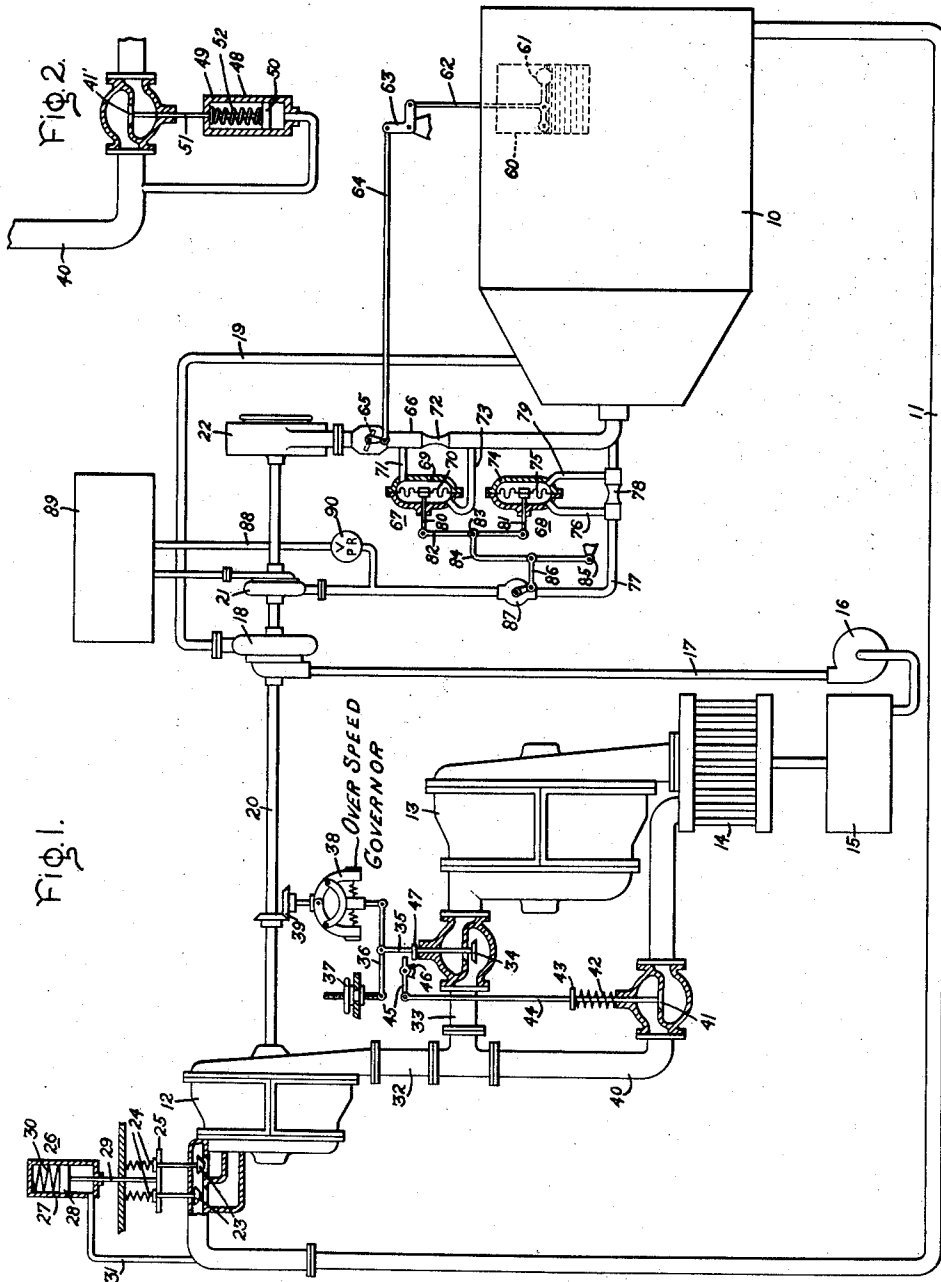


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ELASTIC FLUID POWER PLANT

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ELASTIC FLUID POWER PLANT

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9 Claims. (Cl. 60—70)

The present invention relates to elastic fluid power plants in which elastic fluid, for instance, steam or vapor, is produced in an elastic fluid generator and consumed in the consumer. The elastic fluid generator usually comprises a boiler in which the liquid is heated and evaporated, a furnace for heating the boiler and means for supplying and controlling the supply of fuel and air to the furnace. The consumer may comprise an elastic fluid turbine, means for conducting and regulating the flow of elastic fluid to the turbine and means including a condenser for receiving exhaust fluid from the turbine. The means for supplying and regulating the supply of feed fluid to the boiler and the means for supplying combustible material and air to the furnace may include pumps and a blower driven by an auxiliary motor such as an elastic fluid turbine receiving operated fluid from the boiler.

My present invention is an improvement over the invention disclosed in the application of Glenn B. Warren, Serial No. 244,624, filed December 8, 1938, and assigned to the General Electric Company, which invention was made by the said Glenn B. Warren prior to my invention. I therefore do not claim anything shown or described in said Warren application, which is to be regarded as prior art with respect to this present application.

The object of the present invention is to provide an improved arrangement for power plants of the type specified whereby the control and regulation of the various apparatus is accomplished in a simple manner.

For a consideration of what I believe to be novel and my invention, attention is directed to the following description and the claims appended thereto taken in connection with the accompanying drawing.

In the drawing I have shown a power plant system in a diagrammatic form only, omitting, for the sake of clarity, supplemental apparatus such as pilot valves, valve actuating motors and other incidental control equipment which may be supplied as required by one skilled in the art.

In the drawing, 10 indicates an elastic fluid generator comprising a furnace and a boiler of the pumped through type which supplies elastic fluid through a conduit 11 to an auxiliary turbine 12, the exhaust from which is conducted to a main turbine 13 connected to any suitable load, not shown. The exhaust from the main turbine is fed into suitable condensing apparatus indicated at 14, the condensate from the reservoir or hot-well 15 being returned to the boiler

by a booster pump 16 through a conduit 17, boiler feed pump 18 and conduit 19. It is, of course, understood that other control equipment may be embodied in the boiler feed water system as desired without departing from the scope of this invention. The auxiliary turbine 12 is arranged for driving, as by shaft 20, the auxiliaries including the boiler feed water pump 18, and also a furnace fuel pump 21, and a furnace combustion air blower 22. Although these auxiliaries are shown as directly driven by the shaft 20, it is understood that suitable speed reduction devices may be embodied in the driving connection as desired. It is obvious that the quantity of water, fuel, and air supplied to the boiler and furnace, respectively, and hence, the elastic fluid output of the generator, will vary as the speed of the auxiliary turbine, which in turn will vary in speed in accordance with the demand for elastic fluid as determined by the load on the main turbine, as will be more fully described hereinafter.

The supply of elastic fluid is admitted to the auxiliary turbine 12 preferably through a plurality of sectional admission valves indicated at 23, which may be of any form well known in the art. The sectional admission valves may be biased to the closed position as by springs 24 and adapted to be opened in sequential order by means of the lift bar 25 which is operated by a suitable fluid pressure motor such as that indicated at 26. As shown, this valve actuating motor comprises a cylinder 27 having a piston 28 slidably arranged therein and connected as by stem 29 to the valve lifting bar 25. A suitable spring 30 is arranged within the cylinder 27 above the piston 28 for biasing it in the downward direction. The connection 31 communicates between the elastic fluid supply conduit 11 and the lower end of the cylinder whereby the piston is forced upwardly in accordance with the pressure of elastic fluid supply, the valves 23 being thereby so regulated as to maintain substantially constant the pressure of the supply.

During normal operating conditions of the power plant the exhaust fluid from the auxiliary turbine is supplied to the main turbine 13 through conduits 32 and 33. Valve means 34 is arranged in the inlet of the main turbine 13 for controlling the supply of elastic fluid thereto which is adapted for adjustment in accordance with the load on the turbine 13 and also for supplemental adjustment in accordance with over-speed conditions of the auxiliary turbine 12. As indicated, the valve stem 35 may be connected to a floating lever 36, one end of which is adapted to be ad-

justed in accordance with load requirements by any well known form of control means such as by a manual controller as indicated at 37. The other end of the lever 36 is adapted for supplemental actuation by a speed governor mechanism 38 arranged to be driven from the shaft 20 of the auxiliary turbine through gearing 39. It is understood that the governor 38 is normally ineffective, it being so adjusted that its weights will rise only upon a predetermined overspeed of the auxiliary turbine to move the valve 34 to a more closed position.

A by-pass is provided for conducting the exhaust fluid from the auxiliary turbine around the main turbine during certain conditions obtaining in the system as will be more fully described hereinafter. A conduit 40 extending from the exhaust conduit 32 communicates with the header of the condenser 14. A valve 41 is positioned in the conduit 40 for controlling the passage of elastic fluid therethrough. As indicated, it may be operatively connected with the control mechanism of the valve 34 so that the by-pass circuit will be opened automatically as the valve 34 is moved to a predetermined closed position. The by-pass control valve 41 is normally biased to the closed position by spring 42 arranged between a collar 43 secured to the stem 44 and the casing of the valve 41. The upper end of the stem 44 is connected to one end of the lever 45 which is pivoted upon a stationary fulcrum 46. The other end of the lever is adapted to be engaged by the cam 47 secured on the stem 35, the cam being so adjusted that the valve 41 will be actuated to the open position upon the valve 34 being moved to a predetermined closed position. It is understood, of course, that the specific arrangement shown is merely diagrammatic while the actual embodiment may include the usual pilot valve and hydraulic operating motor, or the like, by which means a predetermined adjustment of the valve 34 may effect a relatively larger movement of the valve 41.

The operation of the power plant as thus far described is as follows: Assume that the power plant is operating in equilibrium with normal conditions obtaining. During such conditions, the valve 34 is in an opened position and a supply of elastic fluid is fed to the main turbine in a quantity sufficient to take care of the load connected thereto. During the condition of equilibrium assumed, the speed of the auxiliary turbine is proportional to the flow of steam to the turbine 13 and the feed water pump, the fuel pump and the combustion air blower are driven at a speed such that a quantity of steam is generated in the boiler 10 as is required by the load on the system. Now, assume that the load on the main turbine 13 is increased whereupon the controller 37 is operated to move the valve 34 to a more opened position to increase the supply of elastic fluid thereto. The back pressure of the auxiliary turbine 12 will drop causing it to accelerate due to the greater pressure drop therethrough. The speed of the boiler auxiliaries is also increased, thereby supplying more fuel and combustion air to the furnace and more feed water for the generation of a greater supply of elastic fluid to accommodate the increased load demand. As the back pressure to the auxiliary turbine drops, the flow of steam through its valves 23 will increase tending to cause a reduction in pressure in the supply conduit 11. This tendency will be met by a slight throttling of the valves 23 to maintain the pressure constant in the conduit 11.

The auxiliary turbine, however, will continue to operate at a speed somewhat greater than that prior to the change. With a slight time lag, depending upon the response characteristics of the boiler 10, the supply of elastic fluid therefrom will be increased, raising the pressure in the supply conduit 11. The device 26, being responsive to this increase of pressure, will actuate the valves 23 toward a more opened position increasing the supply of elastic fluid through the auxiliary turbine and to the main turbine to enable the latter properly to carry the increased burden. The increased flow of elastic fluid through the auxiliary turbine will have little effect upon the speed thereof, for as the flow is increased, the back pressure will accordingly increase, so that the net pressure drop therethrough will remain substantially unchanged. As the supply of elastic fluid fed to the turbine 13 approaches that required for the new condition of load, the valve 34 may be throttled somewhat toward the closed position by means of the controller 37. This movement of the valve 34, however, further increases the back pressure of the auxiliary turbine, reducing the pressure drop thereacross causing it to decrease somewhat in speed and accordingly slightly decrease the supply of fuel, combustion air and feed water to the boiler and to stabilize its output of elastic fluid in accordance with the new load level.

In the event that the load on the main turbine is decreased, the supply of elastic fluid thereto will be decreased by the adjustment of the controller 37 to such a position that the valve 34 will pass only the required amount of elastic fluid. The back pressure to the auxiliary turbine is thereby increased causing it to decrease slightly in speed which in turn brings about, in the converse manner as described above, a decrease in the output of elastic fluid from the generator 10.

Should the controller 37 be so actuated as to suddenly move the valve 34 to a wide open position in response to a sudden increase in the load on the turbine 13, the sudden removal of the back pressure to the auxiliary turbine 12 may cause it to accelerate rapidly to an excessive speed likely to cause injury to itself or to the auxiliaries connected thereto. To preclude such excessive speed of the auxiliary turbine, the governor mechanism 38, driven by the shaft 20, is so adjusted that upon the occurrence of a predetermined maximum safe speed the valve 34 is moved thereby to a throttling position thereby bringing about an increase in the back pressure to the auxiliary turbine and the maintenance of a safe speed thereof.

From the foregoing, it is seen that during the operation of the power plant with only normal variations of load on the main turbine, the elastic fluid passed through the auxiliary turbine is all supplied to the main turbine. When the main turbine is operated under no load conditions or is shut down as for temporary periods, it may be desirable to continue the operation of the elastic fluid generator to maintain the pressure for a subsequent full load operation or restarting of the main turbine. It is understood that unless provision is made for by-passing the main turbine during no load operation thereof, the back pressure to the auxiliary turbine would increase in value approximating the pressure in the supply conduit 11 which would ultimately bring the auxiliary turbine to a standstill. By the arrangement disclosed, when the valve 34 is adjusted to a predetermined closed position, the by-pass

valve 41 is automatically opened. The excess amount of elastic fluid required for maintaining the proper speed of the auxiliary turbine is passed directly to the condenser. The back pressure of the auxiliary turbine may be regulated at any desired value necessary for the proper operation thereof by the adjustment of the control means effecting the operation of the by-pass valve 41 with regard to the position of the valve 34. Immediately upon the reopening of the valve 34, the by-pass valve 41 will automatically be closed by the biasing spring 42. Simultaneously, the back pressure to the auxiliary turbine will drop considerably below the previous level whereupon it will be accelerated for causing the generation of an increased supply of elastic fluid to accommodate the resumption of full load operation of the main turbine.

It is understood, of course, that the by-pass valve 41 may be adapted for manual control or it may be regulated in accordance with some condition such as the back pressure of the auxiliary turbine. As shown in Fig. 2, the valve 41' may be adapted to be actuated in accordance with a predetermined pressure obtaining in the conduit 40 by means of a pressure responsive actuating device 48. This device comprises a cylinder 49 having a piston 50 slidably arranged therein and connected by the stem 51 to the valve 41'. Means such as a spring 52 arranged within the cylinder and above the piston normally bias the valve 41' to the closed position. With this arrangement as the pressure in the by-pass conduit 40 reaches a predetermined high value due to the throttling of the valve 34, the piston 50 will be forced upwardly to move the valve 41' to an opened position. By the proper design or adjustment of the device 48, the back pressure of the auxiliary turbine may be maintained at a substantially constant value somewhat less than the elastic fluid pressure in the supply conduit 11. The speed of the auxiliary turbine for the no load operation of the power plant can thereby be adjusted so that a desired boiler pressure may be maintained during the no load period. Upon the resumption of full load operation of the main turbine and the reopening of the valve 34, the back pressure to the auxiliary turbine will drop whereupon the by-pass valve 41 will automatically be moved to the closed position.

Although the major changes in the output of the elastic fluid generator auxiliaries are taken care of automatically in response to variations in load conditions by the increase and decrease in speed of the auxiliary turbine, secondary adjustments in the ratio of the air, fuel and boiler liquid supplied to the elastic fluid generator are preferably made by supplementary control. This may be effected by controlling the supply of combustibles to the furnace in accordance with the level of liquid in the boiler as supplied by the boiler feed pump. As indicated in the drawing, a drum 60 of the boiler, the liquid level in which is to be held constant, is provided with a float means 61 which through a suitable connection 62, bell crank 63 and link 64 is adapted for adjusting a control means such as a butterfly valve or damper 65 arranged in the air supply conduit 66 extending from the blower 22 to the furnace of the elastic fluid generator 10. The proper ratio between the air passed by the damper 65 and the fuel supplied to the furnace is regulated by means including flow responsive devices 67 and 68. The device 67 comprises a casing 69 having a flexible diaphragm 70 arranged therein forming chambers

on opposite sides thereof with the casing. The chamber on the right of the diaphragm is in communication by conduit 71 with the air supply conduit 66 ahead of a nozzle 72 provided therein. The chamber on the left of the diaphragm is in communication by conduit 73 with the air supply conduit 66 behind the nozzle 72 as regards the air flow therethrough. Similar to the device 67, the device 68 comprises a casing 74 having a flexible diaphragm 75 arranged therein forming chambers on the opposite sides thereof with the casing. The chamber on the left is in communication by conduit 76 with the fuel supply conduit 77 ahead of a nozzle 78 provided therein. The chamber on the right is in communication by conduit 79 with the fuel supply conduit 77 behind the nozzle 78 as regards the direction of fuel flow therethrough. The stems 80 and 81 secured to the diaphragms 70 and 75 of the devices 67 and 68, respectively, are connected together by 20 means of a floating lever 82. The floating lever is pivotally connected intermediate its ends as at 83 to one end of a lever 84 which is pivoted at the other end to a stationary part 85. Movement of the lever 84 is imparted by a connection 25 link 86 to the valve 87 arranged in the fuel supply conduit 77 between the fuel pump 21 and the nozzle 78. In the event that the output of the fuel pump 21 is in excess of that allowed to pass the valve 87 provision is made by means of conduit 88 for by-passing the excess fuel from the conduit 77 back to the fuel storage tank 89. A pressure relief valve 90 is arranged in the by-pass conduit which may be adjusted to open upon a predetermined pressure obtaining in the 35 conduit 77 between the fuel pump 21 and the valve 87.

By operation of the supplementary control apparatus described, should the liquid in the drum 60 fall below a predetermined level, the supply of both fuel and air to the furnace will be decreased. Accordingly, the output of elastic fluid from the generator 10 will decrease causing the valves 23 to move to a slightly more closed position. Since the main turbine 13 will be affected by this decrease in steam to decrease in speed, the controller 37 will be actuated to adjust the valve 34 to a more opened position. As described above, an opening of the valve 34 causes a decrease in the back pressure to the auxiliary turbine 12 resulting in an increase of its speed whereupon the output of the boiler liquid feed pump 18 will be increased to bring the level of the liquid in the drum 60 to a predetermined position. As the level in the drum 60 rises, the supply of air and fuel to the furnace is gradually increased resulting in an increase in the generation of elastic fluid whereupon a normal condition of equilibrium will be reestablished in the power plant system.

Should the level of liquid in the drum 60 rise above a predetermined position, the supply of fuel and air to the furnace will be accordingly increased resulting in an increase in the generation of elastic fluid. The increase of pressure in the supply conduit 11 will cause the valves 23 to move to a more opened position passing more elastic fluid therethrough and through the auxiliary turbine. However, since the valve 34 will be so throttled as to pass only the amount of elastic fluid as is required for the instant load, the pressure in conduit 32 will increase to decrease the pressure drop through the auxiliary turbine. Accordingly, the auxiliary turbine will decrease somewhat in speed, to decrease the sup- 75

ply of feed liquid to the boiler which in turn will result in a decrease in the supply of combustibles to the furnace. Upon the normal level of liquid obtaining in the drum 60, the system will again be stabilized in a condition of operational equilibrium.

Having described the method of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

15 1. The combination of an elastic fluid generator comprising a boiler and a furnace, a main turbine, a conduit for conducting elastic fluid from said generator to said turbine, a valve for controlling the admission of elastic fluid to said turbine, means for regulating said admission valve in response to a load condition of said main turbine, a boiler feed pump, a fuel pump, a furnace draft blower, an auxiliary turbine arranged in said elastic fluid conduit ahead of said main turbine for normally driving said pumps and blower in accordance with the elastic fluid demand by said main turbine, an admission valve for said auxiliary turbine, means for adjusting said auxiliary turbine admission valve so as to maintain substantially constant the elastic fluid pressure in said conduit ahead of said auxiliary turbine, a by-pass conduit extending from said first mentioned conduit between said turbines around said main turbine, a normally closed valve in said by-pass conduit, and means for opening said by-pass conduit valve in response to a predetermined adjustment of said main turbine admission valve.

2. In a power plant, the combination of an elastic fluid generator comprising a furnace, a boiler, a fuel pump, a furnace draft blower and a boiler feed pump, an auxiliary turbine for driving said pumps and said blower, conduit means including a valve for conducting elastic fluid from said boiler to said auxiliary turbine, means for positioning said valve in response to the fluid pressure in said conduit means, a main turbine, conduit means for conducting elastic fluid from said auxiliary turbine to said main turbine, valve means for controlling the flow of elastic fluid to said main turbine, condensing means for receiving the exhaust fluid from said main turbine, conduit means communicating with the exhaust of said auxiliary turbine and said condensing means, valve means in said last mentioned conduit, means for positioning said last mentioned valve means in response to a predetermined exhaust pressure of said auxiliary turbine.

3. In a power plant, the combination of an elastic fluid generator comprising a furnace, a boiler, a fuel pump, a combustion air blower and a boiler feed pump, an auxiliary turbine for driving said pumps and said blower, conduit means for conducting elastic fluid from said boiler to said auxiliary turbine, valve means for controlling the admission of elastic fluid to said auxiliary turbine, a main turbine, conduit means for conducting the elastic fluid exhaust from said auxiliary turbine to said main turbine, valve means for controlling the flow of elastic fluid to said main turbine, condensing means for receiving the exhaust fluid from said main turbine, conduit means for conducting the exhaust fluid from said auxiliary turbine to said condensing means, normally closed valve means in said last mentioned conduit

means, and means for opening said normally closed valve means in response to a predetermined closing movement of said main turbine valve means.

4. The combination of an elastic fluid generator comprising a furnace, a boiler, a fuel pump, a furnace draft blower and a boiler feed pump, an auxiliary turbine for driving said pumps and said blower, conduit means for conducting elastic fluid from said boiler to said auxiliary turbine, sectional admission valves for said auxiliary turbine, means for adjusting said admission valves so as to maintain substantially constant the elastic fluid pressure in said conduit means, a main turbine adapted to be driven by the elastic fluid passing through said auxiliary turbine, a valve for controlling the admission of elastic fluid to said main turbine, a by-pass conduit extending from the exhaust of said auxiliary turbine around said main turbine, a valve in said by-pass conduit, and means for controlling said by-pass conduit valve in response to a predetermined adjustment of said main turbine admission valves.

5. The combination comprising a source of elastic fluid, a turbine, a conduit for conducting elastic fluid from said source to said turbine, sectional admission valves for said turbine, means for adjusting said admission valves so as to maintain substantially constant the pressure of elastic fluid in said conduit, a second turbine adapted to be driven by the elastic fluid passing through said first turbine, admission valves for said second turbine, a by-pass conduit extending from the exhaust of said first turbine around said second turbine, and means including a valve in said by-pass conduit operable to the open position for maintaining the exhaust pressure of said first turbine substantially below the predetermined constant pressure maintained in said conduit ahead of said first turbine.

6. In combination, a variable source of elastic fluid, a turbine, conduit means for conducting elastic fluid from said source to said turbine, sectional admission valves for controlling the flow of elastic fluid to said turbine, means for controlling said admission valves so as to maintain substantially constant the pressure of elastic fluid in said conduit, a second turbine adapted to be driven by the exhaust fluid from said first turbine, admission valves for said second turbine, means for adjusting said second turbine admission valve including means responsive to a predetermined speed of said first turbine, a by-pass conduit extending from the exhaust of said first turbine around said second turbine, a valve in said by-pass conduit normally biased to the closed position, and means for opening said by-pass valve in accordance with a predetermined adjustment of the admission valve adjusting means for said second turbine.

7. In combination, a source of elastic fluid, a non-condensing turbine, a conduit for conducting elastic fluid from said source to said turbine, admission valves for said turbine, pressure responsive means for controlling said admission valves so as to maintain substantially constant the pressure in said conduit, a second turbine adapted to be driven by the exhaust fluid from said first turbine, an admission valve for said second turbine, a by-pass conduit including a valve extending from the exhaust of said first turbine around said second turbine, and means for controlling said by-pass valve in accordance with a predetermined position of adjustment of said second turbine admission valve.

8. In combination, a source of elastic fluid, a turbine connected to said source, admission valves for said turbine, pressure responsive means for controlling said valves so as to maintain substantially constant the pressure of elastic fluid from said source, other elastic fluid consuming apparatus connected for receiving the exhaust from said turbine, a regulating valve for controlling the flow of elastic fluid from said turbine to said other apparatus, a by-pass conduit extending from the exhaust of said turbine around said apparatus, a valve in said by-pass conduit, and means for automatically opening said by-pass conduit valve in response to said regulating valve

being adjusted to a predetermined closed position.

9. In a power plant, the combination of a boiler, means including an auxiliary turbine for regulating the generation of elastic fluid in said boiler, said auxiliary turbine being connected to said boiler, means for controlling said auxiliary turbine in response to pressure changes in said boiler, a main turbine connected to said auxiliary turbine, valve means for controlling the admission of elastic fluid to said main turbine, and means for by-passing elastic fluid from said auxiliary turbine relative to said main turbine.

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