

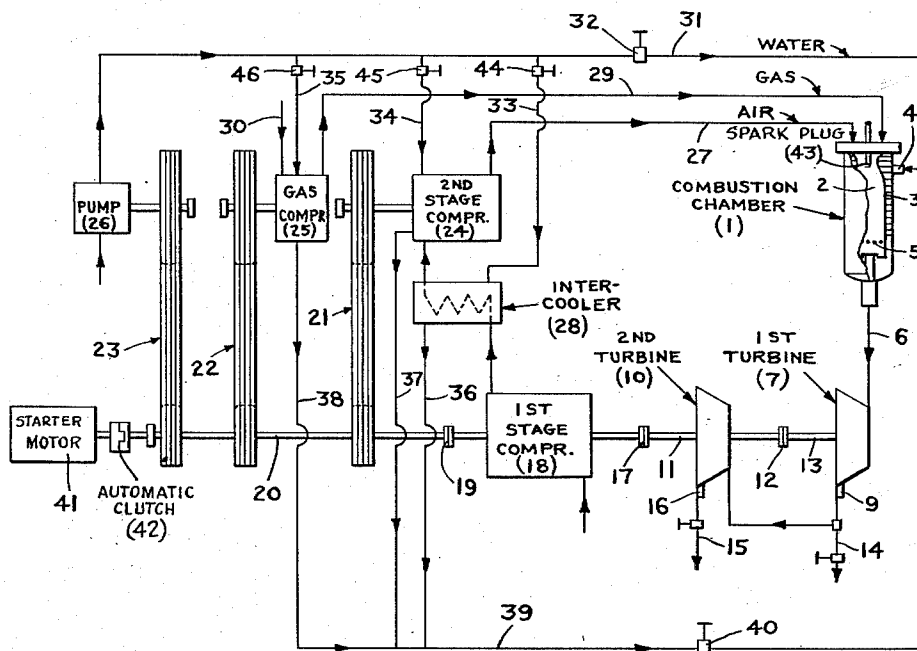
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WORKING PRESSURE FLUID GENERATING APPARATUS

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WORKING PRESSURE FLUID GENERATING APPARATUS

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This invention relates generally to secondary oil recovery from an unproductive underground oil bearing formation or strata, and more particularly to an apparatus for producing one or more gas and superheated steam mixtures at predetermined temperatures and pressures as a working medium either for secondary oil recovery or any other desired use, which also acts as a power source for the prime moving means in the systems which produce gas and superheated steam mixtures.

In my copending application Serial No. 271,512, filed February 14, 1952, now patent No. 2,734,578, issued February 14, 1956, a method and apparatus for secondary oil recovery was described for producing a mixture of gas and superheated steam, at high temperature and at high pressure which was applied as a combined gas and thermal driving means to one or more input wells of an unproductive oil bearing formation or strata to reduce the retentive forces of the residual oil in such formation or rock strata and to move the oil to a producing or output well.

The apparatus for producing the gas and superheated steam mixture included a gas or diesel type engine, as its driving means, which type engines as is well known in the art require a high grade expensive fuel. In addition, approximately two-thirds ($\frac{2}{3}$) of the fuel heat from the driving means is wasted in its cooling water and exhaust, of which only a fraction could be recovered for the heating process of the secondary oil recovery method; and such recovery would require costly and unwieldy apparatus of heat regeneration.

The present invention covers an apparatus for producing one or more gas and superheated steam mixtures at the same or varying temperatures and pressures, to overcome both of these problems, which consists of a combustion chamber fed by air and gas compressors for producing combustion gases, or mediums, a feed water pump to deliver cooling water to the combustion chamber for mixture thereafter with the ignited fuel and gas to form the gas and superheated steam mixture, which compressors and pumps are driven by one or more gas driven prime movers, operated themselves by the working medium issuing from the combustion chamber before it is passed to input wells for secondary oil recovery or for other desired uses, which apparatus produces the most compact arrangement and the most economical arrangement from the standpoint of operating economy.

The crux of the present invention and its primary object therefor reside in the fact that the working medium will have the additional function and use of driving its own gas driven prime movers.

This object will be effected by having the initial temperature and pressure of the gas and superheated steam mixture issuing from the combustion chamber sufficiently high so that the temperature and pressure drop across the turbine will not destroy its quality for the desired use. One such illustration of the use of this fuel mixture

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or mixtures in a secondary oil recovery process is described in my Patent No. 2,734,578.

This method and apparatus allows substantially the full amount of the heat produced in the combustion chamber to be injected into the input well or wells for even the mechanical power extracted from the working medium in the turbines can be fully recovered, as it will be contained partly as increased enthalpy in the compressed air and gas and partly in the jacket water of the compressors through which the cooling water to be fed to the combustion chamber can be used as the cooling medium.

It is believed obvious and well known in the art that whether one or more turbines or prime movers are used that a number of gas and superheated steam mixtures at the same or varying temperatures and pressures can be secured from discharge outlets established in the design of the turbine or turbines. In the case of the preferred form shown diagrammatically in the figure, two outlets one on each of the two turbines are indicated and as will be hereinafter described the temperature and pressure differential will be in a 2 to 1 ratio between these two discharge mixtures. The temperature and pressure ratios are of course easily variable from the maximum temperature and pressure conditions of the issuing gas and superheated steam mixture of the combustion chamber which at present due to the limitations of the materials used therein will be about 1500° F. and at a pressure between 500 to 1500 p. s. i. a. or higher depending upon the depth of the well or the overburden above the oil-bearing formation or strata.

These gas and superheated steam mixtures at varying temperatures and pressures, are particularly adapted to secondary oil recovery.

It is, therefore, another object of the present invention to provide a single apparatus or system compact in design for the amount of working medium needed, which is adapted to provide one or more mixtures of gas and superheated steam at the same or varying temperatures and pressures for use in secondary oil recovery.

With these and other objects in view as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying diagrammatic sketch showing a preferred form of a working pressure fluid generating apparatus, and the features forming the invention will be specifically pointed out in the claims.

Referring to the drawings, 1 is a combustion chamber which may be any one of the type shown and described in my Patent No. 2,734,578, to produce a gas and superheated steam mixture at high temperature and high pressure, as illustrated hereinafter from the combustion of compressed air with fuel oil or fuel gas also under pressure and from the injection of a sufficient quantity of water after combustion to cool down the hot gases to the desired temperature. Thus combustion chamber 1 is shown having an ignition zone 2 surrounded by a cooling jacket 3 having an inlet 4 and cooling jacket outlets 5 opening into the lower end of the ignition zone 2 remote from the point of ignition of the air and fuel as hereinafter described.

The combustion chamber 1 has its outlet connected by connecting conduits 6 to the inlet end of a first gas driven prime mover 7 which in turn has its discharge 9 connected to the steam end of a second gas driven prime mover 10 whose rotor shaft 11 is coupled as at 12 in axial alignment to the rotor shaft 13 of the prime mover 7.

A first tap-off conduit 14 connected to the discharge of the gas driven prime mover 7 and a second tap-off

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conduit 15 connected to the discharge 16 of the second gas driven prime mover 10, will allow gas and superheated steam mixtures at different temperatures and pressures to be drawn from the prime movers for use as desired.

The gas and superheated steam mixtures issuing from the combustion chamber 1 must, of course, have an initial temperature and pressure so predetermined that the heat and pressure drop across the gas driven prime movers 7 and 10 will produce the final mixtures at the desired temperatures and pressures. An example thereof illustrating one such case in reference to the diagrammatic figure of the drawings will be hereinafter described.

Gas driven prime movers are well known to those skilled in the art and are easily purchasable on the open market, hence they are not described further herein. The shafts 11 and 13 are connected coaxially by suitable coupling member 17 to a first stage air compressor 18 which is in turn connected axially by a coupling device 19 to a main driving shaft 20.

The driving shaft 20 is connected by suitable pulley and belt drives generally designated 21, 22 and 23 to a second stage air compressor 24, a gas compressor 25 and a water pump 26 respectively to operatively connect the same for rotation thereof when the main shaft 20 is rotated by the gas driven prime movers 7 and 10. It will be understood that while the power transmission device is shown as a pulley and belt arrangement any other suitable power transmission of the reduction type means may be used and that the same is well known in the art and hence not more fully described herein.

The combustion chamber 1 receives air for mixture with the fuel to be used therein through an air conduit 27 opening into the ignition zone 2 at one end and at the other end connected to the discharge of the second stage compressor 24, which in turn has its suction connected through intercooler 28 to the discharge of the first stage compressor 18 which will take its suction from any suitable source of air either at atmospheric or super-atmospheric pressure whichever is most desirable.

The intercooler 28 will serve a dual purpose. When in a system which includes a reciprocating pump in the second stage, it will reduce the temperature of the air issuing from the first stage controller so that self-ignition of the lubricating oil in the second stage compressor is prevented. When in a system which includes either a reciprocating or a centrifugal pump it will also reduce the mechanical power needed so that the heat drop across the turbine can in turn be reduced whereby a lower input pressure and temperature can be used or a higher pressure and temperature working medium can be secured.

Fuel is similarly supplied to the combustion chamber 1 through a fuel conduit 29 which is connected at one end to the ignition zone 2, preferably at a point adjacent to the air supply entrance, as is also described in my Patent No. 2,734,578 above-mentioned and at the other end to the discharge of the fuel compressor 25 which takes its suction from a suitable source of fuel gas or fuel oil (not shown) through suction inlet pipe 30.

Water preferably treated, deaerated and filtered by methods and apparatus which are well known in the feed water treating art, is pumped to the cooling jacket inlet 4 by either of two paths. It can come directly from the pump 26 through the main water supply conduit 31 connected between the cooling jacket inlet 4 and the discharge of the water pump 26 or in the alternative a main water supply valve 32 is provided in the main water supply conduit 31 which prevents the water from being pumped directly to the cooling water jacket inlet 4 and directs it as a cooling medium by bypass conduits 35, 34 and 33 through the water jackets of the gas and second stage air compressors 25 and 24 and through the intercooler 28 respectively where it absorbs heat energy normally lost and will be preheated. Thence it passes by

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three connecting conduits 38, 37 and 36 to a common duct or conduit 39 which has its discharge end connected to the cooling water inlet 4 of the cooling water jacket 3. The common duct valve 40 will control the flow of this preheated water to the cooling jacket inlet 4.

The water is sent through separate bypass conduits 33, 34 and 35 to each of the respective units above mentioned, so that relatively cool water passes through these units for maximum heat exchange relationship which will be most advantageous to recover heat which is ordinarily lost or would create a difficult problem involving heat recovery apparatus, when the cooling medium for these units is not part of the system as in the present combination.

A prime mover 41 is shown connected through a suitable clutch-engaging and disengaging means 42 to the main driving shaft 20. The prime mover may be any suitable type such as an internal combustion engine or an electric motor, and it is utilized for starting up and initial operation. It will be disengaged and stopped when the gas and superheated steam mixture is up to the operating temperatures and pressures required to produce the desired results.

Operation

Valves 32 and 40 will be set in a closed position initially. The prime mover 41 is then started and coupled by clutch 42 to the main driven shaft 20 to rotate through pulley and belt members 21, 22 and 23, the second stage compressor 24, the gas compressor 25 and the water pump 26. It will rotate directly the first stage compressor 18, and the prime movers 7 and 10.

The valve 32 will be throttled to allow a slow but adequate water flow into the combustion chamber to control the temperature and pressure increase of the gas and superheated steam mixture. As this mixture passes to the prime movers 7 and 10, their speed will increase until a predetermined speed is reached at which point the clutch 42 will automatically disengage itself.

As the pressure at which the air and gas is delivered to the combustion chamber increases, ignition means 43 may be cut off and combustion will continue. The valve 32 might now be fully opened or valve 32 may be closed and valve 40 opened to supply water either directly or preheated to the combustion chamber as above described.

Control valves 44, 45 and 46 for the respective bypass conduits 33, 34 and 35 are provided so that the water can be directed through each of the separate conduits or through one or the other, dependent upon the desired degree of preheating required.

In the diagrammatic sketch of the figure herein we have a case where two final mixtures of gas and superheated steam are desired from the discharge conduits 14 and 15. If, for example, the quantities desired are 64.6% from discharge conduit 14 and 35.4% from discharge conduit 15 with pressures of 213 p. s. i. a. and 107 p. s. i. a. respectively, the pressure required before the gas and superheated steam mixture reaches the prime movers 7 and 10 would be 640 p. s. i. a. at a temperature of 1300° F.

Any other temperature and pressure ratios are, of course, possible, although it has been found that the maximum issuing temperatures and pressures of the gas and superheated steam mixture from the combustion chamber 1 should not exceed 1500° F. and should be less than 1500 p. s. i. a.

It will be understood, of course, that while the present figure shows an arrangement with two prime movers producing two mixtures at different temperatures and pressures that this is intended only as an illustrative example and that the construction can be varied so that only one of the prime movers are used or the prime movers themselves can be designed in a manner well known in the art for additional discharge outlets whereby multiple mixtures at desired temperatures and pressures can be secured.

It will be understood that the invention is not to be

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limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. Apparatus utilizing the working mixture formed thereby as its own source of power comprising, a combustion chamber for producing a gas and superheated steam working mixture at a predetermined temperature and pressure, compressors for continuously supplying air and fuel to said combustion chamber, pumping means, a conduit connected between said pump and said combustion chamber to pass cooling water directly thereto, separate by-pass conduits in parallel circuit to each other connected between said pump and said combustion chamber for directing said cooling water in independent heat exchange relation with each of said compressors to preheat the same, and control means for controlling the flow through direct and by-pass conduits, said combustion chamber having a discharge outlet, at least one gas driven prime mover for driving said compressors and pump having its inlet connected to said discharge outlet and to be operated by the working mixture issuing therefrom, said prime mover having at least one discharge to deliver the working mixture at predetermined temperatures and pressures for any desired purpose.

2. Apparatus utilizing the working mixture formed thereby as its own source of power comprising, a combustion chamber for producing a gas and superheated steam working mixture at a predetermined temperature and pressure, a first and a second air compressor in series for continuously supplying air at a predetermined pressure to said combustion chamber, an intercooler between said first and said second compressor to control the temperature of said air, a fuel compressor to continually supply fuel to said combustion chamber at a predetermined temperature and pressure, a pump for cooling liquid, conduit means connected between said pump and said combustion chamber to pass cooling liquid directly thereto, separate by-pass means in parallel circuit to each other connected to said pump and to said combustion chamber to pass cooling water in independent heat exchange relation with said second compressor and intercooler to preheat said cooling water before it is passed to the combustion chamber, means controlling the flow of water through said direct and said separate by-pass means, said combustion chamber having a discharge outlet, at least one gas driven prime mover for driving said compressors and pump hav-

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ing its inlet connected to said discharge outlet and to be operated by the working mixture issuing therefrom, said prime mover having at least one discharge to deliver working mixtures at predetermined temperatures and pressures for any desired purpose.

3. Apparatus utilizing the working mixture formed thereby as its own source of power comprising, a combustion chamber for producing a gas and superheated steam working mixture at a predetermined temperature and pressure, a first and a second air compressor in series for continuously supplying air at a predetermined pressure to said combustion chamber, an intercooler between said first and said second compressor to control the temperature of said air, a fuel compressor to continually supply fuel to said combustion chamber at a predetermined temperature and pressure, a pump for cooling liquids, conduit means connected between said pump and said combustion chamber to pass cooling liquid directly thereto, a first by-pass conduit connected to said pump and to said combustion chamber to pass cooling water in heat exchange relation with said fuel compressor, a second by-pass conduit in parallel circuit to said first by-pass conduit connected to said pump and to said combustion chamber to pass cooling water in heat exchange relation with said second air compressor, and a third by-pass conduit in parallel circuit to said other by-pass conduits connected to said pump and to said combustion chamber and to said intercooler to pass cooling water in heat exchange relation with the air passing therethrough, said by-pass conduits having separate control means to control the flow of cooling water therethrough whereby the degree of preheating of said cooling water may be controlled, said combustion chamber having a discharge outlet, at least one gas driven prime mover for driving said compressors and pump having its inlet connected to said discharge outlet and to be operated by the working mixture issuing therefrom, said prime mover having at least one discharge to deliver working mixtures at predetermined temperatures and pressures for any desired purpose.

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