May 6, 1930. H. HOLZWARTH 1,757,045

MULTISTAGE COMBUSTION TURBINE

Original Filed Aug. 17, 1926 2 Sheets-Sheet 1

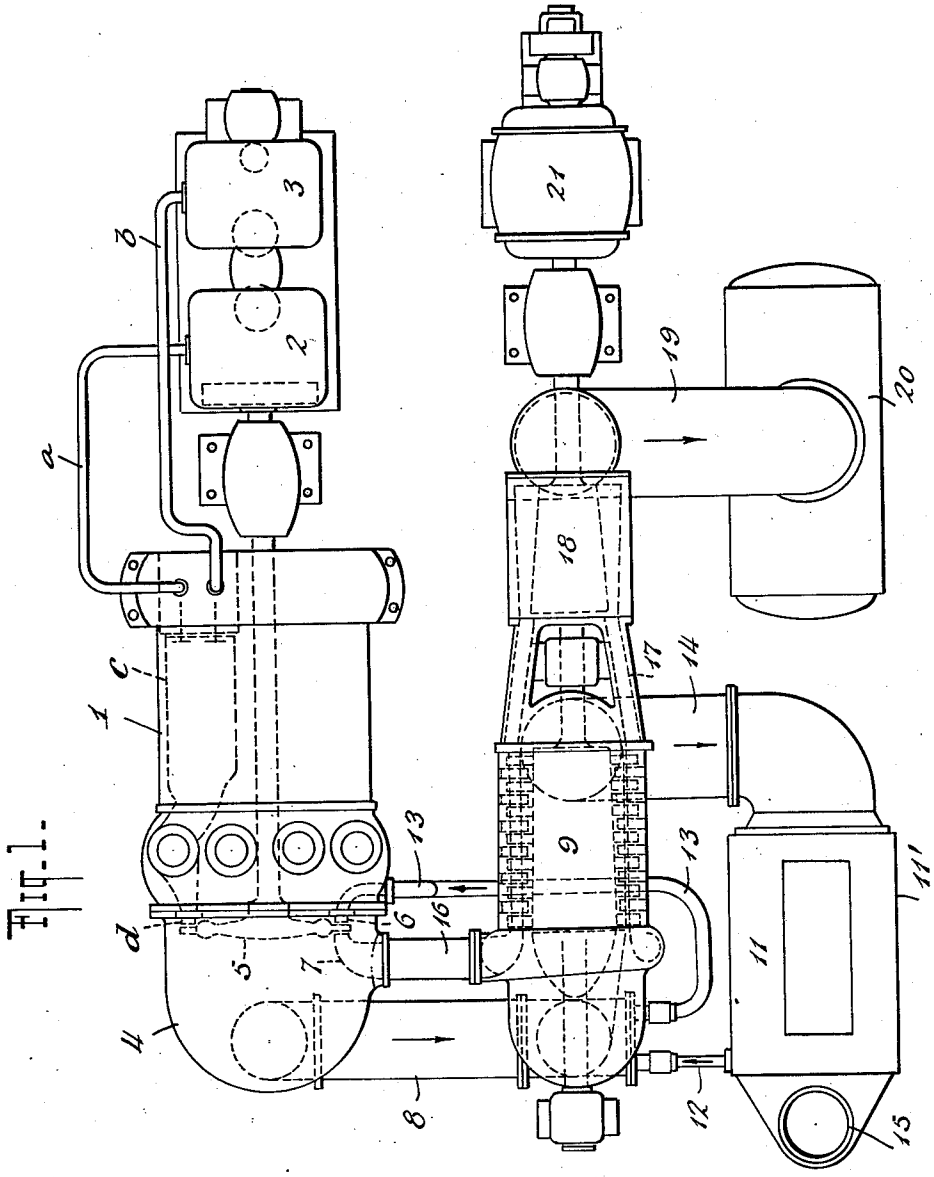

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Fig. 3.

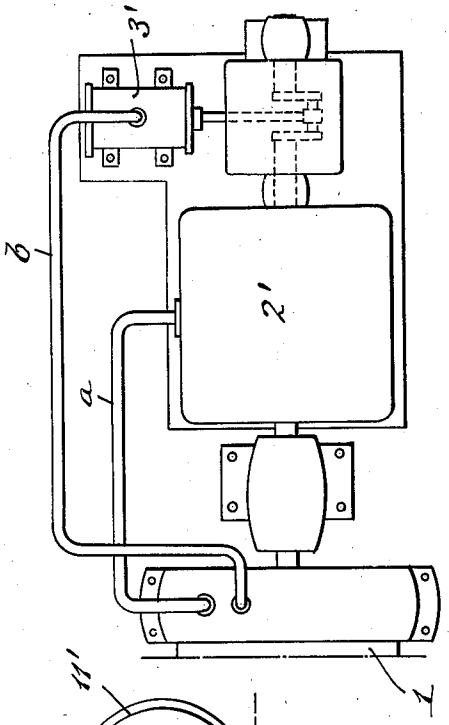
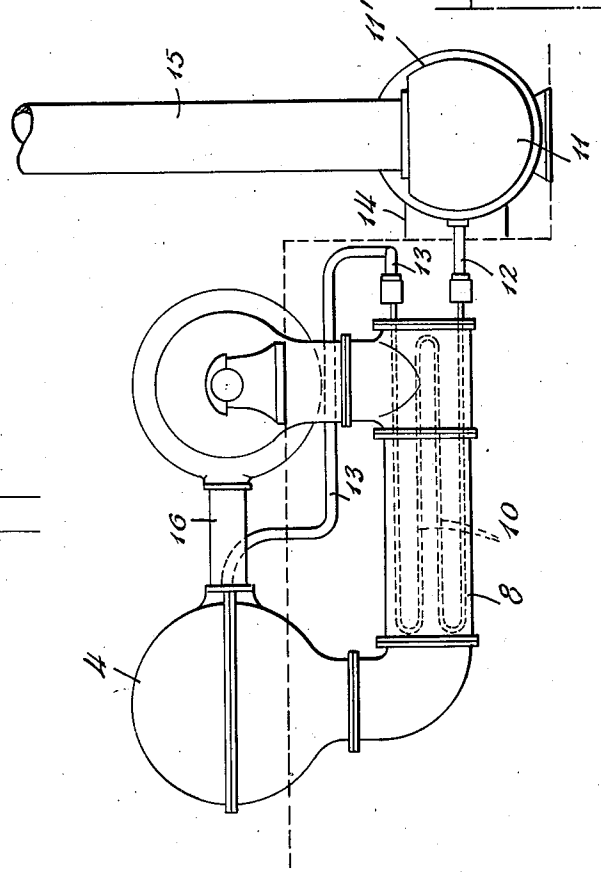


Fig. 2.



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Patented May 6, 1930

1,757,045

UNITED STATES PATENT OFFICE

HANS HOLZWARTH, OF DUSSELDORF, GERMANY, ASSIGNOR TO HOLZWARTH GAS TURBINE CO., OF SAN FRANCISCO, CALIFORNIA, A CORPORATION OF DELAWARE

MULTISTAGE COMBUSTION TURBINE

REISSUED

Application filed August 17, 1926, Serial No. 129,739. Renewed August 24, 1929.

My present invention relates to multi-stage turbines operated by combustion gases, and has for its object to provide a novel and very advantageous combination of the several stages of the turbine and the machinery driven thereby. In carrying out my invention, I prefer to use the high-pressure stage chiefly or exclusively for operating the auxiliary devices which supply air and fuel to the combustion chamber, while the power of the other stages is employed to drive the dynamo or other machine actuated by the turbine. Other features of my invention will appear from the description following hereinafter.

Reference is to be had to the accompanying drawings, in which Fig. 1 is a plan view and Fig. 2 a side elevation showing a typical and satisfactory embodiment of my invention, while Fig. 3 is a partial plan view illustrating a slightly different form of the improvement.

The high pressure turbine 1 is of any suitable construction, but I prefer an explosion gas turbine of a type developed by me, an instance of which is disclosed in my pending application for Letters Patent of the United States, Serial No. 47,422, filed August 1, 1925. This turbine is coupled with the air compressor 2 and the gas compressor 3, preferably turbo-compressors of a well-known type having their rotors mounted directly on the turbine shaft. By conduits *a* and *b* the air and gas respectively are conveyed to the explosion chambers such as *c*, the combustion gases then passing to nozzles *d* and into the exhaust chamber 4, operating the turbine rotor 5 by the gas jets issuing from the nozzles. Any suitable device is provided for igniting the combustible mixture in the chambers *c*, and appropriate valves (as indicated in the application mentioned above) control the admission of the fuel (gas) and air to the chambers *c* and the exit of the combustion gases therefrom after the explosion. As the operation and control of the valves in this type of explosion turbine is well known in the art and has been described e. g. in my Patent No. 877,194, a detailed description thereof may be dispensed with in this specification. When liquid fuel, such as oil, is used instead of gas, the air compressor is made relatively larger, as indicated at 2′ in Fig. 3, and a liquid-fuel pump such as indicated at 3′ (generally of the reciprocating piston type) is substituted for the gas compressor 3.

The pressure prevailing in the exhaust chamber 4 is above atmospheric pressure. The rotor 5 is cooled by passing through its blade channels, high-pressure steam discharged through a set of stationary nozzles 6 and collected, after passing through the rotor, in corresponding catch nozzles 7. The pressure of the steam at the outlet of nozzles 6 and at the inlet of nozzles 7 is preferably substantially equal to the pressure of the combustion gases in the exhaust chamber 4, and in such a case neither the steam nor the combustion gas will have a tendency to pass through the unavoidable gaps between the rotor and the nozzles 6 and 7 and to mix with each other. From the exhaust chamber, the combustion gases pass through a conduit 8 to the intermediate pressure turbine 9, which may be of any suitable construction. In the conduit or pipe 8 are arranged superheater coils 10 to which wet high-pressure steam is conveyed from the boiler 11 through a pipe 12. The superheated steam is conveyed by the pipe 13 to the high-pressure steam nozzle 6. The exhaust combustion gases pass through the pipe 8 to the intermediate pressure turbine 9 where they perform work and then exhaust, at atmospheric pressure, through the pipe 14 to the pipe or casing 11′ which contains the boiler 11, and after generating steam in such boiler, the exhaust combustion gases pass out to the atmosphere through the exhaust pipe 15.

The steam collected by the catch nozzles 7 passes through a path separate from that of the combustion gases, being conveyed from the said nozzles through a pipe 16 to the steam nozzles of the intermediate pressure turbine 9. It will be understood that both the high-pressure turbine 1 and the intermediate pressure turbine 9 are of the type (exemplified by my former application referred to above) in which there are two kinds of nozzles for delivering a gaseous medium to the rotor, one kind of nozzles discharging

steam, and the other combustion gases under pressure. The intermediate pressure turbine 9 has catch nozzles 17 to receive the steam and convey it to a low pressure turbine 18, which therefore is actuated by steam alone. After performing work in the turbine 18, the low pressure steam passes through an exhaust pipe 19 to the condenser 20.

The intermediate pressure turbine 9 and the low pressure turbine 18 are coupled with the machinery to be driven, for instance a dynamo 21, the armature of which may be mounted directly on the common shaft of said turbines 9 and 18. The ratio of the number of revolutions of the high pressure rotor to that of the intermediate and low pressure rotors may be selected arbitrarily. By a proper choice of the combustion pressure or explosion pressure in the chambers *c*, and of the counterpressure in the exhaust chamber 4, I may so proportion the horsepower of the high pressure turbine 1 and of the subsequent stages that the high pressure combustion gas turbine will supply just enough power to operate the compressors or pumps (2, 3 or 2′, 3′) while the power of the turbines 9 and 18 will be used exclusively for driving the dynamo 21 or other machinery. While this is the preferred way of carrying out my invention, I do not desire to restrict myself thereto.

Various modifications may be made without departing from the nature of my invention as set forth in the appended claims.

I claim:

1. A multiple stage turbine arrangement comprising a high-pressure explosion turbine having an explosion chamber and connections for delivering the gases therefrom to the rotor of said turbine, devices, driven by said turbine, for feeding fuel and air under pressure to said chamber, a discharge nozzle arranged adjacent to the path of said rotor, on one side of said path, a catch nozzle arranged on the other side of said path, to receive the medium issuing from said discharge nozzle, an intermediate pressure turbine arranged to rotate independently of said explosion turbine and having two kinds of discharge nozzles in operative relation to its rotor, a connection leading from said catch nozzle to the discharge nozzles of one kind, another connection for leading the exhaust combustion gases from the high pressure turbine to the discharge nozzles of the other kind, a boiler heated by the exhaust combustion gases from the intermediate pressure turbine, a connection for leading the steam generated in said boiler to the discharge nozzle of the high pressure turbine, and a low pressure turbine coupled with said intermediate pressure turbine and driven by the exhaust steam of the same.

2. A multiple stage turbine arrangement comprising a high-pressure explosion gas turbine having an explosion chamber and connections for delivering the gases therefrom to the rotor of said gas turbine, devices, driven by said turbine, for feeding fuel and air under pressure to said chamber, a discharge nozzle arranged adjacent to the path of said rotor, on one side of said path, a catch nozzle arranged on the other side of said path to receive the medium issuing from said discharge nozzle, an intermediate pressure turbine having two kinds of discharge nozzles in operative relation to its rotor, a connection leading from said catch nozzle to the discharge nozzles of one kind, a conduit for leading the exhaust combustion gases from the high pressure turbine to the discharge nozzles of the other kind, a boiler heated by the exhaust combustion gases from the intermediate pressure turbine, a connection including a superheater coil arranged in said conduit, for leading the steam generated in said boiler to the discharge nozzle of the high pressure turbine, and a low pressure turbine driven by the exhaust steam of the intermediate pressure turbine, the rotors of said intermediate pressure turbine and of said low pressure turbine being mounted on the same shaft.

3. A multiple stage turbine arrangement comprising a high-pressure explosion gas turbine having an explosion chamber and connections for delivering the gases therefrom to the rotor of said gas turbine, devices, driven by said turbine, for feeding fuel and air under pressure to said chamber, a discharge nozzle arranged adjacent to the path of said rotor on one side of said path, an exhaust chamber in which the exhaust combustion gases from said high pressure turbine are received under a pressure above atmospheric, a catch nozzle arranged in said chamber on the other side of the rotor path to receive the medium issuing from said discharge nozzle, an intermediate pressure turbine having two kinds of discharge nozzles in operative relation to its rotor, a connection leading from said catch nozzle to the discharge nozzles of one kind, a conduit for leading the combustion gases from said exhaust chamber to the discharge nozzles of the other kind, a boiler heated by the exhaust combustion gases escaping from the intermediate pressure turbine at substantially atmospheric pressure and provided with an exhaust port for conducting said gases into the atmosphere, a connection including a superheater coil arranged in said conduit, for conveying the steam generated in said boiler to the discharge nozzle of the high pressure turbine, a low pressure turbine driven exclusively by the exhaust steam of the intermediate pressure turbine, and a vacuum condenser connected with said low pressure turbine to receive the exhaust steam therefrom.

4. A multiple stage turbine arrangement

comprising a high pressure turbine the rotor of which is driven by combustion gases under pressure, a discharge nozzle arranged adjacent to the path of said rotor on one side of said path, an exhaust chamber in which the exhaust combustion gases from said high pressure turbine are received under a pressure above atmospheric, a catch nozzle arranged in said chamber on the other side of the rotor path to receive the medium issuing from said discharge nozzle, an intermediate pressure turbine arranged to rotate independently of said high pressure turbine and having two kinds of discharge nozzles in operative relation to its rotor, a connection leading from said catch nozzle to the discharge nozzles of one kind, a conduit for leading the combustion gases from said exhaust chamber to the discharge nozzles of the other kind, a boiler heated by the exhaust combustion gases escaping from the intermediate pressure turbine at substantially atmospheric pressure, a connection including a superheater coil arranged in said conduit for conveying the steam generated in said boiler to the discharge nozzle of the high pressure turbine, and a condensing low pressure turbine driven by the exhaust steam of the intermediate pressure turbine and coupled therewith.

In testimony whereof I have hereunto set my hand.

HANS HOLZWARTH.