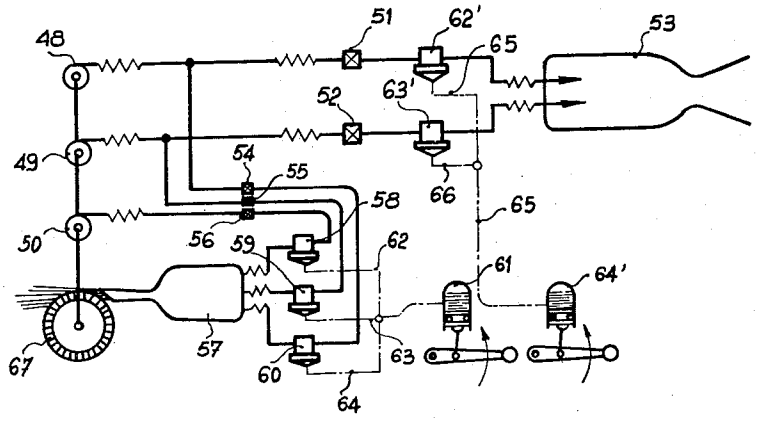
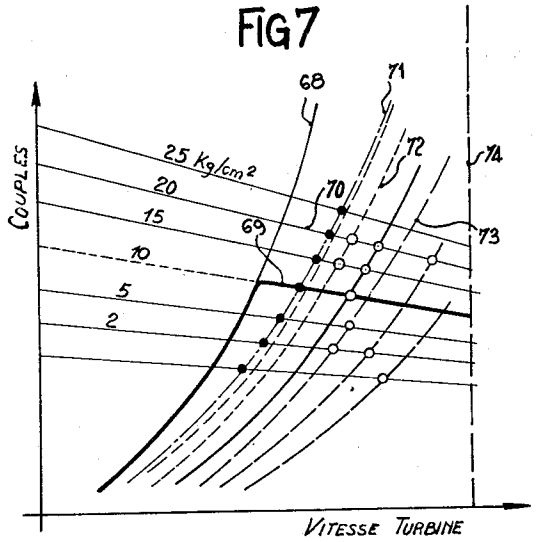


FIG7



United States Patent Office 3,025,669 Patented Mar. 20, 1962

3,025,669

METHODS OF AND DEVICES FOR STABILIZING TURBINE RATING, NOTABLY IN POWER MISSILES

Etienne Fischoff, 2 Rue Anatole France, Vincennes, France

Filed July 28, 1958, Ser. No. 751,539
Claims priority, application France July 31, 1957
8 Claims. (Cl. 60—39.27)

This invention relates in general to power missiles and has specific reference to improvements in the methods of and the devices for stabilizing the velocity or rating of turbines, notably in power missiles.

One of the important problems arising notably in connection with power missiles using liquid propellants as fuels, especially in the case of variable-thrust power missiles incorporating a self-feed turbo-pump group, consists on the one hand in obtaining a perfect stabilization of the speed of the pump-driving turbine so as to develop a well-defined thrust, and on the other hand in ensuring its feed with substantially isothermal gases resulting from the combustion of two or three liquids in the gas generator. This isothermy—resulting from an invariability of the ratios of the "mass" flows of the different liquids—is desirable on the one hand in order to protect the turbine against any increase in the gas temperature at certain speeds, and on the other hand for obtaining a maximum operating efficiency of the generator-turbine group.

Many solutions have already been proposed to this problem, but so far as the applicant is aware none was entirely satisfactory up to now.

It is the essential object of this invention to provide a method whereby this stabilization as well as this isothermy can be obtained in a particularly simple, reliable and efficient manner. This invention is also concerned with devices for carrying out this method.

Another problem quite as much important is to ensure an adequate operation of the main combustion chamber or chambers of a power missile of the variable-thrust type wherein it is necessary not only to accurately meter the aggregate output of the two reacting liquids but also to maintain the ratio of these two outputs to a constant value for obtaining the optimum efficiency values.

It is another object of this invention to provide a particularly simple and reliable solution of this twofold problem.

The method of this invention consists essentially in applying a strictly identical pressure to the different liquids fed to the gas generator of the turbine or to the thrust chambers, this pressure being more particularly the same as a so-called "pilot" pressure of fixed or variable or adjustable value; preferably, this "pilot" pressure is variable either under the operator's control or according to a predetermined program.

Thus, all the pressure irregularities or discrepancies arising before the device of this invention are somewhat "neutralized."

In the following description it is assumed that the invention is applied to the case of a gas generator in which three liquids are utilized, as main combustion chambers in which two liquids are present constitute a specific case of the preceding one.

It will be understood that in this description the term "liquid" designates simple liquids proper as well as solutions, liquid mixtures or gases.

The device for carrying out this method comprises essentially as many pressure regulators as there are separate liquids, each regulator comprising an inlet and an outlet for the liquid concerned, and an inlet for the "pilot" pressure, a generator for generating this "pilot" pressure and possibly a device for varying the value of this "pilot" pressure either under the operator's control or according to a predetermined program.

According to a first form of embodiment of this invention the pilot pressure utilized is the pressure of one of the liquids concerned as obtaining at the outlet of a conventional-type by-pass valve inserted in the circuit of the liquid concerned.

A more advantageous form of embodiment of this invention consists in generating the "pilot" pressure in a separate device, this "pilot" pressure being transmitted to the different regulators by a chemically inert liquid, means being provided for varying the value of this "pilot" pressure.

A regulator according to this invention comprises a flexible diaphragm receiving the pilot pressure on one face and responsive to the delivery pressure of the liquid on the other face, this diaphragm being connected to a movable member of which the movements are adapted to modify the cross-sectional area of the passage interconnecting the inlet and outlet ports for the liquid concerned in the regulator.

Of course, the number of liquids that can be subjected to this regulation is unrestricted as each liquid flows through its own separate regulator.

Other features and advantages of this invention will appear as the following description proceeds with reference to the accompanying drawings forming part of this specification and illustrating diagrammatically by way of example a few forms of embodiment of the invention. In the drawings:

FIGURE 1 is an axial sectional view showing a regulator constructed according to the teachings of this invention.

FIGURE 2 is a modified embodiment of this regulator.

FIGURE 3 is a further modification of the regulator of this invention.

FIGURE 4 is a diagrammatic illustration of a first form of embodiment of an installation according to this invention.

FIGURE 5 is a diagrammatic view illustrating another form of embodiment of this invention.

FIGURE 6 is a diagram illustrating a complete rocket powered aircraft control arrangement according to this invention.

FIGURE 7 is an explanatory diagram, and

FIGURES 8 and 9 are diagrams illustrating two further cases of application of the method and device constituting the subject-matter of this invention.

As already pointed out in the above preample, one of the essential component elements in an installation according to this invention is the pressure regulator, that is, the device which, when subjected to the action of the "pilot" pressure as defined hereinabove, limits to this value the liquid pressure obtained in the downstream portion of the circuit in which this regulator is inserted.

In the form of embodiment illustrated by way of example in FIGURE 1, the regulator comprises a body 1 in which an axial bore 2 is formed; this bore comprises an inlet 3 for the liquid to be controlled and an outlet 4 for the same liquid. These inlet and outlet are off-set along the axis of the body 1 so that a piston 5 slidably mounted in the bore 2 may modify the cross-sectional area available for the liquid between the inlet 3 and outlet 4, thereby creating a loss of pressure that may be used for modifying the pressure of this liquid at the outlet orifice 4.

The piston 5 is connected by a rod 6 to a diaphragm 7 closing the bore 2 beneath the outlet orifice 4; preferably, this diaphragm is flexible, that is, adapted to be deformed without its elasticity or its rigidity interfering with this movement. The inner face 8 of the diaphragm 7 is responsive to the outlet pressure of the liquid to be controlled, and its outer face 9 is responsive to the "pilot"

pressure required for a liquid properly introduced through the orifice 10.

The operation of this device in the general case wherein the output issuing from 4 is not zero, is very simple and appears clearly from the preceding description.

Three cases may arise: in the first case, the pressure obtained at the outlet is higher than the "pilot" pressure; in this case, due to the pressure differential, the diaphragm 7 moves downwards, carries along the piston 5 during its movement and thus the piston 5 will throttle the passage which, in the bore 2, connects the inlet orifice 3 to the outlet orifice 4; thus, the liquid pressure at the outlet will be reduced. In the second case, the pressure obtained at the outlet is lower than the "pilot" pressure; under these conditions, the "pilot" pressure becomes preponderant and moves the diaphragm 7 in the opposite direction, thereby increasing the cross-sectional passage available for the liquid to be controlled and therefore the output pressure of this liquid.

Consequently, in the two cases contemplated hereinabove the output pressure of the liquid to be controlled will tend to become equal to the "pilot" pressure. When this equality condition is attained, the third case arises wherein the diaphragm is stationary, that is, held in a position of equilibrium.

Now, this device cannot operate with a sufficient degree of accuracy unless the piston 5 is free from influences other than those transmitted through the diaphragm 7; it is essential, notably, that the piston 5 moves without encountering any resistance under the control of this diaphragm and consequently that the pressure existing in the chamber situated between the piston and the bottom 11 of the bore be constantly equal to the output pressure of the liquid to be controlled. Under these conditions, it is advantageous to pierce through the piston at least one passage such as 12 to interconnect the two faces of the piston.

In the form of embodiment just described it will be seen that the liquid to be controlled is delivered radially through the orifice 3. As a result of this specific arrangement, the piston receives a radial dynamic thrust which urges it against the wall of bore 2 with a variable force, this force generating a frictional resistance also of variable value which interferes with the free displacement of the piston. To avoid this source of errors, the liquid to be controlled may be fed to the regulators in an axial direction as illustrated in the form of embodiment of FIGURE 2.

In this example the piston 5 and rod 6 are co-axial with the orifice 3 constituting the inlet for the liquid to be controlled. This piston 5 is displaceable in a bore 13 of member 14, this member 14 being supported in the body 1 by arms such as 15, 16. In a third form of embodiment illustrated in FIGURE 3 and to compensate the influence of the dynamic pressure of the fluid fed through the orifice 3 (FIGURE 1), an annular space 46 may be provided around the piston 5, this annular space 46 communicating only through orifices 47 with the piston 5; these orifices 47 are disposed symmetrically and pierced through the wall of a cylindrical sleeve 48 force-fitted in the body 1. Except for these modifications, the device of FIGURE 2 and that of FIGURE 3 are similar to that illustrated in FIGURE 1; more particularly, the operation is exactly the same.

It is an essential object of this invention to provide a pressure regulator of the type described hereinabove in the feed system of ballistic, guided and other missiles, this application being particularly advantageous in that it ensures an isothermal fuel feed of the gas generators of the turbines of these missiles, as well, on the other hand, as a constant-richness fuel feed of the combustion chambers of rocket engines and of the ram-jets, since the pressure regulator described hereinabove is suitable for regulating gas pressures as well as liquid pressures.

This specific application constitutes, as already set forth hereinabove, a combination of a device adapted to generate the "pilot" pressure with as many regulators of the above-described type as there are fluids of which the pressure must be rendered equal to said "pilot" pressure. A first form of embodiment of this combination is illustrated in FIGURE 4. In this example, the liquids delivered to the gas generator of the turbine (not shown) are supplied by pumps 17, 18, 19 and circulate through distributors 20, 21, 22 of known type.

In pipes 23, 24, receiving the liquids from pumps 17 and 18 respectively, there are inserted regulators 25, 26 for example either of the type illustrated in FIGURE 1 or of the type shown in FIGURES 2 or 3. In this case the "pilot" pressure is that of the liquid supplied by pump 19 after this liquid has circulated through the by-pass valve 27 which may be adjustable if it is desired to vary the pressure of the gas generator.

This form of embodiment of the invention is characterized by many advantages, notably that of requiring a number of regulators which is inferior by one unit to the number of liquids utilized, a consequent advantage being the reduction in the length of piping. Finally, with this arrangement the drawbacks characterizing the use of separate by-pass valves inserted in each pipe line are definitely avoided. However, this arrangement is attended by certain inconveniences.

More particularly, it is evident that the different liquids are responsive to the law set up by the by-pass valve generating the "pilot" pressure, which is not an ideal law; as a result, a certain uncertainty still remains as to the point of stabilization of the turbine, due notably to the frictional contacts introduced by the guiding of the spring and its valve, as well as by the possible modification of the spring characteristics, due to the frequent presence of corrosive liquids.

The form of embodiment illustrated in FIGURE 5 is particularly advantageous in that it avoids the drawbacks still holding in the preceding form of embodiment, and that it derives from the invention all the advantages likely to be obtained therefrom. In this example, a regulator 28, 29, 30 is inserted in each pipe line 31, 32, 33 connected to the outlet of the feed pumps, respectively. The "pilot" pressure is supplied by a specific device comprising a bell-shaped member 34 containing a liquid 35 fed through ducts 36, 37, 38 to regulators 28, 29, 30 respectively. A reserve of air or other gas 39 is provided at the top of the bell shaped member 34 to permit variations in the "pilot" pressure by displacing the piston 40 obturating this bell-shaped member with the assistance of a lever 41; this pressure may be read on the dial of a pressure gauge 42.

This form of embodiment of the invention will therefore permit the total suppression of by-pass devices and also of the well-known drawbacks characterizing these devices. More particularly, the pressures of the liquids are strictly equal irrespective of the rate at which the unit is operated; on the other hand, with this arrangement the problem of the isothermal feed of gas generators for missile turbines is solved satisfactorily.

FIGURE 6 shows diagrammatically another form of embodiment wherein the invention is applied not only to the feed of a gas generator for the pump-driving turbine but also to the main injectors supplying the main thrust chamber of the missiles.

In this form of emobdiment the pumps 48', 49 and 50 supply at the same time the main distributors 51, 52 associated with the main thrust chamber 53 and, through adequate branch lines, the distributors 54, 55 and 56 connected to the gas generator 57 of the turbine.

Inserted between the distributors 54, 55 and 56, on the one hand, and the gas generator 57, on the other hand, are regulators 58, 59 and 60 similar to those already described and to which the "pilot" pressure from the device

61 is applied through ducts 62, 63 and 64. This assembly operates in the manner already described hereinabove.

Similarly, between the main distributors 51 and 52 on the one hand and the main chamber 53 on the other hand are inserted regulators 62' and 63' to which the "pilot" pressure of another device 64' is applied through ducts 65, 66. The generator 57 actuates the turbine 67 which drives in turn the three pumps 48, 49 and 50.

These "pilot" pressures may be adjusted separately by acting independently upon the corresponding control levers. If desired, anyone of these control levers may be interlocked with another lever according to any suitable servo-action law.

The advantages deriving from this combination are summarized in the diagram of FIGURE 7 in which the curve 68 designates the natural torque of the turbine, the inclined straight lines such as 69, 70 . . . showing the turbine torques stabilized by the "pilot" device 61. The line 71 of this diagram designates the maximum reaction torque of the pumps and when the "pilot" device 64' is inoperative or not provided it will be seen that a stabilization is obtainable only on line 71, that is, at the point of intersection of lines such as 69 and 70, etc. with this line 71.

The introduction of the "pilot" device 64' and of the relevant regulators 62', 63' permits of varying the maximum reaction torque and in this case this torque is designated by line such as 72, 73, etc. and therefore by varying the values of the two "pilot" pressures it becomes possible to stabilize at any point of the plane situated between the curve 71 and the straight 74 designating the maximum permissible speed of the turbine. Consequently, a thrust notably as close as possible to zero may be obtained in the main chamber 53 while maintaining a pressure in the generator which is substantially equal to the minimum pressure ensuring the proper operation of said generators.

Of course, the forms of embodiment of the invention which are described hereinabove and illustrated in the accompanying drawings should not be construed as limiting the purpose of the invention as they are simple examples showing the manner in which the invention may be carried out and to which many modifications may be brought without departing from the spirit and scope of the invention as set forth in the appended claims.

Thus, notably, an additional loss of pressure may be introduced in each fluid circuit leading to the generator, this additional pressure drop resulting for example from the provision of needle-valves such as 43, 44 and 45 (FIGURE 5). Similarly, the displacements of piston 40 for varying the "pilot" pressure may be effected automatically according to a predetermined law by substituting a cam of adequate contour, driven by a servo-motor, for the aforesaid lever 41; in this case, a remote-control action may also be provided without difficulty.

Similarly, the pipe lines 36, 37 and 38 (FIGURE 5) may be replaced by a single line supplying the "pilot" pressure to all the regulators such as 28, 29, 30, etc.

In FIGURE 8 there is illustrated another form of embodiment of the device of this invention in the case of a remote-controlled variable-output valve. The adjustable "pilot" pressure is supplied by the device 34 of which the piston 40 is connected by a rod 80 to a crank-handle 81, adequate means such as a screw 82 permitting the adjustment of the position of this piston 40 and consequently the value of the "pilot" pressure delivered by the device 34 through the pipe line 83. The latter leads to a device 84 according to the invention which is connected on the other hand at 85 to an upstream source of pressure 86 and on the other hand at 87 to a downstream source of pressure 88.

In FIGURE 9 another example is shown wherein it is assumed that there are three sources of pressure 89, 90 and 91 of which two (90 and 91) are connected through pipe lines 92, 93 to a pair of devices 94, 95 according to the invention, the third source (89) being connected on the one hand through pipe lines 96, 97 to the inlets of devices 94, 95 for the liquid at the "pilot" pressure. The assembly leads into a chamber 98.

From the foregoing it will be readily understood that with this invention the pressures of the liquids delivered at 94 and 95 are strictly equal to each other and also to that delivered at 98.

As already pointed out, many modifications and alterations may be brought to the various forms of embodiment given herein without departing from the spirit and scope of the invention as set forth in the appended claims.

What I claim is:

1. In a variable thrust liquid propellant rocket motor for jet propelled vehicles including at least one combustion chamber with exhaust nozzle for generating said thrust, a gas generator producing burnt gases, three storage tanks for two combustion-supporting liquids (fuel and oxidizer) to be burnt in said combustion chamber and in said gas generator and for a third coolant liquid to be mixed in said gas generator with said burnt gases to limit the temperature thereof to a maximum permissible value, and injectors provided in said combustion chamber and in said gas generator to inject said liquids therein, a fluid supply circuit system comprising three rotary supply pumps provided each with an inlet and an outlet and adapted to feed said liquids from said tanks respectively to said combustion chamber and to said gas generator, a single gas turbine operatively coupled to said pumps to drive same simultaneously whereby the ratios of their speeds remain invariable at all turbine ratings, said gas generator producing said burnt gases to operate said turbine, suction lines connecting said tanks to said inlets of the relevant said pumps, discharge lines connecting said outlets of said two pumps for said combustion-supporting liquids respectively to the relevant injectors of said combustion chamber and to the relevant injectors of said gas generator and said outlet of said third pump for said coolant liquid to the relevant injectors of said gas generator, cut-off valve means inserted in each of said discharge lines, self-actuating pressure regulating devices inserted one in each of said discharge lines downstream of said cut-off valves and immediately up-stream of said combustion chamber and of said gas generator respectively to be each flown through by the relevant said liquid, said devices being each subjected and responsive to an independent constant static reference control pressure so called "pilot pressure" applied thereto, said devices being adapted to deliver said liquids at strictly constant exit pressures to the relevant injectors of said combustion chamber and to the relevant injectors of said gas generator whereby said exit pressures are separately made and kept equal to said pilot pressures respectively, a first control means forming an independent source of stationary pressure fluid of constant inventory to thereby provide a first pilot pressure of determined adjustable value and connected to the two regulating devices feeding said combustion chamber so that both of them are subjected to a same pilot pressure whereby said combustion-supporting liquids are supplied to the relevant injectors of said combustion chamber at strictly constant pressures equal to each other and to said first pilot pressure, and a second control means forming an independent source of stationary pressure fluid of constant inventory to thereby provide a second pilot pressure of determined adjustable value, and connected to the three regulating devices feeding said gas generator so that all three devices are subjected to a same pilot pressure whereby said combustion-supporting and coolant liquids are supplied to the relevant injectors of said gas generator at strictly constant pressures equal to each other and to said second pilot pressure.

2. In a variable thrust liquid propellant rocket motor for jet propelled vehicles including at least one combustion chamber with exhaust nozzle for generating said

thrust, a gas generator producing burnt gases, three storage tanks for two combustion-supporting liquids (fuel and oxidizer) to be burnt in said combustion chamber and in said gas generator and for a third coolant liquid to be mixed in said gas generator with said burnt gases to limit the temperature thereof to a maximum permissible value, and injectors provided in said combustion chamber and in said gas generator to inject said liquids therein, a fluid supply circuit system comprising three rotary supply pumps provided each with an inlet and an outlet and adapted to feed said liquids from said tanks respectively to said combustion chamber and to said gas generator, a single gas turbine operatively coupled to said pumps to drive same simultaneously whereby the ratios of their speeds remain invariable at all turbine ratings, said gas generator producing said burnt gases to operate said turbine, suction lines connecting said tanks to said inlets of the relevant said pumps, discharge lines connecting said outlets of said two pumps for said combustion-supporting liquids respectively to the relevant injectors of said combustion chamber and to the relevant injectors of said gas generator and said outlet of said third pump for said coolant liquid to the relevant injectors of said gas generator, cut-off valve means inserted in each of said discharge lines, a number of self-acting pressure regulating devices which is one less than the number of said discharge lines which all but a selected one discharge line among said three discharge lines feeding said gas generator include each one of said regulating devices inserted therein down-stream of said cut-off valves and immediately up-stream of said combustion chamber and of said gas generator respectively to be each flown through by the relevant said liquids, said regulating devices being subjected and responsive each to an independent constant static reference control pressure so called "pilot pressure" applied thereto, said devices being adapted to deliver said liquids involved at strictly constant exit pressures to the relevant injectors of said combustion chamber and to the relevant injectors of said gas generator whereby said exit pressures are separately made and kept equal to said pilot pressures respectively, a control means forming an independent source of stationary pressure fluid of constant inventory to thereby provide a first pilot pressure of determined adjustable value and connected to the two regulating devices feeding said combustion chamber to subject both of them to a same pilot pressure whereby said combustion-supporting liquids are supplied to the relevant injectors of said combustion chamber at strictly constant pressures equal to each other and to said first pilot pressure, an adjustable by-pass valve means inserted in said selected one discharge line down-stream of said cut-off valve involved, and branch lines connecting said selected one discharge line down-stream of said by-pass valve to each of the two remaining said regulating devices feeding said gas generator to provide said latter devices with a common second pilot pressure which is the pressure of the liquid in said selected one discharge line whereby the three said liquids (fuel, oxidizer and coolant) are fed to the relevant injectors of said gas generator at strictly constant pressures equal to each other.

3. In a rocket motor, a fluid supply circuit system according to claim 1, wherein each of said regulating devices comprises a casing formed with an inner closed cavity consisting of a substantially cylindrical bore closed at one end and expanding at the opposite end into a short coaxial transversely enlarged substantially circular chamber closed by a coaxial bottom of substantially frusto-conical shape, a tubular inlet orifice and a tubular outlet orifice in said casing adapted for detachable connection within said discharge line and axially off-set along and opening in said cylindrical bore in perpendicular relationship to the axis thereof, whereby a flow passage is provided across said cylindrical bore from said inlet orifice to said outlet orifice, said inlet orifice being spaced from said closed end of said bore and said outlet orifice being near said opposite end of said bore, a tubular inlet port in said frusto-conical bottom of said casing coaxially disposed therewith and with said cylindrical bore and opening through a counter-bore in said circular chamber, said inlet port being adapted for detachable connection with said control means to receive therethrough said pilot pressure, an inner annular recess in said casing coaxially surrounding said cylindrical bore and communicating therewith and with said inlet orifice, a movable piston slidably mounted with a determined lateral clearance in said cylindrical bore and having a front end face facing said closed end of said bore and an opposite rear end face facing said opposite end of said bore, said piston being formed with at least one passage opening on either of its opposite faces and extending parallel to its axis whereby said piston is substantially entirely surrounded by said liquid flowing through said bore and is adapted to modify by its displacement the cross-sectional area of said flow passage hence the pressure loss therethrough, a substantially soft yielding nonresiliently deformable diaphragm means in said casing tightly coaxially mounted in said circular chamber to form a transverse partition halving said chamber thus separating said bottom from said cylindrical bore and responsive on the one side to the exit pressure of said liquid and on the other side to said pilot pressure, whereby any difference between said pressures causes a deflection of said diaphragm which moves unconstrainedly within said chamber, an integral stem directly and rigidly connecting said diaphragm to said rear end face of said piston whereby the latter is caused to move according to the actual deflection of said diaphragm, and a stop means provided on that side of said diaphragm which faces said bottom, said stop means registering with said counter-bore which is adapted to accommodate said stop means to limit the deflection of said diaphragm when said pilot pressure is released whereby said diaphragm is allowed to be backed by and to conform to said bottom to prevent undue stresses therein.

4. In a rocket motor, a fluid supply circuit system according to claim 2, wherein each of said regulating devices comprises a casing formed with an inner closed cavity consisting of a substantially cylindrical bore closed at one end and expanding at the opposite end into a short coaxial transversely enlarged substantially circular chamber closed by a coaxial bottom of substantially frusto-conical shape, a tubular inlet orifice and a tubular outlet orifice in said casing adapted for detachable connection within said discharge line and axially off-set along and opening in said cylindrical bore in perpendicular relationship to the axis thereof, whereby a flow passage is provided across said cylindrical bore from said inlet orifice to said outlet orifice, said inlet orifice being spaced from said closed end of said bore and said outlet orifice being near said opposite end of said bore, a tubular inlet port in said frusto-conical bottom of said casing coaxially disposed therewith and with said cylindrical bore and opening through a counter-bore in said circular chamber, said inlet port being adapted for detachable connection with said selected one discharge line to receive therethrough said pilot pressure, an inner annular recess in said casing coaxially surrounding said cylindrical bore and communicating therewith and with said inlet orifice, a movable piston slidably mounted with a determined lateral clearance in said cylindrical bore and having a front end face facing said closed end of said bore and an opposite rear end face facing said opposite end of said bore, said piston being formed with at least one passage opening on either of its opposite faces and extending parallel to its axis whereby said piston is substantially entirely surrounded by said liquid flowing through said bore and is adapted to modify by its displacement the cross-sectional area of said flow passage hence the pressure loss therethrough, a substantially soft yielding nonresiliently deformable diaphragm means in said casing tightly coaxially mounted in said circular chamber to form a transverse partition

halving said chamber thus separating said bottom from said cylindrical bore and responsive on the one side to the exit pressure of said liquid and on the other side to said pilot pressure, whereby any difference between said pressures causes a deflection of said diaphragm which moves unconstrainedly within said chamber, an integral stem directly and rigidly connecting said diaphragm to said rear end face of said piston whereby the latter is caused to move according to the actual deflection of said diaphragm, and a stop means provided on that side of said diaphragm which faces said bottom, said stop means registering with said counter-bore which is adapted to accommodate said stop means to limit the deflection of said diaphragm when said pilot pressure is released whereby said diaphragm is allowed to be backed by and to conform to said bottom to prevent undue stresses therein.

5. In a rocket motor, a fluid supply circuit system according to claim 3, wherein each of said control means comprises a contained gas for generating said pilot pressure, a contained chemically inert liquid in contact with said gas, ducts connecting said control means with said inlet ports of said regulating devices respectively associated therewith, said inert liquid filling said ducts and the relevant halves of said circular chambers in said regulating devices for transmitting thereby said pilot pressure from said gas to said diaphragms and means for varying the value of said pilot pressure according to requirements.

6. In a rocket motor, a fluid supply circuit system according to claim 4, wherein said control means comprises a contained gas for generating said pilot pressure, a contained chemically inert liquid in contact with said gas, ducts connecting said control means with said inlet ports of said regulating devices respectively associated therewith, said inert liquid filling said ducts and the relevant halves of said circular chambers in said regulating devices for transmitting thereby said pilot pressure from said gas to said diaphragms and means for varying the value of said pilot pressure according to requirements.

7. In a rocket motor, a fluid supply circuit system according to claim 3, wherein adjustable restriction means are provided in each of said discharge lines down-stream of each of said regulating devices to permit of locally modifying the cross-section of the flow passage hence the pressure drop in said discharge lines between said regulating devices and said injectors to compensate for casual pressure drop decreases due to wear of said injectors and for casual pressure drop increases due to obstruction of said injectors in order to restore the actual pressure losses to their initial values and means being provided to operate said restriction means according to requirements.

8. In a rocket motor, a fluid supply circuit system according to claim 4, wherein adjustable restriction means are provided in each of said discharge lines including said regulating devices and down-stream thereof to permit of locally modifying the cross-section of the flow passage hence the pressure drop in said discharge lines between said regulating devices and said injectors to compensate for casual pressure drop decreases due to wear of said injectors and for casual pressure drop increases due to obstruction of said injectors in order to restore the actual pressure losses to their initial values and means being provided to operate said restriction means according to requirements.

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