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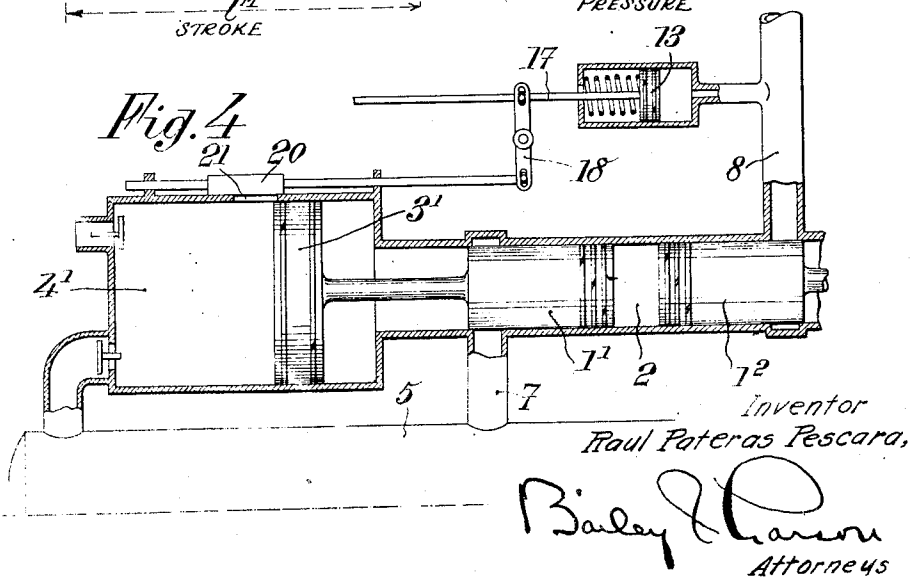
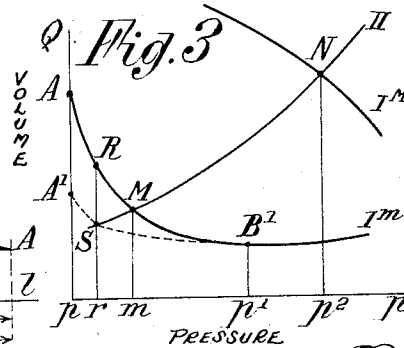
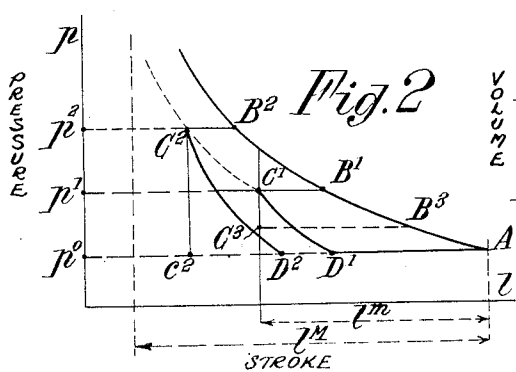
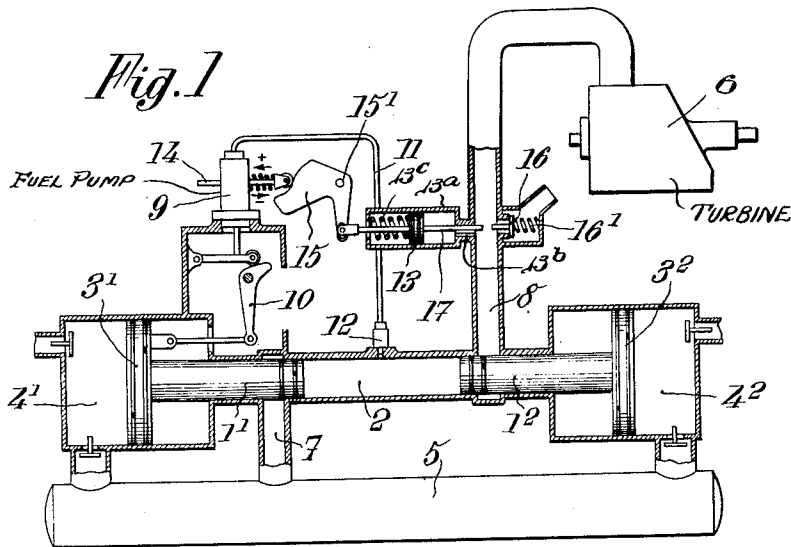
R. PATERAS PESCARA

2,200,892

REGULATING DEVICE FOR COMPRESSED FLUID GENERATORS OF THE FREE PISTON TYPE

Filed Nov. 3, 1936

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

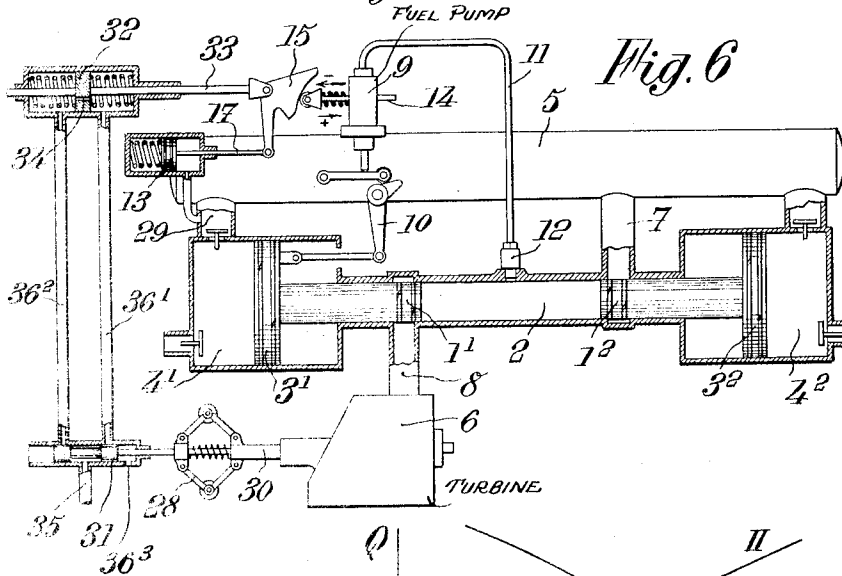
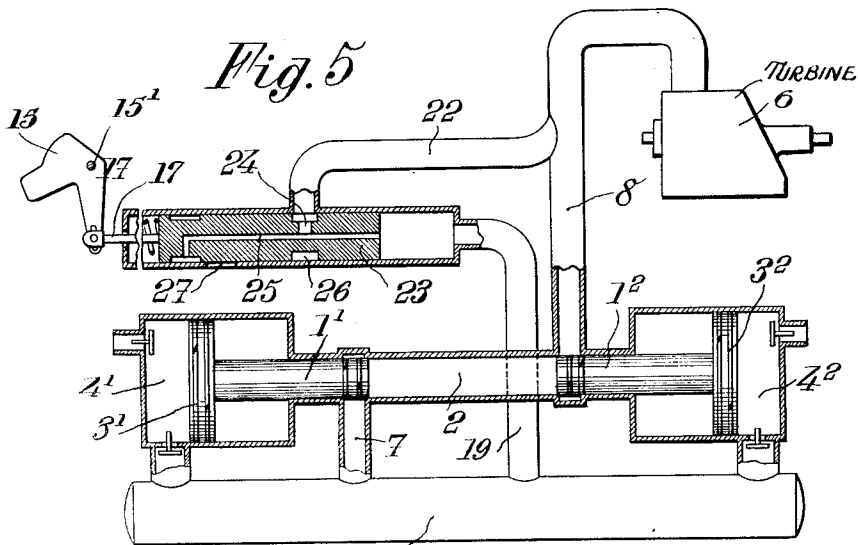
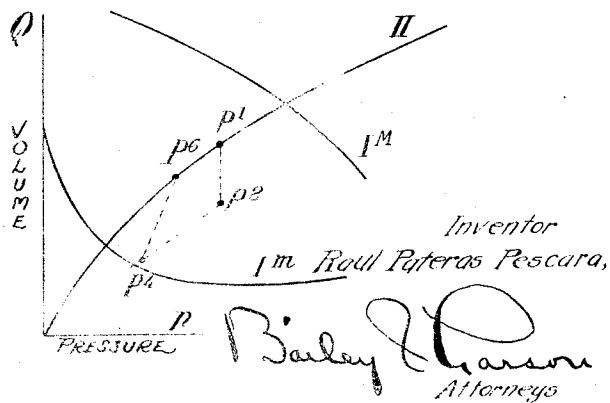


Fig. 7.



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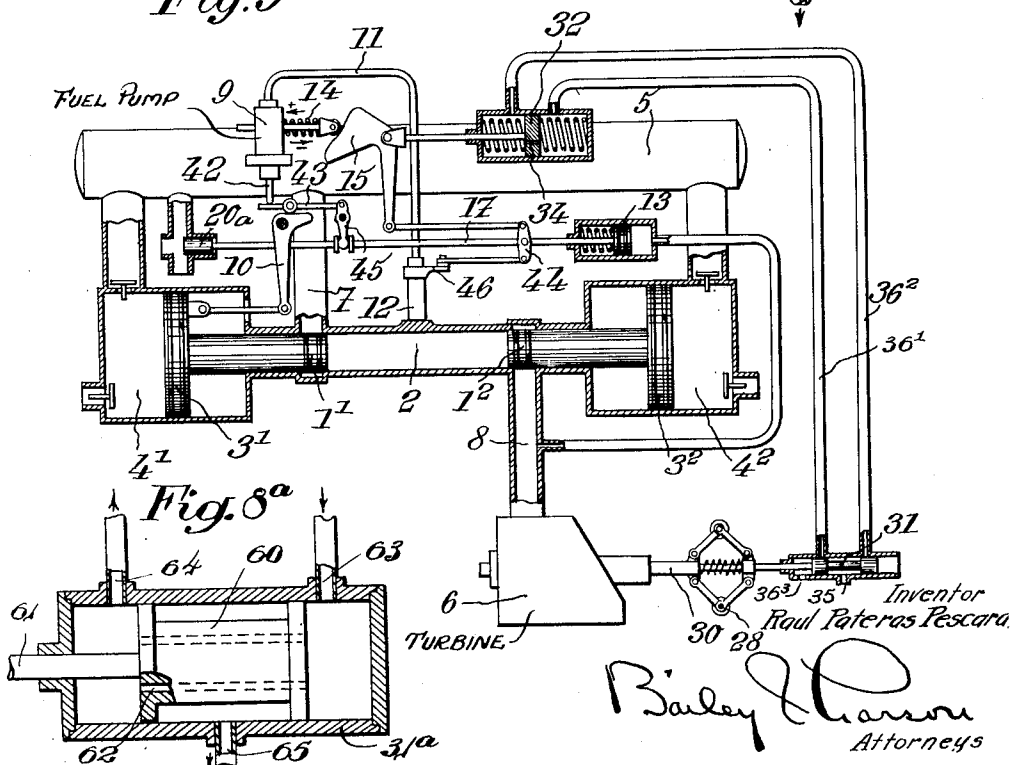
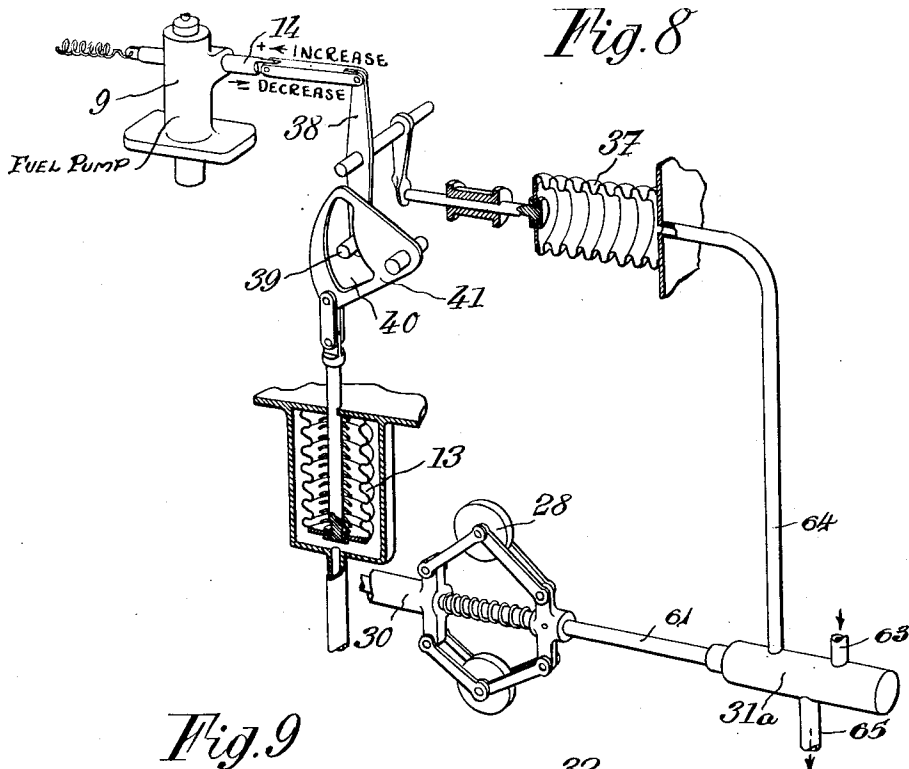
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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,200,892

REGULATING DEVICE FOR COMPRESSED
FLUID GENERATORS OF THE FREE PIS-
TONS TYPE

Raul Pateras Pescara, Paris, France, assignor to
Societe d'Etudes et de Participations, Eau,
Gaz, Electricite, Energie, S. A. Geneva, Switzer-
land

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16 Claims. (Cl. 60—13)

The present invention relates to regulating devices for compressed fluid generators of the type having free pistons, adapted to feed fluid under variable pressure of operation to receiving machines such as turbines.

Compressed fluid generators of the type above mentioned include a scavenging arrangement working at variable feed pressure, the whole or a part of the compressed fluid being caused to flow through the engine for performing the scavenging operation. The excess of the scavenging gases which, in this case, merely passes through the engine, forms with the exhaust gases a mixture at a relatively low temperature which may be used advantageously for operating at least one receiving machine, such as a turbine.

The object of the present invention is to provide a regulating device of the type above referred to which permits of obtaining a correct feed of the receiving machine under variable loads and in accordance with the known characteristics of said receiving machine, which characteristics determine the corresponding variations of pressure and rate of feed of the compressed fluid.

The essential feature of the present invention consists, in systems of the kind above referred to including a compressed fluid generator the pistons of which are capable of undergoing considerable variations of stroke, in exerting the regulating action exclusively on the feed of fuel to the motor cylinder, at least for normal conditions of working of the generator.

Another important feature of the present invention consists in subjecting the means for controlling the rate of feed of fuel to the compressor motor cylinder to the action of both a regulating device responsive to variations of the pressure of the fluid supplied to the receiving machine and a speed regulating device driven by said receiving machine. The connections between said fuel feed control means and these regulating devices respectively may be positive for both of them or they may be arranged in such manner that at least one of said connections leaves the regulating device corresponding to the other connection free to act within certain limits and serves to correct the action thereof only outside of said limits.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described, with reference

to the accompanying drawings, given merely by way of example, and in which:

Fig. 1 is a longitudinal sectional view of a system including a compressed fluid generator of the free piston and variable pressure type and a receiving machine, said system being provided with a regulating device made according to a first embodiment of the present invention;

Figs. 2 and 3 are, respectively, two diagrams illustrating the principle of the invention;

Fig. 4 shows, in a manner similar to Fig. 1, a part of an analogous system, but in which the regulating device is made according to a second embodiment of the invention;

Fig. 5 shows, in a manner similar to Fig. 1, a portion of a system of the same kind, but in which the regulating device is made according to a third embodiment of the invention;

Fig. 6 shows, in a manner similar to Fig. 1, a portion of a system of the same kind, but in which the regulating device is made according to a fourth embodiment of the invention;

Fig. 7 is a diagram illustrating the operation of the last mentioned embodiment;

Fig. 8 is a perspective view showing a regulating device made according to a modification of that of Fig. 6;

Fig. 8a is a cross section through the slide valve of Fig. 8;

Fig. 9 shows, in a manner similar to Fig. 1, a portion of a system of the same kind, but in which the regulating device is made according to a fifth embodiment of the invention.

In the following description, it will be supposed that a compressed fluid generator of the free piston type is arranged to feed a fluid under pressure to a receiving machine, such as a turbine, the regulating device according to the invention being applied to said generator.

Concerning the generator of the free piston type adapted to give a variable pressure (more especially an air compressor) it includes a two-stroke engine with scavenging means. Said engine includes, for instance, two pistons 1¹ and 1², of the single acting type, moving in opposite directions respectively in a motor cylinder 2. These motive pistons 1¹ and 1² are connected respectively with two compressing pistons 3¹ and 3², working in distinct compression cylinders 4¹ and 4² respectively and delivering air into a compressed air reservoir 5.

This reservoir 5 is not directly connected with the receiving machine 6, for instance a turbine, but it is connected with the scavenging and air inlet orifices of generator 2 through a conduit 7,

in such manner that the whole of the compressed air flows through the generator so as to effect the scavenging thereof, only a portion of this air being utilized for combustion, and the excess of the air that has performed the scavenging being fed to the receiving turbine 6 at the same time as the burnt gases.

Such an arrangement is known in the art, and it has been disclosed in a very simplified manner in the drawings, but it should be well understood that it might be modified or completed in various ways without in any way departing from the principle of the invention.

Concerning the feed of fuel to the compressed fluid generator, it will be assumed, in the following description that the fuel is liquid and that it is injected to cylinder 2 by means of a pump 9 actuated through a cam mechanism 10 or the like, itself controlled by a movable element of the generator itself, this pump 9 feeding the fuel into a conduit 11 connected to the injection device, or devices, 12 of the engine.

Pump 9 of the usual Bosch type is provided with an element 14 for regulating the amount of fuel fed and delivered to the engine. This element 14 may consist, in the usual manner, of a slide valve.

In the conduit 8, extending between the generator cylinder 2 and the receiving machine 6, and in which the pressure is the delivery pressure, there is provided passage 13b communicating with the interior of a cylinder 13a in which is arranged a movable or deformable element, for instance a piston 13 with a return spring 13c, a manometric deformable box or the like, which is connected to a piece having a suitable outline, pivoted about a fixed pivot 15', such as an oscillating cam 15, acting upon the regulating element 14 of the pump. The outline of this cam is given a shape such that, through its action upon element 14, the variations of feed of fuel, corresponding to variations of pressure, are the same for generator 2 and receiving machine 6. That is, the variations in fuel quantity delivered to the motor compressor are such that they produce, in the pressure and quantity of drive gas, variations corresponding to the quantity and pressure requirements of the driven machine or turbine. These variations in the requirements of the driven machine or turbine are caused, of course, by variations in the load upon the driven machine or turbine. When the load on the turbine increases, a back pressure caused thereby also increases, and thus produces an increase in pressure in the gas feed line. This causes an increase in the feed of fuel. When the charge of fuel is increased, the pressure and volume of the gas produced are likewise increased, to compensate for the increased load. In the device as shown, the pressure in the cylinder 13a moves piston 13 against spring 13c, thus turning cam 15 and moving control rod 14 of the pump 9. The feed of the pump is thus varied in response to variations in pressure in the outlet conduit 8. The outlet pressure is increased or decreased upon increase or decrease respectively of the load on turbine 6. The pressure and the quantity of the gases in the conduit 8 are thus increased or decreased upon increase or decrease respectively of the load on the turbine 6, so as to compensate for changes in this load.

This automatic regulation of the feed of fuel as a function of the pressure existing in the feed conduit of the receiving machine, and therefore as a function of the load thereof is not always

sufficient for ensuring a correct and smooth working of the system at low speeds of the receiving machine.

It is known, in fact, that for all the working pressures of the generator, a certain minimum of air feed is absolutely necessary for ensuring the scavenging of the engine, and, furthermore, that the machine can work only for strokes of the pistons ranging within two limits, one of which, the minimum limit, l^m , corresponds to the minimum opening of the distribution orifices of the motive cylinder 2, that is, the smallest stroke that will uncover the openings of passages 7 and 8 while the other one, the maximum limit l^M , is determined by conditions of safety.

In Fig. 2, I have shown a diagram in which the pressures are plotted in ordinates and the strokes in abscissas, this diagram corresponding to the compressing portion of the generator. In this figure, I have shown the values of the limit strokes l^m and l^M , and also certain characteristic working curves AB^2 , D^1C^1 and D^2C^2 of this compressing portion. The feed of air that is assumed to be absolutely necessary for ensuring the scavenging of the engine is shown by B^1C^1 , B^2C^2 , etc. Between pressures p^0 and p^1 , the movable parts or pistons of the generator must move a distance at least equal to l^m and the feed B^3C^3 decreases as the pressure increases. For pressure p^1 , the feed B^1C^1 corresponds to the minimum feed necessary for the scavenging of the motive cylinder. For pressures higher than p^1 , the minimum feed such as B^2C^2 must always be maintained for ensuring the scavenging of the engine and for this purpose, stroke Ac^2 becomes greater than the minimum stroke l^m .

In the diagram of Fig. 3, the pressures are plotted in abscissas and the volume or amounts of fluid in ordinates. In this diagram, I have shown at l^m the curve representing the variation of the amount of fluid fed by generator 2 as a function of the pressure for the minimum feed of fuel injected for each value of the pressure.

The maximum amount of fuel injected for each value of the pressure, that is to say the amount corresponding to the maximum stroke l^M , is indicated by curve l^M , which shows the quantitative variation of the amount of fluid under pressure fed by generator 2.

Between these two curves, it suffices to inject, for each pressure, the suitable amount of fuel, and the rate of delivery of the generator is exactly equal to the amount absorbed by the receiving machine at the same pressure, the characteristic curve for the receiving machine being shown at II in Fig. 3.

It is found that the rate of delivery of the generator can be made to correspond to the amount required by the receiving machine only between points N and M of curve II, these points being those where the characteristic curve II of the receiving machine intersects the characteristic limit curves of the generator corresponding to the minimum and maximum strokes.

According to the present invention, I make use of the same element 13, responsive to the variations of the pressure on the delivery side of the generator, between said generator and the receiving machine 6, for adjusting to each other the rates of flow from the generator and to the receiving machine respectively, as well for loads included between points M and N as for lower loads MS corresponding to rates of feed of the receiving machine lower than the limit rates of

delivery of the generator indicated by the curve I^m of Fig. 3.

For this purpose, I may allow the generator to produce, at low pressures, an amount of fluid such as R_r , which corresponds to its working with a minimum injection of fuel, and allow the excess RS which cannot be absorbed by the receiving machine to escape outwardly. In this case, I determine exactly the excess or supplementary amount, such as RS, by variably opening an escape valve 16 (Fig. 1) provided on the conduit 8 before the receiving machine 6. This valve 16, subjected to the action of its return spring 16¹, is located for instance opposite the rod 17 of piston 13 in such manner that said valve is opened when the end of rod 17 is applied thereon. The whole of the device is arranged in such manner that the opening of valve 16 takes place for a pressure m corresponding to the point M of the diagram of Fig. 3.

I may also automatically regulate, through the medium of a distribution member controlled by the pressure, the amount of compressed air that is delivered at low pressures in such manner that generator 2 supplies, for its minimum geometrical stroke I^m (Fig. 2) an amount of air strictly sufficient for the scavenging of the engine (curve A¹ S B¹ of Fig. 3).

In order to obtain this result, it suffices to limit for instance the intake stroke or the compression stroke of the compressors. This limitation of the production of compressed air can be obtained, as shown by Fig. 4, by causing the rod 17 of piston 13 to act, for instance through an equalizing bar 18, upon a sliding element or valve 20. This slide valve 20, by covering more or less an orifice 21 provided in the wall of each of the compression cylinders 4¹ and 4², permits of delaying more or less the beginning of the compression stroke so as to correspondingly vary the amount of air compressed by said compressors.

In the case, already considered for the embodiment of Fig. 1, in which a portion of the gases produced by the generator is allowed to escape outwardly below a given working pressure of the receiving machine, it is advantageous to separate the excess of scavenging air from the hot gases and to send to the receiving machine only said hot gases, in order to protect said receiving machine against too important variations of the temperature.

For this purpose, as shown by Fig. 5, I may cause the excess of scavenging air to flow through a circuit such as 19—22 in which there is inserted an automatic distributing device, for instance a sliding valve 23, subjected to the pressure existing in conduit 19. This sliding valve 23 also plays the part of the piston 13 of Fig. 1 and acts, through its rod 17, upon cam 15 for controlling the amount of fuel that is injected. According to the position occupied by sliding element 23 under the effect of the pressure existing in reservoir 5 and in conduit 19, the supplementary amount of scavenging air flows either through the central conduit 25, orifice 24, groove 26 and conduit 22, to the receiving machine 6 without passing through the engine 2, or through central conduit 25 and orifice 27 to the atmosphere. As soon as the pressure has become sufficiently high in reservoir 5, sliding element 23 fully stops conduit 22 and orifice 27 and the whole of the compressed air flows through the engine.

When the receiving machine is subjected to important variations of load, the regulation re-

sulting merely from pressure variations may be too slow as a consequence of the cushioning mass of compressed fluid stored up in the scavenging reservoir 5 of the generator and in the conduits such as 8 and 19 leading to the receiving machine. As a certain temporary variation of the speed of the receiving machine can generally be admitted when there is a variation of the load, I may also bring into play, for regulating the rate of delivery of the generator, a speed regulator which is associated with the receiving machine 6, and I provide, according to the present invention, means for combining the action of this last mentioned regulator with that of the pressure responsive regulating device 13 of the kind of those above described.

For instance, and as shown in Fig. 6, I may connect, either directly or preferably through a relay, the speed regulator, or centrifugal governor 28 of the receiving machine 6 with the cam 15 which controls the member 14 through which the feed pump 9 is controlled. This cam 15 is simultaneously subjected to the action of the pressure responsive regulator, such as piston 13, the cylinder of which is connected to a conduit 29 extending between generator 2 and receiving machine 6. For instance, the speed regulator acts through a pivoting connection upon cam 15 and the pressure responsive regulator acts through another pivoting connection upon said cam. Each pivoting connection constitutes an axis of rotation about which cam 15 can move angularly when it is subjected to an action from the regulator corresponding to the other pivot.

In the embodiment illustrated by Fig. 6, the centrifugal governor 28 is driven by the shaft 30 of the receiving machine or turbine 6. This governor acts, through a slide valve 31, upon a hydraulic relay including a piston 32 connected with cam 15 through a rod 33. During the permanent or normal working of receiving machine 6, piston 32 is subjected, on both of its faces, to equal pressures, owing to the provision of a small calibrated orifice 34 extending throughout piston 32. When there is a variation of speed, producing for instance an acceleration, of the receiving machine, the centrifugal governor 28 causes slide valve 31 to move, for instance toward the right of Fig. 6. This places tube 35, connected with a source of fluid under pressure, into communication with a conduit 36¹ leading to the cylinder of the piston 32 of the relay. The fluid under pressure pushes piston 32 toward the left hand side of Fig. 6, which produces an angular displacement of cam 15 in a direction which corresponds to member 14 reducing the amount of fuel injected into the cylinder of the generator. The cylinder of valve 31 is open at one end and near its other end has an opening 36².

The pressure responsive regulator 13 can be brought into play either subsequently or simultaneously for reinforcing or reducing the action of the speed regulator upon the rate of feed of fuel injected to the engine, producing an angular displacement of cam 15 in one direction or the opposite one.

In the case of a reduction of the speed of receiving machine 6, the centrifugal governor 28 moves toward the left hand side of Fig. 6, which permits the fluid under pressure, acting through tube 36², to quickly push the piston 32 of the relay toward the right hand side of Fig. 6. This produces an angular displacement of cam 15 in a direction for which, through its action upon control member 14, the rate of feed

of fuel injected to the generator is increased. The pressure responsive regulator 13 is then brought into play for reinforcing or reducing the quick action of the speed regulator 28.

In the diagram shown in Fig. 7, the pressures are plotted in abscissas and the amounts of fluid delivered are plotted in ordinates. I^m and I^M are curves corresponding, respectively, to the minimum and maximum delivery of gas under pressure and II is the characteristic curve of operation of the receiving machine 6.

Fig. 7 illustrates the regulating processes which take place when the momentary load of the turbine varies, said load being characterised, for example, by the point P^1 of the curve II.

If the load of the turbine is reduced, for example, an acceleration of the governor 28 takes place. The acceleration of the governor 28 influences the control of the injection pump 9 by reducing the amount of fuel injected. This reduction of the amount of fuel injected immediately causes the length of stroke of the freely-reciprocating pistons to be shortened and thus the amount of propelling gas to be reduced, whereas the decrease in pressure only takes place gradually. The immediate reduction of the amount of gas is shown in Fig. 7 by the dotted line $P^1 P^2$. Gradually, however, a lowering of pressure also takes place. This lowering of pressure influences the control member of the injection pump in such a manner that the amount injected is still further reduced. Thus, a fresh reduction of the amount of gas takes place simultaneously with the reduction of the gas pressure. This change is indicated in Fig. 7 by the line $P^2 P^4$. The point P^4 , however, is really too low, i. e., the regulation has been too extreme (over-adjustment). The result is that the turbine, which previously ran too fast, reduces its speed. This causes the governor 28 to influence the fuel adjustment by increasing the amount of fuel. By increasing the amount of fuel, the amount of propelling gas and the gas pressure are also increased. Consequently, the amount and pressure of the gas rise according to the line $P^4 P^6$. When the point P^6 is reached, the condition of equilibrium between the amount of injected fuel and the load of the turbine, which load is reduced relatively to the point P^1 , is again obtained.

The same operation would take place, but in the opposite direction, in the case of an increase of the load producing a temporary slowing down of the receiving machine.

When the receiver is liable to undergo instantaneous and important variations of the load, for instance from the maximum load to the conditions of running under no load, and inversely, it is advantageous, especially in the case of turbines, to effect a quick regulation of the generator in order to avoid too important a racing and too considerable a slowing down of receiving device 6. As a limited variation of the working speed is generally admitted, it is possible to effect the regulation of the generator, between two limits which correspond to each delivery pressure, by means of the speed regulator of the receiving machine, and to automatically vary these limits as a function of said variable delivery pressure.

For instance, and as shown by Fig. 8, it is possible to control the member 14 of the injection pump 9 by means of the centrifugal governor 28 of the receiving device, for instance through the medium of a pneumatic relay 37,

provided with its slide valve as shown at 31a in Fig. 8 controlled by rod 61. This slide valve (Fig. 8a) includes a piston 60 connected to rod 61 for selectively connecting a discharge passage 65 to passages 63 (connected to a supply of fluid under pressure) and 64 (connected to casing 24), and connecting passages 63, 64 to each other through passages 62 in piston 60. The flange at the left end of the piston 60 can, when properly positioned, close off passage 64.

If the rotation of the turbine increases because of an increase in the fuel supply, the governor 28 shifts the piston 60 towards the left. The conduit 64 is thus shut off from the pressure supply pipe 63, and is connected to discharge pipe 65. The oil under pressure then escapes from the casing 37 which contracts because of the elasticity of the walls and thus adjusts the control rod 14 of the pump 9 so as to reduce the supply of fuel. When a state of balance is reached, the flange at the left end of the piston 60 covers the conduit 64 so that no passage of fluid takes place through the casing.

If the speed decreases, the piston 60 moves to the right and connects pipe 63 through passages 62 with pipe 64, at the same time closing off communication between pipes 64 and 65, thus supplying fluid under pressure to the casing 37 to increase the fuel supply. This serves to limit the displacements of member 14, for each working pressure, to two extreme values which correspond to the limit rates of delivery of the generator for this pressure. For instance, I limit the angular displacement of control lever 38, provided between pneumatic relay 37 and member 14, by means of at least one abutment, the position of which can be modified by the pressure responsive regulator 13, which, in this embodiment, consists of a manometric deformable box.

For this purpose, said lever 38 may be provided with a pin or lug 39 which is engaged in a slot 40 provided in an oscillating piece 41 subjected to the action of the pressure responsive regulator.

The edges of slot 40, adapted to cooperate with pin or lug 39, are given a suitable outline. Slot 40 might be replaced by a kind of fork, also carried by member 41, and between the branches of which pin 39 would be engaged.

In this embodiment, I obtain, for small variations of load, a variation of the amount of fuel injected into the cylinder of the generator, under the effect of the speed regulator 28 alone. The pressure variation can thus be established slowly without influencing the regulation since oscillating member 41 can come into contact with pin 39 only for important displacements of member 14.

When there is an important variation of the load, the speed regulator 28 first produces the displacement of control member 14 as far as the limit corresponding to the contact of pin 39 with the edge of the slot 40 provided in piece 41, in one direction or the other. This piece 41 then moves as a function of the pressure existing in the conduit 8 in which the generator delivers the gases under pressure, and as this pressure varies, there is obtained a position of equilibrium corresponding to the new load conditions.

At the same time as I obtain the regulation of the amount of fuel injected into the engine, I may also, according to the present invention, automatically and simultaneously regulate the point of injection and the position of the injection

tion nozzles with respect to the combustion chamber.

The form of the invention shown in Fig. 9 embodies this principle. The motor compressor shown in this figure is similar to that previously described, driving the turbine 6 through the outlet 8. The motor cylinder 2, however, includes an injection mechanism 12 having discharge passages arranged in a V, this fuel feed member being mounted for turning about an axis transverse to the longitudinal axis of the cylinder.

Provided in the reservoir 5 is an outlet controlled by a valve member 20a which is connected by a rod 17 to a piston 13, the other side of which is acted on by the pressure in outlet passage 8 through a connecting passage. Thus when the pressure in the discharge outlet drops too low, piston 13 will be moved to the right and will open valve 20a to relieve the pressure in the reservoir 5.

Element 43 is connected to rod 17 and thus to piston 13 by a lever 45, and carries a roller resting on the short arm of lever 10. The free end of member 43 engages the rod 42 which by its movement feeds fuel from the pump 9. The position of piston 13 will thus vary the position of the roller and the degree of movement of rod 42 so as to vary the feed of fuel thereby.

The feed of fuel is also controlled by the rod 14, operated by cam 15 and controlled jointly by pistons 13 and 32 in the same manner as in Fig. 6.

Finally, lever 44 which connects piston 13 to cam 15 also is connected to arm 46 rigid with the turnable fuel injection member 12. When the pressure decreases, this fuel injection member is in the position shown in Fig. 9, and the diverging discharge openings thereof operate the fuel over a considerable area longitudinally of the cylinder. When, on the other hand, the pressure increases, and piston 13 is moved to the left, member 12 is turned thereby until the V is at right angles to the longitudinal axis of the cylinder, whereupon the jets of fuel are operated in the same transverse plane. Thus the distribution of the fuel longitudinally of the motor cylinder is controlled.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. A system of the type described which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable pump for feeding fuel to said motor cylinder, a gas operated receiving machine requiring at low drive gas pressures a quantity of gas less than the minimum output of said motor compressor, means for causing gas under pressure from said compression cylinder to flow to said receiving machine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal running conditions of the system, the whole of said gas to said receiving machine, regulating means, responsive to variations of the working

conditions of said receiving machine, for controlling the feed of said fuel pump, and outlet means disposed between the inlet of the compressor cylinder and the gas operated receiving machine operative by the pressure of the compressed gas, at low pressures only of the compressed gas, for releasing a part of the gas after its entrance into the compressor cylinder.

2. A system of the type described which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable pump for feeding fuel to said motor cylinder, a gas operated receiving machine requiring at low drive gas pressures a quantity of gas less than the minimum quantity of gas delivered by said motor compressor, means for causing gas under pressure from said compression cylinder to flow to said receiving machine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal conditions of the system, the whole of said gas to said receiving machine, regulating means, responsive to variations of the working conditions of said receiving machine, for controlling the feed of said fuel pump, valve means, normally closed, for connecting a point of the path of the gas under pressure between said compression cylinder, inclusive, and said receiving machine, with an atmosphere at a pressure lower than that of said gas under pressure, and means, operative by the gas under pressure, for opening said valve means at low admission pressures of the receiving machine.

3. A system of the type described, which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable pump for feeding fuel to said motor cylinder, a gas operated receiving machine requiring at low gas pressures a quantity of gas less than the minimum quantity delivered by said motor compressor, means for causing gas under pressure from said compression cylinder to flow to said receiving machine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal running conditions of the system, the whole of said gas to said receiving machine, a piston movable in response to variations of the pressure of the gas under pressure at a point of the path thereof between said compression cylinder, inclusive, and said machine, for controlling the feed of said fuel pump, valve means normally closed, for connecting a point of the path of the gas under pressure between said compression cylinder, inclusive, and said receiving machine, with an atmosphere at a pressure lower than that of said gas under pressure, said valve means being opened by the second-mentioned piston at low admission pressures of the receiving machine.

4. A system of the type described, which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable feed pump for supplying fuel to said motor cylinder, a gas operated receiving machine requiring at low drive gas pressures a quantity of gas less than the minimum quantity delivered by said motor compressor, means for causing gas under pressure from said compression

sion cylinder to flow to said receiving machine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal running conditions of the system, the whole of said gas to said receiving machine, a piston movable in response to variations of the pressure of the gas under pressure at a point of the path thereof between said compression cylinder, inclusive, and said receiving machine, for controlling the feed of said fuel pump, and means operative by said second mentioned piston, for reducing the useful stroke of the first mentioned piston at low admission pressures of the receiving machine to reduce the quantity of gas delivered below such minimum.

5. A system of the type described according to claim 4, in which said compression cylinder is provided with a longitudinal slot, the last mentioned means of claim 4 consisting of a sliding member, operatively connected with said second mentioned piston, for covering said slot under predetermined conditions.

6. A system of the type described, which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable pump for feeding fuel to said motor cylinder, a gas operated receiving machine, means for causing gas under pressure from said compression cylinder to flow to said receiving machine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal running conditions of the system, the whole of said gas to said receiving machine, regulating means, responsive to variations of the pressure of the gas under pressure at a point of the path thereof between said compression cylinder, inclusive, and said receiving machine, for controlling the feed of said fuel pump, and regulating means, responsive to variations of the speed of said receiving machine, also for directly controlling the feed of said fuel pump.

7. A system of the type described which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable pump for feeding fuel to said motor cylinders, a gas operated receiving machine, means for causing gas under pressure from said compression cylinder to flow to said receiving machine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal running conditions of the system, the whole of said gas to said receiving machine, means for controlling the feed of said fuel pump, regulating means, responsive to variations of the pressure of the gas under pressure at a point of the path thereof between said compression cylinder, inclusive, and said receiving machine, and regulating means, responsive to variations of the speed of said receiving machine, for both directly operating said pump feed control means.

8. A system according to claim 7 in which said fuel pump feed control means include a cam adapted to cooperate with said pump, each of the two regulating means including an operating member pivotally connected to said cam.

9. A system according to claim 7 in which said fuel feed control means include a cam adapted to cooperate with said pump, the first mentioned

regulating means including a piston subjected to the action of said gas pressure and a rod carried by said piston pivotally connected with said cam, and the second mentioned regulating means including a centrifugal governor operatively connected with said receiving machine, a member pivotally connected with said cam, and a hydraulic relay interposed between said governor and said member.

10. A system of the type described which comprises, in combination, a motor-compressor including an internal combustion motor cylinder at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable pump for feeding fuel to said motor cylinder, a gas operated receiving machine, means for causing gas under pressure from said compression cylinder to flow to said receiving machine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal running conditions, of the system, the whole of said gas to said receiving machine, regulating means, responsive to variations of the speed of said receiving machine, for controlling the feed of said fuel pump, and regulating means, responsive to variations of the pressure of the gas under pressure at a point of the path thereof between said compression cylinder, inclusive, and said receiving machine, for varying the limits of action of said first mentioned regulating means.

11. A system according to claim 10 in which the first mentioned regulating means include a centrifugal governor operatively connected with said machine, a member for controlling the feed of said pump, a pivoting lever for actuating said member, and a relay interposed between said lever for interconnecting them, and the second mentioned regulating means include a part movable in response to variations of said pressure, a movable element adapted to limit the displacements of said lever in accordance with the position of said element, and means for interconnecting said part and said element.

12. A system of the type described, which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders and an adjustable pump for feeding fuel to said motor cylinder, a gas operated turbine, means for causing gas under pressure from said compression cylinder to flow to said turbine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal conditions of the system, the whole of said gas to said turbine, regulating means, responsive to variations of the working conditions of said turbine for controlling the feed of said fuel pump, valve means, normally closed, for connecting a point of the path of the gas under pressure between said compression cylinder, inclusive, and said turbine with an atmosphere at a pressure lower than that of said gas under pressure, and means, operative by the gas under pressure for opening said valve means at low admission pressures of said turbine.

13. A system of the type described, which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said motor cylinder, a second piston freely movable in said compression cylinder and connected to said first piston,

and an adjustable pump for feeding fuel to said motor cylinder, a gas operated turbine, means for causing gas under pressure from said compression cylinder to flow to said turbine by passing at least partly through said motor cylinder, said means being arranged to convey, under normal conditions of the system, the whole of said gas to said turbine, regulating means, responsive to variations of the working conditions of said turbine for controlling the feed of said fuel pump, and gas pressure responsive means operative at low admission pressures of said turbine for releasing from said compression cylinder during the compression stroke thereof, part of the gas in said compression cylinder at pressures below the delivery pressure of said last-named cylinder.

14. A system of the type described, which comprises, in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinders, and an adjustable pump for feeding fuel to said motor cylinder, a gas operated turbine, means for causing gas under pressure from said compression cylinder to flow to said turbine by passing at least partly through said motor cylinder, regulating means, responsive to variations of the pressure of the gas under pressure at a point of the path thereof between said compression cylinder, inclusive, and said turbine for controlling the feed of said fuel pump, and regulating means, responsive to variations of the speed of said turbine for controlling directly the feed of said fuel pump.

15. A system of the type described which comprises, in combination, a motor-compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least

one piston freely movable in said cylinders and an adjustable pump for feeding fuel to said motor cylinder, a gas operated turbine, means for causing gas under pressure from said compression cylinder to flow to said turbine, by passing at least partly through said motor cylinder, regulating means, responsive to variations of the speed of said turbine for controlling the feed of said fuel pump, and regulating means, responsive to variations of the pressure of the gas under pressure at a point of the path thereof between said compression cylinder inclusive, and said turbine for varying the limits of action of said first mentioned regulating means.

16. A system of the type described which comprises in combination, a motor compressor including an internal combustion motor cylinder, at least one gas compression cylinder, at least one piston freely movable in said cylinder, and an adjustable pump for feeding fuel to said motor cylinder, a gas operated turbine, requiring at low drive gas pressures a quantity of gas less than the minimum output of said motor compressor means for causing gas under pressure to flow from said compression cylinder to said turbine by passing at least partly through said motor cylinder, regulating means responsive to variations of the pressure of the gas entering said turbine and capable of controlling the feed of said fuel pump under normal running conditions in such manner that the amount of the gas under pressure increases when the pressure increases, and vice versa, and outlet means disposed between said compression cylinder and said turbine and capable of reducing, at low pressures only of the compressed gas, the quantity of said gas.

RAUL PATERAS PESCARA.

Certificate of Correction

Patent No. 2,200,892.

May 14, 1940.

RAUL PATERAS PESCARA

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, second column, line 37, claim 11, after the word "between" insert *said governor and*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 13th day of April, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.