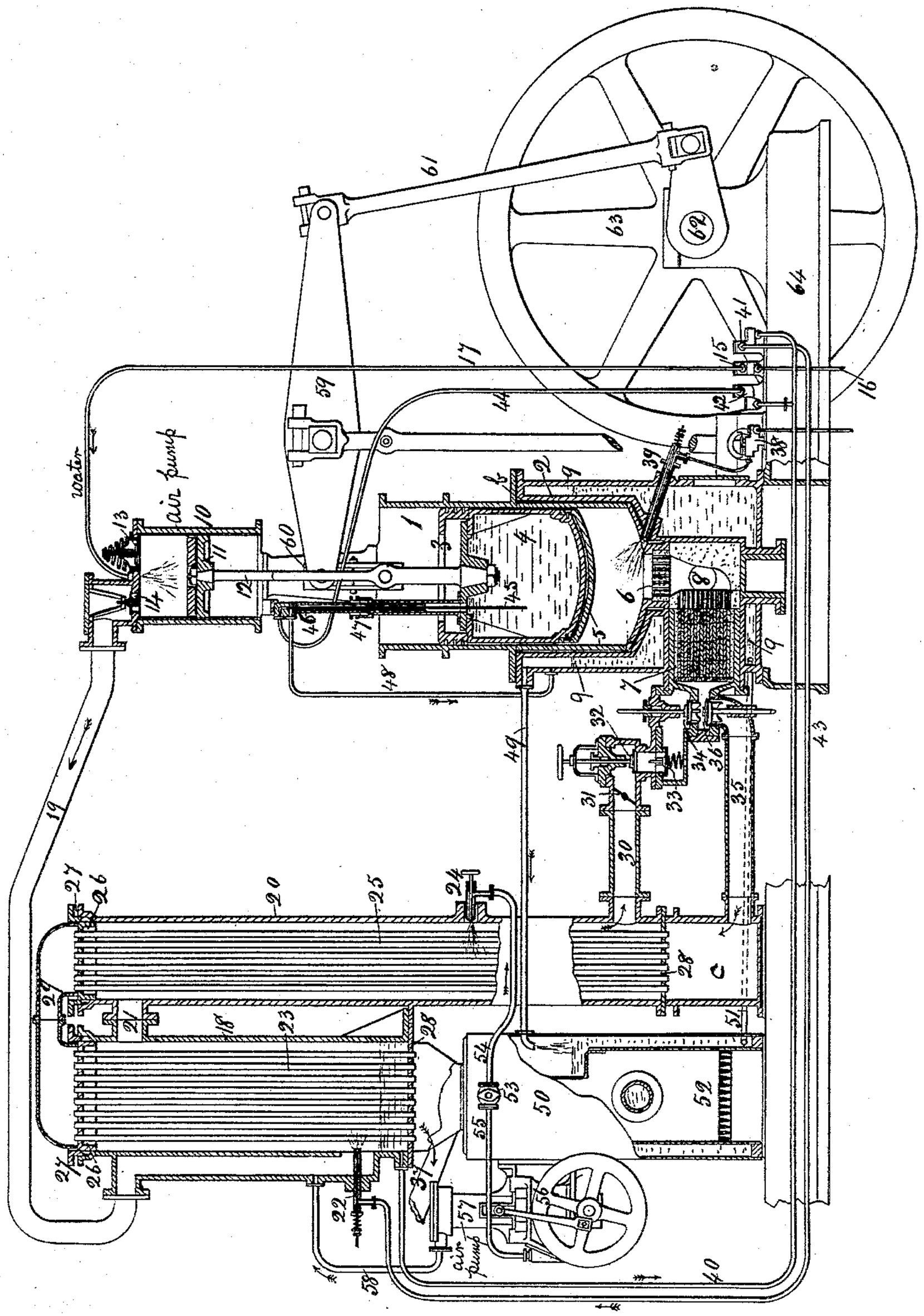
(No Model.)

J. HARGREAVES.

INTERNAL COMBUSTION THERMO DYNAMIC MOTOR.

No. 401,161. Patented Apr. 9, 1889.



WITNESSES.

D. Clinton

M. F. Johnson

INVENTOR

James Hargreaves.

UNITED STATES PATENT OFFICE.

JAMES HARGREAVES, OF FARNWORTH, COUNTY OF LANCASTER, ENGLAND.

INTERNAL-COMBUSTION THERMO-DYNAMIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 401,161, dated April 9, 1889.

Application filed March 29, 1888. Serial No. 268,824. (No model.) Patented in England July 26, 1882, No. 3,540, and April 15, 1887, No. 5,485; in France February 6, 1883, No. 153,536, and December 5, 1887, No. 187,401; in Belgium February 7, 1883, No. 60,385, and December 6, 1887, No. 79,827; in Italy March 31, 1883, No. 15,185, and November 30, 1887, No. 22,711; in Spain April 12, 1888, No. 12,328, and in Canada August 23, 1888, No. 29,736.

To all whom it may concern:

Be it known that I, JAMES HARGREAVES, of Farnworth, in the county of Lancaster, England, have invented a new and useful Improvement in Internal-Combustion Thermo-Dynamic Motors, (for which I have obtained Letters Patent in Great Britain, No. 5,485, April 15, 1887, and No. 3,540, July 26, 1882; in France, No. 153,536, February 6, 1883, and No. 187,401, December 5, 1887; in Belgium, No. 60,385, February 7, 1883, and No. 79,827, December 6, 1887; in Italy, No. 15,185, March 31, 1883, and No. 22,711, November 30, 1887; in Spain, No. 12,328, April 12, 1888, and in Canada, No. 29,736, August 23, 1888;) and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention relates to an improvement in that class of motors which are driven by power obtained from the combustion and explosion of liquid or gaseous fuel and air within a working chamber or cylinder; and its object is to provide a motor in which the heat generated by such combustion shall be, as far as possible, utilized in the performance of work.

The accompanying drawing is a vertical sectional view of my improved motor.

The invention consists, essentially, in combinations of various parts of the motor taken as entireties, which, being used in certain sequence, coact to produce the results which I desire; and it does not consist, necessarily, in the particular details of construction or location of the individual elements of the combinations, which may be varied in many ways by the skilled mechanic without departing from the principles of my invention.

In the drawing, 1 represents the working-cylinder of the motor, which is attached to the combustion-chamber 2. A packing, of asbestus or other non-conducting material, (indicated by the line *b*,) is placed between the working-cylinder and the combustion-chamber to prevent the conduction of heat from one to the other.

3 is the piston, working in the cylinder 1 and provided with a hollow base, 4, through which water is circulated. The combustion-chamber and the base of the piston are made with double walls 5, so disposed as to leave intervening spaces, which are filled with material having a low capacity for the conduction of heat. By this construction the surfaces exposed to heat may be readily renewed when worn, and the main walls of the combustion-chamber and piston-base are largely protected from the effects of the heat generated in the combustion-chamber, while at the same time the temperature of the combustion-chamber is kept so high as not to prevent the proper combustion of the fuel.

At the base of the combustion-chamber is a perforated block of fire-clay, 6, forming a hearth between the combustion-chamber and a regenerator-chamber, 7, which is lined with refractory material, and is filled with strips of metal or tubes or bricks of earthenware arranged in such manner as to expose a large surface for receiving and imparting heat.

8 is the opening to the regenerator, which is hermetically sealed with a suitable door.

The combustion-chamber and the regenerator-chamber are inclosed by a water-jacket, 9. Separate jackets for the several parts may be employed.

10 is an air-pump, whose piston 11 is connected with the piston 3 of the main cylinder by a piston-rod, 12. The air-pump 10 is provided with an inlet suction-valve, 13, and with a delivery-valve, 14, which controls the port connecting the cylinder of the air-pump with a delivery-pipe, 19.

15 is a water-pump, which is driven from any convenient moving part by means of connections so made that the amount of water is regulated by a governor, as is well understood. The suction-pipe 16 of this pump leads from a water-supply and provides all the water used by the motor. The delivery-pipe 17 of the pump discharges into the cylinder of the air-pump 10. The delivery-pipe 19 of the air-pump enters a chamber or vessel, 18, which I call the saturating-chamber, its function being to charge the air with aqueous vapor.

20 is a superheating vessel or chamber

which is connected with the saturating-chamber 18 by a pipe or way, 21. Although it is advantageous to use two vessels, 18 and 20, for saturating and superheating, one vessel may be made to serve both purposes. The chamber 18 is provided with a number of tubes, 23, which extend through the chamber and fit in plates 26 and 28 at or near its ends. In like manner the chamber 20 is provided with tubes 25, which fit at the ends in end plates, 26 and 28, and in order to allow the tubes to expand and contract freely I fit the upper tube-plates, 26, within stuffing-boxes 27, while the lower tube-plates, 28, are fixed within the chambers 18 and 20.

22 is a water-injector pipe or nozzle which discharges into the saturating-chamber 18, and 24 is a steam-injector which discharges into the superheating-chamber 20.

The chambers 18 and 20 are connected at their upper ends above the plates 26 by a hook, 29, which forms a passage from the tubes 23 in the chamber 18 to the tubes 25 in the chamber 20.

30 is a way leading from the chamber 20 to the regenerator-chamber 7. It is provided with a throttle-valve, 31, hand-valve 32, check or non-return valve 33, and inlet-valve 34, the last-named of which valves is operated by the moving parts of the motor.

35 is a way which leads from the regenerator-chamber 7 past an exhaust-valve, 36, to a chamber, *c*, beneath the bottom plate, 28, of the superheating-chamber 20, by which chamber it gains access to the tubes 25.

At the base of the saturating-chamber 18, below the base-plate, 28, is a chamber provided with a discharge flue or chimney, 37, and communicating directly with the tubes 23.

The throttle-valve 31 is connected with a governor on the motor, so that the area of the way 30 will be increased or diminished according to the speed of the engine. The stop-valve 32 is for closing the passage 30 and shutting off the air-supply when the motor is at rest. The non-return valve 33 is for the purpose of preventing the products of combustion traveling back through the way 30 if there should be a pressure in the working-cylinder of the engine in excess of that in the chambers 18 and 20 back of the valve. If desired, one of the ways 30 35 may be arranged inside the other, so that some of the heat of the outgoing products may be transferred to the incoming gases. The inlet-valve 34 and the exhaust-valve 36 are opened and closed at the proper times by eccentric cams or other suitable valve-gear which is connected with the moving parts of the engine. 38 is a pump for forcing liquid or gaseous fluid through the injector 39 into the combustion-chamber 2.

If the fuel is obtainable at sufficient pressure, a valve may be substituted for the pump; but in either case the valve or pump should be controlled by a governor connected with the moving parts of the motor, so that the amount of fuel supplied at each stroke of the engine-piston shall be in proportion to the work to be done.

40 is the pipe which leads from the saturating-chamber 18 to water-pumps 41 and 42.

43 is a pipe which leads from the pump 41 to the water-injector 22 of the chamber 18, and 44 is a pipe from the pump 42 to a pipe, 45, which is secured to the air-pump 10 and leads to the interior of the hollow piston-base 4. The pipe 45 is surrounded by a pipe, 46, attached thereto at the top and leading from the interior of the piston-base 4 through a stuffing-box, 47, to a pipe, 48, which connects it with the water-jacket 9. The stuffing-box 47 is secured to the piston 3 by a stem.

49 is a pipe which leads from the upper part of the water-jacket 9 to the upper part of a vessel or chamber, 50, and which conducts steam generated in the water-jacket to the said chamber, and 51 is a pipe which connects the lower part of the water-jacket with the lower part of the chamber 50. The chamber 50 is heated by a furnace, 52. It serves as a chamber in which water and steam flowing through the pipes 49 and 51 from the water-jacket 9 are separated from each other, and it also serves as a boiler in which steam is generated for use in starting the motor. Two vessels might be used, one for separating and the other for generating steam; but not so conveniently.

53 and 54 are pipes leading from the upper part or steam-space of the chamber 50 and are provided with a two-way valve, 53. The pipe 54 leads to the steam-injector 24 of the superheating-chamber 20, and the pipe 55 leads to the steam-chest of a steam-engine, 56, which actuates an air-pump, 57. This air-pump is connected with the chamber 18 by a pipe, 58.

63 is the fly-wheel of the motor, and 62 is the crank-shaft which is connected with the piston-rod 12 by a beam, 59, links 60, and connecting-rod 61.

64 is the base-plate and framing of the motor. The various moving parts—such as the pumps, governor, and inlet and exhaust valves—are connected with the driven parts of the motor and are actuated thereby in any suitable manner. As these connections will be readily understood by those skilled in the the art, and as they do not form part of my invention, I have not deemed it necessary to illustrate them in the drawing.

A motor under my invention is started as follows: I attach a portable furnace to the opening 8 and allow the products of combustion from the said furnace to pass through the regenerator 7 and exhaust-valve 36 and tubes 25 and 23 to the chimney or flue until the hearth 6 becomes red-hot. I heat the vessel 50 by means of the furnace 52 until steam is formed in the said vessel 50, and the water in the jacket 9 is heated by circulation. I then open the valve 53, so as to allow steam from the vessel 50 to actuate the engine 56, give motion to the pump 57, and force air into the saturator 18 and superheater 20 until sufficient pressure

is obtained to start the motor. I now close the opening 8 and open the stop-valve 32, whereupon the air enters the chamber 2 and gives motion to the piston 3 and its connections. The valve 53 is now turned so as to shut off steam from the engine 56 and allow it to pass by the pipe 54 to the injector 24. It will be evident that the regenerator and furnace must be sufficiently heated before the steam is allowed to flow from the jacket to the engine.

When the motor is started, as above set forth, the following actions take place: During the downstroke of the piston 3 air is drawn into the pump 10, and the products of combustion in the cylinder 1 and chamber 2 are expelled through the hearth 6, regenerator 7, and tubes 25 and 23 to the chimney or flue 37, and as the piston reaches the bottom of its stroke the pump 38 forces liquid or gaseous fuel through the injector 39 into the chamber as soon as the exhaust-valve 36 is closed. The inlet-valve 34 is now opened, hot air and water-vapor enter the combustion-chamber, mix with the fuel, and combustion takes place. The inlet-valve 34 is now closed and the heated products of combustion force the piston to the top of its stroke. During the passage of the air through the chambers 18 and 20, regenerator-chamber 7, and hearth 6 it becomes heated by the radiating-surfaces of these chambers, which are heated by the outgoing products of combustion. In passing through the chamber 18 it is charged with water, which is forced in a spray into the chamber by the injector 22, so that the air shall be thoroughly subjected thereto. In passing through the vessel 20 it is further charged with steam and superheated, and as a final step an intense heat is given to the air and vapor by the regenerator-chamber 7, which affords a common way for the alternate passage of the outgoing products of combustion from the working-cylinder and the incoming air. By thus supplying very hot air and vapor to the engine-cylinder much more power is obtainable from the engine than if the air were fed in a cold state thereto, and in this way I am enabled to utilize the waste heat and to cause it to contribute directly to the efficiency of the engine. The hearth 6 and regenerator-chamber 7 really form part of the same element, their functions being analogous, and one may be used without the other. I therefore include both and either by the use of the term "generator" in the following claims. During the upstroke of the piston 3 water is injected into the air-pump 10 by the water-pump 15, and the air and water mixed are forced out of the pump 10 into the saturator and superheater 18 and 20. The pumps 41 and 42 are also actuated, and cause water to be circulated by the pump 41 from the saturator 18 to the injector 22 and by the pump 42 from the saturator 18, through the piston 3 and jacket 9, to the vessel 50, whence the said water passes in the form of steam through the injector 24 into the chamber 20.

The circulation of water through the piston-base 4 and jacket 9 not only serves the purpose of producing steam for use in the motor, but also serves to carry off excess of heat conducted through the walls of the combustion-chamber 2.

When gaseous fuel is used, it is advantageous to heat it before it is injected into the combustion-chamber.

I claim—

1. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, a heating-chamber with which the supply-passage communicates, an air-pump, 10, communicating with the heating-chamber, and a water-supply which discharges into the working-cylinder, of the air-pump, whereby the air is mingled with water or aqueous vapor prior to its delivery to the heating-chamber, substantially as and for the purposes described.

2. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, of a saturating chamber or vessel communicating with the air-supply passage, through which chamber or vessel the air-supply passes, said saturating chamber or vessel being provided with a steam or water supply, whereby the air is charged with aqueous vapor, and a superheating-chamber, through which the air and aqueous vapor pass and wherein they are superheated, substantially as and for the purposes described.

3. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage having the valves 34 and 26, of a saturating chamber or vessel communicating with the air-supply passage, through which chamber or vessel the air-supply passes, said saturating chamber or vessel being provided with a steam or water supply, whereby the air is charged with aqueous vapor, and a regenerator-chamber communicating with the exhaust-port of the engine and also interposed in the air-supply passage between the saturator and the combustion-chamber, substantially as and for the purposes described.

4. In an internal-combustion motor, the combination, with the main piston, an air-pump operated therefrom, and an air-duct and a combustion-chamber having an air-supply passage, of a saturating chamber or vessel communicating with the air-supply passage and the air-duct, through which chamber or vessel the air-supply passes, said saturating chamber or vessel being provided with a steam or water supply, whereby the air is charged with aqueous vapor, a regenerator-chamber communicating with the exhaust-port of the engine and also interposed in the air-supply passage between the saturator and the combustion-chamber, and valves controlling the passage from the saturator to the generator, and also controlling the passage from the regenerator to the delivery end of the exhaust.

5. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, of a saturating chamber or vessel communicating with the air-supply passage, through which chamber or vessel the air-supply passes, said saturating chamber or vessel being provided with a steam or water supply, whereby the air is charged with aqueous vapor, and a flue or flues extending through the saturating-chamber and forming a passage-way for the exhaust from the motor-cylinder, whereby the exhaust is used for heating the said saturating-chamber, substantially as and for the purposes described.

6. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, of a saturating chamber or vessel communicating with the air-supply passage, and through which chamber or vessel separately pass the air and the products of combustion, said saturating chamber or vessel being provided with a water-supply, whereby the air is charged with aqueous vapor, and a pump, 41, connected with the water-supply and adapted to spray the water into and saturate the air in the saturating chamber or vessel, substantially as described.

7. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, of a saturating chamber or vessel communicating therewith, through which chamber or vessel the air-supply passes, a water-jacket for the motor, which water-jacket is connected with the saturating-chamber, and a pump also connected therewith, whereby a circulation of the water through the jacket and the saturating-chamber is maintained, substantially as and for the purposes described.

8. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, of a chamber or vessel communicating therewith, through which chamber or vessel the air-supply passes, a water-jacket for the motor, a boiler, 50, communicating with the water-jacket and with the said chamber or vessel, and an air-pump whose engine is connected with the boiler, the delivery-pipe of said air-pump communicating with the air-supply, substantially as and for the purposes described.

9. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, of a saturating-chamber, 18, communicating with the said air-supply passage, through which chamber the air-supply passes, said saturating-chamber being provided with a water-supply, whereby the air is charged with aqueous vapor, a second saturating-chamber, 20, interposed between the chamber 18 and the air-supply passage and provided with a steam-supply pipe, and a passage leading from the exhaust of the said combustion-chamber through said saturating-chambers, whereby the air and aqueous vapor passing through the saturating-chambers are heated, substantially as and for the purposes described.

10. In an internal-combustion motor, the combination, with the combustion-chamber having an air-supply passage, of a saturating chamber or vessel, 18, communicating therewith, through which chamber or vessel the air-supply passes, and a water-supply pump having its inlet and discharge ports communicating with said saturating-chamber, whereby a continuous circulation of water into and from said saturating-chamber is maintained, substantially as and for the purposes described.

In testimony whereof I, the said JAMES HARGREAVES, have hereunto set my hand.

JAMES HARGREAVES.

Witnesses:
J. KING,
W. B. JOHNSON.