

[54] GAS-STEAM ENGINE

[72] Inventors: **Walter J. Ewbank**, 1722 Pickard; **Darrel G. Harden**, 1509 Oklahoma, both of Norman, Okla. 73069; **Walter C. Bauer**, 118 Pleasant Street, Santa Cruz, Calif. 95060

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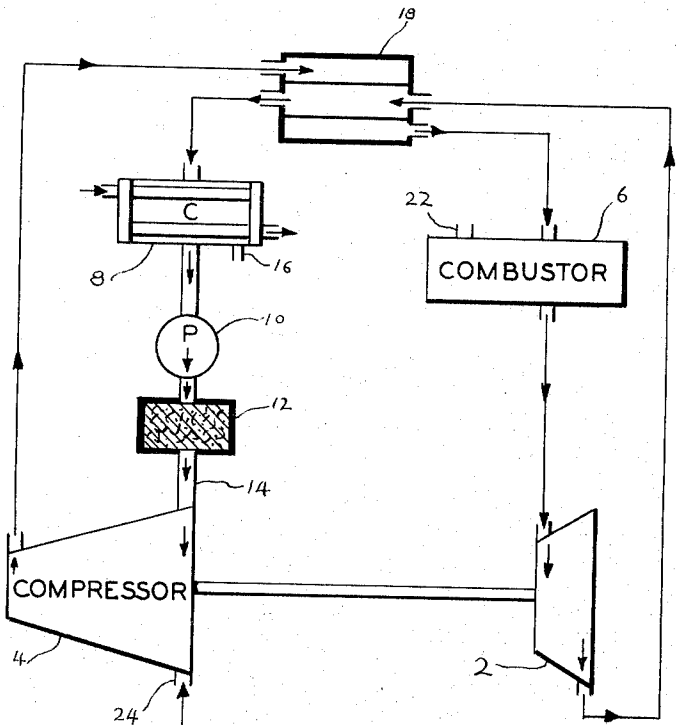
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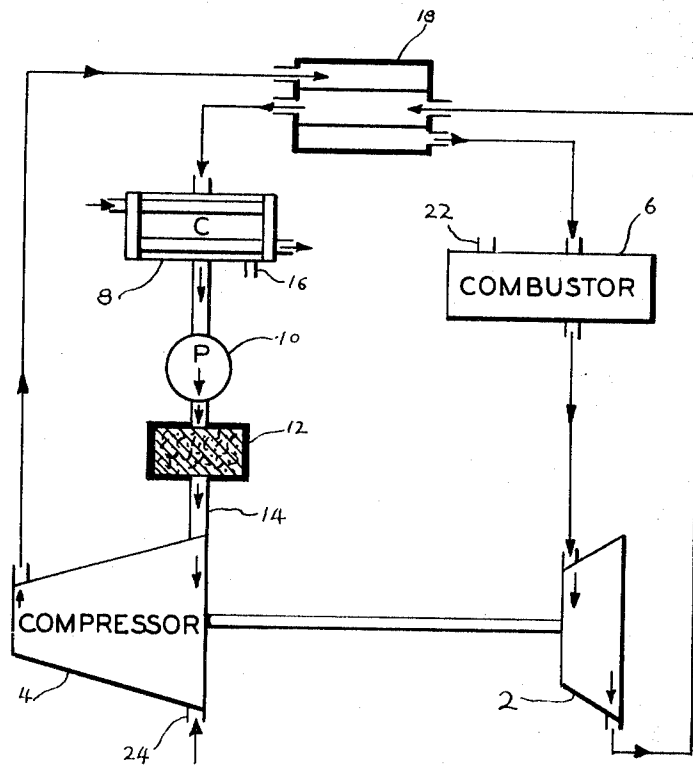
Primary Examiner—Mark M. Newman
Assistant Examiner—Warren Olsen
Attorney—Richard W. Collins

[57] **ABSTRACT**

A gas-steam engine utilizing wet compression, in which the water requirement is provided by recovering water from the engine exhaust gases by means of a condenser which is an integral part of the system. Water from the exhaust gas is condensed and injected back into the engine at an appropriate location, eliminating the need for an external source of water.

3 Claims, 1 Drawing Figure





WALTER J. EWBANK
 DARREL G. HARDEN
 WALTER C. BAUER
 INVENTORS.

BY *Richard W. Collins*

ATTORNEY

GAS-STEAM ENGINE

BACKGROUND OF THE INVENTION

This invention relates to improved engine systems suitable for use in generation of power, and especially in automotive vehicles such as trucks, busses and passenger cars.

Air pollution resulting from conventional type engines has reached a critical level. Much work has been done in an effort to perfect a satisfactory substitute for the reciprocating piston engine, which has several inherent disadvantages, including primarily an exhaust that contains high levels of pollutants, due to incomplete combustion of fuel.

At light loads and speeds there are emissions of carbon monoxide and unburned fuel. At full power delivery combustion temperature and pressures are attained sufficient to cause the formation of oxides of nitrogen.

It is well known that an engine operating with steady-state combustion produces a much "cleaner" exhaust than does non-steady state operation. Also, the conventional automotive engine has undesirable inefficiencies and complexities. Most of the recent efforts by the industry have been directed toward improving the pollutant level in exhaust gases from conventional engines, and only a nominal amount of work has been directed toward developing a substitute for the conventional engines.

The small amount of work done toward developing a substitute power plant suitable for automotive vehicles has been directed in two major areas. The first is the gas-turbine, and the second is the closed cycle steam power plant. Some success has been had with gas-turbine engines for large trucks and busses, but development work on gas-turbines for passenger cars has apparently been abandoned or minimized by the automobile industry. The two major factors which have retarded development of a gas-turbine for passenger cars have been; (1) it is difficult to keep the size small enough, and, (2) it has been expensive due to requirements of special alloys or materials for the turbines.

In the area of steam powered passenger cars, the only efforts appear to be toward refinements of the early-day steam powered cars. These efforts still face the problem of freeze-up in cold weather, assuming that the other problems could be solved.

SUMMARY OF THE INVENTION

The present invention overcomes the difficulties which have hampered development of a suitable steady-state combustion engine. It involves a combination steam-gas engine which has no freeze-up problem due to the fact that a separate water supply is not required, and that complete drainage of all water is made immediately after shut-down. The invention provides an engine which utilizes any suitable hydrogen-containing fuel, preferably an inexpensive hydrocarbon such as kerosene, to produce hot exhaust gases which in turn drive an engine which is connected to a load. The engine is also connected to a compressor to provide compressed air to the combustion zone in a conventional manner. An important feature of the invention is that the exhaust gases, instead of being vented directly to the atmosphere, are first passed through a condenser to remove a substantial part of the water from the exhaust gases. As is well known, approximately one volume of water is produced by combustion of one volume of hydrogen-containing fuel such as kerosene. The condensed water is collected from the condenser and pumped back into the engine either in the compressed air ahead of a regenerator, into the air ahead of the compressor, or into the combustion chamber itself, or some combination of these. By injecting the water into the system as a liquid, an important saving in compressor back-work is realized, since it requires much less energy to compress or pressurize a liquid than to compress or pressurize the same amount of material as a gas.

There is an increase in capacity per unit of motive fluid due in part to the greater available energy of steam over that of air. Another advantage of having water in the system is that the

conditions of combustion can be controlled to provide optimum efficiency, or to maintain the operating temperature low enough that expensive materials of construction are not required. This last feature in itself could reduce the cost of an engine in accordance with this invention sufficiently that it would be competitive economically.

It is of course known in the art that some of the above-described advantages can be obtained in engine operation by the so-called "wet-compression" method of operation. However, none of the prior art systems provided an exhaust gas condenser to recover the necessary water from the exhaust gas, but instead relied on external sources of water, making the system impractical for use on automotive vehicle systems.

The present invention, providing a combination gas-steam engine, would operate initially at start-up as a conventional engine, but since the condenser would be cold, and therefore at maximum efficiency, the water necessary to produce the desired operating conditions would be available within a matter of seconds, and the operation would then be self-sustaining as far as the water requirement is concerned.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic representation of a gas-steam turbine having means for condensing water from exhaust gas and returning the water to the engine.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with a preferred embodiment of the invention, as illustrated in the drawing, a turbine engine 2 is coupled by suitable power-transmission means (not shown) to the drive wheels of an automotive vehicle. The turbine 2 also drives a compressor 4 which supplies air to the combustor 6 of the turbine engine. An exhaust-gas condenser 8 is provided for condensing a substantial part of the water produced as a product of combustion, and the condensed water is returned to the engine by a controllable injection pump 10. Uncondensed exhaust gases exit condenser 8 through outlet 16.

In the drawing, the discharge from injection pump 10 leads to a filter 12 and from there to the compressor 4 by means of conduit 14. Alternatively, by means of suitable manifold (not shown), the water could be directed from injection pump 10 to regenerator 18 or to combustor 22, or by any combination of these.

In one preferred embodiment of the invention, about one half of the water would be returned to the regenerator 18, and the remaining one half to combustor 6. Fuel is supplied through conduit 22 to combustor 6, and air to compressor 4 is supplied through inlet 24.

The amount of water returned to the engine can vary considerably, but would have to be above 5 percent, based on the volume of fuel combusted, assuming a liquid fuel being, to show any appreciable benefit in engine operation. The maximum amount of water returned is only limited by the amount which can be efficiently utilized in the engine, and may be several times the amount of fuel being combusted. This is possible even though the amount of water produced by a preferred fuel such as kerosene is only about equal to the volume of kerosene combusted, due to the fact that the water is recycled back into the system, permitting build-up to any desired level.

In a preferred embodiment of the invention, the amount of water in the engine is maintained sufficiently high to keep the temperature of the gases in the turbine below 1,500° F., as this is about the temperature above which special heat-resistant alloys would be required for the turbine parts.

In the operation of a gas-steam engine in accordance with this invention, the engine is started by combusting fuel in combustor 6, producing hot gases to power turbine 2. The gases pass through regenerator 18 and then to condenser 8, where water in the exhaust gases is condensed out and returned by pump 10 back into the system. Shortly after start-up, the amount of water being returned reaches the desired level,

such as about 50 to 300 percent based on the volume of fuel being combusted, and the operation utilizing a combination gas-steam turbine engine is continued without a necessity of an external water supply.

The resulting operation combines most of the advantages of both steam and gas-turbine engines, and simultaneously eliminates the most serious drawbacks to the steam engine and the gas-turbine engine for automotive vehicle use. That is, as to steam engines, the freeze-up problem of the water supply is eliminated, and as to gas-turbines, the high temperature of operation is controlled and reduced, eliminating the need of special materials of construction, while the efficiency is improved due to the fact that the compressor back work load is reduced on account of part of the motive fluid (the water) being compressed or pressurized as a liquid. Also, by this method it is possible to maintain combustion at relatively fixed air-fuel ratios under all conditions of power requirement from idle to full capacity.

We claim:

1. A steady-state combustion system suitable for powering an automotive vehicle comprising:
 - combustion means for combusting a hydrogen-containing fuel;
 - turbine engine means adapted to power an automotive vehi-

cle and powered at least in part by gaseous combustion products from said combustion means;

a compressor driven by said turbine engine means and connected thereto for providing compressed air to the combustion means;

said combustion products after expansion in said turbine means being first passed through the hot pass of a single pass contraflow regenerator, with said compressed air from said compressor in contraflowing heat exchange relation therein, said combustion products secondly passed through a condenser adapted to condense a substantial amount of the water from exhaust gases exiting from the said regenerator and

means for controllably injecting at least part of the condensed water back into the air inlet of said compressor for providing compressed air such that the water is returned to the air being compressed in said compressor.

2. The system of claim 1 in which the amount of water injected is between about 5 and 300 percent based on the amount of fuel burned.

3. The system of claim 1 in which the amount of water injected is sufficient to maintain the combustion temperature in the combustion means below 1,500° F.

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