

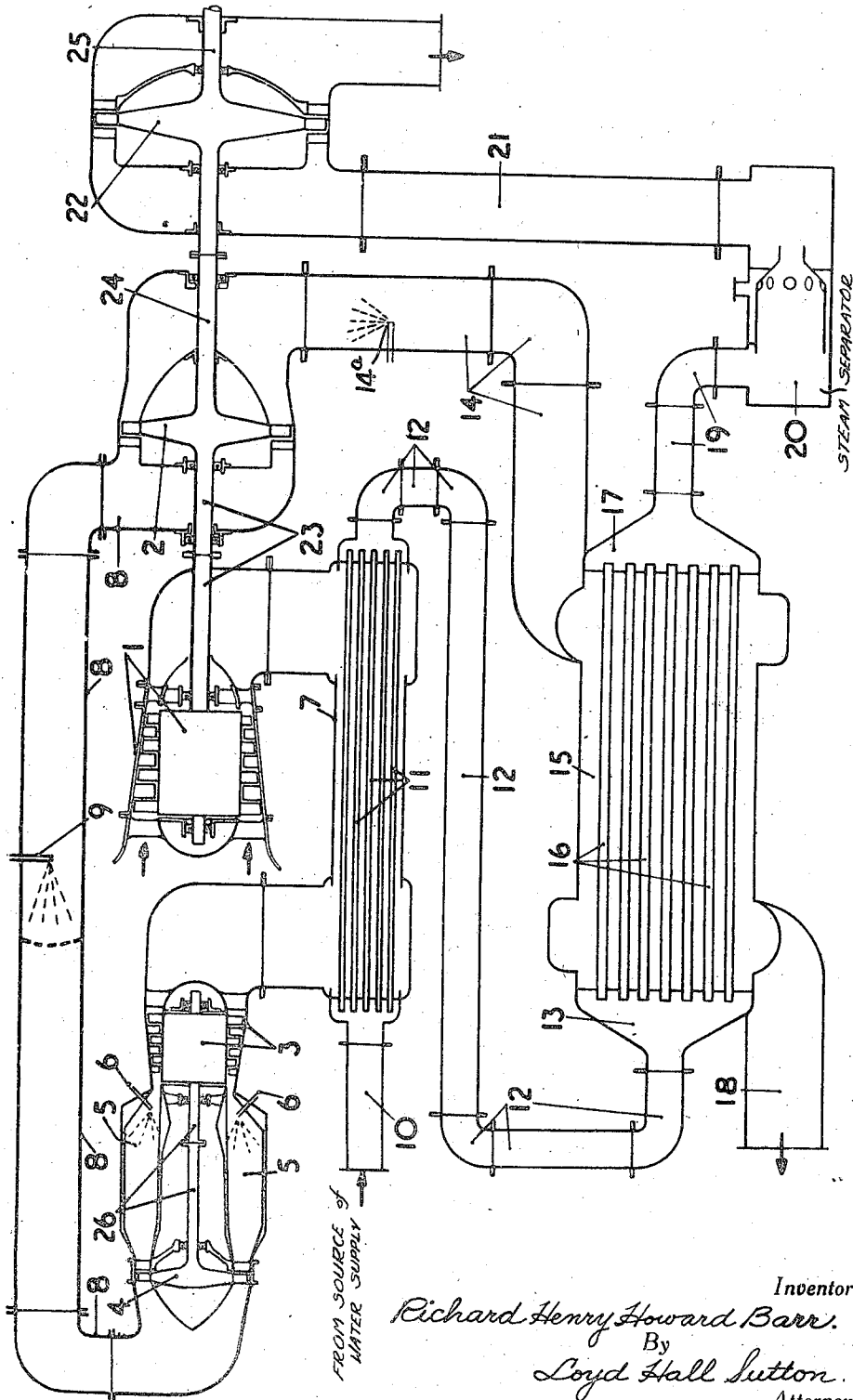
Sept. 30, 1947.

R. H. H. BARR

2,428,136

COMBUSTION GAS AND WASTE HEAT STEAM TURBINES

Filed Sept. 18, 1945



Inventor

Richard Henry Howard Barr.

By

Lloyd Hall Sutton.

Attorney

UNITED STATES PATENT OFFICE

2,428,136

COMBUSTION GAS AND WASTE HEAT
STEAM TURBINE

Richard Henry Howard Barr, Normanton, England, assignor to Power Jets (Research and Development) Ltd., London, England, a British company

Application September 18, 1945, Serial No. 617,012
In Great Britain April 25, 1944

Section 1, Public Law 690, August 8, 1946.
Patent expires April 25, 1964

6 Claims. (Cl. 60—49)

1

This invention relates to internal combustion turbine power plants of the type operating on the constant pressure cycle and commonly referred to as compound engines. These compound engines comprise two or more turbine driven compressors which are mechanically independent, and the air after passing through the compressors in sequence passes into a combustion chamber into which fuel is injected and burnt, the gaseous products then passing through the turbines.

In order to obtain the most efficient operation of compound turbocompressors or engines, it is preferable to connect the high pressure turbine to the high-pressure compressor, the intermediate pressure turbines to the intermediate compressors respectively, and the low pressure turbine to the low pressure compressor. Reheating may be employed between adjacent turbines or turbine stages to increase the useful power or efficiency of the compound engine, whilst shaft power may be taken off either from one or more of the turbine driven rotors or from a separate power turbine.

The chief object of the invention is to improve the overall efficiency of the gas turbine by the introduction of a steam cycle.

According to the invention, an internal combustion turbine power plant of the kind first herein referred to includes a steam turbine and a heat interchanger which extracts heat from the exhaust gases of the lowest pressure internal combustion turbine of the compounded series for raising steam which is used to drive the steam turbine.

According to a feature of the invention means are provided whereby the water supply of the heat interchanger is used to cool one or other or more than one of the compressors or an intercooler or intercoolers operatively positioned between a pair or pairs of the compressors, the feed water being thereby preheated.

The steam turbine may drive a power take-off shaft and/or be connected to the low-pressure compressor rotor so as to supplement the gas turbine drive thereof, whilst the exhaust from the steam turbine may be condensed in a condenser and the condensation water be returned to the feed water supply.

The invention will now be described more particularly with reference to the double compound engine illustrated diagrammatically in the accompanying drawing.

In the drawing, the double compound engine comprises a low pressure axial flow compressor 1 driven by a low pressure gas turbine 2, and a mechanically independent high pressure axial

2

flow compressor 3 driven by a high pressure gas turbine 4. An annular combustion chamber 5 into which fuel is injected and burned continuously by burner jets 6 is interposed between and connects the outlet of the high pressure compressor 3 and the inlet side of the high pressure gas turbine 4.

The outlet of the low pressure compressor 1 is connected through the jacket 7 of an intercooler of the water-tube type, to the inlet of the high pressure compressor 3, and the outlet side of the high pressure turbine 4 is connected by ducting 8 to the inlet side of the low pressure turbine 2, whilst said ducting 8 is adapted to serve as a reheating chamber by the provision of the fuel injection burner 9.

Feed water supplied by a pipe 10 from a steam condenser or other convenient source (not shown) passes through the water tubes 11 of the intercooler and flows through ducting 12 to the water header 13 of a water tube boiler, and ducting 14 connects the exhaust side of the low pressure turbine 2 to the jacket 15 of said boiler, which jacket 15, through which the tubes 16 extend from the water header 13 to the steam header 17, has a gas exhaust pipe 18 discharging to atmosphere. Ducting 19 connects the steam header 17 of the boiler to a steam separator 20, and the latter is connected by a duct 21 to the inlet side of a steam turbine 22 the exhaust from which may be condensed and recirculated to the inlet 10 by conventional means.

The low pressure compressor 1, low pressure gas turbine 2 and steam turbine 22 are co-axially arranged and operatively connected by shafts 23, 24 so that the steam turbine supplements the power of the low pressure gas turbine in driving the rotor of the low pressure compressor 1. Also the rotor of the steam turbine 22 is provided on its discharge side with a coaxial power output shaft 25.

The high pressure turbine 4 drives the rotor of the high pressure compressor 2 through coupled shafts 26.

With the arrangement above described, air passing from the low pressure compressor through the jacket 7 of the intercooler to the high pressure compressor is cooled in flowing over the water tubes 11 and the feed water flowing through the latter is preheated. The hot gases from the combustion chamber 5 are expanded through the high pressure turbine 4, so as to drive it and the associated high pressure compressor 3, and are then reheated in passing through the combustion zone of the burner 9 in the duct 8, prior to

3

being further expanded through the low pressure turbine 2. Exhaust gases from the turbine 2 are led by the ducting 14 to the boiler jacket 15 so as to give up their heat to the preheated feed water flowing through the tubes 16 and generate steam, the waste gases being discharged to atmosphere through the exhaust pipe 18. The steam passes from the boiler header 17, through the ducting 19, separator 20, and duct 21 to the steam turbine 22, through which it is expanded so as to drive the steam turbine rotor and, through the shafts 24 and 25 respectively, supplement the power of the gas turbine 2 and drive a propeller or other external device or mechanism (not shown).

In order to obtain efficient cooling of the air passing to the high pressure compressor, it may be necessary to use a large quantity of feed water and to employ, in the ducting 14 between the low pressure gas turbine and the steam generator, further reheating means, such as a burner 14^a similar to burner 9 in duct 8, so as to ensure evaporation of the feed water led to the heat exchanger or boiler.

It will, of course, be understood that the tandem serial order of the compressor and turbine components of the plant may be changed from that illustrated, provided appropriate modifications are made to the ducting arrangement.

What I claim as my invention and desire to secure by Letters Patent is:

1. A compound internal combustion turbine power plant comprising mechanically independent series-connected compressors, at least two mechanically independent series-connected turbines, each of which drives one of the said compressors, combustion chamber means for receiving compressed air from the last in series of said compressors and wherein fuel is burned continuously, means delivering products of combustion from said combustion chamber means to the first in series of said gas turbines, steam raising heat exchanger means having water inlet and steam outlet means and duct means to deliver the exhaust gases of the lowest pressure internal combustion turbine of the compounded series to the heating space of said heat exchanger for steam raising, intercooler means through which compressed air flows from compressor to compressor, means for supplying feed water to the inlet of said heat exchanger means by way of said intercooler means, a steam turbine, and duct means connecting the steam outlet of said heat exchanger to the said steam turbine.

2. A compound internal combustion turbine power plant comprising mechanically independent series-connected compressors, at least two mechanically independent series-connected turbines, each of which drives one of the said compressors, combustion chamber means for receiving compressed air from the last in series of said compressors and wherein fuel is burned continuously, means delivering products of combustion from said combustion chamber means to the first in series of said gas turbines, steam raising heat exchanger means having water inlet and steam outlet means and duct means to deliver the exhaust gases of the lowest pressure internal combustion turbine of the compounded series to the heating space of said heat exchanger for steam raising, intercooler means through which compressed air flows from compressor to compressor, means for supplying feed water to the inlet of said heat exchanger means by way of said intercooler means, a steam turbine, duct means connecting

4

the steam outlet of said heat exchanger to said steam turbine, means for taking off shaft power from said steam turbine, and means operatively connecting said steam turbine to the last in series of said gas turbines so as to supplement its power.

3. A compound internal combustion turbine power plant as claimed in claim 2, wherein means are provided for reheating the exhaust gases before passing to the heat exchanger.

4. A double compound internal combustion turbine power plant comprising two mechanically independent series-connected compressors, two mechanically independent series-connected turbines, each of which drives one of said compressors, combustion chamber means in which fuel is burned continuously and receiving compressed air from the high pressure compressor and delivering products of combustion to the high pressure gas turbine, ducting connecting the high pressure turbine to the low pressure turbine, reheating means in said duct, a heat exchanger, duct means delivering the exhaust gases from the low pressure gas turbine to the heating space of said heat exchanger, an intercooler through which air flows from the low pressure compressor to the high pressure compressor, means for supplying feed water through said intercooler to the water space of said heat exchanger, a steam turbine operatively connected to the low pressure gas turbine and having means for taking off shaft power, a steam separator, and ducting supplying steam from the steam space of the heat exchanger and through said steam separator to said steam turbine.

5. In a turbine power plant, mechanically independent series-connected air compressors, an equal number of mechanically independent series-connected gas turbines, each driving one of said compressors, combustion chamber means intermediate said compressors and said turbines and having fuel burning means, means for utilising a part at least of the heat generated in said combustion chamber means for raising steam, said steam raising means being provided with feed water heating means utilising heat extracted from the air in the course of its passage through said series-connected air compressors and thereby cooling said air, and turbine means for utilising said steam for power output.

6. In a turbine power plant, mechanically independent series-connected air compressors, an equal number of mechanically independent series-connected gas turbines, each driving one of said compressors, combustion chamber means intermediate said compressors and said turbines and having fuel burning means, means for utilising a part at least of the residual heat of the final exhaust from the last of said series-connected gas turbines for steam raising, said steam raising means being provided with feed water heating means utilising heat extracted from the air in the course of its passage through said series-connected compressors and thereby cooling said air, and turbine means for utilising said steam for power output.

RICHARD HENRY HOWARD BARR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,978,837	Forsling	Oct. 30, 1934
2,115,338	Lysholm	Apr. 26, 1938