This invention relates to improvements in internal combustion engines of the type having two or more banks of cylinders of 4 or 6 cylinders per bank. The general object is to provide an efficient and compact engine specifically adapted to automotive use. The chief object is to provide a short and narrow 8 or 12 cylinder engine of the variable compression ratio type. For convenience the invention will be described as an 8 cylinder engine having two banks of 4 cylinders in each bank.

In the field of automobiles for personal use the increasing use of the automatic transmission has made it very desirable, in order to simplify the automatic transmission, to obtain more power for acceleration, to increase the torque of the engine. If the engine has sufficiently high torque, automatic gear changing in the transmission can be eliminated and the hydraulic torque converter can be of very simple and inexpensive construction.

Increased engine torque is most easily provided by increasing the size or displacement of the engine. The use of larger engines, however, would normally lower the fuel mileage of the automobile because of the increasingly poorer engine efficiency as the percentage load is increased. In order to avoid any appreciable lowering of fuel mileage with increasing engine size much effort has been directed toward otherwise improving the efficiency of the engine. For example, fuel economy has been improved through the use of higher compression ratios and through the reduction of engine friction by the use of lower stroke-to-bore ratios.

The use of higher compression ratios has made it necessary to use overhead valves in order to obtain a small combustion chamber. This construction, when applied to the V-8 type of engine, has greatly increased the width of the engine. This increase in engine size combined with that from increasing the engine displacement has made the engine too large to conveniently fit into the automobile chassis. An object of this invention is to provide a new combination or arrangement whereby the advantages of the present engine are made available in a very compact form readily adapted to the space provided.

Engine compactness is obtained in the present invention by placing the cylinder banks parallel and adjacent to each other instead of in a V arrangement. With the conventional crank and connecting rod mechanism the use of parallel cylinder banks is not practical because of the resulting uneven firing intervals. This invention provides a lever mechanism which produces even firing intervals and at the same time makes it possible to conveniently vary the engine compression ratio.

It has long been known that very substantial improvements in part-load efficiency can be made by increasing the compression ratio as the engine is throttled. Many attempts at making practical variable compression ratio engines have been made. Generally, the devices increased the size of the engine and greatly added to its complexity. The resulting advantages were not sufficient to warrant its use. The present invention provides a unique engine combination involving a simple variable compression ratio mechanism in an engine of extreme compactness.

A further object of the invention is to provide an engine having substantially harmonic motion of the pistons. This feature provides a reduction of unbalanced forces and lower bearing loads.

Another object of the invention is to provide a single compact cylinder head block which covers both cylinder banks. This cylinder head block incorporates a unique arrangement of intake manifolding which avoids the necessity for a separate intake manifold.

These and other advantages of the invention will become apparent from the drawings in which:

Figure 1 is a cross-section through one form of the invention.

Figure 2 is a schematic diagram of the lever and eccentric shaft mechanism of Figure 1.

Figure 3 is a schematic diagram of the linkage mechanism showing preferred proportions.

Figure 4 is a schematic diagram showing a bottom view of the cylinder head in which the manifolding is illustrated.

Referring now to Figures 1 and 2 of the drawings, the crankshaft 2 is journalled in the engine frame 3 in which are located cylinders 4, pistons 5, camshaft 6, follower 7 and fulcnum shafts 8. The connecting rods 9 connect the crank pin 10 with the levers 11 by means of pins 12. Lever 11 is mounted for oscillation on the eccentric journal 13 of the fulcnum shaft 8 as shown in Figure 2. Pistons 5 are connected with levers 11 by means of links 14, piston pins 15 and link pins 16. The fulcnum shafts 8 are actuated by any convenient means. For simplicity of description I have shown means for adjustably positioning fulcnum shaft 8 in various angular positions by means of arm 17 which is attached to shaft 8 and which is adjustably fastened to quadrant 18 by means of bolt 19.

Figure 3 shows a diagram of the lever and link mechanism of the invention in which the proportions of the parts constitute a preferred arrangement within plus or minus 10 percent of the individual dimensions. In this diagram the chief dimensions that determine the kinematics of the mechanism are presented in terms of the crank radius R. These proportions are particularly important if the motion of the piston is to be substantially harmonic and if substantially equal intervals between power strokes are to be obtained in a 2-bank 8 cylinder engine having 4 crank throws. Harmonic piston motion is defined here as that motion in which the piston travels approximately one-half of its stroke in 90 degrees of crank motion. Approximate harmonic motion is obtained in this design by a unique variation of the effective lever arm A of lever 11, Figure 3, with respect to the axis of connecting rod 9 and the variation of the effective lever arm B of lever 11 with respect to the axis of link 14. These effective lever arms A and B vary cyclically in such a manner as to approximately cancel the normal deviations from harmonic piston motion produced by the crank 2 and connecting rod 9.

In a 4-stroke engine cycle one complete engine cycle requires 720 degrees of crankshaft rotation. In order to obtain evenly spaced power strokes (even firing intervals) in such an engine it is thus necessary to divide 720 degrees by the number of cylinders in the engine to obtain the crank angle between power strokes. For example, the crank angle between power strokes for pistons connected to the same crank pin must be 720 divided by 8 for an 8 cylinder engine or must be 720 divided by 12 for a 12 cylinder engine.
The design shown in Figure 3 is for an 8 cylinder engine with 4 crank throws in which the crank angle between top-center piston positions of pistons connected to the same crankpin must be 360 divided by 8 or 90 degrees in order to obtain even firing intervals. By duplicating the mechanism shown in Figure 3, except for the crankshaft, in opposite hand as shown in Figure 1, the one piston reaches top center position 90 crankshaft degrees after the other piston. In this case angle C of Figure 3 must be substantially 45 degrees. For a two-bank, 12 cylinder engine having 6 crank throws angle C must be 30 degrees.

From the drawings it will be observed that unique compactness of the engine is obtained by placing the cylinder banks adjacent and parallel. Furthermore, the engine height has been reduced by bringing the cylinders close to the crankshaft. This has been made possible by the use of the lever 11 placed below the crankshaft. The design makes it convenient to locate the camshaft close to the crankshaft without having to resort to long push rods for operating the valve gear.

A further object of the invention is to reduce piston friction by reducing the side thrust caused by angularity of the link rods attached to the pistons. In the design of Figure 3, the angularity of the link 14 is less than one-third of that had the link been attached directly to a crank in a conventional manner.

The use of the lever system as shown in this invention also permits a longer piston stroke than twice the crank throw. This enables the use of a short radius crank which permits overlapping of the crank pin and the crankshaft journals with consequent increase in crankshaft strength.

The unique placement of cylinder banks permits a unique cylinder head and manifold construction as shown in Figure 1 in which 20 is the cylinder head block which covers both cylinder banks 21 and 22. In the cylinder head block 20 are mounted valves 23, guides 24, valve springs 25, valve rockers 26, rocker pivot 27, rocker shaft supports 28, push rods 29 and valve covers 30.

The ducts to the valves in the cylinder head 20 are diagrammatically illustrated in Figures 1 and 4 in which the ducting 31 for one set of valves, either inlet or exhaust, is manifolded together in the cylinder head between the manifold branches. In Figure 4 the 30, 33, 34 and 35 are brought into a common duct 36. The two ducts 36 are then brought either to separate carburetors or to a common duct or connection 37. The ducting for the other set of valves is also shown in Figure 4 in which 38 and 39 are branches leading to the connecting flange opening 40.

The center manifold 31 illustrated in Figure 4 is well-suited for induction manifolding because of the equal length, short branches provided. The dual manifolds 38 and 39 are suited for engine exhaust because of the small amount of water-jacketed port area.

The cylinder head, as described in the foregoing, combines a large part of the required induction and exhaust manifolding within the cylinder head. This construction contributes to compactness and low cost. The arrangement is made possible by the unique combination of crank and lever mechanisms together with the parallel, and adjacent arrangement of cylinder banks.

It will be observed from Figures 1 and 3 that the main objective of this invention, that of achieving a very compact engine having two banks of cylinders, is achieved by providing a power transmitting mechanism between the crankpin and the piston that is capable of transmitting piston motion along a line parallel to a main center line passing through the axis of the crankshaft into motion of the crankpin such that the crankpin is substantially on a line passing through the crankshaft axis and which is C degrees from the main center line at top center piston position. As previously explained, C degrees is the angle equal to 360 divided by the number of cylinders in the engine.

While I have shown a preferred mechanism that is adapted to achieving variable compression ratio and harmonic piston motion it is to be understood that other intermediate mechanisms may be used between the piston and crankpin for achieving the main objective of this invention.

Having thus described my invention, I claim:

1. In a mechanism for reciprocating a piston, a frame, a cylinder mounted on said frame, a piston reciprocable in said cylinder, a crank journaled on said frame, an eccentric journaled on said frame, a lever having one extremity journaled on said eccentric, a link connecting the other extremity of said lever with said piston, and a crank rod connecting said crank with an intermediate point on said lever, the axis of said eccentric being located at one side of the axis of said crank, and the axis of said cylinder lying between the axis of said eccentric and the axis of said crank, the axis of said crank being located between said cylinder and a line drawn through said eccentric normal to the axis of said cylinder.

2. In a mechanism for reciprocating pistons, a frame, a crank journaled in said frame, cylinders on said frame adjacent to said crank, pistons reciprocable in said cylinders, a combination comprising fulcrums mounted on said frame, levers pivoted at one extremity on said fulcrums, links connecting said levers and said pistons, crank rods connecting said crank and said levers, said cylinders being mounted a distance substantially equal to 2.56 times the crank radius from said main center line, said fulcrums being mounted a distance substantially equal to 5 times the crank radius from said main center line and substantially 1.72 times the crank radius from said second center line in a direction away from said cylinders, the length of said lever from said fulcrum to the point of attachment of said crank rod being an amount substantially equal to 2.4 times the crank radius, and the length of said lever from said fulcrum to the point of attachment of said link being an amount substantially equal to 3.28 times the crank radius.

3. In an internal combustion engine, a frame, a crankshaft journaled in said frame, a cylinder on said frame on each side of said crankshaft, pistons reciprocable in said cylinders, eccentrics mounted for rotation on said frame, levers pivoted on said eccentrics, piston rods connecting said pistons and said levers, crank rods connecting said levers and said crankshaft, said cylinders being located an equal distance on each side of a center line which intersects the axis of said crankshaft, the location of said crankshaft, said levers and said cylinders being such that the angle between a first crank rod and said center line is substantially 45 degrees when a piston actuated by said first crank rod is in a position nearest to said crankshaft.

4. In a mechanism for reciprocating a piston, a frame, a cylinder mounted on said frame, a piston reciprocable in said cylinder, a crank journaled in said frame, a lever pivoted at one extremity to said frame, a crank rod connecting said lever and said crank, a piston rod connecting said piston and said lever, said lever having an effective lever arm defined as the shortest distance between the extended axis of said crank rod and the lever pivot on said frame, said crank having one phase of movement designated as an outer semi-circle of crank travel in which said crank moves in that semi-circle farthest away from said lever and an inner semi-circle of crank travel in which said crank moves in that semi-circle of crank travel nearest said lever, said crank be-
ing so positioned as to make the length of said effective lever arm of said lever to which said crank rod is attached shorter during said outer semi-circle of crank travel than during said inner semi-circle of crank travel to provide substantially as much piston movement during said outer semi-circle of crank travel as during said inner semi-circle of crank travel.

5. In an internal combustion engine, a frame, a cylinder mounted on said frame, a piston reciprocable in said cylinder, a crank journal in said frame, an eccentric journal in said frame, a lever pivoted at one extremity to said eccentric, a crank rod pivotally connecting said lever and said crank, a piston rod connecting said piston and said lever, said lever having an effective lever arm defined as the length of the normal between the axis of said crank rod and the center of said eccentric, said crank having one phase of movement designated as an outer semi-circle of crank travel in which said crank moves in that semi-circle farthest away from the pivot on said lever to which said crank rod is attached and an inner circle of crank travel in which said crank moves in that semi-circle of crank travel nearest said pivot point on said lever to which said crank rod is attached, said crank being so positioned relative to said lever as to make the length of said effective lever arm of said lever to which said crank rod is pivoted shorter during said outer semi-circle of crank travel than during said inner semi-circle of crank travel to provide substantially as much piston movement during said outer semi-circle of crank travel as during said inner semi-circle of crank travel, said eccentric being adjustable in angular position for varying the compression ratio of said engine.

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