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HEAT ENGINE

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FIG. 1

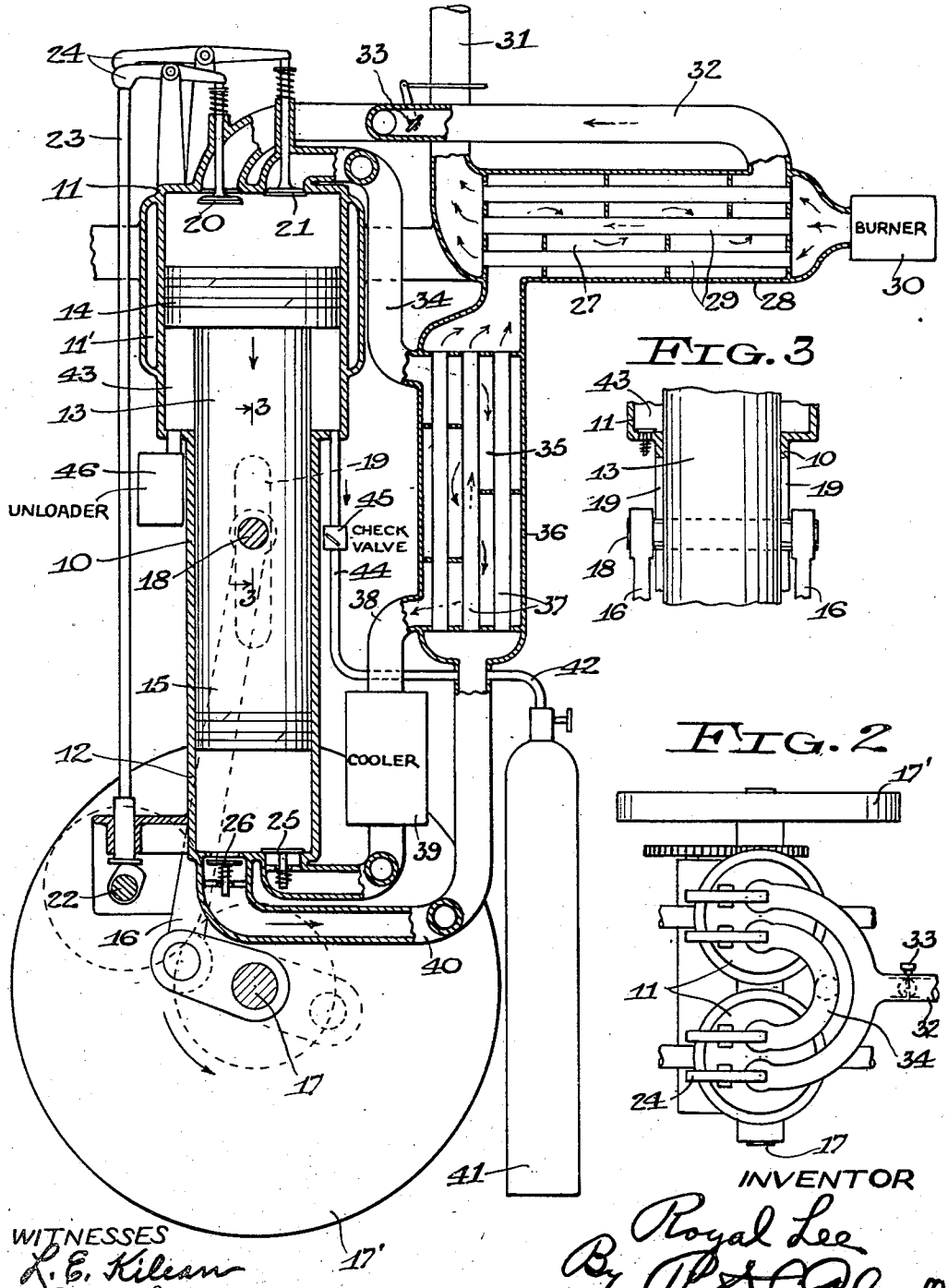


FIG. 3

FIG. 2

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HEAT ENGINE

Royal Lee, Milwaukee, Wis.

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1 Claim. (Cl. 60—59)

The invention relates to heat engines of the hot-air type.

An object of the invention is to provide a hot-air engine of improved efficiency and of increased capacity for a given size.

Another object of the invention is to provide a hot-air engine in which the air or other gaseous working substance is regeneratively heated in such manner as to permit continuous flow of air and also to permit one regenerator to serve in common for a plurality of cylinders.

A further object is to provide means for facilitating the starting of the engine and for replenishing the working substance.

The invention further consists in the several features hereinafter described and claimed.

In the accompanying drawing, which illustrates one specific form of heat engine embodying the invention,

Fig. 1 is a sectional elevation of a hot-air engine constructed in accordance with the invention, parts being shown schematically;

Fig. 2 is a top view of the engine, and

Fig. 3 is a sectional view taken generally along the line 3—3 of Fig. 1, the engine piston being shown in elevation.

In the drawing, 10 designates each of a plurality of cylinder members which are here shown to extend side by side in parallel relation. Each cylinder member has an engine cylinder 11 at one end and a pump cylinder 12 at the other end, the engine cylinder being preferably larger in diameter than the pump cylinder and preferably having a surrounding heat jacket for chamber 11'. Each cylinder member has movable therein a piston member 13 having a piston head or portion 14 fitting in the engine cylinder 11 and a long piston portion 15 fitting in the pump cylinder 12. Power is delivered by each piston in any suitable manner, as by means of a pair of connecting rods 16 engaging a crank-shaft 17 and secured to opposite ends of a piston pin 18 passing through the reduced portion of each piston and through opposite slots 19 in the walls of the pump cylinder. In some instances the crank-shaft may have a fly-wheel 17'. In the case of a two-cylinder engine, the cranks are 180° apart.

The passage of air or other gaseous working substance to and from each engine cylinder is controlled by any suitable mechanically operated valve means. For the purpose of illustration, the valve means are here shown to be poppet valves 20 and 21 for admission and exhaust, respectively, operated by a suitably driven cam shaft 22 rotating at crank-shaft speed and acting through push rods 23 and rocker arms 24.

The passage of the working substance to and from each pump cylinder is controlled by any suitable pressure-operated valve means, here exemplified by check valves 25 and 26 for admission and delivery, respectively.

The working substance, which is air or other gas, is conducted through one or more passages 27 of a heater 28, here indicated to have fire tubes 29, supplied with hot gases of combustion by a suitable burner 30. The air and the hot gases of combustion flow through the heater in opposite directions, so that the air leaves the heater at the hottest part of the heater. The gases of combustion are discharged from the heater through a flue 31 which is in communication with the heat jacket 11'.

Hot air is conducted from the heater 28 to the admission or inlet valves 20 of the engine cylinders by a conduit 32 having a throttle valve 33. Beyond the throttle valve the conduit 32 is branched to lead to the engine cylinders.

A branched outlet conduit 34 conducts the air or other gas exhausted from the engine cylinders to one or more passages 35 of a suitable heat exchanger or regenerator 36. Tubes 37 in the heat exchanger conduct another stream of air at higher pressure to the heater 28. The high-pressure air passing to the heater and the low-pressure air from the engine cylinders flow through the heat exchanger in opposite directions, so that the air flowing to the heater leaves the heat exchanger at the hottest part of the heat exchanger, and the air exhausted from the engine cylinders leaves the heat exchanger at its coolest part.

The cooled air from the heat exchanger flows through a branched conduit 38 to the pressure-operated inlet valves 25 of the pump cylinders 12. The air may be further cooled in its passage through the conduit 38 by a cooler 39. The cooled air enters each pump cylinder on the suction stroke of the piston 13, and when compressed on the following stroke of the piston, the air passes through the delivery valve 26 and into a branch of a conduit 40 through which the air flows to the tubes 37 of the heat exchanger 36. Air is delivered from each pump cylinder 12 at a temperature not greater than the temperature of the low-pressure air leaving the heat exchanger. Heat is preferably abstracted from the air undergoing compression in the pump cylinders, as by radiation from the cylinder walls.

In order to compensate for any leakage and to facilitate starting, a valved air reservoir 41 is

provided to discharge air into the system through a conduit **42**, preferably connected to the high-pressure side of the system at the conduit **40**. In addition, an air pump is provided to supplement the reservoir and preferably discharges into the high pressure side of the system. In the present instance, the air pump forms a part of the engine, an annular compression chamber **43** being formed at the end of the engine cylinder **11** adjacent the pump cylinder **12**. Air is conducted from the compression cylinder to the conduit **40** through a pipe **44** having a check valve **45**. An unloader **46** of any well known construction connected to the compression chamber **43** prevents delivery of an excessive amount of air.

When the engine is to be started for the first time or after the system has lost its pressure on standing, air or other suitable gas is admitted into the high-pressure side of the system from the valved reservoir **41**, and the burner **30** is placed in operation. Hot air from the heater **28** flows through the conduit **32** to the engine cylinders and enters one of the engine cylinders **11** through its then open inlet valve **20**, causing the corresponding piston **13** to move on a power stroke. The inlet valve **20** closes at part stroke, and the air in the cylinder then expands during the rest of the stroke. At the end of the power stroke the exhaust valve **21** opens, and during the return stroke of the piston, the air is exhausted into the conduit **34** and enters the passage **35** of the heat exchanger **36**, imparting heat to the high-pressure air flowing through the tubes **37** to the heater **28**. The cooled exhaust air leaving the heat exchanger flows through the conduit **38** to the inlet valves **25** of the pump cylinders, being further cooled in transit in the cooler **39**. The cooled air is drawn into each pump cylinder **12** on the up-stroke of the piston. At the end of the return stroke of the piston head **14**, the inlet valve **20** of the engine cylinder again opens and the power stroke is repeated. On the power stroke the air drawn into the pump cylinder **12** is compressed, and when the pressure in the pump cylinder exceeds that in the conduit **40** air is discharged from the pump cylinder into this conduit and flows therethrough and through the heat exchanger back to the heater, thus completing the cycle. After the few revolutions of the crank-shaft the pressures in the system reach their normal values, and thereafter additional air is admitted to the system only to compensate for leakage. The speed of the engine is controlled by the throttle valve **33**, or by varying the air pressure, or by burner adjustment.

When the engine is stopped, a sufficient amount of air is stored in the valved reservoir **41** to facilitate subsequent starting. The air capacity of the heater **28** and heat exchanger **36** is preferably somewhat greater than that of the cylinders, so that the pressures in the heater and heat exchanger remain substantially constant during the operation of the engine. The air entering the engine cylinder **11** expands at approximately constant pressure during the first part of the power stroke of the piston, and after the inlet valve **20** closes, the air in the cylinder expands with dropping pressure and temperature, although some heat is absorbed by the expanding gas from the hot walls of the piston and heat-jacketed cylinder.

By providing a closed path for the working substance, the minimum pressure can be above atmospheric pressure so as to increase the mean effective pressure in the engine cylinders. The closed system also permits the use of gases other than air, such as carbon dioxide or nitrogen. A suitable vapor, such as water vapor, may be added to the working substance to improve heat conductivity and absorption.

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

In a heat engine, the combination of a cylinder member forming a pair of tandem cylinders of different diameter, the larger cylinder being an engine cylinder and the smaller cylinder being a pump cylinder, a two-diameter piston movable in said cylinders, the end of the larger cylinder adjacent the smaller cylinder forming an annular compression space with the larger end of said piston, means for heating gas and for conducting the heated gas to said engine cylinder, means for conducting the gas exhausted from said engine cylinder to said pump cylinder, said cylinders and all of said means forming a closed system for the gas, the minimum pressure in said system being above atmospheric, and means supplied by said annular compression space for maintaining the minimum pressure in the system.

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