Oct. 20, 1953 M. H. L. SEDILLE 2,655,788

TURBINE GAS ENGINE ADAPTED TO OPERATE WITH OR WITHOUT ATMOSPHERIC AIR CHIEFLY FOR THE PROPULSION OF WARSHIPS

Filed Sept. 10, 1947 4 Sheets-Sheet 1

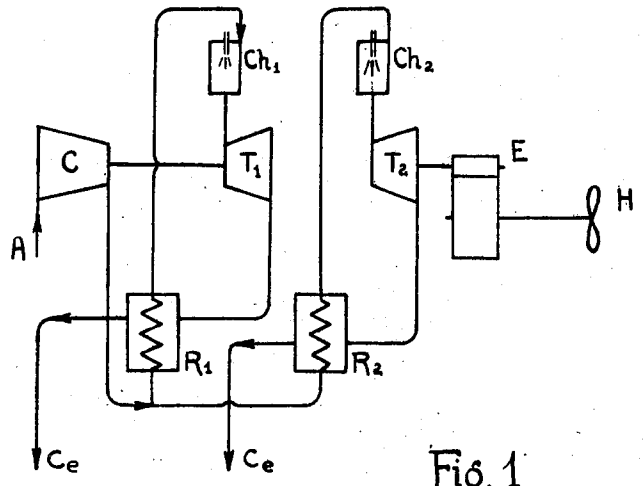


Fig. 1

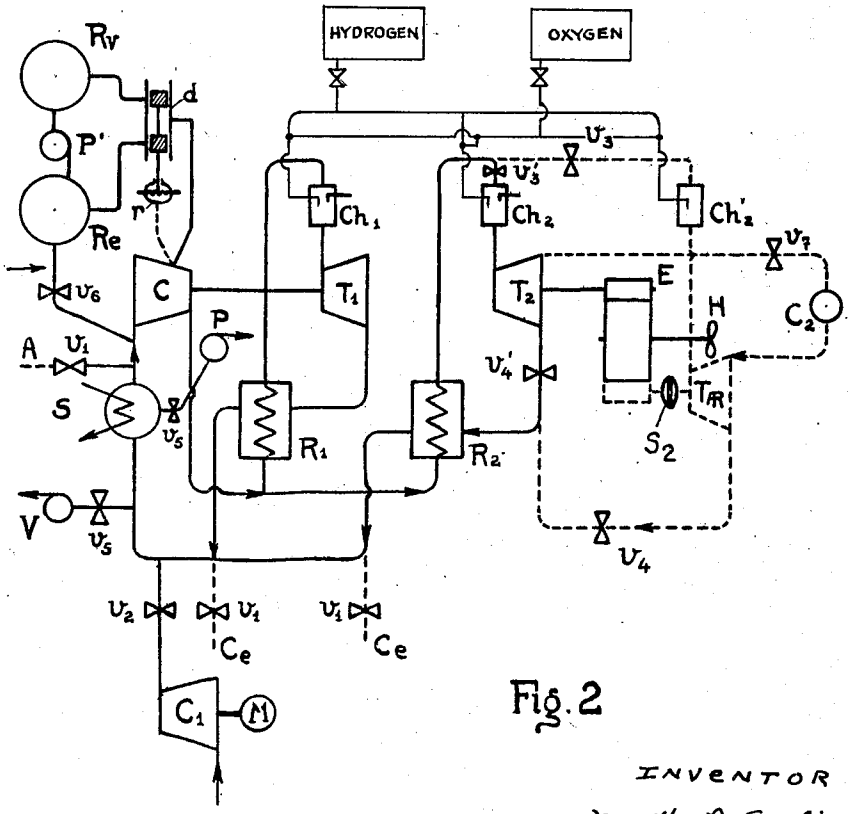


Fig. 2

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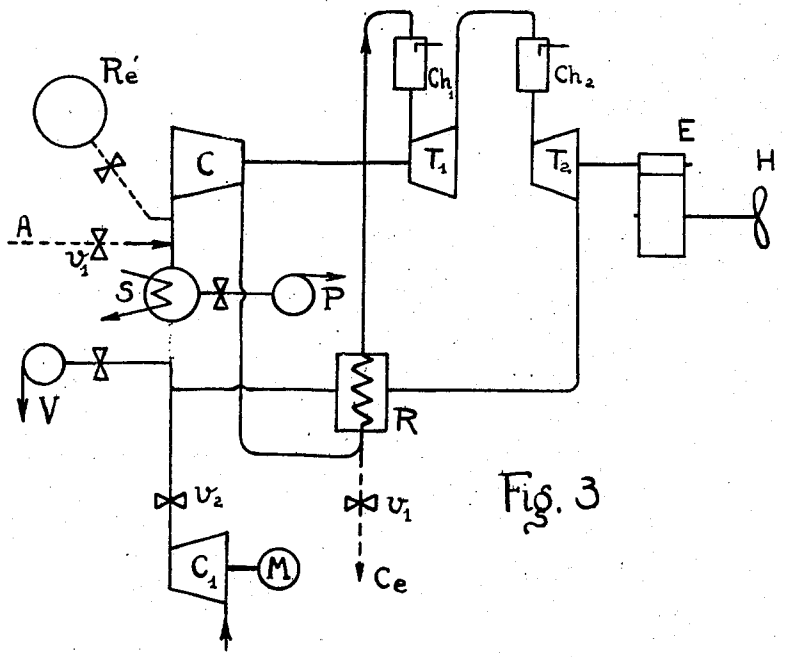


Fig. 3

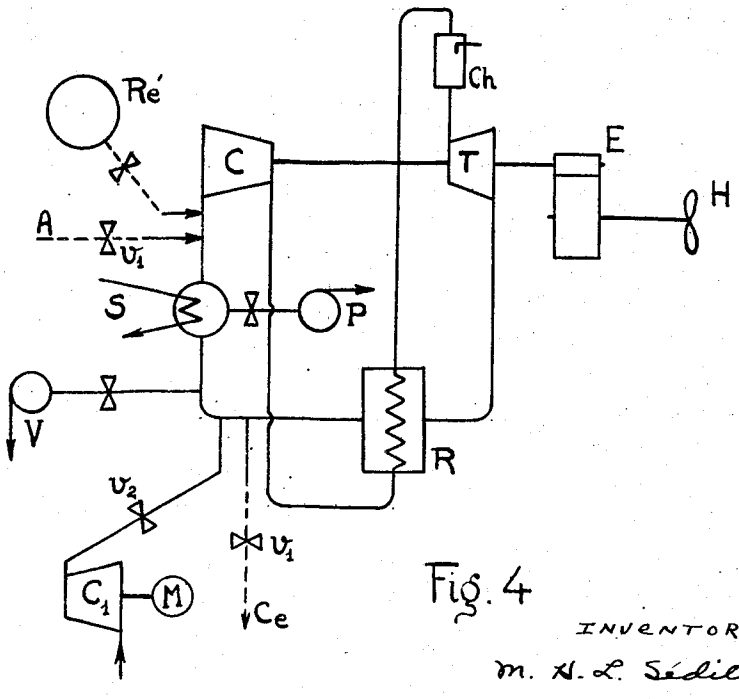


Fig. 4

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TURBINE GAS ENGINE ADAPTED TO OPERATE WITH OR WITHOUT ATMOSPHERIC AIR CHIEFLY FOR THE PROPULSION OF WARSHIPS

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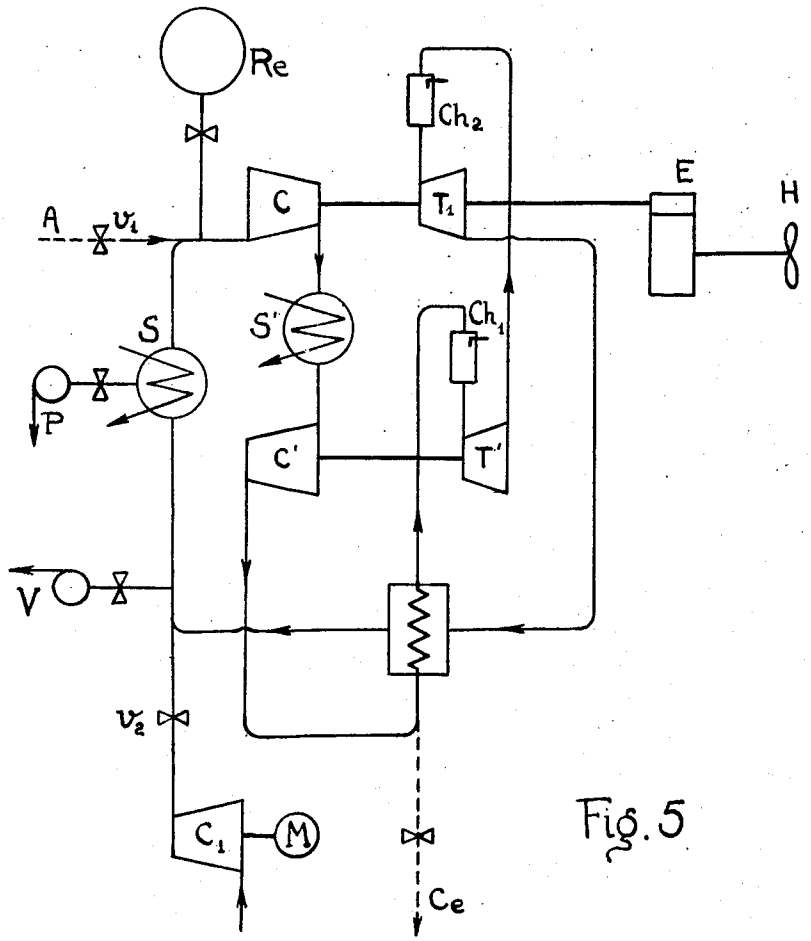


Fig. 5

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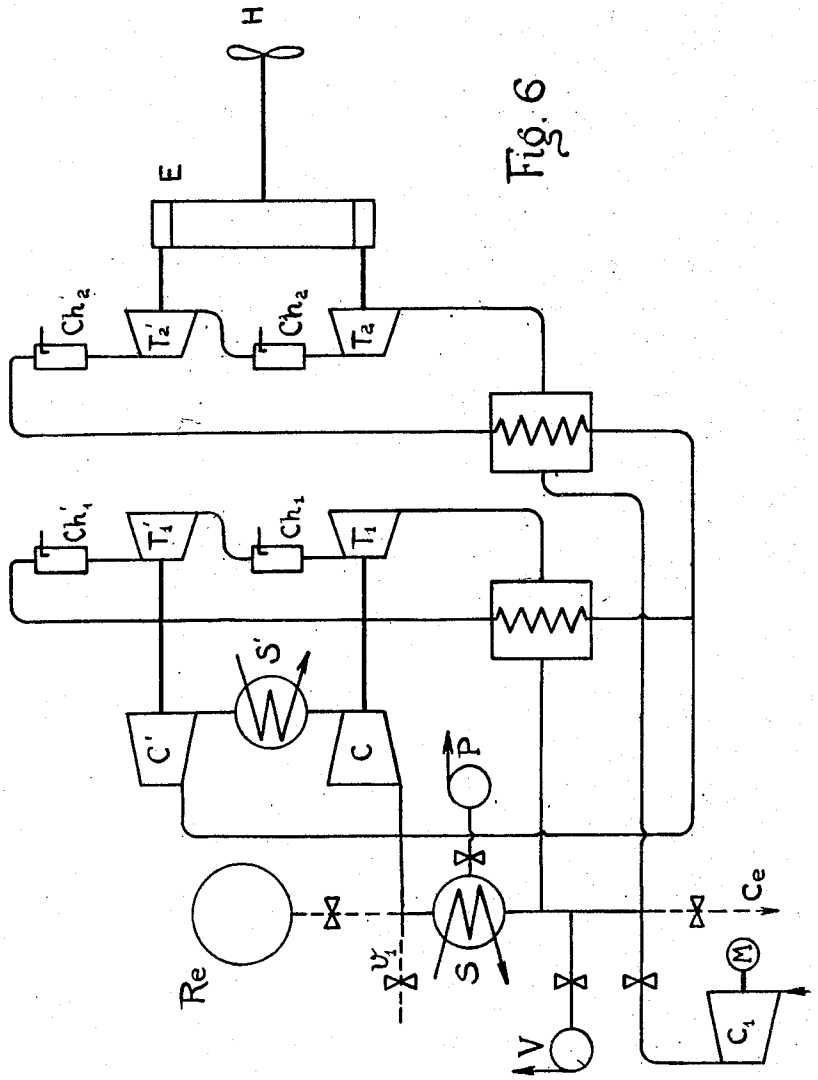
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Oct. 20, 1953 M. H. L. SEDILLE 2,655,788

TURBINE GAS ENGINE ADAPTED TO OPERATE WITH OR WITHOUT ATMOSPHERIC AIR CHIEFLY FOR THE PROPULSION OF WARSHIPS

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Fig. 6



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TURBINE GAS ENGINE ADAPTED TO OPERATE WITH OR WITHOUT ATMOSPHERIC AIR CHIEFLY FOR THE PROPULSION OF WARSHIPS

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4 Claims. (Cl. 60—39.33)

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One of the difficulties in the adaptation of internal combustion engines to the problems of the propulsion of warships consists sometimes in the necessity of feeding them with combustive air and removing the combustion products. This is the case of submarines when running submerged, and also that of surface ships when the requirements of battle with atomic weapons will constrain them to completely protect their machinery from the action of the outer atmosphere.

It is known that the problems of propulsion chiefly in the case of submarines during the submersion period have been solved by using special engines or certain particular contrivances.

The use of gas turbines is particularly of interest for solving such difficulties and the present invention has for its object gas turbine systems adapted to operate alternatively after the manner of ordinary combustion gas turbines for which atmospheric air forms the combustive agent, or else, in a completely protected manner with reference to the outer atmosphere, while answering however all the particular conditions corresponding to the object sought for and chiefly, allowing the obtention of high power rates for battle and a cruising rate at small power, both rates being obtained under the best conditions possible.

The present invention has more specifically for its object a gas turbine plant, adapted to operate with atmospheric air as a combustive agent during normal cruising operation and provided moreover with a system of valves for isolating it with reference to the atmosphere when the ship is submerged or under battle conditions. The atmospheric air, and the usual liquid fuel are then replaced by components of an exothermic reaction producing liquid or gaseous reaction products adapted to be easily exhausted into the outer atmosphere.

The following description and accompanying drawings given out solely by way of example, and by no means in a limitative sense, will make different embodiments of the invention appear more readily, the features given out by the drawing and the specification forming of course part of said invention. In said drawings:

Fig. 1 illustrates a ship propelling plant, including gas turbines, operating in association with the outer atmosphere while Fig. 2 illustrates

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the same arrangement designed in accordance with the invention for allowing operation, both in association with the atmosphere and when isolated with reference thereto.

Fig. 3 shows a modification of such a plant with the turbine arranged in series and Fig. 4 hows a simplified plant including a single gas turbine driving the compressor and a reversible screw propeller.

Lastly, Figs. 5 and 6 illustrate modifications wherein the compressor is subdivided into two bodies with intermediary cooling means.

Fig. 1 shows one of the simplest diagrams for a gas turbine engine operating in an open circuit. A designates the suction for atmospheric air, C the compressor, T1 the auxiliary turbine driving the compressor, T2 the driving turbine which in the example chosen is supposed to be located in parallelism with the auxiliary turbine, E the reducing gear controlling the screw propeller H. R1 and R2 are heat recovering means inserted at the output of the turbines and Ce designates the exhaust of the gases from the turbine into the chimney after passage through the corresponding heat recovering means. In normal operation, the combustion chambers Ch1 and Ch2 make use of hydrocarbons or the like standard liquid fuel.

Such an engine is reproduced in Fig. 2, as equipped in accordance with the invention with special fittings allowing it to operate in a closed circuit.

During such operation, the communication with the chimney Ce and also with the suction means A may be closed by suitable valves V1 and the exhaust gases from the turbine return to the compressor C after they have been cooled to a maximum inside the water cooler or the like means S. Simultaneously there is sent into the combustion chambers Ch1 and Ch2 instead of standard liquid fuel the elements of an exothermic chemical reaction that is suitably chosen for the reaction product to have no chemical action on the different parts of the plant and to be easily removed to the outside of the plant either under the form of condensable liquid products or under the form of gases which are removed out of the circuit either in water directly into the atmosphere through a pump P and/or a compressor V that may to this purpose be provided with a valve V5 which is

closed during cruising, or again said reaction products may be exhausted under the mere action of the inner pressure of the circuit. The most known and the simplest type of such a reaction is constituted by the combustion of hydrogen in oxygen, said two gases being stored in the holds of the ship inside tanks under pressure. They may both be introduced into the combustion chambers *Ch1* and *Ch2* by means of burners that are the same as the ordinary burners or else are provided in addition thereto.

It is generally required that the power available in battle may be several times larger than the power that is used during cruising. This condition is satisfied in the case of Fig. 2 by increasing the weight of the gas circulating when the circuit is closed for operating without the interference of the atmosphere, this being provided by increasing the pressure at the suction end of the compressor C. To this end, an auxiliary compressor C1, before the beginning of operation in a closed circuit without connection with the atmosphere and after closing of the valves V1, compresses air inside the closed circuit after which the valve V2 is closed for complete separation from the atmosphere, and from the compressor C1.

The increased pressure required inside the circuit for the battle running may be obtained easily if the combustion products are gaseous through adjustment of the speed of the compressor or fan V that is used for the exhaust of a part of the combustion gases. If the combustion products are not gaseous the pressure may be kept at the desired value, through an adjustable admission at any point of the circuit, of compressed air of another compressed gas taken out for example from a tank or container Re that may be connected with the circuit through a valve V6 and a pipe opening preferably into said circuit ahead of the compressor C.

The adjustment of power during battle conditions may be performed through a variation in the pressure at the suction end of the compressor. However, in order to avoid any important variations in the amount of fluid circulating in the circuit, it is preferable to keep constant the suction pressure of the compressor C and to adjust the compression ratio of said compressor. With such a regulating process, if for example, the power during the battle is reduced, the pressure in the high pressure part of the cycle is reduced while the pressure in the low pressure part of the cycle should increase in relationship with the new value of the load. It is then desirable to provide a suitable adjustment to keep said last named pressure at a predetermined value for each value of the load.

Now it is well known that there exists a certain stage in the compressor and in the turbines for which the pressure varies but little with the load.

As a matter of fact, the circuit system of the gas turbine engine contains a substantially constant amount of fluid circulating inside an unvarying total volume. An increase in the load, that is in the speed of the motor group will of necessity lead to a reduction in the suction pressure of the compressor and in the exhaust pressure of the turbine together with an increase in the delivery pressure of the compressor and of the admission pressure into the turbines; hence, there is an intermediary stage both in the compressor and in the turbines for which the pressure remains substantially constant when the load and speed vary. This stage varies according to the relative volume between the high pressure and low pressure parts of the circuit; it is then possible to simplify the adjustment while maintaining the pressure at a constant value at said stage whatever may be the load of the motor group.

Fig. 2 shows also in a diagrammatic manner a system for adjusting under constant pressure conditions for a predetermined stage of the compressor for instance; the arrangement comprises then a second tank *Rv* inside which vacuum or a very low absolute pressure is maintained while a pressure regulator *r* acting on a three-way distributor *d* is connected respectively with the compressor stage considered and with the tanks *Rv* and *Re* respectively under vacuum and under pressure. If the pressure in the compressor stage considered sinks, the regulator *r* and the distributor *d* set the compressor in communication with the tank under pressure *Re* until the original pressure is restored. In case of a rise in pressure in said compressor stage, the regulator and the distributor set the compressor in communication with the tank *Rv* under vacuum. Lastly for maintaining the reservoir *Rv* under vacuum, there is provided an auxiliary compressor P' ensuring constantly the removal of pressure out of *Rv* through delivery of any gas therein into *Re*.

In the plants according to the invention, the form of execution for rearward operation may be of any type and it may include either hydraulic couplings or reversible propellers or special turbines for rear operation. In this latter case, it is possible to consider different possibilities.

If it is desired to obtain as speedily as possible reverse rear speed, the corresponding turbine TAR should be connected under battle conditions with the general circuit as illustrated in dotted lines in Fig. 2, by means of valve V3 and V4. During forward motion valve V3 is closed and valve V4 open so that the circuit of the turbine TAR is submitted to the lowermost pressure of the main circuit. For obtaining the rearward motion it is then sufficient to close V'3 and V'4, to open V3 and to start the combustion in the combustion chamber *Ch2*. In order to avoid said reverse speed turbine from being driven by the ship propeller during forward motion and from absorbing then in a completely useless manner a certain amount of energy, there may be inserted a clutch S2 for disengaging said propeller with reference to the reverse speed turbine.

It is also possible during forward motion to close both valves V3 and V4 so as to isolate temporarily the whole part of the circuit corresponding to the reverse speed turbine with reference to the main circuit and to open it into the atmosphere. If this is performed while leaving the reverse speed turbine mechanically connected with the propeller even when it is not operative, this reduces the corresponding absorbed power. When it is desired to provide for rearward motion, it is then sufficient to close the circuit of the turbine TAR with reference to the atmosphere and to open valves V3 and V4 and of course to close the valves V'3 and V'4 controlling the forward operating turbine. This operation of course lowers the general pressure in the circuit as a whole, but the suitable pressure may then be restored through the adjusting means described precedingly. The fluid under pressure

contained inside the circuit of the forward operation turbine may also be used for filling the circuit of the reverse speed turbine through the agency of the auxiliary compressor C2 after opening of the valve V7.

The compressors C1 and C2, the fan V and the pump P may be driven through any suitable means; there is illustrated for instance for the control of the compressor C1 an electric motor M.

The above described example is not given out in a restrictive manner and in particular the turbines T1 and T2 may be arranged in series instead of being parallel in which case a reheating chamber Ch2 may be provided between them (Fig. 3).

If a reversible propeller is used for the propulsion in both directions of operation, the turbines T1 and T2 may be associated to form a single turbine as shown in Fig. 4.

Lastly, for reasons of general efficiency, the compressor C may be subdivided into two parts C and C' (Figs. 5 and 6) separated by an intermediary cooler S', each compressor part being driven by a turbine which is the same as the driving turbine (Fig. 5) or is separate therefrom (Fig. 6).

What I claim is:

1. In a power plant of the kind described, the combination of a gas circuit including at least one main compressor, at least one combustion chamber and at least one gas turbine and being adapted to operate selectively in open circuit fed by hydrocarbon fuel and atmospheric air and in substantially closed circuit fed by products adapted to evolve heat by a chemical exothermic reaction; duct means for connecting the exhaust side of said gas turbine to the suction side of said main compressor, first valve means on the exhaust side of said gas turbine for directing the exhaust of said gas turbine selectively to the atmosphere and into said duct means, an auxiliary compressor connected to said duct means for delivering into same air under pressure, a motor linked to said auxiliary compressor and adapted to be actuated independently of said power plant for driving said auxiliary compressor, second valve means on the suction side of said main compressor for selectively connecting the inlet of said main compressor to said duct means and to the atmosphere, cooling means on said duct means for refrigerating the turbine exhaust, pump means connected to said duct means for eliminating condensation products and gas in excess from said duct means, a storage tank connected to the suction side of said main compressor and adapted to supply an extra amount of gas into said circuit, and third valve means between said storage tank and the suction side of said main compressor for selectively opening and cutting off extra supply of gas.

2. In a power plant of the kind described, the combination of a gas circuit including at least one main compressor, at least one combustion chamber and at least one gas turbine, and being adapted to operate selectively in open circuit fed by hydrocarbon fuel and atmospheric air and in substantially closed circuit fed by products adapted to evolve heat by a chemical exothermic reaction, duct means for connecting the exhaust side of said gas turbine to the suction side of said main compressor, first valve means on the exhaust side of said gas turbine for directing the exhaust of said gas turbine selectively to the atmosphere and into said duct means, an auxiliary compressor connected to said duct means for delivering into

same air under pressure, a motor linked to said auxiliary compressor and adapted to be actuated independently of said power plant for driving said auxiliary compressor, second valve means on the suction side of said main compressor for selectively connecting the inlet of said main compressor to said duct means and to the atmosphere, cooling means on said duct means for refrigerating the turbine exhaust, pump means connected to said duct means for eliminating condensation products and gas in excess from said duct means, a storage tank connected to the suction side of said main compressor and adapted to supply an extra amount of gas into said circuit, third valve means between said storage tank and the suction side of said main compressor for selectively opening and cutting off extra supply of gas, pipe means between said circuit and said storage tank for connecting said circuit between the suction side and the discharge side of said main compressor to said storage tank, and control means arranged on said pipe means and responsive to the pressure in said circuit at said point between the suction and discharge sides of said main compressor for regulating the flow of gas between said circuit and said storage tank.

3. In a power plant of the kind described, the combination of a gas circuit including at least one main compressor, at least one combustion chamber and at least one gas turbine and being adapted to operate selectively in open circuit fed by hydrocarbon fuel and atmospheric air and in substantially closed circuit fed by products adapted to evolve heat by a chemical exothermic reaction, duct means for connecting the exhaust side of said gas turbine to the suction side of said main compressor, first valve means on the exhaust side of said gas turbine for directing the exhaust of said gas turbine selectively to the atmosphere and into said duct means, an auxiliary compressor connected to said duct means for delivering into same air under pressure, a motor linked to said auxiliary compressor and adapted to be actuated independently of said power plant for driving said auxiliary compressor, second valve means on the suction side of said main compressor for selectively connecting the inlet of said main compressor to said duct means and to the atmosphere, cooling means on said duct means for refrigerating the turbine exhaust, pump means connected to said duct means for eliminating condensation products and gas in excess from said duct means, a storage tank connected to the suction side of said main compressor and adapted to supply an extra amount of gas into said circuit, third valve means between said storage tank and the suction side of said main compressor for selectively opening and cutting off extra supply of gas, pipe means between said circuit and said storage tank for connecting said circuit at a point between the suction side and the discharge end of said main compressor to said storage tank, a vacuum tank on said pipe means between said circuit and said storage tank for withdrawing gas from said circuit, further pump means on said pipe means between said vacuum tank and said storage tank for discharging gas from said vacuum tank into said storage tank, a conduit connecting said storage tank to a point of said pipe means between said circuit and said vacuum tank for returning gas under pressure into said circuit, a three-way distributor on said pipe means at the connection of same to said conduit for selectively cutting off said pipe means, connecting said pipe means to said vacuum

tank and connecting said pipe means to said storage tank, and a regulator linked to said three-way distributor and responsive to the pressure in said circuit at said point between the suction side and the discharge side of said main compressor for controlling said three-way distributor.

4. In a power plant of the kind described, the combination of a gas circuit including at least one multistage main compressor, at least one combustion chamber and at least one gas turbine and being adapted to operate selectively in open circuit fed by hydrocarbon fuel and atmospheric air and in substantially closed circuit fed by products adapted to evolve heat by a chemical exothermic reaction, duct means for connecting the exhaust side of said gas turbine to the suction side of said main compressor, first valve means on the exhaust side of said gas turbine for directing the exhaust of said gas turbine selectively to the atmosphere and into said duct means, an auxiliary compressor connected to said duct means for delivering into same air under pressure, a motor linked to said auxiliary compressor and adapted to be actuated independently of said power plant for driving said auxiliary compressor, second valve means on the suction side of said main compressor for selectively connecting the inlet of said main compressor to said duct means and to the atmosphere, cooling means on said duct means for refrigerating the turbine exhaust, pump means connected to said duct means for eliminating condensation products and gas in excess from said duct means, a storage tank connected to the suction side of said main compressor and adapted to supply an extra amount of gas into said circuit, third valve means between said storage tank and the suction side of said main compressor for selectively opening and cutting off extra supply of gas, pipe means between an intermediate stage of said multistage main compressor and said storage tank for connecting said circuit to said storage tank, a vacuum tank on said pipe means between said intermediate stage of said multistage main compressor and said storage tank for withdrawing gas from said circuit, further pump means on said pipe means between said vacuum tank and said storage tank for discharging gas from said vacuum tank into said storage tank, a conduit connecting said storage tank to a point of said pipe means between said intermediate stage of said multistage main compressor and said vacuum tank for returning gas under pressure into said circuit, a three-way distributor on said pipe means at the connection of same to said conduit for selectively cutting off said pipe means, connecting said pipe means to said vacuum tank and connecting said pipe means to said storage tank, and regulator means linked to said three-way distributor and responsive to the pressure in said intermediate stage of said multistage compressor for controlling said three-way distributor.

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