

Oct. 25, 1960

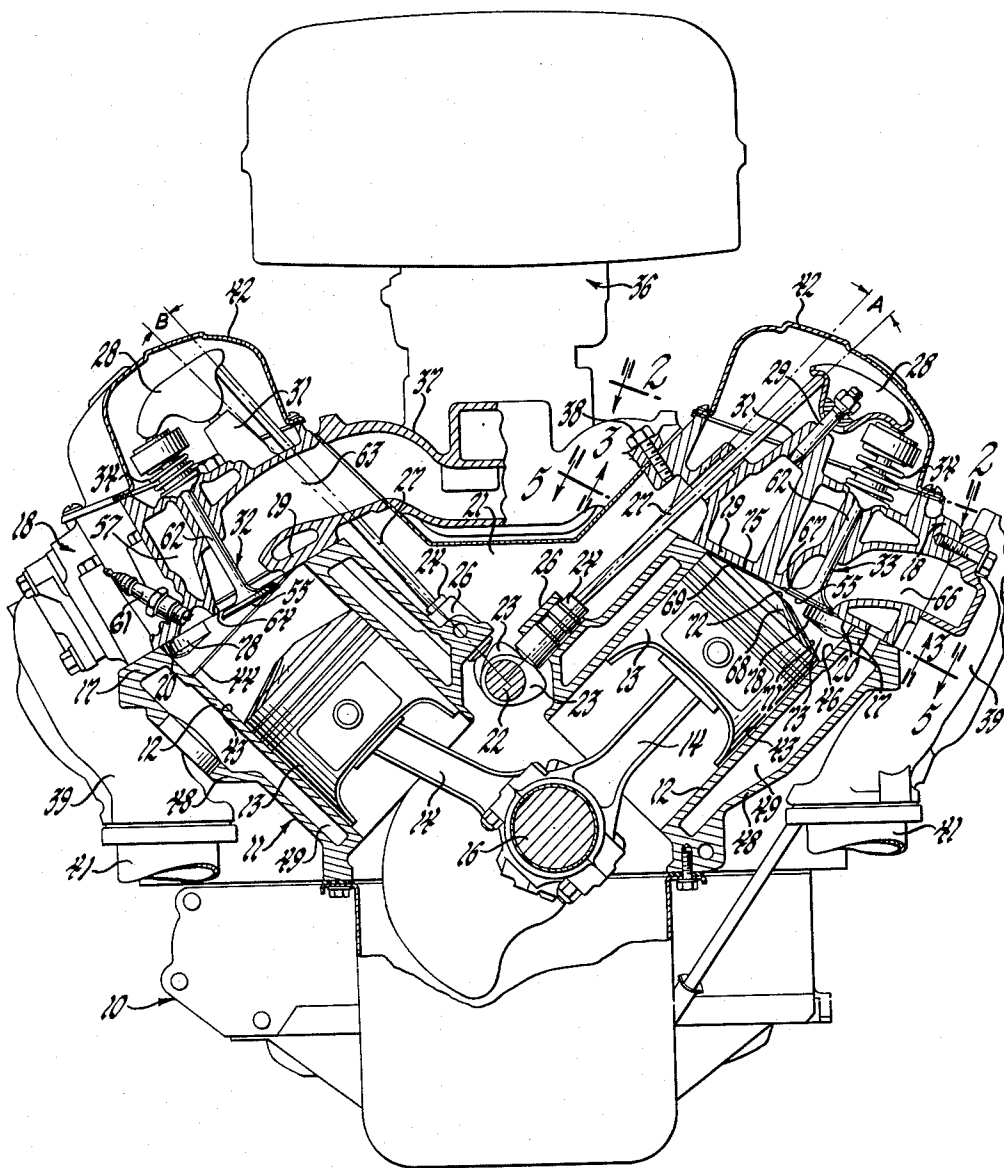
A. E. KOLBE

2,957,460

INTERNAL COMBUSTION ENGINE

Filed Sept. 27, 1957

4 Sheets-Sheet 1



Exp. 2

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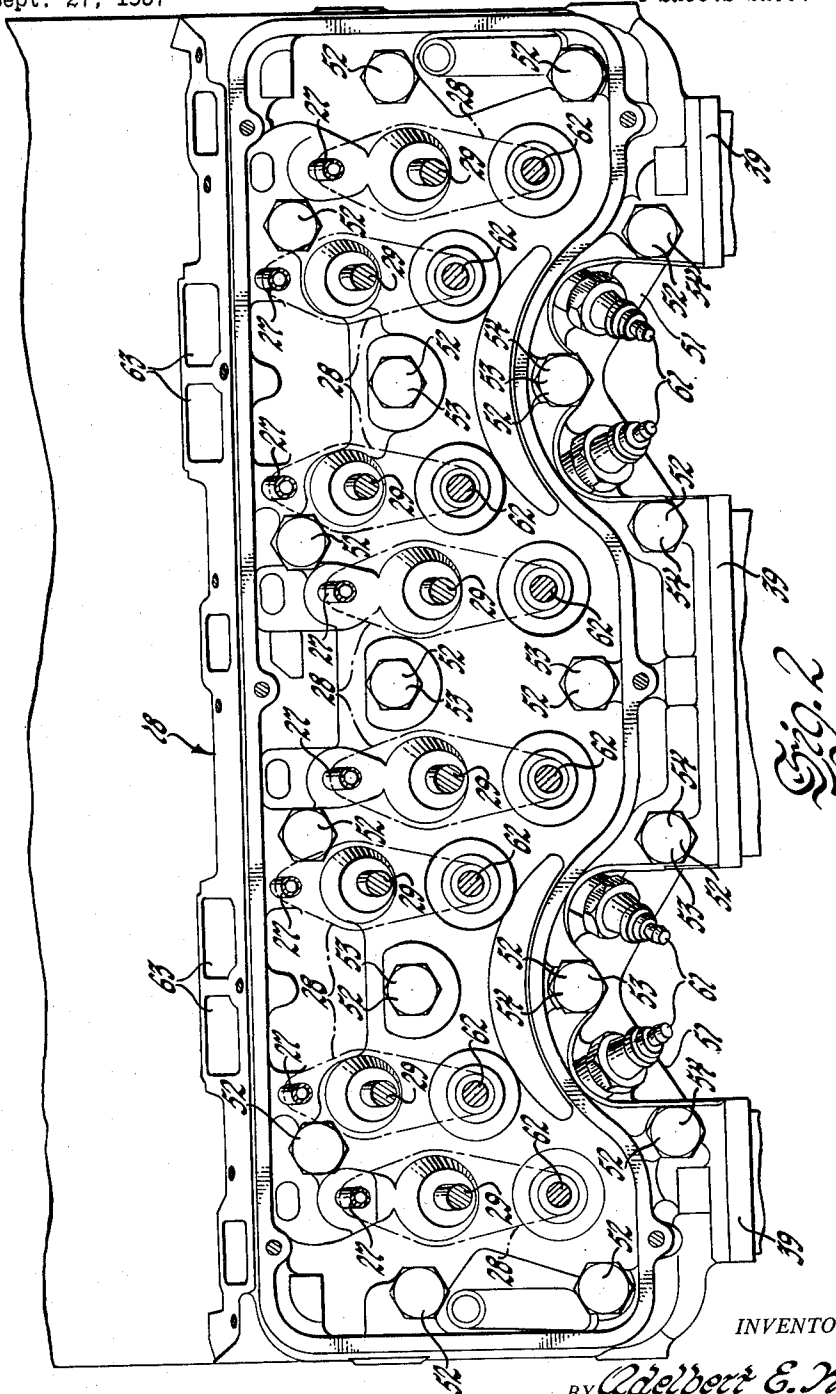
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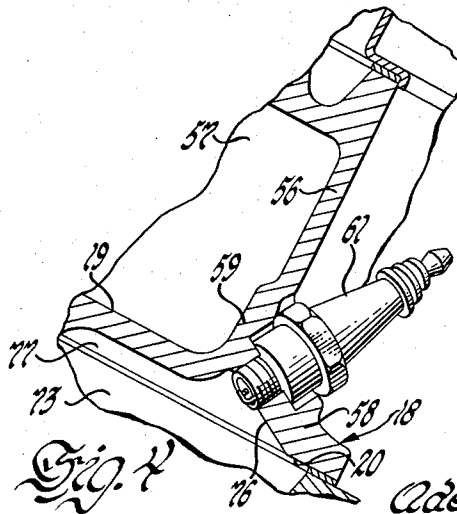
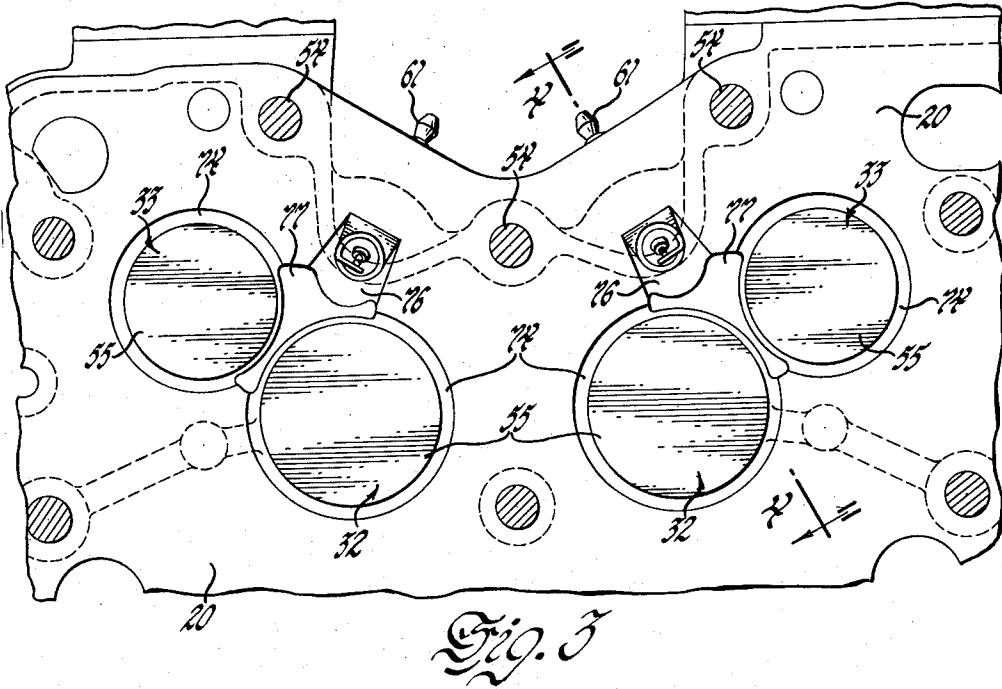
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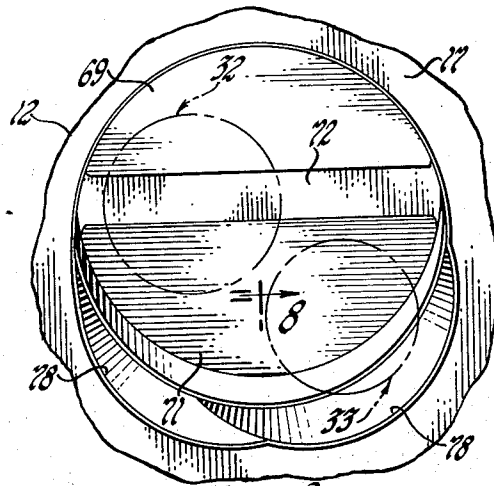
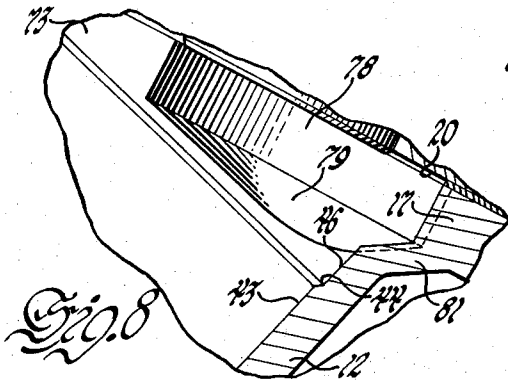
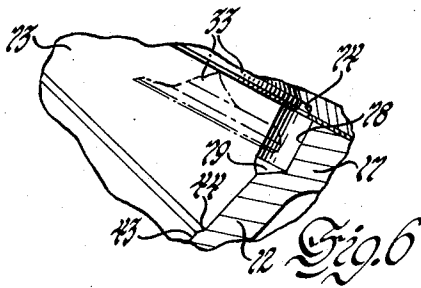
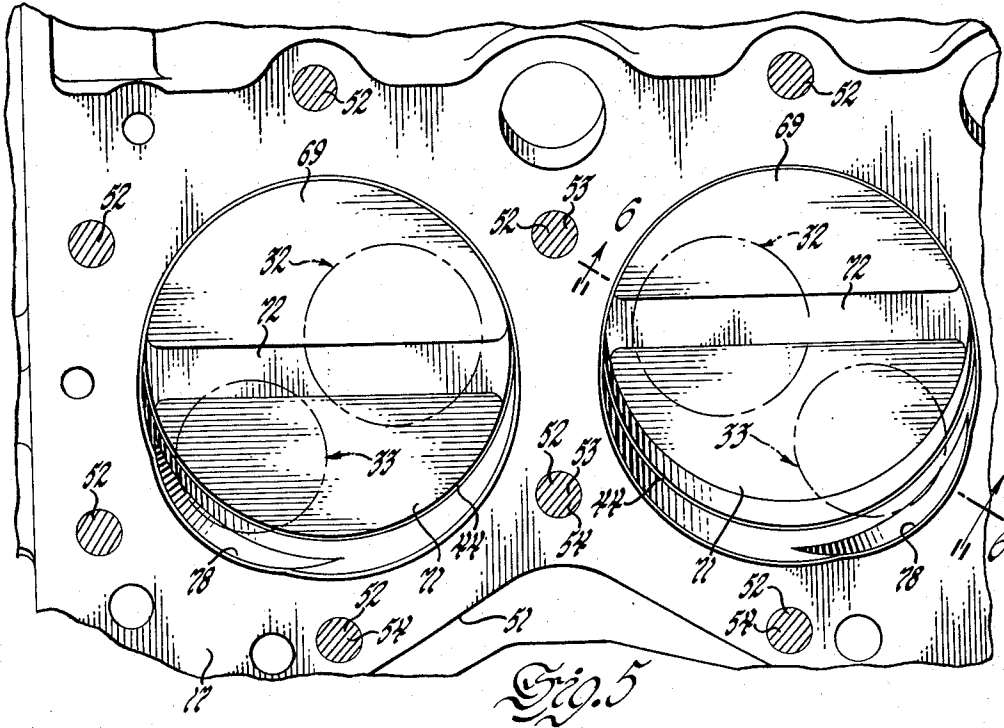


Fig. 7 = 18
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2,957,460

INTERNAL COMBUSTION ENGINE

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Filed Sept. 27, 1957, Ser. No. 686,654

9 Claims. (Cl. 123—55)

This invention relates to internal combustion engines for automotive and other purposes and has particular relation to internal combustion engines suitable for manufacture in large quantities, in a large number of different sizes and by substantially the same facilities.

Until recently it has been possible to manufacture engines for use in passenger cars and in light trucks in a small number of different sizes. Where production has been high enough it has been the practice perhaps to have one or more assembly lines for each size engine and a plant for each size engine. In many instances it has been the practice to manufacture engines of different designs to prove the different sizes of engines required. Now it has become necessary to manufacture engines having a large number of different displacements, with a number of different compression ratios for the engines of each displacement, thereby dividing the total number of engines manufactured into a much greater number of sizes and a lesser number of units of each size. In designing the present engine an important objective has been to provide an economical and efficient engine suitable for high production operations, which can be manufactured in a large number of sizes and compression ratios from substantially identical parts and by the use of manufacturing facilities that vary only in minor detail and that can be employed in manufacturing all of such engines on the same production lines.

In the drawings:

Figure 1 is a transverse sectional view of an internal combustion engine embracing the principles of the invention.

Figure 2 is a fragmentary plan view of the engine illustrated by Figure 1 and particularly showing the head of the engine on one side of the engine and as the latter might appear with the rocker arm cover removed and in the plane of line 2—2 on Figure 1 looking in the direction of the arrows thereon.

Figure 3 is a fragmentary view of the lower surface of the engine head shown by Figure 2. Figure 3 is taken substantially in the plane of line 3—3 on Figure 1 looking in the direction of the arrows thereon.

Figure 4 is a fragmentary view through the spark plug and combustion chamber of one of the cylinders of the engine. Figure 4 is taken substantially in the plane of line 4—4 on Figure 3 looking in the direction of the arrows thereon.

Figure 5 is a fragmentary view illustrating the outer ends of a pair of the cylinders of the engine disclosed by the preceding figures. Figure 5 is taken in the plane of line 5—5 on Figure 1 looking in the direction of the arrows thereon.

Figure 6 is a fragmentary cross sectional view through one of the cylinders of the engine and taken substantially in the plane of line 6—6 on Figure 5 looking in the direction of the arrows thereon.

Figure 7 is a fragmentary view illustrating a cylinder of an engine and embodying a modified form of combustion chamber.

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Figure 8 is a fragmentary view of the cylinder illustrated by Figure 7 as the latter might appear in the plane of line 8—8 on Figure 7.

The engine 10 embodying the invention includes an engine block 11 having rows of cylinders 12 formed therein at approximately 90°. The cylinders 12 have pistons 13 mounted for reciprocation therein and connected by connecting rods 14 to a crankshaft 16 mounted in bearings formed in the block 11. The cylinders 12 have outer ends terminating in end walls 17 disposed obliquely to the axes of the cylinders 12 and including diameters of the cylinders in each row of cylinders of the engine that extend longitudinally of the engine in planes of the axes of the cylinders in the different rows of cylinders. The outer ends of the cylinders 12 are closed by heads 18 having obliquely disposed inner walls 19 engaging the end walls 17 in which the ends of the cylinders 12 terminate. The block 11 is formed to provide a camshaft gallery 21 in which a camshaft 22 operatively associated with the crankshaft 16 is located. The camshaft 22 has cams 23 which are adapted to drive valve lifters 24 which are mounted for reciprocating movement in rows of bosses indicated at 26. The valve lifters operatively engage push rods 27 which actuate the engine valves through rocker arms 28 which are individually mounted on studs 29 secured in bosses 31 projecting upwardly from the engine head 18. The opposite ends of the rocker arms 28 engage the stems of the engine valves. The inlet valves are indicated at 32, the exhaust valves at 33, the valves being normally held in closed position in the heads 18 by valve springs 34. The engine 10 has any suitable charge forming device 36 for supplying the cylinders with charges of combustible mixture. In the present instance the charge forming device includes an inlet manifold 37 which is rigidly secured by bolts 38 to the sides of the engine heads 18 and to the ends of the engine block 11. The exhaust gas from the engine is discharged to the atmosphere through exhaust manifolds 39 and exhaust pipes 41. The valve mechanism for each row of cylinders may be enclosed in part by rocker arm covers indicated at 42.

The cylinders 12 of the engine have inner cylindrical surfaces 43 which terminate in chamfers 44 formed in the cylinder walls in normal relation to the axes of the cylinders 12. Beyond the chamfers 44 the wall surfaces 46 also are of cylindrical formation but are of larger diameter than the diameter of the wall surfaces 43. The pistons 13 also have outer cylindrical surfaces, operatively associated with and bearing against the cylindrical surfaces 43 of the cylinders 12 and which, when the pistons are in outer dead center position in the cylinders, terminate in end extremities normal to the axes of the pistons and in directly opposed relation to the edges of chamfers 44.

The obliquely disposed inner walls 19 of the heads 18 which close the outer ends of the cylinders 12 have generally plane inner wall surfaces 20 extending across the ends of all of the cylinders 12 and the wall 17 in which the cylinders 12 terminate. It will be apparent that the fact that the walls 19 are obliquely disposed with respect to the cylinders 12 will provide a greater area in which to locate the valves 32 and 33 than would be the case were the walls 19 normal to the axes of the cylinders. Since the walls are oblique with respect to the cylinders, the walls 19 close elliptical areas at the ends of the cylinders with the major axes of these areas extending transversely to the engine and intersect diameters of the cylinders at the adjacent sides of the cylinders and at the edges of the chamfers 44 where the inner cylindrical surfaces 43 of the cylinders 12 terminate.

It is proposed to locate the inlet and exhaust valves of each cylinder on opposite sides of the aforesaid major

axes of the cylinder closing areas of the surfaces of the inner walls 19 and on opposite sides of transverse planes through the axes of the cylinders and including such major axes of such elliptical areas. It is also proposed to locate the inlet valve of each cylinder on the short side of each cylinder, this being the inside of each cylinder in the rows of cylinders of the engine and generally speaking on the inside of a plane extending longitudinally of the engine and through the axes of the cylinders in each row of cylinders. The exhaust valve is located on the opposite side of such longitudinally extending plane and on the side of the major axis of each cylinder opposite the inlet valve of each cylinder. It is then proposed to locate the inlet and exhaust valves of each cylinder obliquely and in opposite relation in each pair of adjacent cylinders. For example, in Figures 2 and 5 it will be noted that in the first two cylinders in the row of cylinders illustrated the inlet valves are on the inside and short sides of the cylinders and are adjacent one another, the exhaust valves being on the outside or long sides of the cylinders and remote from one another. The valves of all of the cylinders of the engine are arranged in pairs in this manner so that there will be two pairs of cylinders in each row of cylinders with the inlet valves adjacently disposed and two pairs of cylinders with the exhaust valves remotely disposed.

On the outside of each pair of cylinders it is proposed to depress the outer side walls 48 of the block 11 inwardly of the cooling cavity space 49 around the cylinders 12 to provide depressions 51 between each pair of cylinders. The depressions extend between the cylinders and in parallel relation to the axes of the cylinders. Such depressions do not limit the effective cooling of the cylinders because the depressions will allow sufficient cooling liquid to circulate around the cylinders to cool the cylinders but they will cut down the amount of cooling liquid in the cooling liquid cavities in the block so that a smaller amount of liquid can be circulated more rapidly and more effectively. The heads 18 are also depressed inwardly to provide the depressions 51 as will be seen from Figure 2 of the drawing. Also in the heads of the engine it will be noted from Figures 2 and 5 that six head bolts indicated at 52 are employed in a circle around each cylinder, two of the six bolts for each cylinder being common to adjacent cylinders and being further indicated by the reference numerals 53. Also on the sides of the cylinders adjacent the depressions 51, three of the bolts are further indicated by the numeral 54 and form clusters of bolts with one bolt being common to each pair of cylinders. In order to improve the cooling of the heads and the cylinders, it is proposed to make the walls of the head thicker where the bolts 54 extend through the heads and in the areas between the bolts 54. This is done by merging at 58 the inner walls 19 of the head with the outer walls 56 which form the cooling liquid cavity spaces 57 in the heads. With this construction it will be apparent that there will be no cooling liquid cavity spaces within the heads in the areas where the bolts 54 extend through the heads and in the areas between the bolts 54. The wall sections 58 in these areas will be thicker than the walls 19 and 56 as will be apparent from examining Figure 4. The elongated edges of the wall sections 58 will be subjected to wide and normally disposed heat exchanging surfaces indicated at 59 where the cooling liquid in the cavities 57 will be available to conduct heat away from the edges of the wall sections 58.

It is proposed to extend the spark plugs 61 through the wall sections 58 in locations between the pairs of bolts 54 and in the spaces between and on the outside of each pair of obliquely and oppositely disposed valves 32 and 33 with which the cylinders 12 are provided.

The valves 32 and 33 being located on the inside and outside of each row of cylinders of the engine also form two rows of valves in each row of cylinders of the engine. It will be apparent that there is a row of valves

on the outside of each row of cylinders of the engine and a row of inlet valves on the inside of each row of cylinders of the engine. The stems 62 of the valves are disposed in parallel relation in the two rows of valves for each row of cylinders and in planes normal to the plane inner surfaces 20 of the walls 19. It is proposed to operate the valves in the two rows of valves for each row of cylinders by employing rocker arms 28 of the same length. It will therefore be apparent that if the rocker arms extend inwardly of the engine from where they engage the ends of the valve stems 62 the inner ends of the rocker arms 28 will form two rows of rocker arm ends for each row of cylinders 12. It is proposed to operate the rocker arms 28 by two rows of identical push rods 27 for each row of cylinders of the engine, there being one row of outwardly sloping rocker arms 27 for the exhaust valves 33 and another row of inwardly sloping rocker arms 27 for the inlet valves 32. The inner extremities of the rocker arms intersect the axes of single rows of valve actuating means or valve lifters 24 for each row of cylinders of the engine. The axes of the row of valve lifters 24 for each row of cylinders 12 are in planes parallel to the plane of the axes of each row of the cylinders 12. The inwardly and outwardly sloping rows of rocker arms 27 for each row of cylinders of the engine form the indicated angles A and B in each row of cylinders of the engine. The planes of the axes of the valve lifters 24 bisect the angles A and B of the push rods for each row of cylinders of the engine.

The cylinders 12 of the engine are supplied with combustible charges through inlet passages 63 formed in the heads 18 and terminating in inlet ports 64 formed in the inner walls 19 of the heads. The products of combustion are exhausted from the cylinders by exhaust passages 66 formed in the heads 18 and terminating in exhaust ports 67 formed in the walls 19. Ports 64 and 67 are so located that the inner plane surfaces 55 of the valves 32 and 33 are substantially in the plane of the inner plane surface 20 of the walls 19 which engage the walls 17 of the block 11 to close the ends of the cylinders 12. The pistons 13 at the outer dead center positions of the pistons in the cylinders 12 have outwardly projecting ends 68 which project beyond the outer ends of the inner cylindrical surfaces 43 in which the pistons are operatively supported for reciprocating movement in the cylinders 12. The ends 68 of the pistons 13 have obliquely disposed plane end wall surfaces 69 on the adjacent sides of each of the pistons which are parallel to the inner wall surfaces 20 of the heads 18 and obliquely disposed plane surfaces 71 on the remote sides of the pistons which have the same slope as the inner wall surfaces 69 but which slope oppositely with respect to the axes of the cylinders 12. The wall surfaces 69 and 71 are connected at their adjacent edges by plane and connecting surfaces 72 which are generally normal to the axes of the cylinders 12 and which generally extend in alignment in each row of cylinders of the engine. The wall surfaces 69, 71 and 72 are formed symmetrically on the pistons 13 so that the pistons 13 are reversible and applicable for use in either row of cylinders of the engine.

The pistons 13, the heads 18 and the cylinders 12 are spaced at the inner dead center positions of the pistons in the cylinders to provide combustion chambers indicated at 73. The end wall surfaces 69 of the pistons 13 are spaced from the wall surfaces 45 of the heads 18 at the inner dead center positions of the pistons 13 in the cylinders 12 to provide minimum mechanical clearance spaces 75 forming parts of the combustion chamber 73. The surface 20 of the walls 19 also are formed to provide annular grooves 74 around the valves 32 and 33 to provide valve clearance means around the seats 64 and 67. The spark plugs 61 are obliquely disposed in the heads 18 in symmetrical but opposite angular relation to the axes of the cylinders 12 and to the valves 32 and 33. The terminal ends of the spark plugs 61 project into ignition cavities 76 formed in the inner surfaces 20 of the walls 19. The

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ignition cavities 76 are connected to the annular grooves 74 around valves 32 and 33 by connecting cavity means 77 extending into the walls 19.

Notwithstanding that the valves 33 are located within the cylindrical surfaces 46 of the cylinders 12, it has been found desirable to provide cavities 78 in the outer extremities of the cylinders 12 and in such positions as to receive the exhaust valves 33, thereby providing further clearance for the outer edges of the exhaust valves 33 when the valves are opened within the combustion chambers 73. The cavities 78 are formed in the outer extremities of the cylinders 12 by cylindrical surfaces of revolution formed about axes normal to the plane inner surfaces 20 of the walls 19 of the heads. As is illustrated by Figures 7 and 8 it is possible to make the cavities 78 of variable sizes by variably extending the cavities radially and laterally into the end walls 17 of the block 11 in which the cylinders 12 terminate. The walls 17 are made of considerable thickness to make possible this extension of the cavities 78 and to provide thick supporting surfaces in which to engage the threaded ends of the bolts 52 employed in securing the heads 18 upon the block 11. As will be seen from Figures 7 and 8, it is also possible to extend the cavities 78 around the cylinders 12 and into other locations within the cylinders 12. It will be noted that the inner extremities of the cavities 78 are formed to provide conically shaped ends 79 which are approximately parallel to the surfaces of connecting wall sections 81 joining the cylinders 12 and the end walls 17 at the outer or long sides of the cylinders 12. The connecting sections 81 provide the required wall thickness so that the cavities 78 can be varied in size and may be extended outwardly with the conical surfaces 79 extending in parallel relation to the slope of the surfaces of the connecting wall sections 81.

While the cavities 78 are employed for the purpose of providing clearance for the exhaust valves 33, as is illustrated by Figure 6, the cavities 78 also may be made larger than required for valve clearance purposes. The extension of the cavities 78 beyond the requirements of clearance for the exhaust valves 33 and around the cylinders 12 may be made to provide a wide variety of compression ratios for the cylinders of the engine. This may be accomplished without extensively modifying the operations and tools required for manufacturing the engine. For example so long as the cavities 78 are formed normally to the surface 20 of the heads, which is also normal to the outer surfaces of the end walls 17 of the cylinders 12, it will be possible to vary the sizes of the cavities to a great extent merely by varying the diameter of the tool employed. This will extend the cuts into the walls 17 in parallel relation to the walls 17 and to the surfaces of the connecting parts 81 of the walls 17. The sizes of the engine can also be easily changed by modifying the bore and stroke of the engines to provide a large number of different sizes of engines each of which can be further modified by varying the compression ratio by varying the extent the cavities project laterally and axially and peripherally into the walls 17.

The claims:

1. An internal combustion engine comprising, a cylinder having an obliquely disposed end, a head secured to said end of said cylinder, a piston reciprocally mounted in said cylinder and having inner and outer dead center positions in said cylinder, said piston and said cylinder respectively being formed to provide external and internal cylindrical bearing surfaces thereon in operative bearing engagement, said cylindrical bearing surfaces on said piston and said cylinder terminating at the outer end extremities thereof normally with respect to the common axes of said cylinder and said piston, said cylinder beyond said end extremity of said cylindrical bearing surface on said cylinder and to said end of said cylinder being enlarged and being formed to provide wall surface disposed radially outwardly of said cylindrical bearing surface on

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said cylinder, said head and said cylinder and said piston being spaced at said outer dead center position of said piston in said cylinder to provide combustion chamber means for said cylinder, said piston being formed with an end projecting beyond said outer end extremity of said bearing surface on said piston, said piston end being disposed in spaced relation to and within said cylindrical bearing surface on said cylinder and said wall surface on said cylinder when said piston moves between said inner and said outer dead center positions of said piston in said cylinder.

2. An internal combustion engine comprising, a cylinder having an obliquely disposed end, a head secured to said end of said cylinder, a piston reciprocally mounted in said cylinder and having inner and outer dead center positions in said cylinder, said piston and said cylinder respectively being formed to provide external and internal cylindrical bearing surfaces thereon in operative bearing engagement, said cylindrical bearing surfaces on said piston and said cylinder terminating at the outer end extremities thereof normally with respect to the common axes of said cylinder and said piston, said cylinder beyond said end extremity of said cylindrical bearing surface on said cylinder and to said end of said cylinder being enlarged and being formed to provide cylindrical wall surface of greater diameter than said cylindrical bearing surface on said cylinder and disposed concentrically outwardly of said cylindrical bearing surface on said cylinder, said head and said cylinder and said piston being spaced at said outer dead center position of said piston in said cylinder to provide combustion chamber means for said cylinder, said piston being formed with an end projecting beyond said outer end extremity of said bearing surface on said piston, said piston end being disposed in spaced relation to and within said cylindrical bearing surface on said cylinder and said cylindrical wall surface on said cylinder when said piston moves between said inner and said outer dead center positions of said piston in said cylinder.

3. An internal combustion engine comprising, a cylinder having an obliquely end, a head secured to said end of said cylinder, a piston reciprocally mounted in said cylinder and having inner and outer dead center positions in said cylinder, said piston and said cylinder respectively being formed to provide external and internal cylindrical bearing surfaces thereon in operative bearing engagement, said cylindrical bearing surfaces on said piston and said cylinder terminating at the outer end extremities thereof normally with respect to the common axes of said cylinder and said piston, said cylinder beyond said end extremity of said cylindrical bearing surface on said cylinder and to said end of said cylinder being enlarged and being formed to provide wall surface disposed radially outwardly of said cylindrical bearing surface on said cylinder, said head and said cylinder and said piston being spaced at said outer dead center positions of said piston in said cylinder to provide combustion chamber means for said cylinder, said piston being formed with an end projecting beyond said outer end extremity of said bearing surface on said piston, said piston end being disposed in spaced relation to and within said cylindrical bearing surface on said cylinder and said wall surface on said cylinder when said piston moves between said inner and said outer dead center positions of said piston in said cylinder, said wall surface on said cylinder being formed in part by surface of revolution wall surface means formed about axis means normal to said obliquely disposed end of said cylinder and to said head.

4. An internal combustion engine comprising, a cylinder having an obliquely disposed end, a head secured to said end of said cylinder, a piston reciprocally mounted in said cylinder and having inner and outer dead center positions in said cylinder, said piston and said cylinder respectively being formed to provide external and internal cylindrical bearing surfaces thereon in operative bearing engagement, said cylindrical bearing surfaces on said

piston and said cylinder terminating at the outer end extremities thereof normally with respect to the common axes of said cylinder and said piston, said cylinder beyond said end extremity of said cylindrical bearing surface on said cylinder and to said end of said cylinder being enlarged and being formed to provide wall surface disposed radially outwardly of said cylindrical bearing surface on said cylinder, said head and said cylinder and said piston being spaced at said outer dead center position of said piston in said cylinder to provide combustion chamber means for said cylinder, said piston being formed with an end projecting beyond said outer end extremity of said bearing surface on said piston, said piston end being disposed in spaced relation to and within said cylindrical bearing surface on said cylinder and said wall surface on said cylinder when said piston moves between said inner and said outer dead center positions of said piston in said cylinder, said wall surface on said cylinder being formed in part by surface of revolution wall surface means formed about axis means normal to said obliquely disposed end of said cylinder and to said head and being formed in part by surface of revolution wall surface means formed about said common axis of said cylinder and said piston.

5. An internal combustion engine comprising, a cylinder having an obliquely disposed end, a head secured to said end of said cylinder, a piston reciprocably mounted in said cylinder and having an outer dead center position in said cylinder, said head and said cylinder and said piston at said outer dead center position of said piston in said cylinder having spaced head and cylinder and piston wall surface means providing combustion chamber means for said cylinder, said cylinder wall surface means being formed in part by surface of revolution wall surface means formed about different axis means within said cylinder and normal to said obliquely disposed end of said cylinder and to said head.

6. An internal combustion engine comprising, a cylinder having an obliquely disposed end, a head secured to said end of said cylinder, a piston reciprocably mounted in said cylinder and having an outer dead center position in said cylinder, said head and said cylinder and said piston at said outer dead center position of said piston in said cylinder having spaced head and cylinder and piston wall surface means providing combustion chamber means for said cylinder, said cylinder wall surface means being formed in part by surface of revolution wall surface means formed about different axis means within said cylinder and on opposite sides of the major axis of said obliquely disposed end of said cylinder and normal to said obliquely disposed end of said cylinder and to said head.

7. An internal combustion engine comprising, a cylinder having inner side wall means and an obliquely disposed end, a head secured to said end of said cylinder and having plane inner wall means closing said end of said cylinder, a piston having obliquely disposed plane end wall means on opposite sides of a diameter of said cylinder and reciprocably mounted in said cylinder and having an outer dead center position in said cylinder, said wall means of said head and said cylinder and said piston at said outer dead center position of said cylinder being spaced to provide combustion chamber means for said cylinder, a pair of valves having plane inner wall means forming substantially a continuation of said plane inner wall means of said head and mounted in said head and opening into said combustion chamber means through valve seat means surrounded by annular recess means formed in said inner wall means of said head and having opening and closing movements in said combustion chamber means normal to said end of said cylinder and said head, a spark plug in said head and projecting into said combustion chamber means through ignition chamber means formed in said inner wall means of said head, said head between

said annular recess means and said ignition chamber means being formed to provide connecting cavity means within said inner wall means of said head, one of said end wall means of said piston being spaced from and parallel to said inner wall means of said head and said valves to provide a minimum mechanical clearance space forming a part of said combustion chamber means between said head and said piston, said combustion chamber means being disposed largely between said piston and said cylinder and said head on the side of said cylinder opposite said minimum mechanical clearance space and in directly opposed relation to said ignition chamber means and said spark plug.

8. An internal combustion engine comprising, a pair of parallel cylinders having inner side wall means and obliquely disposed ends, said ends being disposed in a plane including a diameter of each of said cylinders, head means secured to said ends of said cylinders and having plane inner wall means closing said ends of said cylinders, pistons having outer end wall means and reciprocably mounted in said cylinders and having outer dead center positions in said cylinders, said wall means of said head means and said cylinders and said pistons at said outer dead center positions of said pistons in said cylinders being spaced to provide combustion chamber means for said cylinders, a pair of obliquely disposed valves for each of said cylinders and mounted in said head means in opposite angular relation to said cylinders and opening into said combustion chamber means through valve seat means in said inner wall means of said head means, one of said valves in each pair being disposed on the short side of said cylinders and on adjacent sides of said cylinders, the other of said valves in each pair being disposed on the long side of said cylinders and on remote sides of said cylinders, a spark plug in said head means for each of said cylinders and projecting into said combustion chamber means through said inner wall means of said head means, said spark plugs being disposed on the long side of said cylinders and on adjacent sides of said cylinders and between and on one side of said valves in each of said cylinders.

9. An internal combustion engine comprising, a pair of parallel cylinders having inner side wall means and obliquely disposed ends, said ends being disposed in a plane including a diameter of each of said cylinders, head means secured to said ends of said cylinders and having plane inner wall means closing said ends of said cylinders, pistons having outer end wall means and reciprocably mounted in said cylinders and having outer dead center positions in said cylinders, said wall means of said head means and said cylinders and said pistons at said outer dead center positions of said pistons in said cylinders being spaced to provide combustion chamber means for said cylinders, a pair of obliquely disposed valves for each of said cylinders and mounted in said head means in opposite angular relation to said cylinders and opening into said combustion chamber means through valve seat means in said inner wall means of said head means, one of said valves in each pair being disposed on the short side of said cylinders and on adjacent sides of said cylinders, the other of said valves in each pair being disposed on the long side of said cylinders and on remote sides of said cylinders, a spark plug in said head means for each of said cylinders and projecting into said combustion chamber means through said inner wall means of said head means, said spark plugs being obliquely disposed with respect to one another and said cylinders on the long side of said cylinders and on adjacent sides of said cylinders and between and on one side of said valves in each of said cylinders and extending both radially and axially inwardly with respect to said cylinders.

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