Dec. 3, 1940. H. W. DAVIS 2,223,953

TURBINE

Filed Sept. 27, 1937 4 Sheets-Sheet 1

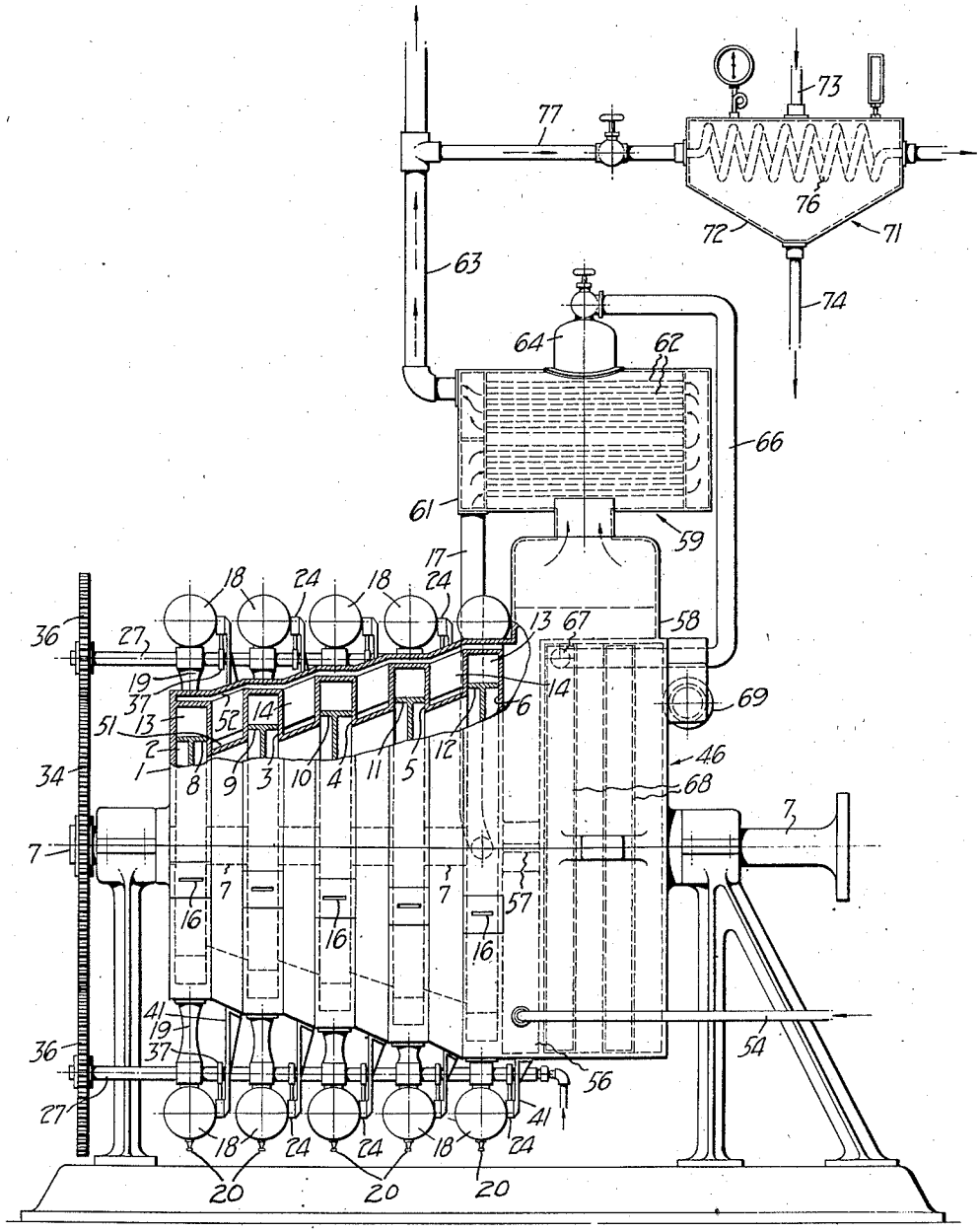


FIG. 1

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TURBINE

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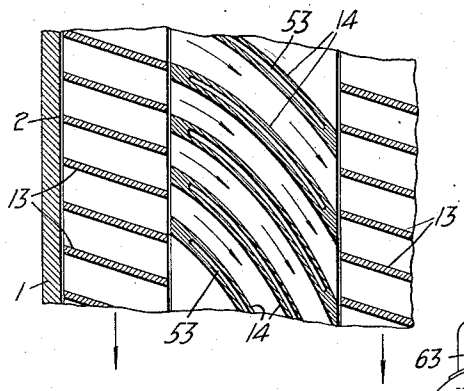


FIG. 3

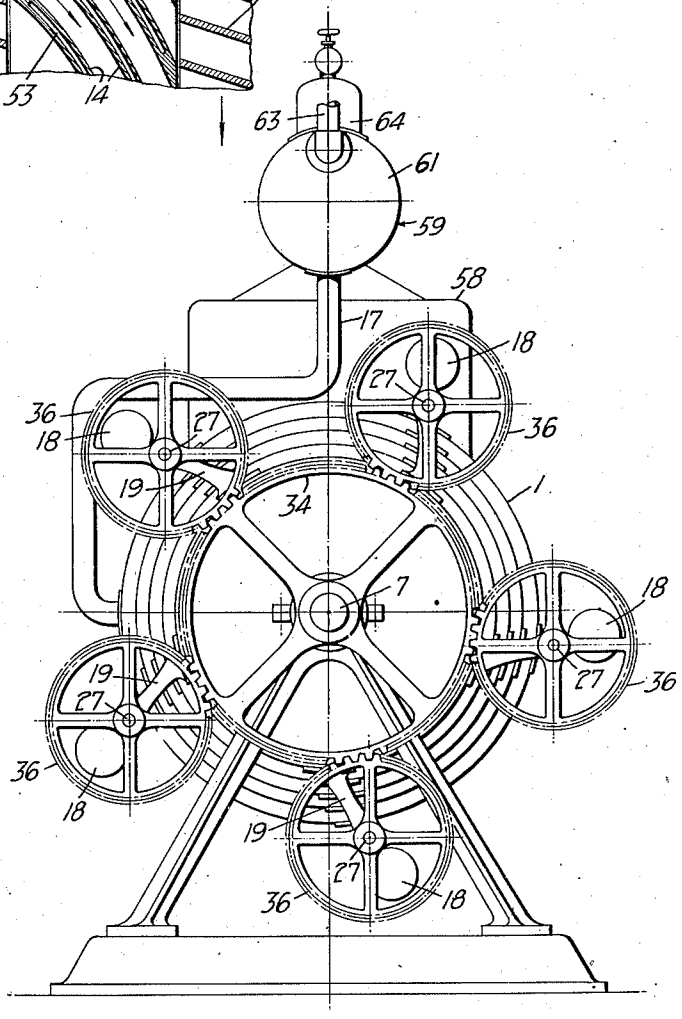


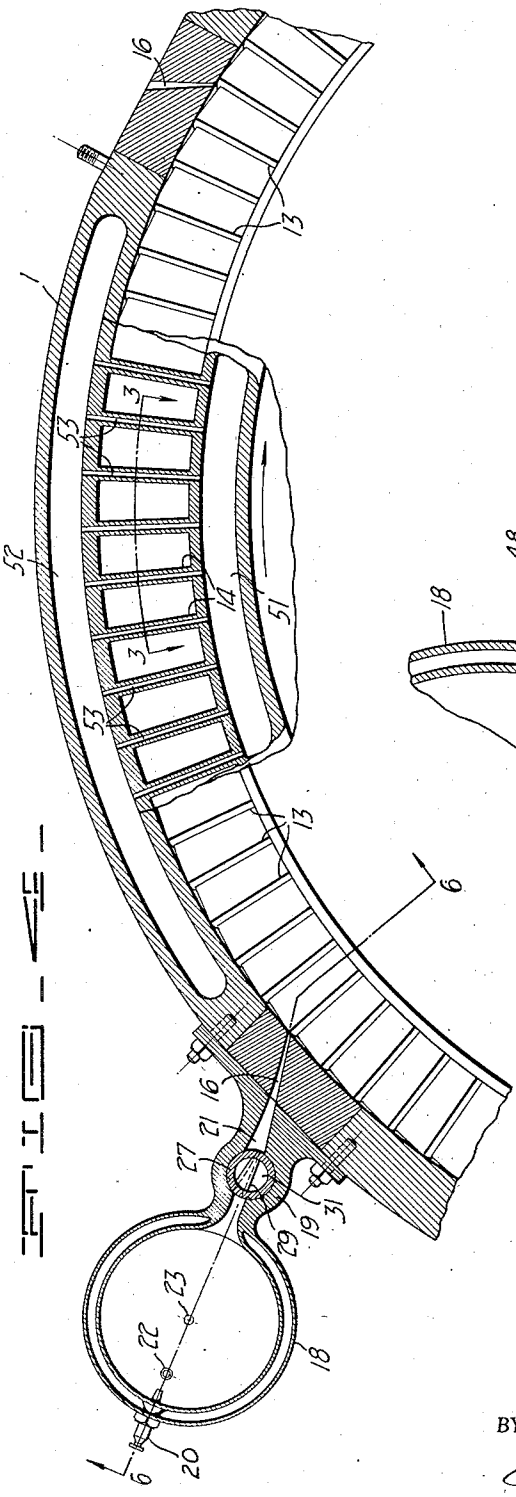
FIG. 2

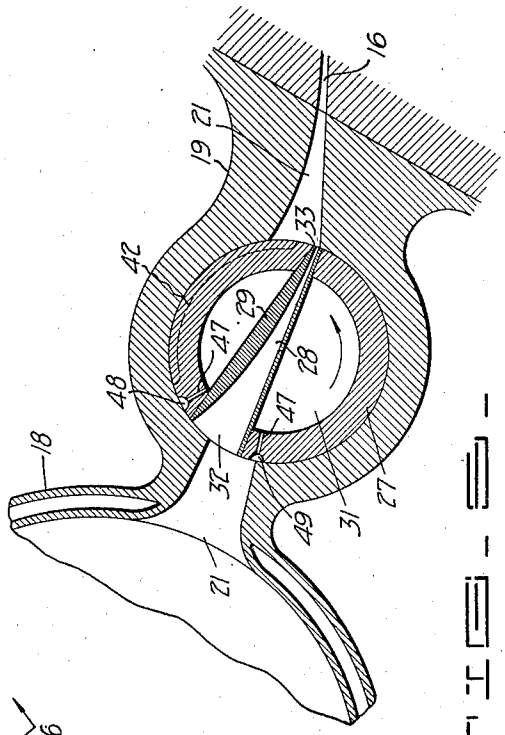
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TURBINE

Filed Sept. 27, 1937 4 Sheets-Sheet 4

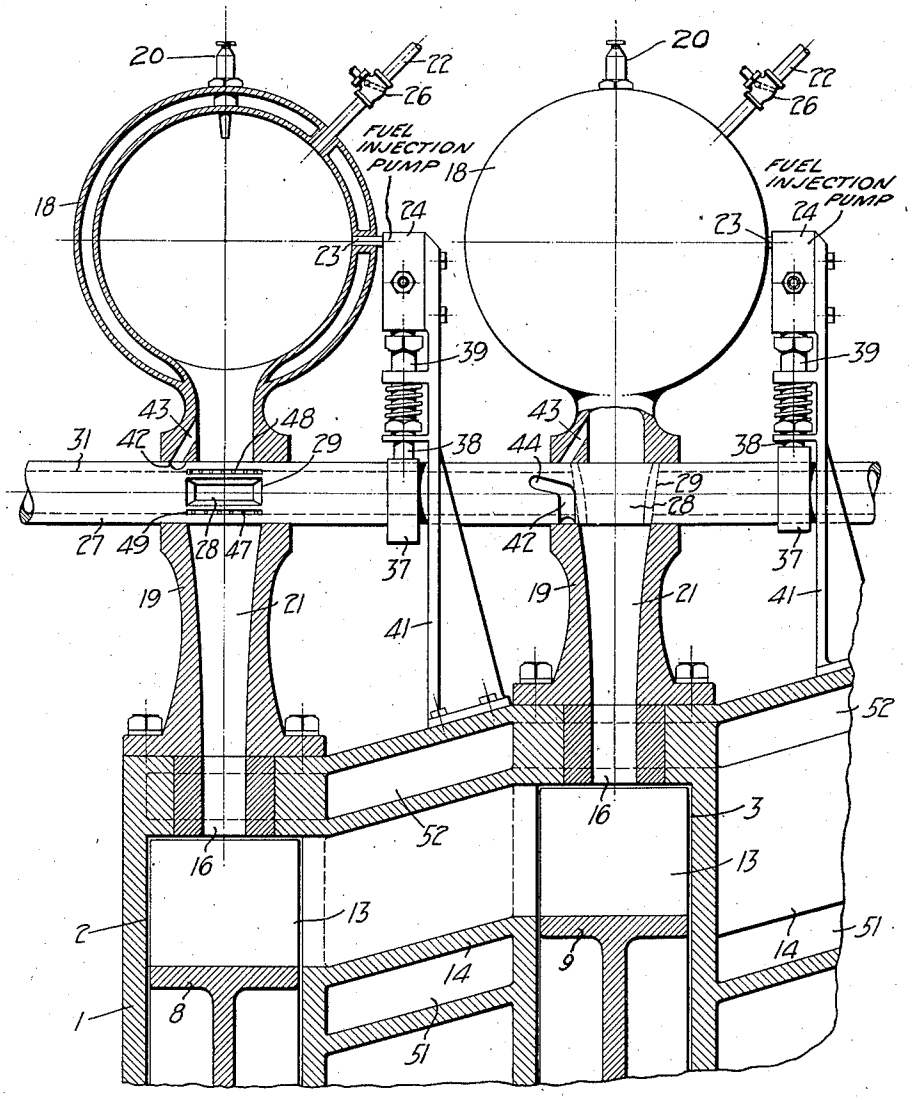


FIG. 5.

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Patented Dec. 3, 1940 2,223,953

UNITED STATES PATENT OFFICE

2,223,953

TURBINE

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Application September 27, 1937, Serial No. 165,811

6 Claims. (Cl. 60—49)

The invention relates to turbines and more particularly to turbines adapted for operation by a motivating fluid consisting of the gases of combustion of a combustible fuel such as a hydro-carbon oil or liquid.

Gas turbines of the character described which have been proposed heretofore have in the main been unsatisfactory due to their inability to withstand the excessively high temperatures of the products of combustion of the hydro-carbon fluid. As will be understood in turbines of this character the combustible fluid is first compressed together with a charge of air and is then ignited to produce a body of gas having a high temperature and pressure and which gas is expanded through the turbine for producing mechanical energy. The present invention has been designed to operate at a substantially lower temperature than the turbines heretofore and at the same time produce a greater expansion ratio of the operating fluid than previous turbines. In addition and as a further object of the present invention, a greater portion of the available heat is converted into usable mechanical energy.

A further object of the invention is to provide a turbine of the character described having a generally improved mechanical design and one which may be manufactured by standard shop equipment and methods and at a reasonable cost.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of the preferred form of the invention which is illustrated in the drawings accompanying and forming part of the specification. It is to be understood, however, that variations in the showing made by the said drawings and description may be adopted within the scope of the invention as set forth in the claims.

Referring to said drawings:

Figure 1 is a side elevation of a turbine constructed in accordance with the present invention and is shown with a part of the outer casing cut away, so as to illustrate certain of the internal parts.

Figure 2 is an end elevation of the turbine.

Figure 3 is a fragmentary cross-sectional view showing the arrangement of the stationary and runner vanes and is taken substantially on the plane of line 3—3 of Figure 4.

Figure 4 is a fragmentary transverse sectional view showing the fuel injection arrangement and the positioning of the stationary and runner vanes relative thereto.

Figure 5 is an enlarged sectional view similar to Figure 4 of the fuel inlet means to the turbine.

Figure 6 is a fragmentary transverse sectional view taken substantially on the plane of line 6—6 of Figure 4.

The turbine of the present invention, and as illustrated in the accompanying drawings, comprises a casing 1 which is formed with a plurality of side by side rotor chambers 2, 3, 4, 5 and 6 which are graduated in size, increasing in the direction of the chamber 6, so as to accommodate an increased expansion of the operating fluid from stage to stage of the turbine. Rotatably mounted in each of these chambers and on a common shaft 7 are a plurality of rotors or runners 8, 9, 10, 11 and 12, each being provided around its periphery with a set of vanes 13 which cooperate with a set of stationary vanes 14 formed in the casing 1 between each of the rotor chambers for providing a longitudinal passage for the operating fluid through the turbine. The casing 1 is provided around each of the rotor chambers with a plurality of circumferentially spaced inlet passages 16 for directing the operating fluid against the rotors and the operating fluid after passing through the final stage 6 is discharged through a discharge conduit 17.

In accordance with the present invention the operating fluid here used for actuating the turbine consists of the gases or products of combustion of a combustible fluid such as crude oil or substantially any of the petroleum oil products, or the like, the present turbine being particularly designed for the burning of a relatively low grade crude hydro-carbon oil. The combustion of the oil is here effected in a plurality of combustion chambers 18 here shown in the form of hot balls and formed in auxiliary casing 19 which are bolted or otherwise affixed to and form part of the main casing 1 at the inlet passages 16 aforesaid. The casing 19, in addition to the provision of the combustion chamber 18, carry an ignition plug 20 and are formed with a discharge passage 21 which registers with the inlet passage 16 of the turbine for permitting the escape of the products from the chambers 18 into the inlet passages 16 and against the rotors. The chambers 18 are charged with air and fuel under pressure by means of an air line 22 and an oil line 23 which are connected to sources of air and oil, the former consisting preferably of an air pressure storage tank not shown and the latter comprising a fuel injection pump 24 similar to that commonly used in Diesel engines. The air lines 22 are each preferably provided

with a check valve 26 so as to present the back flow of the products after combustion into the air line. Preferably the air pressure is maintained constant at approximately three hundred and fifty pounds per square inch pressure and the oil injection is effected periodically at somewhat above this pressure as will be more fully hereinafter described.

In order to alternately seal off the combustion chamber 18 for charging and combustion of the fuel and to thereafter communicate the chambers with the rotor chambers of the turbine for passage of the products into the turbine, an appropriate valve mechanism is used in the passages 21 which open and close these passages in timed relation to the operation of the turbine. This valve mechanism is here shown in the form of a plurality of elongated tubes 27 which are extended through a plurality of the casings 19 positioned in aligned relation longitudinally of the turbine, the tubes in each instance being extended through the several casings 19 transversely across and intersecting and closing the passages 21 and being journaled in each of the casings for rotation. At each of the passages 21, each tube is provided with a transverse passage 28 formed by a conduit 29 inserted through the tube and having the passage 28 therein sealed from the hollow interior 31 of the tube, the positioning of the passage 28 through the tube being such as to open and close the passage 21 on rotation of the tube. Preferably the passage 28 is in the form of a nozzle having a widened end 32 arranged to receive the heated products from the chamber 18 and a reduced end 33 for directing these products at a high velocity into the inlet passages of the turbine.

The timing of the turbine so as to cause the proper charging of the combustion chambers 18 and the proper opening and closing of the passage 21 by the valve mechanism is here effected by a gear arrangement including a master gear 34 mounted on the rotor shaft at an end of the turbine and which is engaged with a plurality of circumferentially spaced gears 36 carried by the tubes 27. Also mounted on each of the tubes intermediate the several stages of the turbine are a plurality of cams 37 which are positioned to engage the lower end 38 of a plunger 39 of the fuel pumps 24, the latter here being supported by a bracket 41 from the turbine casing 1. The timing for the several combustion chambers for each cylinder is preferably staggered so as to minimize vibration.

Means are also provided for scavenging the chambers 18 after combustion of the fuel and escapement of the products. Such means is here provided in the form of a circumferential groove 42 at each position on the tubes in the casings 19 and which are adapted to register with a side passage 43 of the chambers 18 and which is provided with an offset end 44 which extends to the outside of the casings 19 to provide for the discharge of products from the chamber to the exterior of the casings 19 upon registration of the grooves 42 with the passages 43.

The basic operation of the turbine, as will be clear from the foregoing, is as follows: Assuming a counterclockwise direction of rotation of the valve tubes 27, as illustrated in Figure 5 and starting with the tube rotated to a position closing the chambers 18, the chamber will be first charged with air. On further rotation of the tubes the cams 37 will actuate the oil pumps to inject a spray of oil into each of the combustion chambers and this is followed by an ignition of the mixture by the spark plugs 25. On further rotation of the valve the passage 28 is placed in registration with the passage 21 and the products are allowed to escape from the chamber 18 into the turbine. On further rotation of the valve the passage 21 is closed and the side passage 43 is registered with the scavenger groove 42 and the chambers are flushed out by the action of the air pressure which is constantly applied by way of the line 22. On closure of the scavenger ports, the chambers 18 are again sealed off and are successively charged with air and fluid and then ignited to repeat the operation above.

The extremely high temperature and heat content of the products of combustion generated in the chambers 18 has heretofore constituted a very serious problem in turbine of the present character in that no practical means has been heretofore devised for making a maximum beneficial use of the high heat content of the gases and furthermore the metals heretofore available in the construction of the turbine have not been capable of withstanding the high temperatures. In accordance with the present invention, I make a very substantial reduction in operating temperature of the turbine and further make a greater beneficial use of the available heat in the products of combustion. This is effected in two ways, one by the introduction of water into the turbine together with the products of combustion so as to absorb a substantial amount of heat and at the same time convert the water into steam which greatly increases the expansion ratio of the operating fluid. Secondly, a substantial amount of heat is absorbed in the casing of the turbine into a water jacket and the heat thus absorbed is used to vaporize the water in the jacket to produce steam and the latter is used to drive a steam turbine unit 46 provided in the casing 1 and operating on the rotor shaft 7 aforesaid.

The introduction of water directly into the turbine, together with the products of combustion from the chambers 18, is effected at the valve tubes 27, the latter being charged with water in the interior space 31 thereof and being communicated with the outer periphery of the tubes by way of a plurality of passages 47 which lead from the interior 31 of the tubes to a pair of longitudinal grooves 48 and 49 spaced at opposite sides of the passage end 32 of the gas conduit 29. Thus, on rotation of the tubes, water is discharged from the groove ports 48 and 49 into the passage 21 and is carried, together with the products of combustion, into the turbine.

More specifically, the operation of the valve is this: Referring to Figure 5 of the drawings, as the valve is rotated in a counter-clockwise direction and moves past the discharge position, at which time the opening 32 is coincident with the passage 21 adjacent the combustion chamber, water is injected into the passage from ports 47 and groove 48. This injection into the hot gas vaporizes the water and removes the heat of vaporization from the gas. As the valve continues its counter-clockwise rotation the slot 42 comes adjacent the passage 43 and the pressure inside the combustion chamber combined with air from the port 22, forces the remaining products of combustion out through the slot. This exhausting continues until the opening 33 is in the center of the combustion chamber passage 21. The charging air which has been forcing the

exhaust gases from the chamber does not build up an appreciable pressure until the opening **33** has crossed the passage and therefore only a negligible amount is carried through the valves to the turbine blades. At the same time the water ports **48** and **49** discharge water into the nozzle passages **21** and **16**, thereby cooling the parts and at the same time forming steam under pressure and thereby doing work on the rotor blades. The balance of the cycle is occupied by the charging of the combustion chamber with compressed air. The injector then is operated and the ignition system causes combustion to occur. The water ports **49** discharge into the chamber causing a substantial decrease in the gas temperature and an accompanying pressure increase before the gases leave the combustion chamber. The ports **49** continue to discharge water during passage of the gases into the turbine until the ports are closed by rotation of the valve. During passage of gases to the turbine, the ports **48** are opened and said ports discharge water into the combustion chamber until after the gas passage is closed off and the scavenging begun.

The absorption of heat from the turbine itself is effected as above mentioned by a water jacket which as here shown is in the form of a plurality of radially spaced circumferentially extending water chambers **51** and **52** formed in the turbine casing **1** and being spaced radially at opposite sides of the stationary vanes **14** and circumferentially between the several inlet passages **16** of each stage, the outer water chamber **52** being preferably extended for the full length of the several stages **2**, **3**, **4**, **5** and **6**. As an important feature of this cooling structure the stationary vanes **14** are each formed of a hollow construction having an interior passage **53** communicated at its outer and inner ends with the water chambers **52** and **51** respectively so as to cause the circulation of water directly through the stationary vanes of the turbine. Water is fed into the water jacket by way of a conduit **54** which is connected to the casing **1** adjacent the fifth stage of the turbine and is communicated thereat with an annular water chamber **56** which separates the steam turbine unit **46** from the combustion gas turbine. Preferably, the chamber **56** is provided with a partition **57** so as to cause the circulation of the incoming water longitudinally through the water jacket towards the first stage and then the circulation of the water back through the turbine to the fifth stage to the other side **58** of the partition **57**. To achieve this result, the water jacket passages in the stator blades and adjacent the rotor is partitioned off in stages **2** to **5** at the horizontal plane in which lies the main shaft and in which also lies the partition **57**. In this manner the flow of water is from pipe **54** to the lower half of chamber **56**, into the lower half of the water jacket and toward stage **1**, circumferentially around the water jacket surrounding stage **1**, and back through the upper water jacket toward stage **5** and into the chamber portion **58**. The water in traversing this course absorbs a very substantial amount of heat and is converted into a saturated steam by the time it reaches the chamber portion **58**. This saturated steam is then passed through an exhaust heater unit **59** so as to change the saturated steam into a superheated steam before passing to the steam turbine unit **46**. The exhaust heater unit is here shown in the form of a casing **61** having a plurality of transverse heater tubes **62** therein through which the exhaust gases are passed from the exhaust conduit **17** and which in turn exhaust into conduit **63**. The saturated steam is passed over these heater tubes and is gathered in a steam dome **64** for passage by conduit **66** to the inlet **67** of the steam turbine unit **46**. The steam turbine **46** may be of more or less standard design and preferably consists of several stages having the rotors or runners **68** affixed to for rotation with the rotor shaft **7** of the turbine. The steam is exhausted from the turbine **46** by way of a conduit **69** and the steam is passed by the conduit to a suitable condenser not shown and then preferably to a storage reservoir and preferably caused to flow back to the water jacket and also to the valve tubes **27** by means of a pump, or the like, not shown.

If desired, an exhaust heating unit **71** may be employed for pre-heating the oil and as here shown such a heater is provided in the form of a casing **72** providing for the passage of oil therethrough by way of inlet and discharge conduits **73** and **74**, and the interior of the casing is heated by means of a coil **76** connected by conduit **77** with the exhaust conduit **63**.

I claim:

1. A heat power plant comprising, a combustion chamber adapted to receive a combustible fluid under pressure, means to ignite said fluid, a rotor casing having a rotor chamber therein, a rotor mounted in said rotor chamber, said casing being provided with inlet and discharge passages for directing an operating fluid against said rotor and for discharging said fluid therefrom, passage means connecting said combustion chamber with said inlet passage, valve means in said passage operative to close said chamber during charging thereof with said fluid and ignition of said fluid and to communicate said chamber with said inlet passage after ignition of said fluid to permit passage of the products to said rotor, means for conveying cooling water through the interior of said valve means and surrounding said gas passage, said casing providing a water jacket for heating by said products and for vaporizing said water, a steam engine connected to said water jacket.

2. A turbine comprising, a casing having a rotor chamber and a combustion chamber with a passage connecting said chambers, a rotor in said rotor chamber, said combustion chamber being adapted to receive a combustible fluid under pressure, means to ignite said fluid to produce a gas under heat and pressure for expansion through said passage and against said rotor, a valve comprising a tube rotatably carried by said casing in transverse intersecting relation across said passage, having a conduit mounted transversely across said tube and adapted on rotation of said tube to register with said passage and being sealed from the interior of said tube, said tube being adapted for charging with water and having ports leading to the periphery thereof from the interior for passing water together with said gases into said turbine.

3. A turbine comprising, a casing having a rotor chamber and a combustion chamber with a passage connecting said chambers, a rotor in said rotor chamber, said combustion chamber being adapted to receive a combustible fluid under pressure, means to ignite said fluid to produce a gas under heat and pressure for expansion through said passage and against said rotor, a valve comprising a cylindrical member jour-

nalled in said casing in transverse intersecting relation across said passage and being provided with a diametrically arranged passage for registering with said first passage in one rotated position of the valve and closing off said passage in the second position of the valve, said member being provided with a groove in the periphery thereof having one portion substantially aligned with said first passage and extending partially around the circumference of said member and another portion extending to without said casing to provide on registration of said first portion with said passage for the escape of gases from said combustion chamber to the exterior of said casing.

4. A turbine comprising, a casing having a combustion chamber and a rotor chamber and a passage connecting said chambers, a rotor mounted in said rotor chamber and having a shaft extending from said casing, air and oil passages leading to said combustion chamber, an oil pump connected to said oil passage, a rotary valve carried by said casing across said first passage for alternately connecting and disconnecting said chambers, a continuous water passage through said valve, means for injecting water from said water passage in said valve into said connecting passage with gases from said combustion chamber, gear means for turning said valve from said rotor shaft, and cam means motivated by said valve for actuating said pump.

5. A turbine comprising, a casing having a plurality of adjacent rotor chambers graduated in size and formed with stationary vanes for directing an operating fluid from one of said chambers to another, rotors mounted in said chamber and having a common rotor shaft, said casing being provided with a plurality of combustion chambers surrounding each of said rotor chambers and formed with passages connecting said combustion chambers with said rotor chambers, said combustion chambers being adapted to receive a combustible fluid under pressure, means to ignite said fluid, and a plurality of multiple rotary valve means each connecting one of a series of said combustion chambers with each of said rotor chambers, said valve means comprising hollow members extending through one passage to each of said rotor chambers and having a flow of water through its length.

6. A turbine comprising, a casing having a rotor chamber and a combustion chamber with a passage connecting said chambers, a rotor in said rotor chamber, means in said combustion chamber to receive and ignite a combustible fluid, valve means in said passage for controlling the flow of gas between said chambers, means incorporated in said valve for exhausting gases remaining in said combustion chamber after connection with said rotor chamber, and water passages in said valve positioned for discharging water into said combustion chamber between the time of combustion and the time of connection with said rotor chamber.

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