Jan. 30, 1962 R. F. WILLIAMS ETAL 3,018,618

STARTING AND STOPPING MECHANISM FOR INTERNAL-COMBUSTION ENGINES

Filed March 31, 1959 2 Sheets-Sheet 1

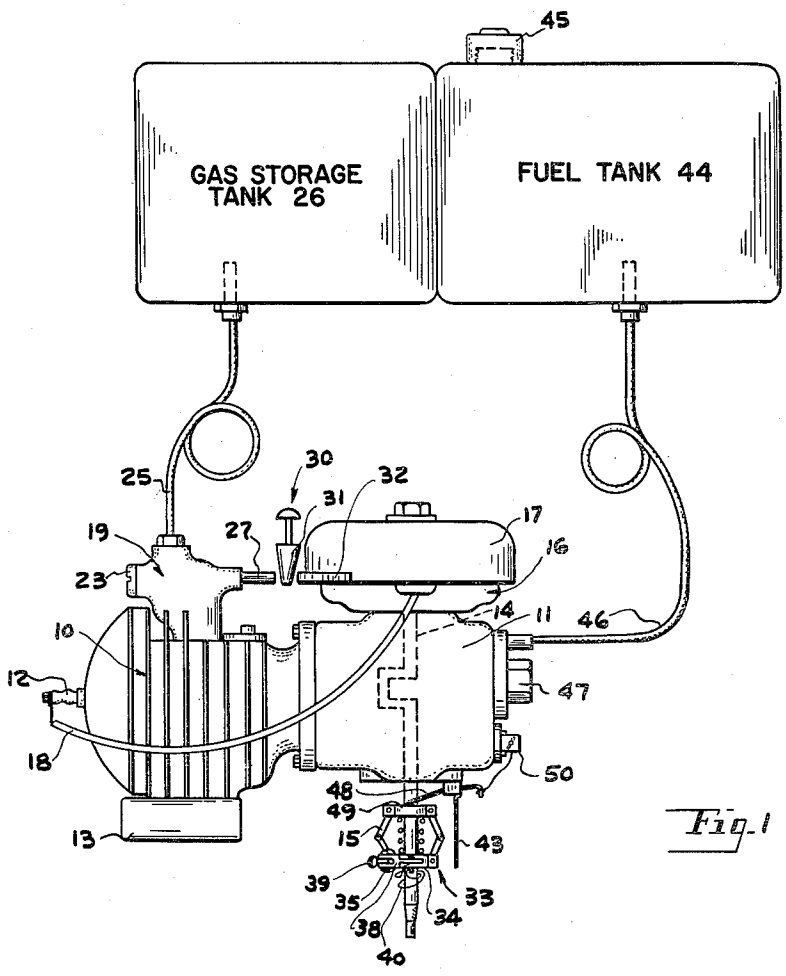


Fig. 1

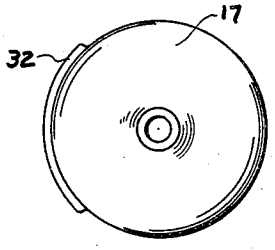


Fig. 2

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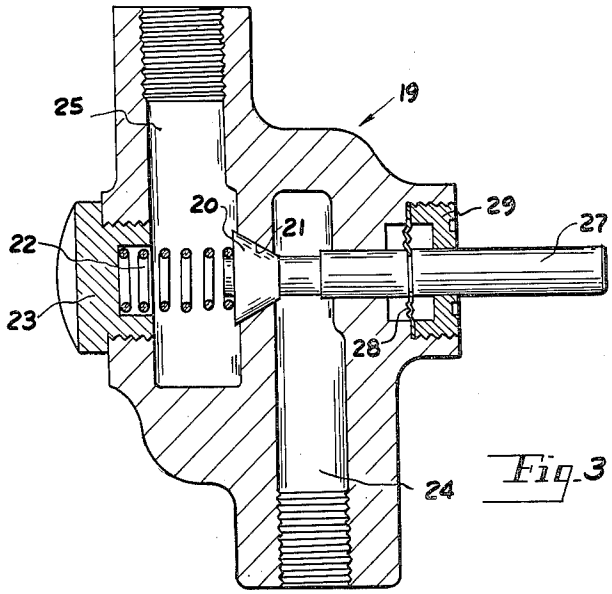
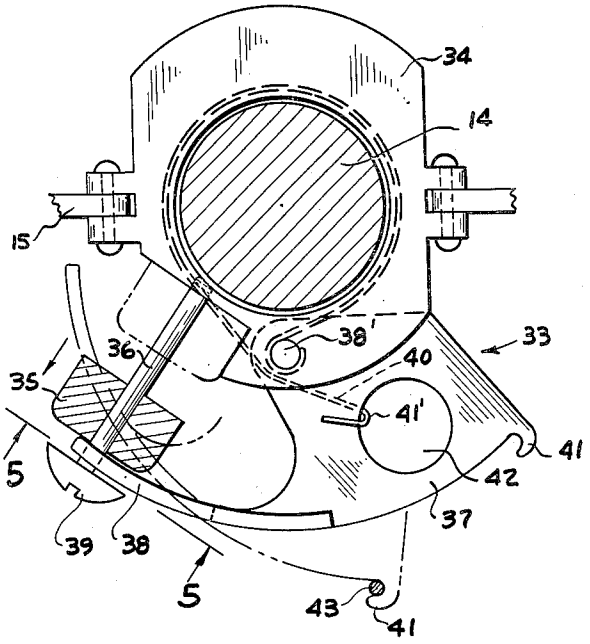


Fig. 3

Fig. 4



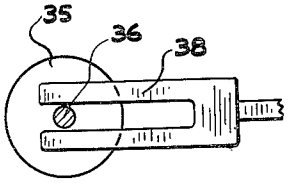


Fig. 5

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STARTING AND STOPPING MECHANISM FOR INTERNAL-COMBUSTION ENGINES

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7 Claims. (Cl. 60—16)

This invention relates to starting mechanisms for internal-combustion engines. More particularly, it relates to starting mechanisms for small utility gasoline engines, for example two-cycle engines of the type used in power lawn mowers and in motor boats.

The conventional method of starting such engines is by means of a "pull-cord." This method is very crude and not very effective. It requires a considerable amount of effort, and frequently fails to work without a number of repetitions.

The principal object of the present invention is to provide, in place of the "pull-cord" starter, a push button starting system which is highly effective and reliable, and which requires virtually no effort. In general, we accomplish this purpose by using gas pressure to turn the engine over. This gas pressure is obtained by bleeding the combusion cylinder during the normal operation of the engine. This gas is stored in a storage tank at elevated pressure, preparatory for use in subsequently starting the engine. In starting it is re-admitted into the cylinder, for example by manually operating a check valve.

In order for such a system to be operable, for starting, it is necessary that the gas be admitted to the cylinder at a particular stage of the cycle. For example, if the piston was on the way up when the engine stopped, and gas is admitted, the engine will start (if at all) in the wrong direction. Furthermore, if the gas is introduced to the cylinder when the piston is at its lowest point, there will be no tendency to move the piston. And if the gas is introduced when the exhaust ports are uncovered by the piston, most of the gas will be lost. In the latter case the engine may not start at all, or if it does, an excessive quantity of gas will be required, and this consequently means a larger storage tank with greater bulk and weight. Thus, a feasible starting system of this type must admit the gas to the cylinder only at the proper stage of the cycle.

Thus, our invention provides not only means for bleeding gas under pressure from the cylinder during normal operation, and means for re-admitting it into the cylinder upon starting, but also means for stopping the engine at the proper stage of the cycle, and means for limiting the admission of gas to the cylinder to a pre-determined portion of the cycle. In this way, we have been able to provide very simple, inexpensive, reliable, and efficient starting mechanisms, which are small in bulk and low in weight.

Other objects and advantages of our invention will more fully appear from the following description and drawings, wherein is disclosed a preferred embodiment of the invention.

In the drawings, similar numerals represent similar parts.

FIG. 1 shows a schematic general assembly of a small engine of the type to which our invention is preferably applied, with a preferred embodiment of our starting mechanism attached;

FIG. 2 is a partial top view of the engine, showing a starting cam mechanism used to limit the admission of gas to the cylinder to a predetermined portion of the cycle;

FIG. 3 is a cross-sectional view of a preferred form of check valve which may be used for automatically bleeding gas from the cylinder during normal operation; and for manually readmitting gas to the cylinder upon starting;

FIG. 4 is a cross-sectional view of a preferred rotational stopping mechanism, which ensures that the engine will be stopped at the correct portion of the cycle, so that the starting cam mechanism of FIG. 2 will be in actuating position for the subsequent admission of gas to the cylinder upon starting; and

FIG. 5 is a cross-sectional view, taken along the lines 5—5 of FIG. 4, showing a portion of the rotational stopping mechanism.

Referring now to the drawings in detail, and in particular to FIG. 1, the engine cylinder is shown generally at **10**, and the crankcase at **11**. The cylinder **10** contains a piston and inlet and exit ports (not shown), as is conventional in two-cycle gasoline engines, as well as a spark plug **12**. FIG. 1 also shows the exhaust box **13**, the crankshaft **14**, a centrifugal speed governor **15**, a magneto shown generally at **16**, a magneto ring **17** attached to and rotating with the crankshaft **14** and acting also as a flywheel, and an electrical conduit **18** connecting the spark plug **12** to the magneto **16**. Since the engine itself does not comprise a portion of the present invention, and is well known in the art, it is not shown or described here in detail.

We now proceed to describe a preferred embodiment of our means for starting the engine.

During normal operation of the engine, gas is automatically bled from the cylinder **10** through a check valve **19**, which is shown in detail in FIG. 3. While it is not necessary that the means for bleeding gas be of this type, we prefer it because it acts as an automatic bleeding means or relief valve during normal operation, and also as a manually operated check valve for the admission of high pressure gas to the cylinder during starting. Alternatively, we may use a separate bleed valve and admission valve.

The check valve **19** comprises a valve stem **20** operating in conjunction with a valve seat **21**. The valve stem **20** is loaded by a pre-setting spring **22**, which tends to maintain the valve in a closed position, and to begin to open at a predetermined pressure. The setting of spring **22** may, if desired, be varied by rotation of a sealing plug **23**. The proper adjustment of compression in spring **22** is such that during normal operation of the engine, the valve stem **20** will be urged by the pressure of the gases leaving the cylinder **10** through conduit **24** to a slightly open position, i.e. slightly to the left in FIG. 3. Conduit **24** preferably is connected to the head of engine cylinder **10**, or to a portion of the cylinder which will be above the piston at top dead center. Thus a small portion of the combustion gases will automatically be bled from the engine cylinder **10**, through conduit **24**, around the valve stem **20**, and out through conduit **25** to gas storage tank **26** (shown in FIG. 1) where gas will be stored at an elevated pressure, e.g. 60 p.s.i.g. As the gas pressure in tank **26** approaches this pressure (or whatever the predetermined tank pressure is), valve stem **20** will be urged back towards its closed position; thus the construction of valve **19** is such that gas will automatically be bled from the cylinder **10** during normal operation until the predetermined storage tank pressure is reached, after which the valve **19** will automatically operate as a check valve, preventing the flow of gases from the storage tank **26** to the cylinder **10**.

Means are also provided in valve **19** for manually opening said valve during starting of the engine, to cause the admission of high pressure gas from tank **26** to the engine cylinder **10**. These means comprise a tappet rod **27** attached to valve stem **20** and extending outwardly from the valve body, as shown in FIGS. 1 and 3. A spring diaphragm **28** is used to seal off the body of the valve from the ambient atmosphere, being sealed around tappet rod **27** as shown in FIG. 3. A retaining collar **29** seals the outer periphery of said diaphragm **28**. Thus,

the valve **19** may be manually opened by pushing the tappet rod **27** inwardly. This may conveniently be done, for example, by depressing the starting button **30** which, as shown in FIG. 1, may comprise a wedge-shaped member **31** which, upon depression, forces tappet rod **27** inwardly thereby opening valve **19**, and causing the admission of gas from tank **26** to the engine cylinder **10**.

As pointed out above, gas should be admitted to the engine cylinder **10** during starting only during a predetermined stage of the cycle. This must be after the piston has reached top dead center and is on the way down, but before it has moved far enough to cover the exhaust ports. In other words, it must be at a stage substantially equivalent to the combustion stage for ordinary operation. In order to limit admission of gas to the cylinder **10** during starting to the proper stage of the cycle, a starting cam **32** (shown in FIGS. 1 and 2) is preferably mounted on the flywheel or magneto ring **17**. Said starting cam **32** extends outwardly from said magneto ring **17** sufficiently to cooperate with the starting button **30** and the tappet rod **27**. However, said starting cam **32** extends around said magneto ring **17** only for a limited region of its periphery, preferably not exceeding approximately 90 space-degrees. Furthermore, its location on said magneto ring **17** is such that it cooperates with starting button **30** and tappet rod **27** only when the crankshaft **14** to which it is affixed is in the proper position, i.e. when the piston is slightly beyond top dead center. Thus, it is clear that gas can be admitted to the engine cylinder **10** during starting, only when the piston is in the proper position to be able to utilize such gas effectively.

As pointed out above, it is necessary to stop the engine at the appropriate stage of the cycle, in order to be able subsequently to start it in the proper position. In fact, as indicated above, if the piston is not stopped at the appropriate stage of the cycle, the starting cam **32** will be improperly positioned, and depression of the starting button **30** will not start the engine.

We therefore proceed next to describe a preferred embodiment of our means for stopping the engine at the appropriate stage of its cycle. Said preferred embodiment of our stopping means is shown generally in FIGS. 1 and 4 at **33**. It is preferably mounted on a collar **34** of the governor **15**, as shown.

Said rotational stopping mechanism **33** preferably comprises an annular centrifugal weight **35**, riding freely on a weight guide rod **36** which extends radially outwardly from collar **34**. During normal operation of the engine, collar **34** (which is attached to and rotates with the crankshaft **14**) will be rotating at a relatively high speed. Hence there will be a relatively high centrifugal force acting on said centrifugal weight **35**, thereby urging it outwardly to its outermost position (shown in solid lines in FIG. 4). On the other hand, when the rotational speed of the crankshaft **14** is reduced, centrifugal weight **35** will move inwardly toward its rest position (shown in dotted lines in FIG. 4).

Thus, when the air and fuel supply to the engine has been shut off, and the engine is slowing down to a stop, centrifugal weight **35** will be moving inwardly. This fact is utilized as the operative principle of said rotational stopping mechanism **33**, as described below.

A pivoted hooking member **37** is pivoted for rotation about a hinge pin **38'** which extends through collar **34**, substantially parallel to shaft **14**. The outer end of said pivoted hooking member **37** comprises a fork **38** (shown best in FIG. 5) which overlies centrifugal weight **35**, and whose prongs lie on opposite sides of the weight guide rod **36**, as shown. A screw head **39** is shown acting as a stop for outward motion of the weight guide rod **36** and the fork **38**. A spring **40**, shown in FIG. 4 as being affixed to hinge pin **38'**, extending around shaft **14**, and then catching at **41'** in a transverse hole **42** extending through pivoted hooking member **37**, urges

said pivoted hooking member towards the weight guide rod **36** and urges the centrifugal weight **35** towards its rest position in contact with collar **34**. Thus, as the centrifugal weight **35** is thrown outwardly by operation of the engine at relatively high speeds, the pivoted hooking member **37** will be moved to the position shown in solid lines in FIG. 4; and when the centrifugal weight **35** moves inwardly at reduced speeds, the pivoted hooking member **37** will move towards the position shown in dotted lines in FIG. 4. It will be observed that the hook **41** at the outermost end of the pivoted hooking member will thus be at a greater radial distance from shaft **14** at low speeds than at high speeds. This fact is utilized as the operative principle for stopping the engine at the appropriate stage of its cycle, as described below.

When the air and fuel supply to the engine has been shut off, and the engine is slowing down to a stop, centrifugal weight **35** will be moving inwardly, the pivoted hooking member **37** will be following in contact with it, and the hook **41** will be moving radially outwardly. When the speed has decreased to some predetermined value, e.g. 200 r.p.m., hook **41** will have reached a predetermined radial distance from shaft **14**, sufficient to catch on an appropriately positioned anchor spring **43** (shown in FIGS. 1 and 4). Said anchor spring **43** must possess sufficient flexibility to be able to absorb the momentum of the engine at this decreased speed and bring it to a dead stop without further rotation. Preferably it is in the form of a spring wire, as shown, but we may use such other types of anchor springs as are convenient in any particular case.

The engine will thus be stopped when the hook **41** is at a predetermined position. But this necessarily fixes the position of the crankshaft **14** (to which it is attached, through the hinge pin **38** mounted in collar **34**). Hence it also necessarily fixes the position of the piston in the cylinder at shutdown. This position is selected so that shutdown occurs slightly beyond top dead center, as indicated above.

In starting the engine, gas is admitted from the tank **26** to the engine cylinder **10**, as discussed above. However, the piston is not permitted to move downwardly as soon as the first amount of gas reaches the cylinder at a low pressure, since that would give very feeble starting torque. The piston cannot in fact move downwardly until a sufficient pressure is built up in the cylinder **10** to cause the anchor spring **43** to be deformed sufficiently to allow hook **41** to slip its anchor. Thus, the engine will start rotation at a momentum roughly equivalent to the momentum it had when it stopped at, say, 200 r.p.m. In other words, the starting torque will be sufficiently high to assure a brisk start.

To complete the general description of the engine shown in FIG. 1, we now refer to the fuel tank **44** (which may, if desired, be housed structurally along with the gas storage tank **26**). Said fuel tank **44** is vented to the atmosphere through a vent plug **45**, and is connected to the engine by means of a fuel conduit **46**. Normally, the fuel will be fed to a carburetor. However, we prefer to feed it to a novel fuel injector **47** described in our co-pending application, Serial No. 803,145, filed March 31, 1959, now abandoned. The speed governor **15** will also operate in conjunction with means for varying the admission of fuel and/or air to the engine. In the case of our novel fuel injector **47**, the fuel supply automatically adjusts itself to the air supply; consequently, in this case, the action of the governor operates solely on the air supply by known means, including a linkage **48** activated by the top collar **49** of governor **15**, which in turn actuates a control valve in the air supply conduit **50**.

Thus, it will be seen that we have provided novel push-button starting mechanisms for internal-combustion engines, which are inexpensive, small in size, low in weight, efficient, reliable, and high in starting torque. While we

prefer to use the present starting mechanisms in conjunction with our aforementioned fuel injector, we may use other means for feeding fuel to the engine, such as a conventional carburetor.

While we have thus shown and described preferred embodiments of our invention, it is undertood that various other modifications may also be made in the details of construction wtihout departure from the spirit of the invention, the principal novel features of which are set forth below.

We claim:

1. In a starting mechanism for an internal-combustion engine including a cylinder, inlet and exhaust ports in said cylinder, a piston adapted for reciprocating motion in said cylinder in an engine cycle, a piston rod affixed to said piston, and a crankshaft driven by said piston rod, the combination comprising: bleeding means for bleeding gaseous products of combustion at elevated pressure from said engine cylinder during operation of said engine; storage means for receiving said gaseous products of combustion at elevated pressure during operation of said engine and for storing them during shut-down of said engine; admission means for admitting said gaseous products of combustion at elevated pressure from said storage means to said engine cylinder during start-up of said engine thereby forcing said piston to move and to start said engine; and means cooperating with said admission means for limiting the admission of said gaseous products of combustion at elevated pressure to said engine cylinder substantially to the stage of said engine cycle in which said piston is beyond top dead center and in which said exhaust ports remain closed, said means cooperating with said admission means being automatically responsive to the position of said piston rod and crankshaft to render said admission means operable only at the aforesaid stage of said engine cycle.

2. In a starting mechanism for an internal-combustion engine including a cylinder, inlet and exhaust ports in said cylinder, a piston adapted for reciprocating motion in an engine cycle in said cylinder, a piston rod affixed to said piston, and a crankshaft driven by said piston rod, the combination comprising: bleeding means for bleeding gaseous products of combustion at elevated pressure from said engine cylinder during operation of said engine; storage means for receiving said gaseous products of combustion at elevated pressure during operation of said engine and for storing them during shut-down of said engine; admission means for admitting said gaseous products of combustion at elevated pressure from said storage means to said engine cylinder during start-up of said engine thereby forcing said piston to move and to start said engine; means cooperating with said admission means for limiting the admission of said gaseous products of combustion at elevated pressure to said engine cylinder substantially to said stage of the engine cycle in which said piston is beyond top dead center and in which said exhaust ports remain closed; and stopping means for stopping said engine at a stage in which said piston is beyond top dead center and in which said exhaust ports remain closed, preparatory to subsequent re-starting of said engine.

3. In a starting mechanism for an internal-combustion engine including a cylinder, inlet and exhaust ports in said cylinder, a piston adapted for reciprocating motion in an engine cycle in said cylinder, a piston rod affixed to said piston, and a crankshaft driven by said piston rod, the combination comprising: bleeding means for bleeding gaseous products of combustion at elevated pressure from said engine cylinder during operation of said engine; storage means for receiving said gaseous products of combustion at elevated pressure during operation of said engine and for storing it during shut-down of said engine; admission means for admitting said gaseous products of combustion at elevated pressure from said storage means to said engine cylinder during start-up of said engine thereby forcing said piston to move and to start said engine; and means cooperating with said admission means for limiting the admission of said gaseous products of combustion at elevated pressure to said engine cylinder substantially to the stage of said engine cycle in which said piston is beyond top dead center and in which said exhaust ports remain closed; wherein the aforesaid means cooperating with said admission means to limit the admission of gas to the cylinder at the aforesaid stage of the engine cycle comprises: a rotatable cam member mounted co-axially for rotation with said crankshaft of said engine, and being operably engageable with the aforesaid admission means only when said engine piston connected to said crankshaft is in the aforesaid stage of its cycle.

4. A starting mechanism for an internal-combustion engine including a cylinder, inlet and exhaust ports in said cylinder, a piston adapted for reciprocating motion in an engine cycle in said cylinder, a piston rod affixed to said piston, and a crankshaft driven by said piston rod, comprising in combination: bleeding means for bleeding gaseous products of combustion at elevated pressure from an engine cylinder during operation of said engine; storage means for receiving said gaseous products of combustion at elevated pressure during operation of said engine and for storing them during shut-down of said engine; admission means for admitting said gaseous products of combustion at elevated pressure from said storage means to said engine cylinder during start-up of said engine thereby forcing the piston to move and to start the engine; means cooperating with said admission means for limiting the admission of said gaseous products of combustion at elevated pressure to the engine cylinder substantially to the stage of the engine cycle in which the piston is beyond top dead center and in which the exhaust ports remain closed; and stopping means for stopping the engine at a stage in which the piston is beyond top dead center and in which the exhaust ports remain closed, preparatory to subsequent re-starting of the engine; wherein the aforesaid stopping means comprises: a pivoted hooking member mounted transversely to the crankshaft of said engine for rotation therewith and for pivoting about a longitudinal pivot axis substantially parallel to said crankshaft, said pivoted hooking member comprising a pair of opposed lever arm members, one at each side of said pivot axis; centrifugal weight means rotating with said crankshaft at varying radial distances therefrom dependent on the speed of rotation of said crankshaft, said centrifugal weight means urging one of said lever arm members radially outwardly as said centrifugal weight means moves outwardly at increased speeds of rotation of said crankshaft, thereby causing the other lever arm member correspondingly to move radially inwardly; spring means continually urging the first of said lever arm members radially inwardly, and the other correspondingly outwardly; a fixed anchor means positioned at a predetermined radial distance from said crankshaft; and catch means affixed to the second of said lever arm members at a maximum radial distance from said crankshaft so selected that at a predetermined reduced rotational speed of said crankshaft said catch means will extend radially outwardly a sufficient distance to become engaged with said fixed anchor means, thereby stopping said engine; the relative position of said catch means and said fixed anchor means being such that the crankshaft of said engine, when stopped, will cause the engine to be in the aforesaid stage of its cycle.

5. The stopping means set forth in claim 4, wherein said catch means comprises a hook, and wherein said fixed anchor means comprises a spring means engageable with said hook, possessing sufficient flexibility to absorb the momentum of said engine at the aforesaid reduced stopping speed, and to retard the subsequent starting of said engine until sufficient gas pressure has been built up in said engine cylinder to create a substantial starting torque.

6. The starting mechanism for an internal-combustion engine set forth in claim 2, wherein the means for bleeding gaseous products of combustion and for subsequent admission thereof to the engine cylinder upon starting comprises a valve body; a valve seat located therein; a valve stem engaging said seat for closure thereof; spring loading means urging said valve stem to closed position; a tappet rod affixed to said valve stem in opposition to said spring loading means; manually operable means for moving said tappet rod and said valve stem to open position, in opposition to said spring loading; a port in said valve body communicating on the tappet side of said valve stem, to the engine cylinder; and a second port in said valve body communicating on the spring loading side of said valve stem, with said storage means; said spring loading means being set to a predetermined loading such as to permit limited opening of said valve stem under the pressure of gases in the engine cylinder during operation of the engine, thereby permitting bleeding of gaseous products of combustion from the engine cylinder during operation of the engine; and, further, wherein the means for limiting admission of gaseous products of combustion to the cylinder to the aforesaid stage of the engine cycle comprises a rotatable cam member mounted co-axially for rotation with the crankshaft of said engine, and being operably engageable with the aforesaid admission means only when the engine piston connected to said crankshaft is in the aforesaid stage of its cycle; and, further, wherein the stopping means comprises a pivoted hooking member mounted transversely to the crankshaft of said engine for rotation therewith and for pivoting about a longitudinal pivot axis substantially parallel to said crankshaft, said pivoted hooking member comprising a pair of opposed lever arm members, one at each side of said pivot axis; centrifugal weight means rotating with said crankshaft at varying radial distances therefrom dependent on the speed of rotation of said crankshaft, said centrifugal weight means urging one of said lever arm members radially outwardly as said centrifugal weight means moves outwardly

at increased speeds of rotation of said crankshaft, thereby causing the other lever arm member correspondingly to move radially inwardly; spring means continually urging the first of said lever arm members radially inwardly, and the other correspondingly outwardly; a fixed anchor means positioned at a predetermined radial distance from said crankshaft; and catch means affixed to the second of said lever arm members at a maximum radial distance from said crankshaft so selected that at a predetermined reduced rotational speed of said crankshaft said catch means will extend radially outwardly a sufficient distance to become engaged with said fixed anchor means, thereby stopping said engine; the relative position of said catch means and said fixed anchor means being such that the crankshaft of said engine, when stopped, will cause the engine to be in the aforesaid stage of its cycle.

7. The starting mechanism for an internal combustion engine set forth in claim 6, wherein the catch means comprises a hook, and wherein said fixed anchor means comprises a spring means engageable with said hook, possessing sufficient flexibility to absorb the momentum of said engine at the aforesaid reduced stopping speed, and to retard the subsequent starting of said engine until sufficient gas pressure has been built up in said engine cylinder to create a substantial starting torque.

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