May 29, 1934. H. A. GUTHRIE 1,960,243

APPARATUS FOR FUELING ENGINES

Filed Sept. 26, 1932 2 Sheets-Sheet 1

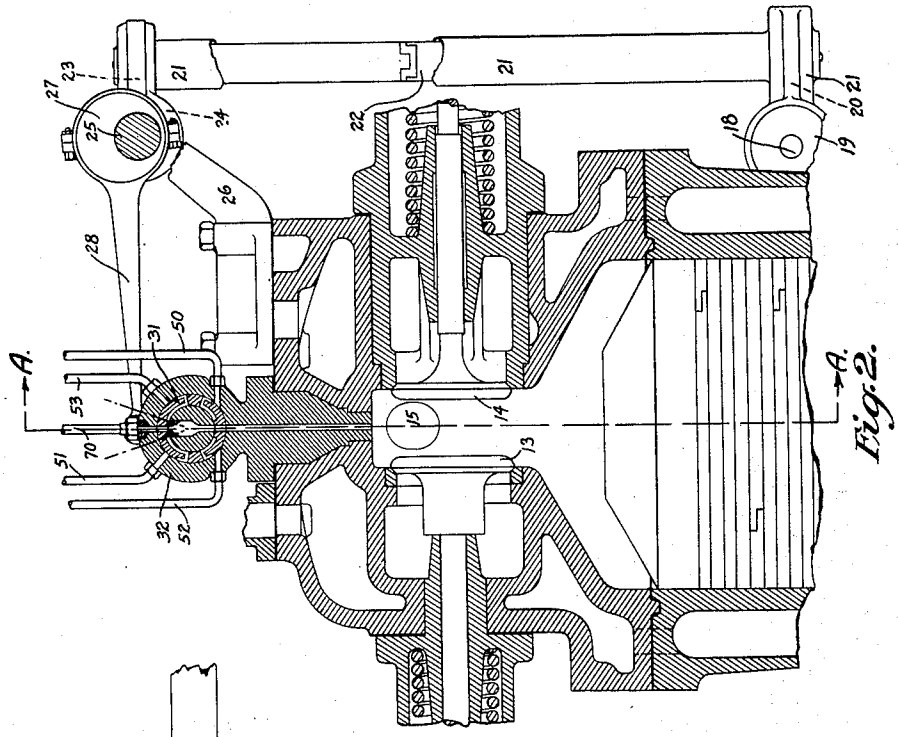
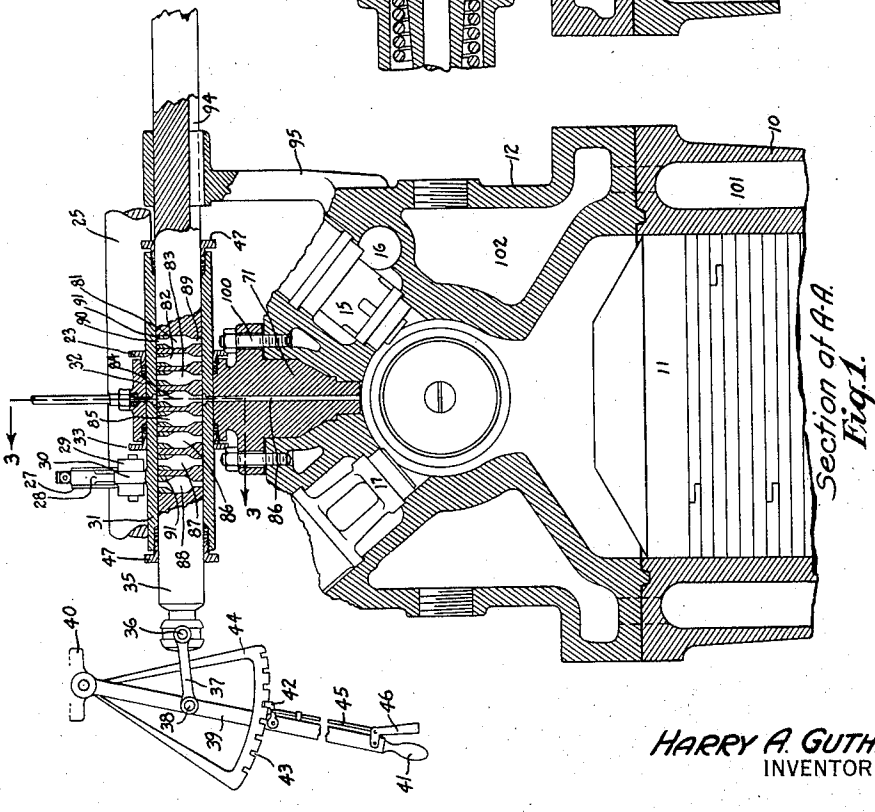


Fig. 2.



Section of A-A.
Fig. 1.

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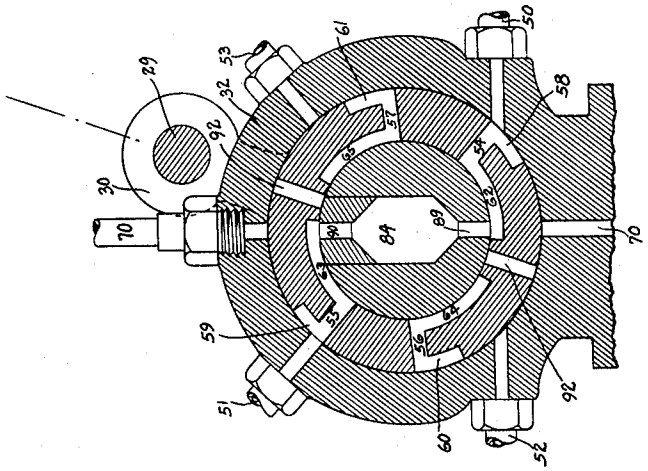


Fig. 5.

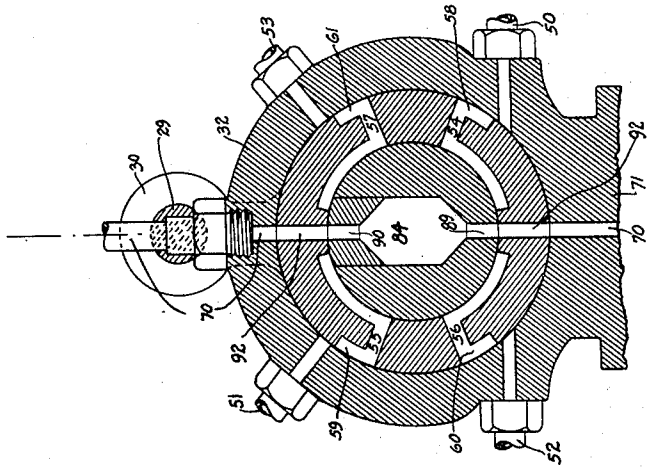


Fig. 4.

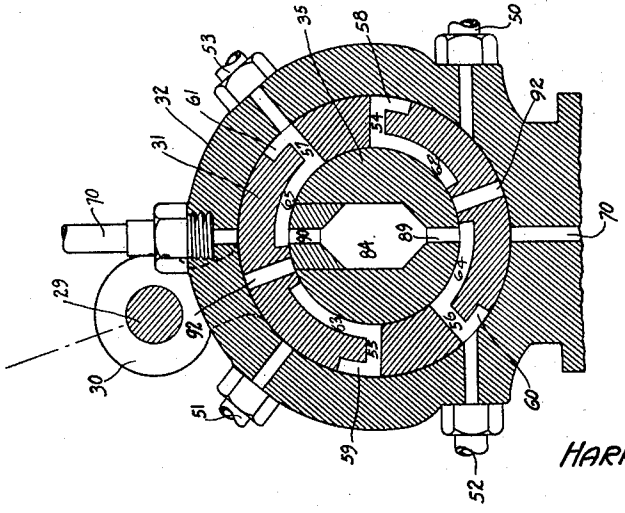


Fig. 3.

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Patented May 29, 1934 1,960,243

UNITED STATES PATENT OFFICE

1,960,243

APPARATUS FOR FUELING ENGINES

Harry A. Guthrie, United States Navy

Application September 26, 1932, Serial No. 634,933

7 Claims. (Cl. 123—33)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

My invention relates to an improved method of and apparatus for metering and injecting fuel charges for engines, and more particularly for Diesel engines.

The objects of my invention are to provide a method of and apparatus for enabling the substantially unrestricted utilization of all of the speeds of mechanism within its available speed ranges; greatly increasing the flexibility of the Diesel engine in the sense that its work may vary far more widely without tendency to excessive or undue speeds or stalling; applying the energy as a substantially constant pressure exerted during a relatively long period of the power cycle or stroke of each piston and not as a violent impulse of short duration; widely varying at will the volume of fuel supplyable to each cylinder relative to the work being performed and/or its rate of performance; enabling greater power to be developed from the same sized engine; making more practicable, durable and efficient larger Diesel installations, and enabling even very much smaller Diesel units to be constructed which will be practicable, durable and efficient, with higher operative speeds for both heavy and light such engines without harmful torsional vibration and of far longer wearing and operative useful life than has heretofore been possible.

To attain these and other objects, and in accordance with the general features of this unitary invention of related and interdependent components, my new and useful method has been devised by me. My method contemplates varying each application of the force required to perform the work desired and more specifically contemplates that the work be performed by an isothermal expansion of substantially constant pressure extending throughout practically the entire power cycle or piston stroke, that is, the force applied to perform the work desired shall be exerted at an approximately constant pressure throughout the greater part of the power cycle or piston stroke.

I have found that such applications of fuel and/or force do not tend to excite torsional vibrations of a harmful character, and that the long period of the substantially uniform application of the maximum of such fuel and/or force tends substantially to avoid harmful synchronism of such torsional vibrations as may be excited in the practice of my method.

My method also contemplates varying the volume of the fuel within each cylinder relative to the magnitude of the work desired and/or relative to the rate at which such work is desired to be performed.

If such harmful synchronism tends to develop at any operating speed, such speed may be changed to one at which such condition does not exist by varying the volume of fuel fed to each cylinder.

My invention may be readily understood from the accompanying drawings and following detailed description, which also specifically demonstrate the preferred practice of my method.

In the drawings, Figure 1 is a central vertical sectional view on line A—A of Figure 2 of an apparatus devised for the advantageous practice of my method;

Figure 2 is a central vertical sectional view of the said apparatus taken at right angles to line A—A of Figure 2;

Figure 3 is an enlarged sectional elevation view substantially on line 3—3 of Figure 1 but illustrating the parts in position to receive a charge of fuel;

Figure 4 is a view similar to Figure 3 but illustrating the position of the parts when the supplied fuel is injected into a cylinder; and

Figure 5 is a view similar to Figure 3 but illustrating the parts in position to receive a measured supply of fuel at the opposite end of the stroke from that shown in Figure 3.

In the drawings, in which like characters of reference denote the same parts, 10 designates the cylinders each containing a piston 11 suitably connected to the crankshaft and having a head 12. Each head 12 is provided with the usual exhaust valve 13 and air inlet valve 14. Each head 12 is also provided with the usual starting air valve 15 receiving its air pressure supply from duct 16. Head 12 is also provided with the usual air scavenging valve 17. Cam-shaft 18, Figure 2, driven by and at half the speed of the crankshaft, is provided with the usual means for operating the valves. Spur-gear 19, having its teeth cut at substantially 45°, is suitably fixed to shaft 18 and meshes with a corresponding gear 20 in casing 21 and fixed to one end of shaft 22 on the other end of which is a similar gear 23 inclosed in casing 21 and meshing with a corresponding gear 24 in the casing and secured on shaft 25, preferably extending across the top of each cylinder head 12 and provided with suitable bearings in brackets 26 secured to cylinder heads 12.

Shaft 25 is by gears 19, 20, 23 and 24 operated preferably at one-quarter the speed of the crankshaft which is not shown but is of conventional construction and provided with a conventional drive for cam shaft 18.

Fixed upon shaft 25 are a plurality of eccentrics 27, one for each cylinder 10, each eccentric 27 being set differently upon shaft 25 to time the fuel admission to each cylinder 10. Each eccentric 27 is provided with a pitman 28 having at one end a conventional strap for embracing and being operated by its eccentric 27 and at its other end pitman 28 is connected by pin 29 to crank-arm 30 rigidly mounted upon a sleeve 31

provided intermediate its ends with a bearing in tubular housing 32 mounted upon the top of each cylinder head 12. Each housing 32 is provided with suitable packing means 33 at each end to prevent leakage between the juxtaposed surfaces of sleeve 31 and housing 32.

Each cylinder 10 is provided preferably with an individual eccentric 27, pitman 28, sleeve 31 and housing 32, the sleeve 31 of each cylinder 10 being preferably arranged at right angles to the bore of cylinder 10 with the bores of all the sleeves 31 of an engine in alignment. Longitudinally slidable in the bore of all the sleeves 31 is a valve member 35 common to the fuel supply systems of all the cylinders, having pins 36 projecting from its opposite sides near one end thereof. Pins 36 are provided with bearings in the bifurcated end of link 37 whose opposite end is pivoted by bearing 38 to lever 39 fulcrumed upon portion 40 suitably mounted upon the engine. Lever 39 is provided with handle 41 and latch 42 adapted to engage in any of a plurality of notches 43 in segment 44 preferably rigidly attached to portion 40. Latch 42 is conventionally operated by connection 45 to pivoted operating member 46 whose arm extends convenient to handle portion 41 of lever 39. The operation of lever 39 moves shaft 35 longitudinally in the bore of each sleeve 31, while latch 42 engaging in one of the various notches 43 in segment 44 positions shaft 35 at different points longitudinally with respect to each sleeve 31. The opposite ends of each sleeve 31 are provided with conventional packing means 47 to prevent leakage from between the juxtaposed surfaces of shaft 35 and the sleeve.

Fuel or fuel oil supply-lines 50, 51, 52 and 53 are extended through the wall of each housing 32, preferably in a common plane and at definite relative points about the vertical diameter of said housing 32. Each sleeve 31 is provided with ports 54, 55, 56 and 57, respectively for supply-lines 50, 51, 52 and 53, extending substantially radially through sleeve 31. Ports 54, 55, 56 and 57 are each respectively provided with enlarged outer mouths 58, 59, 60 and 61 extending circumferentially from the ports and enlarged inner mouths 62, 63, 64 and 65 likewise extending circumferentially from the ports. Both enlarged mouths of each port lie on the same side thereof, those of ports 54 and 55 extending in one angular sense and those of ports 56 and 57 extending in the sense opposite thereto.

Preferably in the same plane with supply-lines 50, 51, 52 and 53 and between lines 51 and 53 is an air-line 70 extending radially through housing 32, having an aligned continuation through the downwardly projecting portion 71 of housing 32 and that opens into the compression space between cylinder head 12 and piston head 11.

In the valve 35 for each cylinder 10 is a series of metering chambers, one of said chambers being provided for each notch 43 upon segment 44, and disposed to be in alignment with supply line 70 when latch 42 engages in the corresponding notch 43. In the instance shown, these chambers (Figure 1) are designated 81 to 88, inclusive. Each of the chambers is provided with an outlet opening 89 and an intake opening 90. The metering chambers are preferably formed by drilling a hole of suitable diameter a definite distance into shaft 35 and the openings 89 are formed by drilling a relative smaller hole the balance of the distance through shaft 35. Openings 90 are preferably formed in a hollow bushing 91 threaded or otherwise secured into the mouth of each chamber 81 to 88 inclusive.

The volume of the chambers varies as does the area of each of their respective outlet openings 89, while the area of openings 90 may be constant. For instance, in one arrangement from which satisfactory results may be obtained the relative volumes of chambers 81 to 88 may have the values of 0.290, 0.562, 0.450, 0.500, 0.350, 0.450, 0.550 and 0.650, respectively, and the outlet openings therefrom have cross sectional areas proportional to 0.150, 0.160, 0.170, 0.180, 0.190, 0.185, 0.120 and 0.125 respectively.

The housing 32 with its projection 71 extending through head 12 of cylinder 10 to the combustion space between cylinder head 12 and the head of piston 11 is, in the instance shown, removably secured to each head 12 by bolts 100, Figure 1, with spaces 101 and 102 for the circulation of water or other cooling medium.

The fuel, which is preferably fuel oil of relatively low grade is constantly supplied under substantial pressure (satisfactory results are obtained with a pressure of approximately 50 pounds per square inch) to supply lines 50 and 52, while air is constantly supplied during operation to supply-line 70 under pressure of 500 to 600 pounds per square inch. In the operation of the engine the shaft 25 with its eccentrics 27 variably set thereon, one for each cylinder 10, is preferably rotated at one-quarter the speed of the crankshaft. In such rotation the sleeve 31 of each cylinder 10 is turned about its axis back and forth to a predetermined degree by eccentrics 27, while valve 35 and housing 32 are not oscillated about their longitudinal axis by the operation of the engine.

When sleeve 31 is at the limit of its rocking movement, shown in Figure 5, the fuel under pressure from fuel supply-line 50, Figure 5, enters enlarged outer mouth 58 of port 54 and thence to enlarged inner mouth 62 which is then in communication with discharge opening 89 of one of the chambers in valve 35. The fuel oil from mouth 62 passes through opening 89 into the chamber and thence through opening 90 to inner mouth 63 of port 55, through port 55 to its outer mouth 59 and thence to supply-line 51 through which the surplus fuel oil returns preferably to a common supply tank from which supply-line 50 is fed. Supply-line 51 and its port 55, communicating with opening 90, afford an overflow for the fuel oil supply to insure that the chamber is completely filled by fuel oil, as without such overflow the chamber may contain part air and part fuel oil.

During the rocking movement of sleeve 31 about its longitudinal axis from the position shown in Figure 5 toward that shown in Figure 4, the fuel oil supply is shut off and radial openings 92 through sleeve 31 register with air supply line 70 intake opening 90 and outlet opening 89, whereupon the air under pressure coming from supply line 70 forces the charge of fuel in the metering chamber into the compression space between the juxtaposed portions of piston head 11 and head 12. In Diesel engine operation this compression space has during compression a pressure of approximately 450 pounds per square inch, and the heat developed by such compression is sufficient to deflagrate the fuel oil even of the low grade which usually constitutes Diesel engine fuel. This high pressure in air supply line 70 forces the fuel oil from the metering chamber into the cylinder but the relatively slow oscillation of sleeve

31 affords a substantial period of time between the initial commencement of the opening to the final closing of the openings 70, 92, 89 and 90, and thus affords progressive feeding of the fuel charges to their respective cylinders as hereinafter explained. The discharge of fuel begins slowly as soon as the edges of openings 92 overlap upon openings 90 and 89, and reaches its maximum rate when these passages are in complete registry, thus increasing the rate of charging as the combustion volume in the cylinder 10 is augmented by downward movement of piston 11.

In the further rocking of sleeve 31, about its longitudinal axis, toward the position shown in Figure 3, the openings 92 are moved to disconnect the air supply line 70 from openings 89 and 90, after which the fuel supply line 52 registers with outer mouth 60 of port 56 and inner mouth 65 registers with opening 89, through which fuel oil flows to fill the metering chamber in line therewith, when the oversupply of fuel oil rises through opening 90 to inner mouth 66 of radial opening 57 to outer mouth 61 through which the surplus fuel oil passes to fuel supply line 53 which returns the surplus fuel oil to the tank supplying fuel oil to lines 52 and 50.

The outer mouths of each port 54, 55, 56 and 57 are to enable the flow of fuel oil therethrough as aforesaid for a definite period during the rocking of sleeve 31 to make sure of a full measured supply of fuel oil for injection into each cylinder while the inner mouths 62, 63, 64 and 65 are likewise designed to prolong the registration thereof respectively with openings 89 and 90. The fuel is thus supplied alternately from the fuel supply lines 50 and 52.

The longitudinal movement of shaft 35, which is restrained from rotary movement by a slot 94 therein engaged by a pin 95 secured to head 12, will cause the volume of fuel to be supplied to each cylinder 10 to be varied according to the volume of the metering chamber that is disposed to function at any given time.

Each eccentric 27 is positioned upon its shaft 25 to inject the fuel into its coacting cylinder at the proper point in the working cycle.

The provision for supplying fuel oil to the measured volume desired is accomplished substantially at each limit of rocking about its longitudinal axis of sleeve 31, which slow motion of the eccentric in approaching, attaining, and receding from each limit of its movement insures the full measured supply of fuel oil being provided in advance of the time required for its injection into the cylinder.

The placing of the fuel injection point substantially centrally between the limits of the rocking movement of sleeve 31, with the relatively small cylindrical registering openings 70 and 92, afford a short period within which the oil injection to each cylinder must occur, and at the same time the progressive character of the registration of such relatively small cylindrical openings affords a progressive increase in the volume of oil injected into each cylinder, from nothing to the maximum, while the closing of such registering openings occurs after the fuel oil has been discharged from the provided measured volume.

This progressive increase in the volume of fuel oil injected into each cylinder causes a progressive increase of pressure within the cylinder, which quickly attains a maximum, which maximum pressure is maintained throughout a very substantial portion of the power stroke of each piston 11 by the continued injection of the fuel oil in the manner specified.

A very wide range of flexibility of the engine is provided by varying the measured volume of fuel oil to be injected into each cylinder. Each different measured volume of fuel oil represented by metering chambers 81 to 88, inclusive, is adapted to do different work at the same speed or the same work at different speeds and the operator may select the measured volume of fuel oil best suited to the needs of the occasion by controlling the position of shaft 35 relative to each cylinder 10.

It is obvious that, with the understanding of my method and its exemplification in the apparatus heretofore described, many forms of apparatus may be devised and reconstructions of many existing apparatus may be made conveniently to practice this method, and that variations therein and the sequence of its steps, with or without changes in form and arrangement and otherwise of the mechanism, may be made without departure from the invention and the essence and spirit of the appended claims.

In accordance with the patent statutes, I have herein described my method together with its exemplifying apparatus which I now consider to represent the best embodiment of my invention to obtain the most advantageous results, but I desire to have it understood and appreciated that the apparatus shown is only illustrative and that my method may be advantageously practiced by other means which may be readily selected and adapted by those skilled in the art after becoming familiar with my method; and that the method and apparatus features of my invention in their basic contemplation are entitled to a broad range of equivalents. Furthermore, while it is designed in the obtainance of the most satisfactory results to employ the various steps, features and elements of my method and apparatus in the combination and relations described, many of these may be separately used, altered or omitted without interfering with the more general result or results indicated, and that my invention contemplates and extends thereto.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalty thereon.

Having now so fully described my invention that others skilled in the art may therefrom make and use the same, what I claim and desire to secure by Letters Patent is:

1. Means for charging combustion engines including means provided with a plurality of chambers of different volumes for measuring by any one of said volumes the amount of fuel to be combusted per charge, means for supplying fuel to any of said chambers, means for discharging the fuel supplied to any one of said chambers, and means for associating and disassociating any one of said chambers alternately with each of said fuel supply and discharge means.

2. Means for charging combustion engines including means provided with a plurality of chambers of different volumes for measuring by any one of said volumes the amount of fuel to be combusted per charge, means for supplying fuel ing a plurality of columns, means for associating and disassociating any one of said chambers alternately with each of said columns, and means for discharging each supply of fuel to the chamber.

3. Means for charging combustion engines including means provided with a plurality of chambers of different volumes for measuring by any one of said volumes the amount of fuel to be combusted per charge, means for supplying fluid fuel in a plurality of separated columns, means for relatively moving said columns and said means having said chambers, means for relatively moving a selected one of said columns at a rate equivalent to one fourth of the engine speed for a four cycle engine into and out of alternate registration with a selected one of said chambers, and means for discharging the fuel content of said selected chamber intermediate each said registration.

4. Means for charging combustion engines including means provided with plurality of chambers of different volumes for measuring by any one of said volumes the amount of fuel to be combusted per charge, means for supplying fluid fuel in a plurality of separated columns, means for relatively moving said columns and said means having said chambers, means for relatively moving a selected one of said columns at a rate equivalent to one fourth of the engine speed for a four cycle engine into and out of alternate registration with a selected one of said chambers, and means for sealing each of said columns intermediate each said registration.

5. In charging means for combustion engines having combustion means, the combination of a substantially cylindrical member provided with a plurality of openings of different volumes extending therethrough at an angle to its length, a sleeve surrounding and in bearing contact with a cylindrical surface of said member and provided with a plurality of definitely spaced openings extending therethrough and movable into registration with any one of said openings in said member, a housing surrounding and in bearing contact with an outer surface of said sleeve and provided with a plurality of definitely spaced openings extending through said housing to said sleeve and adapted for registration with said openings in said sleeve and with a selected opening in said member, one of said housing openings extending to said combustion means; means for relatively moving said member, sleeve and housing in two directions one of which selects the one of the openings in said member to be brought into registration with said sleeve and housing openings and the other attains the registration of said selected member opening alternately with definite associated openings in said sleeve and housing.

6. In charging means for combustion engines the combination of a substantially cylindrical member provided with a plurality of openings of different volumes extending therethrough at an angle to its length, a sleeve surrounding and in bearing contact with the surface of said member and provided with a plurality of definitely spaced openings extending therethrough and movable into registration with any one of said openings in said member, a housing surrounding and in bearing contact with an outer surface of said sleeve and provided with a plurality of definitely spaced openings extending through said housing to said sleeve and positioned to be brought into registration with a selected opening in said sleeve and with an opening in said member, one of said housing openings extending to said combustion means; means for supplying fluid fuel to one or more of said housing openings, means for supplying air under pressure to an unsupplied opening in said housing, means for relatively moving said member, sleeve and housing in two directions, one of which selects the one of the openings in said member to be brought into registration with said sleeve and housing openings and the other attains the registration of said selected member opening alternately with definite associated openings in said sleeve and housing.

7. In charging means for combustion engines the combination of a substantially cylindrical member provided with a plurality of openings of different volumes extending therethrough, means surrounding and in bearing contact with the surface of said member and provided with a plurality of definitely spaced openings extending therethrough and adapted for registration with any selected one of the openings in said member, means for supplying fluid fuel to an opening in said means for transmission to the said selected opening in said member, means for relatively moving said member and means for selecting the one of said openings of different volumes for registration with said means openings, and means for relatively moving at a rate proportionate to the engine speed said member and means for registering said selected member opening alternately with each of said means openings.

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