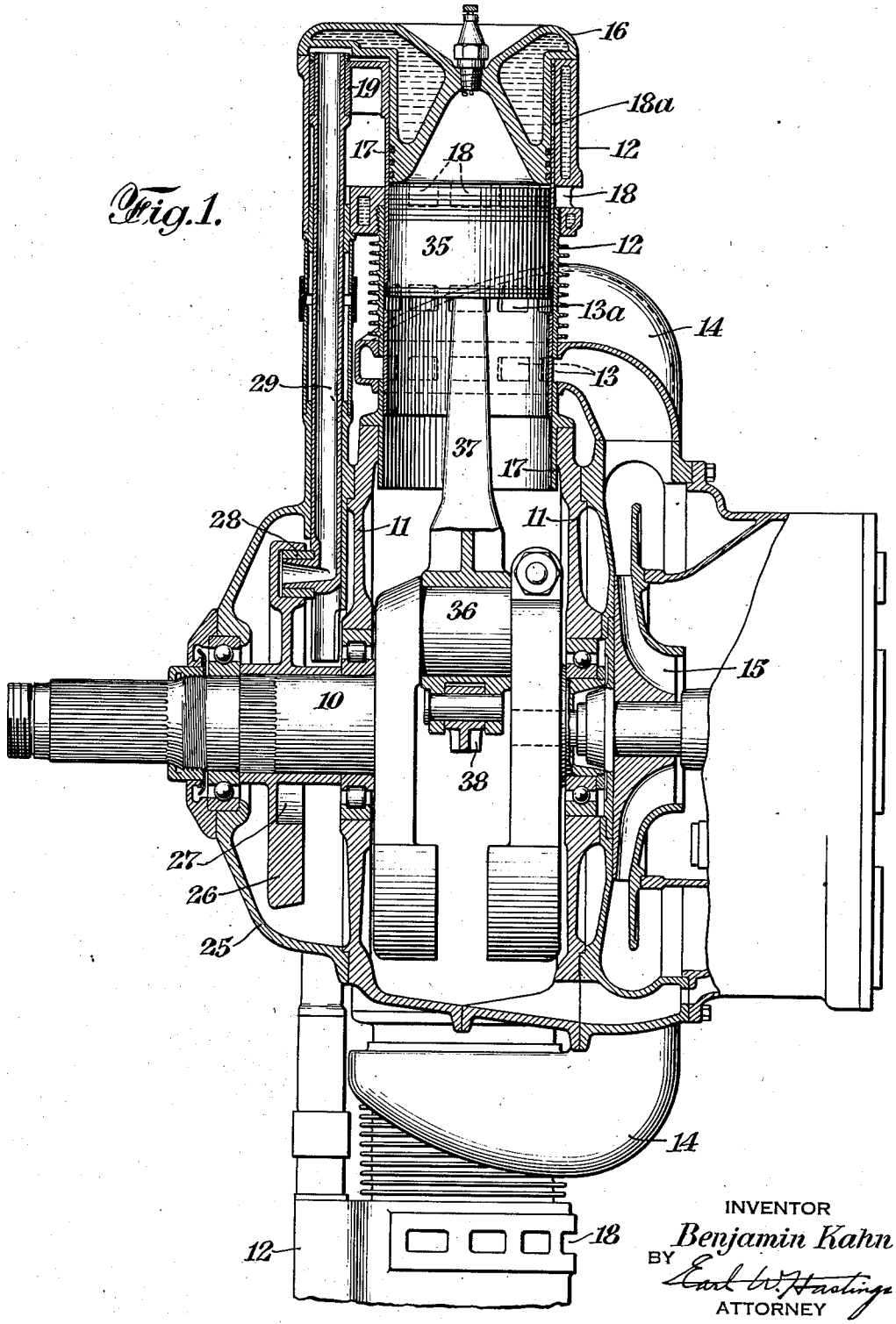
Sept. 22, 1936. B. KAHN 2,055,352

TWO-CYCLE SINGLE SLEEVE VALVE ENGINE

Filed Jan. 29, 1934 4 Sheets-Sheet 1

Fig. 1.



INVENTOR
Benjamin Kahn
BY Earl W. Hastings
ATTORNEY

Sept. 22, 1936. B. KAHN 2,055,352

TWO-CYCLE SINGLE SLEEVE VALVE ENGINE

Filed Jan. 29, 1934 4 Sheets-Sheet 2

Fig. 2.

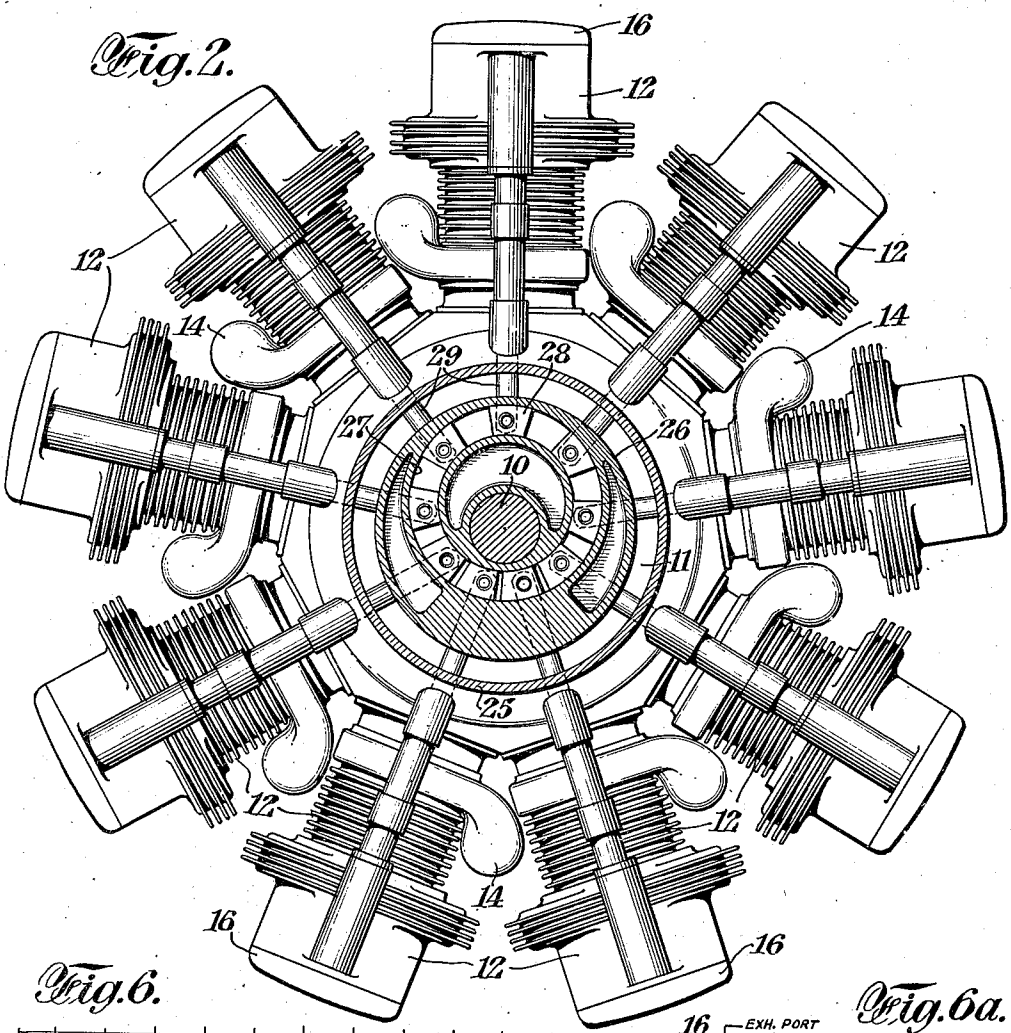


Fig. 6.

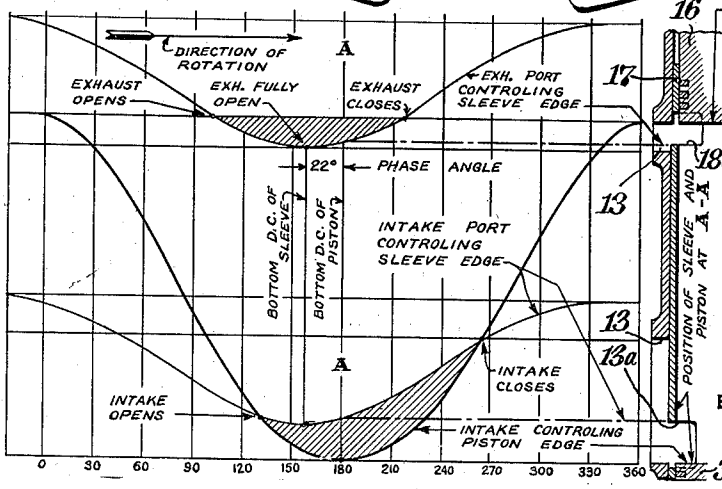
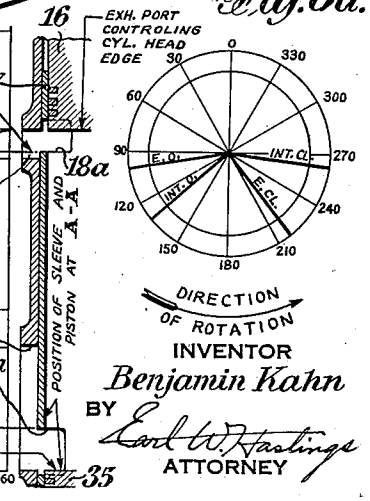


Fig. 6a.



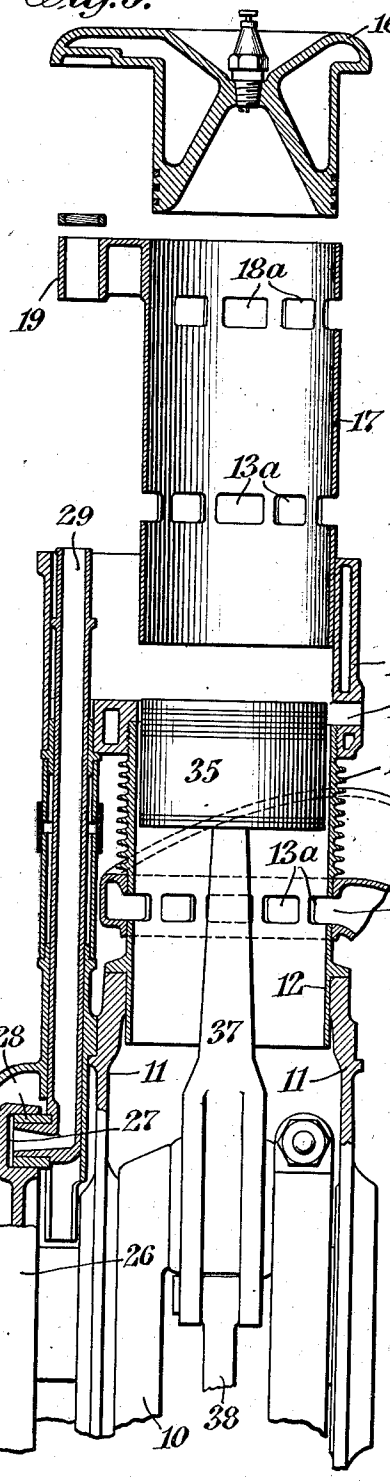
INVENTOR
Benjamin Kahn
BY Earl W. Hastings
ATTORNEY

Sept. 22, 1936. B. KAHN 2,055,352

TWO-CYCLE SINGLE SLEEVE VALVE ENGINE

Filed Jan. 29, 1934 4 Sheets-Sheet 3

Fig. 3.



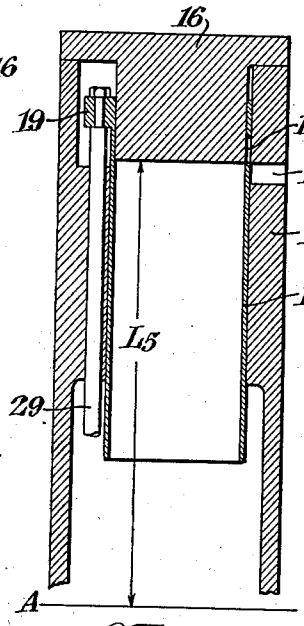


Fig. 4.

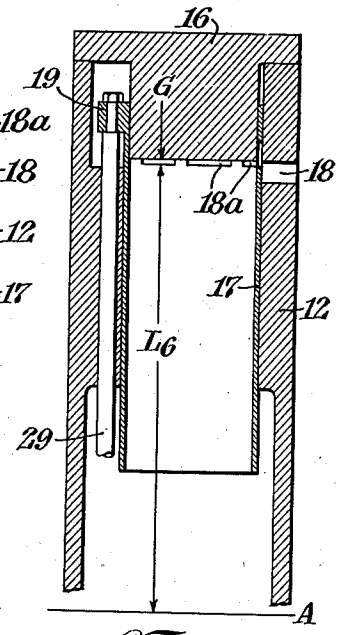


Fig. 5.

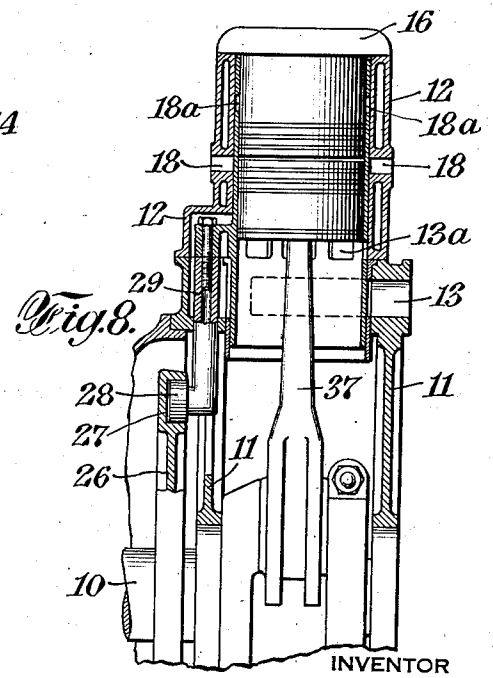


Fig. 8.

INVENTOR
Benjamin Kahn
BY Earl W. Hastings
ATTORNEY

Sept. 22, 1936. B. KAHN 2,055,352

TWO-CYCLE SINGLE SLEEVE VALVE ENGINE

Filed Jan. 29, 1934 4 Sheets-Sheet 4

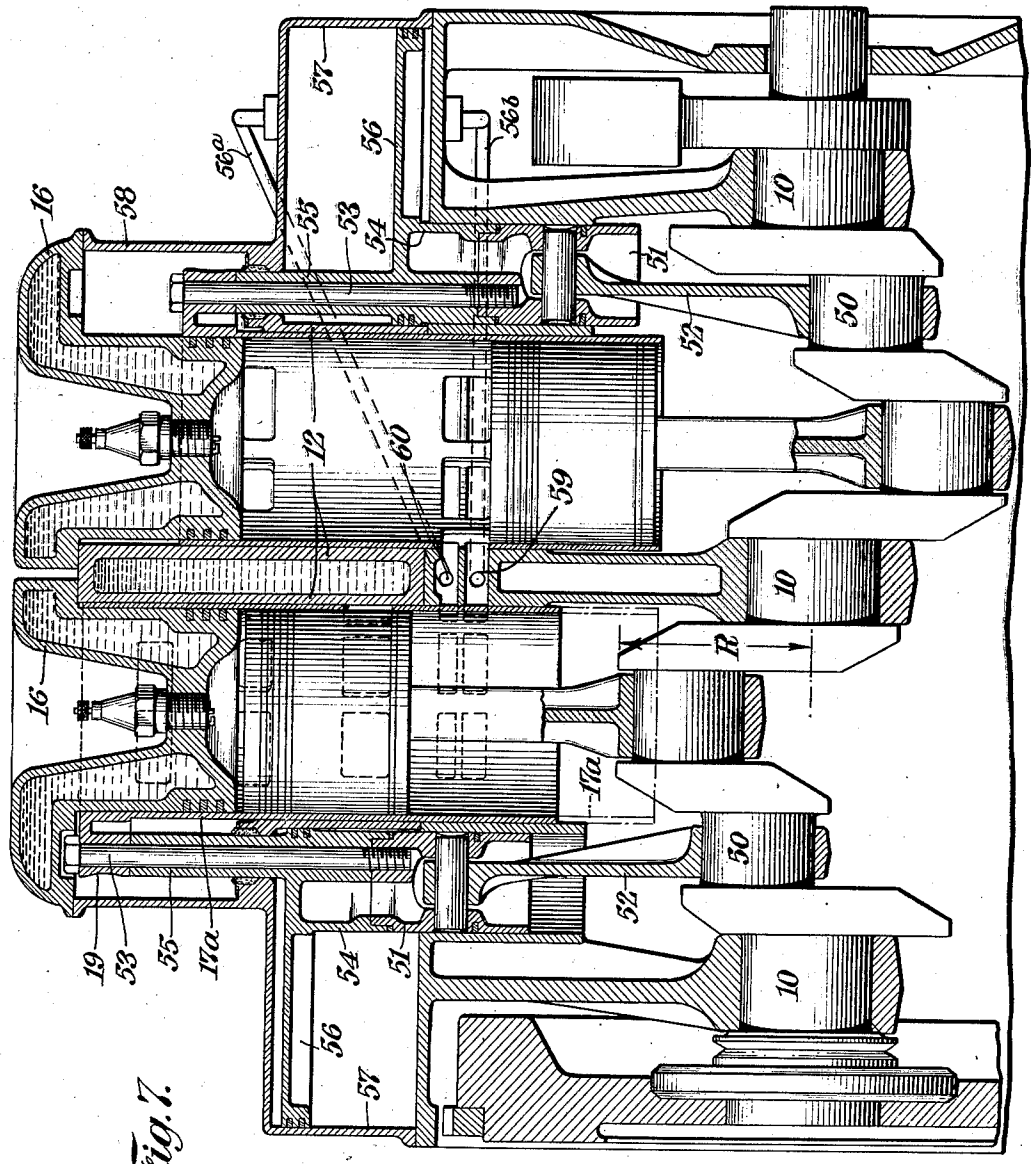


Fig. 7.

INVENTOR
Benjamin Kahn
BY
Earl W. Hastings
ATTORNEY

Patented Sept. 22, 1936 2,055,352

UNITED STATES PATENT OFFICE

2,055,352

TWO-CYCLE SINGLE SLEEVE-VALVE ENGINE

Benjamin Kahn, New York, N. Y.

Application January 29, 1934, Serial No. 708,819

32 Claims. (Cl. 123—65)

This invention relates to improvements in internal combustion engines, particularly "straight-thru" scavenging of the two-stroke type, and more particularly to engines employing single sleeve valves.

One of the main objects of the invention is to provide in an engine of this character for the removal of sleeve or piston with the removal of a minimum number of other parts.

Another object is to provide such an engine with a minimum height dimension.

Another further object is to provide a single sleeve engine having over-compensated port timing.

A still further object is to provide an engine having the above objects incorporated and further to permit the accomplishment of fluid pumping without undue complication of parts.

Still another important object is to provide a radial engine of the character described having features accomplishing all of the above mentioned objects effectively incorporated therein.

Other objects are to improve the operation and utility of high output engines, having other desirable features as will become apparent hereinafter.

Broadly stated the invention consists in the provision of a single sleeve-valve engine, the operating means for the sleeves being connected to the sleeves outside the crankcase by any suitable operating connection. These sleeves are preferably provided with extensions outside the crankcase for connection with the operating means.

This connection permits the sleeves to be removed outwardly and away from the crankshaft, by removing the head, or the head and cylinder only. In all previous sleeve engines where the sleeves are driven from their end adjacent the crankshaft, and within the crankcase, the connecting projection on these sleeves prevents their outward removal and requires the removal of the crankshaft, and practically dismantling of the entire engine.

The connecting projection of a sleeve in the present invention is further adapted to be located within the minimum sleeve length; thereby requiring no additional operating space, and consequently a minimum height engine may be maintained. In all previous sleeve engines, the connecting projection being adjacent the crankshaft, requires some additional space between the cylinder bottom and the sleeve bottom, to permit the connecting projection and its associated parts, to clear in their operation, whereas in the present invention the sleeve bottom may encroach well within the clearance space of the crank throw.

It is well known that the expansion of the fluid charge in entering the highly heated engine reduces the quantity of the charge and consequently reduces the maximum efficiency of the engine. It is further well known that a heated engine grows in length and naturally, any ports in the cylinder, "grow" in distance, further from the crankshaft than when the engine is running "cool". A sleeve in such a cylinder having its operating connection at the bottom, would also extend its ports in the same direction as the ports in the sleeve and produce no appreciable change in port timing when the engine is "hot". A sleeve having its operating connection at the top, however, as in the present invention, would cause its port to "grow" toward the crankshaft and in a direction opposite to the directional "growth" of the port in the cylinder, so that the earlier opening and later closing of the ports is thus effected. This effect permits a greater period of inlet and exhaust to the fresh and burned charges respectively, to compensate for the rise in temperature and the accompanying reduction in time of port opening at higher speeds. This is generally known as over-compensating port timing, and is important in aeroplane engines, or other high output engines.

Conversely to the prior mentioned effect of the "growing" of cylinder and sleeve in opposite directions to each other, the subsequent idling of the engine of the present invention, causes the sleeves and cylinders to "cool". Consequently the cylinder and sleeve shrink toward and away from the crankshaft respectively, to a point where the ports remain open a shorter period.

This over-compensating arrangement permits the design of ports for good idling without sacrificing port efficiency at higher speeds.

It is particularly desirable to provide radial engines wherein the accessibility and disassembly of the sleeves individually in order to reach the piston can be accomplished without removing the propeller, the nose, the front crankcase section, the reduction gearing and the crankshaft.

These and other analogous improved features are accomplished by the novel construction, combination and arrangement of parts hereinafter described as well as illustrated in the accompanying drawings, constituting a material component of this disclosure, and in which:

Figure 1 is a longitudinal cross section of a radial two-cycle engine incorporating the invention,

Figure 2 is a front elevation of the engine shown in Fig. 1, with the nose portion seen in section to disclose the mechanism for driving the sleeves.

Figure 3 is a fragmentary exploded view of one cylinder of the engine, with the parts shown in disassembled relationship.

Figure 4 is a diagrammatic view of the sleeve and cylinder relationship in a "cool" engine.

Figure 5 is a similar view of the sleeve and cylinder relationship when the parts in Fig. 4 are expanded due to heat.

Figures 6 and 6*a* are views showing port timing diagrams of the engine shown in Fig. 1.

Figure 7 is a longitudinal view of a two-cycle "in-line" engine embodying the invention.

Figure 8 is a fragment of a modified form of the invention.

The reference character **10** represents the crankshaft of a two-stroke cycle radial engine, adapted to be supported in a crankcase **11**. Secured to the crankcase are a plurality of cylinders **12** having inlet ports **13** near the inner end surrounded by inlet manifolds **14**, and exhaust ports **18** at the outer ends of the cylinders. A supercharge **15** is adapted to supply fluid to the inlet manifold. Secured to the outer ends of the cylinders are cylinder heads **16**, which heads are adapted to be extended inwardly into the cylinders and adapted to provide sliding space for the outer ends of sleeves **17**, between these heads and the cylinders.

The sleeve **17** in each of the cylinders is provided with inlet ports **13***a* adapted to cooperate with the inlet ports **13** of the cylinder. Exhaust ports **18***a* are also provided in the sleeve which are adapted to cooperate with the ports **18**. The sleeve is provided with a projection **19** at its outer end adapted to connect with operating means for the sleeve.

A nose section **25** is secured to the front of the crankcase **11** and provides a housing for the sleeve driving mechanism. This mechanism comprises a disc **26** secured to the crankshaft **10** and is provided with an eccentric groove **27**. A plurality of sliding shoes **28**, one for each sleeve of the engine, is adapted to slide in the groove **27** as the disc is rotated. Adapted to slide in the housing **25** and pivotally connected to each shoe **28**, is a driving rod **29**. This rod is adapted to be suitably connected to the projection **19**, of the sleeve **17**, at its outer end.

A piston **35** is adapted to be operated in the sleeve **17**, and is further adapted to assist in the control of the inlet ports during its operation. The pistons **35** are connected to the crank throw **36** of the crankshaft by the usual master connecting rod **37** and the associated articulated rods **38**.

By this construction it is apparent that the sleeve may be removed outwardly thru the head end of the cylinder, by removal of the head only, without removing or affecting the adjacent cylinders, sleeve drives and cranktrain, as clearly shown in Fig. 3.

This construction permits the provision of an engine of minimum diameter or height, as will be seen with reference to Fig. 7. The dimension R represents the radius of the clearance path required by the crank throw. The sleeve **17***a* is shown in its innermost position in dot and dash lines and the lower end of this sleeve is shown as encroaching considerably in the clearance circle of the radius R. The sleeves **17** and **17***a* are capable of moving completely within the cylinder and outside of the clearance space circle of the crank throw since there is no drive connecting projection at this end of the cylinder.

Referring to Fig. 3. In the event it is desired to remove the piston, the removal of the cylinder as well as the sleeve is necessary. This can be easily accomplished by removing the nuts or other securing means of the individual cylinder to expose said piston completely. It will be particularly noted that the crankshaft and its associated drives and connections are not dismantled. This arrangement distinctly avoids the necessity of removing the entire engine from its mountings, or substantially dismantling it, as would be the case in sleeve engines where the sleeves are operated from their bottoms and necessarily removed inwardly and toward the chankshaft.

Figs. 4 and 5 show the relative growth and disposition of the ports when the engine is "cool" and "hot", respectively. The reference letters L5 and L5 represent the distance from a common index line A—A which may be the center line of the crankshaft. The letter G represents the advance of earlier opening and later closing of the exhaust ports to produce over-compensating port timing.

Figs. 6 and 6*a* are typical diagrams of port timing of a reciprocating two-cycle single sleeve valve engine shown in the drawings.

Fig. 7 shows the invention as applied to a two-cycle single sleeve valve "in-line" engine. The parts bearing similar reference characters are similar to those previously described.

The sleeve drive consists of a crank throw **50** formed on the crankshaft **10** and adapted to operate a crosshead **51** by a connecting rod **52** therebetween. Secured to the crosshead **51** as by means of a bolt **53**, is a member **54**, having an extension **55** which is connected at its outer end to the projection **19** of the sleeve **17***a*. Integrally formed with the member **54** is a disc piston **56** adapted to reciprocate in a housing **57** integrally formed with the cylinder block **58**. The disc **56** may be adapted to pump air on one side and a fuel mixture on the other to the respective inlet chambers **59** and **60**, through suitable conduits **56***a* and **56***b*.

In Fig. 8 the projection **19** of the sleeve is substantially midway thereof but outside the crankcase. The sleeve may be removed outwardly by removing the cylinder and head.

The foregoing disclosure is to be regarded as descriptive and illustrative only, and not as restrictive or limitative of the invention, of which obviously an embodiment may be constructed including various modifications without departing from the general scope therein indicated and denoted in the appended claims.

Having thus described the invention what is claimed as new and desired to secure by Letters Patent, is:—

1. In an internal combustion engine the combination of a crankcase, a crankshaft in the crankcase, a cylinder secured to the crankcase having inlet ports at the bottom and exhaust ports at the top thereof, a piston, a head secured to the cylinder, and a reciprocating sleeve in the cylinder having intake and exhaust ports therein adapted to register with the ports in the cylinder, said sleeve adapted to circumscribe the head and the entire piston at all times during its operation, said sleeve being operatively connected to the crankshaft at its end remote of the crankshaft.

2. In a radial internal combustion engine the combination of a crankcase, a crankshaft in the crankcase, a plurality of cylinders radially disposed around and secured to the crankcase, each

cylinder having intake and exhaust ports, a sleeve having intake and exhaust ports respectively registrable with the ports in the cylinder, and means for operating the sleeve extending outside the crankcase and connected at its outer end to the sleeve.

3. In a radial internal combustion engine the combination of a crankcase, a crankshaft in the crankcase, a plurality of cylinders radially disposed around and secured to the crankcase, each cylinder having intake and exhaust ports, a sleeve having intake and exhaust ports respectively registrable with the ports in the cylinder, and means for operating the sleeve extending outside the crankcase and connected at its outer end to the sleeve at the end of the sleeve farthest from the crankshaft.

4. An internal combustion engine having a crankcase, a crankshaft, a cylinder on the crankcase, intake ports in the cylinder, a sleeve operating in the cylinder and having ports adapted to register with said ports in the cylinder, a piston in the sleeve adapted to establish communication between the ports in the cylinder and the interior of the sleeve when the piston is operated, and an operating connection on the sleeve radially outward of sleeve ports from the crankshaft, said sleeve ports being radially outward of the cylinder ports during the closed position thereof, said sleeve ports being adapted to move toward the cylinder ports when the sleeve is expanded under the influence of heat, thereby effecting an earlier opening of the ports when the sleeve is expanded than when the sleeve is not expanded.

5. In a two-stroke cycle internal combustion engine having a crankshaft, a sleeve, ports in the sleeve, and a sleeve driving connection on the outer end of the sleeve whereby the ports are advanced toward the crankshaft when the sleeve is heated.

6. In an internal combustion engine the combination of a crankcase, a crankshaft therein, a cylinder on the crankcase adapted to thermally expand in a direction away from the crankshaft, a sleeve in the cylinder, operating means for the sleeve secured to the crankshaft and the outer end of the sleeve whereby the sleeve may thermally expand in a direction toward the crankshaft, and cooperating ports in the sleeve and in the cylinder adapted to extend toward and away from each other during expansion and contraction of the port containing members.

7. In an internal combustion engine the combination of a crankcase, a crankshaft therein, a cylinder on the crankcase adapted to expand away from the crankshaft, a sleeve in the cylinder adapted to expand toward the crankshaft, an inlet port in the cylinder, and an inlet port in the sleeve adapted to cooperate with the inlet port in cylinder.

8. In a two-stroke cycle sleeve valve engine having a cylinder, a crankshaft, reciprocating sleeve valve means asssociated with the engine cylinder, and sleeve valve actuating means including an eccentric means directly on the crankshaft and connected to the outer end of the sleeve.

9. In a sleeve valve engine having a cylinder, a crankshaft, reciprocating sleeve valve means associated with the engine cylinder, and sleeve valve actuating means secured to the outer end of the sleeve, said means including an eccentrically grooved disc on the crankshaft.

10. In a sleeve valve engine having a crankshaft, a plurality of cylinders disposed radially about the crankshaft, sleeve valve means associated with each cylinder, and sleeve valve actuating means, including an eccentric means on the crankshaft operatively connected to all sleeves at the outer ends of the sleeves.

11. In an internal combustion engine having a crank case, a cylinder thereon, a crankshaft in the crank case, a sleeve valve in the cylinder, a piston in the sleeve, intake ports in the sleeve and intake ports in the bottom of the cylinder, said ports adapted to cooperate during the operation of the sleeve, a crank pin on the crankshaft, for operating the piston, sleeve operating means on the crank shaft in phased relation to the crank pin for opening and closing said ports, and means between the sleeve and sleeve operating means, whereby the instant of opening of the ports is advanced and the instant of closing is retarded with respect to the crank pin angle, in direct proportion to the temperature of the sleeve.

12. An internal combustion engine having a crankshaft, a cylinder, ports in the bottom of the cylinder, a sleeve operating in the cylinder, ports in the sleeve cooperating with said first mentioned ports in open relationship for a predetermined period of the engine cycle, and means operably associated with the crankshaft for increasing said period in direct proportion to the temperature of the sleeve.

13. In an internal combustion engine, a crankshaft, a cylinder, intake ports in the bottom of the cylinder, and a heat responsive port registering sleeve in said cylinder operatively connected to the crankshaft whereby the open period of said ports in the cylinder is increased when the engine is heated.

14. In an internal combustion engine, a cylinder with intake ports at the bottom thereof, a reciprocatory sleeve in the cylinder having ports registrable with the ports in the cylinder, and sleeve operating means connected to the outer end of the sleeve.

15. In an internal combustion engine, a crankshaft, a cylinder with intake ports at the bottom thereof, a reciprocatory sleeve in the cylinder having ports registrable with the ports in the cylinder and means whereby the sleeve expands toward the crankshaft when the sleeve is heated.

16. In an internal combustion engine having a crankshaft, a cylinder with intake ports at the bottom, a reciprocatory sleeve in the cylinder having ports registrable with the ports in the cylinder, eccentric means on the crankshaft for actuating the sleeve, and reciprocating connecting means between the sleeve and the eccentric means disposed in a plane common to the crankshaft and the cylinder.

17. In an internal combustion engine, a crankshaft, a cylinder with intake ports at the bottom, a reciprocatory sleeve in the cylinder having ports registrable with the ports in the cylinder, means on the crankshaft for actuating the sleeve, reciprocating connecting means between the sleeve and the actuating means, a pump cylinder communicating with the intake ports, and a fluid pumping piston in the pump cylinder secured to the reciprocating connecting means.

18. In a two-cycle internal combustion engine including a working cylinder having intake and exhaust ports, a reciprocatory sleeve in the working cylinder having intake and exhaust ports registrable with the respective ports in the cylinder, a pump cylinder having communication with the interior of the sleeve through the intake ports, a fluid pumping piston in the pump cylinder, and common actuating mechanism for the sleeve and

the fluid pumping piston, said pumping piston disposed between the sleeve and the sleeve actuating mechanism.

19. In an internal combustion engine, a crankshaft, a cylinder with intake ports at the bottom, a sleeve reciprocatory in the cylinder and having ports registrable with the ports in the cylinder, means on the crankshaft for actuating the sleeve, reciprocating connecting means between the sleeve and the actuating means, a pump cylinder communicating with the intake ports, and a fluid pumping piston in the pump cylinder secured to the reciprocating connecting means, said crankshaft, cylinder, reciprocating connecting means and pump cylinder disposed in a common plane.

20. In an internal combustion engine, a cylinder with intake and exhaust ports therein, said ports being respectively at the bottom and top of the cylinder, a single sleeve adapted to operate in said cylinder and having ports adapted to cooperate with the ports in the cylinder, and operating means for said sleeve connected to the outer end of the sleeve, whereby the sleeve when heated expands axially inward and in a direction opposite to the direction of expansion of the cylinder when heated, thereby causing an earlier opening and later closing of the intake ports to effect a greater valve capacity when the engine is so heated.

21. In a two-stroke cycle radial internal combustion engine, cylinders having intake ports at the inner ends thereof, sleeves with intake ports therein registrable with the intake ports in the cylinders, pistons in the sleeves cooperating with the intake ports, and operating means for the sleeves connected to the outer ends of the sleeves.

22. In an internal combustion engine, a cylinder having intake ports near the inner end thereof, a reciprocatory sleeve in the cylinder having ports registrable with the ports in the cylinder, a pump cylinder having communication with the intake ports in the cylinder, a fluid pumping piston in the pump cylinder, and common actuating means for the sleeve and fluid pumping piston.

23. In an internal combustion engine, a cylinder having intake ports near the inner end thereof, a reciprocatory sleeve in the cylinder having ports registrable with the ports in the cylinder, a piston operable in the sleeve to control the intake ports, a pump cylinder having communication with the intake ports in the cylinder, a fluid pumping piston in the pump cylinder, and common actuating means for the sleeve and fluid pumping piston.

24. In a "straight-thru" scavenging sleeve valve engine, a crankcase, a crankshaft in the crankcase, a plurality of cylinders on the crankcase and disposed radially about the crankshaft, sleeves in the cylinders, and operating means for the sleeves connected to the sleeves exterior of the crankcase.

25. In a two-stroke cycle "straight-thru" scavenging sleeve valve engine, a crankcase, a crankshaft in the crankcase, a cylinder on the crankcase, a sleeve in the cylinder, ports in the sleeve at opposite ends thereof, a piston in the sleeve, and operating means for the sleeve connected to the sleeve exterior of the crankcase.

26. In a two-stroke cycle "straight-thru" scavenging sleeve valve radial engine, a crankcase, a crankshaft in the crankcase, a cylinder on the crankcase having ports near the inner end thereof, a sleeve in the cylinder having ports cooperative with said cylinder ports, a piston in said sleeve cooperative with said sleeve ports, and operating means for the sleeve connected to the sleeve exterior of the crankcase.

27. In a two-stroke cycle internal combustion engine the combination of a crankcase, a crankshaft in the crankcase, a cylinder secured to the crankcase having exhaust ports at the top and inlet ports at the bottom thereof, a head secured to the cylinder, and a reciprocating port controlling sleeve in the cylinder and having intake and exhaust ports therein adapted to register with the ports in the cylinder, said sleeve being operatively connected to the crankshaft at its end remote from the crankshaft.

28. In a two-stroke cycle internal combustion engine the combination of a crankcase, a crankshaft in the crankcase, a cylinder secured to the crankcase and having exhaust ports at the top and inlet ports at the bottom thereof, a head secured to the cylinder, and a reciprocating port controlling sleeve in the cylinder having intake and exhaust ports therein adapted to register with the ports in the cylinder, said sleeve being operatively connected to the crankshaft exterior of the crankcase.

29. In a two-stroke cycle internal combustion engine having a crankcase, a crankshaft therein, a stationary cylinder on the crankcase having exhaust ports at the top and inlet ports at the bottom thereof, a reciprocatory port controlling sleeve operable within said cylinder and having intake and exhaust ports adapted to register with the ports in the cylinder, and means for operating the sleeve by the crankshaft, said operating means being connected to the end of the sleeve remote of the crankshaft.

30. In a two-stroke cycle internal combustion engine the combination of a crankcase, a crankshaft therein, a stationary cylinder on the crankcase having exhaust ports at the top and inlet ports at the bottom thereof, a reciprocatory port controlling sleeve operable within said cylinder and having ports therein adapted to register with the ports in the cylinder, and means connected to said sleeve exterior of the crankcase for operating the sleeve directly from the crankshaft.

31. In an internal combustion engine of the single-sleeve valve type the combination of a cylinder having exhaust ports at the top and intake ports at the bottom thereof, a sleeve having intake and exhaust ports at the top and bottom thereof to register with the ports in the cylinder, and means for operatively connecting the sleeve at its end remote from the crankshaft to move sleeve ports into and out of register with the cylinder ports.

32. In an internal combustion engine of the single sleeve valve type, the combination of a cylinder having a head and exhaust ports at the head end of the cylinder and intake ports at the inner end of the cylinder, a sleeve having intake and exhaust ports adapted to register with the ports in the cylinder, and means to move said sleeve ports into and out of register with the cylinder ports connected to the head end of the sleeve.

BENJAMIN KAHN.