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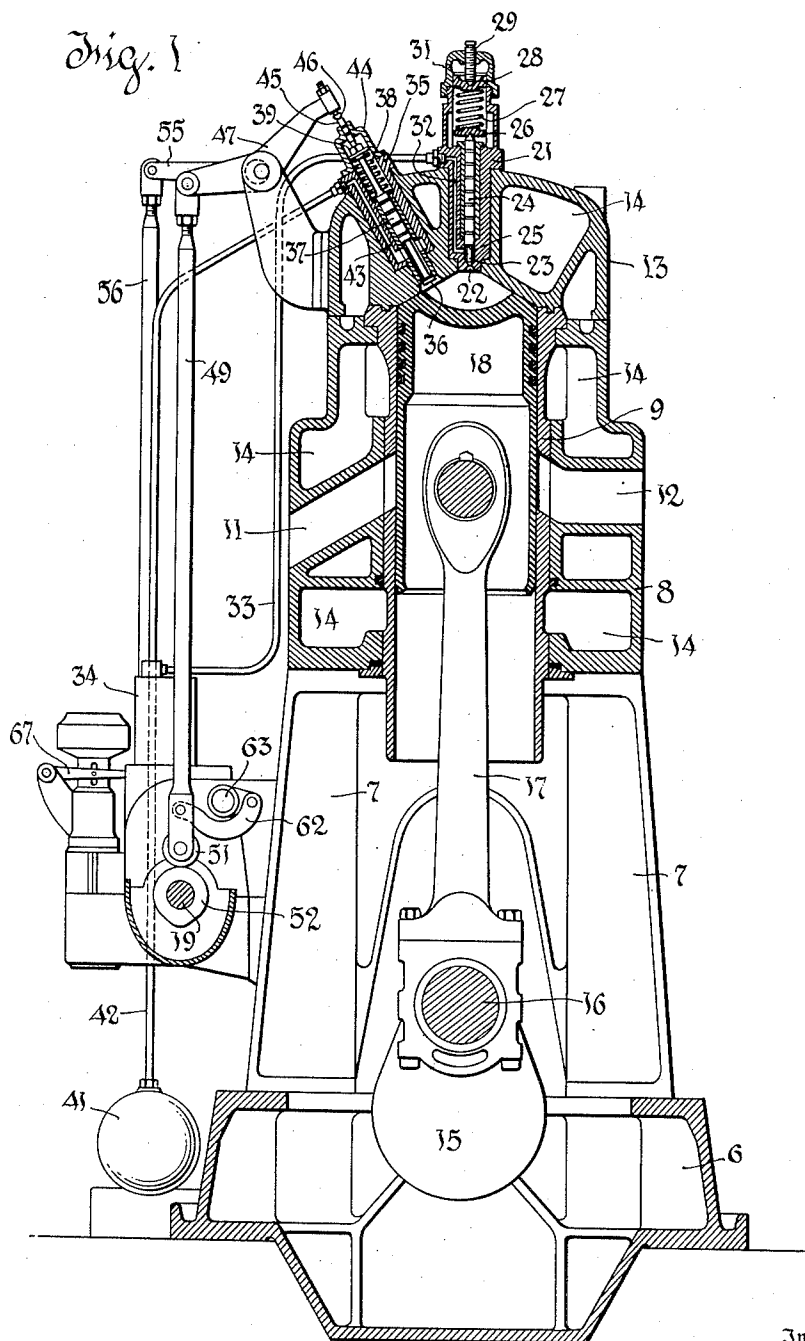
B. V. E. NORDBERG

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DIESEL ENGINE

Filed June 19, 1931

2 Sheets-Sheet 1



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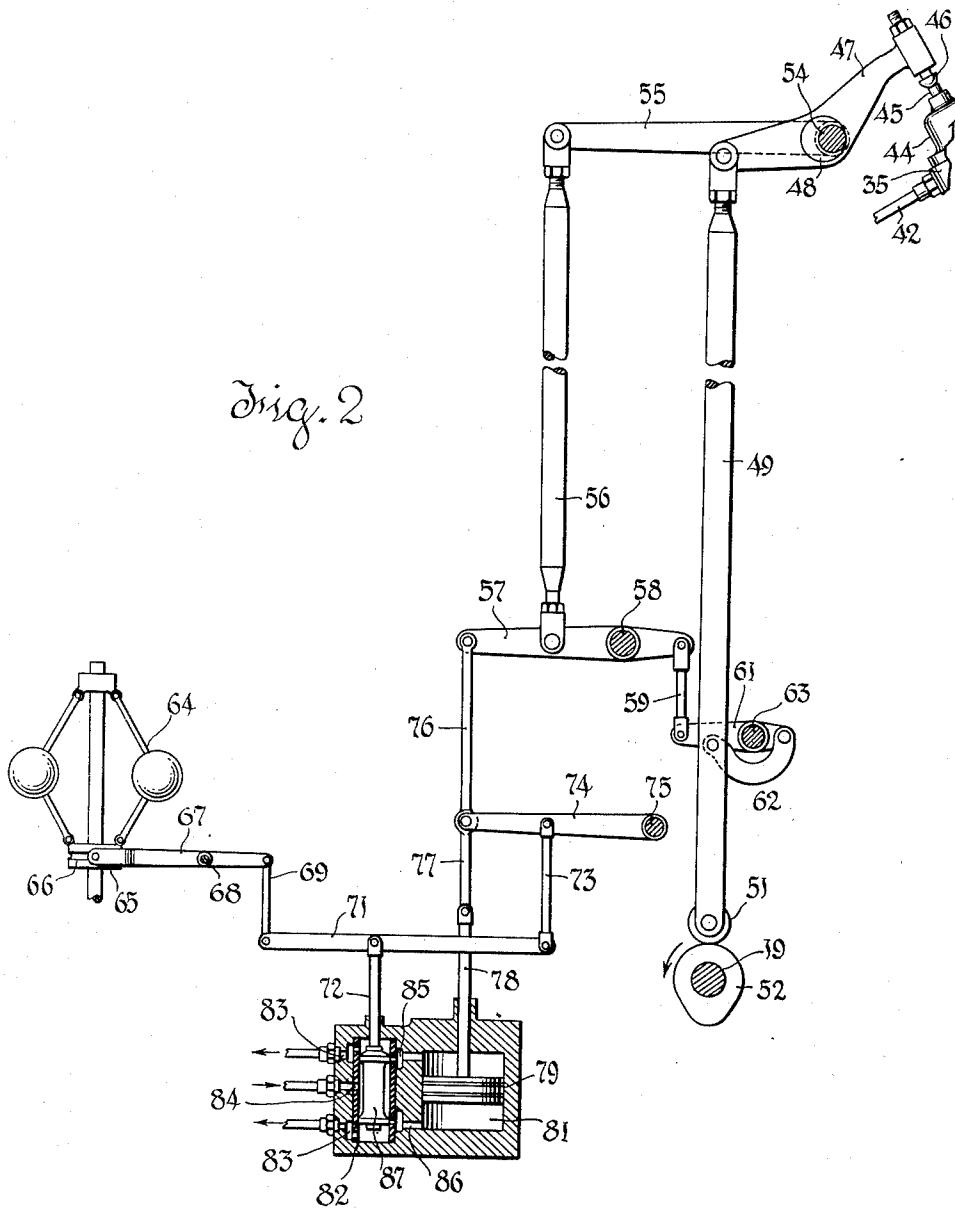
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UNITED STATES PATENT OFFICE

1,962,283

DIESEL ENGINE

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Application June 19, 1931, Serial No. 545,550

11 Claims. (Cl. 123—32)

This invention relates to internal combustion engines, and particularly to engines operating on what is known as the Diesel cycle, in which fuel is injected through a substantial portion of the working stroke, so that sustained combustion, as contradistinguished from momentary or explosive combustion, is secured.

The present application is subordinate to my prior application Serial No. 342,442, filed February 25, 1929 (since issued as Patent 1,857,256, May 10, 1932) which is drawn to a method of operating Diesel engines in which the principal fuel is a combustible gas, and is ignited by the spontaneous ignition of a relatively minute charge of comparatively more combustible fuel oil.

As illustrated in that prior application, the invention is carried out by adapting an engine of what is known as the "air injection type" in such manner that the oil is injected into the working space by the combustible gas under pressure. That is a highly desirable arrangement because the gas may be compressed by the compressor customarily used to compress the injecting air, and because the injecting action insures intimate mixture of the oil and gas and thus ensures complete ignition of the gas.

The invention may, however, be practiced with engines having what is known as "solid" (i. e., mechanically forced) injection of the fuel oil; and one purpose of the present application is to disclose and claim specifically such an arrangement.

Other features of patentable novelty reside in the control of the fuel to permit the engine to operate at substantially uniform speed under varying load.

In any such engines as are here contemplated, the usual purpose in using a combustible gas is economy under those circumstances where natural or manufactured gas is cheaper than fuel oil. The normal tendency therefore is to use the minimum quantity of oil per cycle, necessary to ensure ignition of the gas. This requirement can be met by injecting a fixed charge of oil for each working cycle, but so far as the invention is concerned it is not essential that the oil charge be fixed in quantity.

Since some oil should be injected for each working cycle to secure ignition, the quantity supplied under no-load condition cannot exceed, and preferably should be less than, the quantity necessary to overcome the internal friction of the engine and keep the engine in motion. If the quantity of oil injected under no-load con-

ditions is less than sufficient to operate the engine, some gas will be injected during each working cycle, a condition favorable to uniform operation as well as economy.

The engine may be either two or four cycle, and any arrangement for exhaust and scavenging suitable for use in Diesel engines may be used.

The invention will now be described by way of example as applied to a two cycle engine in which the exhaust and scavenging ports are controlled by the engine piston, this being a familiar and satisfactory arrangement.

In the drawings,—

Fig. 1 is a vertical section transverse to the crank shaft and through the axis of a cylinder of an engine embodying the invention.

Fig. 2 is a diagram of the governor and connections for controlling the supply of gaseous fuel.

The bed plate 6 supports the frames 7, which in turn carry the cylinder casting (or castings) 8. Each cylinder has a liner 9 with scavenging port 11 and exhaust port 12. The liner is held in place by the cylinder head 13 in which the fuel injection valves are mounted. There are the usual water jackets, indicated at 14.

The crank shaft 15, crank pin 16, connecting rod 17 and piston 18 follow usual construction. The cam shaft 19 is driven from the crank shaft 15 at crank shaft speed by any usual means (not shown). It will be readily understood that in a four cycle engine the cam-shaft would be driven at half the crank shaft speed.

The fuel oil injection valve includes a body 21 which is inserted through the head 13 and has a discharge nozzle or port 22 within the working space. This port 22 is controlled by a needle valve 23 formed on the end of a plunger 24 of larger diameter than the needle valve. The change in diameter affords a shoulder 25 which acts as a piston to open the valve when the oil is supplied under pressure. The upper end of the plunger 24 engages a spring seat 26 against which reacts the lower end of a coil thrust spring 27. This spring reacts at its upper end against a spring seat 28 which is adjustable to vary the stress on the spring by means of the thrust screw 29. Screw 29 is mounted in a removable cap 31 which is threaded on the outer end of the body 21. Leading into the space between the needle valve 23 and the shoulder 25 is an oil passage 32, to which the pressure oil pipe 33 connects. The pipe 33 leads from a force pump 34 which is driven from the

cam shaft 19 by means not illustrated in the drawings.

The pump 34 is simply a measuring force pump of the type commonly used in Diesel engines. In the pump there is one cylinder and piston for each working space in the engine, and the pump is so timed relatively to the engine that each pump cylinder delivers its oil to the corresponding working space in the engine just as the piston approaches the dead point, and flow continues for at least a small engine crank angle beyond the dead point to insure complete ignition of the gas. Pump 34 delivers the oil under pressure through the pipe 33, and this oil under pressure reacting against the shoulder 25, unseats the valve 23 and holds the valve open as long as pressure persists. As soon as the oil pressure drops the spring 27 again seats the valve 23.

Various other solid injecting fuel valves are known and may be substituted.

Since the oil is not the primary fuel, and since its function is merely to ignite the gas which serves as the primary fuel, the duration of injection of oil may be quite short, but its duration may be extended according to the preference of designers without departing from the broad scope of the present invention.

The gas injection valve includes a body 35 which is also inserted through the head 13. It is formed with a seat for a poppet valve 36 which opens inwardly relatively to the cylinder and which is guided on a stem 37. The valve is urged in a closing direction by a coil compression spring 38 which reacts outwardly relatively to the engine cylinder against a spring seat with adjustable nut 39.

The combustible gas is delivered under high pressure from a storage bottle 41 through a pipe 42 and passage 43 to the valve 36. The gas is stored in the bottle 41 under a pressure of the order of 800 pounds per square inch by any suitable means, not shown in the drawings. It is convenient to use an ordinary three-stage compressor not unlike those used to furnish the blast air in air injection Diesel engines, but the particular compressor is not a feature of the invention and consequently requires only passing comment.

Mounted on the body 35 is a cap 44 with a guide for the tappet or thrust member 45 which enters into thrust relation with the end of the valve stem 37. The tappet 45 is engaged by an adjustable thrust member 46 on the rock lever 47 which serves as means for mechanically actuating the gas valve 36.

In the embodiment illustrated the pump 34 delivers uniform measured charges and the engine is controlled by control of the gas valve 36. Its control is effected by governor mechanism which is so contrived that the extent and duration of the opening movement of the valve 36 is varied without however varying in any substantial degree the time in the working cycle at which the valve 36 starts to open.

A part of the governor mechanism is visible in Fig. 1. Its operation will now be explained with reference to the diagram of Fig. 2.

The rocker 47 is journaled on an eccentric 48 and is actuated through the thrust rod 49 and cam follower roller 51 by a cam 52 on the cam shaft 19. The eccentric 48 is mounted on a shaft 54 which is oscillated through a limited angle under the control of the governor. The shaft 54 carries fixed to it a lever arm 55 which is

connected by a link 56 with a second lever 57. The lever 57 is fulcrumed at 58 and is the lever which is directly controlled by the governor mechanism. The lever 57 is connected by a link 59 with one arm of a two arm lever 61 whose other arm is connected by the arcuate link 62 with the thrust rod 49. The lever 61 is fulcrumed at 63 and the cam shaft turns in the direction of the arrow. The reason for the connections just described can be readily explained.

Assume that the lever 57 moves counterclockwise (as viewed in Fig. 2): The lever 55 will move similarly, the eccentric 48 will be slightly lowered, and the thrust member 46 will be moved toward the engine cylinder increasing the lift of the valve 36 and also tending to cause the valve 36 to start opening earlier in the working cycle. This tendency to early opening is counteracted as follows: Counterclockwise motion of the lever 57 draws link 59 upward and rotates lever 61 clockwise slightly, so that link 62 shifts the thrust rod 49 slightly to the left, thus delaying the lifting effect of the cam 52 an amount which approximately compensates for the tendency of the valve 56 to open earlier.

As the mechanism just described imposes considerable load on the lever 57, there is interposed between this lever and the governor, a servo-motor which acts to carry the load on the lever 57 without impairing the sensitiveness of the governor.

An ordinary fly-ball governor is illustrated at 64, and has a collar 65 which rises with increase of speed. The collar 65 has a groove 66 which is engaged by the forked end of lever 67. Lever 67 is fulcrumed at 68 and is connected by link 69 with floating lever 71.

The lever 71 is pinned directly to the valve stem 72 of the servo-motor and is connected by link 73 with lever 74 which is pivoted at 75. The lever 74 is connected by link 76 with the end of lever 57 and by link 77 with a piston rod 78 of the servo-motor. The piston rod 78 has a piston 79 working in the cylinder 81. Mounted on the cylinder is a valve chamber 82 having end exhaust ports 83 and a central supply port 84. There are also combined admission and exhaust ports 85 and 86 leading respectively to opposite ends of the cylinder 81.

Working in the valve chamber is an ordinary piston valve 87 which is connected to the valve stem 72. If the engine slows down, the governor 64, which is driven by the engine, will lower collar 66 and thus raise the left hand end of lever 71. This will cause valve 87 to move upward, admitting pressure fluid above the piston 79 and exhausting the space below the piston 79. Consequently the piston 79 moves downward. This motion lowers the right hand end of floating lever 71 and again laps the valve 87. Consequently, the piston 79 assumes a definite position for every position of the governor collar 66. The pressure fluid used in the servo-motor cylinder 81 may be oil under pressure from any suitable source, for example, the force feed lubricating pump. The valve 87 is designed with substantially zero lap so that the servo-motor responds very sensitively to the indications of the governor.

The operation of the device will be readily understood from the description given. Generally speaking, the valve 23 will open shortly before the dead point, and the valve 36 will open as nearly simultaneously as possible. Since

the quantity of oil furnished is preferably kept to the minimum necessary to insure ignition of the gas, the injection of the oil will ordinarily terminate after a short interval, but the gas valve 36 will remain open through a substantial portion of the working stroke to furnish fuel for sustained combustion according to the Diesel cycle.

It is preferred that the two valves be so arranged that their axes are inclined to each other, to the end that the gas and oil entering through these valves shall flow in intersecting paths. This is believed to insure more certain ignition of the gas by the burning fuel but even without this effect, propagation of the flame throughout the entire combustion space is virtually inevitable.

While I have illustrated and described one particular engine used for practicing the invention, various others are obviously possible within the scope of the invention, as has already been suggested.

What is claimed is,—

1. The method of operating a Diesel engine which consists in injecting fuel oil in small quantity into highly compressed air in the working space, as the piston approaches the dead point; substantially simultaneously starting to inject combustible gas into the working space independently of the oil, continuing such injection after the injection of oil has ceased, and regulating the quantity of combustible gas so injected.

2. The method of operating a Diesel engine which consists in injecting fuel oil in small quantity into highly compressed air in the working space, as the piston approaches the dead point; substantially simultaneously starting to inject combustible gas into the working space independently of the oil, continuing such injection after the injection of oil has ceased; and varying the duration of gas injection according to the load.

3. The method of operating a Diesel engine which consists in injecting fuel oil in small quantity into highly compressed air in the working space, as the piston approaches the dead point; substantially simultaneously starting to inject combustible gas into the working space independently of the oil, continuing such injection after the injection of oil has ceased; and varying the rate and duration of gas injection according to the load.

4. The method of operating a Diesel engine, which consists in injecting into highly compressed air in the working space, as the piston approaches the dead point, fuel oil in charges less than sufficient to operate the engine at no load; substantially simultaneously starting to inject combustible gas into the working space independently of the oil, continuing such injection through a substantial portion of the working stroke, and regulating the quantity of combustible gas so injected.

5. The method of operating a Diesel engine which consists in injecting into highly compressed air in the working space, as the piston approaches the dead point, fuel oil in charges less than sufficient to operate the engine at no load; substantially simultaneously starting to inject combustible gas into the working space independently of the oil, continuing such injection after the injection of oil has ceased; and varying the duration of gas injection according to the load.

6. The method of operating a Diesel engine which consists in injecting into highly compressed air in the working space, as the piston approaches the dead point, fuel oil in charges less than sufficient to operate the engine at no load; substantially simultaneously starting to inject combustible gas into the working space independently of the oil, continuing such injection after the injection of oil has ceased; and varying the rate and duration of gas injection according to the load.

7. In a Diesel engine, the combination with a cylinder, a piston and scavenging and exhaust means, producing a working space in which air is compressed to the ignition temperature of fuel oil; of a fuel oil injecting valve of the solid injection type; means for operating said valve; a combustible gas injecting valve; and independent means for actuating said gas valve.

8. In a Diesel engine, the combination with a cylinder, a piston and scavenging and exhaust means, producing a working space in which air is compressed to the ignition temperature of fuel oil; of a fuel oil injecting valve; means for operating said valve as the engine approaches the dead point; a combustible gas injecting valve; actuating means for opening said gas injecting valve substantially at the moment of oil injection and causing it to close during the working stroke of the piston; and means associated with said actuating means for varying the point in the working stroke at which such closure occurs.

9. In a Diesel engine, the combination with a cylinder, a piston and scavenging and exhaust means, producing a working space in which air is compressed to the ignition temperature of fuel oil; of a fuel oil injecting valve; means for operating said valve as the engine approaches the dead point; a combustible gas injecting valve; actuating means for opening said gas injecting valve substantially at the moment of oil injection and causing it to close during the working stroke of the piston; and means associated with said actuating means for varying the degree and duration of opening of said gas injection valve.

10. In a Diesel engine, the combination with a cylinder, a piston and scavenging and exhaust means, producing a working space in which air is compressed to the ignition temperature of fuel oil; of a fuel oil injecting valve; means for operating said valve as the engine approaches the dead point; a combustible gas injecting valve; actuating means for opening said gas injecting valve substantially at the moment of oil injection and causing it to close during the working stroke of the piston; and a speed responsive governor controlling said actuating means to vary the point in the working stroke at which such closure occurs.

11. In a Diesel engine, the combination with a cylinder, a piston and scavenging and exhaust means, producing a working space in which air is compressed to the ignition temperature of fuel oil; of a fuel oil injecting valve; means for operating said valve as the engine approaches the dead point; a combustible gas injecting valve; actuating means for opening said gas injecting valve, substantially at the moment of oil injection and causing it to close during the working stroke of the piston; and governor controlled means serving to regulate the total fuel injected into the working space for each working cycle.

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