No. 805,859. PATENTED NOV. 28, 1905.

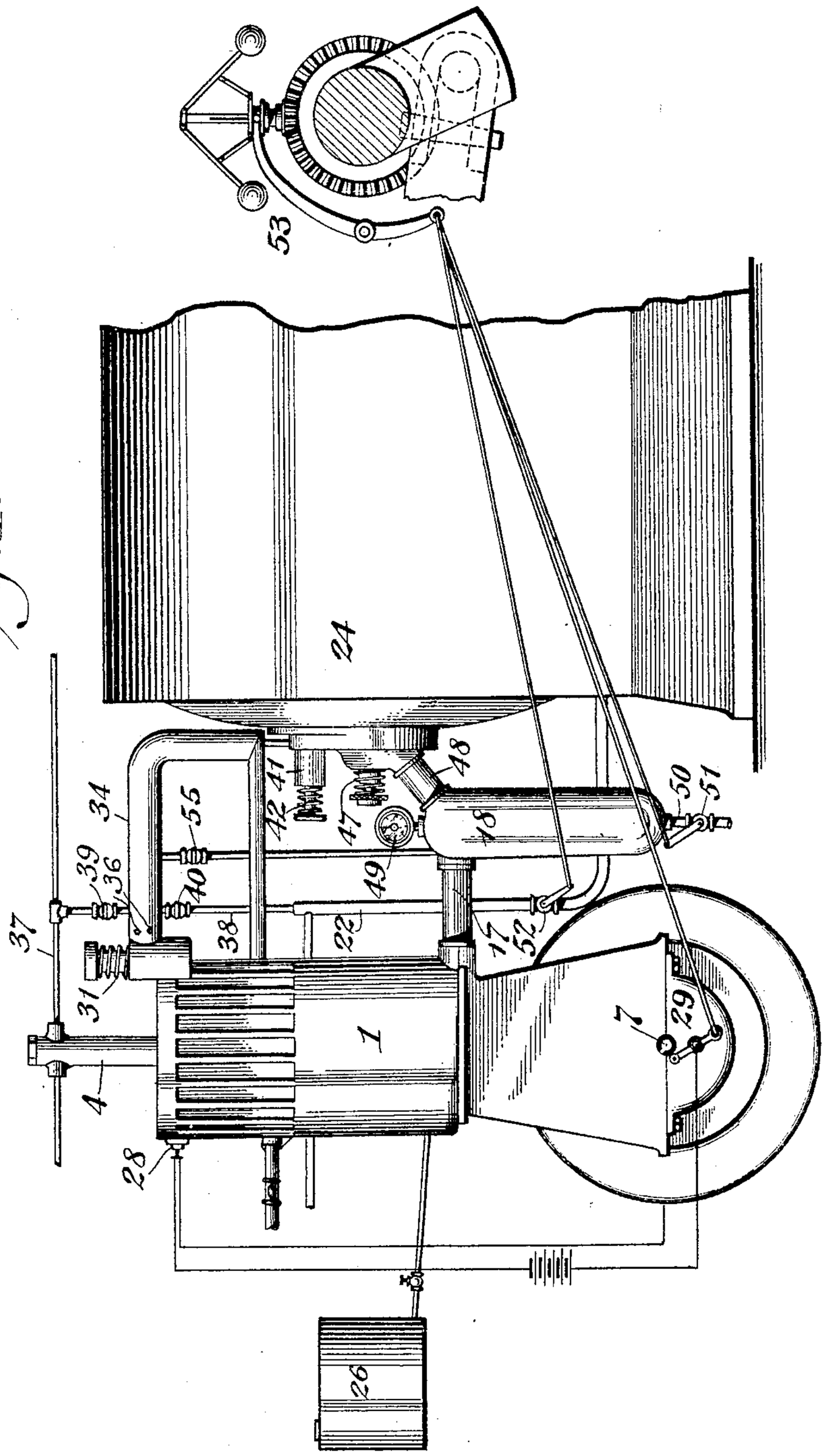
F. E. JUNGE.

HEAT ENGINE.

APPLICATION FILED JULY 11, 1903.

3 SHEETS—SHEET 1.

Fig. 1.



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3 SHEETS—SHEET 2.

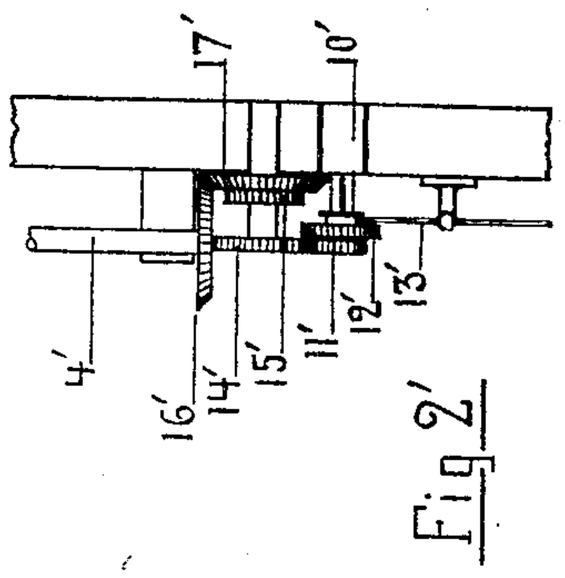

Fig 2'

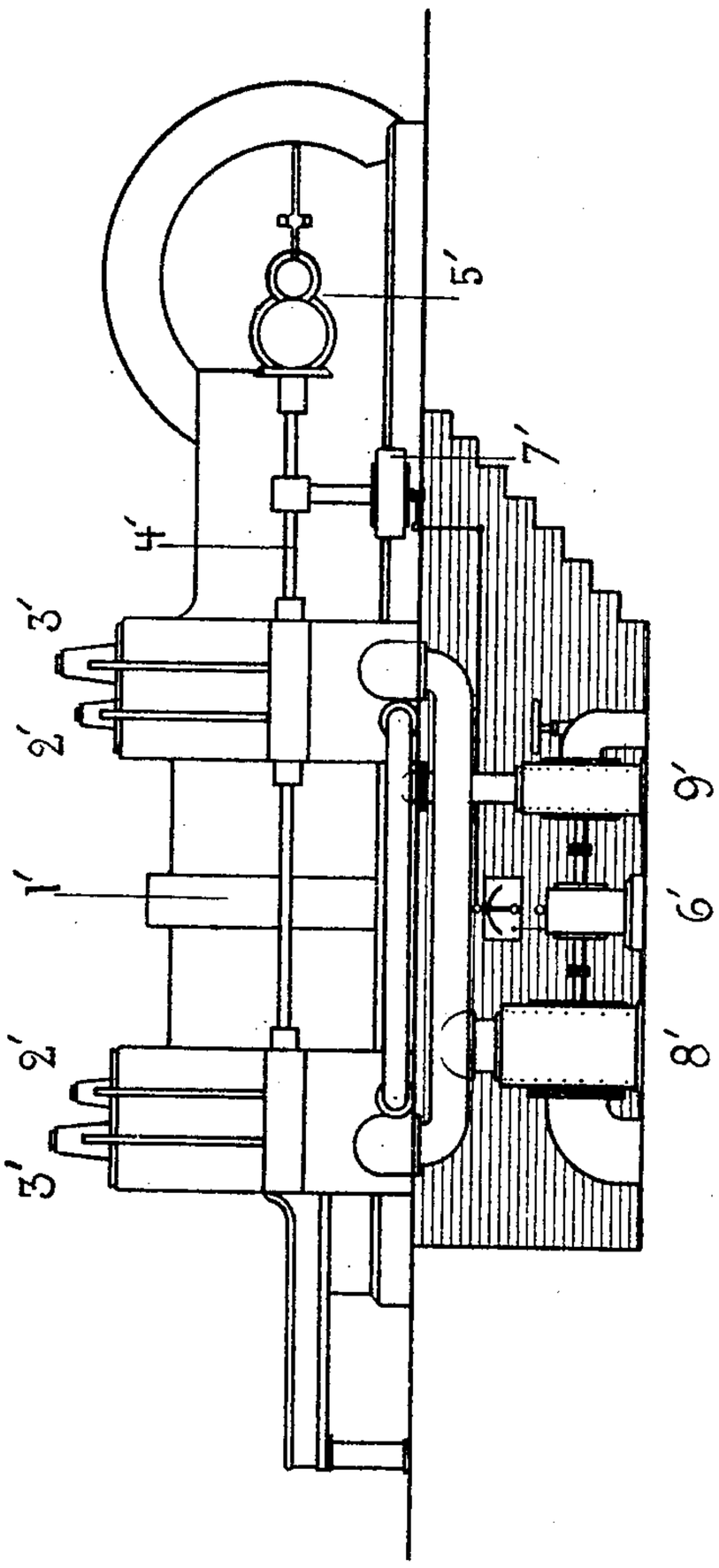

Fig 1'

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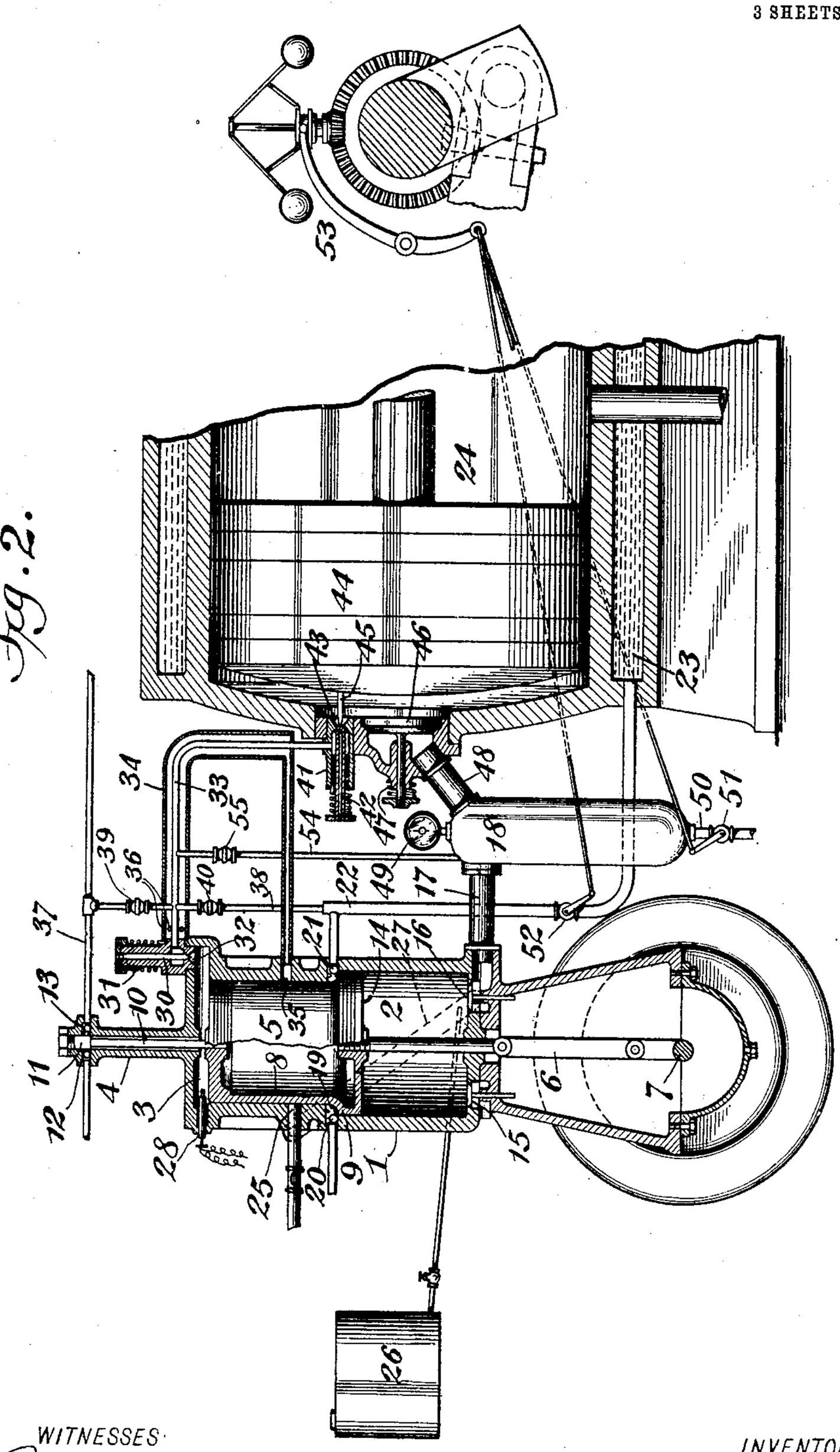
3 SHEETS—SHEET 3.

Fig. 2.



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HEAT-ENGINE.

No. 805,859. Specification of Letters Patent. Patented Nov. 28, 1905.

Application filed July 11, 1903. Serial No. 165,085.

To all whom it may concern:

Be it known that I, FRANZ ERICH JUNGE, of New York, in the county of Kings and State of New York, have invented certain new and useful Improvements in Heat-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The inflexibility of the heat-engine prior to the present invention, especially the heat-engine of the explosive type—that is, its disability to work at all loads equally well—has been one of the main factors to retard its progress and to allow the steam-engine to still hold an important rank among the producers of motive power notwithstanding its inferiority in thermal efficiency.

Compared with that type of engine known as the "Otto cycle," (heating and cooling the gas at constant volume,) which has occupied the first place among heat-engines, owing to its simplicity and attractive principle, the introduction of that type of engine known as the "Diesel cycle" (heating and cooling the gas at constant pressure) meant a great improvement with regard to elasticity, as it is obvious that the heating of a fixed quantity and quiet mass of gas, as in the Otto cycle, results in a certain inflexibility and that, on the other hand, by varying the quantity of fuel injected and by varying the cut-off to the power-cylinder, as in the Diesel cycle, the amount of heating compared to the amount of expansion permitted can be changed, and consequently also the cycle, and thereby the work output.

In the two-cycle type of engine, which embodies many advantages over the four-cycle type and which uses one side of the piston and the inclosed crank-chamber or separate arrangements coupled with the crank-shaft for pumping air into the power-cylinder, in all these engines of the two-cycle type the volumetric delivery of air depends to a large extent on the number of revolutions of the engine and can only be varied within small limits by using large air-pumps and throttling the delivery of the same, more or less, or by varying the pressure in the air-receiver. As it is undesirable to deliver high-pressure air into the engine-cylinder, because it rushes through the exhaust-ports and mixes with the exhaust-gases instead of wiping them out, it becomes necessary to adopt large receivers to get uniform delivery of low-pressure air in regular quantities. Now it is obvious that large air-pumps and large air-receivers increase the size, the weight, the complications, and the cost of manufacture of engines of large units. Moreover, the narrow ranges between the upper and lower limits of the volumetric delivery of air and the imperfect arrangements for regulating the uniformity of this delivery are the reasons for heat-suppression and loss during combustion and the resulting loss in pressure.

Only by mixing the air and fuel at every load in the proper chemical proportions is it possible to get non-reducing non-oxidizing products of combustion, and since none of the heat is then wasted to warm excesses of fuel or oxygen the temperature of combustion will be the highest possible.

Another disadvantage of the heat-engine in its present form prior to this invention is the disability to work with different kinds of fuel equally well without material changes, as the amount of air necessary for the complete combustion of different sorts of fuel is different, and so is the degree of compression required for giving the highest thermal efficiency in each case.

A further drawback is that with the exception of the Diesel type of engine above mentioned none have been able to use crude oil and oil residiums directly without meeting with considerable difficulty with regard to the introduction and regulation of the fuel-supply, and the Diesel method of igniting the fuel charge by compressing the air to about four hundred and fifty pounds to the square inch makes it necessary to construct a heavy engine.

The objects of the present invention are to overcome the difficulties mentioned above and to provide air and fuel pumping devices that are separate from the main engine and that are combined in an auxiliary motor influenced by the governor of the main engine and arranged to work at high speed independently of the speed of the main engine.

The present embodiment of my invention is illustrated in the accompanying drawings, to which reference is to be had in connection with this specification, and in which—

Figure 1 is a side elevation of the auxiliary motor of the invention in its relation to the main engine. Fig. 2 is a vertical section thereof with parts in side elevation. Fig. 1′ is a side elevation of an embodiment of my invention as providing means for transform-

ing an engine of the four-cycle type to an engine of the two-cycle type, and Fig. 2′ is a detail view illustrating the device for changing the gears in such transformation.

Referring to the drawings, and more particularly now to Figs. 1 and 2, the numeral 1 designates the cylinder of my auxiliary motor, which is formed with two communicating compartments 2 3 of different diameters and a reduced extension 4, which together produce three working chambers. Within the said cylinder is mounted a piston 5, connected by a pitman 6 to a crank-shaft 7 and consisting of a body portion 8, working in the chamber 3, and enlargement or step 9, working in the larger chamber 2, and a projected stem or rod 10, working in the cylinder extension 4 and provided at one end with a head 11, controlling a fuel-admission valve 12 and a fuel-delivery valve 13. The chamber 2 of the cylinder, together with the lower face 14 of the step or enlargement 9 of the piston, constitutes an air-pump and is provided below said face with an aspiration-valve 15 and an air-delivery valve 16, the latter controlling a port opening to a pipe 17, which leads to an air-receiver 18. At the same time the said chamber 2 or, more specifically, so much thereof as lies between the upper face 19 of the step 9 during the movement of the piston 5, constitutes with said upper face a water-pump, and for this purpose the cylinder is provided in its wall above said upper face 19 with ports governed by a water-admission valve 20 and a water-delivery valve 21, the latter controlling the delivery of water to a pipe 22, which leads to the water-jacket 23 of the main engine-cylinder 24.

The chamber 3 of the cylinder 1, in which the body portion 8 of the piston works, constitutes a compression and combustion chamber and for this purpose is provided with an inlet-port 25 for air, which may be carbureted in any suitable manner, such as by a gravity-feed device 26, opening into a branch pipe 27, leading from the air-pipe 17 to said inlet-port 25. For this purpose also the said chamber 3 contains at its upper end a sparking plug 28, the sparking of which may be timed and also cut out entirely for any required interval by suitable means—as, for instance, by an ignition-regulating device 29, controlled from the governor of the main engine. A pressure-valve 30, arranged to open at any predetermined pressure, (the regulating means consisting in the present instance of a spring 31, whose tension can be adjusted,) controls a port 32 in the upper end of the cylinder, said port 32 when open permitting the combustion-gases that are raised to incandescence by the sparking plug 28 to rush into a receiver 33, which is in the form of a pipe preferably surrounded or inclosed by an exhaust-pipe 34. The exhaust-pipe 34 is at one end connected to a gas-exhaust port 35 of the chamber 3 and serves to carry off the hot exhaust combustion-gases and to discharge them into the atmosphere through orifices 36 at its other end, thus constituting at the same time a silencer or muffler for the exhaust and a heater for the receiver 33.

The extension 4 of the cylinder 1, together with the projecting rod 10 of the piston, constitutes a fuel-pump, the fuel being pumped from any suitable source of supply past the valves 12 and 13 and thence through a pipe 37 into the receiver 33, where it mixes with the incandescent combustion-gases and with water or steam entering the receiver through a branch 38 of the water-pipe 22. The pipe 37 and branch 38 are both provided with stop-cocks, (designated, respectively, 39 and 40.)

The receiver 33 is connected with a valve-casing 41, located in one end of the cylinder 24 of the main engine, said casing containing an adjustable spring-closed mixture-inlet valve 42, which controls a port 43, leading into the cylinder at one end thereof. The power-piston 44 is provided with a stud or projection 45, arranged to open the valve 42 when the piston arrives near the end of its return stroke, and the point at which said valve is opened may be varied by changing the longitudinal position of the valve. In the same end of the cylinder 24 as the inlet-valve 42, and preferably in proximity thereto, is an air-inlet valve 46 for the main cylinder, said valve being arranged to open inwardly and normally held to its seat at various predetermined pressures by means of a spring 47, whose tension can be adjusted; and communicating with the chamber back of the valve 46 is a pipe 48, leading from the air-receiver 18 and intended to deliver fresh air into the cylinder 24 when the valve 46 is opened.

The air-receiver 18 may be provided with a gage 49, and it is also provided with a vent-pipe 50, having a cock 51. The water-pipe 22, that supplies the water-jacket, is also provided with a cock, (designated 52,) and these two cocks, and likewise the ignition-regulating device 29, may all be controlled and regulated by the governor 53 of the main engine. As any regulating device of this general character may be employed and as many are well known in the art to which this invention appertains, although new in the relation they are herein used, I have deemed it unnecessary to herein set them forth in detail.

The receiver 33 is preferably connected by a pipe 54 to the air-receiver 18, and such pipe is provided with a stop-cock 55, by which the connection between the two receivers may be regulated or completely shut off.

Referring now particularly to Figs. 1′ and 2′, wherein is illustrated my invention applied to a heat-engine of the four-cycle type, 1′ designates an ordinary double-acting four-cycle engine with gas and air inlet valves 2′

and 3′, which are actuated by the secondary shaft 4′, such shaft being driven by a reduction-gear 5′ from the main shaft of the engine. The exhaust valves or ports are not visible in this construction, and it is understood that the action of this engine is identical with that of the well-known type of Otto engine having aspiration, compression, expansion, and exhaust strokes, so as to give one power impulse on two revolutions of the fly-wheel under conditions of low load. To this ordinary four-cycle engine there is added an auxiliary apparatus consisting of a motor 6′, which is regulated in its speed from the governor 7′, according to the load on the engine 1′, and which drives an air-pump 8′ and a gas-pump 9′, which deliver their respective media through valves 3′ and 2′ into the power-cylinder of the main engine as soon as the gear-transmission 5′ is changed from two to one into one to one. Fig. 2′ shows such change-speed gear in plan view. On the extension of the main shaft 10′ there are fastened, by means of a slide-key, two spur-pinions 11′ and 12′, which may, by means of a lever 13′, be brought in or out of mesh with two corresponding pinions 14′ and 15′ in such manner that if 11′ and 14′ mesh the secondary shaft 4′ will, by means of a miter-gear transmission 16′ 17′, run at half the speed of the crank-shaft. If, on the other hand, pinions 12′ and 15′ mesh, the secondary shaft will run at the same speed as the main shaft and will therefore actuate the valves 2′ and 3′, so as to open them once at each revolution of the engine, thereby admitting a power charge for every downstroke. If the lever 13′ is in the position shown in the drawings, the engine will run as a four-cycle engine; but when the load on the engine increases above a certain point then the lever may be actuated so as to transform the four-cycle engine into a two-cycle engine, thereby giving double capacity. It is manifestly to be understood that the present drawings illustrate only one of various possible constructions for attaining the desired result.

The operation of the auxiliary motor with relation to a main engine is as follows: When the piston 5 travels downwardly, the lower face 14 will compress the air which was aspirated on the preceding upstroke, and the air will flow past the valve 16 and through the delivery-pipe 17 into the air-receiver 18. At the same time the upper face 19 of the step 9 will draw in water through the inlet-valve 20, and the rod 10 will draw in fuel past the valve 12. The compressed air from the receiver 18 will as soon as the piston 5 shall have moved downwardly far enough to uncover the port 25 rush through the pipe 27 (in which it may be carbureted, as before mentioned) into the compression and combustion chamber 3 of the cylinder. During the succeeding upstroke of the piston after the inlet-port 25 and exhaust-port 35 have been closed the charge of carbureted air will be compressed and afterward ignited by an electric spark sooner or later, according as it is timed by the regulating device 29, and the same upstroke will deliver water through the pipe 22 into the water-jacket 23 and through the branch 38 into the receiver 33 and will also deliver fuel through the pipe 37 into said receiver. At a predetermined combustion-pressure of the charge in the compression and combustion chamber 3 the pressure-valve 30 will open and allow a portion of the incandescent combustion-gases to rush into the receiver 33, where they may mix with the fuel, air, and water therein contained. There will be sufficient pressure left in the compression and combustion chamber to drive the piston 5 downwardly again by expansion and to thereby actuate the pumps. The piston traveling downwardly will uncover the exhaust-port 35 and allow the exhaust combustion-gases to escape into the silencer and heater 34. Now assuming that there has been an expansion in the main cylinder 24 then the piston 44 will travel forwardly and uncover its exhaust-port and the pressure in the cylinder will sink to atmospheric pressure. As soon as the pressure in the main cylinder is lower than that in the air-receiver 18 the air-inlet valve 46 will open and allow more or less compressed air to enter the main cylinder, where it is recompressed by the succeeding return stroke to a certain degree, dependent on the quantity of air admitted. As soon as the pressure on the cylinder side of the valve 46 exceeds the pressure on the receiver side of the same the inlet-valve will close when worked automatically. Before the point of maximum compression has been reached the projection 45 will open the mixture-inlet valve 42, and the charge of highly vaporized and heated fuel will rush, by means of its own pressure, into the compressed air in the main cylinder, mixing therewith and igniting itself and affording the expansion to drive the main piston, and therefore the main engine. It is readily understood how the governor of the main engine will act on the speed of the motor by regulating the igniter and on the delivery of the water and air by regulating the respective cocks 52 and 51 more or less.

I have below enumerated some of the advantages derived by using an arrangement as described in this invention.

In reference to simplicity, by separating the air, fuel, and water or steam pumping devices from the main engine and combining them in a special motor, which may be run at a high speed independently of the speed of the main engine, the dimensions of the pumps and of the air-receiver decrease in proportion to the increase in the number of revolutions. The construction and appearance of the main engine are simplified by omitting these accessories, and the size, weight, and cost of the

entire plant are reduced. Starting the main engine is effected by starting the small auxiliary motor, which latter can be done by hand. This causes the first downstroke to be effected by means of compressed air, while at the end of the following compression-stroke the incandescent fuel charge is injected, ignited, and creates the expansion for the working stroke, just as during the time of actual working. No auxiliary receivers for storing compressed air and no starting-valves or other complications are required. Any four-cycle engine can be changed into a two-cycle engine, giving twice the horse-power, by adjusting the transmission to the secondary shaft and gearing it "one to one," as above described. If thus connected with an auxiliary motor, the two idle strokes of the main engine (aspirating and compressing) will be replaced by a working and an exhaust stroke, the result being one expansion at every revolution, and thereby doubling the efficiency.

In reference to elasticity, the expulsion of the exhaust-gases is done more perfectly and completely, as the uniformity of the air delivery is maintained and increased with the increased number of revolutions of the air-pump. As the auxiliary motor can be worked on widely-variable speeds, either influenced by hand or by the governor of the main engine by regulating and changing the point of ignition, the ranges between the upper and lower limits of the quantity of fuel delivery and air delivery are raised, and thereby the capability of minutely adjusting the quantity of the combustible power charge in proportion to the load of the main engine is created. By regulating the tension of the pressure-valve the amount of pressure in the fuel charge and the time of its injection into the power-cylinder can be changed. By regulating the time of opening and cut-off of the fuel-valve the amount of heating compared to the amount of expansion permitted can be changed. By changing the time of opening the air-valve the point where the wiping out of the exhaust-gases begins and to a certain extent the degree of compression allowed can be changed. By changing the connections between the governor of the main engine and the air and water cocks it is possible to keep the degree of compression constant or diminish it with the increase of load, as well as to adjust the degree of cooling according to the load and to the kind of fuel used.

In reference to economy, if the main motor or engine is not running the auxiliary motor can be used for either pumping and compressing air or for pumping water or for any other purpose, its power being increased when the pressure-valve 30 is completely closed. Any kind of fuel can be used and without fear of getting an inferior degree of efficiency, as the degree of compression can be changed according to the fuel used as well as the amount of admixture with the products of combustion from the auxiliary motor and the amount of preheating. Crude oil and oil residuums can be used. As before mentioned, the utilization of heavy oils has hitherto been attended with considerable difficulty, the combustion being imperfect, except in the Diesel type of engine, and as to such type instead of compressing the air to such a high and fixed pressure, as four hundred and fifty pounds, this invention provides the preheating of the fuel charge to such an extent that it reaches a temperature higher than the point of ignition, so that it will inflame as soon as it comes into contact with air, even if such air be of lower pressure and temperature. Combustion-gases at the point of explosion are the best means of vaporizing, heating, and decomposing a fuel. If water or steam be added, the fuel will be decomposed into light and heavy gases, such as hydrogen, carbon monoxid, and the like. If combustion-gases are alone used—namely, steam-vapor and carbonic acid—the fuel will also be decomposed into carbon monoxid and the like.

The advantages derived from the decomposition of the fuel are the following: The ranges of explosibility are increased. The light and volatile gases are first ignited, leaving the carbon monoxid to inflame later, the combustion being of a progressive nature and more perfect. Neither hydrogen nor carbonic-oxid gases when undergoing combustion emit smoke or smell, and both gases are permanent or free from condensation when in a cold state.

I claim as my invention—

1. The combination with a heat-engine, of air and fuel pumping devices, an independent motor in which said devices are combined, and means for controlling the speed of said motor by the main-engine governor so as to vary the output of said devices according to the load, while the respective proportions of air and fuel remain the same.

2. The combination with a heat-engine, of separate air and fuel pumping devices independent thereof and arranged to pump air and fuel separately thereto, a motor in which such pumping devices are incorporated, and means, controlled by the engine-governor, for running the motor at different speeds according to the load on the engine.

3. The combination with a heat-engine, of separate air and fuel pumping devices therefor, an independent motor in which said pumping devices are incorporated, said motor being arranged for regulation by the main-engine governor and capable of running at variable speeds according to the load, and such pumping devices compressing the air and fuel, separate from each other, to such temperatures that the fuel will ignite after being injected into the main-engine cylinder by mere contact with the air injected therein.

4. The combination with a heat-engine, of an auxiliary motor independent thereof and providing the main engine with dynamic medium, said motor being influenced in its speed by the engine-governor so as to vary the quantity of such dynamic medium according to the load while its quality remains the same.

5. The combination with a heat-engine, of fuel, water, and air pumping devices connected therewith, and a motor in which said pumping devices are incorporated, said motor being provided with its own variable igniting device which is under the control of the main-engine governor, whereby it may run at various speeds according to the load on the engine.

6. The combination with a heat-engine, of a fuel-pumping device connected therewith and arranged to pump fuel to the engine separate from the air necessary for its complete combustion, said pumping device being provided with its own impelling or driving power which is independent of the engine and which is arranged for regulation by the governor of the engine.

7. The combination with a heat-engine, of a motor provided with a fuel-pumping device arranged to pump fuel into the engine and also provided with a combustion-chamber, means for mixing the incandescent combustion-gases with the fuel exclusive of air, means for admitting air into the engine-cylinder separately from the mixture of incandescent combustion-gases and fuel, and means for admitting the mixture of incandescent combustion-gases and fuel into the engine-cylinder to there mix with the air and ignite.

8. The combination with a heat-engine, of a motor provided with a fuel-pumping device arranged to pump fuel to the engine, and also provided with a compression and combustion chamber and a piston working therein, means for igniting the compressed gases in said chamber, and means for mixing the combustion-gases with the fuel before they are admitted to the engine.

9. The combination with a heat-engine, of a motor provided with a fuel-pumping device, a fuel-receiver connected therewith and with the engine, and a compression and combustion chamber, a piston working in said chamber, means for incandescing the compressed combustion-gases in said chamber, there being a passage connecting the said chamber and the fuel-receiver, and a valve controlling the said passage.

10. The combination with a heat-engine, of a motor provided with a fuel-pumping device, a fuel-receiver connected therewith and with the engine, and a compression and combustion chamber, a piston working in said chamber, means for incandescing the compressed combustion-gases in said chamber, there being a passage connecting said chamber and the fuel-receiver, and a valve controlling said passage and adjustable to predetermined pressures.

11. The combination with a heat-engine, of a motor provided with a fuel-pumping device having a receiver arranged to deliver fuel into the engine, and also provided with a compression and combustion chamber, a piston working in said chamber, there being a passage connecting the said chamber with the fuel-receiver, and a valve in said passage, said valve being arranged to permit, at a predetermined pressure, a portion of the combustion-gases to mix with the fuel in the receiver, and the remaining portion of the gases serving to work the piston by expansion.

12. The combination with a heat-engine, of a motor provided with a fuel-pumping device arranged to pump fuel into the engine, and also provided with a compression and combustion chamber and a piston working therein, means for igniting the compressed combustion-gases in said chamber, means for mixing the combustion-gases with the fuel, and means whereby the piston will work the pumping devices.

13. In a device of the character described, a motor provided with a cylinder constituting an air-pump chamber, a water-pump chamber, a gas compression and combustion chamber, and a fuel-pump chamber, and a piston working in said cylinder and serving for all of said chambers.

14. The combination with a heat-engine, of separate air and fuel pumping devices independent of the engine and arranged to pump air and fuel separately thereto, means for compressing said air and fuel separately to any desired degree, and means for injecting said compressed air and fuel separately into the engine to there mix and ignite, a motor in which said devices are incorporated, and means for regulating the speed of the motor according to the load of the engine.

15. In a device of the character described, a motor provided with a cylinder having air aspiration and delivery ports, gas inlet and delivery ports, water inlet and delivery ports, and fuel inlet and delivery ports, and a piston working in said cylinder and controlling said ports.

16. The combination with a heat-engine of the four-cycle type, of air and fuel pumping devices independent of said engine, a separate motor in which said devices are incorporated and arranged to run at variable speeds and having its own impelling power, means for controlling the speed of said motor according to the load on the engine, and means controlled by the engine for admitting the charge of air and fuel into the engine-cylinder once at each revolution of the engine, whereby the four-cycle engine is transformed into a two-cycle engine.

17. In a device of the character described, a motor provided with a cylinder having two communicating compartments and an extension, one of said compartments being of larger

diameter than the other, and one of said compartments constituting an air-pump chamber and a water-pump chamber, while the other constitutes a gas compression and combustion chamber, and the extension constituting a fuel-pump chamber, and a piston working in said cylinder, said piston consisting of a body portion working in the compression and combustion chamber, a stepped or enlarged portion working in the air-pump and water-pump chamber, and a stem working in the fuel-pump chamber.

18. The combination with a heat-engine of the four-cycle type, of an auxiliary motor arranged to pump air and fuel separately into said engine and having means for precompressing said air and fuel separately to any desired degree, means for recompressing and igniting the charge in the main engine, and means for regulating the admission and ignition of the air and fuel charge to take place once at every revolution of the main engine.

19. Means for transforming a four-cycle engine into a two-cycle engine, consisting in the combination of the four-cycle engine with an independent motor, said motor having means for delivering air and fuel into the main engine once at each revolution of the same, said means being controlled by the main engine.

20. The combination with a heat-engine, of a fuel-pumping device separate from the engine and arranged to pump fuel thereto, means for preheating said fuel to its own ignition temperature so that it will ignite when brought into contact with air even of lower temperature and pressure in the main-engine cylinder, a motor in which said means are incorporated, and means for varying the speed of the motor according to the load on the main engine.

21. The combination with a heat-engine, of a motor provided with air and fuel pumping devices having receivers arranged to deliver air and fuel into the engine, and said motor also provided with a compression and combustion chamber and means for mixing combustion-gases with the fuel, and means for automatically admitting air from the air-receiver into the compression and combustion chamber.

22. The combination with a heat-engine, of a motor provided with air and fuel pumping devices having receivers arranged to deliver air and fuel to the engine, and said motor also provided with a compression and combustion chamber and means for mixing combustion-gases with the fuel, means for automatically admitting air from the air-receiver into the compression and combustion chamber, and means for carbureting the air on its way to the said chamber.

23. The combination with a heat-engine, of separate air and fuel pumping devices, an independent motor in which said pumping devices are incorporated, and means for injecting said air and fuel separately under variable pressures and during any part of the stroke of the main-engine piston into the cylinder of the main engine, said pressures being controlled according to the load on the main engine.

24. The combination with a heat-engine, of a fuel-pumping device separate from the engine and arranged to pump fuel thereto, a gas-motor in which said pumping device is incorporated, and a variable ignition-regulating device for said motor, said ignition-regulating device being arranged for control or influence by the governor of the engine.

25. The combination with a heat-engine, of air and fuel pumping devices separate therefrom and provided with a combustion-chamber and an igniting device therefor, means for mixing the incandescent combustion-gases produced in said chamber with the fuel to form a superheated inexplosive mixture, means for admitting such mixture to the engine-cylinder, and means for admitting air to the said cylinder separately from the said mixture, whereby the latter will, in said cylinder, mingle with the air and ignite.

26. The combination with a heat-engine, of means combined in a motor separate from the engine, for injecting air and combustibles into the engine, and means controlled by the engine-governor for regulating the motor to various speeds according to the load on the engine.

27. The combination with a heat-engine, of a motor provided with a fuel-pumping device and an air-pumping device both arranged to deliver to the engine, and said motor also provided with a compression and combustion chamber and with means whereby a portion of the gases incandesced in said chamber will mix with the fuel and the remainder will actuate or drive the motor.

28. The combination with a heat-engine, of a motor provided with a fuel-pumping device arranged to deliver to the engine, and said motor also provided with a combustion-chamber and a piston working therein and arranged to actuate the pumping device, means for incandescing gases in said chamber whereby to drive said piston, and means whereby a portion of the incandescent combustion-gases, at a predetermined pressure, will be permitted to mix with the fuel and be pumped to the engine.

29. The combination with a heat-engine, of air and fuel pumping devices, combined in an independent motor which is arranged for regulation by the main-engine governor, such devices precompressing the air and fuel separately and injecting them into the main engine-cylinder, where they may be recompressed and ignited.

30. The combination with a heat-engine, of a pumping device connected therewith and arranged to pump air to the engine separate from the fuel necessary for combustion, said pumping device being provided with its own im-

pelling or driving power arranged for regulation by the governor of the engine.

31. The combination with a heat-engine, of an auxiliary motor providing the main engine with cooling medium the quantity of which is regulated by the governor of the engine.

32. The combination with a heat-engine, of an auxiliary motor whose speed is regulated by the governor of the main engine, and delivering into said engine air, fuel, and cooling medium in quantities varying with the load.

33. The combination with a heat-engine, of an auxiliary pumping-motor which aspirates air from the surrounding atmosphere and gas from some source of production and delivers these two constituents separately into the main engine, said motor being arranged for regulation by the main-engine governor so as to vary the quantity of such air and gas delivery according to the load.

34. The combination with a heat-engine, of an air-pumping device separate from the engine and arranged to pump air thereto means for preheating the air by recompression in the auxiliary pump and by precompression in the main-engine cylinder to such temperatures that the fuel will ignite when brought into contact with such compressed air in the main-engine cylinder, a fuel-pumping device for delivering fuel to the main-engine cylinder, a motor in which said means are incorporated, and means for varying the speed of the motor according to the load on the main engine.

35. The combination with a heat-engine, of an auxiliary engine embodying air and fuel pumping devices separate from the engine and arranged to pump air and fuel thereto, means for heating the air or fuel or both the constituents separately by compression, first in the auxiliary and then in the main engine, to such temperatures that combustion will ensue when the air and fuel are brought in contact in the main-engine cylinder, and means for varying the speed of the auxiliary according to the load on the main engine.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

FRANZ ERICH JUNGE.

Witnesses:

H. DIEDERICH,

FREDERICK S. STITT.