H. J. KLINE.

INTERNAL COMBUSTION ENGINE.

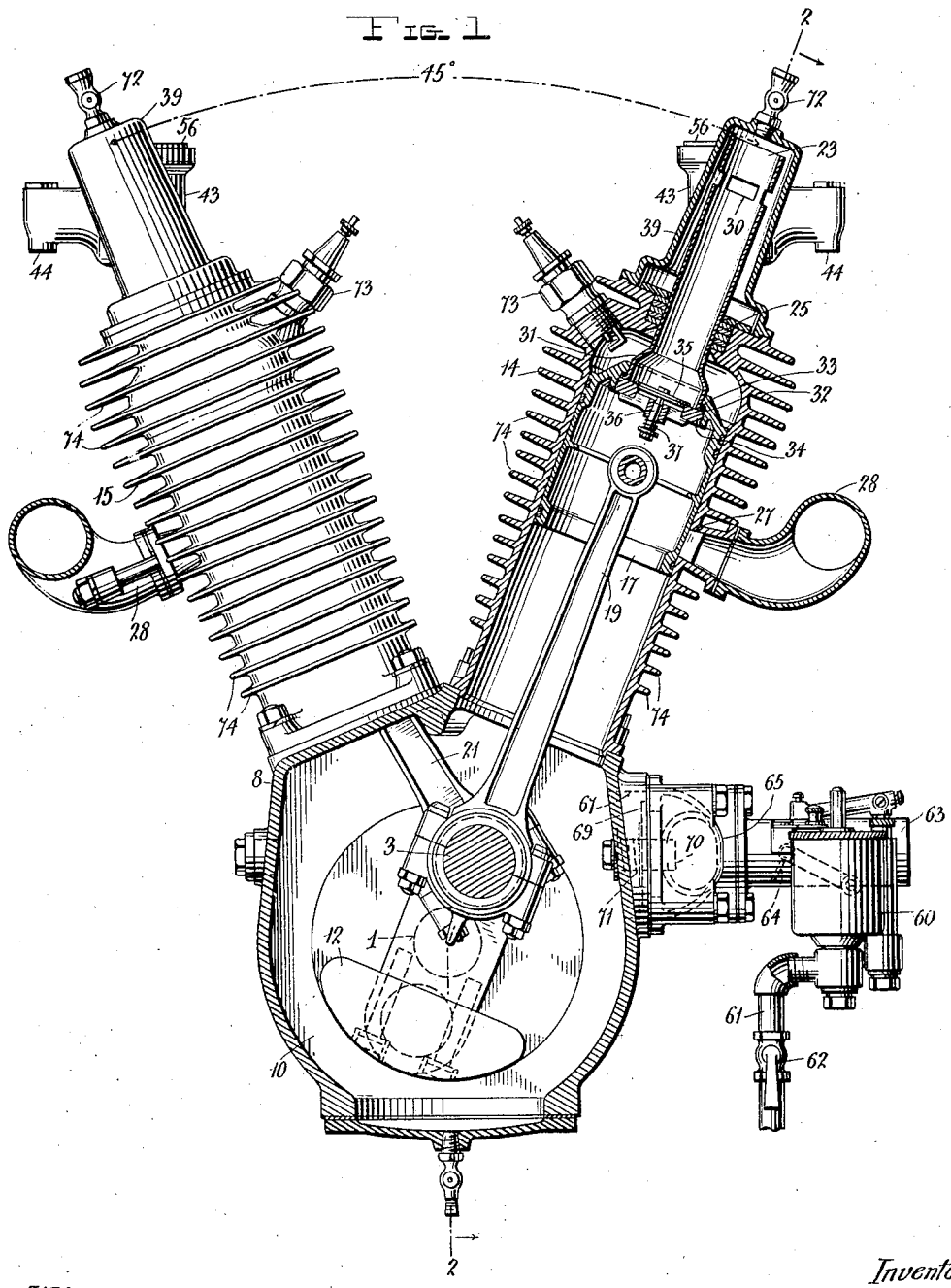
APPLICATION FILED APR. 7, 1916.

1,360,958.

Patented Nov. 30, 1920.

3 SHEETS—SHEET 1.

FIG. 1



Witnesses

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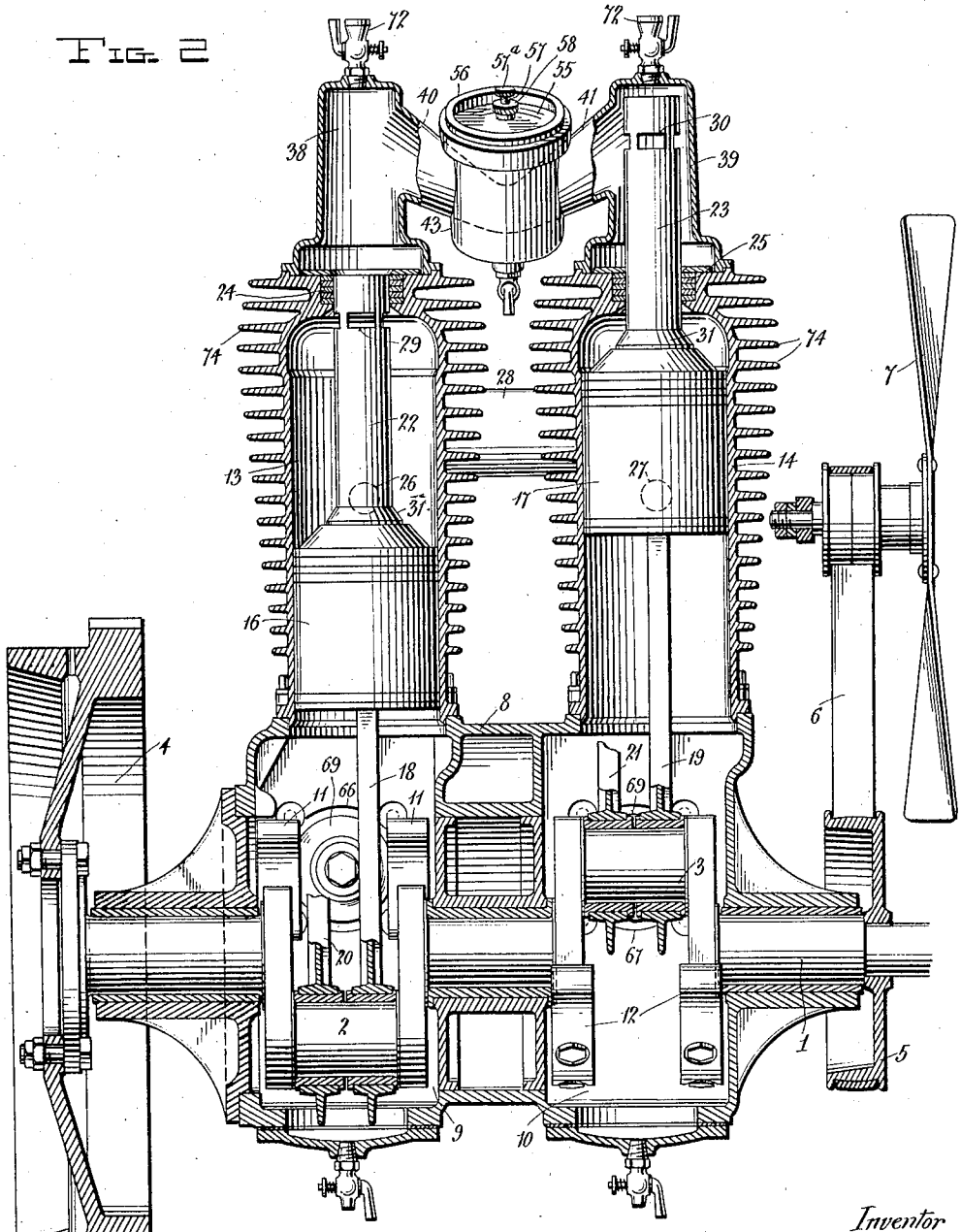
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3 SHEETS—SHEET 2.

FIG. 2



Witnesses

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INTERNAL COMBUSTION ENGINE.

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3 SHEETS—SHEET 3.

Fig. 3

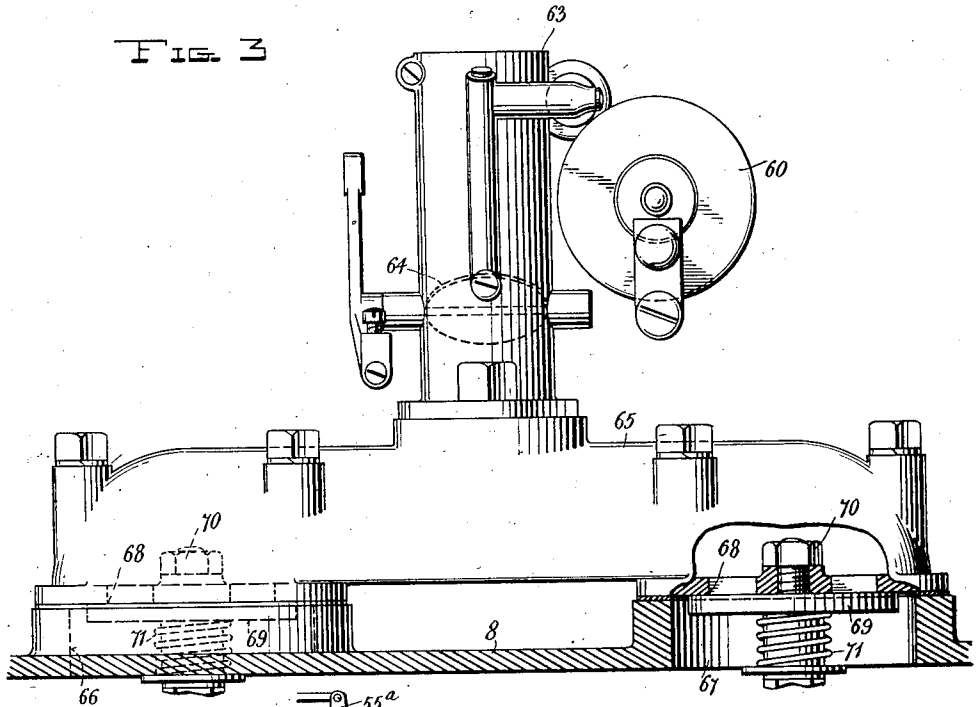


Fig. 4

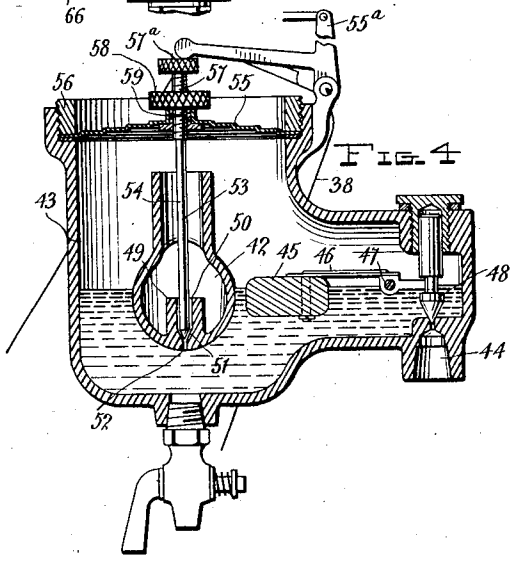
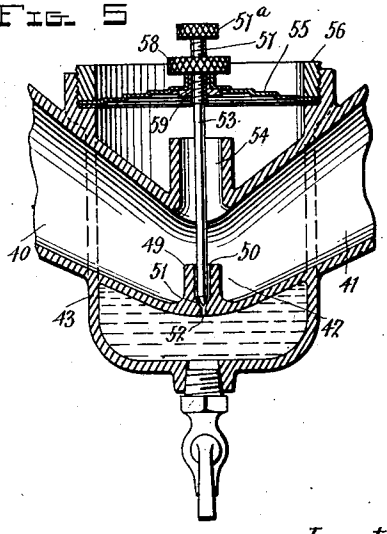


Fig. 5



Witnesses

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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

1,360,958. Specification of Letters Patent. Patented Nov. 30, 1920.

Application filed April 7, 1916. Serial No. 89,599.

To all whom it may concern:

Be it known that I, HARMON J. KLINE, a citizen of the United States, residing at Detroit, in the county of Wayne and State of Michigan, have invented new and useful Improvements in Internal-Combustion Engines, of which the following is a specification.

My present invention relates to improvements in internal combustion engines, and more especially to those of the two-cycle type wherein the charges of explosive gas or the bodies of air to be used in making up such charges are compressed in the crank case of the engine and subsequently transferred to and finally compressed in the working cylinder.

One of the primary objects of the invention is to provide an engine of this type which can be started easily and then run or operated on kerosene, alcohol or low-grade liquid fuels.

Another object of the invention is to provide an engine of this type which is capable of being operated efficiently and successfully without the necessity of employing a water-cooling system and the accessories necessary thereto, the engine being air-cooled, both externally and internally, the internal cooling being effected in such manner as to increase the efficiency of the engine and to enable it to operate on low-grade liquid fuels.

Further objects are to improve the structure of the engine generally, enabling it to be manufactured at relatively low cost, and in particular to provide an improved fuel supply and control and an improved construction for the pistons.

The present application discloses subject-matter claimed in my prior application, Serial No. 750,028, filed February 21, 1913, upon which Letters Patent No. 1,178,648 were granted on April 11, 1916.

The invention consists in certain improvements, and combinations and arrangements of parts, all as will be hereinafter more fully described, the novel features being pointed out particularly in the claims at the end of the specification.

In the accompanying drawings:—

Figure 1 represents a transverse section through an internal combustion engine of the V-type and embodying the present invention.

Fig. 2 represents a section on the line 2—2 of Fig. 1.

Fig. 3 shows the intake manifold and carbureter in top plan view, the adjacent wall of the crank case to which the intake manifold is attached being shown in section.

Fig. 4 represents a transverse section through the intercommunicating passage between a pair of cylinders, this view showing the carbureter or fuel supply device also in section.

Fig. 5 represents a longitudinal section through a portion of the intercommunicating passage between a pair of the cylinders, this view showing the carbureter or fuel supply device in section.

Similar parts are designated by the same reference characters in the several views.

The present invention is particularly applicable to internal combustion engines of the two-cycle type employing a plurality of cylinders. An engine of such type is shown in the drawings and will be hereinafter described in detail. It is to be understood, however, that the invention is not necessarily limited to the particular construction shown, as equivalent constructions within the scope of the claims are contemplated and will be included as within the scope of the invention, and that modifications or changes may be made by those skilled in the art without departing from the invention.

In the embodiment of the invention shown in the present instance, the engine comprises a crank shaft 1 having a pair of cranks 2 and 3 set in diametrically opposite relation thereon, a fly wheel 4 being attached to the rear end of the crank shaft and a driving pulley 5 being attached to the forward end of the crank shaft, the pulley 5 driving a belt 6 which in turn drives a fan 7 which latter serves, as will hereinafter appear, to direct an air current past the cylinders of the engine to effect external cooling thereof. The base 8 of the engine is formed in the present instance with a pair of separate crank cases 9 and 10 in which the cranks 2 and 3 operate and also, as shown, counterweights 11 and 12 are provided for the cranks 2 and 3 respectively, to counterbalance the cranks and thereby minimize vibration during the running of the engine. The crank cases 9 and 10 are non-communicating, that is to say, each of these crank cases is closed to form a separate compression chamber.

According to the present invention, one or more pairs of cylinders are used, two

pairs of cylinders being shown and, preferably, they are arranged to provide an engine of V-form. To this end, the top of the base 8 of the engine is suitably constructed to receive the different pairs of cylinders, 13 and 14 designating the pair of cylinders appearing at the right-hand side of Fig. 2, and a similar or duplicate pair of cylinders 15 is arranged toward the opposite side of the base or crank case casting. For the purposes of the present invention it is preferable to arrange the pairs of cylinders at an included angle of 45°, or substantially so. The construction of the cylinders, pistons and related parts at one side of the engine is preferably the same as that of the cylinders and pistons at the opposite side of the engine, and hence a detailed description of one pair of cylinders, pistons and related parts will be sufficient for both pairs of cylinders, pistons and related parts. As shown in Fig. 2, pistons 16 and 17 are provided in the cylinders 13 and 14, these pistons being suitably packed in order that they may fit properly therein. These pistons are connected by the connecting rods 18 and 19 to the cranks 2 and 3 respectively, the connecting rods 20 and 21 for the pistons of the opposite pair of cylinders being also connected to the cranks 2 and 3. The pistons 16 and 17 for each pair of cylinders are provided with barrels 22 and 23, these barrels being attached to and reciprocate with the respective pistons and they are preferably arranged with their axes in alinement with the axes of the respective pistons. The heads or tops of the cylinders of each pair have openings through which the barrels 22 and 23 may reciprocate, and suitable packings 24 and 25 are provided to coöperate with the respective piston barrels. The cylinders are provided with exhaust ports 26 and 27 which are located in the walls of the respective cylinders a suitable distance above the upper end of the respective pistons when the latter are at the ends of their working strokes, these exhaust ports communicating with an exhaust manifold 28. As usual, in the operation of engines of this type, the exhaust ports 26 and 27 are uncovered by the upper ends of the respective pistons as the latter approach the ends of their working strokes, thereby exhausting the products of combustion from the corresponding cylinders. The piston barrels 22 and 23 are provided with intake ports 29 and 30 which are so located in respect to the lengths of the respective piston barrels and their strokes that these intake ports will pass within the heads of the respective cylinders and will be uncovered when the respective pistons approach the ends of their working strokes.

According to the present invention, each piston barrel is composed of a tube or sleeve of steel or other relatively thin material. As shown in Fig. 1, the piston barrel 23 is composed of such a tube or sleeve, its lower end being flared or enlarged, as at 31, and the lower edge of the flared or enlarged portion of the barrel is formed with an out-turned flange 32. The head of the corresponding piston 17 has an opening therein which forms a shoulder 33 in which the flared or enlarged portion of the barrel rests and against which the out-turned flange 32 abuts. A valve cage 34 is threaded or otherwise fitted to or into the head of the piston, it being shown in the present instance as threaded into the opening in the head of the piston and tightened so as to clamp the out-turned flange 32 of the piston barrel between it and the shoulder of the piston head against which this flange abuts. The piston barrels when so constructed may be manufactured cheaply and they may be easily applied and removed. The relatively thin walls of the piston barrel also promote the interchange of heat between the burned or burning gases within the cylinder and the air or explosive charge flowing through the piston barrel. The valve cage 34 carries a check-valve 35 which permits air or fuel mixture compressed in the crank case to be transferred to the piston barrel and to the parts in communication therewith and prevents a back-flow of such air or mixture to the crank case. As shown, the valve seats on the upper side of the valve cage 34 and has a stem 36 which operates in the valve cage as a guide, and a compression spring 37 encircles the stem of the valve and abuts against the valve cage, this spring acting yieldingly to seat the valve or to retain it on its seat, although permitting the valve to open when the pressure of the air or fuel mixture in the crank case reaches a predetermined amount.

According to the present invention, a chamber or fuel storage reservoir is provided for each pair of cylinders and it forms with the piston barrels of those cylinders a space of relatively large and substantially constant capacity or volume, as is the case in my prior application hereinbefore referred to. As shown, a closed casing is fitted to the heads of the cylinders of each pair, it being shown in Fig. 2 as fitted to the heads of the cylinders 13 and 14. This casing embodies chambers 38 and 39 which are bolted or otherwise suitably secured with fluid-tight joints to the heads of the cylinders 13 and 14 in alinement with the axes of these cylinders and of dimensions sufficient to accommodate the piston barrels 22 and 23 when the latter are elevated or at the limits of the in-strokes of their pistons. A communicating passage connects the chambers 38 and 39, thereby providing means of communication between the cham-

bers and the piston barrels 22 and 23 which latter are open at their tops. In the present embodiment of the invention, means is connected in the communicating passage between the chambers 38 and 39 for supplying fuel to the fluid as the latter flows through this communicating passage. Preferably, and as shown, a carbureter, atomizer or vaporizer is used, and the same is of a type capable of successfully vaporizing or atomizing kerosene, alcohol, or a low-grade of liquid fuel. To this end, the communicating passage between the chambers 38 and 39 comprises portions 40 and 41 which contract and form a relatively narrow neck or venturi 42 at the point where they meet. Preferably, the portions 40 and 41 of the communicating passageway are inclined downwardly to the narrow neck or venturi. In order to utilize the heat from the fluid passing through this communicating passage to assist in vaporizing the relatively heavy liquid fuel, a liquid fuel bowl or chamber 43 is provided which is immediately adjacent to the venturi. Preferably, and as shown, this liquid fuel bowl or chamber is cast as a part of the casing which forms the communicating passage and it surrounds the venturi. The bowl or chamber for the liquid fuel is provided with a connection 44 to which a pipe may be attached to supply the liquid fuel thereto, and a float 45 is provided, it being carried by a lever 46 which is pivoted within the liquid containing space of the bowl on the axis 47, and the lever coöperates with a valve 48 which latter serves, as in a manner common to carbureters, to maintain the liquid fuel at a given level in the fuel chamber or bowl. A jet or nozzle is provided which receives liquid fuel from the bowl and introduces it into the venturi to be there taken up by the fluid passing therethrough. As shown, a boss or nozzle 49 is cast or otherwise formed in the bottom of the venturi, it having a vertical or upwardly directed bore 50, a valve seat 51 at the bottom of said bore, and an opening 52 which serves to admit liquid fuel from the bowl into the bore 50 under the control of a valve 53 which latter coöperates with the seat 51. The liquid fuel chamber of the vaporizer communicates with the venturi not only through the opening 52, which is below the level of the liquid fuel therein, but also through a sleeve 54 which extends upwardly from the venturi and provides means of communication between the latter and the portion of the liquid fuel bowl or chamber above the level of the liquid fuel therein. The liquid fuel containing bowl or chamber is also closed to the atmosphere, and a pump or other equivalent means is provided for forcing the liquid fuel into the bowl or chamber under the control, however, of the float valve 48. The liquid containing bowl or chamber will, therefore, be subjected to the same pressure conditions as those existing in the venturi.

It is preferable to regulate or control the amount of liquid fuel supplied to the venturi, according to the amount of power demanded of the engine. The present invention provides means which will supply liquid fuel in amounts proportionate to the pressure of the fluid in the venturi. As shown, such means comprises a diaphragm 55 which is tightly clamped in the top of the bowl by a ring 56, the diaphragm being preferably corrugated, as shown, in order to resist distortion, and the diaphragm is connected to the valve 53 which controls the supply of liquid fuel to the nozzle or jet. For this purpose, the valve 53 has a relatively long stem which extends upwardly through the diaphragm and has a threaded portion 57 to coöperate with a nut 58, the latter being secured to the diaphragm through the agency of the sleeve 59. Turning of the head 57^a on the valve stem will raise or lower the valve 53 relatively to its seat 51. Also, an increase in the pressure of the fluid in the venturi will correspondingly increase the pressure beneath the diaphragm, this causing the diaphragm to move upwardly, thereby lifting the valve 53 and increasing the amount of fuel passing to the nozzle. A reduction in the pressure of the fluid in the venturi will correspondingly cause the diaphragm to move downwardly, lowering the valve 53 and proportionately closing or reducing the amount of fuel flowing through the valve seat 51 to the nozzle.

Kerosene, alcohol and other relatively low-grades of liquid fuel require considerable heat for vaporization when used as fuel for internal combustion engines. The present invention provides means for facilitating the starting of the engine whereby the engine will be heated to a degree sufficient to permit its operation on the relatively low grade fuel. Preferably, and as shown, means is provided for supplying gasolene or other easily volatile fuel for starting purposes, and this gasolene or volatile starting fuel is preferably supplied as a vapor to the air drawn into the crank cases of the engine. In the construction shown, a carbureter 60, which may be of any ordinary construction, is used, the gasolene supply pipe 61, however, being provided with a valve 62 for cutting off the supply of gasolene thereto when desired, and the air intake pipe 63 of the carbureter is provided with a throttle or vane 64 which controls the volume of fluid, whether in the form of air or air containing fuel in vapor form, to the crank cases. This intake pipe 63 may, as shown, be connected to an intake manifold 65, the branches or ends of the latter being bolted or otherwise

secured to the sides of the crank cases 9 and 10 in register with openings 66 and 67 leading into the respective crank cases. Valves are provided for permitting the admission of fluid from the intake pipe 63 into the crank cases but preventing backflow of such fluid and thus causing compression of the fluid in the crank cases. In the present instance, each end of the intake manifold 65 is provided with a slotted valve seat 68, and a valve 69, preferably of flat form, is arranged to engage the inner side or face of the valve seat 68. The valve is guided by a stem 70 which is bolted or otherwise fixed to the valve seat, and a compression spring 71 is carried and supported by the valve stem and it acts yieldingly to seat the valve.

The mode of operation of the engine constructed as shown and herein described is, briefly, as follows:—In order to start the engine, the gasolene supply valve 62 for the carbureter 60 is opened, admitting gasolene to the carbureter or vaporizer which supplies volatile fuel vapor to the air drawn into the crank cases. The diaphragm 55 of the vaporizer is also held down by a lever 55^a or any other suitable exterior means with appropriate operating connections, thereby holding the low grade fuel supply valve 53 closed during starting. By rotating the crank shaft of the engine in the usual way, the pistons are caused to reciprocate. It will be observed that the cranks 2 and 3 of the crank shaft are set diametrically opposite and that a pair of pistons is connected to each of these cranks. Furthermore, it is to be understood that each crank case is closed, except for its valve-controlled fluid admission port and its communication with the lower ends of the cylinders corresponding to the pistons which are connected to the crank operating in this crank case. Rotation of the crank shaft will, therefore, cause two of the pistons to move upwardly in their cylinders, thereby producing a partial vacuum in the corresponding crank case and causing gasolene or other volatile fuel vapor to be drawn from the carbureter 60 through the intake 65 and into this crank case. This will continue until the other crank causes the pistons for the other pair of cylinders to move upwardly in their cylinders, whereupon gasolene or other volatile fuel vapor will be drawn into the other crank case. This alternating supply of gasolene or other volatile fuel vapor to the crank cases will continue during the starting and the preliminary running of the engine, the amount of this starting fuel being regulated by adjustment of the throttle or vane 64. To assist starting of the engine in cold weather, priming cups 72 may be tapped into the tops of the overhead chambers 38 and 39, whereby gasolene or other easily volatile fuel may be introduced directly into the fuel storage chamber. After the engine has continued to run on gasolene or other volatile fuel supplied by the carbureter 60 for a period sufficient to heat the engine to a degree that will enable it to operate on a relatively low-grade of fuel, the supply of gasolene or other easily volatile fuel is gradually cut off by closing the gasolene supply valve 62, and simultaneously the diaphragm 55 is gradually released, permitting the valve 53 to open, in consequence of which the relatively heavy or low-grade of fuel is introduced into the venturi 42 from the nozzle 49.

During the operation of the engine it will be observed that the pistons 16 and 17 for each pair of cylinders reciprocate simultaneously in reverse directions, the piston barrels 22 and 23 reciprocating in unison with their respective pistons. During the downstroke of each piston, the fluid in the corresponding crank case is compressed, and when this compression reaches a predetermined amount, the valve 35 in the head of the respective piston will be opened, permitting such compressed fluid to be transferred from the crank case through the piston barrel 22 or 23, as the case may be, and thence to the fuel storage chamber or reservoir connected to the heads of the cylinders. While one piston is moving downwardly and is effecting a transfer of the compressed fluid from the crank case into the fuel storage chamber or reservoir, the other piston is moving upwardly with its valve 35 closed, thereby preventing a backflow of fluid from the overhead storage chamber or reservoir into the other crank case. When the descending piston approaches the end of its out or downstroke, it uncovers the exhaust ports for this cylinder, thereby discharging the waste products of combustion therefrom, and the intake ports 29 or 30, as the case may be, in the piston barrel come into communication with the cylinder, thereby admitting explosive mixture into the cylinder which displaces any remaining products of combustion and fills the cylinder with fuel. The succeeding in or up-stroke of this piston causes the charge of explosive mixture to be compressed and the compressed charge is fired at the proper point by a spark plug or equivalent ignition device 73. This action is reversed during each half revolution of the crank shaft, and in an engine of the V-type employing two pairs of cylinders, each crank case compresses fluid for the two opposite cylinders connected thereto. By arranging the cylinders at an included angle of 45°, the cylinders are brought sufficiently near to the vertical to insure the requisite compression in the crank case.

It will be understood that, as each piston barrel approaches or moves downwardly, its coöperating piston barrel moves upwardly,

thereby causing a flow of fluid through the venturi 42, and the flow of fluid through the venturi causes the same to take up fuel from the nozzle 49. Each piston barrel serves as a conduit through which fluid used in making up the explosive charges is transferred from the respective crank cases to the overhead fuel storage chamber or reservoir. Each piston barrel is subjected to the heat generated in the exploding charges in its respective cylinder. By constructing these piston barrels of relatively thin metal, they quickly and efficiently absorb the heat from the combustion chambers of the cylinders and transmit such heat to the incoming fluid flowing through them, thereby cooling or reducing the temperature of the interior of the cylinder and heating the incoming fluid to a temperature that will enable it to readily volatilize and form a gas from the relatively heavy or low-grade liquid fuel supplied to the venturi 42. The rapid conduction of heat by the piston barrel also maintains the wall of the piston which engages the cylinder at a sufficiently low temperature to avoid vaporizing or burning of the lubricating oil thereon. The exterior of each cylinder is cooled, preferably, by fins 74 upon which air currents are directed by the fan 7.

The throttling of the engine may be accomplished by adjustment of the throttle or vane 64 in the intake pipe 63 leading to the crank cases, either when gasolene or easily volatile fuel is being supplied from the carbureter 60, or when the gasolene or easily volatile fuel is cut off from the carbureter 60 and the engine is operating on the low-grade or relatively heavy fuel supplied by the vaporizer. If preferred, however, a separate throttle or air vane may be provided to control the admission of air to the crank cases and thereby throttle the engine when the same is operating on the heavy or relatively-low grade fuel. The vaporizer shown is capable of automatically regulating the amount of fuel supplied to the engine, according to the amount of power required of the engine. For example, increasing the extent of opening of the valve which controls the admission of air to the crank cases will admit correspondingly increased volumes of air to the crank cases, resulting in higher compression in the crank cases and a higher compression in the overhead fuel storage chamber or reservoir. This increased pressure of fluid in the overhead fuel storage chamber or reservoir acts on the diaphragm 55 to open the valve 53, thereby admitting an increased amount of liquid fluid to the venturi. Conversely, reduction in the amount of air in the crank cases by adjustment of the air-controlling valve causes a reduced pressure in the crank cases and in the overhead fuel storage chamber or reservoir, this causing the valve 53 to close more or less, thereby diminishing the amount of fuel supplied to the venturi. During the operation of the engine, the explosive mixture is caused to flow to and fro through the venturi, and this results in thorough and uniform mixing of the fuel with the air to produce an efficient explosive charge, and it affords ample opportunity for the explosive mixture to absorb heat generated by the explosions of the charges. This internal absorption of heat serves not only to produce a more efficient explosive gas, but it also facilitates starting in that all the air and gasolene mixture used for starting passes up through the piston and its barrel, thus becoming heated thereby to a temperature that facilitates ignition. At the same time the engine is cooled internally by the absorption of heat by the relatively cool incoming air, all of which passes through the piston barrel, and this internal cooling of the engine, supplemented by the external cooling thereof enables the engine to operate efficiently and without overheating. Furthermore the necessity of employing a water-cooling system with its weighty, expensive and complicated accessories is avoided. The amount of heat necessary to vaporize the fuel oil is supplied by the heat of combustion absorbed by the incoming cool air, the amount of heat so absorbed being proportional to the heat generated by combustion, the heat of combustion in turn being proportional to the amount of air supplied to make up the explosive charge. In consequence, the heating of the air to make up the explosive mixture is accomplished in the most advantageous way, and the engine will operate under all conditions of load and speed as well as a four cycle engine.

By arranging the venturi and its fuel supply nozzle in the depression formed by the meeting ends of the downwardly inclined portions 40 and 41 of the communicating passage of the overhead chamber or reservoir, any overflow of fuel from the nozzle will be trapped in the bottom of the venturi to be vaporized subsequently by the flow of fluid through the venturi, thus avoiding unsteady operation and stoppage of the engine by an over-rich mixture.

In embodying the invention in an engine of V-form comprising four cylinders or a multiple thereof, a steady pull or torque on the shaft is secured and a substantially perfect balance in operation is attained. I have found that the best mechanical balance in a motor of this type is attained when the cylinders are placed at an included angle of from 38 to 46 degrees, that shown having the cylinders placed at an intermediate angle of 45 degrees. However, this angle may vary from 30 to 60 degrees. When the

cylinders are placed at an angle within such limits, the axes of the opposed cylinders sufficiently approach parallelism to give a higher crank case pressure than is attained with a single cylinder, the actual displacement of the crank case for each pair of cylinders being only slightly increased over that of a single cylinder.

I claim as my invention:—

1. In an internal combustion engine, means comprising a fuel storage chamber for atomizing and vaporizing fuel oil under pressure and high temperature therein, said chamber having means for introducing fuel oil therein, and means for supplying air heated by the heat of combustion in the combustion chamber of the engine and under pressure to said chamber to mix therein with said fuel oil to form explosive charges prior to the admission of such charges into the combustion chamber of the engine.

2. In an internal combustion engine, the combination of means for supplying a volatile fuel thereto for starting the operation thereof, means comprising a fuel storage chamber for atomizing and vaporizing heavy fuel oil under pressure and high temperature therein, said chamber having means for supplying fuel oil thereto, and means for supplying air heated by the heat of combustion in the combustion chamber of the engine and under pressure to said chamber to mix therein with said fuel oil to form explosive charges prior to the admission of such charges to the combustion chamber of the engine.

3. In an internal combustion engine embodying a fuel chamber forming a passage and storage reservoir for fluid heated by the heat of combustion within the combustion chamber of the engine, and having means for introducing heavy fuel oil therein, means for supplying an easily volatile liquid fuel to the engine to start the operation thereof, and means for supplying to said chamber air under pressure and heated by the heat of combustion in the combustion chamber of the engine, and for atomizing and vaporizing the heavy fuel oil under pressure and high temperature and for mixing the same with said heated air in said chamber to form explosive charges prior to the admission of such charges into the combustion chamber of the engine.

4. In an internal combustion engine having a crank case for compressing constituents of the explosive charges, a fuel storage chamber, and a piston having means for conducting compressed charges from the crank case through it to said chamber, of means for supplying air and an easily volatile liquid fuel to the crank case to start operation of the engine, means for cutting off the supply of such liquid fuel, and means for supplying a difficultly volatile liquid fuel to the storage chamber to maintain the operation of the engine.

5. In an internal combustion engine having a crank case for compressing constituents of the explosive charges, a fuel storage chamber, and a piston having means for conducting compressed charges from the crank case through it to said chamber, of means for supplying air and an easily volatile liquid fuel to the crank case to start operation of the engine, means for cutting off the supply of such liquid fuel while maintaining a supply of air to the crank case, and means for supplying another fuel to the storage chamber independently of the crank case to maintain operation of the engine.

6. In an internal combustion engine having a crank case for compressing constituents of the explosive charges and also having a chamber to receive and store such constituents after compression in the crank case, of means for supplying constituents of explosive charges to the crank case, means for conducting such compressed explosive charges from the crank case through the respective piston to said chamber, and additional means for supplying a constituent of explosive charges directly to said chamber.

7. In an internal combustion engine having a crank case for compressing constituents of the explosive charges and also having a fuel chamber separate from the combustion chamber to receive such constituents after compression in the crank case, of means, including a throttle, for admitting constituents of explosive charges to the crank case, and independent means for supplying a constituent of explosive charges directly to said fuel chamber.

8. In an internal combustion engine having a crank case for compressing constituents of the explosive charges, means for cutting off the supply of fuel to the crank case, and a chamber to receive such charges after compression in the crank case and to introduce such charges into the cylinder, of a throttle for admitting and regulating a supply of air to the crank case, and means for supplying fuel directly to said chamber to mix therein with air compressed in the crank case.

9. In an internal combustion engine having a crank case for compressing constituents of the explosive charges, means for cutting off the supply of fuel to the crank case, and a chamber to receive such charges after compression in the crank case and to introduce such charges into the cylinder, of a throttle for admitting and regulating a supply of air to the crank case, and means controlled by the pressure in said chamber as determined by the degree of opening of said throttle for supplying fuel directly to said chamber to mix therein with air compressed in the crank case.

10. In an internal combustion engine having a crank case for compressing constituents of the explosive charges, means for controlling the supply of fuel to the crank case, and a chamber heated by the heat of combustion and arranged to receive such charges after compression in the crank case and to introduce such charges into the cylinder, of a throttle for admitting and regulating a supply of air to the crank case, and means for supplying fuel directly to said chamber to mix therein with air compressed in the crank case.

11. In an internal combustion engine, the combination with a fuel chamber having means for introducing constituents of explosive charges therein, and a piston having a passage therethrough for heating such constituents by the heat of combustion, of a vaporizer for supplying fuel directly to said chamber to mix therein with the heated constituents of charges.

12. In an internal combustion engine having a fuel chamber adapted to be heated by the heat of combustion within the engine, a piston having a passage therethrough for heating and supplying constituents of explosive charges to said chamber, and means for admitting explosive charges from said chamber into the combustion chamber of the engine, of means adapted to contain a supply of liquid fuel subject to the heat of said chamber and to supply such fuel to the chamber to mix therein with the constituents of the explosive charges.

13. In an internal combustion engine having a fuel chamber provided with a passage for the flow of constituents of explosive charges, a piston having a passage therethrough for heating and supplying constituents of explosive charges heated by the heat of combustion to said chamber, and means for admitting explosive charges from said fuel chamber into the combustion chamber, of means connected to said passage for supplying an atomized heated fuel to the constituents flowing through said passage.

14. In an internal combustion engine, the combination of a fuel storage chamber having means for supplying heavy fuel oil thereto, means for atomizing and vaporizing heavy fuel oil in said chamber under pressure and high temperature and mixing the same in said chamber with air to form explosive charges, and means comprising a conduit heated by the heat of combustion in the combustion chamber of the engine for admitting such explosive charges from said fuel chamber into the combustion chamber of the engine.

15. In an internal combustion engine having a fuel storage chamber, means for introducing compressed constituents of charges into said chamber and for maintaining such constituents under pressure therein, said constituents being heated by the heat of combustion in the combustion chamber of the engine prior to their introduction into said chamber, and means for introducing fuel into said chamber to mix therein under pressure with said compressed constituents of charges.

16. In an internal combustion engine having a fuel storage chamber, means for introducing compressed constituents of charges preheated by the heat of combustion in the combustion chamber of the engine into said chamber and for maintaining such charges under pressure therein, and means subject to the heating influence of such constituents in said chamber for introducing heated and atomized fuel into said chamber.

17. In an internal combustion engine having a fuel storage chamber provided with a passage having therein a venturi through which the constituents of the charges pass before entering the cylinder, means for supplying compressed constituents of charges previously heated by the heat of combustion in the combustion chamber of the engine into said chamber and for maintaining such charges under pressure therein, and means for subjecting a liquid fuel to the heating influence of the heated constituents in said passage and for introducing the fuel so heated into said venturi.

18. In an internal combustion engine, the combination with a fuel storage chamber having a passage through which the constituents of charges flow before entering the combustion chamber, of means including a conduit through said combustion chamber for introducing air, heated by the heat of combustion in said combustion chamber, into said storage chamber and for maintaining a pressure in said storage chamber, and a liquid fuel chamber for subjecting liquid fuel therein to the heat of the fluid in said passage.

19. In an internal combustion engine, the combination of a fuel chamber having a venturi for the flow therethrough of constituents of charges prior to the introduction thereof into the combustion chamber, means for supplying heated compressed air alternately to the opposite ends of said fuel chamber to induce a to-and-fro movement of the fuel in said venturi and for maintaining a pressure in said fuel chamber, and means including a nozzle located in said venturi for introducing fuel into said chamber.

20. In an internal combustion engine having a fuel chamber, and means for compressing and introducing a constituent of charges into said chamber, of means for introducing fuel into said chamber to mix therein under pressure with said compressed constituent of charges, and means including a valve controlled by the amount of pressure in said

chamber for regulating the amount of fuel admitted thereto.

21. In an internal combustion engine having a fuel chamber, and means for compressing and introducing a constituent of charges into said chamber, of means for introducing fuel into said chamber to mix therein under pressure with said compressed constituent of charges, and means, including a diaphragm, subject to the pressure in said chamber for controlling the amount of fuel admitted thereto.

22. In an internal combustion engine having a fuel chamber, and means for compressing and introducing a constituent of charges into said chamber, of means for introducing fuel into said chamber to mix therein under pressure with said compressed constituent of charges, means including a valve and a diaphragm controlled by the amount of pressure in said chamber for regulating the amount of fuel admitted thereto, and means for controlling the pressure in said chamber.

23. In an internal combustion engine, the combination of a fuel chamber, means for supplying compressed air thereto and for maintaining such air under pressure in said chamber, means for controlling the amount of compressed air supplied to said chamber, and means including a pressure control valve for introducing fuel into said chamber in amounts determined automatically by the pressure in said chamber.

24. In an internal combustion engine of the two-cycle type having a fuel chamber for supplying fuel to the cylinder, and a crank case for compressing charges of air and introducing the same into said chamber, means for admitting and controlling at will the supply of air to the crank case for compression therein, and means, including a pressure-controlled valve, for introducing fuel into said chamber in amounts determined automatically by the pressure therein.

25. In an internal combustion engine of the two-cycle type embodying a pair of cylinders, oppositely movable pistons therein and compressing crank cases, a fuel chamber connecting the heads of the cylinders and adapted to receive compressed fluid from the crank cases, said chamber having a venturi formed therein at a point located intermediately of the cylinders and through which compressed fluid in said chamber flows during reciprocation of said pistons, and means for supplying fuel to said venturi.

26. In an internal combustion engine of the two-cycle type embodying a cylinder and a compressing crank case, the combination of a piston reciprocable in the cylinder, a piston barrel carried by and reciprocable with the piston, said barrel comprising a relatively thin sleeve having a thin flange thereon and a rigid ring fitted internally into the piston from its under side and clamping the flange of the sleeve separably to the head of the piston.

27. In an internal combustion engine of the two-cycle type embodying a cylinder and a compressing crank case, the combination of a piston reciprocable in the cylinder and having an opening in the head thereof, a piston barrel carried by and reciprocable with the piston and comprising a relatively thin metal sleeve formed with a thin attaching flange fitting the opening in the head of the piston, a rigid valve cage fitted internally into the piston head from its under side and clamping the flange on said sleeve to the piston head, and a valve in the cage for automatically controlling communication between the crank case and the piston barrel.

28. In an internal combustion engine, the combination of a cylinder having fins thereon for air-cooling it exteriorly, a fuel storage chamber, means including a piston having a passage through its head for supplying compressed air to said chamber, and constituting means interiorly of the cylinder for transferring heat of combustion from the body of the piston to constituents of charges prior to introduction of the same into the cylinder, and means for supplying fuel to said chamber.

29. In an internal combustion engine of the two-cycle type, the combination of compressing crank cases, a fuel storage chamber, means for transferring fluid compressed in the crank cases to said chamber to maintain pressure therein, a crank shaft in the crank cases, and pairs of cylinders with pistons therein connected to the crank cases and shaft respectively, the fuel storage chamber being adapted to communicate with one cylinder of one pair and with another cylinder of another pair and the axes of the cylinders of one pair being arranged at an angle of between thirty degrees and sixty degrees with respect to the axes of the cylinders of the other pair.

30. In an internal combustion engine of the two-cycle type, the combination of a base containing a pair of compressing crank cases, a crank shaft having a pair of diametrically opposite cranks, a pair of cylinders arranged with their axes convergent and at the same side of one crank case, the pistons in said cylinders being connected to the crank in said crank case, and another pair of cylinders arranged with their axes convergent and at the same side of the crank shaft, the pistons in the latter cylinders being connected to the crank which is positioned oppositely to the crank to which the first-mentioned pistons are connected, and a fuel storage chamber adapted to communi-

cate with the combustion chamber of one cylinder of one pair and with another cylinder of the other pair.

31. In an internal combustion engine of the two-cycle type, the combination of a base containing a pair of compressing crank cases, a crank shaft having a pair of diametrically opposite cranks, a pair of cylinders arranged with their axes convergent and at the same side of one crank case, the pistons in said cylinders being connected to the crank in said crank case, and another pair of cylinders arranged with their axes convergent and at the same side of the crank shaft, the pistons in the latter cylinders being connected to the crank which is positioned oppositely to the crank to which the first-mentioned pistons are connected, a fuel storage reservoir for supplying fuel to one cylinder of each pair of cylinders, and means for supplying compressed fluid to said reservoir from the crank cases.

32. A two-cycle internal combustion engine comprising a pair of compressing crank cases, a set of four cylinders connected in pairs to the respective crank cases, a fuel storage chamber connecting a cylinder of one pair to another cylinder of the other pair, and means for transferring compressed fuel from the crank cases and heated by the heat of combustion in the combustion chamber of the engine to the respective fuel storage chambers to maintain pressure therein.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

HARMON J. KLINE.

Witnesses:
HOWARD H. CAMPBELL,
WALTER M. PRATT.