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W. TRAUPEL
GAS TURBINE PLANT

2,543,677

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2 Sheets-Sheet 1

Fig. 1

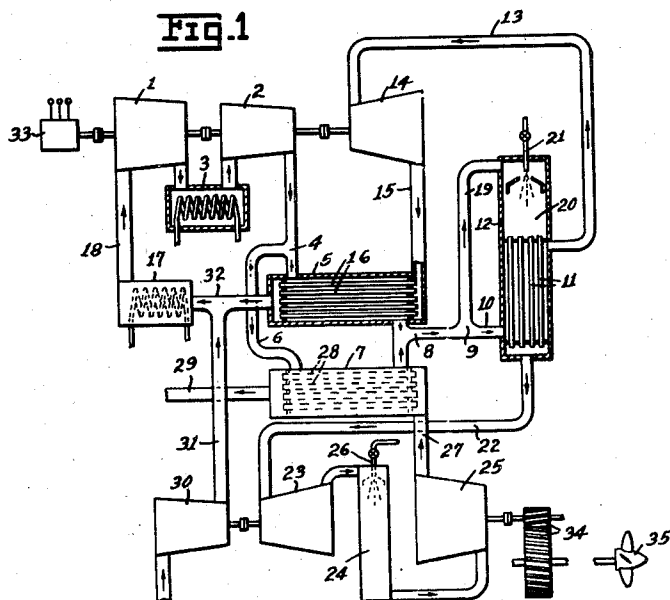
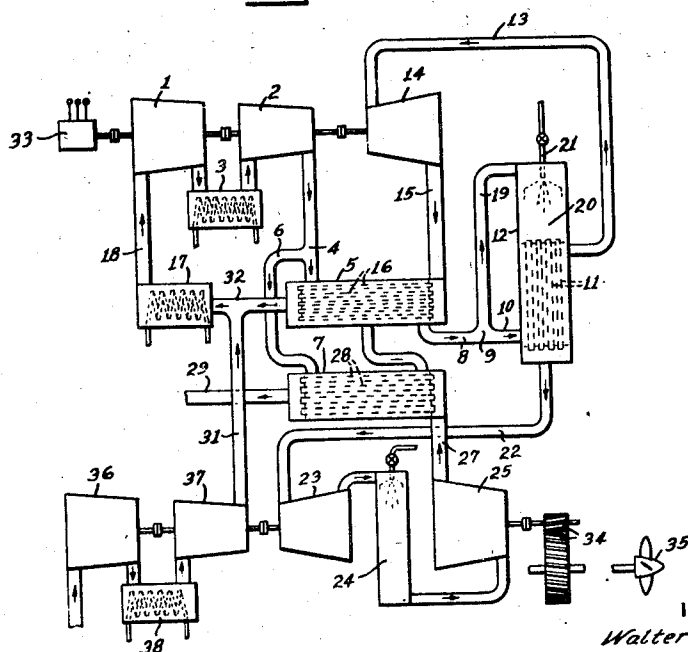


Fig. 2



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2 Sheets-Sheet 2

Fig. 3

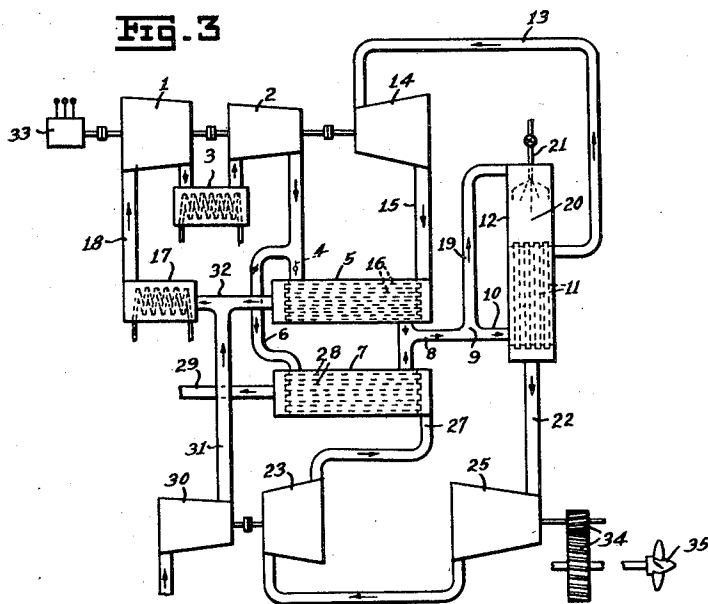
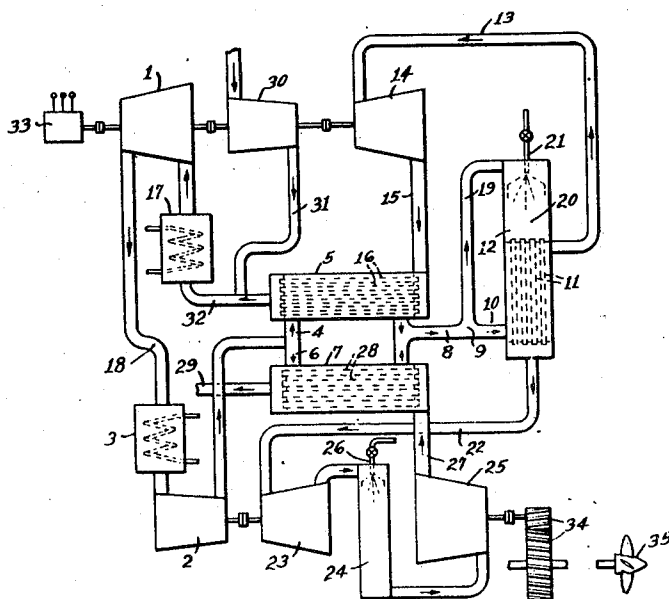


Fig. 4



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GAS TURBINE PLANT

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4 Claims. (Cl. 60-49)

1

This invention relates to a gas turbine plant in which one part of the working medium flows round in a circuit in which it is compressed in at least one compressor and expanded in at least one turbine, from which circuit a partial quantity of the working medium is continually withdrawn and expanded in at least two turbines, and into which circuit, as make-up for the working medium extracted, working medium is again introduced through at least one compressor. The invention is characterised in that at least one turbine driving a compressor is fed by the part of the working medium flowing round in the circuit, and that at least one other turbine also driving a compressor, and the useful output turbine are fed by the part of the working medium taken from the circuit.

The turbines fed by the part of the working medium taken from the circuit are preferably arranged in series. It is also preferable to arrange the turbine driving a compressor before the turbine producing useful work. Between the compressor turbine and the useful work turbine a gas heater may be arranged which is formed for example as a combustion chamber in which fuel is consumed with the help of the oxygen contained in the working medium extracted from the circuit.

The invention is further described below with reference to the four embodiments illustrated in the drawings, in which:

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

Fig. 2 similarly illustrates a plant equipped with certain refinements which lead to an improvement with regard to efficiency, regulating possibilities and space requirements;

Fig. 3 similarly illustrates a plant in which the turbines which are fed with working medium extracted from the circuit are arranged in the opposite order; and

Fig. 4 similarly illustrates a plant in which the turbine which is fed with the part of the working medium taken from the circuit drives a compressor in the circuit, whilst the compressor supplying the make-up air is driven by a circuit turbine.

In the embodiment illustrated in Fig. 1 the air compressed by compressors 1 and 2 with intermediate cooling in a cooler 3 is led partly through pipe 4 to a heat exchanger 5 and partly through pipe 6 to another heat exchanger 7. The two heat exchangers 5 and 7 are arranged in parallel in the air current and function as preheaters, between which it is possible to

2

arrange the distribution of the air by means of control member arranged in pipes 4 and 6 according to working conditions. The two quantities of air unite in the preheated state in pipe 8 and are divided again into two parts at the spot 9. One part flows through pipe 10 into the space surrounding the tubes 11 of a gas heater 12. This compressed air then passes in the heated state through pipe 13 into a turbine 14, where expanding and cooling, it gives up an essential part of its energy to the rotor. The air thus expanded then flows through pipe 15 into the heat exchanger 5 where it, when flowing through the tubes 16, preheats the partial quantity of compressed air introduced through pipe 4. After issuing from the heat exchanger 5, a further part of its residual heat is withdrawn from the expanded air in a cooler 17. The cooled air now flows through the pipe 18 into the compressor 1 where the circuit begins again.

From the air circuit just described, a part of the air is continually extracted at the spot 9 and led through pipe 19 into the combustion space 20 of the gas heater 12. Here it serves for the combustion of the fuel atomised by the burner 21. The combustion gas then flows through the heat exchange tubes 11 of the gas heater 12, whereby the air flowing round in the circuit is heated. After giving up a part of its heat, the combustion gas flows through pipe 22 into a turbine 23, and after being heated again in a second gas heater 24 it passes into a second turbine 25. The gas heater 24 is arranged as a combustion chamber in which fuel introduced through the burner 26 is consumed with the help of the oxygen still contained in the combustion gas coming from the gas heater 12. The gas expanded in the turbine 25 finally flows through pipe 27 into the heat exchanger 7, where, when flowing through the tubes 28 a part of its residual heat is transferred to the partial quantity of compressed air of the circuit introduced through the pipe 6. After leaving the heat exchanger 7 the combustion gas flows through pipe 29 to further points of use not shown in the drawing, for instance into a heat recuperator, or direct to atmosphere.

To replace the part of the working medium extracted from the circuit at the spot 9, air is taken from the atmosphere through a compressor 30, compressed and introduced through pipe 31 into the circuit pipe 32 connecting the heat exchanger 5 with the cooler 17. When working with normal load, the air is compressed to about 3 atmospheres gauge by the compressor 30, at

which pressure it flows to the low-pressure compressor 1. At the outlet from the high-pressure compressor the air of the circuit is compressed to a final pressure of about 12 atmospheres gauge. At this pressure the air, after being heated in the gas heater 12, flows into the turbine 14 where it expands again to the original pressure of about 3 atmospheres gauge while doing work. For changing the output, the compression ratio of the compressor 30 may be changed, for instance by changing the speed of the turbine 23. At no load the compressor will compress the air to about 0.2 atmosphere gauge and at the highest overload to about 3.5 atmospheres gauge. The highest pressures in the circuit then are 3 and 16 atmospheres gauge respectively at the outlet of the compressor 2. The compression ratio in the circuit is consequently altered in the same manner with the altering of the output, the ratio being at low output considerably smaller than at a big output. By altering the compression ratio in the circuit the regulating range may be considerably extended without having to put up with drawbacks of an economical nature. If it is possible to do without a particularly high efficiency, the output of the plant may be still further increased by raising the pressure of the make-up air already at normal load to 4-5 atmospheres gauge for instance.

The maximum pressure in the circuit at normal load will consequently then rise over 16 atmospheres gauge, for instance to 20 atmospheres gauge or still higher.

The turbine 14 fed with air in the circuit drives the circuit compressors 1 and 2. With the machine set consisting of the compressors 1 and 2 and the turbine 14 an electric auxiliary machine 33 is also coupled, which comes into action as required either as a motor or as a generator and thus can be made use of when starting the plant and when compensating for a lack of output or an excess of output at the turbine 14. The turbine 23, to which the combustion gas is first fed, drives the compressor 30 introducing the make-up air into the circuit. Finally, the useful output turbine 25 drives through the gear 34 the ship's screw 35, which is arranged as an adjustable propeller.

In the embodiment illustrated in Fig. 2, two compressors 36 and 37 are adapted for introducing make-up air into the circuit. Between the compressors at least a part of the compression heat is withdrawn from the partly compressed air in a cooler 38. In this manner the pressure level of the circuit can be considerably raised. The pressure of the air introduced into the circuit through the pipe 31 may for instance amount to 5 atmospheres gauge or even more, whilst the maximum pressure at the outlet from the circuit compressor 2 amounts to about 20 atmospheres gauge and more. The output of the plant may thus be varied within a big range. It is for instance possible with good efficiencies to obtain an overload which is up to 8 times greater than the normal load.

A further improvement is obtained by introducing the air preheated in the heat exchanger 7 through the pipe 39 to the spot in the heat exchanger 5 where the same temperature prevails as at the outlet from the heat exchanger 7. In this manner it is possible to preheat to the same high temperature the part of the circuit air flowing through the pipe 4 and also the part of the circuit air flowing through the pipe 6 and thereby recover again the maximum quantity of waste

heat. Plants as shown in Fig. 2 are particularly suitable for cases where big outputs have to be installed in limited spaces and high efficiencies must be obtained, for instance for the propulsion of ships, especially warships.

In the embodiment shown in Fig. 3, the combustion gas from the gas heater 12 is fed first of all to the useful output turbine 25 and only after that to the compressor turbine 23. In this manner it is possible in certain cases to obtain a simplification of the regulating. Likewise one may do without intermediate heating of the combustion gas between the two turbines.

These can be coupled into a single set as in the plant illustrated in Fig. 4, the low-pressure circuit compressor 1, the compressor 30 supplying the make-up air, the circuit turbine 14 and the electric auxiliary machine 33. The high-pressure circuit compressor 2 is then driven by the turbine 23 which is fed by the combustion gas from the gas heater 20. Through this arrangement a better flexibility of the regulating can be obtained in certain cases, since the drive of the high-pressure compressor 2 can be more quickly influenced in this manner than if it were driven by a circuit turbine.

I claim:

1. In a gas turbine plant of the type which includes a working medium circuit having a compressor and a turbine therein, two turbines driven by working medium extracted from said circuit, and a compressor introducing make-up working medium into said circuit, the improvement which comprises arranging the turbo machines of the plant in three sets, each set having one shaft, one of said sets including circuit turbine and circuit compressor, a second set including make-up compressor and an extraction turbine, and the third set including the plant external load and another extraction turbine, said extraction turbines being arranged in series in the flow of extracted working medium.

2. The improvement of claim 1 characterized by the arrangement of the turbine driving the make-up compressor before the turbine driving the plant load in the flow of extracted working medium from the circuit.

3. A gas turbine plant according to claim 2 in which a gas heater is arranged to heat the working medium flowing from the turbine driving the make-up compressor to the turbine driving the plant load.

4. A gas turbine plant according to claim 3 in which the gas heater is of the type including a combustion chamber in which fuel is burned by residual oxygen in the working medium heated.

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