Aug. 28, 1934. M. CASERTA 1,971,767

MEANS FOR STARTING INTERNAL COMBUSTION ENGINES

Filed Aug. 1, 1930 3 Sheets-Sheet 1

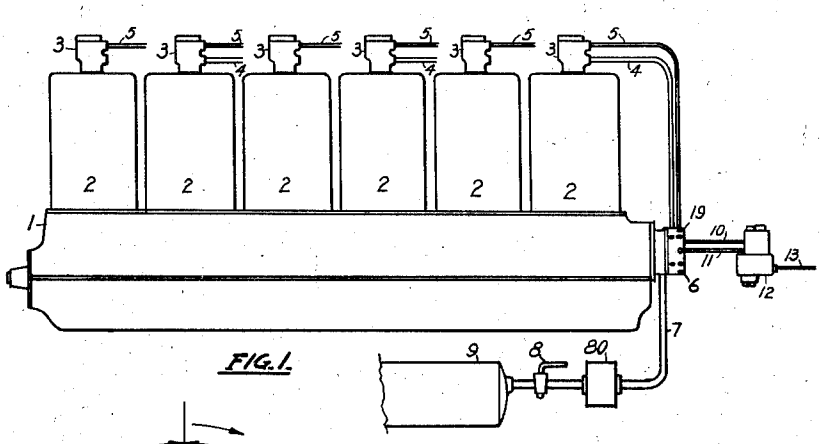


FIG. 1.

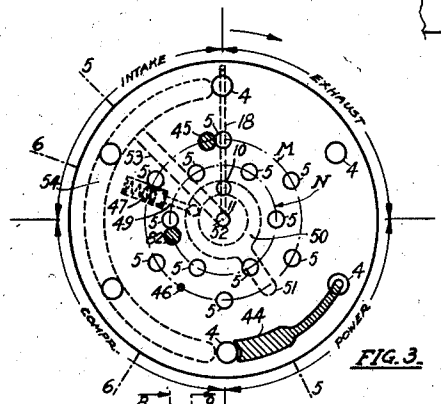


FIG. 3.

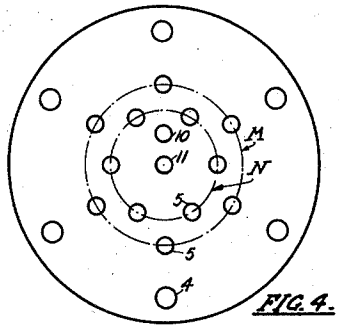


FIG. 4.

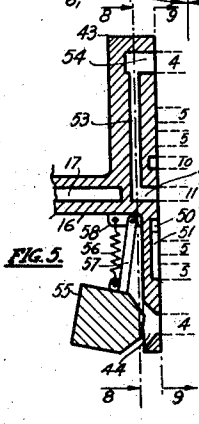


FIG. 5.

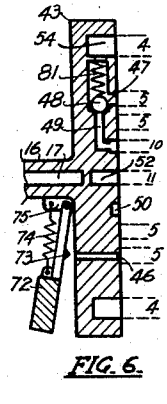


FIG. 6.

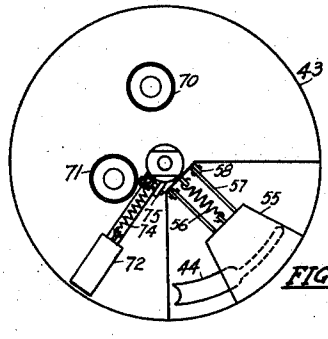


FIG. 7.

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MEANS FOR STARTING INTERNAL COMBUSTION ENGINES

Filed Aug. 1, 1930 3 Sheets-Sheet 2

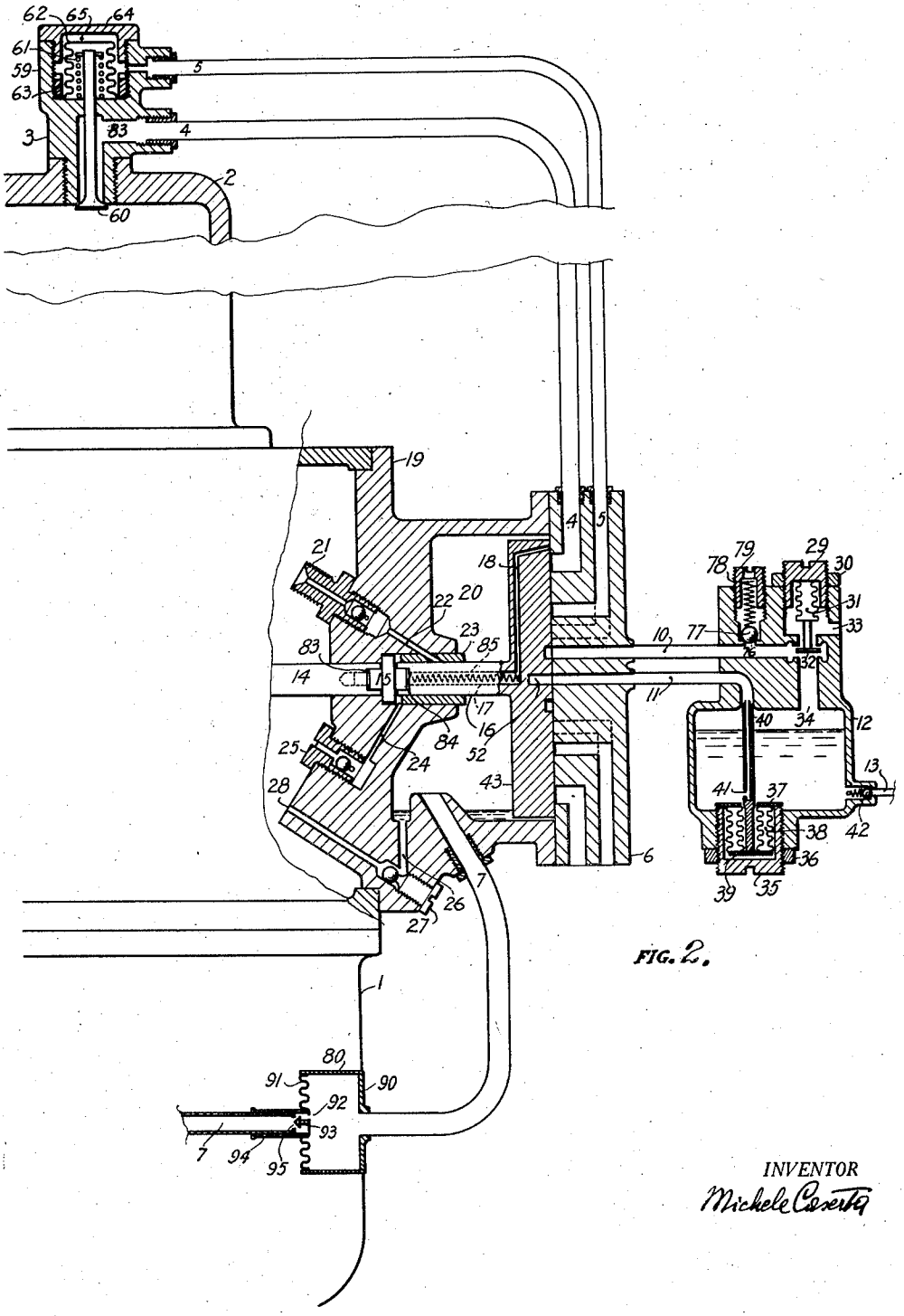


FIG. 2.

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MEANS FOR STARTING INTERNAL COMBUSTION ENGINES

Filed Aug. 1, 1930 3 Sheets-Sheet 3

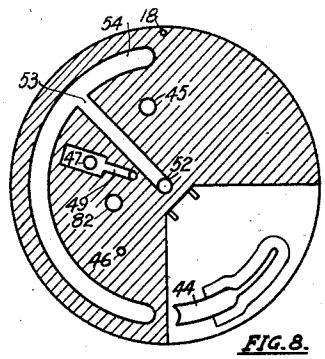


FIG. 8.

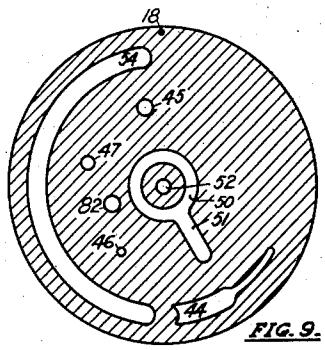


FIG. 9.

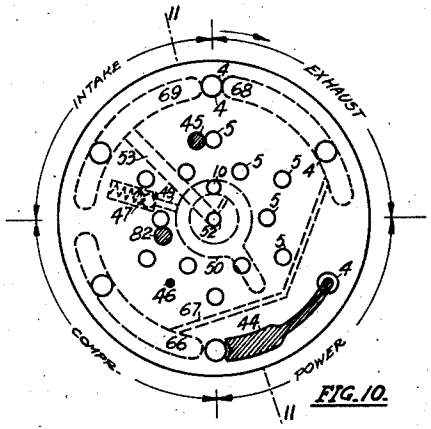


FIG. 10.

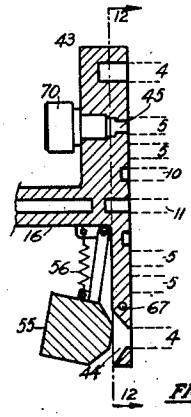


FIG. 11.

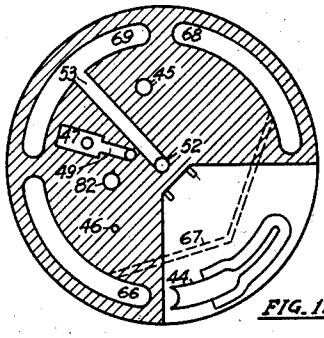


FIG. 12.

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Patented Aug. 28, 1934 1,971,767

UNITED STATES PATENT OFFICE

1,971,767

MEANS FOR STARTING INTERNAL COMBUSTION ENGINES

Michele Caserta, Detroit, Mich.

Application August 1, 1930, Serial No. 472,448

21 Claims. (Cl. 60—16)

This invention relates to means for starting internal combustion engines and more particularly to a new and novel construction thereof tending to simplify, render more efficient and improve the same generally.

Heretofore different systems and means have been proposed, by which the engine cylinders are temporarily set in communication with the atmosphere to prevent that pressure be built in them during the compression stroke, which pressure unduly opposes the rotation of the engine while starting. However in these heretofore known structures the absence of compression at the firing point renders the firing itself very uncertain and prevents the picking up of the engine.

It has also been proposed, in prior art structures, to provide the engine with means to open communication between the cylinders and the atmosphere, and with a heavy flywheel. To start such an engine it is necessary to crank it rapidly to store energy in the flywheel, then close the cylinders and rely on the energy stored in the flywheel to overcome the compression and rotate the engine at a speed sufficient for starting. This system involves heavy and cumbersome parts, as well as skill in the operator to choose the proper time at which to stop cranking and restore compression in the cylinders.

Other means are also known, for starting engines, which do not affect the regular compression in the cylinders undergoing compression stroke, or even increase it, and waste considerable energy in overcoming said compression in the earlier part of the starting action.

To avoid these objections my invention provides means for automatically relieving compression from all or part of the engine cylinders at the beginning of the starting action, means for automatically restoring compression in the cylinders as soon as the engine speed is sufficient for normal operation, and means for turning the engine through the whole starting period without having to rely on the energy stored in the rotating parts to overcome compression.

Another object of my invention is the provision of a simple single valve which is mounted on the cylinders, does not affect the volume nor the shape of the combustion chamber, and is active in introducing compressed fluid in the cylinder during its power stroke to turn the engine, in priming the cylinder, and in setting the cylinder in communication with the atmosphere during the compression stroke to release compression at the earlier stage of the starting action.

My invention moreover contemplates the automatic proportioning of the priming mixture, the lubrication of the moving parts, the careful utilization of the compressed air, and other improvements and novel details of construction which will be more apparent as this description proceeds.

For the purpose of setting forth a clear description and understanding of my invention, I have shown the preferred general arrangement thereof in connection with a twelve cylinder, four cycle, internal combustion engine, it being clearly understood that the said invention can be employed with facility in connection with any multi-cylinder internal combustion engine of any type, by a rearrangement that anyone skilled in the art can devise, and can be applied to all or part of the engine cylinders.

Furthermore it should be understood that while in the accompanying drawings and description, distributing means are represented as rotary distributors, poppet valves and ball valves, any other means capable of performing the same operation are considered as coming within the scope of this invention; this also applies to vaporizing means, nozzles, springs, ports, conduits, diaphragms and other details shown in the instant embodiment of my invention illustrated herein.

Many details pertaining to the combination of the engine, starter, and other accessories being already known in the art, have been represented only in diagrammatical form, while a full disclosure has been made of the new means and arrangements forming the particular subject matter of my invention.

In the accompanying drawings:

Figure 1 is a view showing the general arrangement of a starting means constructed in accordance with my invention, the structure being illustrated semi-diagrammatically for the purpose of clearness;

Figure 2 is an organization view showing more in detail and in section some of the parts indicated in Figure 1;

Figure 3 is a semi-diagrammatical view of the preferred form of distributor, showing the arrangement and location of the ports;

Figure 4 is a front elevation of the stationary distributor;

Figures 5 and 6 are sectional views through the preferred form of rotary distributor, taken substantially along lines 5—5 and 6—6 respectively of Figure 3;

Figure 7 is an elevation view of said rotary distributor;

Figures 8 and 9 are sectional views through said rotary distributor taken substantially along lines 8—8 and 9—9 of Figure 5;

Figure 10 is a semi-diagrammatical view of a modified form of distributor, showing the arrangement and location of the ports;

Figure 11 is a sectional view through said modified form of rotary distributor taken substantially along line 11—11 of Figure 10;

Figure 12 is a sectional view through said modified form of rotary distributor taken substantially along line 12—12 of Figure 11.

Referring now more especially to the drawings, wherein like reference characters indicate corresponding elements throughout the several figures, and more particularly to Figure 1, it will be noted that reference character 1 indicates a twelve cylinder engine, of which only 6 cylinders are shown, the other 6 cylinders being arranged and connected in a similar way; 2 indicates an engine cylinder, each cylinder being provided with a cylinder valve 3; 4 and 5 are pipes connecting the cylinder valves 3 to the distributor 6, which in turn is connected through the main pipe 7 and starting valve 8 to the reservoir 9. The pipes 10 and 11 connect the distributor with the mixing chamber 12 which is supplied with fuel by the line 13; 80 is a pressure regulator inserted between the reservoir and the distributor.

In Figure 2, the numeral 14 indicates a shaft driven in time with the engine and provided with a screw driver slot 83 which provides a slidable but nonrotatable connection with the short shaft or disc 15, which in turn drives in a similar manner through slot 84 the shaft 16 of the rotary distributor 43; 17 and 18 are oil leads through the shaft 16 and the rotary distributor 43. Numeral 19 indicates the distributor casing which is preferably fastened to the engine and provides a fluid chamber 20 to which fluid under pressure is supplied from port 7; 21 is a check valve which allows the flow of oil from any suitable source to port 22 and bearing 23, but prevents the escape of fluid in opposite direction; 24 is another oil port leading to valve 25, which allows a slow flow of fluid such as normally draining from the bearing, but closes as soon as the flow tends to increase and is sufficient to lift the valve ball to its seat; 26 is a similar oil port and 27 a similar valve which collaborate in a similar way to allow drainage of oil and prevent escape of fluid under pressure from chamber 20 to port 28.

Numeral 12 indicates a mixing chamber body, to which fluid under pressure is supplied through port 10, as will hereinafter more fully be described; a threaded part 29 screwed in said body and checked by nut 30, carries a thermostat body 31, to which a valve 32 is fastened; said valve, according to the regulation of the threaded part 29 and the temperature of the thermostat 31 will direct the flow from the port 10 to port 33, which is communicating with the atmosphere, or to mixing chamber 34. Another threaded part 35 is assembled to the bottom of the mixing chamber, 36 being a check nut; fastened to said threaded part 35 preferably by solder, are the disc 37 and the hollow thermostat 38 and the disc 39 solid with nozzle 40, which is provided with a port 41 for the passage of fuel. A valve 42 connected to any suitable source of fluid, allows the flow of said fuel to chamber 34 and prevents its escape under pressure. Branching from port 10 is port 76, normally closed by ball 77, which is held against its seat at a predetermined pressure by spring 78; the tension of said spring can be regulated by means of the threaded plug 79, which is drilled to allow escape of fluid.

Numeral 3 indicates a cylinder valve assembly; 83 and 5 indicate ports which can be connected to stationary distributor 6, and 59 indicates the cylinder valve body in which the poppet valve 60 is kept seated by spring 61. Numeral 62 indicates a flexible diaphragm or sylphon which is assembled to the body 59 in a fluid-tight manner by means of a threaded tubular part 63; a plug or cover 64 completes the chamber 65 which communicates with port 5. Numeral 80 again indicates the pressure regulator which in the form illustrated consists of a casing 90 solid for instance with the crankcase 1. A flexible diaphragm 91, provided with a port 92 a valve 93 and a sleeve 94, responds to the pressure inside said casing 90 and brings said valve 93 against valve seat 95 when a predetermined pressure is attained in said casing; this stops the flow of fluid, so that a constant pressure is maintained in casing 90.

Referring now to Figure 3, which is a semi-diagrammatical view of the rotary distributor 43 and the stationary distributor 6, the ports which set communication from one side to the other of the rotary distributor are indicated in full line and cross-etched; the ports which would be in sight on the stationary distributor if the rotary distributor were removed are indicated in full line; and the ports or grooves which are open on the surface of contact between the rotary and stationary distributor, and the ports inside of the rotary distributor, are indicated in dotted lines.

A better understanding of Figure 3 can be had if Figures 4 to 9 are considered at the same time. The numeral 4 indicates ports in communication with 6 of the engine cylinders through the corresponding valves 3; port 44 sets communication between chamber 20 and each of said ports 4 when the corresponding cylinder is undergoing power stroke, with the result that the engine is turned if there is sufficient pressure in chamber 20, as already known to the art.

Six ports 5 are equally spaced on a circle M in the stationary distributor and each one is in radial alignment with a port 4 and in communication with the same valve 3 to which said port 4 is connected; a port 45 provided in the rotary distributor on the same circle M sets communication between chamber 20 and each of said ports 5 about at the beginning of the intake stroke in the corresponding cylinder, and another port 46 performs the same function during the compression stroke. Six more ports 5 are equally spaced on a smaller circle N in the stationary distributor, and connected to the other six valves 3 which do not have any port 4 connection; a port 82 on the same circle N in the rotary distributor sets communication between chamber 20 and each of these last mentioned ports 5 when the corresponding cylinder is about at the beginning of the compression stroke; 47 indicates a port in the rotary distributor, so located on circle M as to register with each of the six ports 5 of the same circle M when the corresponding cylinder is about at the end of the intake stroke; a ball 48 checks communication between port 47 and port 49 which is carried inside the rotary distributor to connect with the circular groove 50; said groove has a radial extension 51 timed to register with each of the 12 ports 5 when the corresponding cylinder is undergoing power stroke; groove 50 is at all times in communication with port 10 leading to the mixing chamber through the stationary distributor.

Port 11 leads from the mixing chamber centrally through the stationary distributor and is in continuous communication with the axial port 52 and the radial port 53 carried inside the rotary distributor to groove 54; said groove 54 is extended to register at the same time with sev-

eral ports 4 leading to cylinders undergoing intake and cylinders undergoing compression.

Referring now also to Figure 7, 55 indicates a heavy valve so shaped and proportioned as to close only part of port 44 when lowered against tension of spring 56; 57 indicates two links connecting said valve 55 to hinge 58, which is solid with rotary distributor 43; 72 is a weight carried at the end of member 73, which is so shaped as to close port 46 when rotated around hinge 75 against tension of spring 74.

It will be noted that in the present embodiment all of the twelve cylinder valves 3 are connected to the distributor by ports 5, but only six of said valves have also a connection 4 between port 83 and the distributor, while the other six communicate directly with the atmosphere through port 83.

In Figure 10, which shows an alternate form of rotary distributor, groove 66 is so timed as to register with ports 4 when the corresponding cylinders undergo compression; 67 is a port internal to the rotary distributor and setting communication between groove 66 and groove 68, which is timed to register with ports 4 when the corresponding cylinders undergo exhaust.

Figure 11 is a sectional view of the rotary distributor taken substantially along line 11—11 of Figure 10. A pressure regulator 70 is fastened to the rotary distributor and sets communication between chamber 20 and port 45; a similar pressure regulator 71, shown in Figure 7, sets communication between chamber 20 and port 82. Said regulators 70 and 71 may be of any suitable construction known in the art, as shown for instance for regulator 80 in Figure 2.

It will be noted that in the present specifications and drawings, the intake, compression, power and exhaust cycles are represented as being completed each during 180° of rotation of the crankshaft of the engine, or during 90° of rotation of the rotary distributor, which in this embodiment turns at half crankshaft speed. However in practice such angles are different, according to the particular timing of each engine and the engine type; the rearrangement and timing of the distributor ports in accordance with the engine timing, is a simple matter and can be performed easily by anyone skilled in the art, according to my invention as herein described.

To turn the engine the valve 8 is shown open by the operator, so that compressed fluid can flow from reservoir 9 through pipe 7 and pressure regulator 80 to chamber 20 of the distributor; the pressure regulator can be of any suitable kind known to the art, and is active in holding the pressure in chamber 20 down to a predetermined value, as long as the pressure in the reservoir is higher than said value.

It will be noted that in prior art it has been customary to let full reservoir pressure act in the cylinders through the distributor, trusting that the pistons would rapidly move away and so prevent any damage due to excessive pressure in the cylinders; however such practice involves considerable waste of fluid as long as the pressure in the reservoir is higher than necessary to turn the engine at the minimum speed necessary to start in the worse conditions. Therefore I prefer to have a pressure regulator that will allow in chamber 20 a pressure slightly above the minimum pressure necessary for a sure start in the worse conditions; such pressure is in dependence of several elements and is preferably determined by experiment. In some cases, as for instance when a constant pressure fluid source is used, the pressure regulator may be omitted.

From chamber 20 the fluid passes through ports 44 and 4 and valve 3 to one or more cylinders that in regular running would be undergoing power stroke, exerts its pressure on the pistons and compels the engine to turn. It will be noted that while a slot or opening of constant section has heretofore been used in the rotary distributor to deliver fluid to the cylinders, I provide a slot which allows free flow of fluid to the cylinders at the beginning of the power stroke, and reduces such flow as the power stroke progresses; by this I attain the result of delivering a powerful charge of pressure fluid to the cylinder at the beginning of the power stroke, and then let said charge expand in the cylinder during said stroke developing power and be exhausted at a very reduced pressure. It will be noted that the flow reducing effect of the restricted part of port 44 is felt more when the engine is rotating fast, than at the beginning of the starting action, when fluid has time to flow and build full pressure in the cylinder even through a restricted port; this action is advantageous as more power is required at the beginning of the starting action to turn the engine; however it would be difficult to proportion port 44 in such a way as to attain the best result for economy and power, and therefore I provide a valve 55 which closes part of port 44 only after the starting action has begun and the engine is turning at such a speed that the centrifugal force holds valve 55 against port 44; the shape of port 44, the weight of valve 55, and the tension of spring 56 can be so proportioned as to give full power at the beginning of the starting action and then use only enough compressed fluid to turn the engine at the minimum speed necessary for a start in the worse conditions.

From chamber 20 another stream of fluid passes through the pressure regulator 70 and port 45 to a port 5, and finally builds pressure in chamber 65 of valve 3 connected to a cylinder which at the time is undergoing intake stroke; the regulator 70 is set to deliver to chamber 65 sufficient pressure to deflect diaphragm 62 which engages the stem of valve 60 and opens said valve to set communication between the cylinder and port 4; as the engine turns the distributor cuts off communication between chamber 20 and port 5, and some compressed fluid is trapped in chamber 65 and port 5; after the intake of the cylinder we are considering has progressed, port 47 comes to register with the corresponding port 5 of the stationary distributor and it will be seen that the back flow of trapped fluid from port 5 through port 47 and 49 to groove 50 is controlled by valve 48 which is held against its seat by spring 81; said spring is so proportioned that it will yield to the centrifugal force developed by ball 48 when a predetermined velocity of rotation is reached, and then the fluid trapped in port 5 will expand through groove 50 and port 10 to the mixing chamber 12, which will be later described in detail; suffice now to say that as a result a mixture under pressure will be delivered from the mixing chamber through port 11.

Reverting to the distributor it will be seen that as long as the speed of rotation is low valve 48 prevents the escape of fluid from port 5 and chamber 65, and therefore valve 60 remains open through the compression stroke with the result that at low speed the engine cylinder undergoing compression is in communication with port 4 and the fluid present in the cylinder instead of being

compressed escapes through port 4 to groove 54 which, as already said, is always in communication also with at least one of the ports 4 leading to a cylinder undergoing intake stroke; we have seen that valve 60 of said intake stroke cylinder is open, and the gases coming from the compression cylinder can rush past it, fill the suction cylinder and eventually escape to the atmosphere through the intake valve which is open during the intake stroke. However, when the speed of rotation attains a predetermined value, sufficient for regular running of the engine, valve 48 allows the fluid to escape from port 5 and chamber 65, so that valve 60 closes when the compression stroke is about to begin, with the result that the charge inside the corresponding cylinder is compressed in the regular way and can be easily ignited.

The compressed fluid which through port 32 is made active in chamber 65 of the six valves 3 which do not have any port 4 connection, holds said valves open to the atmosphere until port 51 releases the pressure from port 5 corresponding to each valve 3; therefore no compression takes place in the corresponding cylinders as long as there is sufficient pressure in chamber 20 to deflect diaphragm 62 and open valve 60.

The pressure regulators 70 and 71, of any suitable kind known to the art, allow in all ports 5 only enough pressure to operate the diaphragms 62 and later perform a priming action, and so avoid waste of fluid as well as facilitate the proportioning of the priming mixture.

When the engine is being started and the speed of rotation of distributor 43 increases, ball 48 has an increasing tendency to open communication between port 47 and port 49 under the influence of centrifugal force and against the joint action of spring 81 and of the pressure communicated to the spring chamber by the ports 5 in which fluid is trapped; at a certain moment the centrifugal force attains such value that it slightly unseats ball 48 and this is sufficient to allow the escape through port 49 of fluid trapped in port 47 and the spring chamber during the time that port 47 is travelling between a port 5 and the next one; the action of pressure back of ball 48 being so eliminated, the centrifugal force suddenly unseats the ball, and when port 47 comes to register with the next port 5 the fluid trapped in said port 5 escapes through port 49 without acting on ball 48; this action insures that as long as the predetermined speed of rotation is not attained, the compression in the cylinders is completely released to speed up the engine; and as soon as said predetermined speed of rotation is attained, full compression is suddenly reinstated in the engine cylinders with the result of easy firing and powerful combustion, without losing time and energy in a period of transition during which the compression in the cylinders would not be sufficient for a good combustion. This arrangement is particularly advantageous in engines of the Diesel type, in which the ignition is dependent entirely on compression.

The function of port 46 will now be explained; at the beginning of the intake stroke of some of the cylinders, the corresponding valve 3 receives a fluid charge that holds it open for compression release through the compression stroke. The valves 3 of such cylinders which had passed the beginning of the intake when the engine last stopped, but did not reach the power stroke, would therefore not receive the fluid charge and the corresponding cylinders would be subject to compression at the beginning of the starting action, and would oppose the rotation of the engine right when the engine is harder to rotate for other reasons; to avoid this I provide in the rotary distributor a small port 46 which renders the compression releasing means active during the compression stroke, by setting communication between chamber 20 and port 5. As the action of port 46 is desirable only at the very beginning of the starting action, I provide a valve 73 which closes said port 46 as soon as the centrifugal force acting on weight 72 is sufficient to overcome the tension of spring 74; the different parts are preferably so proportioned that valve 73 will close port 46 before ball 48 is unseated.

Port 46 is made preferably so small that it will allow sufficient flow of fluid to operate valve 3 at very low speed of the rotary distributor, but insufficient flow to operate valve 3 at higher speeds; so that should valve 73 be out of order, the compression in the cylinders would still finally be allowed and the engine would be started with the only disadvantage of waste of fluid and a priming not perfectly proportioned owing to the excess of fluid provided to ports 5 through port 46 and delivered to the mixing chamber through port 51.

Port 51 releases from all ports 5 whatever compressed fluid is trapped in them, preferably after the beginning of the power stroke, so that the main flow of fluid coming through port 44 to act on the pistons and turn the engine finds the valve 60 unseated at the beginning of the power stroke, which is advantageous for the same reasons for which the action of valve 55 is provided.

Port 50 collects fluid from ports 49 and 51 and delivers it to port 10.

Communicating with port 10 is port 76, normally closed by ball 77, which is held on its seat by spring 78; the function of this vave is to reduce the pressure in line 10 to whatever constant value is found more convenient for the priming purposes for which the fluid passing through port 10 is to be used; said pressure value depends on the volume of ports 4 and 5, on the characteristics of the engine and on other elements, and is best determined by experiment.

A valve 32 controlled by thermostat 31 may or may not, according to conditions, release to the atmosphere some of the fluid from port 10 to reduce the priming, and may even close communication between port 10 and chamber 34 when the engine and the atmosphere are so warm that no priming is necessary; the best adjustment for this valve is also preferably determined by experiment.

Chamber 34 is supplied with fuel through line 13 and valve 42 from any convenient source, and is normally supplied with fluid from port 10.

As the fluid rushes from chamber 34 to port 11 a mixture with fuel is formed with the collaboration of nozzle 40, which is controlled by thermostat 38 and gives a richer mixture when said thermostat is cold and contracted than when it is warmer and expanded, as it is apparent from the drawings to those skilled in the art, said action being in accordance with the needs of the engine. The adjustment of plug 35 which supports the thermostat and the nozzle, is also to be determined by experiment.

Through port 11 the priming mixture is led to port 52 of the rotary distributor, which is always in communication with port 11, and through port 53 reaches port 54 which registers with a

number of ports 4; some of these ports 4 correspond to cylinders undergoing compression, and some to cylinders undergoing intake. Before the speed of the engine is sufficient to lift ball 48, as already described, all said ports 4 are in open communication with the corresponding cylinders, and a flow of fluid discharges from the cylinders undergoing compression into the cylinders undergoing intake; the priming mixture coming from port 11 mixes with said flow of fluid and enters the cylinder undergoing intake; whatever excess of fluid there is, escapes from the intake valve of the cylinder into the manifold, if any, and eventually into the atmosphere.

It will be seen that in this way the manifold or the ports from which the cylinders will later draw their charge are filled with a rich mixture which may even settle as a liquid deposit on the walls of said ports and will help the engine to continue operation after starting means have been rendered inoperative.

Even after the compression is restored in the cylinders by the action of valve 48, and communication between the cylinders undergoing compression and ports 4 is cut off, communication between ports 4 and the cylinders undergoing intake is still open, and the priming takes place in the usual manner as long as there is pressure in chamber 20, or as long as the operator keeps the starting valve open.

By the arrangement of ports shown in Figure 10, at the beginning of the starting action six of the cylinders are directly set in communication with the atmosphere through port 83 of their own valve 3 during the compression stroke, and the other six through ports 83, 4, 66, 67 and 68, which port 68 is timed to communicate with cylinders undergoing exhaust stroke; the arrangement of Figure 10 differs from the arrangement of Figure 3 in that the compression in the cylinders undergoing compression stroke is released through the cylinders which are open to the atmosphere for exhaust in one case, and for intake in the other; however with the arrangement shown in Figure 10 the fluid coming from the cylinder undergoing compression must lift from its seat valve 60 of the cylinder undergoing exhaust, and therefore a little back pressure is present; all other elements are similar in both arrangements.

Having now described the function of the different elements, it will be easier to follow the cycle of operation for each cylinder, for instance the one to which the ports 5 and 4 located on the lower half of the vertical centerline in Figure 3 are connected. Said cylinder is at dead center at the beginning of power stroke, and if we consider the earlier stage of the starting process, the speed of the rotary distributor has not yet been sufficient to lift the ball 48 from its seat; therefore port 5 and chamber 65 corresponding to our cylinder are still charged with compressed fluid which keeps valve 60 open. As the rotary distributor rotates in the direction of the arrow, port 44 registers with port 4 and a current of compressed fluid finds its way into the cylinder through port 83 of valve 3, acts on the piston and speeds up the engine. Then groove 51 comes to register with port 5, and the air trapped in chamber 65 and port 5 escapes through grooves 51 and 50 to port 10 and to the mixing chamber 12; the diaphragm 62 is released but the valve 60 is kept open as long as there is a stream of fluid coming through ports 44, 4 and 83.

Before the beginning of the exhaust stroke port 44 passes beyond port 4, no more compressed fluid is allowed to the cylinder, and valve 60 closes.

During the exhaust stroke, the exhaust valve of the engine cylinder opens and discharges the compressed fluid from the cylinder.

At the beginning of the intake stroke port 45 of the rotary distributor registers with port 5 and compressed fluid fills port 5 and chamber 65 and opens valve 60 again; about at the same time groove 54 registers with port 4 which communicates freely with the cylinder through the open valve 60; in turn the cylinder communicates freely with the manifold and the atmosphere through its open intake valve; so the rich priming charge coming from the priming chamber 12 through ports 11 and 53, and the compression gases coming through ports 4 from the cylinders undergoing compression and collected by groove 54, can fill the intake cylinder, and the excess can escape into the atmosphere. About at the end of the intake stroke port 47 registers with port 5, but the pressure in port 5 and chamber 65 is not released as ball 48 is tightly seated and precludes the escape of fluid. As the cylinder enters the compression stroke, valve 60 is still open and the gases instead of being compressed in the cylinder, may escape through port 4 and groove 54 to another cylinder undergoing intake stroke, and eventually to the atmosphere.

During the compression stroke the small orifice 46 passes in front of port 5 without any change in the situation, as port 5 and chamber 20 are at the same pressure.

We shall now repeat the cycle supposing the engine has attained sufficient speed to unseat ball 48 by centrifugal force.

At the beginning of the power stroke, port 44 registers with port 4 and a powerful unrestricted flow of compressed fluid rushes through 4 to the cylinders; as the stroke proceeds, however, the flow is hindered by the restricted part of port 44, or altogether checked by valve 55 which closes part of port 44. Groove 51 registers with port 5 without any result, as port 5 and chamber 65 have already been discharged through port 47 during the intake stroke.

During the exhaust stroke the compressed fluid escapes from the cylinder through the exhaust valve.

At the beginning of the intake stroke port 45 registers with port 5 and the fluid charges chamber 65 and opens valve 60. Also groove 54 registers with port 4 and the priming fluid coming from the priming chamber through ports 11, 53, 54, 4, 83 and the open valve 60, charges the cylinder. Towards the end of the intake stroke port 47 registers with port 5 and the fluid previously trapped in port 5 and chamber 65 escapes past ball 48 (which is off its seat) through port 49 and 10 to the priming chamber 12; as said fluid escapes from chamber 65, valve 60 closes and compression takes place normally when the cylinder enters the compression stroke.

The action of the orifice 46 has already been described as effective only at extremely low speeds of rotation of the engine to prevent compression by opening valve 60 of such cylinders as happened to be in intake or compression stroke before the engine is started; at the speed usually attained by the engine in half a turn, the quantity of fluid which reaches chamber 65 through orifice 46 and port 5 is preferably insufficient to open valve 60.

Referring now to the form of distributor repre-

sented in Figure 10, and particularly to the cylinder connected to the ports 4 and 5 which in said figure are on the lower half of the vertical centerline, it will be seen that, at low speed of rotation, at the beginning of the power stroke port 44 registers with port 4 and allows compressed fluid to the cylinder through the open valve 60; later in the stroke groove 51 registers with port 5 and releases the trapped fluid from chamber 65 through ports 5, 51, 50 and 10 to the priming chamber.

At the beginning of exhaust stroke groove 68 registers with port 4 and the gases coming from a compression cylinder through the open valve 60, ports 4, 83, 66, 67, 68, 4 and 83 pass into our cylinder and escape through its open exhaust valve into the atmosphere.

At the beginning of intake stroke port 45 registers with port 5 and the fluid charges port 5 and chamber 65 and opens valve 60; groove 69 registers with port 4, and the priming fluid passes from chamber 12 through ports 11, 53, 69, 4, 83 and the open valve 60 into the cylinder and eventually into the atmosphere. Port 47 passes in front of port 5 without results, as ball 48 prevents any transfer of fluid.

During the compression stroke groove 66 registers with port 4 with the result that the gases instead of being compresed in the cylinder escape through the open valve 60 and ports 4, 83, 66, 67, 68, 83 and 4 to an exhaust cylinder and eventually to the atmosphere.

At higher speeds ball 48 is not seated and the cycle is altered as follows; at the beginning of power stroke port 44 allows unrestricted flow of fluid through port 4 and the open valve 60 to the cylinder to turn the engine; but as the stroke progresses the restriction in port 44 and the action of valve 55 check said flow of fluid. Groove 51 passes in front of port 5 without result, as the fluid has been already discharged from port 5 and chamber 65. Also without result groove 68 registers with port 4 during exhaust stroke, as no gases are fed to groove 68 through port 67, and valve 60 is closed.

At the beginning of intake stroke port 45 allows fluid to port 5 and chamber 65, and valve 60 is opened; also port 69 registers with 4 and priming fluid from chamber 12 charges the cylinders through ports 11, 53, 69, 4, 83 and the open valve 60. About at the end of intake stroke, as port 47 registers with port 5, the fluid trapped in chamber 65 and port 5 escapes through port 47 past open valve 48, through 49 and 10 to the priming chamber, allowing valve 60 to close. So, during the compression stroke, when port 66 registers with port 4, valve 60 is closed and a regular compression takes place.

It will be noted that in both forms of distributor shown in Figure 3 and Figure 10, the six ports 5 of the smaller circle N are charged with fluid through port 82 during the compression stroke; the result is that valve 60 is opened and no compression takes place in the corresponding cylinder, as the gases are directly discharged into the atmosphere through port 83. During the power stroke groove 51 collects the fluid trapped in said ports 5 and the corresponding chambers 65 and directs it to the priming chamber 12 through the ports 50 and 10; valve 60 is then free to close.

With reference to the timing of some of the distributor ports, for instance as shown in Figure 3, it will be noted that port 45 is active in opening the valve 60 at the beginning of the intake stroke, and groove 51 in allowing said valve to close about the middle of power stroke: at low speeds, when valve 48 is closed, this allows free communication from one cylinder to another (through port 4 and groove 54) during the whole compression stroke of one cylinder and the whole intake stroke of the other. In other words, no compression at all is allowed as the gases can escape from the cylinder at any time during compression stroke, and said gases may escape into other cylinders (or through other cylinders into the atmosphere) during the whole intake stroke of said other cylinders, and only during the intake stroke. While such timing is preferred, the purpose of the invention would not be defeated if some of the distributor ports were timed to be active somewhat earlier or later in the cycle. If, for instance, groove 51 is active later in the power stroke, valve 60 is kept open until said later phase, and the starting air arriving to the cylinder through valve 60 has easier access to said cylinder for a longer period; for a shorter period inversely, if groove 51 is timed to be active earlier during power stroke allowing the full tension of spring 61 to act to close valve 60. If groove 51 is timed even earlier than the power stroke, for instance towards the end of the compression stroke, then valve 60 closes before the end of the compression stroke and a slight compression may take place, which will not necessarily hinder the rotation of the engine in undue degree.

In a similar way, if port 45 is timed to be active during intake stroke, valve 60 will open later and the passage of gases through groove 54 and port 4 into said cylinder will not be as easy: conversely, if port 45 is timed to open valve 60 earlier, during exhaust stroke, gases (including priming mixture) may enter the cylinder during exhaust stroke and be wasted, unless the cylinder back pressure is sufficient to keep valve 60 closed until the beginning of intake stroke.

As already seen, after a speed sufficient for a start is attained, port 47 is active in closing valve 60 and allowing compression in the cylinders; a later timing of port 47 which would allow valve 60 to close after the beginning of compression stroke, would result in only a partial compression in the cylinders during the starting period, and this, within limits, does not need to be objectionable.

These considerations, in conjunction with the figures and especially Figure 3, will be sufficient to show that alterations of the preferred timing of ports can be made without altering their specific function which is part of the present invention and depends more on the interrelated sequence of activity than on a particular timing. The timing shown in Figure 10 may be considered as an extreme example of said alterations.

In prior art it has been customary to lubricate by hand the surface of contact of the distributor every predetermined number of hours of operation of the engine; to avoid this manual operation and obtain constant lubrication I provide an axial hole 17 in shaft 16, and a communicating radial hole 18 in the rotary distributor; small quantities of lubricant from bearing 23 fall through slot 84 in hole 17, and are carried by centrifugal force through hole 18 to the surface of contact of the distributor outside of the circle circumscribed to the ports on the surface of the distributor; by this arrangement no lubricant flows to the distributor ports, but only enough is supplied by capillarity to the

surface of contact of the distributor to keep the same well oiled. A small spring 85 keeps the distributors always in contact and prevents flow of oil: the same spring holds the disc 15 against its seat provided in body 19.

To lubricate shaft 16, oil is supplied through valve 21 and port 22 to bearing 23, and hence drips either through port 24 and valve 25 back into the engine crankcase, or to the bottom of chamber 20; port 28 acts as an overflow to keep in chamber 20 only enough oil to touch the rotary distributor outside of the circle circumscribed to the ports on the surface of the distributor, so that at least a very slight lubrication is supplied to the distributor surface by capillarity, should port 18 become clogged.

When compressed fluid is allowed to chamber 20, the stream of fluid trying to escape automatically closes the valves 21, 25 and 27 and pushes the disc 15 against its seat, preventing any loss of pressure; as soon as the starting action is terminated all parts are automatically released and continuous lubrication restored.

What I claim as my invention is:

1. In means for starting internal combustion engines, a first cylinder, a first unit connected to said first cylinder, a second cylinder, a second unit connected to said second cylinder, each one of said units comprising fluid flow checking means and fluid initiated means operating said check means; a source of compressed fluid, means distributing predetermined quantities of said fluid to said fluid initiated means and means releasing said quantities according to a predetermined cycle, means for supplying fuel, means for mixing said fuel to said quantities of fluid, and means for priming the engine cylinders with the resulting mixture.

2. In means for starting internal combustion engines, an engine cylinder, a source of compressed fluid, a port from said source to said cylinder, fluid flow check means in said port, fluid initiated means active in operating said check means, means for delivering a charge of fluid to said fluid initiated means, and speed responsive means releasing said charge of fluid at different times of the cylinder cycle in dependence upon the engine speed.

3. In means for starting internal combustion engines by which compressed fluid is made operative to turn the engine, means for keeping said compressed fluid at a constant pressure, means for metering a plurality of charges of predetermined volume of said constant pressure compressed fluid, and means for delivering under pressure said charges to the engine cylinders prior to power stroke in cyclic manner to prime said engine.

4. In means for starting internal combustion engines, a compressed fluid chamber, a shaft extending in said chamber a bearing for said shaft, a port conveying lubricant to said shaft, fluid flow check means in said port preventing escape of fluid from said chamber, a drainage port for said lubricant, and means allowing the drainage of lubricant through said drainage port and checking the escape of fluid from said chamber through said drainage port.

5. In means for starting internal combustion engines, means for distributing compressed fluid to the engine cylinders during power stroke to turn the engine, check valves opening towards said engine cylinders, fluid pressure responsive means, including a predetermined capacity, for operating said check valves, means for distributing fluid to said responsive means to open said valves, a priming chamber, means for releasing said fluid from said responsive means to said priming chamber, speed responsive means for releasing said fluid from said pressure responsive means to said priming chamber before completion of the compression stroke, said speed responsive means being active only after a predetermined engine speed is attained, and means for distributing said fluid from said priming chamber to said engine cylinders.

6. In means for starting internal combustion engines including ports connected to the engine cylinders, check valves between said ports and said cylinders, said valves opening toward said cylinders, means for distributing compressed fluid to said ports in cyclic manner while the corresponding cylinders undergo power stroke to turn the engine, pressure responsive means for controlling each of said check valves, and engine timed means for distributing fluid in cyclic manner to said pressure responsive means to keep said check valves open during compression stroke to relieve the compression pressure.

7. In means for starting internal combustion engines, means for distributing fluid to ports connected to the engine cylinders during power stroke, valves in said ports, said valves opening toward said cylinders, pressure responsive means for controlling said valves, means for distributing fluid to said responsive means in cyclic manner to keep said valves open during a predetermined cycle phase, means for releasing said fluid in cyclic manner to let said valves close at a later cycle phase, and means including ports connected to said release means and said engine cylinders for distributing said released fluid to the engine cylinders to prime said engine.

8. In means for starting internal combustion engines, cylinder valve units comprising a check valve opening towards the cylinder when supplied with compressed fluid, fluid tight pressure responsive means for controlling said valve independently from the fluid supplied to it, and means for alternately supplying compressed fluid to said responsive means in cyclic manner to open said valves and set communication between said responsive means and said valves to discharge said compressed fluid into said cylinders to prime said engine.

9. In means for starting internal combustion engines, cylinder valve units comprising two ports, a check valve between a first one of said ports and said cylinder, said valve opening towards said cylinder when compressed fluid is supplied to said first port, means responsive to the pressure in the other one of said ports for opening said check valve independently from the pressure in said first port and engine timed means for alternately distributing predetermined volumes of fluid to said other ports and discharging said volumes from said other ports to said first ports in cyclic manner to prime said engine.

10. In means for starting internal combustion engines, a fluid distributor, a first and a second port between said distributor and each of a plurality of engine cylinders, check valves in said first ports, said check valves opening towards said cylinders, pressure responsive means connected to said second ports for controlling each of said check valves independently from the pressure in said first ports, means for distributing compressed fluid to said first ports during power stroke to turn the engine, means for distributing measured volumes of compressed fluid to said second ports to keep

said check valves open during compression stroke, means for connecting one of said check valves, while open during compression stroke, with an other check valve corresponding to a cylinder undergoing a different stroke to relieve compression, speed responsive means for rendering said connecting means inoperative at a predetermined engine speed, means for releasing said measured volumes of fluid and means for delivering said volumes to the engine cylinders.

11. In means for starting internal combustion engines, a fluid distributor, a first and a second port connecting said distributor to an engine cylinder, a check valve in said first port, said check valve opening towards said cylinder, pressure responsive means connected to said second port for controlling said check valve independently from the pressure in said first port, and engine timed means for distributing compressed fluid to each of said ports in cyclic manner.

12. In means for starting internal combustion engines, a fluid distributor, a first and a second port connecting said distributor to an engine cylinder, a check valve in said first port, said check valve opening towards said cylinder, pressure responsive means connected to said second port for controlling said check valve independently from the pressure in said first port, and engine timed means for distributing compressed fluid in cyclic manner to said first port during power stroke to turn the engine and to said second port to keep said check valve open during compression stroke to relieve the compression pressure.

13. In means for starting internal combustion engines, a fluid distributor, a first and a second port connecting said distributor to an engine cylinder, a check valve in said first port, said check valve opening towards said cylinder, pressure responsive means connected to said second port for controlling said check valve independently from the pressure in said first port, engine timed means for distributing compressed fluid to each of said ports in cyclic manner, and means for releasing said compressed fluid from said second port in cyclic manner.

14. In means for starting internal combustion engines, a fluid distributor, a first and a second port connecting said distributor to an engine cylinder, a check valve in said first port, said check valve opening towards said cylinder, pressure responsive means connected to said second port for controlling said check valve independently from the pressure in said first port, engine timed means for distributing compressed fluid to each of said ports in cyclic manner, and means responsive to the engine speed for releasing said fluid from said second port at different cycle phases.

15. In means for starting internal combustion engines, a fluid distributor, a first and a second port connecting said distributor to an engine cylinder, a check valve in said first port, said check valve opening towards said cylinder, pressure responsive means connected to said second port for controlling said check valve independently from the pressure in said first port, means for distributing compressed fluid to said ports in cyclic manner, means responsive to the engine speed for releasing said fluid from said second port, and means for distributing said released fluid to the engine cylinders.

16. In means for starting internal combustion engines, means including check valves for distributing compressed fluid to the engine cylinders during power stroke to turn the engine, means for storing predetermined volumes of fluid, means responsive to the pressure in said storing means for controlling said valves, and means for distributing said predetermined volumes of fluid to the engine cylinders prior to power stroke to prime said engine.

17. In means for starting internal combustion engines, a fluid chamber, a stationary distributor unit provided with ports leading to the engine cylinders, a rotary disc distributor provided with an aperture for setting communication between said chamber and said ports in cyclic manner, a member for closing a portion of said aperture, means for connecting said member to said disc distributor in movable manner, resilient means tending to keep said member away from said aperture, and speed responsive means antagonizing said resilient means.

18. In means for starting internal combustion engines, a distributor body forming a compressed fluid chamber, a distributor shaft extending through said chamber and body, a port for supplying lubricant to said shaft, a check valve in said port to allow flow of lubricant towards said shaft and prevent the escape of fluid in opposite direction, a drainage port at the bottom of said chamber, and a fluid flow responsive member for closing said drainage port whenever a fast flow of fluid takes place in said drainage port.

19. In means for starting internal combustion engines including ports connected to the engine cylinders, check valves between said ports and said cylinders, said valves opening towards said cylinders, a source of compressed fluid, means for setting communication in cyclic manner between said source and said ports while the corresponding cylinders undergo power stroke to turn the engine, means for setting communication between one of said ports connected to a cylinder undergoing compression stroke and an other one of said ports connected to a cylinder undergoing a different stroke, and means for keeping the compression cylinder check valve open during compression stroke to relieve compression.

20. In means for starting internal combustion engines including ports connected to the engine cylinders and flow controlling means between said ports and said cylinders, means for injecting compressed fluid, through said ports and controlling means, into said cylinders during power stroke to turn the engine, pressure responsive means of predetermined fluid capacity for controlling said flow controlling means, means for charging with fluid said responsive means in cyclic manner to operate said flow controlling means and to meter predetermined quantities of fluid, speed responsive means for releasing said quantities and again operate said flow controlling means at different cycle phases in dependence upon the engine speed, and means for injecting said released quantities of fluid into the engine to prime said engine.

21. In means for starting internal combustion engines including a compressed fluid chamber and a member moving on a bearing surface connected to said chamber, means for conveying lubricant to said surface, a drainage port for said lubricant, and pressure responsive means for allowing slow drainage of lubricant and checking fast escape of fluid from said chamber through said drainage port.

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