May 15, 1956 R. C. HEIDNER ET AL 2,745,390

TWO-CYCLE INTERNAL COMBUSTION ENGINE WITH IMPROVED FUEL INDUCTION MEANS

Filed May 15, 1952 4 Sheets-Sheet 1

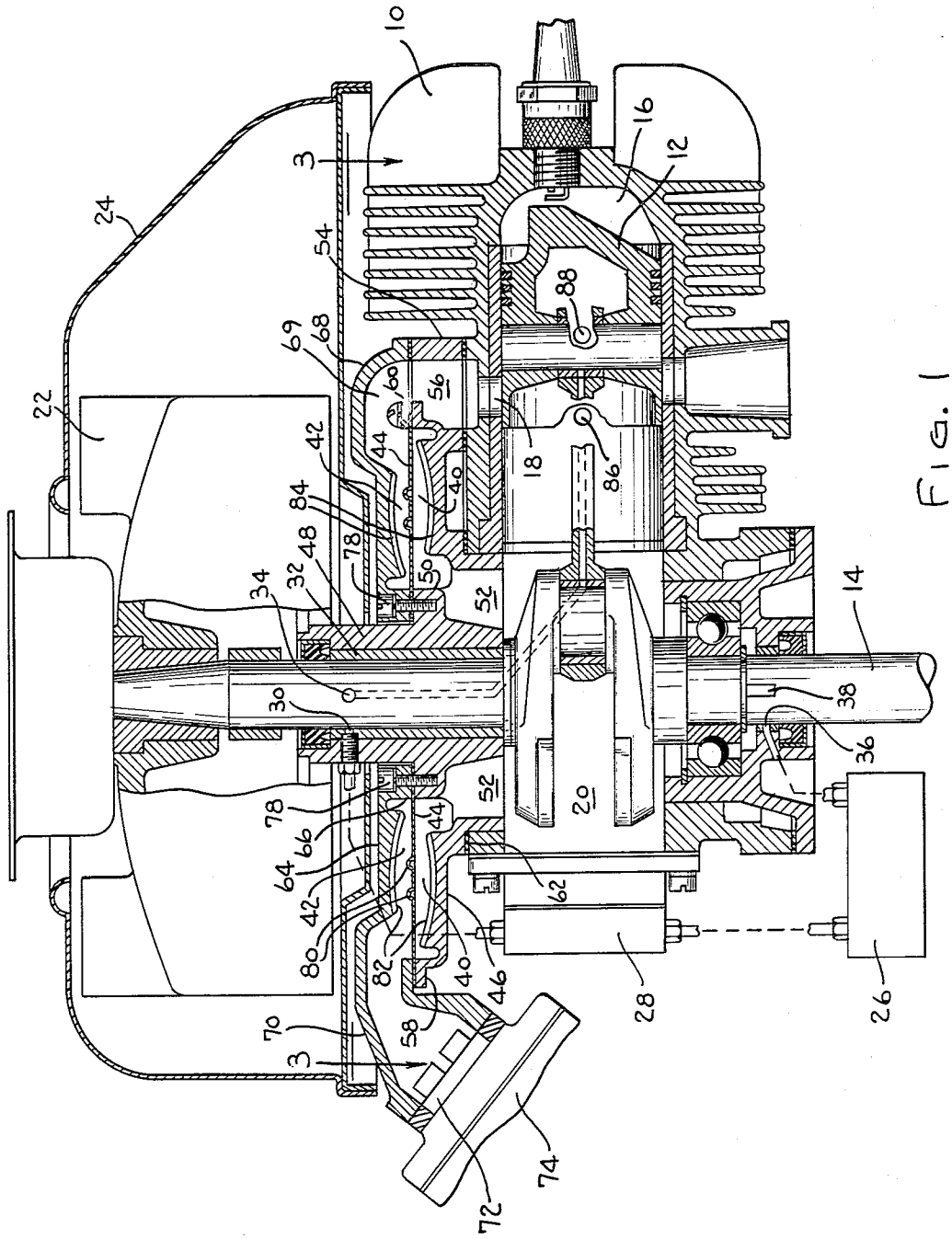


Fig. 1

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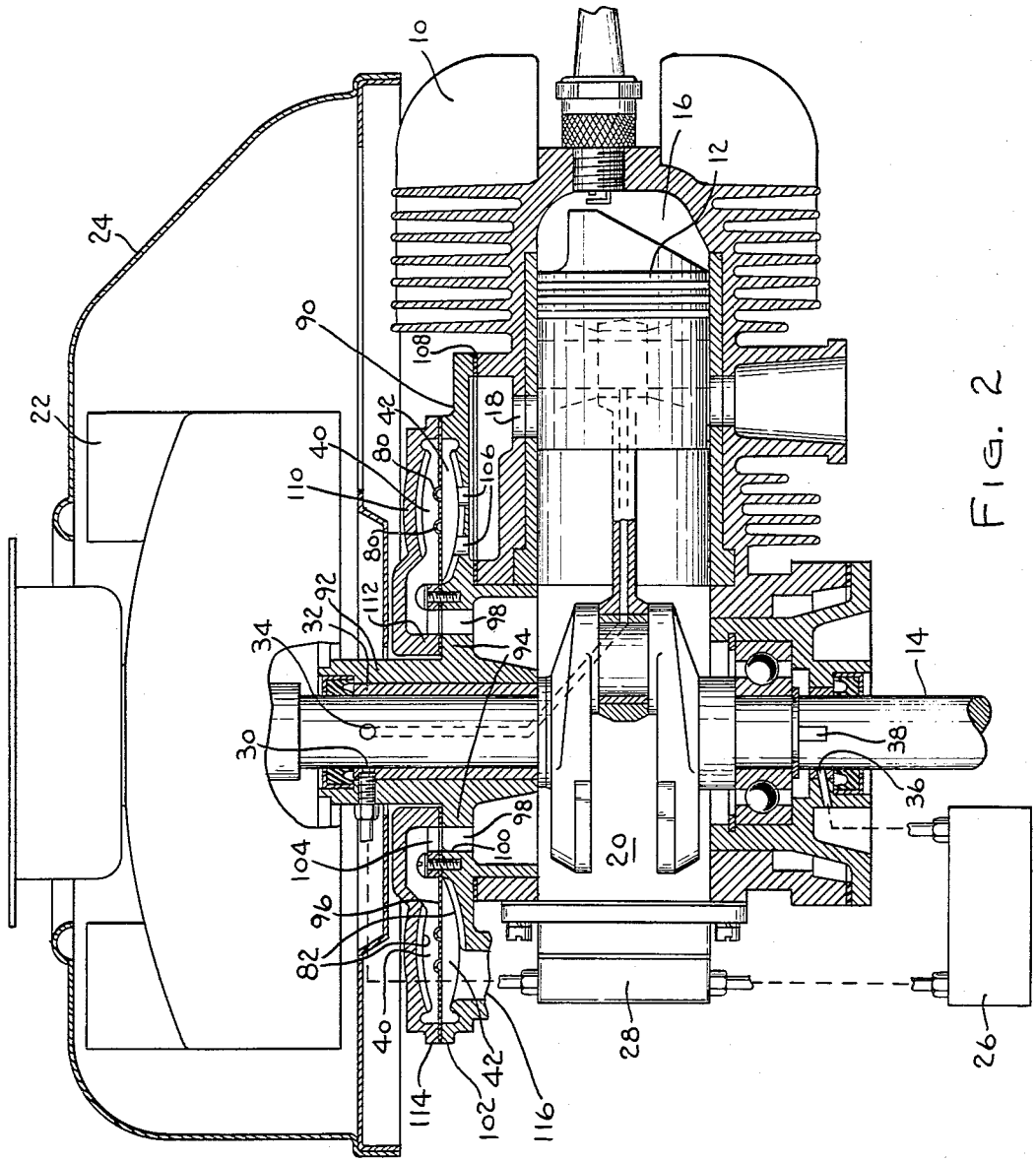


FIG. 2

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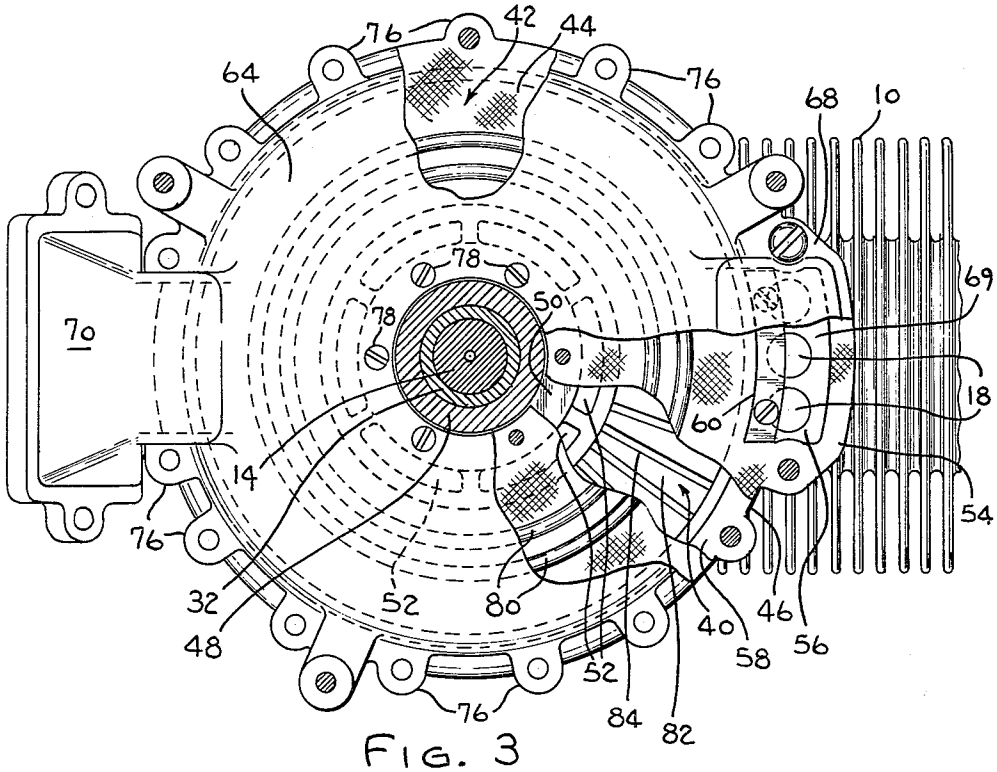


FIG. 3

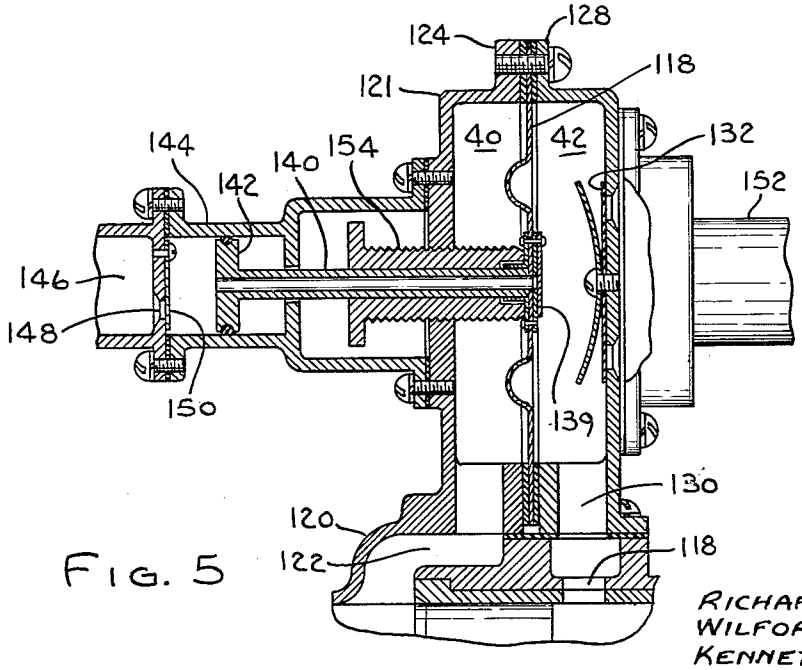


FIG. 5

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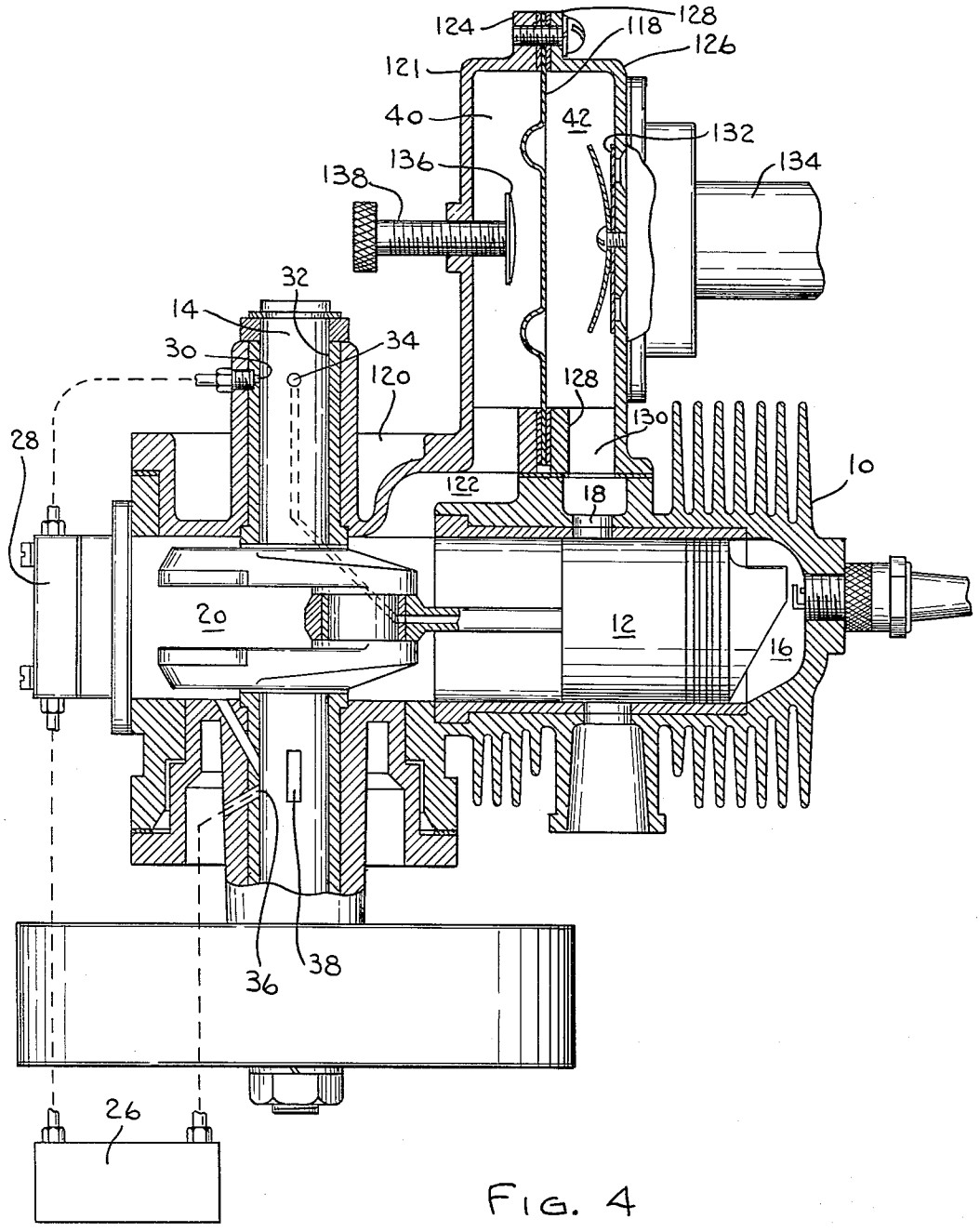


FIG. 4

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TWO-CYCLE INTERNAL COMBUSTION ENGINE WITH IMPROVED FUEL INDUCTION MEANS

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Application May 15, 1952, Serial No. 287,912

7 Claims. (Cl. 123—73)

This invention relates to improvements in two-cycle internal combustion engines and particularly to the induction of a combustible mixture into the combustion chamber.

It has been the practice in this type of engine to mix oil with the fuel and force the combustible mixture from the carbureter into the crank case on the up or compression stroke and then pump such mixture from the crank case through the intake port into the combustion chamber on the down or explosion stroke. Because of this the combustible mixture contains vaporized lubricating oil which has been carried through the crank case. If a lubricating oil containing additives such as a detergent is used the spark plug will be quickly fouled by the deposit of a conductive film which shorts out the plug. To avoid such fouling oil containing no such additives must be used. This means, in the case of the Armed Forces and other large users of both two-cycle and four-cycle internal combustion engines, that supplies of both types of lubricating oils must be available. Such dual supply is not economical or practical. The operators must be instructed as to which type of oil is to be used in a particular engine and even with such instruction mistakes are frequent.

It is an object of this invention, therefore, to provide a two-cycle internal combustion engine which can successfully operate with lubricating oil containing additives without the consequent fouling of spark plugs.

This object is obtained by separating the crank case with its pulsating pressure from an induction chamber directly connected with the intake port of the engine by a flexible diaphragm which is resistant and non-permeable to gasoline and oil in liquid or vapor state. The induction chamber is connected with the carbureter or other source of combustible material by check valves preventing back-flow to such carbureter or source. As pressure increases in the crank case on the down stroke the diaphragm will flex to force the combustible mixture in the induction chamber through the intake port into the combustion chamber. On the compression stroke pressure in the crank case is reduced to less than atmospheric pressure and atmospheric pressure will force the combustible mixture from the carbureter or other source into the induction chamber. Such chamber is then charged and in readiness for the downstroke. Thus the atmosphere in the crank case, which may contain vaporized or liquid oil, is never mixed with the incoming combustible mixture. Hence no oil will mix with incoming combustible mixture and thereby reach the combustion chamber of the engine to foul the spark plug.

Different ways of supporting the flexible diaphragm to obtain the longest life will be hereafter described. Such flexible diaphragm may be adjusted as to stroke to control the volume of the charge. With such diaphragm it is also possible to use a fuel pump operated thereby to inject metered quantities of raw fuel into the induction chamber where it is admixed with air. The induction chamber thus acts as a carbureter.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawings in which:

Fig. 1 is a sectional view of a two-cycle internal combustion engine embodying the present invention;

Fig. 2 is a view similiar to the view of Fig. 1 showing a modification of the invention;

Fig. 3 is a view partly in section and partly in elevation taken from line 3—3 of Fig. 1;

Fig. 4 is a sectional view of a two-cycle internal combustion engine embodying another modification of the invention; and

Fig. 5 is a fragmentary sectional view of a fuel induction chamber embodying still another modification of the present invention.

With the exception of the novel devices by which fuel is induced into the combustion chamber, the engine shown in Figs. 1 to 3 is of well-known construction. It is a single cylinder two-cycle air-cooled internal combustion engine of the type adapted for use in out-board motors. However, the same design of engine may be used with its shaft in horizontal position by changing the position of the oil-collecting sump.

Such engine has a cylinder 10 in which is reciprocally guided a piston 12 operatively connected to a crank shaft 14. The cylinder has a combustion chamber 16 with inlet ports 18 leading thereto. The crank shaft 14 operates in a crank case 20 and its outer end carries an impeller-flywheel 22 rotatable in a housing 24.

The engine is lubricated by a pressure system which has a reservoir 26 and an oil pump 28. The pump delivers oil under pressure to an opening 30 in a plain bearing 32. An opening 34 in the crank shaft 14 is moved into communication with the opening 30 when the piston is about half way through a stroke. At this time the pressure in the crank case is approximately equal to atmospheric pressure. The opening 34 is connected by passageways to the connecting rod and wrist pin bearings. The reservoir 26 is connected with a collecting opening 36 which communicates with a slot 38 in the crank shaft at about the same time as the openings 30 and 34 are in communication. Thus at each revolution of the engine the pump 28 forces oil into the bearings. However, the crank case pressure can reach the pump 28 and reservoir 26 only when the crank case pressure is substantially atmospheric pressure, thus avoiding back pressures detrimental to the operation of the system.

During operation of the engine, the crank case 20 will contain an atmosphere which includes vaporized and liquid oil. In this engine the pulsating pressures in the crank case are utilized to induce a combustible mixture into the combustion chamber 16 without permitting such vaporized or liquid oil from entering such combustion chamber with the combustible mixture. This is accomplished by providing a pressurized chamber 40 connected with the crank case 20 and an induction chamber 42 connected with the intake ports 18, such chambers being separated by a flexible diaphragm 44 which constitutes a wall of each chamber.

In the modification illustrated in Figs. 1 and 3 the pressurized chamber 40 is below the diaphragm 44 and is formed by a circular bearing cage 46 mounted on the cylinder 10 concentric with the crank shaft 14. A central hub 48 of this cage provides the support for the plain bearing 32 and an annular shoulder 50 for holding the inner edge of the diaphragm. Adjacent this shoulder and arranged angularly thereabout are a plurality of

ports 52 leading to the crank case 20. The cage 46 has an offset 54 (see Fig. 3) defining a passage 56 in alinement with the intake ports 18 and communicating with the induction chamber 42. The outer periphery of the diaphragm 44 seats on a flange 58 on the cage 46 and on the offset 54 and the inner periphery seats on the shoulder 50. It has an opening coextensive with the passage 56 to provide free transfer from the chamber 42. The inner edge of such opening is secured to such flange by an insert 60 fastened to such flange and fitted within a recessed passage 69 in the cover. A gasket 62, placed between the cage 40 and the seating surfaces of the cylinder 10, is cut away so as not to obstruct the passage 56.

The induction chamber 42 is placed above the diaphragm 44 and is formed by a cover 64 apertured to fit over the hub 48 and rest on the bearing cage 46. Such cover has an inner shoulder 66 positioned opposite to the annular shoulder 50 to engage and hold the inner periphery of the diaphragm 44 between such shoulders. The cover also has an offset 68 (see Fig. 3) complemental to the offset 54 and containing a passage 69 providing a connection between the induction chamber 42 and the passage 56 whereby such chamber is directly connected with the intake ports 18. A hollow arm 70 projecting from the cover 64 provides a support for a reed plate 72 and manifold 74 and forms a passage for combustible mixture from such manifold to the induction chamber 42. Suitable apertured pads 76 adapted to receive fastening bolts are spaced annularly about the cover 64 and the bearing cage 46 to clamp them together and create a tight outer seal for the diaphragm 44. The inner seal for such diaphragm is made tight by screws 78 extending between the shoulders 50 and 66. The reed plate 72 is of well-known design and acts as a check valve permitting inward flow to the induction chamber 42 but preventing outward flow therefrom.

The diaphragm 44 is flexed from its inner to its outer extremes of travel in synchronism with the pulsating pressure created in the crank case 20 by the reciprocal motion of the piston 12. In some engines this diaphragm will be flexed approximately four thousand times per minute. The material must therefore be strong enough to take such rapid flexing without cracking or breaking. It has been found that a nylon fabric moulded in a synthetic oil-resistant rubber provides ample strength and is resistant to oil. Such diaphragm may be as thin as .010" to .12". In order to have flexing without stretching of the diaphragm it is provided intermediate its peripheries with annular convolutions 80 containing enough material to provide the necessary elongation without detrimental stretching of such material. The edges of the shoulders 50 and 66, flange 58 and its complementary surface on cover 64 may all be curved to lengthen the curve about which the diaphragm flexes to prevent cracking.

It has been found desirable to provide backing up supports for the diaphragm at its outer limits of flexing. Such supports are provided by curved surfaces 82 on the pressurized chamber 40 and induction chamber 42. These surfaces may be provided with scallops, indicated generally at 84, to prevent a large unbroken area of surface-to-surface contact between the diaphragm and such supporting surfaces. This prevents the diaphragm from sticking to the backing up surfaces thereby preventing its proper flexing in synchronism with the motor operation. In lieu of scallops a grid effect or other surface irregularity may be used. The essence of this feature is to provide paths for pressure to get behind the diaphragm and quickly reverse its position upon change in pressure.

Starting with the piston at the end of its compression stroke, as shown in Fig. 1, and assuming that the pressure in the crank case due to a non-operating period is substantially atmospheric, a complete cycle of operation will be described. Upon rotation of the crank shaft 14 the piston 12 will move toward the crank case 20 raising

the pressure therein, especially after passing the mid-stroke position. Such increase in pressure, which may in some engines amount to three pounds per square inch over atmospheric pressure, will flex the diaphragm 44 upwardly compressing the atmosphere in the induction chamber 42 until the intake ports 18 are uncovered. When the intake ports are uncovered the diaphragm 44 will flex to its fullest upward extent because pressure in the induction chamber 42 then drops to substantially atmospheric pressure. As the piston 12 moves toward the combustion chamber 16 the pressure in the crank case 20 lowers toward atmospheric pressure and approximately at the mid-stroke the diaphragm 44 will have pressures on each side thereof equalized and be in the neutral or central position shown in Fig. 1. During the movement of the diaphragm from the upper to the central position the cubic volume of the induction chamber 42 has increased taking in combustible mixture through the reed plate 72. As the compression stroke continues past the mid-stroke, the pressure in the crank case 20 drops below atmospheric pressure and the diaphragm 44 is flexed fully downwardly to its lower limit by atmospheric pressure with the consequent induction of still more combustible mixture into the induction chamber 42. As the result of continuous piston movement each time the piston 12 moves from the top of its stroke to the bottom of its stroke the diaphragm 44 will be flexed from fully down to fully up position and the induction chamber being fully charged will deliver a full complement of combustible mixture to the combustion chamber 16. Upon subsequent compression and ignition the engine will start operation with a rapid repetition of the foregoing sequences of operations.

Experimentation has developed that there is a tendency to accumulate pressures in the crank case 20 during rapid operation of the engine with the result that average pressure may be above or below atmospheric pressure and finally the diaphragm 44 will cease flexing. One method of preventing such occurrence is to vent the crank case each time the piston reciprocates. A small port 86 may be made in the cylinder wall at about mid-stroke or other convenient position which communicates with the exterior of the cylinder. Another small port 88 is made in the wall of the piston 12 and located so that it will be in momentary alinement with the port 88 as the piston reciprocates. Thus each time the piston reciprocates the crank case is momentarily connected with atmospheric pressure and pressure therein will be brought back to atmospheric pressure.

In the modification shown in Figs. 1 and 3 the pressurized chamber is below the diaphragm while in the modification shown in Fig. 2 the pressurized chamber is above the flexible diaphragm. In the modification illustrated in Fig. 2 the induction chamber 42 is below the diaphragm 96 and formed by a bearing cage 90 which seats on the cylinder in substantially the same manner as the bearing cage 46 of the modifications of Figs. 1 and 3. This cage also has a hub 92 for support of the bearing 32, a shoulder 94 for forming an inner seal, and spaced ports 98 communicating with the crank case 20. An inner flange 100 and an outer flange 102 on the bearing cage 90 provide support for the inner periphery and outer periphery respectively of the diaphragm 96. The inner periphery of the diaphragm is secured to the inner flange 100 by a ring 104 screwed to such inner flange. Passages 106 in the cage 90 lead from the induction chamber 42 to the inlet ports 18. A gasket 108 is interposed between the bearing cage 90 and the adjacent parts of the cylinder to form a proper seal.

The pressurized chamber 40 in this modification is placed above the diaphragm 96 and is formed by a cover 110. This cover fits over the hub 92 and has a shoulder 112 in sealing relationship with the shoulder 94 and an outer flange 114 opposite the flange 102 and engaging the diaphragm 96 therebetween. In this modification the

support for the reed plate and manifold, as indicated at **116**, is made a part of the bearing cage **90** rather than the cover. In other aspects the two modifications are substantially the same and both operate in substantially the same way. The diaphragm **96** has a more symmetrical shape than the diaphragm **44** but still is provided with convolutions **80** of identical construction. Both the pressurized chamber **40** and the induction chamber **42** have backing-up surfaces **82** and scallops **84** identical with those in the first modification. In the modification of Fig. 2 there is some possibility of liquid oil collecting on the surface of the diaphragm because of the pressurized chamber being above such diaphragm. However, since such diaphragm is rapidly flexed such oil will be dispersed and changed from liquid to vaporized state during operation. An offsetting advantage is the more direct communication between the induction chamber **42** and the intake ports **18** which assists in the induction of combustible fuel into the combustion chamber.

In the modification shown in Fig. 4 the pressurized chamber **40** and the induction chamber **42** are positioned radially outwardly from the side of the cylinder **10** in alinement with the intake openings **18**. The bearing cage **120** has a projecting body **121** forming the pressurized chamber **40** and providing a port **122** leading to the crank case **20**. This body has a flange **124** which provides a seat for the diaphragm **118**. The induction chamber **42** is formed by a cover **126** which has a flange **128** clamping the diaphragm **118** against the flange **124**. This cover provides a passage **130** leading to the intake ports **118**. In this modification reed valves **132** of a design well known to those skilled in this art are mounted directly on the wall of the cover to let combustible mixture enter into the induction chamber **42** from an intake manifold **134**. An adjustment for regulating the length of the stroke of the diaphragm **118** is obtained by a disc **136** positioned within the pressurized chamber **40** on the end of a screw **138**. This disc limits the leftward flexing of the diaphragm **118** and hence controls the volume of combustible mixture induced into the induction chamber **42** on such stroke. The positioning of disc **136** might also be controlled by a governor and thus automatically control the speed of the engine. In all other aspects the operation of the induction device is substantially the same as that of the other modifications heretofore described.

In Fig. 5 there is shown a modification of an induction device similar to that described in the modification shown in Fig. 4 with the exception that liquid fuel is delivered into the induction chamber **42** where it is mixed with air. The induction device thus acts as a carburetor. To accomplish the delivery of liquid fuel a hollow piston rod **140** has its inner end suitably secured to the central part of the diaphragm **118** and the opening therein communicates with the induction chamber **42**. The opening at such inner end is covered by a reed valve **139** which flexes to let liquid enter into the induction chamber when the diaphragm is moved to the left. At its outer end the piston rod **140** has a piston **142** operable in a cylinder **144** connected to a source of liquid fuel **146** through a port **148** closed by a reed valve **150**. When pressure in the pressurized chamber **40** drops below atmospheric the piston **142** will travel toward the left as viewed in Fig. 5 and force liquid fuel within the cylinder **144** through the hollow piston rod and through the reed valve **139** into the induction chamber **42**. At the same time air will be induced through an air intake manifold **152** and the reed valve **132** into the induction chamber **42** where it will be mixed with the liquid fuel. When the pressure rises in the pressurized chamber **40** from below atmospheric pressure to atmospheric pressure and above, the diaphragm **118** will be flexed to the right forcing the combustible mixture through the passage **130** into the intake ports **118**. At the same time the piston **142** will be moved to the right lowering the pressure within the cylinder **144** and causing liquid fuel to enter therein through the port **148** and reed valve **150**. The cylinder **144** is thus charged and ready for the next repetition of the sequence of operation.

It is desirable to regulate the length of the stroke of the diaphragm **118** to control the volume of liquid fuel delivered with each stroke. This is done by a hollow threaded screw **154** in which the piston rod **140** is slidably mounted. The inner end of such screw engages the piston rod mounting fixture on the diaphragm **118** to determine its leftward movement. The smaller the leftward stroke the smaller the amount of liquid fuel which will be pumped into the induction chamber.

In all of the modifications the essential characteristic of the invention is the separating of the atmosphere within the crank case from the combustible mixture being induced into the combustion chamber to prevent including with such combustion mixture vaporized oil from the crank case. The use of a flexible diaphragm separating a pressurized chamber connected to the crank case and an induction chamber connected to the source of combustible mixture eliminates the necessity of using expensive valves and timing mechanism required in four-cycle engines.

Although only several embodiments of the invention are shown and described herein it will be understood that this application is intended to cover such other changes or modifications as come within the spirit of the invention or scope of the following claims.

We claim:

1. In a two-cycle internal combustion engine, a crankcase, a crankshaft operably mounted in said case, a piston operatively associated with said crankshaft, a combustion chamber, an inlet port in said combustion chamber, a bearing for said crankshaft, a pressurized chamber encircling said bearing and connected with said crankcase, an induction chamber encircling said bearing and connected with said inlet port, a flexible impervious diaphragm encircling said bearing and separating said pressurizing chamber and said induction chamber, and means for supplying combustible mixture to said induction chamber.

2. In a two-cycle internal combustion engine, a crank case, a combustion chamber, an inlet port for said combustion chamber, a pressurizing chamber connected with said crankcase, a flexible diaphragm impervious to oil vapor forming a wall of said chamber whereby said diaphragm is pulsated by the pulsating pressure in said crankcase, an induction chamber connected to said inlet port, a fuel pump operated by said diaphragm and connected with said induction chamber to supply liquid fuel to said induction chamber, a source of air connected to said induction chamber, and check valve means preventing the escape of pressure from said induction chamber to said source, said flexible diaphragm forming a wall of said induction chamber whereby pressure variations in said pressurizing chamber are transmitted to said induction chamber to charge said combustion chamber.

3. In a two-cycle internal combustion engine, a crank case, a combustion chamber, an inlet port for said combustion chamber, a pressurizing chamber connected with said crank case, a flexible diaphragm impervious to oil vapor forming a wall of said chamber whereby said diaphragm is pulsated by the pulsating pressure in said crank case, an induction chamber connected to said inlet port, a hollow piston rod connected with said flexible diaphragm with the opening in said rod communicating with said induction chamber, a reed valve carried by said diaphragm normally closing the inner end of said opening in said piston rod, a piston on the outer end of said rod, a cylinder connected with a source of liquid fuel, said piston reciprocating in said cylinder, a check valve between said source and said cylinder whereby movement of said diaphragm causes said piston to pump liquid fuel into said induction chamber, and means for induc-

ing air into said induction chamber under the influence of the movement of said diaphragm.

4. In a two-cycle internal combustion engine, a crank case, a crank shaft operably mounted in said case, a piston operatively associated with said crank shaft, a combustion chamber, an inlet port in said combustion chamber, a bearing cage for said crank shaft and forming a pressurized chamber encircling said shaft and connected with said crank case, a cover for said pressurized chamber forming an induction chamber encircling said shaft and connected with said inlet port, a flexible diaphragm interposed between said bearing cage and said cover to separate said pressurizing chamber and said induction chamber, and means for supplying combustible mixture to said induction chamber.

5. In a two-cycle internal combustion engine, a crank case, a crank shaft operably mounted in said case, a piston operatively associated with said crank shaft, a combustion chamber, an inlet port in said combustion chamber, a bearing cage for said crank shaft and forming an induction chamber encircling said shaft and connected with said inlet port, a cover for said induction chamber forming a pressurized chamber encircling said shaft and connected with said crank case, a flexible diaphragm interposed between said bearing cage and said cover to separate said pressurizing chamber and said induction chamber, and means for supplying combustible mixture to said induction chamber.

6. In a two-cycle internal combustion engine, a cylinder, a crank case, a combustion chamber, an inlet port for said combustion chamber, a reciprocally moving piston, an induction chamber connected with said inlet port, a pressurizing chamber connected with said crank case, a flexible diaphragm between said chambers and forming a wall of each whereby changes of pressure in said pressurizing chamber cause flexing of said diaphragm to change the volumetric capacity of said induction chamber, said cylinder having a vent leading to atmosphere and normally covered by said piston, said piston having a vent in momentary registration with said first vent during reciprocation of said piston and leading to said crank case whereby said crank case is momentarily vented to atmosphere to prevent accumulation therein of pressures above or below atmosphere, and means for supplying a combustible mixture to said induction chamber under the influence of the change of volumetric capacity of said induction chamber.

7. In a mechanism comprising a cylinder having a piston reciprocal therein, a crank case, a fuel induction chamber operated by changes of pressure in said crank case, and a vent in said cylinder communicating to atmosphere, said vent being closed except during momentary opening thereof as said piston reciprocates to prevent pressures in said crank case from accumulating sufficiently above or below atmospheric pressure to stop operation of said fuel induction chamber.

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