Sept. 25, 1923. 1,468,819

C. H. KNUDSEN

INTERNAL COMBUSTION ENGINE

Filed July 1, 1922 2 Sheets-Sheet 1

Fig. 1.

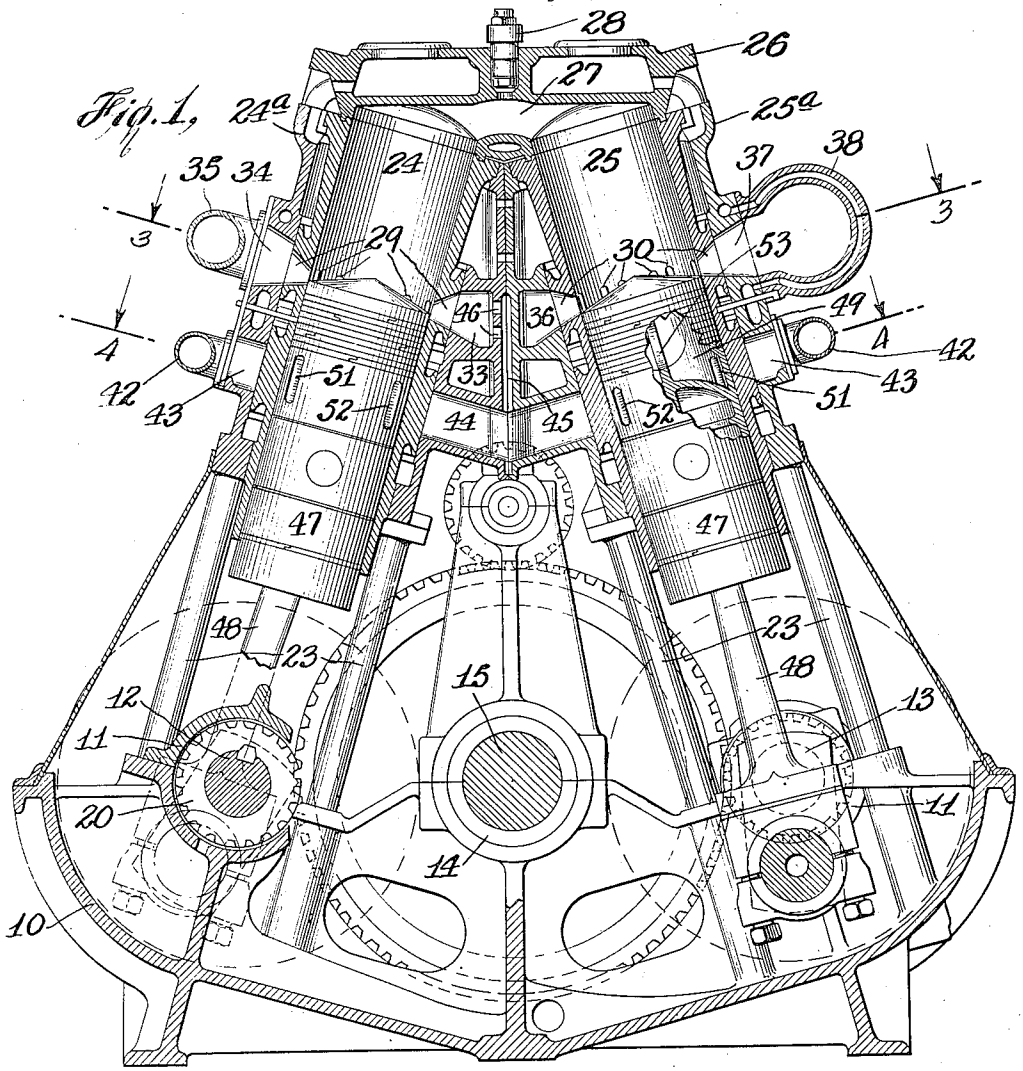
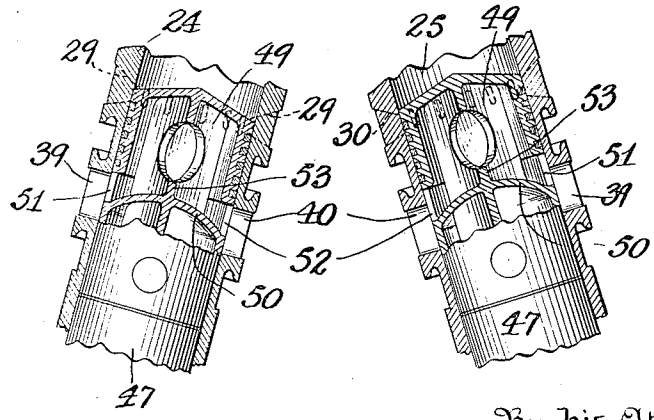


Fig. 2.



Inventor

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By his Attorneys

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Fig. 3.

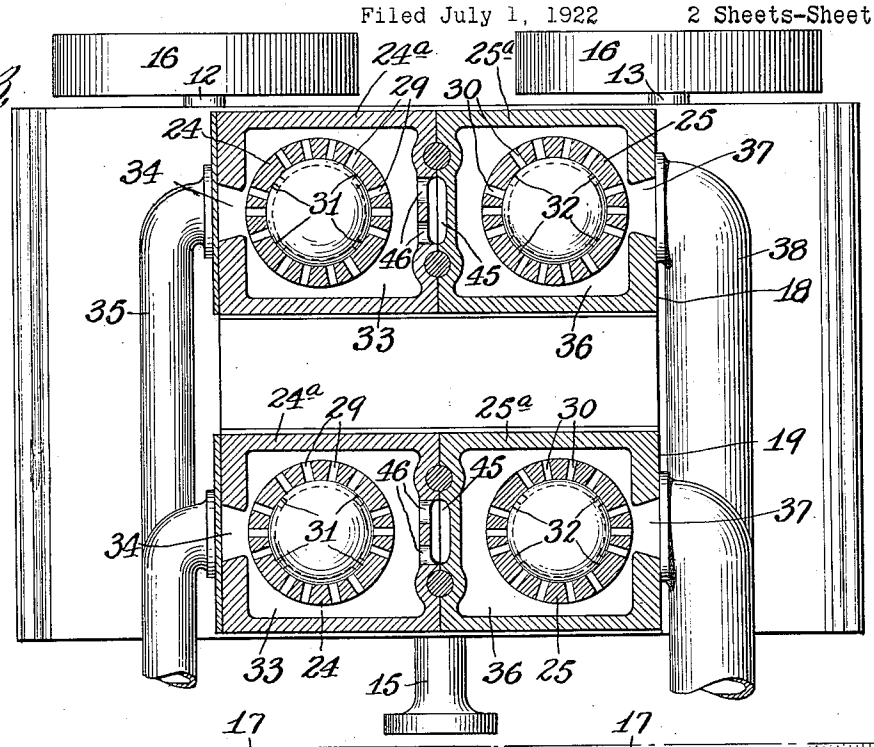
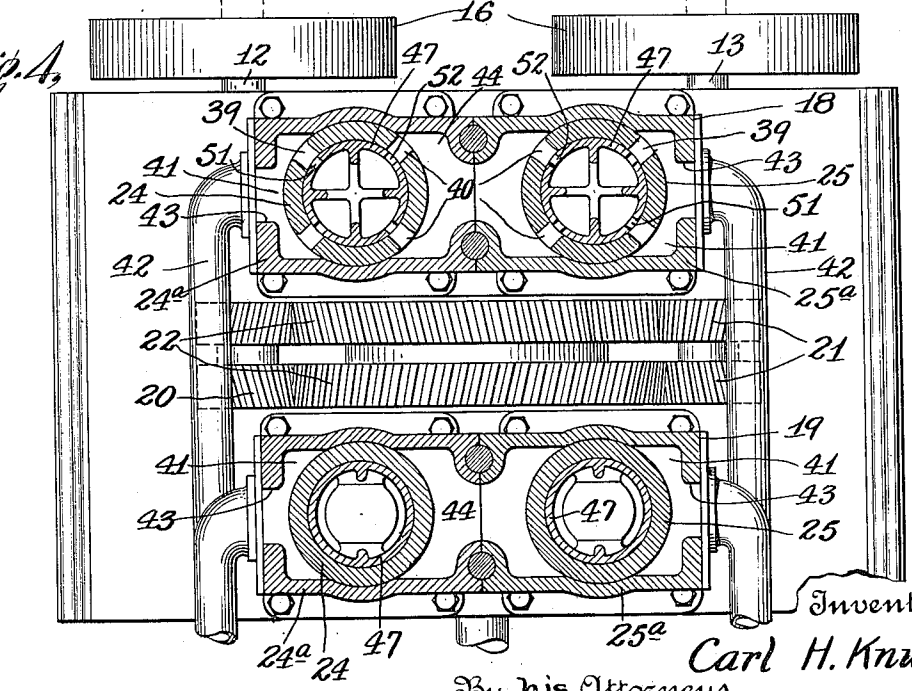


Fig. 4.



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Patented Sept. 25, 1923. 1,468,819

UNITED STATES PATENT OFFICE.

CARL H. KNUDSEN, OF BROOKLYN, NEW YORK, ASSIGNOR TO THE KNUDSEN MOTOR CORPORATION, OF WILMINGTON, DELAWARE, A CORPORATION OF DELAWARE.

INTERNAL-COMBUSTION ENGINE.

Application filed July 1, 1922. Serial No. 572,265.

To all whom it may concern:

Be it known that I, CARL H. KNUDSEN, a citizen of the United States, and residing at Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Internal-Combustion Engines, of which the following is a specification, such as will enable those skilled in the art to which is appertains to make and use the same.

This invention relates to internal combustion engines and particularly to what are known as oil engines using fuel oil under pressure discharged into the combustion chambers of the cylinders, and the object of the invention is to provide an engine of this class of the two-cycle inverted V-type comprising pairs of converging cylinders having a common cylinder head with a combustion chamber therein, one of the cylinders in each pair being provided with intake ports or passages and the other with exhaust ports or passages, and the pistons in the separate pairs of cylinders being operated one slightly in advance of the other, whereby the exhaust ports are opened in advance of the intake ports and are closed in advance of the said intake ports; a further object of the invention is to provide an engine of the class specified with improved means for introducing scavenging and charging air into the separate pairs of cylinders under pressure and for passing part of the scavenging and charging air through the head end portions of the pistons in the separate pairs of cylinders for cooling said pistons and for preheating the air prior to its charge into said cylinders; a further object of the invention is to provide improved means for gearing the crank shafts of the engine with the power or driven shaft, whereby the revolutions of the crank shafts may be reduced to the drive shaft to produce the maximum driving power on the driven shaft; and with these and other objects in view the invention consists in an engine of the class and for the purpose specified which is simple in construction, efficient in use and which is constructed and operated as hereinafter described and claimed.

The invention is fully disclosed in the following specification, of which the accompanying drawings form a part, in which the separate parts of my improvement are designated by suitable reference characters in each of the views, and in which;—

Fig. 1 is a longitudinal sectional view through one pair of cylinders of my improved engine, and showing the pistons in one position;

Fig. 2 a sectional detail view of a part of the construction shown in Fig. 1 with the pistons in a different position:

Fig. 3 a partial transverse sectional view on the line 3—3 of Fig. 1; and,

Fig. 4 a partial transverse sectional view on the line 4—4 of Fig. 1.

It will be understood that my improved engine may be made up in any number of pairs of cylinders, but in the accompanying drawing, I have shown for the purpose of illustrating my invention, a longitudinal section through one pair of cylinders and transverse sections through two pairs of cylinders, and in the drawing, I have shown at 10 the crank case of the engine which is provided with crank shaft bearings 11 in the opposite side portions thereof and in which crank shafts 12 and 13 are mounted, and centrally of the crank case is a main bearing 14 for a power or driven shaft 15. The crank shafts 12 and 13 are provided at one end with fly wheels 16, or if desired the crank shafts 12 and 13 may be connected by gears 17 as indicated in dotted lines in Fig. 4 of the drawing, in which event the shaft 15 is eliminated, this construction being used in stationary power units of this class.

Secured to the crank shafts 12 and 13 between the separate pairs of cylinders 18 and 19, as shown in Fig. 4 of the drawing, are two pairs of gears 20 and 21 which mesh with a pair of larger gears 22 secured to the shaft 15. In other words, the shaft 15 is driven by the crank shafts 12 and 13 through the gears 20, 21 and 22, and it will be noted that the teeth of the separate pairs of gears, or the gears in each pair are arranged at different angles, whereby these gears will operate to take up longitudinal stress or strain on the shaft 15.

The separate pairs of cylinders 18 and 19 are of the same general construction, and in Fig. 1 of the drawing I have shown a vertical longitudinal sectional view through one pair of cylinders, and these cylinders are mounted in connection with the crank cases by substantial rods 23 which support

the separate pairs of cylinders, or the intake cylinder 24 and exhaust cylinder 25 of each pair at an angle to each other with the head end portions of said cylinders directed toward each other to form a substantially inverted V-type engine. The cylinders 24 and 25, in the construction shown, are provided with cylinder casings or jackets 24ª and 25ª which encircle the cylinders proper to form a part thereof. The separate pairs of cylinders or the cylinders 24 and 25 are joined by a common cylinder head 26, which forms a common combustion chamber 27 between the head end portions of said cylinders and centrally of said combustion chamber the head 26 is provided with a fuel injecting valve 28 through which oil under pressure is adapted to be sprayed into the combustion chamber in the operation of the engine.

The cylinders 24 and 25 as well as the cylinder head 26 are provided with the usual water-jackets formed between the cylinders proper and the jackets thereof, and the cylinder 24 is provided with a plurality of circumferentially arranged intake ports 29, and in approximately the same horizontal alinement the cylinder 25 is provided with circumferentially arranged exhaust ports 30. It will be noted on a consideration of Fig. 3 of the drawing that the arrangement of the intake ports 29 in the cylinder 24 is such as to form comparatively wide spaces 31 between said ports at four different points circumferentially of the cylinder and similar spaces 32 are formed by the arrangement of the ports 30 in the cylinder 25.

The ports 29 open into a comparatively large chamber 33 formed between the cylinder 24 proper and the jacket or casing 24ª thereof and a port 34 in the casing 24ª communicates with the chamber 33 and opens outwardly through said casing and into an air supply pipe or manifold 35. A chamber 36 similar to the chamber 33 is formed between the cylinder 25 proper and the casing 25ª thereof and with which the ports 30 communicate, and the casing 25ª is provided with an exhaust port 37 which opens outwardly into an exhaust pipe or manifold 38.

The cylinders 24 and 25 are each provided at a predetermined distance below the ports 29 and 30 and in common vertical alinement with the spaces 31 and 32 with two sets of ports 39 and 40, the ports 39 opening outwardly into the chambers 41 formed between the cylinders 24—25 and their casings 24ª—25ª, and these chambers are placed in communication with air supply pipes or manifolds 42 at the opposite sides of the engine through intake ports 43. A chamber 44 similar to the chambers 41 is formed between the cylinders 24 and 25 and their casings 24ª and 25ª and with which the ports 40 communicate, and the chamber 44 is placed in communication with the chamber 33 of the cylinder 24 through a vertical passage 45 formed between the casing 24ª and 25ª where they abut, and by ports 46 which communicate with the passage 45 and with the chamber 33, as clearly shown in Figs. 1 and 3 of the drawing.

Mounted in the cylinders 24 and 25 are pistons 47 both of which are of the same general form and construction and which are placed in operative connection with the crank shafts 12 and 13 respectively by connecting rods 48 in the usual manner, and the pistons 47 are provided in their head ends with closed chambers 49 formed by transverse partition walls 50 at a predetermined distance from the heads of the pistons, and the pistons are provided with two sets of ports or passages 51 and 52 which open outwardly therethrough and which communicate with the chamber 49 of said pistons, and said chambers are divided by apertured partition walls 53, and the ports 51 and 52 of the pistons are in the same vertical alinement with the ports 39 and 40 in the cylinders 24 and 25 and are adapted to register therewith. It will also be apparent that these ports operate upon the faces 31 and 32 of the cylinders or, in other words, will not cooperate with the ports 29 and 30 of said cylinders.

In practice air under pressure is supplied to the pipes or manifolds 35 and 42 respectively from any suitable mechanism such as a compressor or scavenger pump and, if desired, the pressure in the pipe or manifold 35 may be greater or less than that in the pipes or manifolds 42 and oil under pressure from a suitable pump is discharged through the valve or spray device 28 from any suitable mechanism at predetermined intervals, or when the pistons 47 are adjacent to the upper ends of the cylinders at approximately the end of the compression stroke.

The operation of my improved engine will be readily understood from the foregoing description when taken in connection with the accompanying drawings and the following statement. In Fig. 1 of the drawing, I have shown the pistons 47 in the separate cylinders in the position assumed thereby when the exhaust ports are fully open and the intake ports partially open, while in Fig. 2 I have shown the exhaust ports fully closed and the intake ports partially closed, which result is accomplished by operating the pistons one in advance of the other. As the pistons descend in the cylinders on the firing stroke the exhaust ports 30 of the cylinder 25 are first opened to allow for the exhaust of the products of combustion after which the intake ports

29 are opened and air is passed into the cylinder 24, combustion chamber 27 and cylinder 25 and out through the ports 30 to thoroughly clean out the cylinders and combustion chamber. The scavenging air is admitted into the cylinder 24 through the pipes or manifolds 35 and 42, the charge through the pipe or manifold 35 being direct while the charge through the pipes or manifolds 42 passes first into the chambers 43 in each cylinder structure into the piston in each cylinder through the ports 51 and thus into the chambers 49 in the head ends of said pistons over the partition walls 53 in said chambers and out through the ports 52 of the pistons into the chamber 44, through the passage 45 and ports 46 and thus into the chamber 33, and the cylinder 24 through the ports 29.

The passage of the air under pressure through the chambers 49 in the pistons will operate to cool the head end portions of the pistons and also preheat the air passed therethrough, and this air is also introduced into the separate cylinders above the pistons therein and into the combustion chamber.

On the upward or compression stroke of the pistons the exhaust ports 30 are first closed and a charge of air under pressure is admitted through the ports 29 which are still open as shown in Fig. 2 of the drawing, and this air is then compressed in the combustion chamber 27 to ignite the oil spray which is timely introduced thereinto.

It will be understood that the ports 51 and 52 of the piston register with the ports 39 and 40 in the separate cylinders when the intake ports 29 of the cylinder 24 are opened, and these ports are closed when the ports 29 are closed. It will also be apparent that an engine constructed in the manner herein shown and described may be manufactured at a nominal expense and may be made considerably lighter than similar engines of its class, and by reason of the thorough scavenging action and charging of the cylinders, as herein set out and the method of controlling the intake and exhaust ports as well as the arrangement of the cylinders, the maximum power may be developed, and while I have shown certain details of construction for carrying my invention into effect, it will be understood that I am not necessarily limited to these details, and various changes therein and modifications thereof may be made, within the scope of the appended claims without departing from the spirit of my invention or sacrificing its advantages.

Having fully described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. An engine of the class described comprising cylinders arranged in pairs, one cylinder of each pair being provided with intake ports and the other with exhaust ports, pistons in said cylinders adapted to control said ports, and means independent of the cylinders and pistons for passing air under pressure through the separate pistons and into said cylinders through said intake ports.

2. An engine of the class described comprising cylinders arranged in pairs, one cylinder of each pair being provided with intake ports and the other with exhaust ports, pistons in said cylinders adapted to control said ports, and means independent of the cylinders and pistons for passing air under pressure through the separate pistons and into said cylinders through said intake ports and for discharging the same through said exhaust ports.

3. An engine of the class described comprising cylinders arranged in pairs, one cylinder of each pair being provided with intake ports and the other with exhaust ports, pistons in said cylinders adapted to control said ports, means for passing air under pressure through the separate pistons and into said cylinders through said intake ports, and means independent of said first named means for supplying air under pressure to said cylinders through said intake ports.

4. An engine of the class described comprising cylinders arranged in pairs, one cylinder of each pair being provided with intake ports and the other with exhaust posts, pistons in said cylinders adapted to control said ports, means for passing air under pressure through the separate pistons and into said cylinders through said intake ports, and means independent of said first named means for supplying air under pressure to said cylinders through said intake ports, said pistons being operated one in advance of the other whereby said exhaust ports are opened and closed in advance of the intake ports.

5. An engine of the class described comprising a pair of cylinders, pistons in said cylinders having closed chambers at their head end portions and adapted to control intake ports in one cylinder and exhaust ports in the other cylinder, and means for passing scavenging and charging air under pressure through the closed chambers of the pistons and into said cylinders through said intake ports whereby said pistons are cooled and the scavenging and charging air preheated.

6. An engine of the class described comprising a pair of cylinders, pistons in said cylinders and adapted to control intake ports in one cylinder and exhaust ports in the other cylinder, means for passing scavenging and charging air under pressure through the head end portions of the pistons and into said cylinders through said intake ports whereby said pistons are

cooled and the scavenging and charging air preheated, and means independent of said last named means for supplying additional scavenging and charging air to the cylinders through said intake ports or passages.

7. An engine of the class described comprising a pair of cylinders, pistons in said cylinders and adapted to control intake ports in one cylinder and exhaust ports in the other cylinder, means for passing scavenging and charging air under pressure through the head end portions of the pistons and into said cylinders through said intake ports whereby said pistons are cooled and the scavenging and charging air preheated, means independent of said last named means for supplying scavenging and charging air to the cylinders through said intake ports or passages, and said cylinders being provided with a common combustion chamber through which the scavenging and charging air is adapted to pass.

8. An engine of the class described comprising a pair of cylinders, pistons in said cylinders and adapted to control intake ports in one cylinder and exhaust ports in the other cylinder, means for passing scavenging and charging air under pressure through the head end portions of the pistons and into said cylinders through said intake ports whereby said pistons are cooled and the scavenging and charging air preheated, means independent of said last named means for supplying scavenging and charging air to the cylinders through said intake ports or passages, said cylinders being provided with a common combustion chamber through which the scavenging and charging air is adapted to pass, and a high pressure oil discharge valve communicating centrally with said combustion chamber.

9. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers in the heads thereof, and means for passing air under pressure into and through the chambers of said pistons and into the cylinders through said intake ports or passages.

10. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing air under pressure into and through the chambers of said pistons and into the cylinders through said intake ports or passages, and means independent of said last named means for supplying air under pressure to said cylinders through said intake ports or passages.

11. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber between said pistons, and means for passing the air from said last named chamber into the cylinders through said intake ports or passages.

12. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber between said pistons, means for passing the air from said last named chamber into the cylinders through said intake ports or passages, and means on one of said cylinders for passing another charge of air into said cylinders through said intake ports or passages.

13. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber between said pistons, means for passing the air from said last named chamber into the cylinders through said intake ports or passages, and means on one of said cylinders for passing another charge of air into said cylinders through said intake ports or passages, said cylinders being provided with a common combustion chamber.

14. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber

between said pistons, means for passing the air from said last named chamber into the cylinders through said intake ports or passages, means on one of said cylinders for passing another charge of air into said cylinders through said intake ports or passages, said cylinders being provided with a common combustion chamber, and a solid fuel injecting valve communicating with said combustion chamber.

15. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber between said pistons, means for passing the air from said last named chamber into the cylinders through said intake ports or passages, means on one of said cylinders for passing another charge of air into said cylinders through said intake ports or passages, said cylinders being provided with a common combustion chamber, a solid fuel injecting valve communicating with said combustion chamber, and independent crank shafts for operating said pistons.

16. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber between said pistons, means for passing the air from said last named chamber into the cylinders through said intake ports or passages, means on one of said cylinders for passing another charge of air into said cylinders through said intake ports or passages, said cylinders being provided with a common combustion chamber, a solid fuel injecting valve communicating with said combustion chamber, independent crank shafts for operating said pistons, one in advance of the other whereby the exhaust ports are opened and closed in advance of the intake ports.

17. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber between said pistons, means for passing the air from said last named chamber into the cylinders through said intake ports or passages, means on one of said cylinders for passing another charge of air into said cylinders through said intake ports or passages, said cylinders being provided with a common combustion chamber, a solid fuel injecting valve communicating with said combustion chamber, independent crank shafts for operating said pistons, one in advance of the other whereby the exhaust ports are opened and closed in advance of the intake ports, and a driven shaft mounted between said crank shafts and geared in connection therewith.

18. An engine of the class described comprising a pair of cylinders, one of said cylinders being provided with intake ports and the other with exhaust ports arranged circumferentially of said cylinders, pistons in said cylinders and adapted to control said intake and exhaust ports, said pistons being provided with closed chambers, means for passing independent charges of air under pressure into and through the chambers of the separate pistons into a common chamber between said pistons, means for passing the air from said last named chamber into the cylinders through said intake ports or passages, means on one of said cylinders for passing another charge of air into said cylinders through said intake ports or passages, said cylinders being provided with a common combustion chamber, a solid fuel injecting valve communicating with said combustion chamber, independent crank shafts for operating said pistons, one in advance of the other whereby the exhaust ports are opened and closed in advance of the intake ports, a driven shaft mounted between said crank shafts and geared in connection therewith by reduction gearing.

19. An engine of the class described comprising a pair of cylinders having a common combustion chamber, one of said cylinders being provided with circumferentially arranged intake ports and the other of said cylinders with correspondingly arranged exhaust ports, each of said cylinders being provided below said first named ports with ports or passages, pistons in said cylinders for controlling said intake and exhaust ports and being provided with ports or passages adapted to register with said last named cylinder ports or passages, and means for supplying air under pressure to the last named ports or passages of the cylinder and into and through the pistons through the ports or passages therein and into said cylinders through said intake ports or passages.

20. An engine of the class described com-

prising a pair of cylinders having a common combustion chamber, one of said cylinders being provided with circumferentially arranged intake ports and the other of said cylinders with correspondingly arranged exhaust ports, each of said cylinders being provided below said first named ports with ports or passages, pistons in said cylinders for controlling said intake and exhaust ports and being provided with ports or passages adapted to register with said last named cylinder ports or passages, means for supplying air under pressure to the last named ports or passages of the cylinder and into and through the pistons through the ports or passages therein and into said cylinders through said intake ports or passages, and means for confining the air passed through said pistons to a predetermined area thereof.

21. An engine of the class described comprising a pair of cylinders having a common combustion chamber, one of said cylinders being provided with circumferentially arranged intake ports and the other of said cylinders with correspondingly arranged exhaust ports, each of said cylinders being provided below said first named ports with ports or passages, pistons in said cylinders for controlling said intake and exhaust ports and being provided with ports or passages adapted to register with said last named cylinder ports or passages, means for supplying air under pressure to the last named ports or passages of the cylinders and into and through the pistons through the ports or passages therein and into said cylinders through said intake ports or passages, and means for supplying another charge of air to the cylinders through said intake ports or passages.

22. An engine of the class described comprising a pair of cylinders having a common combustion chamber, one of said cylinders being provided with circumferentially arranged intake ports and the other of said cylinders with correspondingly arranged exhaust ports, each of said cylinders being provided below said last named ports with ports or passages, pistons in said cylinders for controlling said intake and exhaust ports and being provided with ports or passages adapted to register with said last named cylinder ports or passages, means for supplying air under pressure to the last named ports or passages of the cylinders and into and through the pistons through the ports or passages therein and into said cylinders through said intake ports or passages, means for confining the air passed through said pistons to a predetermined area thereof, means for supplying another charge of air to the cylinders through said intake ports or passages, and independent crank shafts for said pistons whereby said pistons are operated one in advance of the other to open and close the exhaust ports in advance of the intake ports.

23. An engine of the class described comprising a pair of cylinders having a common combustion chamber, one of said cylinders being provided with circumferentially arranged intake ports and the other of said cylinders with correspondingly arranged exhaust ports, each of said cylinders being provided below said last named ports with ports or passages, pistons in said cylinders for controlling said intake and exhaust ports and being provided with ports or passages adapted to register with said last named cylinder ports or passages, means for supplying air under pressure to the last named ports or passages of the cylinders and into and through the pistons through the ports or passages therein and into said cylinders through said intake ports or passages, means for confining the air passed through said pistons to a predetermined area thereof, means for supplying another charge of air to the cylinders through said intake ports or passages, independent crank shafts for said pistons whereby said pistons are operated one in advance of the other to open and close the exhaust ports in advance of the intake ports, and a power shaft between said crank shafts.

24. An engine of the class described comprising a pair of cylinders having a common combustion chamber, one of said cylinders being provided with circumferentially arranged intake ports and the other of said cylinders with correspondingly arranged exhaust ports, each of said cylinders being provided below said last named ports with ports or passages, pistons in said cylinders for controlling said intake and exhaust ports and being provided with ports or passages adapted to register with said last named cylinder ports or passages, means for supplying air under pressure to the last named ports or passages of the cylinders and into and through the pistons through the ports or passages therein and into said cylinders through said intake ports or passages, means for confining the air passed through said pistons to a predetermined area thereof, means for supplying another charge of air to the cylinders through said intake ports or passages, independent crank shafts for said pistons whereby said pistons are operated one in advance of the other to open and close the exhaust ports in advance of the intake ports, a power shaft between said crank shafts, and reduction gears for gearing the crank shafts to said power shafts.

25. An engine as claimed in claim 24, including a crank case and a plurality of rods for coupling said cylinders with the crank case and for spacing the cylinders therefrom.

26. An engine as claimed in claim 24, including a crank case, the cylinders being mounted in spaced relation with the crank case and supported by rods.

27. An internal combustion engine including a plurality of converging cylinders, a common head for both cylinders provided with a combustion chamber communicating with the interior of both cylinders, air ports arranged in one of said cylinders and exhaust ports arranged in the other cylinder, ported pistons arranged in said cylinders and having closed chambers, the tops of which form the heads of the pistons, and means for passing compressed air through the ports and closed chambers of the pistons and into said air ports.

28. An engine as claimed in claim 27 in which the last mentioned means includes pipes arranged at opposite sides of said cylinders and adapted to introduce compressed air through the ports of the cylinders and into the closed chambers of the latter, a chamber arranged between said cylinders and adapted to receive the air leaving the chambers of the pistons, and a passageway connecting the chamber between the cylinders to said air ports.

29. In an internal combustion engine having a pair of cylinders, means for charging the cylinders with heated compressed air, and means for subsequently introducing unheated compressed air into said cylinders.

30. An internal combustion engine including a pair of cylinders having intake and exhaust ports, pistons in said cylinders controlling said ports, means including the pistons for introducing heated compressed air into the cylinders through said intake ports, and means for subsequently introducing unheated compressed air into said cylinders through said intake ports.

31. In an engine of the class described, a cylinder structure comprising a pair of cylinders, one of said cylinders being provided with circumferentially arranged intake and auxiliary ports, the other of said cylinders being provided with circumferentially arranged exhaust ports and correspondingly arranged auxiliary ports, chambers encircling the intake and exhaust ports, chambers associated with said auxiliary ports, and means placing the chambers of the auxiliary ports in communication with the chamber of the intake ports.

32. An engine as claimed in claim 31 including an intake pipe communicating with the chamber of the intake ports.

In testimony that I claim the foregoing as my invention I have signed my name this 30th day of June, 1922.

CARL H. KNUDSEN.