

Jan. 8, 1946.

W. TRAUPEL

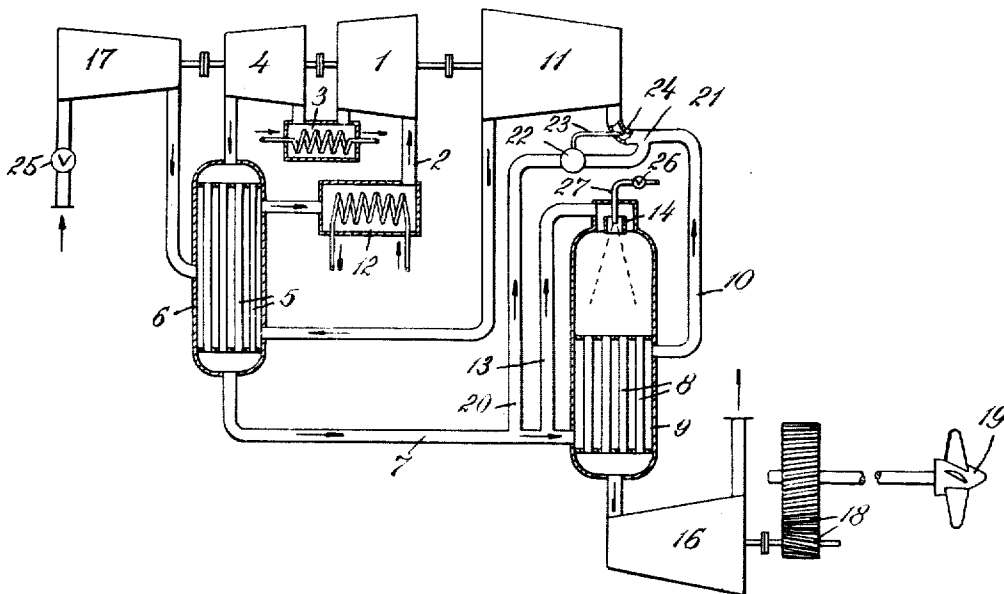
2,392,622

GAS TURBINE PLANT

Filed May 25, 1943

3 Sheets-Sheet 1

Fig. 1



INVENTOR
Walter Traupel
BY
Perris, Davis, Munn & Chandler
ATTORNEYS

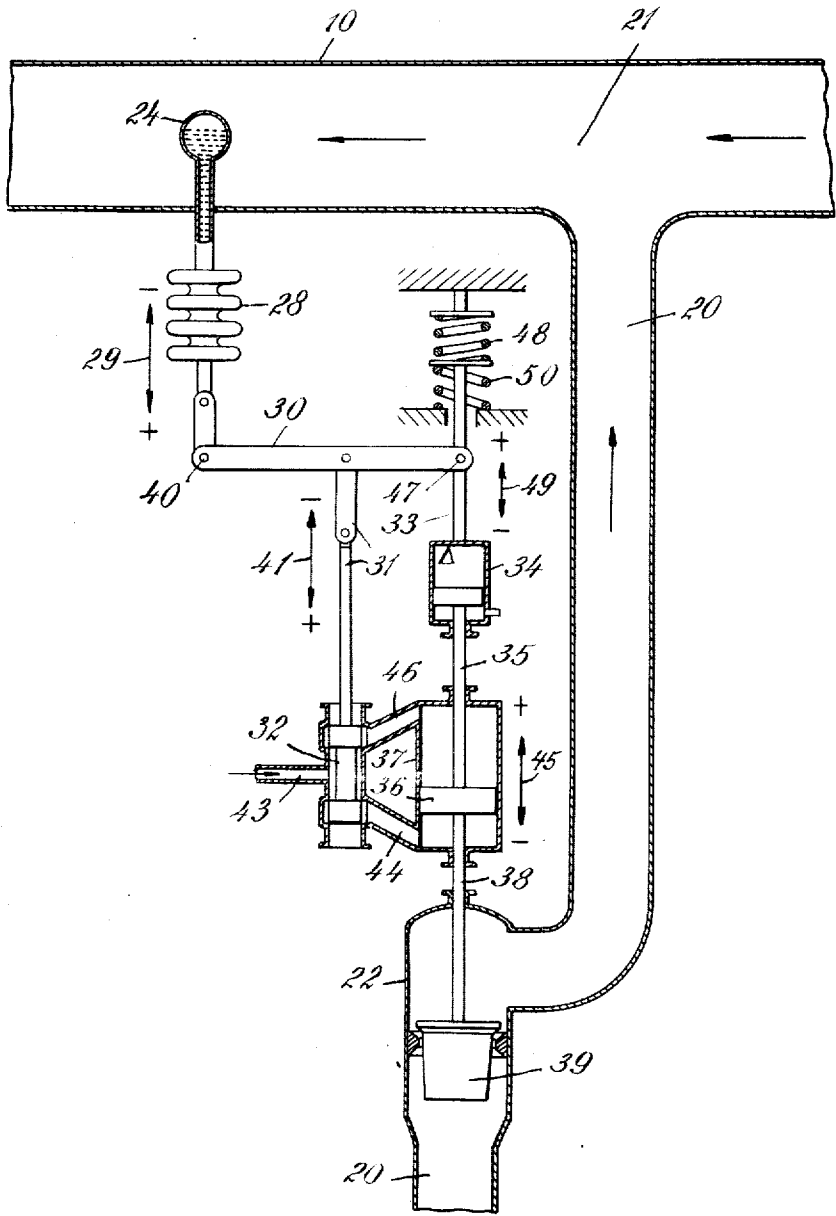
Jan. 8, 1946.

W. TRAUPEL
GAS TURBINE PLANT
Filed May 25, 1943

2,392,622

3 Sheets-Sheet 2

Fig. 2.



INVENTOR
Walter Traupel
BY
Pauline Davis, Mary T. Chandler
ATTORNEYS

Jan. 8, 1946.

W. TRAUPEL

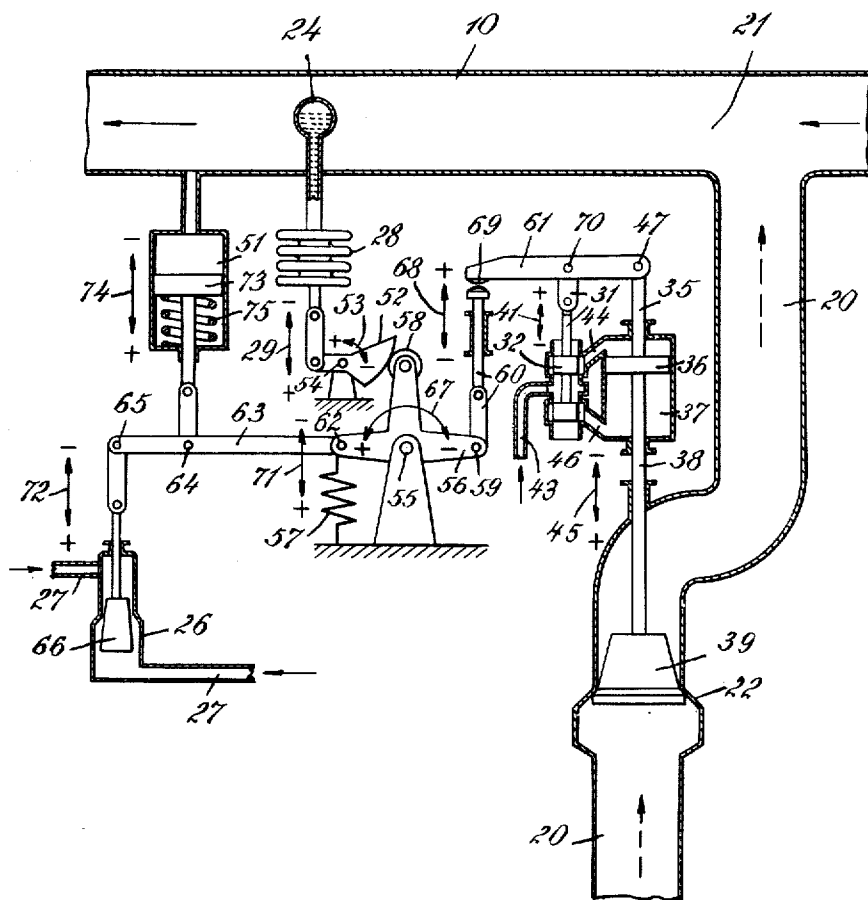
2,392,622

GAS TURBINE PLANT

Filed May 25, 1943

3 Sheets-Sheet 3

Fig. 3,



INVENTOR
Walter Traupel
BY
Benjamin Davis, Maurice A. Chandler
ATTORNEYS

UNITED STATES PATENT OFFICE

2,392,622

GAS TURBINE PLANT

Walter Traupel, Winterthur, Switzerland, assignor to Sulzer Freres, Societe Anonyme, Winterthur, Switzerland

Application May 25, 1943, Serial No. 488,402
In Switzerland April 18, 1942

4 Claims. (Cl. 60—49)

The invention relates to a gas turbine plant in which a working medium in a circuit is compressed by a compressor, then heated in a heat exchanger by the combustion gases from a combustion chamber, and thereupon expanded in a turbine driving the compressor, a part of the working medium being withdrawn from the circuit and led as combustion air to the combustion chamber from which the combustion gases are passed first to said heat exchanger and then into a turbine producing the work delivered outside the plant. Accordingly two kinds of working media are taken from the heat exchanger which is constructed as a gas heater, first the working medium which receives heat through heat exchange and operates the turbine driving the compressor, and secondly the working medium heated direct by combustion and led in the form of combustion gases to the turbine producing the work delivered outside the plant. In order to be able to maintain an uninterrupted service, it must be possible to regulate separately, and independently from each other, the working of the two turbines and thereby also the condition (state) of the two working media. This task is solved by the invention in that the part of the circuit situated between the compressor and the heat exchanger is connected by piping containing an adjusting device to the part of the circuit situated between the heat exchanger and the turbine driving the compressor. Through this adjustable piping a greater or smaller part of the working medium flowing round in the closed circuit can be diverted from the heat-exchange surface of the gas heater, and in this manner the quantity of heat transferred from one working medium to the other can be regulated in accordance with requirements. It is thus possible to keep at a suitable height, and separate from each other, on the one hand the temperature of the combustion gases passing to the turbine producing the work delivered outside the plant, and on the other hand the temperature of the air passing into the compressor turbine.

The plant may be simplified to a certain extent if the adjusting device in the piping connecting the two parts of the circuit is not opened until the temperature of the working medium entering the compressor turbine exceeds a limiting value lying above the normal service temperature of that turbine.

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

Fig. 1 shows diagrammatically a gas turbine plant according to the invention.

Fig. 2 illustrates separate details of the regulating device of the plant according to Fig. 1.

Fig. 3 shows a regulating device designed in accordance with other considerations.

The low-pressure compressor 1 (Fig. 1) draws air from the pipe 2 and delivers it through the intermediate cooler 3 to the high-pressure compressor 4. The compressed air passes through the tubes 5 of the heat-exchanger 6 into the pipe 7. A part of the heated air flows through the space surrounding the tubes 8 in the air heater 9 and then through the pipe 10 into the turbine 11. After expanding in that turbine, the air flows through the space surrounding the tubes 5 in the heat exchanger 6, and then through the cooler 12 and the pipe 2 back into the compressor 1.

From the pipe 7 a certain quantity of the air is extracted through the pipe 13 and led to the burner 14 of the air heater 9. The combustion gases flow through the tubes 8 of the air heater and pass into the turbine 16 which produces useful work. To replace the air extracted from the circuit, air is again supplied to it through the compressor 17. This replaced air comes into the circuit at an intermediate place in the heat exchanger 6 and at once gives up a part of its heat of compression to the air flowing in the circuit. Consequently there is no closed circuit, in so far that a quantity of working medium is continually being extracted from the plant and a corresponding quantity being supplied in its place.

The air turbine 11 and the compressors 1, 4 and 17 have one shaft in common and are of such dimensions that the output of the turbine is equal to the power required for driving the compressors. The turbine 16 to which the combustion gases are led drives the propeller 19 through the gear 18.

To regulate the temperature of the air flowing into the turbine 11 a bypass pipe 20 is provided, through which a part of the air not yet heated is led past the air heater 9 and mixed at place 21 with the already heated air. For adjusting the quantity of bypassed air, a regulating member 22 is provided, which is controlled through the impulse pipe 23 by the thermostat 24 in accordance with the temperature of the mixture at place 21, so that temperature fluctuations in the air flowing into the turbine 11 are at least diminished.

The replaced air led into the air circuit can be adjusted by means of the valve 25, and the quantity of fuel led to the air heater 9 can be adjusted by the regulating valve 26 arranged in the fuel pipe 27, both adjustments being made in accordance with the prevailing load conditions. By means of the adjustment of the replace quantity,

the pressure level or, in other words, the degree of supercharging of the air circuit, is suited to the load on the turbine 10 producing useful work. The quantity of fuel is then adjusted in accordance with the degree of supercharging. The regulating device 22—24 can be set in such a way that it allows air to be bypassed round the air heater 9 only when a temperature above the normal service temperature is exceeded.

The air flowing through the pipe 10 (Figs. 1 and 2) influences the thermostat 24 (Fig. 2), which is designed as an enclosed container partially filled with liquid. According to the changing temperature of the air flowing through the pipe 10, this liquid will be under a higher or a lower evaporating pressure. In accordance with the changes in the evaporating pressure, the bellows 28 will be more or less pressed out in the direction of the double arrow 29.

The movements of expansion of the bellows 28 are transmitted to the valve 32 through the lever 30 and the linkage 31. The lever 30 is also connected to the rod 33 of a hydraulic dash-pot control 34, which comes into action as a loose return motion. The dash-pot control device is connected through the rod 35 to the piston 36 of the servomotor 37 and through the rod 38 to the valve 39 of the regulating member 22 in the pipe 20.

An increase in the air temperature at the spot 21 in the pipe 10 causes an increase in pressure in the bellows 28, so that the lever 30 moves at its joint 40 in the plus direction of the arrow 29 and the rod 31 and the valve 32 in the plus direction of the arrow 41. Liquid under pressure then passes from the pipe 43 through the pipe 44 and under the piston 36, which is moved in the plus direction of the arrow 45. The liquid forced out from the upper side of the piston 36 can flow away through the pipe 46.

The valve 39 of the regulating member 22 is moved by the servomotor piston 36 in the plus direction of the arrow 45. The cross-sectional area of flow through the regulating member is increased, and by introducing a greater quantity of gas through the bypass 20 the temperature of the mixed gases at place 21 in the pipe 10 is again reduced to the desired figure.

Through the dash-pot 34, in the described regulating process the lever 30 is first of all moved at its joint 47 against the spring 48 in the plus direction of the double arrow 49, whereby the displacement of the control valve 32 that starts the regulating action is again reversed. Since the servomotor piston 36 and the return-motion rod 33 are loosely connected to each other through the dash-pot, the regulating process will come to rest only when the springs 48 and 50 balance each other, and the control valve 32 closes both the pipe 44 and the pipe 46. But such a position is only possible at one and the same nominal temperature, which has been set as desired. The regulating device therefore acts isothermally; it brings the temperature always back to the same desired figure.

If the temperature of the mixed gases falls at place 21, a similar regulating process takes place, but with the regulating motions in the opposite direction. The cross-sectional area of flow through the regulating member 22 is diminished and the temperature of the mixed gases is thereby brought to its original nominal figure.

Fig. 3 shows a regulating device by which non-heated air is bypassed round the heater only temporarily—during fluctuations of load, particular-

ly during drops in the load. A thermostat 24 and also a pressurestat 51 are influenced by the air in the pipe 10. The bellows 28 of the thermostat moves the cam 52 in the directions of the double arrow 53 round the fixed pivot point 54.

The inverted T lever 55, pivoted at the fixed point 55, is held pressed through its roller 58 against the curved path of the cam 52 by means of the spring 57. The joint 59 of the T lever influences the control valve 32 through the link 60, the lever 61 and the link 31. By means of the rod 38, the piston 36 of the servomotor 37 adjusts the valve 39 of the regulating member 22 in the bypass pipe 20.

At the joint 62 of the T lever 55 is linked the lever 63 which is connected at the joint 64 to the pressurestat 51 and at the joint 65 to the valve 66 of the fuel regulating member 26.

If the temperature of the mixed gases rises at place 21 in the pipe 10, the bellows 28 expands in the plus direction of the double arrow 29 and moves the path of the cam 52 in the plus direction of the arrow 53. Thereby the T lever 55 moves in the plus direction of the arrow 67 and consequently the link 60 in the plus direction of the arrow 68. When the link 60 comes into contact with the lever 61 at place 69, the control valve 32 is raised by the link 31. From the pipe 43 liquid under pressure then passes through the pipe 44 into the servomotor 37 and moves the piston 36 and the valve 39 in the plus direction of the arrow 45. Thereby the cross-sectional area of flow through the regulating member 22 is increased.

At the same time the lever 61 is pushed at the joint 47 in the plus direction of the arrow 45, so that the pivot point 10, the link 31 and the valve 32 are moved in the minus direction of the arrow 41, thus counteracting the motion introducing the regulating process. Because of the increased, non-heated quantity of air introduced through the pipe 20 into the heated quantity of air, the rising of the temperature of the mixed gases at place 21, which initiates the regulating operation, is again neutralised and the temperature is brought back to the normal desired figure.

During the regulating operation described above, the joint 62 pushes the lever 63 in the plus direction of the double arrow 71, so that the joint 65, the lever 63 and the valve 66 of the fuel regulating member are pushed in the minus direction of the arrow 72. Thereby also the quantity of fuel introduced to the burner of the air heater through the pipe 27 is reduced. The increasing of the temperature of the mixed gases at place 21 in the pipe 10 not only allows a greater quantity of cold air to flow into the pipe 10 through the pipe 20, but at the same time diminishes the quantity of fuel led to the burner of the air heater.

The pressurestat 51 has a piston 73 which is pressed to a greater or less extent in the positive direction of the double arrow 74 against the spring 75. When the air pressure increases, the joint 64 of the lever 63 is moved in the plus direction, thereby moving the valve 66 in the plus direction of the arrow 72. The cross-sectional area of flow of the fuel regulating member 26 is thereby increased and a greater quantity of fuel is led to the burner of the air heater.

When the air pressure in the pipe 10 decreases, the valve 66 is moved in the minus direction of the arrow 72, thereby reducing the quantity of fuel introduced to the air heater. The regulat-

ing member 22 in the bypass pipe 20 cannot be affected by the pressurestat 51.

The play between the point 69 of the lever 61 and the rod 60 is, in conjunction with the shape of the cam 52 and the influencing of the fuel regulating member 26 by pressure and temperature, chosen in such a way that the valve 39 of the regulating member 22 opens only when a rise in temperature because of the heat stored in the exchange surfaces cannot be prevented even by reducing the quantity of fuel introduced. When the influence of the stored heat has been removed, the valve 39 will be closed again.

The invention can also be adopted when a gas other than air is heated in the heat exchanger. The important point is that the bypassing of cold working medium to the side of the heat transmitting medium takes place at a low temperature.

I claim:

1. A gas turbine plant which comprises at least one compressor, a first turbine for driving the compressor, a combustion heater, a power turbine for driving an outside load, a conduit for passing a part of the compressed air gas from the compressor through the heater to the first turbine, another conduit for passing another part of the compressed air into the heater for use as combustion air, the combustion gases passing in heat exchange contact with the compressed gas air passing through the heater to the first turbine, a bypass pipe for by-passing a part of the compressed air around the heater and into the first turbine, a valve for controlling the flow of air through the by-pass, and means responsive to the temperature of the air entering the first turbine for operating the valve in the by-pass.

2. A gas turbine plant according to claim 1

which comprises means responsive to the pressure and other means responsive to the temperature of the air entering the first turbine to control the operation of the valve in the by-pass.

3. A gas turbine plant according to claim 1 which comprises fuel supply means for the heater, means responsive to the pressure and the temperature of the air entering the first turbine to actuate the valve in the by-pass and the fuel supply means.

4. A gas turbine plant which comprises a first turbine, a high pressure compressor and a low pressure compressor each driven by the first turbine, means for passing compressed make-up gas into the low pressure compressor, a heat exchanger, means for passing expanded gas from the first turbine through the heat exchanger to mix with the make-up gas and enter the low-pressure compressor, means for passing the compressed gas from the high-pressure compressor through the heat exchanger in heat exchange contact with the make-up gas and expanded gas from the first turbine, a combustion heater, a power turbine for driving an outside load, a conduit for passing a part of the compressed gas from the compressor through the heater to the first turbine, another conduit for passing another part of the compressed gas into the heater for use as combustion gas, the combustion gases passing in heat exchange contact with the compressed gas passing through the heater to the first turbine, a by-pass pipe for by-passing a part of the compressed gas around the heater and into the first turbine, a valve for controlling the flow of gas through the by-pass, and means responsive to the temperature of the gas entering the first turbine for operating the valve in the by-pass.

WALTER TRAUPEL.

CERTIFICATE OF CORRECTION.

Patent No. 2,392,622.

January 8, 1946.

WALTER TRAUPEL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, lines 25 and 31, claim 1, strike out the word "gas"; 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 16th day of April, A. D. 1946.

(Seal)

Leslie Frazer
First Assistant Commissioner of Patents.

ing member 22 in the bypass pipe 20 cannot be affected by the pressurestat 51.

The play between the point 69 of the lever 61 and the rod 60 is, in conjunction with the shape of the cam 52 and the influencing of the fuel regulating member 26 by pressure and temperature, chosen in such a way that the valve 39 of the regulating member 22 opens only when a rise in temperature because of the heat stored in the exchange surfaces cannot be prevented even by reducing the quantity of fuel introduced. When the influence of the stored heat has been removed, the valve 39 will be closed again.

The invention can also be adopted when a gas other than air is heated in the heat exchanger. The important point is that the bypassing of cold working medium to the side of the heat transmitting medium takes place at a low temperature.

I claim:

1. A gas turbine plant which comprises at least one compressor, a first turbine for driving the compressor, a combustion heater, a power turbine for driving an outside load, a conduit for passing a part of the compressed air gas from the compressor through the heater to the first turbine, another conduit for passing another part of the compressed air into the heater for use as combustion air, the combustion gases passing in heat exchange contact with the compressed gas air passing through the heater to the first turbine, a bypass pipe for by-passing a part of the compressed air around the heater and into the first turbine, a valve for controlling the flow of air through the by-pass, and means responsive to the temperature of the air entering the first turbine for operating the valve in the by-pass.

2. A gas turbine plant according to claim 1

which comprises means responsive to the pressure and other means responsive to the temperature of the air entering the first turbine to control the operation of the valve in the by-pass.

3. A gas turbine plant according to claim 1 which comprises fuel supply means for the heater, means responsive to the pressure and the temperature of the air entering the first turbine to actuate the valve in the by-pass and the fuel supply means.

4. A gas turbine plant which comprises a first turbine, a high pressure compressor and a low pressure compressor each driven by the first turbine, means for passing compressed make-up gas into the low pressure compressor, a heat exchanger, means for passing expanded gas from the first turbine through the heat exchanger to mix with the make-up gas and enter the low-pressure compressor, means for passing the compressed gas from the high-pressure compressor through the heat exchanger in heat exchange contact with the make-up gas and expanded gas from the first turbine, a combustion heater, a power turbine for driving an outside load, a conduit for passing a part of the compressed gas from the compressor through the heater to the first turbine, another conduit for passing another part of the compressed gas into the heater for use as combustion gas, the combustion gases passing in heat exchange contact with the compressed gas passing through the heater to the first turbine, a by-pass pipe for by-passing a part of the compressed gas around the heater and into the first turbine, a valve for controlling the flow of gas through the by-pass, and means responsive to the temperature of the gas entering the first turbine for operating the valve in the by-pass.

WALTER TRAUPEL.

CERTIFICATE OF CORRECTION.

Patent No. 2,392,622.

January 8, 1946.

WALTER TRAUPEL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, lines 25 and 31, claim 1, strike out the word "gas"; 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 16th day of April, A. D. 1946.

(Seal)

Leslie Frazer
First Assistant Commissioner of Patents.