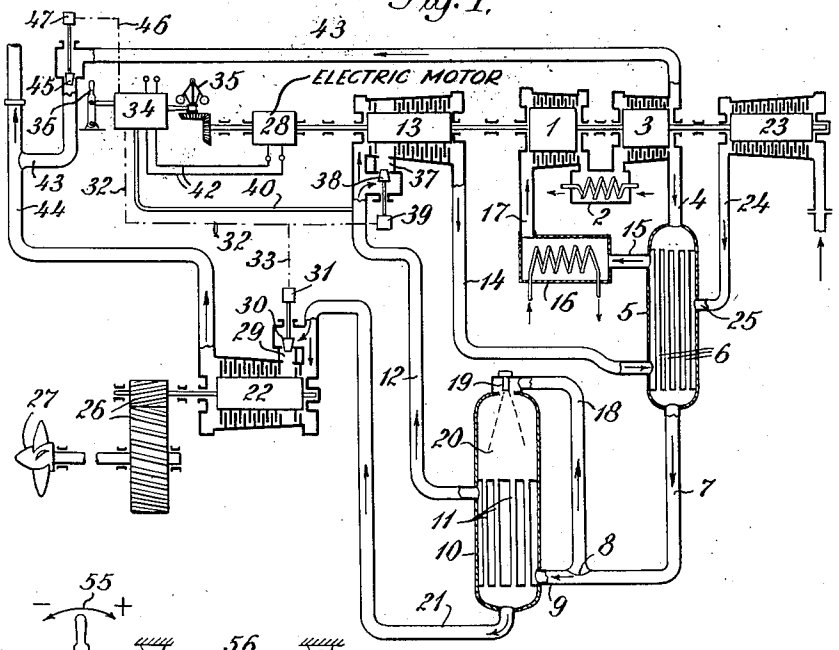
Oct. 30, 1951 W. TRAUPEL 2,573,289

GAS TURBINE PLANT WITH CONTROLLER OF STAGE-BY-PASS IN TURBOCOMPRESSOR AUXILIARY

Filed Feb. 16, 1945

Fig. 1.



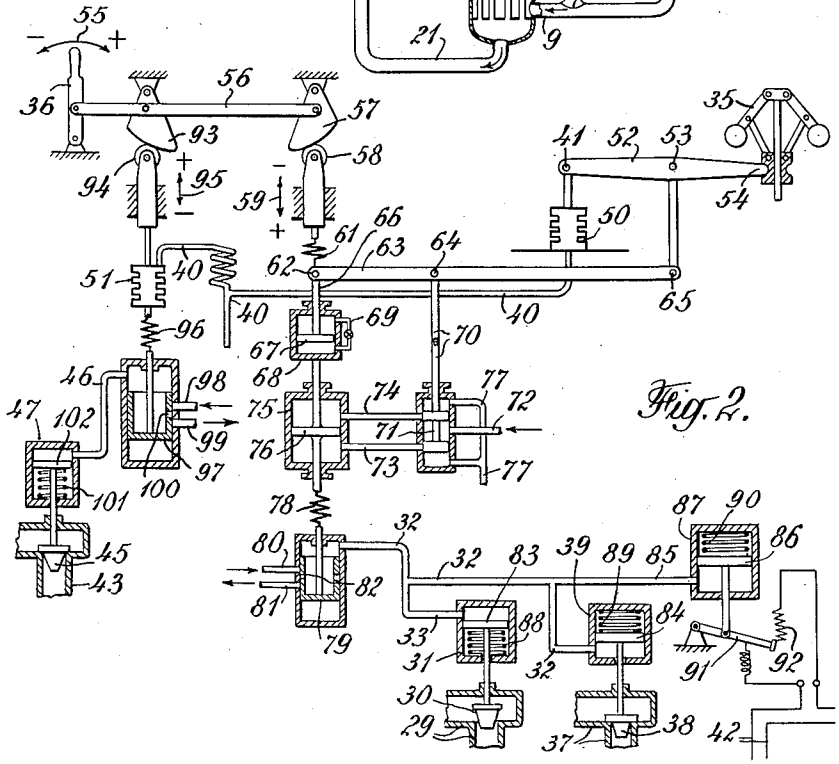


Fig. 2.

INVENTOR

WALTER TRAUPEL

BY

ATTORNEYS

Patented Oct. 30, 1951

2,573,289

UNITED STATES PATENT OFFICE

2,573,289

GAS TURBINE PLANT WITH CONTROLLER OF STAGE BY-PASS IN TURBOCOMPRESSOR AUXILIARY

Walter Traupel, Winterthur, Switzerland, assignor to Sulzer Frères, Société Anonyme, Winterthur, Switzerland

Application February 16, 1945, Serial No. 578,290
In Switzerland May 19, 1944

4 Claims. (Cl. 60—49)

1

The invention relates to a gas turbine plant of the semi-circuit type with at least one gas turbine for generating the useful output, at least one gas turbine for driving a compressor and a regulating device which correctly sets the quantities of working medium for the turbines. The invention is characterised in having a pipe which bypasses at least one stage of the compressor turbine and has a flow regulating member which may be opened temporarily by the regulating device when the useful output is raised if, and only if, necessary.

An auxiliary machine coupled to the compressor set may further be provided, which can be temporarily put into supplementary service by the regulating device when the load increases. A blow-off member may also be provided which is temporarily opened by the regulating device when the load falls and allows a part quantity of working medium to flow off from the plant. It is expedient for the regulating device for setting the part quantities to influence a regulating member which is arranged in a pipe bypassing at least one stage of the useful output turbine.

The invention is explained in more detail below with the aid of the drawings.

Fig. 1 shows in simplified form an embodiment of a gas turbine plant according to the invention which serves for propelling a ship.

Fig. 2 shows in diagrammatic form the regulating device used for this plant.

In the two figures identical parts are provided with identical numerals.

The gas-turbine plant shown in Fig. 1 works with a circuit of a gaseous working medium, for instance air, from which a partial quantity is continuously extracted and to which in return a make-up quantity is continuously supplied at another point. The working medium compressed by the low-pressure compressor 1 passes through the intermediate cooler 2 into the high-pressure compressor 3. After being brought to the highest circuit pressure, the working medium flows through the pipe 4 into the heat-exchanger 5, where it is preheated while flowing through the tubes 6. Through the pipe 7 the working medium flows further until it is divided up into two parts at the point 8. A major part passes through the pipe 9 into the gas heater 10 and is brought up to the highest circuit temperature while flowing over the heat-exchange tubes 11 and is then supplied through the pipe 12 to the turbine 13.

The working medium expanded in the turbine 13 passes through the pipe 14 into the heat-exchanger 5 and here, while flowing over the heat-

2

exchange tubes 6, gives up part of its residual heat to the working medium flowing through the tubes. The working medium passes through the pipe 15 with a lower heat content into the cooler 16, in which a further part of its residual heat is given up to a cooling medium. Finally the working medium is again supplied through the pipe 17 to the low-pressure compressor 1, in which the circuit begins anew.

From the circuit of the working medium described a partial quantity is continually extracted at the point 8 and is supplied as combustion air through the pipe 18 to the burner 19 of the gas heater 10. The combustion gases flow from the combustion space 20 into the heat-exchange tubes 11, through the walls of which the heat is given up to the working medium of the circuit flowing over the tubes. Afterwards the combustion gases pass through the pipe 21 into the turbine 22.

To replace the quantity of working medium extracted from the circuit at the point 8, air from the atmosphere is continuously supplied to the circuit by the compressor 23. This make-up quantity is introduced into the heat-exchanger 5 through the pipe 24 at a point 25 at which the working medium flowing over the heat-exchange tubes 6 has approximately the same temperature and the same pressure as the make-up quantity.

The turbine 13 is driven by the quantity of working medium flowing in the circuit and drives the compressors 1, 3 and 23. The turbine 22 is driven by the part quantity of working medium extracted from the circuit and produces a useful output, driving, for example, a ship's propeller 27 through a reduction gear 26. The turbine 13 and the compressors 1, 3 and 23 are further coupled to an electric motor 28 which serves as a starting motor and as an auxiliary motor for equalising surplus or lacking power.

To make possible the correct setting of the working medium quantities for the turbines 13 and 22, the useful output turbine 22 is equipped with a bypass pipe 29 which bypasses the first stage and in which a flow regulating member 30 is built. The servomotor 31 of this regulating member is influenced through the impulse pipes 32 and 33 by the regulating device 34. The control of the regulating device is effected on the one hand by the centrifugal governor 35 and on the other hand by the pressure of the working medium in the inlet pipe 12 of the turbine 13, transmitted by means of the pipe 40. By means of the lever 36 the normal value of the useful out-

put to be maintained by the regulating devices can be set by hand.

A reduction of the cross-section of flow in the bypass pipe 29 reduces the absorption capacity of the useful output turbine 22, so that less working medium is extracted from the circuit and supplied to the turbine. At the same time, however, the working medium is dammed as a result of this reduced extraction, and the pressure in the circuit is therefore raised, so that the output increases correspondingly. An increase in the cross-section of flow in the bypass pipe gives the useful output turbine 22 a greater absorption capacity and therefore causes a greater extraction of working medium from the circuit with a corresponding pressure drop. As a result of the pressure drop the useful output is diminished.

In accordance with the decrease or increase of the quantity of working medium extracted by the useful output turbine 22, an increase or decrease of the quantity of working medium available for the compressor turbine 13 comes about. The working medium is divided up by the regulating device 34 in such a way that, at constant load, stable service of the plant is ensured. With the aid of the lever 36 the output desired at any time for driving the propeller, and thus the speed of travel of the ship, can be adjusted.

The compressor turbine 13 has a bypass pipe 37 which bypasses the first turbine stage. The flow regulating member 38 in the bypass pipe can, in order to increase the output of the useful output turbine 22 more rapidly, be temporarily opened by the regulating device 34, whereby the absorption capacity of the turbine is increased. For this purpose the regulating device 34 influences the servomotor 39 of the regulating member 38 through the impulse pipe 32. As a result of the damming of the working medium at the useful output turbine, which is caused by means of the regulating device 34 for increasing the useful output, an increased quantity of working medium is available for the compressor turbine. With the absorption capacity of the compressor turbine temporarily increased, an increased output is given up. Therefore the speed of the compressor turbine set rises and the pressure in the circuit is thus raised. Through the pressure rise in the circuit the desired increase of the useful output is then obtained.

The auxiliary machine 28 can also be put into temporary service by the regulating device 34 when the useful output is raised. The regulating device 34 has for this purpose a regulating switch not shown in Fig. 1, to which the electric lead 42 of the machine 28 is connected.

To the high-pressure compressor 3 is connected a blow-off pipe 43 which leads into the outlet pipe 44 of the useful output turbine 22. In this pipe is provided a blow-off member 45 which is temporarily opened by the regulating device 34 acting through the impulse pipe 46 and the servomotor 47 when the useful output of the turbine 22 is decreased, and which allows a quantity of working medium to flow off from the plant.

The regulating device 34 with the regulating members connected to it, as shown in Fig. 1, is illustrated diagrammatically in Fig. 2.

The regulating device is influenced by the centrifugal governor 35 and the pressure responsive bellows 50 and 51 attached to the pressure pipe 40. With the aid of the lever 36 the normal value of the output desired for driving the ship's propeller can be set by hand.

The higher the pressure in the circuit of the gas turbine plant, the more the bellows 50 expands and raises the hinge 41 of the lever 52. If the speed of the compressor turbine in the gas turbine plant rises, the hinge 54 of the lever 52 moves upwards. The position of the linkage point 53 is thus a function of the magnitude of the pressure in the circuit of the plant and the speed of the compressor turbine. As in stable service pressure and speed are allocated to each other in a definite relationship, the position of the point 53 finally depends on the speed of the compressor turbine alone. During changes of the useful output the values of the speed and pressure are no longer allocated to each other in the same way, since the changes of the pressure condition in the circuit are brought about with a certain time lag in relation to the changes of the speed.

In order to increase the useful output the lever 36 is displaced in the +direction of the arrow 55, so that by means of the rod 56 and the cam 57 the roller 58 is displaced in the +direction of the arrow 59 and the spring 61 is compressed. Thus there acts upon the hinge 62 of the lever 63 a force directed downwards, which forces the displacer piston 67 downwards through the rod 66. In the process the liquid present in the cylinder 68 below this displacer piston is forced through the throttle pipe 69 to the upper side of the piston. The linkage points 62 and 64 of the lever 63 and the attached rod 70 of the control valve 71 are moved downwards. Thus the path through the pipe 73 into the lower part of the cylinder 75 is freed for the pressure fluid supplied through the pipe 72, and the piston 76 is raised. The fluid displaced on the upper side then passes through the pipe 74 into the drain pipe 77.

The rising of the piston 76 causes an increase of the tension in the spring 78, so that the control valve 79 is also drawn upwards. Pressure fluid then passes out of the pipe 80 into the pipe 32, in which the pressure now rises. The control valve 79 is now forced downwards again by the increased fluid pressure until the increased fluid pressure acting upon it balances the previously increased tension of the spring 78 in a position in which the control opening 82 of the valve is situated between the control openings of the supply pipe 80 and the discharge pipe 81.

The rising control pressure in the pipe 32 sets in motion first, through the pipe 33, the piston 83 of the sermomotor 31, then the piston 84 of the servomotor 39 and, finally, through the pipe 85, upon the piston 86 of the servomotor 87. First the piston 83 is pressed downwards in opposition to the spring 88 by the increase of the control pressure, so that the cross-section of flow freed by the member 30 is diminished, in given cases to the point of complete closing. Second, because spring 89 loading the piston 84 of the servomotor 39 is so chosen, the flow member 38 is only raised from its seat when the flow member 30 has just arrived in the closed position. Third, when the flow member 38 is completely open, if there is further rising of the control pressure in the pipes 32 and 85, the piston 86 is then raised in opposition to the spring 90 so that the contactor 91 begins to move over the regulating resistance 92. When the piston 86 rises a current of increasing strength is then supplied through the lead 42 to the auxiliary electric motor of the gas turbine plant.

Under the influence of the regulating actions described the speed of the compressor turbine and the pressure in the circuit of the gas turbine plant, and consequently also the speed and thus the output of the useful output turbine, rise. The

linkage points 41 and 54 of the lever 52, and thus also the linkage points 53 and 65, are then raised. The control valve 71 thus frees the supply of pressure fluid through the pipe 74 to the upper side of the servomotor piston 76 and by unloading the spring 78 again decreases the control pressure through the control valve 79. The regulating device only comes to rest once more when pressure and speed have reached their specified values.

In steady service the position of the linkage point 62 of the lever 63 is fixed by the curved disc 57, as in the position of equilibrium the spring 61 must be unloaded. Likewise the linkage point 64 is fixed during steady service in the position in which the control valve holds the two control pipes 73 and 74 closed. From the fixed positions in steady service of the linkage points 62 and 64 of the lever 63 there results a position of the linkage point 65 which corresponds to the speed and the pressure of the new level of steady service.

The regulating range of the member 30 is so fixed that every state of steady service can be maintained by the setting of this valve alone. It then proves that during steady service there prevails in the pipe system 32, 33, 85 a control pressure which keeps the member 38 in a closed position and the switch 91 switched out.

In order to decrease the useful output, the lever 36 is displaced in the —direction of the arrow 55, whereby the blow-off member 45 in the pipe 43 is temporarily opened.

This blow-off member is controlled by the curved disc 93 and the pressure responsive bellows 51 in such a way that it is opened as soon as the pressure of the circuit in the pipe 40 exceeds a limiting value lying somewhat above the normal value of the useful output set by the lever 36. If the lever 36 is displaced in the —direction of the arrow 55, the roller 94 moves in the —direction of the arrow 95. The spring 96 is then given a compression stress which presses the control valve 97 downwards. Thus communication is established between the cylinder of the servomotor 47 and the drain pipe 99 through the pipe 46 and the control opening 100.

The control pressure falls correspondingly, so that the spring 101 raises the piston 102, whereby the member 45 frees the flow through the pipe 43. Working medium then escapes from the circulating system of the gas turbine plant through the blow-off pipe 43 and the pressure of the circuit sinks, so that the pressure responsive bellows 51 is shortened. The spring 96 is then placed under tension and the control valve 97 again raised. Fluid can again flow out of the pipe 98 through the control opening 100 and the pipe 46 into the cylinder 47 in such quantities that by means of the piston 102 the member 45 is again pressed against its seat and thus the flow is interrupted.

At the same time, with the displacement of the lever 36 in the —direction of the arrow 55, a further drop of pressure will take place in the pipe system 32, 33, 85, so that the regulating member 30 frees a larger cross-section of flow. Hereby the useful output is reduced. The bypass member 38 of the compressor turbine, which is already closed, remains closed, and the switch 91, already switched out, remains in the switched-out position.

If in order to increase the output the lever 36 is displaced in the +direction of the arrow 5, the control pressure in the pipe 46 is increased, and the blow-off member 45, which is already closed, remains in a closed position.

Obviously the usual known means of regulation are employed in common with the regulation described. For instance, the fuel quantity supplied to the air heater must be set to correspond to the output required.

I claim:

1. In a gas turbine plant having a circuit for working medium closed off from the atmosphere from which circuit a quantity of working medium is continually extracted and into which a substantially constant make-up quantity is continually introduced and which plant includes a compressor for compressing the working medium flowing round in the circuit, and at least two turbines, one driven by the working medium flowing round in the circuit and the other driven by the quantity extracted from the circuit and one delivering the plant useful output and the other driving said circuit compressor, the combination including a plurality of stages in the turbine driving said compressor, a by-pass around at least one of said stages, a valve controlling said by-pass, a servomotor operating said valve, a speed governor driven from said compressor-driving-turbine, a manual output-setting control for said governor, and a servo-system for regulating plant useful output controlled by said governor to produce equilibrium at the level set by said control, said servo-system including said servomotor, means responsive to an adjustment of said control in the sense of increasing the useful output, for initiating a primary regulating action to reduce the quantity of working medium extracted from said circuit and thus to increase the quantity of working medium delivered to said compressor-driving turbine and means for following said primary regulating action, if the effect thereof is insufficient to increase the speed of said compressor-driving-turbine to the new equilibrium level within a predetermined time, by a secondary regulating action causing said servomotor to actuate said valve in the sense to open said by-pass.

2. The combination of claim 1 including an electric motor coupled to the circuit compressor, a source of electric power, means for adjustably connecting said motor to said source, and a second servomotor in the servo-system operating said means, said second servomotor being so arranged in said servo-system that if the effect of the secondary regulating action is insufficient to increase the speed of the compressor-driving turbine to the new equilibrium level within a predetermined time, said servo-system initiates a tertiary regulating action causing said second servomotor to actuate said means in the sense to connect said motor to said source.

3. The combination of claim 1 including a passage from the circuit to atmosphere, a second valve controlling said passage, a second servomotor operating said valve, and means responsive to the circuit pressure at a level set by the manual control whereby said second servomotor opens or closes said second valve as required to maintain said level.

4. The combination of claim 1 including a plurality of stages in the turbine delivering the plant useful output, a second by-pass around at least one of said useful-output-turbine stages, a second valve controlling said second by-pass, a second servomotor operating said second valve, said second servomotor being so arranged in the servo-system that when the manual control is adjusted in the sense of increasing the useful output, said

second servomotor is caused to actuate said second valve in the sense to close said by-pass.

WALTER TRAUPEL.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,309,796	Dahlstrand	July 15, 1919
1,978,837	Forsling	Oct. 30, 1934
2,095,991	Lysholm	Oct. 19, 1937
2,219,994	Jung	Oct. 29, 1940
2,353,929	Ray	July 18, 1944
2,361,887	Traupel	Oct. 31, 1944
2,365,616	Zweifel	Dec. 19, 1944
2,371,889	Hermitte	Mar. 20, 1945
2,399,152	Traupel	Apr. 23, 1946
2,493,509	Traupel	Jan. 3, 1950

FOREIGN PATENTS

Number	Country	Date
210,659	Switzerland	Oct. 16, 1940