Nov. 30, 1943. W. R. APPEMAN 2,335,252

INTERNAL COMBUSTION ENGINE

Filed July 24, 1941 2 Sheets-Sheet 1

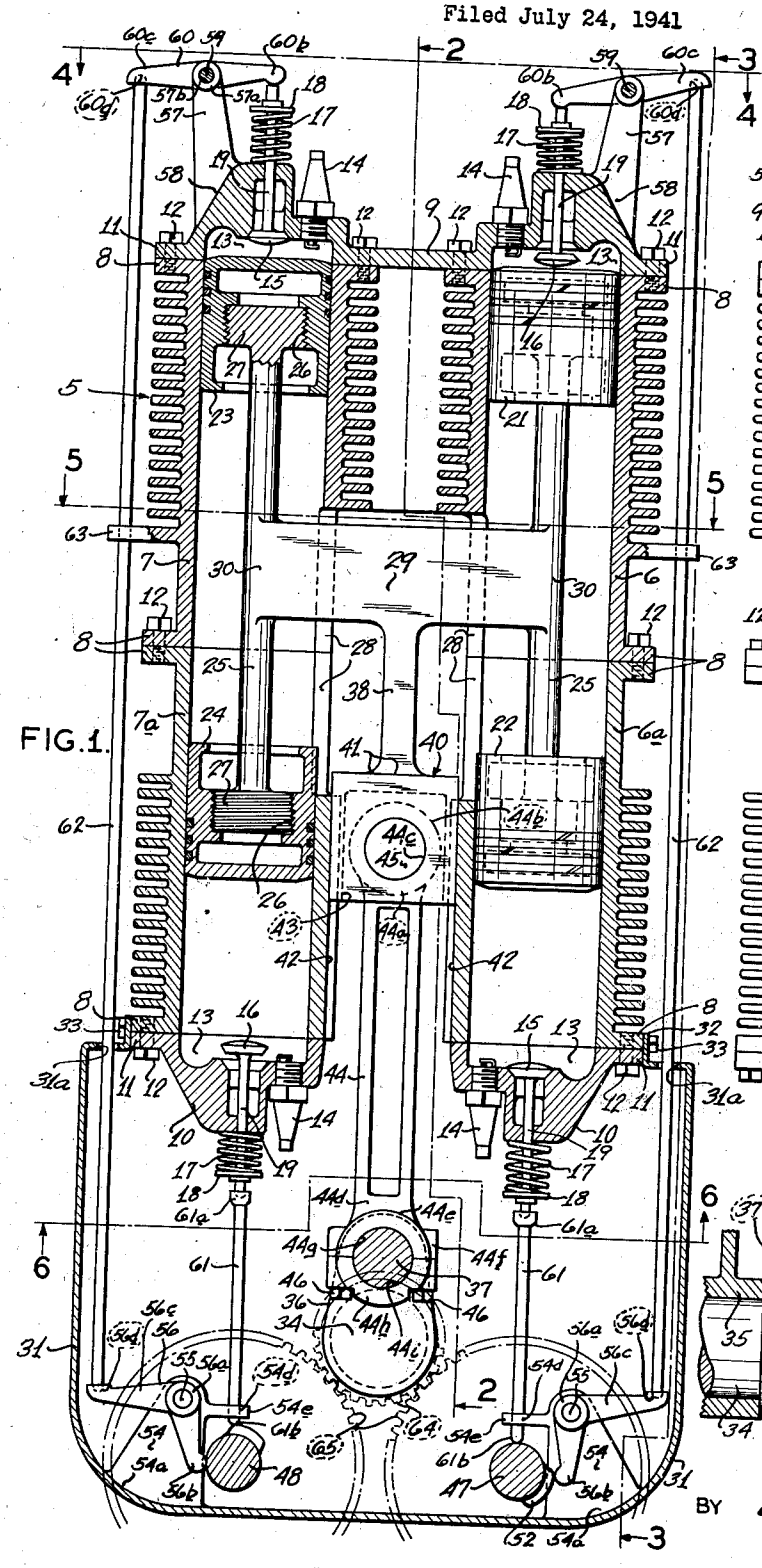

FIG. 1.

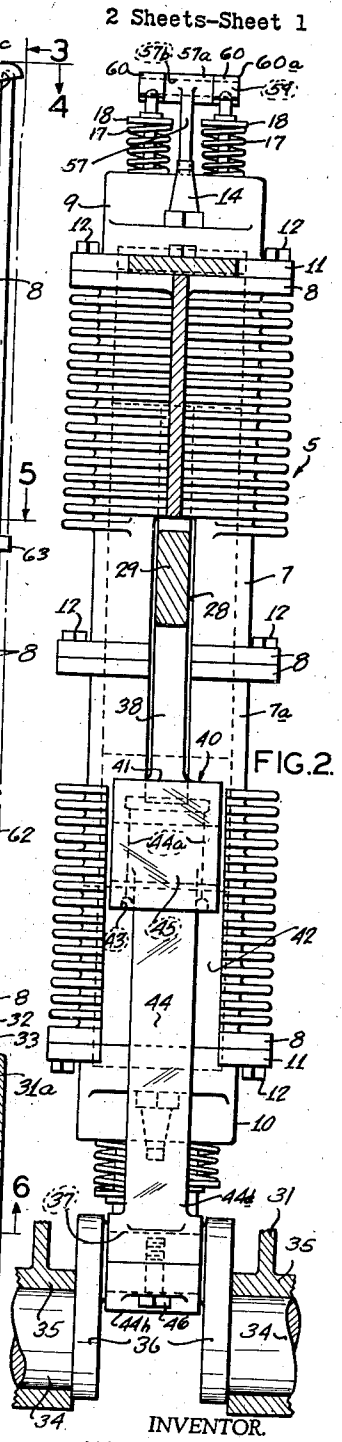

FIG. 2.

INVENTOR.
W. R. APPEMAN
BY
ATTORNEY

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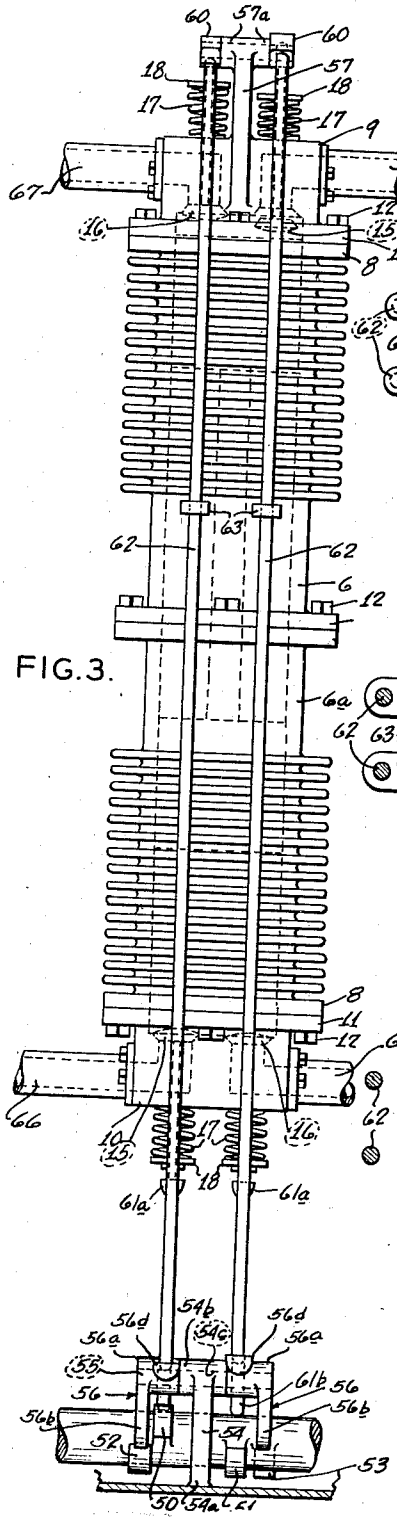

FIG. 3.

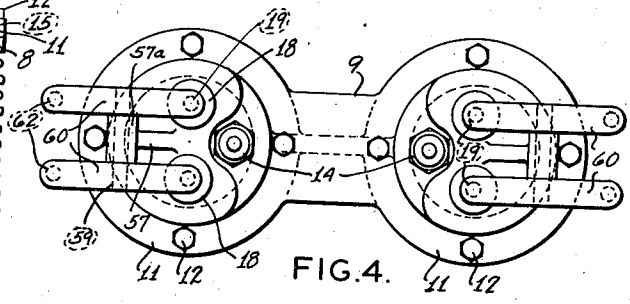

FIG. 4.

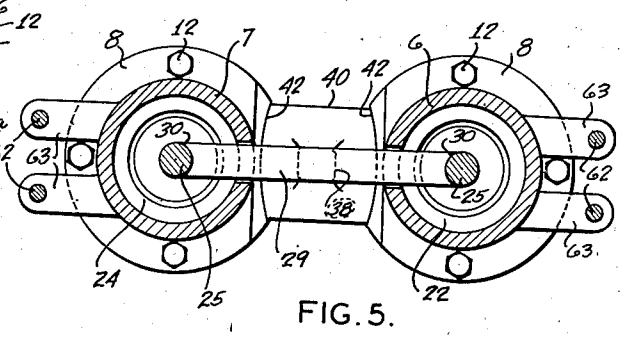

FIG. 5.

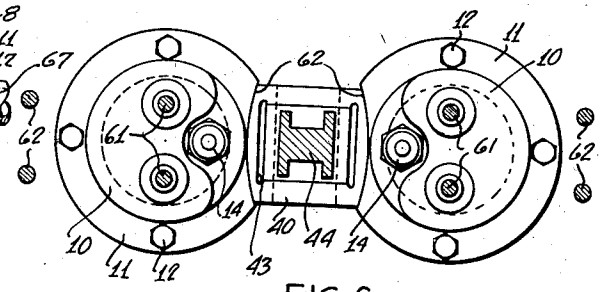

FIG. 6.

INVENTOR.
W. R. APPEMAN

BY

ATTORNEY

Patented Nov. 30, 1943

2,335,252

UNITED STATES PATENT OFFICE

2,335,252

INTERNAL COMBUSTION ENGINE

Walter R. Appeman, St. Louis, Mo.

Application July 24, 1941, Serial No. 403,858

7 Claims. (Cl. 123—63)

This invention relates to internal combustion engines, and the main object of the invention is to provide an engine of simple and efficient form, wherein a power impulse is imparted to the crank-shaft on each "throw" or half revolution thereof.

Another object of the invention is to provide an internal combustion engine, comprising a pair or pairs of elongate, closed cylinders mounted together in operative formation or alignment as a unit, as side by side, or one above another, or tandem, with pairs of pistons reciprocably mounted in the ends of each cylinder and rigidly connected by piston rods, means for rigidly connecting the rods, so that all the pistons will reciprocate as a unit, means for operatively connecting the piston unit to the crank pin of a crank shaft, means on the cylinders for reproducing in each the conventional charging, compressing, firing and exhausting phases of operation of a four-cycle motor, and means for so timing the said phases of operation that the similar operations in the ends of the cylinders shall follow one another in regular sequence, alternately between the cylinder ends, and so as to produce simultaneously a charging operation with one piston, a compressing operation with a second piston, a firing operation with a third piston and an exhausting operation with a fourth piston, whereby a power impulse is imparted to the crank shaft upon each half turn thereof.

Another object of the invention is to provide in an internal combustion engine, in a unitary form, a pair of elongate engine cylinders closed at their ends and arranged in parallel spaced relation, the same being slotted medially through their inner adjacent sides, in a plane passed axially through the cylinders, pairs of pistons rigidly mounted on the ends of piston rods and reciprocably seated in the ends of the cylinders, a piston carrier in the form of a flat link or yoke extended freely through the side slots of the two cylinders and rigidly anchored at its ends to the said piston rods to form a piston unit, a crank shaft, a connecting rod operatively connecting the piston rod carrier with the crank of the crank shaft, means for operating the four pistons each in accordance with conventional four-cycle engine practice, and means for timing the several phases of operation of the four pistons, so as to impart a power impulse to the crank-shaft on each reciprocation of the piston unit.

Still another object of the invention is to provide an internal combustion engine, a unitary multiple cylinder and piston assembly comprising a pair of elongate, closed cylinders mounted in cooperative relation, each cylinder carrying a pair of pistons reciprocably mounted in its ends and rigidly connected by a common piston rod, means for rigidly connecting the piston rods, and means for operatively linking the piston assembly to the crank pin of a crank-shaft.

With the foregoing and such other objects in view as may appear from the specification, a preferred embodiment of the invention is shown in the accompanying drawings, wherein:

Figure 1 is a longitudinal vertical section through a two cylinder engine unit constructed in accordance with this invention.

Figure 2 is a section on the line 2—2 of Figure 1.

Figure 3 is a plan view on the line 3—3 of Figure 1.

Figure 4 is an end view on the line 4—4 of Figure 1.

Figure 5 is a section on the line 5—5 of Figure 1.

Figure 6 is a section on the line 6—6 of Figure 1.

The drawings show a single unit of the invention, referred to generally at 5, and which comprises a pair of elongated, two-part cylinders 6—6*a*, 7—7*a*, of equal length and diameter, the parts being aligned axially end to end and flanged at their ends as at 8. The cylinders are positioned horizontally one over the other and in spaced, parallel relation. An integral rear end casting 9 closes the rear ends of the cylinders, and separate front end castings 10 close the front ends thereof, said castings being flanged at 11 to meet the flanges 8 of the cylinders. Bolts 12 passed freely through one flange and threaded into the other flange, as shown, firmly lock the parts together. The end castings 9, 10, are formed to provide combustion chambers 13 at the outer ends of the cylinders, and to receive the spark plugs 14, intake valves 15 and exhaust valves 16, which are operatively mounted in conventional manner, and are urged to their seats by the expansion springs 17 braced between the end castings and the stops 18 on the extended valve stems 19.

Four pistons 21, 22, 23, 24, are reciprocably mounted in the four ends of the cylinders 6—6*a*, 7—7*a*, the same being rigidly anchored on the ends of piston rods 25. As here shown this mounting is effected by forming the pistons with internally threaded sockets 26 within the inwardly turned skirts of the pistons, and forming complementally threaded heads 27 on the ends of the

rods 25, which are then screwed tightly into the sockets and locked against unturning or loosening by any conventional means.

The two cylinders 6—6a, 7—7a, are slotted longitudinally and medially of their end portions, through their inner adjacent sides, in a plane passed axially through the two cylinders and through the rods 25, as shown at 28, and a flat and substantially wide carrier link or yoke 29 is extended at either end transversely and slidably through these slots. By welding or other desirable method, the ends of the link 29 are firmly and rigidly anchored medially to the rods 25, as indicated at 30, in equi-spaced relation to the pistons at the ends of the rods. The slots 28 are sufficiently wide and the link 29 of corresponding thickness and of such width as to withstand the strains and stresses incident to its function of rigidly joining and supporting all four pistons as a floating and reciprocating unit or assembly. The lengths of the slots 28 conform of course to the required degree of movement or reciprocation of the pistons or of the piston unit as described.

The forward end of the unit 5 is inclosed in a a deep, rigid housing or casing 31, the inner side thereof being open and the margins defining this open side being drawn in and flanged as at 32, and thereby anchored in place by means of bolts 33 passed through the flanges and threaded into the ends of the cylinders.

A crank-shaft 34 is journaled transversely through the sides of the housing 31, in bearings 35 formed integrally with the housing. The shaft 34 is located forwardly of the end of the cylinders comprising the unit 5, and with its axis in a plane extended exactly mid-way between the cylinders 6—6a, 7—7a, and cutting perpendicularly through a plane passed through the axes of the cylinders. The shaft 34 is provided with a conventional form of crank 36 and crank-pin 37 adapted to turn nicely between the inner ends of the bearings 35. The carrier link 29 is formed integrally with a medial, forwardly extended drive arm 38, and a cross-head 40 is welded or otherwise anchored at 41 to the forward end of this arm and adapted on its upper and lower margins to reciprocate in parallel slideways or guides 42 formed or separately mounted longitudinally on the inner sides of the cylinders 6—6a, 7—7a, in alignment with the direction of movement of the link 29 as it reciprocates in the cylinder guide slots 28. The head 40 is formed with an oblong rectangular socket 43, opening forwardly. A connecting arm or bar 44 is flattened at one end 44a at its sides, and rounded marginally as at 44b, so as to fit freely and nicely into the socket 43. The said end is pierced transversely with a large circular eye 44c, and a heavy, rounded stud 45 passed freely through this eye and seated at its ends in the side walls of the socket, serves to pivotally link the arm 44 to the arm 38. The forward end 44d of the arm 44 is formed with a head 44e, rounded marginally as at 44f, flattened on its sides and having a transverse semi-circular socket 44g in its forward end adapted to receive and partially embrace the crank-pin 37. A complemental head-plate 44h, formed with a semi-circular socket 44i is positioned over the opposite side of the crank-pin 37 and secured to the half-head 44e by means of bolts 46 passed marginally through the opposite sides of the element 44h, and threadedly into the element 44e. The described elements of the driving assembly are of course so proportioned, that with the piston unit retracted to its rearmost position, the crank-pin will be similarly turned, and on a half turn of the shaft 34 the piston unit and crank-pin will be carried to their forward-most positions.

Upper and lower cam shafts 47, 48, are journaled, transversely through the sides of the housing 31 adjacent its outer closed end, in longitudinally spaced alignment with the ends of the valve stems 19 at that end of the assembly, each cam shaft carrying two pairs of cams, including an inner pair 50, 51, spaced apart and directly aligned with the stems 19 of the intake and exhaust valves 15, 16, respectively, at that end, and an outer pair 52, 53, for controlling similar valves at the rear end of the assembly, in manner to be explained.

Upper and lower T-shaped brackets 54 are anchored by their central stems, as indicated at 54a to the inner face of the end of the housing 31, outwardly of the cam shafts 47, 48, with the central stems extending inwardly in a plane cutting the cylinders axially and with the cross stems 54b extending perpendicularly to each side of said plane. The stems 54b are bored through from end to end, as at 54c, lever shafts 55 are extended through and fixedly seated in these bores. Bell crank rocker levers 56 are formed with bored hubs 56a, whereby they are mounted to oscillate freely on the extended ends of the shafts 55. These levers include outer arms 56b, the tips of which are adapted to ride upon the outer cams 52, 53 of the cam shafts 47, 48, and inwardly offset arms 56c extending angularly outward and ending in the socketed extremities 56d disposed slightly beyond, or above and below the outer lines of the cylinders 6—6a, 7—7a.

Similar T-shaped brackets 57 are anchored at 58, upon the rear end casting 9, above the extended axial line of the upper cylinder 6—6a, and below the axial line of the lower cylinder 7—7a, and in alignment in the common axial plane of the cylinders. The cross-stems 57a of these brackets are likewise extended perpendicularly at each side of said axial plane, and are bored through endwise as at 57b. Shafts 59 are tightly seated through the bores 57b, and rocker levers 60, formed with medially located, bored hubs 60a, are thereby oscillatably mounted on the extended ends of the shafts 59, with the inner tips 60b adapted to ride upon the ends of the valve stems 19 controlling the intake and exhaust valves 15, 16, and the outer tips 60c extended beyond, or above and below, the outer lines of the cylinders 6—6a, 7—7a, and formed with sockets 60d, positioned in direct longitudinal alignment with the socketed extremities 56d of the lever arms 56c located at the forward end of the assembly.

The four intake and exhaust valves 15, 16, are operated at the forward end of the assembly by means of pairs of short push rods 61, formed with sockets 61a at their inner ends for engaging the ends of the valve stems 19, said rods being slidably passed at their outer ends through guide apertures 54d pierced through fingers 54e extended from the brackets 54. The outer tips 61b of the rods 61 are thus positioned nicely in contact with the cam-shafts 47, 48, and in circumferential alignment with the cams 50, 51, which on rotation of the said cam-shafts push the rods 61 inward against the tension of the springs 17, thus alternately opening and closing the valves in accordance with conventional practice.

Similarly, pairs of long push-rods 62 are extended horizontally along the upper and lower

sides of the cylinders 6—6a, 7—7a, slidably through apertured guides 63 extended from the cylinders and through apertures 31a in the inturned inner margins of the housing 31, and are seated at their ends in the sockets 56d, 60d, of the rocker levers 56, 60, mounted as stated at the ends of the assembly. These rods are sized to nicely span the distances between the levers and to closely fit into the sockets when the lever tips 56b contact the cam-shafts 47, 48, and the valve springs 17 at the opposite ends of the assembly are expanded to their limit. Then, as the cam shafts rotate, the cams 52, 53, push the rods 62 rearwardly against the tension of the valve springs 17 at that end, thus operating alternately the intake and exhaust valves 15, 16, in accordance with conventional practice. Conventional intake and exhaust pipes 66, 67, are provided at each end of the engine, for serving the intake and exhaust valves 15, 16.

A timing gear 64 is rigidly keyed to the crank-shaft 34, outwardly of the housing 31, and is placed in mesh with a pair of larger timing gears 65 similarly keyed to the cam-shafts 47, 48, for operating the described pairs of cams controlling the opening and closing of the intake and exhaust valves 15, 16.

Inasmuch as there are four pairs of these valves, that is to say two pairs at each end of the engine, it follows that the crank-shaft must make two revolutions to one revolution of the cam-shafts, in the operation of the engine, to accomplish which the gears 65 must be twice the diameter of the gear 64.

The timing of the valves is such, through the setting of the valve control cams on the two cam shafts, that opposed phases of four-cycle engine operation occur simultaneously in the four ends of the two cylinders, thus imparting a power impulse to the crank shaft at each half turn thereof. Thus in practice it will be found that the four phases incident to the operation of a four cycle engine cylinder—charging, compression, firing and exhausting, will shift about and will alternate between the two ends of each cylinder and then again between the two cylinders themselves, so that any two successive phases of engine operation will occur simultaneously either in the ends of one cylinder or in opposed ends of the two cylinders considered as a unit. It follows that as a firing phase occurs at one end of the engine, a compression phase is taking place at the opposite end, which receives and cushions the piston thrust of the explosion, thus effecting a smooth, resilient and floating engine action analogous to the action of a steam engine.

Other advantages of this engine structure are relatively great power combined with compactness of form, simplicity and lightness. The two-part structure of the cylinders facilitates manufacture, assembly and repair, although the cylinders may of course be formed integrally if desired. The unitary reciprocating assembly, including the carrier, carrier arm and head, the two parallel piston rods and rod heads, can be made as an integral casting of aluminum alloy or other suitable material, machined to size, and the piston rods bored through axially to lighten them, and their heads threaded and then screwed into their respective pistons and locked, preparatory to inserting this assembly into the separated cylinders through the slots, after which the cylinder parts are bolted together end to end, at their flanged ends, as already stated. The carrier may also be bored through at spaced intervals, if desired, in order to lighten it. Since the two pistons of each cylinder support their rods in straight-away axial, reciprocating movement, and laterally oscillating pitmans or connecting rods inside the cylinders to necessitate long piston skirts are eliminated, these skirts may be substantially shortened (though not here so shown) to lighten the mass of the piston unit. The piston rods themselves may be tubular for the same purpose. Also in this engine there is only one connecting rod to the crank shaft, as against four in the ordinary four-cylinder engine. The engine comprises two cylinders with four pistons working therein and integrally joined to form a floating reciprocating unit, without internal wrist pins or bearings, and with a common exteriorly mounted connecting rod or arm running to and operating the crank-shaft.

Any required number of these engine units may be assembled side by side and connected to a common drive shaft.

While specific forms of valve operating and timing mechanisms are here shown, any other desirable mechanisms or devices for the purpose may be substituted, and the cylinder and piston assembly shown may also be readily adapted for use with the Diesel type of engine or the like, and while I have here shown and described a certain embodiment of the invention as a whole, and specific structural features thereof, the same may be changed or modified within the scope of the claims.

I claim:

1. In an integral combustion engine embodying a pair of elongate cylinders in parallel relation and pistons in the four cylinder ends connected to reciprocate as a unit for rotating a crank shaft extended medially, transversely and forwardly at one end of the cylinder assembly and operatively connected with the unitary piston assembly,—means for reproducing in sequence in the four cylinder ends the several phases of operation of a four-cycle internal combustion engine, said means comprising spaced intake and exhaust valves in each of the four ends of the cylinder assembly, the said valves having outwardly extended stems and being spring-set to close, a pair of cam-shafts journaled outwardly at either side of the crank shaft and parallel therewith, cams positioned inwardly on the cam-shafts aligned with and adapted to operate the intake and exhaust valves at this forward end of the two-cylinder unit, push rods slidably connecting said cams with the stems of the intake and exhaust valves at this forward end, cams positioned outwardly on the cam shafts for operating the intake and exhaust valves at the rear end of the cylinder unit, lever shafts mounted transversely on the ends of the cylinders, those at the forward end being adjacent the cam-shafts and all parallel thereto, rocker levers journaled on the lever shafts, those at the rear end having arms directed inwardly over and in free contact with the stems of the intake and exhaust valves at that end, with also arms extended outwardly beyond the cylinder walls, the rocker levers at the forward end having arms riding upon the cams of the cam-shafts for control of the intake and exhaust valves at the rear of the unit, with also arms extending outwardly beyond the cylinder walls and in alignment with the outwardly extended arms of the rear rocker levers, long push rods slidably connecting said outwardly extended arms, and means for synchronizing and regulating the speed of rotation

of the cam shafts relative to the crank shaft to effectuate the required sequence of phases of operation in the cylinder ends.

2. In an engine according to claim 1, means for operating the several pistons and valves each in accord with conventional four-cycle engine practice by fuel explosions in sequence in the cylinder ends and alternately between the cylinders, exhausting the spent gases and drawing in and compressing fresh fuel charges.

3. In an engine according to claim 1, means synchronized with the speed of the crank shaft for successively injecting through the intake valves fuel charges into the cylinder ends, compressing and exploding the fuel charges and then exhausting the spent gases through the exhaust valves in accordance with four cycle engine practice.

4. In an engine according to claim 1, spark plugs operatively mounted in the cylinder ends for exploding fuel charges therein, and means for timing the operation of the spark plugs to successively explode the charges in accordance with four cycle engine practice.

5. In an engine according to claim 1, means operable by the crank shaft for timing the intake, compression, explosion and exhausting of fuel charges in the cylinder ends in sequence.

6. In an internal combustion engine, a pair of elongated, two-part cylinders anchored together side by side in spaced and parallel relation, the parts of each cylinder being of equal diameter, aligned axially end to end and communicating through their inner abutted ends, means for securing the cylinder parts together in said end to end relation, the said cylinders being slotted medially through their adjacent sides in their common axial plane for slidably receiving a piston carrier extended transversely through the cylinder slots for rigidly joining piston rods at their inner ends within the cylinders, whereby the piston rods and attached pistons at the ends of the rods may reciprocate within the cylinders as a unit, and the cylinder parts may be assembled or disassembled for facilitating their realignment and the insertion, removal and repair of the piston rods and pistons.

7. In an assembly according to claim 6, the means for securing together the cylinder parts comprising flanges outwardly extended around the inner abutting ends of the cylinder parts, and means utilizing the said flanges for releasably anchoring the cylinder parts together.

WALTER R. APPEMAN.