The invention relates to a gas turbine plant with high and low-pressure turbines arranged so that the high-pressure turbine produces the useful output and the low-pressure turbine drives at least one auxiliary machine and so that to diminish or interrupt the useful output, the working medium must be diverted from the high-pressure turbine and may be introduced directly to the low-pressure turbine.

It is necessary to divert the working medium from the high-pressure turbine of turbines connected in series when the useful output of the high pressure turbine is diminished for a short time or interrupted. This must be done so as to maintain the service of the rest of the plant, if, when desired, the production of useful output is to be resumed or increased without any delay. If the working medium merely bypasses the high-pressure turbine, the low-pressure turbine receives it directly at a considerably higher temperature than during normal service, since there is no expansion of the working medium to do mechanical work. If this method is followed, it is necessary to construct the low-pressure turbine as well as the high-pressure turbine of material highly resistant to heat, and to keep the mechanical stresses within low limits as in the high-pressure turbine. By carrying out the method of this invention the drawbacks described above are avoided.

A part of the bypassed working medium is then led away from the plant and the remainder, which is not led away, is mixed with air at the most only slightly heated before being introduced into the low-pressure turbine. Preferably, air is introduced to a mixing chamber from the working medium circuit of the plant, this air being for instance taken from the outlet from the circuit compressor.

The invention is further explained by reference to the single figure of the drawing which illustrates, in simplified form, a preferred arrangement of a gas turbine plant for carrying out the disclosed method.

The compressor 1 compresses the working medium flowing in from pipe 2, intermediate cooling during compression being effected in the cooler 3, and delivers it in a compressed state partly through pipe 4 into a heat exchanger 5 and partly through pipe 6 into a heat exchanger 7.

The part of the working medium retained in the circuit is preheated in heater exchanger 5 and flows through pipe 8 into the space surrounding the tube system 9 of the gas heater 10. This working medium, thus heated, then flows through pipe 11 into the turbine 12, and, after expanding in the turbine, passes through pipe 13 into the tube system 14 of the heat exchanger 5. Here, a part of the heat still contained in the expanded working medium is transmitted to the working medium arriving through pipe 4 from the compressor 1. A further part of the residual heat is withdrawn from the working medium in a cooler 15. After this recoupling, the working medium passes through pipe 2 again into the compressor 1, where the circuit described begins anew.

The part of the working medium withdrawn from the circuit through pipe 6 passes through the heat exchanger 7 and pipe 16 as the combustion air for the burner 17 of the gas heater 10. The products of combustion flow through the tube system 9 and give thereby a part of their heat to the working medium coming from pipe 8. With diminished temperature, the products of combustion flow through pipe 18 into the useful output turbine 19. The exhaust pipe 20 from the useful output turbine has diverting means consisting of two valves 21 and 22, by means of which the exhaust gas from the useful output turbine 19 can be led as desired either to the heat exchanger 5 or to the exhaust gas turbine 23. The exhaust gas from the useful output turbine 19 then flows either through the space surrounding the tube system 24 or through the exhaust gas turbine 23 into the outlet pipe 25.

As make-up for the working medium withdrawn from the circuit, air is led to the plant through pipe 26. This air can, depending on the setting of diverting means consisting of two valves 27 and 28, either be taken direct from the atmosphere through pipe 29 or supplied by the precompressor 31 through pipe 30 in a precompressed state. The compressor 31 receives air for its part from the atmosphere through pipe 32. While being compressed, this air passes through an intermediate cooler 33.

Turbine 12, which is worked with pure air, drives the circuit compressor 1. To the set consisting of the turbine 12 and the compressor 1, an electric machine 34 is also coupled, with the help of which the plant can be started, any lack of energy during service made up or superfluous energy led away. The output of the useful output turbine 19 is transmitted to the ship's propeller 37 through the gear 35 and the shaft 38. The compressor 31 is driven by the exhaust turbine 23.

For quickly diminishing for or completely interrupting the useful output, the useful output turbine 19 is equipped with bypass pipes 39 and 50, through which working medium can be led...
direct from pipe 18 into pipe 20. Of the working medium, bypassed through pipe 38 past the turbine 19, a part may be led through pipe 39 away from the plant direct into the exhaust pipe 28. The remainder, not only through the useful output, but also through with slightly heated air from the outlet pipe 6 of the compressor 1 which has been led through pipe 40 into the mixing chamber 41. In pipe 18 a valve 42 is arranged, in pipe 38, a valve 43, and in pipe 39, a valve 44. The quantity of working medium bypassed past the useful output of pipe 19 on the one hand, and the quantity of working medium led away from the plant through the pipe 39 on the other hand, can be regulated by means of these values. The quantity of air mixed with the bypassed working medium for cooling, can be regulated by valve 45 in pipe 39.

The plant described is particularly suitable for the propulsion of warships in which sudden and erratic maneuvers are frequently necessary. The separate machines and heat exchangers are designed in such a way that the maximum efficiency is obtained at an output intended for cruising speed. Valve 21 is then open, valves 22 and 28, closed, and valve 27, opened. The exhaust gas from the useful output turbine 19 flows through the space surrounding the tube system 24 of the heat exchanger 1 and into the exhaust pipe 28. In this way, combustion air intended for the gas heater 10 is preheated and residual heat in the working medium being exhausted from the plant is to a large extent recuperated. The air freshly introduced into the circuit as make-up for the exhausted working medium is introduced into the plant direct through pipes 29 and 26. The plant thus works with low pressure levels in the circuit, through which the blades of the blades and the cross-sectional areas of flow of the machines are designed, so that a very high efficiency is ensured.

For increasing the output, valves 22 and 28 are opened and valves 21 and 27 closed. The exhaust gases from the useful output turbine 19 consequently flow through the exhaust gas turbine 23 into the exhaust pipe 28. The exhaust gas turbine drives the compressor 31 which draws air from the atmosphere through pipe 32 and delivers it into the circuit, in a more or less highly compressed state, through pipe 30. The pressure level in the circuit is thus correspondingly raised. In this manner, the useful output of the plant can be increased to a multiple of the normal output, to 5-10 times that value, and reasonable efficiencies can still be obtained.

Whenever production of useful output by the turbine 23 has to be diminished or interrupted, valve 43 is opened to a greater or less extent and the cross-sectional area of flow of valve 42 is diminished or the valve is completely closed. A part or all of the working medium coming through pipe 18 from the gas heater 10 then flows into bypass pipe 38, where it is further divided, one part into mixing chamber 41 and the other part through the more or less widely opened valve 44 and pipe 39 into exhaust pipe 28. At the same time, valve 45 is also opened, so that air comes into the mixing chamber 41 from the compressor 1. The cross-sectional area of flow of the valves 42, 43, 44 and 45 is chosen in such a way that, on the one hand, the turbine 23 still gives the required diminished output, and, on the other hand, the working medium bypassed into the pipe 20 is cooled to a temperature at which there is absolutely no danger of damage occurring to the exhaust turbine 23 or heat exchanger 1. This makes the cost of applying this invention to a gas turbine plant low, since the heat exchanger 7, the turbine 23 and the pipes and valves associated with them may thus be made of a material which is not necessarily particularly suited for high pressure, is mixed with air, and the cooperating valves which have a small cross-section and represent simple and compact elements, must be made of a material highly resistant to heat.

It will be understood that in warship operation sudden changes of useful output may be necessary whether the plant is at normal load or at peak load. The by-pass system of the invention, therefore, will be called on to meet these sudden changes and hence will divert working medium from pipe 18 into mixing chamber 41 at once or both and from pipe 20 into heat exchanger 7 or exhaust turbine 23 as the plant may be at no load, normal load or peak load.

The invention may be adopted for any kind of gas turbine plant in which a turbine for driving one or more auxiliary machines is arranged after a useful output turbine.

I claim:

1. In a gas turbine plant in which there is a circuit including a compressor, a gas heater, a turbine driving said compressor, and passages delivering working medium from said compressor to said turbine and from said turbine back to said compressor, the improvement which includes, in combination, an extraction passage for withdrawing a part of the working medium from said circuit, a useful output turbine driven by working medium withdrawn through said extraction passage, an exhaust gas turbine driven by working medium exhausted from said useful output turbine, a supply passage for introducing make-up working medium to said circuit, a make-up compressor driven by said exhaust gas turbine feeding said supply passage, a bypass around said useful output turbine to said exhaust gas turbine, a mixer in said bypass, and a duct for supplying said mixer with working medium taken from said circuit after said compressor and before said heater.

2. The improvement of claim 1 in which valves are provided to regulate the flow through the bypass and the duct.

3. The improvement of claim 2 in which there is provided a direct exhaust passage from the bypass before the mixer, and a valve in said direct exhaust passage for regulating the flow thereof.

4. The improvement of claim 3 in which there is provided a direct exhaust passage for admitting make-up working medium to the circuit without passing through the make-up compressor and valve means are provided in said direct intake passage and elsewhere in the supply passage for regulating the flow through said direct intake passage and said make-up compressor.

5. The improvement of claim 1 in which the extraction passage leads off of the circuit between the compressor and the gas heater, said gas heater is fed with combustion air from said extraction passage and the useful output turbine is supplied with combustion products from said gas heater.

6. The improvement of claim 5 in which a heat exchanger is arranged in the extraction passage before the gas heater, a diversion passage is arranged after the mixer to supply said heat exchanger with heating medium in parallel with the exhaust gas turbine and valves are ar-
ranged in said diversion passage and after said diversion passage before said exhaust gas turbine for regulating the flow therethrough.

7. The improvement of claim 6 in which there is provided a direct intake passage for admitting make-up working medium to the circuit without passing through the make-up compressor and valve means are provided in said direct intake passage and elsewhere in the supply passage for regulating the flow through said direct intake passage and said make-up compressor.

WALTER TRAUPEL.

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