

**July 3, 1962**

**D. D. FENTON-SMITH**  
**RECIPROCATING PISTON AND DOUBLE SLIDE AND**  
**SLIDE END PLATE ENGINE AND PUMP**

**3,042,011**

Filed Dec. 28, 1953

9 Sheets-Sheet 1

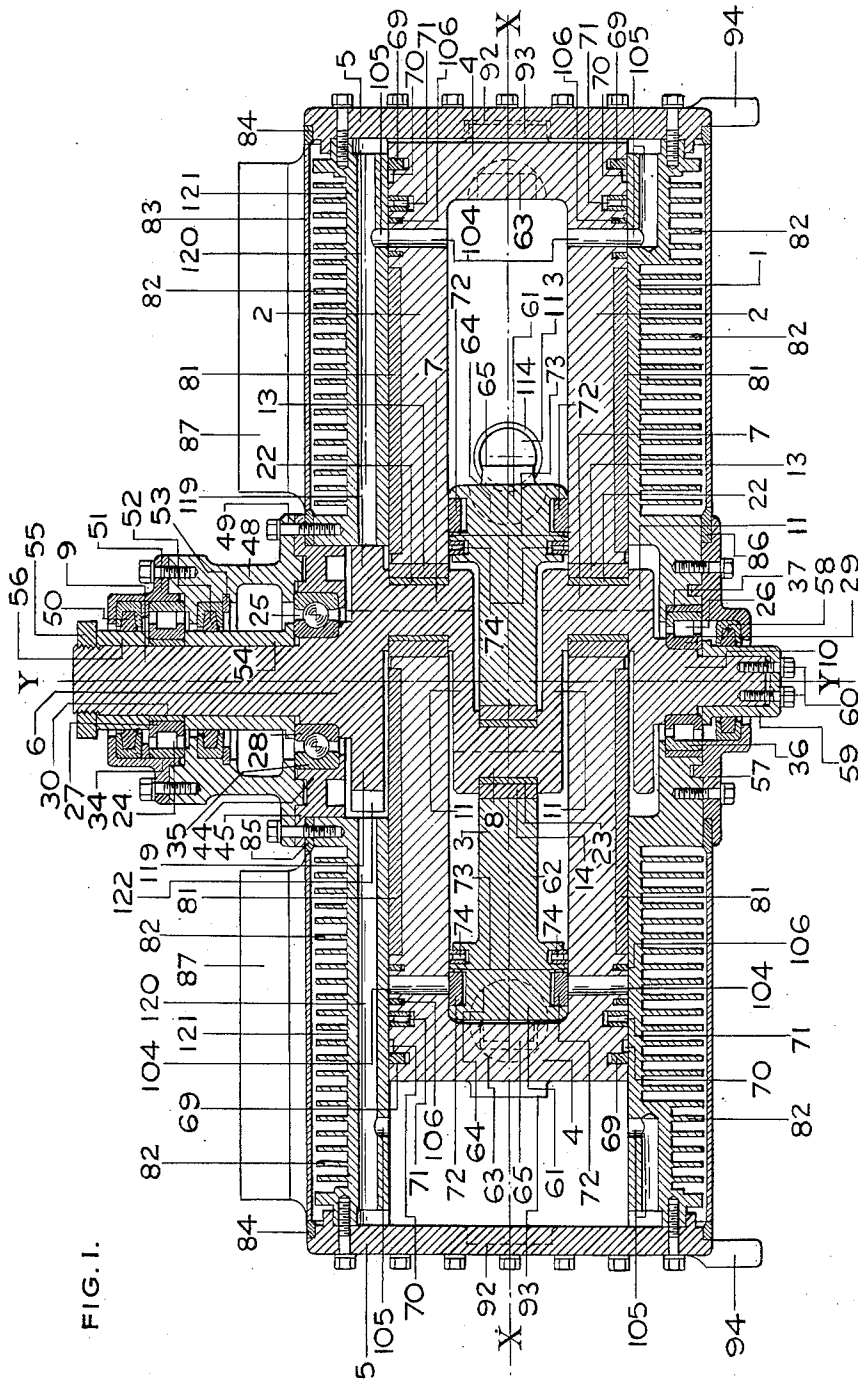


Fig. 1.

July 3, 1962

D. D. FENTON-SMITH  
 RECIPROCATING PISTON AND DOUBLE SLIDE AND  
 SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 2

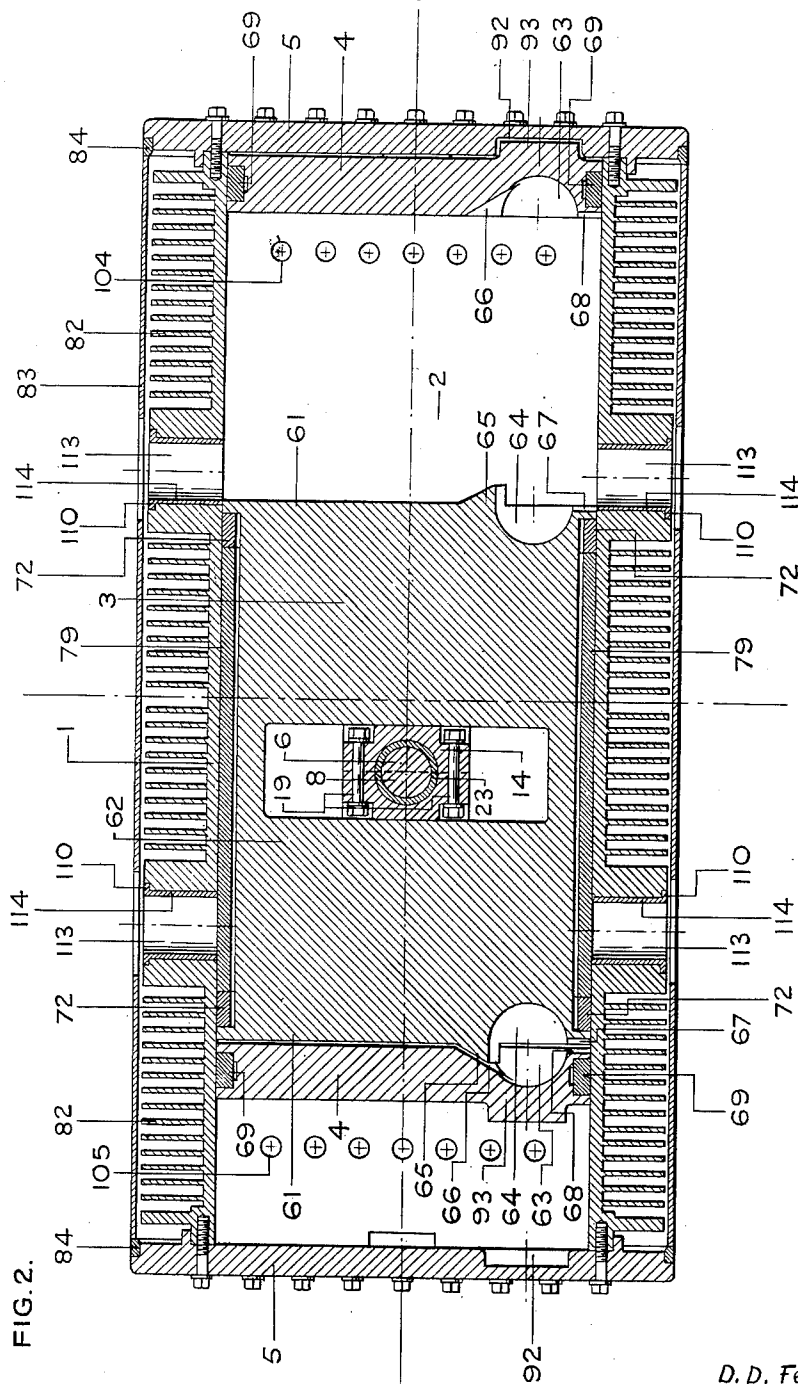


FIG. 2.

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RECIPROCATING PISTON AND DOUBLE SLIDE AND  
SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 3

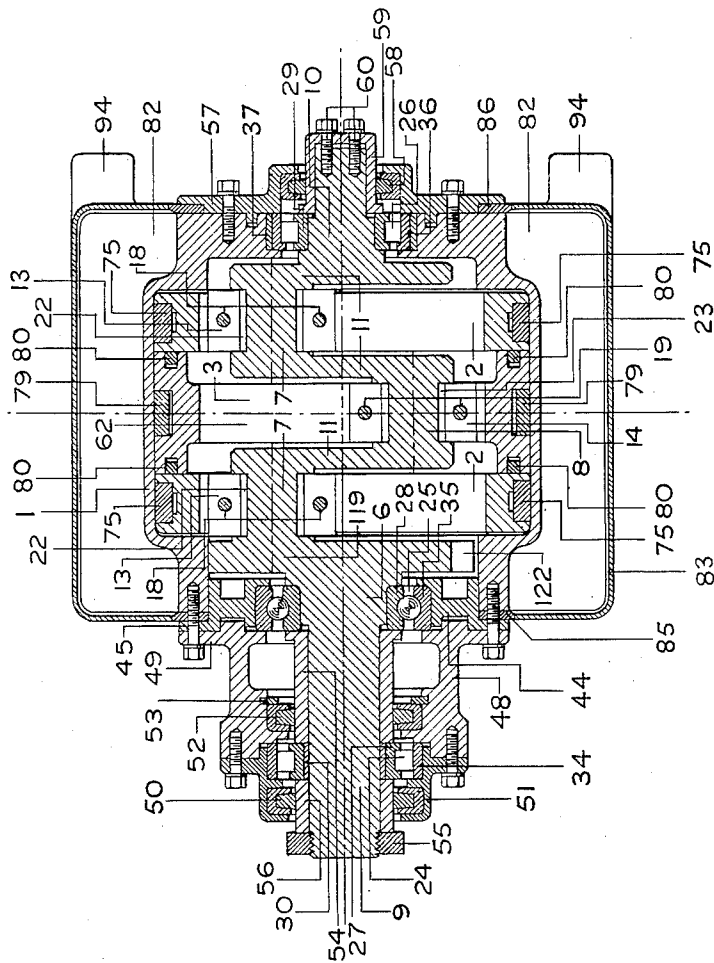


FIG. 3.

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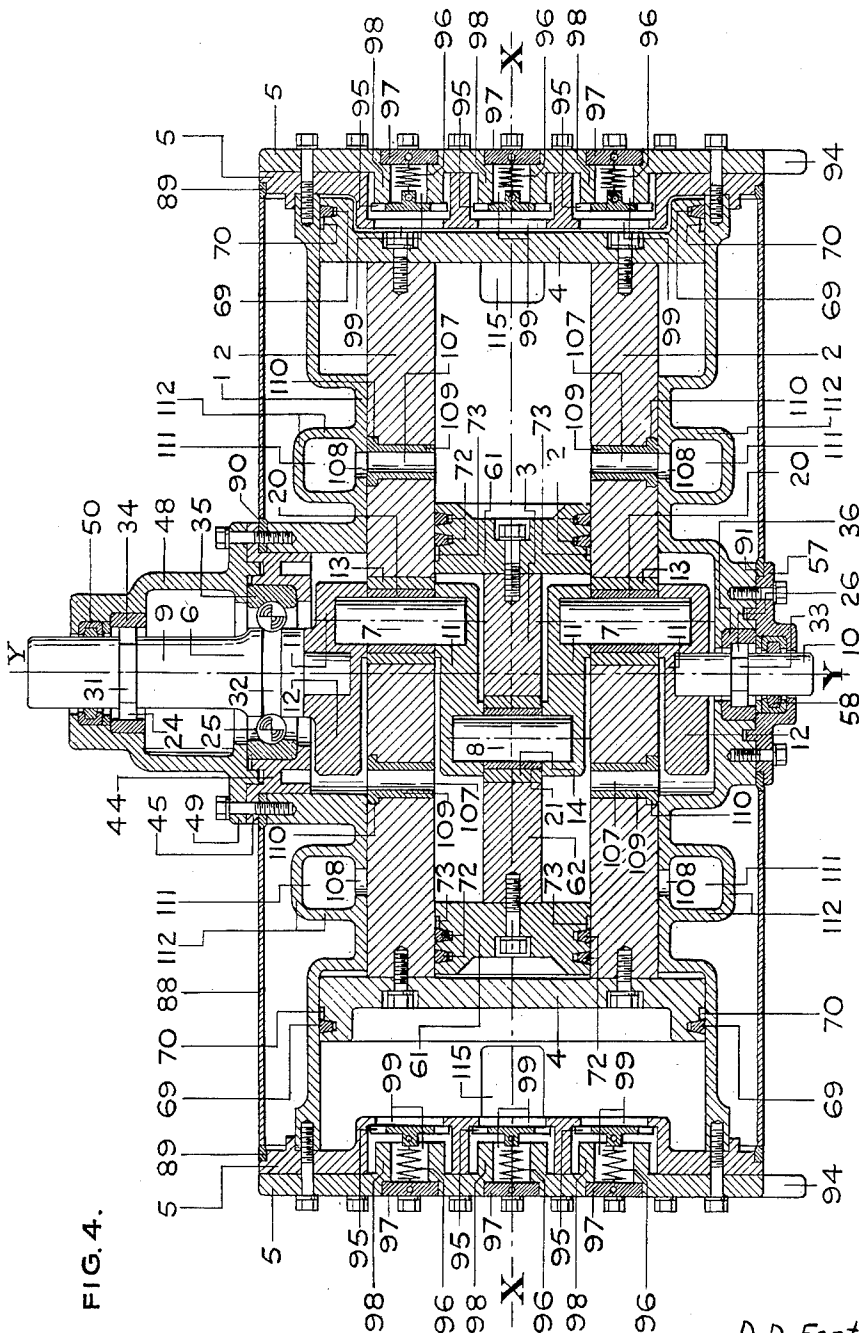
July 3, 1962

D. D. FENTON-SMITH  
RECIPROCATING PISTON AND DOUBLE SLIDE AND  
SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 4



July 3, 1962

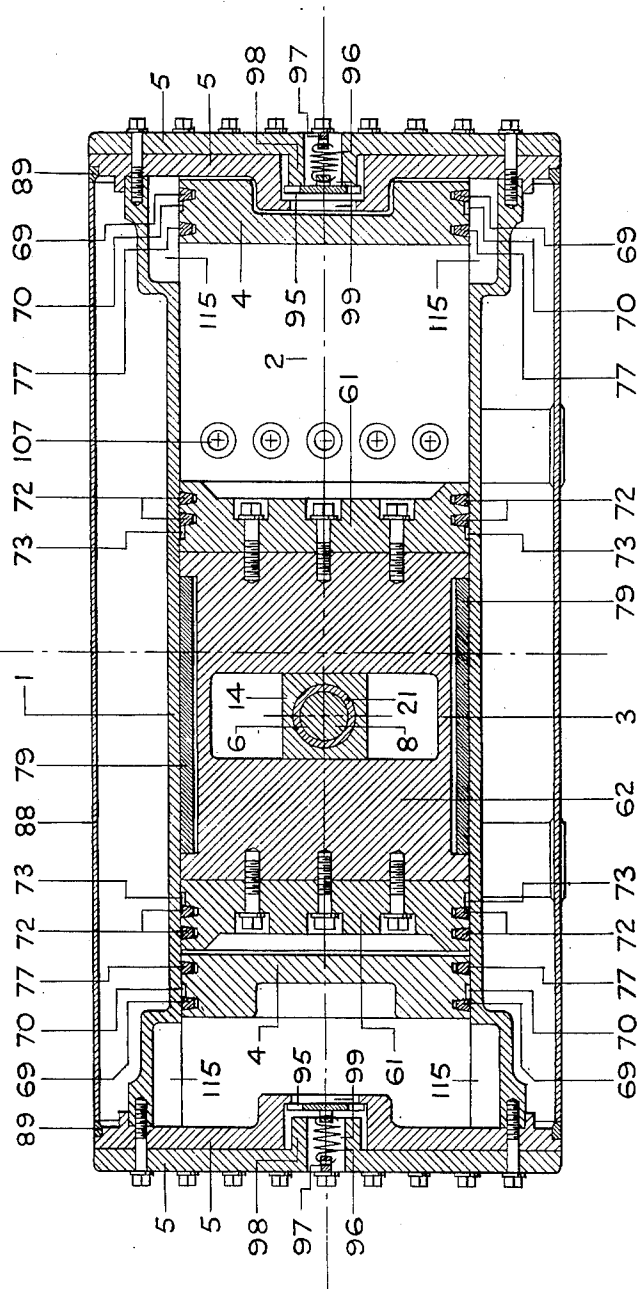
D. D. FENTON-SMITH  
 RECIPROCATING PISTON AND DOUBLE SLIDE AND  
 SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 5

FIG. 5.



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D. D. FENTON-SMITH  
RECIPROCATING PISTON AND DOUBLE SLIDE AND  
SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 6

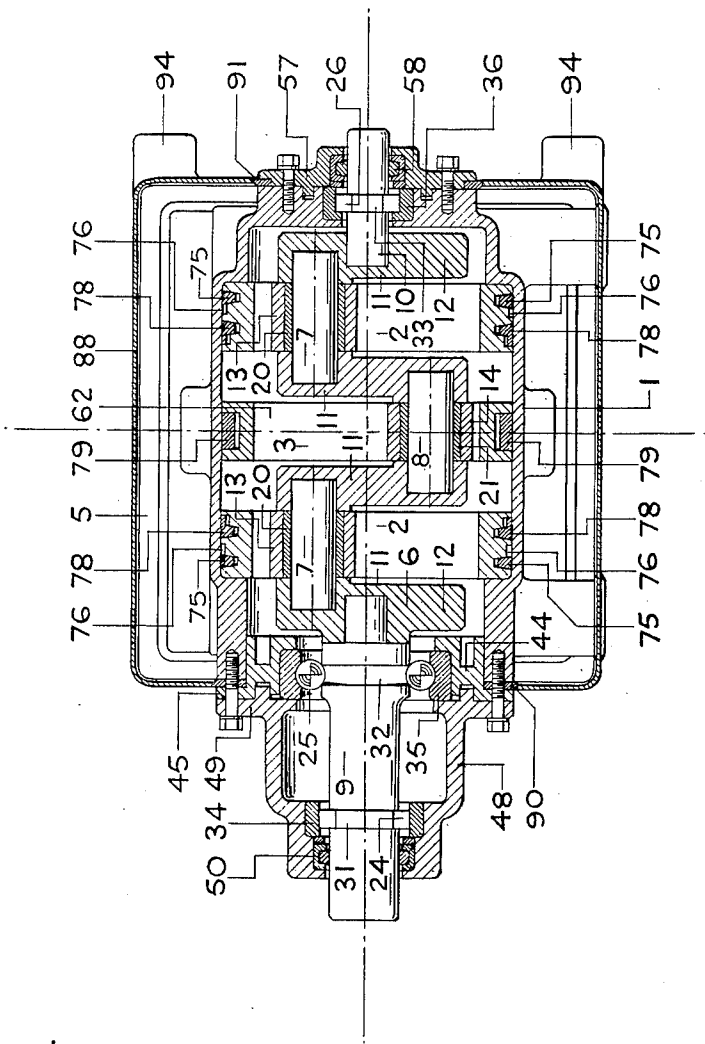


FIG. 6.

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RECIPROCATING PISTON AND DOUBLE SLIDE AND  
SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 7

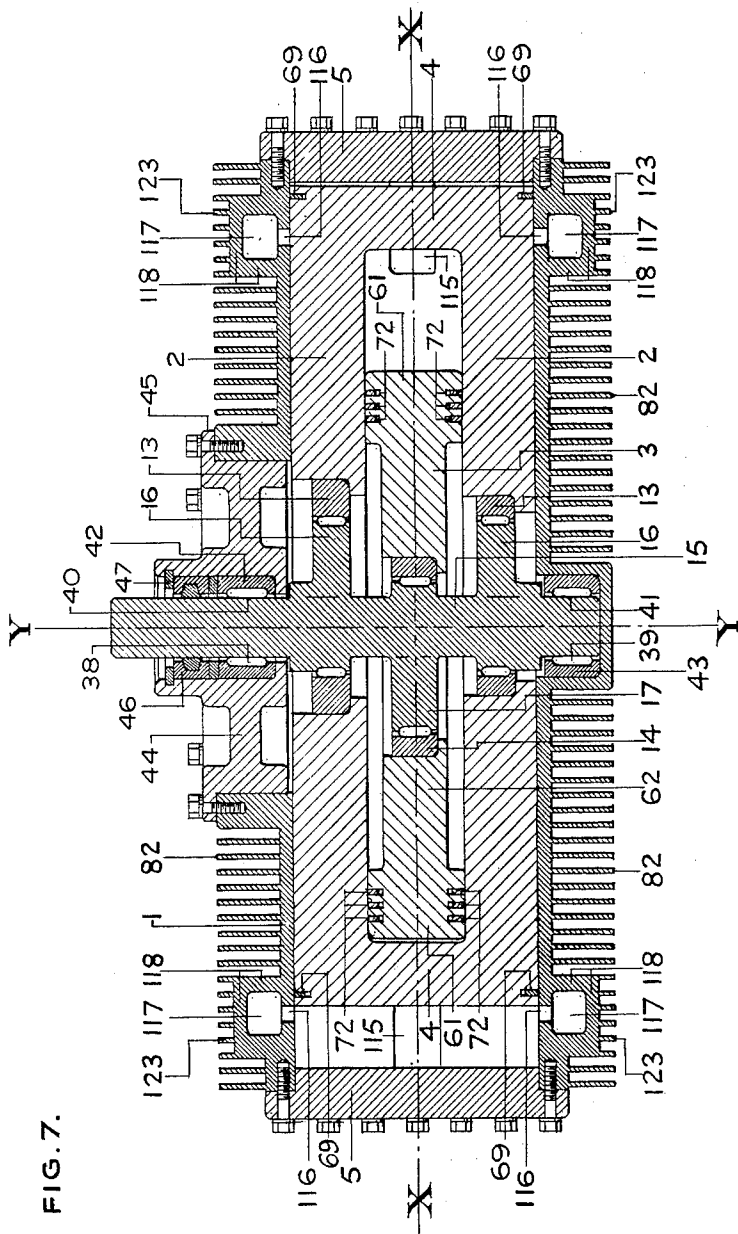


FIG. 7.

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RECIPROCATING PISTON AND DOUBLE SLIDE AND  
SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 8

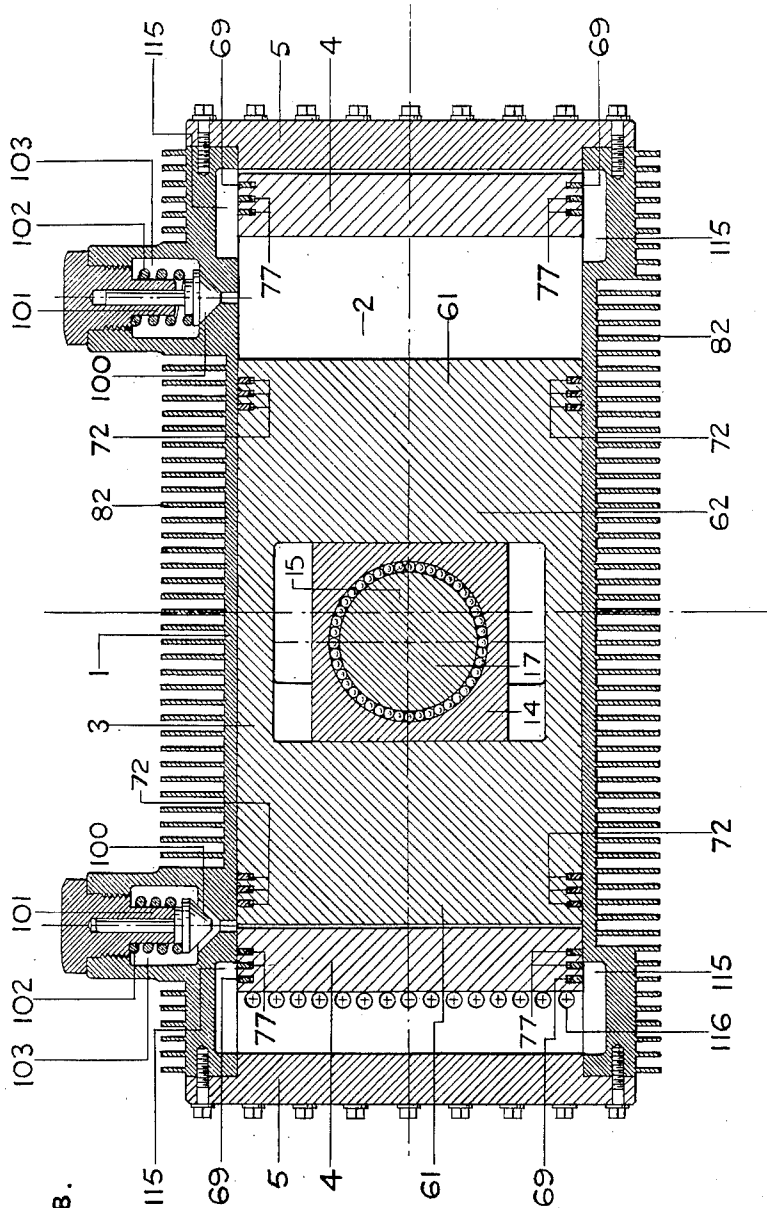


FIG. 8.

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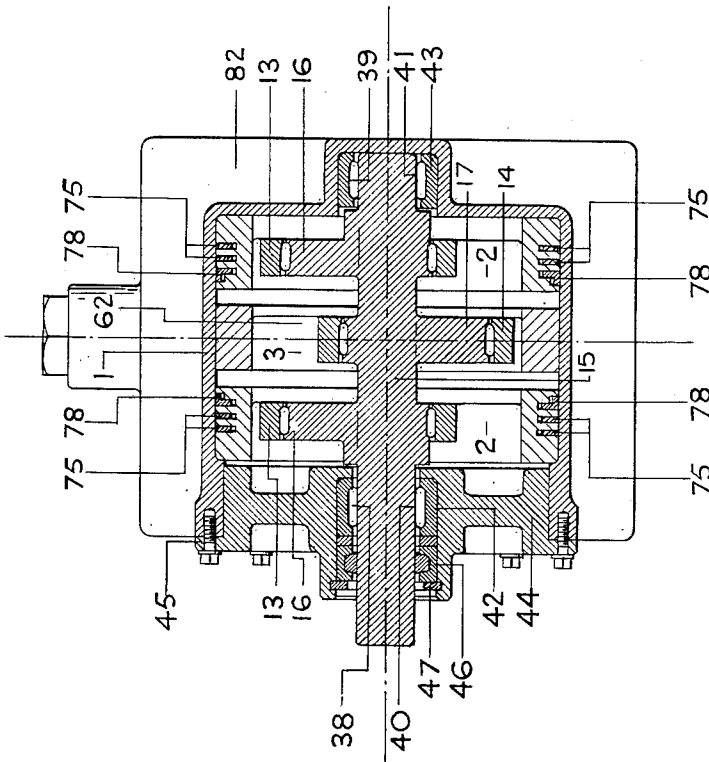
July 3, 1962

D. D. FENTON-SMITH  
RECIPROCATING PISTON AND DOUBLE SLIDE AND  
SLIDE END PLATE ENGINE AND PUMP

3,042,011

Filed Dec. 28, 1953

9 Sheets-Sheet 9



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1

3,042,011

## RECIPROCATING PISTON AND DOUBLE SLIDE AND SLIDE END PLATE ENGINE AND PUMP

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9 Claims. (Cl. 123-50)

This invention relates to a reciprocating engine and a pump and the like in which there is a reciprocating piston or pistons and in which there are reciprocating slides.

An object of this invention is to provide an engine and a pump and the like in which the overall dimensions and the weight can be reduced to a minimum for a given swept volume.

Another object of this invention is to provide an engine and a pump and the like in which perfect inertia balance of the main reciprocating components and perfect centrifugal balance of the main rotating components can be obtained and in which the attainment of no rocking inertia couples and no rocking centrifugal couples can be realised.

Another object of this invention is to provide an engine and a pump and the like in which a very short rotating shaft can be used for a mechanism of given swept volume and thereby enabling torsional vibration and whipping troubles to be reduced to a minimum and thereby ensuring that the mechanism operates under the best possible conditions of alignment and minimum frictional losses.

Another object of this invention is to provide an engine and a pump and the like in which great rigidity can be obtained in a mechanism of given swept volume and thereby enabling elastic vibration troubles to be reduced to a minimum and ensuring that the mechanism operates under the best conditions of alignment and minimum frictional losses.

Another object of this invention is to provide an engine and a pump and the like in which the dynamic loading acting on the main reciprocating components can be opposed by the fluid loading acting on the main reciprocating components at each end of each stroke; thereby enabling the mean combined loading on crank-pin bearings if used, or on eccentric bearings if used, to be reduced to a minimum for a mechanism of given swept volume.

Another object of this invention is to provide an engine and a pump and the like in which if a rotatably mounted shaft is used the mean loading acting on the main bearings can be reduced to a minimum by causing the dynamic loading produced by the main reciprocating components to cancel out and also by causing the fluid loading acting on the main reciprocating components to cancel out.

Another object of this invention is to provide an engine and a pump and the like in which a main-shaft can be used which operates with a high rotational speed without the main reciprocating components being subjected to unduly high mean linear speeds and therefore without unduly high mean rubbing velocities.

Another object of this invention is to provide an engine and a pump and the like which for a given number of variable volume spaces can have a minimum number of moving components and which will therefore operate with minimum frictional losses and therefore with a high mechanical efficiency.

Another object of this invention is to provide an engine and a pump and the like which for a given number of variable volume spaces can have a minimum total

2

number of components and which will therefore lend itself well to low production costs.

Another object of this invention is to provide a mechanism which is particularly suitable for use as a double-acting multiple-stage pneumatic pump and which is also particularly suitable for use as a double-acting internal combustion engine operating on the two-stroke cycle, and which will therefore give the most uniform torque output and torque recoil possible for a given number of pistons; thereby reducing reactionary vibration to a minimum.

Another object of this invention is to provide a mechanism which is particularly suitable for use as a double-acting internal combustion engine operating on the two-stroke cycle for use as a power gas generator for compounding with a gas turbine; thereby enabling a very high power output prime-mover of small overall dimensions and light weight to be obtained.

Another object of this invention is to provide a mechanism which is particularly suitable for use as a combined single-acting internal combustion engine operating on the two-stroke cycle and a single-stage or multiple-stage pneumatic pump; thereby enabling an internal combustion engine driven pneumatic pump of small overall dimensions and light weight to be obtained.

An engine and a pump and the like described herein-after may be a single barrel and single piston unit or may be a multiple barrel and multiple piston unit. A multiple barrel and multiple piston unit may have the barrels disposed in accordance with any desired suitable geometrical arrangement.

According to this invention there is an engine and a pump and the like in which within a barrel there are reciprocating slides which are disposed longitudinally to the barrel and which slides are so disposed that there is a space between them and in which space a piston reciprocates and at their ends the slides are joined together by reciprocating slide end plates which are disposed transversely to the slides and at the ends of the barrel there are barrel end covers.

In order that this invention may be clearly understood and readily carried into effect the same will now be fully described by way of examples and with reference to the accompanying drawings in which:

FIGURE 1 is a sectional plan view of a mechanism in accordance with this invention arranged to function as an air-cooled double-acting internal combustion engine, operating on the two-stroke cycle, the section being taken through the central axis of the barrel and the central axis of the crankshaft.

FIGURE 2 is a sectional end elevation taken through the central axis XX of the barrel of FIGURE 1 and viewed in a direction along the central axis of the crankshaft.

FIGURE 3 is a sectional side elevation taken through the central axis YY of the crankshaft of FIGURE 1 and viewed in a direction along the central axis of the barrel, but with the central axes of the crank-pins cutting the vertical plane.

FIGURE 4 is a sectional plan view of a mechanism in accordance with this invention arranged to function as a liquid-cooled double-acting internal combustion engine operating on the two-stroke cycle, the section being taken through the central axis of the barrel and the central axis of the crankshaft.

FIGURE 5 is a sectional end elevation taken through the central axis XX of the barrel of FIGURE 4 and viewed in a direction along the central axis of the crankshaft.

FIGURE 6 is a sectional side elevation taken through the central axis YY of the crankshaft of FIGURE 4 and

viewed in a direction along the central axis of the barrel, but with the central axes of the crank-pins cutting the vertical plane.

FIGURE 7 is a sectional plan view of a mechanism in accordance with this invention arranged to function as an air-cooled two-stage double-acting air-compressor, the section being taken through the central axis of the barrel and the central axis of the eccentric carrying shaft.

FIGURE 8 is a sectional end elevation taken through the central axis XX of the barrel of FIGURE 7 and viewed in a direction along the central axis of the eccentric carrying shaft.

FIGURE 9 is a sectional side elevation taken through the central axis YY of the eccentric carrying shaft of FIGURE 7 and viewed in a direction along the central axis of the barrel, but with the central axes of the eccentric-sheaves cutting the vertical plane.

Referring to all the drawings from FIGURE 1 to FIGURE 9 inclusive there is a barrel 1 extending longitudinally in which there are reciprocating slides 2 which are disposed longitudinally to the barrel 1 and which slides 2 are so disposed that there is a space between them and in which space a piston 3 reciprocates and at their ends the slides 2 are joined together by reciprocating slide end plates 4 which are disposed transversely to the slides 2 and at the ends of the barrel 1 there are barrel end covers 5.

As the slides 2 and the slide end plates 4 are caused to reciprocate in a barrel 1 so a piston 3 is also caused to reciprocate in a barrel 1 and in a space between the slides 2 but a piston 3 has a movement of opposite directional sense to the slides 2 and the slide end plates 4.

According to this invention and as shown in the engine in FIGURES 1, 2, and 3, and in the air-compressor in FIGURES 7, 8, and 9, the stroke of the slides 2 and slide end plates 4 in a barrel 1 may be of an equal length to the stroke of a piston 3 in that barrel 1.

The geometrical form of a mechanism in accordance with this invention is such that it is usually desirable for the total volume of material contained in the slides and slide end plates in a barrel to be considerably greater than the volume of material contained in a piston in that barrel, and for this reason in order to make the mass of a piston equal to the combined mass of the slides and slide end plates it is usually preferable to make the piston in a heavy weight material and to make the slides and slide end plates in a light weight material. A piston could be made in (alloy) cast-iron or (alloy) steel; and the slides and slide end plates could be made in a magnesium or aluminium alloy.

According to this invention and as shown in the engine in FIGURES 4, 5, and 6, the stroke of the slides 2 and slide end plates 4 in a barrel 1 may be of an unequal length to the stroke of a piston 3 in that barrel 1. In this particular example the piston 3 has a stroke of a greater length than the stroke of the slides 2 and slide end plates 4.

If the slides and slide end plates are caused to reciprocate with a simple harmonic motion and if a piston is likewise caused to reciprocate with a simple harmonic motion but with a movement of opposite directional sense, and if the product of the combined mass of the slides and slide end plates and their linear acceleration at a given instant of time is equal to the product of the mass of a piston and its linear acceleration at that instant of time, then the advantage of perfect inertia balance of the main reciprocating components will be obtained.

The geometrical form of a mechanism in accordance with this invention is such that the centre of the combined mass of the slides and the slide end plates can be made coincident with the central axis of a barrel, and the centre of mass of a piston can also be made coincident with the central axis of a barrel, thereby enabling the advantage of the attainment of no rocking inertia couples to be realised.

According to this invention and as shown in the engines in FIGURES 1, 2, and 3, and in FIGURES 4, 5, and 6, there may be a rotatably mounted crankshaft 6 which is situated completely or as shown is situated partly within a barrel 1 and which extends through apertures in the slides 2 and a piston 3. This form of construction has the advantage that a mechanism in accordance with this invention may then be constructed in which if there is a horizontal barrel the depth is reduced to a minimum.

According to this invention and as shown in the engines in FIGURES 1, 2, and 3, and in FIGURES 4, 5, and 6, a crankshaft 6 may have three crank-pins which are situated within a barrel 1 the outer two crank-pins 7 being coaxial and being connected to the slides 2 and being opposite to an inner crank-pin 8 which is connected to a piston 3. This geometrical arrangement of the crank-pins has the advantage that the loading to which the reciprocating components are subjected is as symmetrically applied and as directly transmitted as possible.

According to this invention and as shown in the engine in FIGURES 1 and 3 an inner crank-pin 8 and the outer two crank-pins 7 which may be situated within a barrel 1 may be joined together and joined to the main-shafts 9 and 10 by three crank-webs 11 and a crank-web 119 and two of which crank-webs 11 are each situated between a piston 3 and a slide 2 and one of which crank-webs 11 and a crank-web 119 are situated outside the slides 2. This form of construction has the advantages of providing a crankshaft of minimum overall dimensions and maximum flexural and torsional rigidity.

According to this invention some or all of the four crank-webs may be of rectangular or substantially rectangular external cross sectional shape. This form of construction has the advantage that the geometrical form of each crank-web is related in the best possible manner to the geometrical form of the remainder of the mechanism; thereby enabling a crankshaft situated within a space of given overall dimensions to have maximum flexural and torsional rigidity.

According to this invention and as shown in the engine in FIGURES 4 and 6 one or as shown both of the two crank-webs 11 which may be situated outside the slides 2 may be extended to the opposite side of the axis of rotation of a crankshaft 6 to form a rotating balance-weight or as shown balance-weights 12. With this form of construction the centre of mass of a crankshaft can be made coincident with its axis of rotation thereby enabling perfect centrifugal balance of the crankshaft to be obtained; also the geometrical form can be such that the advantage of the attainment of no rocking centrifugal couples can be realised.

According to this invention and as shown in the engine in FIGURES 1 and 3 there may be situated within a barrel 1 the outer two crank-pins 7 each with a crank-throw of an equal length to the crank-throw of an inner crank-pin 8. This form of construction has the advantage of enabling a mechanism of maximum swept volume to be obtained within a barrel of given depth.

According to this invention and as shown in the engine in FIGURES 4 and 6 there may be situated within a barrel 1 the outer two crank-pins 7 each with the same length of crank-throw but of an unequal length to the crank-throw of an inner crank-pin 8. In this particular example the crank-throw of an inner crank-pin 8 is of longer length than the crank-throw of each of the outer two crank-pins 7. This form of construction has the advantage that if desired the stroke of the slides and slide end plates may be made of a shorter length than the stroke of a piston thereby enabling perfect inertia balance of the main reciprocating components to be obtained when the combined mass of the slides and slide end plates is greater than the mass of a piston.

According to this invention and as shown in the engine in FIGURES 1 and 3 there may be a crankshaft 6

which within a barrel 1 has the outer two crank-pins 7 and an inner crank-pin 8 and three crank-webs 11 and a crank-web 119 and main-shafts 9 and 10 which are all in one piece.

This form of construction has the advantage of providing a crankshaft of maximum flexural and torsional strength and rigidity.

According to this invention a crankshaft which within a barrel has three crank-pins and four crank-webs may consist of any desired number of separate pieces suitably attached together and which form of construction is shown in the engine in FIGURES 4 and 6 in which there may be a crankshaft 6 which within a barrel 1 has the inner two crank-webs 11 which are separate from and are shrunk onto two crank-pins 7, and which are separate from and are shrunk onto an inner crank-pin 8, and in which the outer two crank-webs 11 are separate from and are shrunk onto the outer two crank-pins 7 and the main-shafts 9 and 10. This form of construction has the advantage of enabling different materials and/or different heat treatments to be used if desired for the separate pieces.

According to this invention and as shown in the engines in FIGURES 1, 2, and 3, and in FIGURES 4, 5, and 6, the slides 2 may be connected to the outer two crank-pins 7 of a crankshaft 6 by means of the slider-blocks 13 and a piston 3 may be connected to an inner crank-pin 8 by means of a slider-block 14. The slider-blocks 13 may each have a plain bearing in them which operates on the corresponding outer crank-pin 7 and each have flat faces on their outsides which move between flat parallel faces of the corresponding aperture in a slide 2. The slider-block 14 may also have a plain bearing in it which operates on the inner crank-pin 8 and also has flat faces on its outside which move between flat parallel faces of an aperture in a piston 3. The flat parallel faces preferably being perpendicular to the central axis of a barrel 1.

According to this invention and as shown in the air-compressor in FIGURES 7, 8, and 9, there may be a rotatably mounted shaft 15 carrying eccentrics which is situated completely or as shown is situated partly within a barrel 1 and which extends through apertures in the slides 2 and a piston 3. This form of construction has the advantage that a mechanism in accordance with this invention may then be constructed in which if there is a horizontal barrel the depth is reduced to a minimum.

According to this invention and as shown in the air-compressor in FIGURES 7, 8, and 9, a shaft 15 may carry three eccentric-sheaves which are situated within a barrel 1 the outer two eccentric-sheaves 16 being coaxial and being connected to the slides 2 and being opposite to an inner eccentric-sheave 17 which is connected to a piston 3. This geometrical arrangement of the eccentric-sheaves has the advantage that the loading to which the reciprocating components are subjected is as symmetrically applied and as directly transmitted as possible.

According to this invention and as shown in the air-compressor in FIGURES 7, 8, and 9, there may be situated within a barrel 1 an inner eccentric-sheave 17 which is of a greater width than each of the outer two eccentric-sheaves 16. This form of construction has the advantage that the centre of mass of a shaft and its eccentrics can be made coincident with its axis of rotation therefore enabling perfect centrifugal balance of the main rotating component to be obtained; also the geometrical form can be such that the advantage of the attainment of no rocking centrifugal couples can be realised.

According to this invention and as shown in the air-compressor in FIGURES 7 and 9 there may be situated within a barrel 1 the outer two eccentric-sheaves 16 each with an eccentric-throw of an equal length to the eccentric-throw of an inner eccentric-sheave 17. This form of construction has the advantage of enabling a mechanism

utilising eccentrics to be of maximum swept volume within a barrel of given depth.

According to this invention there may be situated within a barrel the outer two eccentric-sheaves each with the same length of eccentric-throw but of an unequal length to the eccentric-throw of an inner eccentric-sheave. This form of construction has the advantage that if desired the stroke of the slides and slide end plates may be of a shorter length than the stroke of a piston thereby enabling perfect inertia balance of the main reciprocating components to be obtained when the combined mass of the slides and slide end plates is greater than the mass of a piston.

According to this invention and as shown in the air-compressor in FIGURES 7, 8, and 9, there may be a shaft 15 which within a barrel 1 carries and is integral with the outer two eccentric sheaves 16 and carries and is integral with an inner-eccentric sheave 17. This form of construction has the advantage of eliminating eccentric-sheave fixing troubles.

According to this invention there may be a shaft within a barrel which is separate from the carried eccentric-sheaves which may be attached in position by any desired suitable method. This form of construction has the advantage of enabling different materials and/or different heat treatments to be used if desired for the eccentric-sheaves and a shaft.

According to this invention and as shown in the air-compressor in FIGURES 7, 8, and 9, the slides 2 may be connected to the outer two eccentric-sheaves 16 by means of the slider-blocks 13 and a piston 3 may be connected to an inner eccentric-sheave 17 by means of a slider-block 14. The slider-blocks 13 and 14 may each have a (needle) roller bearing within them. The construction of the slider-blocks and the apertures in which they operate are similar to those described in the foregoing for use with a crankshaft.

According to this invention and as shown in the engine in FIGURES 4, 5, and 6, on each of the outer two crank-pins 7 and on an inner crank-pin 8 there may be slider-blocks 13 and 14 respectively which are each in one piece.

According to this invention and as shown in the air-compressor in FIGURES 7, 8, and 9, on each of the outer two eccentric-sheaves 16 and on an inner eccentric-sheave 17 there may be slider-blocks 13 and 14 respectively which are each in one piece.

This form of construction has the advantage of providing slider-blocks of maximum strength and rigidity.

According to this invention and as shown in the engine in FIGURES 1, 2, and 3, on each of the outer two crank-pins 7 and on an inner crank-pin 8 there may be slider-blocks 13 and 14 respectively which are each diametrically divided into two separate components which may be clamped together by the bolts 18 and 19 respectively. This form of construction has the advantage of enabling a crankshaft which is in one piece to be used.

According to this invention and as shown in the engine in FIGURES 1, 2, and 3, the slider-blocks 13 and 14 may have within them the diametrically divided plain bearing bushes 22 and 23 respectively.

According to this invention and as shown in the engine in FIGURES 4, 5, and 6, the slider-blocks 13 and 14 may have within them the one piece plain bearing bushes 20 and 21 respectively.

These forms of construction have the advantage of providing slider-block bearings which can be readily replaced.

But if desired in an engine and a pump any other suitable mechanism may be used for converting the reciprocating motion into rotary motion or for converting rotary motion into the reciprocating motion.

According to this invention a crankshaft or a shaft carrying eccentrics situated completely or partly within a barrel may be rotatably mounted on ball and/or (needle) roller main bearings and which form of construction is

shown in the engines in FIGURES 1 and 3 and in FIGURES 4 and 6 in which a crankshaft 6 may be rotatably mounted on the roller main bearings 24 and 26 and the ball main bearing 25; and which form of construction is shown in the air-compressor in FIGURES 7 and 9 in which a shaft 15 may be rotatably mounted on the needle roller main bearings 38 and 39. This form of construction has the advantage of reducing the frictional losses to a minimum and of making for maximum durability.

According to this invention an inner race ring or rings may be mounted directly and/or on a sleeve or sleeves on a main-shaft or shafts of a crankshaft or on a shaft carrying eccentrics and which form of construction is shown in the engine in FIGURES 1 and 3 in which the inner race rings 28 and 29 may be mounted directly on the main-shafts 9 and 10 respectively and an inner race ring 27 may be mounted on a sleeve 30 on a main-shaft 9.

According to this invention an inner race track or tracks may be formed directly on a main-shaft or shafts of a crankshaft or on a shaft carrying eccentrics and which form of construction is shown in the engine in FIGURES 4 and 6 in which the inner race tracks 31 and 32 may be formed directly on a main-shaft 9 and an inner race track 33 may be formed directly on a main-shaft 10; and which form of construction is shown in the air-compressor in FIGURES 7 and 9 in which the inner race tracks 40 and 41 may be formed directly on a shaft 15. This form of construction has the advantage of reducing the weight to a minimum.

According to this invention an outer race ring or rings may be housed directly and/or in a sleeve or sleeves in an aperture or apertures and/or a recess or recesses in a wall or walls of a barrel and which form of construction is shown in the engine in FIGURES 4 and 6 in which an outer race ring 36 may be housed directly in an aperture in a wall of a barrel 1 and is shown in the air-compressor in FIGURES 7 and 9 in which an outer race ring 43 may be housed directly in a recess in a wall of a barrel 1; and which form of construction is again shown in the engine in FIGURES 1 and 3 in which an outer race ring 36 may be housed in a sleeve 37 which is housed in an aperture in a wall of a barrel 1.

According to this invention an outer race ring or rings may be housed in an aperture or apertures in a bearing carrier or carriers which are attached to a wall or walls of a barrel and which form of construction is shown in the engines in FIGURES 1 and 3 and in FIGURES 4 and 6 and in the air-compressor in FIGURES 7 and 9 in which the outer race rings 35 and 42 respectively may be housed in an aperture in a bearing carrier 44. The bearing carrier 44 may be integral with a flange 45 which is attached to a wall of a barrel 1. This form of construction has the advantage that an aperture or apertures of large enough diameter to enable a crankshaft or a shaft carrying eccentrics to be inserted through them can be provided in a wall or walls of a barrel.

According to this invention and as shown in the air-compressor in FIGURES 7 and 9 there may be an oil seal 46 as shown or oil seals of any desired form which may be housed in an aperture in a bearing carrier 44 as shown or in apertures in bearing carriers. There may as shown be a circlip 47 for the axial location of an oil seal 46 in a bearing carrier 44.

According to this invention there may be a casing which surrounds a portion of a main-shaft of a crankshaft or a portion of a shaft carrying eccentrics and which is held in position by a wall of a barrel and which form of construction is shown in the engines in FIGURES 1 and 3 and in FIGURES 4 and 6 in which there may be a casing 48 which surrounds a portion of a main-shaft 9 and which is held in position by a wall of a barrel 1. The casing 48 may be integral with a flange 49. This form of construction has the advantage that the casing may be used for housing and or supporting auxiliaries and or accessories.

According to this invention and as shown in the engine in FIGURES 4 and 6 an outer race ring 34 as shown or outer race rings may be housed in an aperture in a casing 48.

According to this invention and as shown in the engine in FIGURES 4 and 6 there may be an oil seal 50 as shown or oil seals of any desired form which are housed in an aperture in a casing 48.

According to this invention and as shown in the engine in FIGURES 1 and 3 an outer race ring 34 as shown or outer race rings may be housed in an aperture in a bearing housing 51 which is held in position by a casing 48. The bearing housing 51 may be integral with a flange as shown. This form of construction has the advantage of enabling a very rigid housing for the outer race ring or rings to be obtained.

According to this invention and as shown in the engine in FIGURES 1 and 3 an oil seal 50 as shown or oil seals of any desired form may be housed in an aperture in a bearing housing 51 which is held in position by a casing 48.

According to this invention and as shown in the engine in FIGURES 1 and 3 there may be oil seals 50 and 52 on each side of a ball or (needle) roller main bearing 24 as shown. There may as shown be a circlip 53 for the axial location of an oil seal 52 in a casing 48. This form of construction has the advantage of providing a closed space occupied by a main bearing which can be used for the commencement of the distribution of the lubricating oil in a pressure lubricated mechanism.

According to this invention and as shown in the engines in FIGURES 1 and 3 and in FIGURES 4 and 6 there may be closure plate 57 over an aperture in a wall of a barrel 1. The closure plate 57 may have an aperture in it out of which a portion of a main-shaft 10 projects. An outer race ring 36 may be axially located by the closure plate 57.

Separate inner and outer race rings used in the various forms of construction described in the foregoing have the advantage of enabling a worn or damaged main bearing to be readily replaced.

According to this invention and as shown in the engines in FIGURES 1 and 3 and in FIGURES 4 and 6 an oil seal 58 as shown or oil seals of any desired form may be housed in a recess or an aperture in a closure plate 57.

Oil seals used in the various forms of construction described in the foregoing have the advantage of retaining the oil inside; and preventing the entry of foreign matter into the mechanism.

According to this invention and as shown in the engine in FIGURES 1 and 3 there may be a tubular distance piece 54 through which a portion of a main-shaft 9 extends and which is situated between two inner race rings 27 and 28.

According to this invention and as shown in the engine in FIGURES 1 and 3 the inner race rings 27 and 28 which are separated by a tubular distance piece 54 may be axially clamped in position by a nut 55 which is screwed onto a threaded portion of a main-shaft 9 as shown or by any other desired suitable means. There may be a collar 56 of any desired axial length through which a portion of a main-shaft 9 extends which is located between a nut 55 and an inner race ring 27.

According to this invention and as shown in the engine in FIGURES 1 and 3 there may be a collar 59 of any desired axial length into which a portion of a main-shaft 10 extends at the closure plate end and which axially clamps an inner race ring 29. Set-screws 60 may be used for such axial clamping.

These forms of construction have the advantage of providing a means of axial location of the inner race rings which ensures that their faces are truly square with the axis of rotation.

According to this invention a crankshaft or a shaft carrying eccentrics situated completely or partly within a barrel may be rotatably mounted on plain main bearings

of any desired type which are each housed or formed directly in an aperture or recess in a wall of a barrel or in a bearing carrier or housing or in a casing. This form of construction has the advantage of enabling the weight and production costs to be reduced to a minimum.

According to this invention a barrel may be of square or rectangular or of substantially square or rectangular internal cross sectional shape throughout its entire axial length or throughout a portion or portions of its axial length. This form of construction has the advantage of enabling a barrel to be of maximum internal cross sectional area and therefore of enabling the maximum total swept volume to be enveloped within a barrel of given overall dimensions; and also has the advantage of enabling the available depth of a mechanism to be utilised to the best advantage from the view point of accommodating a crankshaft slider-block mechanism, and thereby of enabling the maximum length of stroke of a piston and slides to be obtained.

According to this invention a barrel with an internal cross sectional shape as described may have a blending radius at each of its four corners. This form of construction has the advantage of making for maximum fatigue strength and facilitating manufacture.

A barrel utilising these forms of construction is shown in the engine in FIGURE 6 in which a barrel 1 may as shown be of square internal cross sectional shape throughout its entire axial length with the exception of those portions in the vicinity of the apertures through which the main-shafts 9 and 10 extend and with the exception of the stepped portion at each end which is of rectangular internal cross sectional shape. There may as shown be a small blending radius at each of the four interior corners.

Barrels utilising these forms of construction are again shown in the engine in FIGURE 3 and in the air-compressor in FIGURE 9 in which a barrel 1 may as shown be of rectangular internal cross-sectional shape throughout its entire axial length with the exception of those portions in the vicinity of the apertures through which the main-shafts 9 and 10 and a shaft carrying eccentrics 15 extend respectively. There may as shown be a small blending radius at each of the four interior corners.

According to this invention the slides situated in a barrel may each be of rectangular or substantially rectangular external cross sectional shape throughout their entire length or throughout a portion or portions of their length and which form of construction is shown in the engines in FIGURES 3 and 6 and in the air-compressor in FIGURE 9 in which the slides 2 may each be of rectangular external cross sectional shape throughout most of its length. The slides 2 are a bearing fit in the barrel 1 but in the engine in FIGURE 3 they are not in bearing contact with the barrel 1. Such slides have the advantage that they can be accommodated within a barrel of square or rectangular internal cross sectional shape; and also have the advantage of a large area of bearing surface disposed to resist the cyclical rocking action that the slides are subjected to by a crankshaft slider-block or eccentric slider-block mechanism, thereby making for maximum durability.

According to this invention and as shown in the engines in FIGURES 3 and 6 and in the air-compressor in FIGURE 9 the slides 2 may have longitudinally extending blending radii which correspond with the blending radii of a barrel 1.

According to this invention the slides may have recesses of any desired geometrical form in some or all of their bounding surfaces. Such recesses have the advantage of enabling the slides to have their weight reduced to a minimum.

According to this invention the slide end plates may be of square or rectangular or of substantially square or rectangular peripheral shape to correspond with the internal cross sectional shape of a barrel. Such slide end plates may be any suitable bearing fit in a barrel. Such

slide end plates used in conjunction with slides of rectangular external cross sectional shape have the advantage that no provision need be made to prevent them turning about the central axis of a barrel.

According to this invention the flat peripheral surfaces of the slide end plates may be blended by means of longitudinally extending radii which correspond with the blending radii of a barrel.

But if desired a barrel may be of any other suitable internal cross sectional shape; and also each of the slides may be of any other suitable external cross sectional shape; and also the slide end plates may be of any other suitable peripheral shape.

According to this invention the slide end plates may be of rectangular or substantially rectangular external cross sectional shape and which form of construction is shown in the air-compressor in FIGURES 7 and 8 in which the slide end plates 4 are of rectangular external cross sectional shape on plan view and on end elevation.

According to this invention and as shown in the engine in FIGURES 4 and 5 the slide end plates 4 may each have a recess in them as shown or recesses in them on the same side as the inwardly projecting barrel end covers 5. This form of construction has the advantage of enabling inwardly projecting barrel end covers to be used if desired in combination with small clearance volumes.

But if desired the slide end plates may be of any other suitable external cross sectional shape.

According to this invention and as shown in the engine in FIGURES 1 and 2 and in the air-compressor in FIGURES 7 and 8 the slide end plates 4 may be integral with the slides 2. There may be a blending radius at each end of the four inside corners as shown in FIGURES 1 and 7. This form of construction has the advantage of making for maximum strength and rigidity together with minimum reciprocating mass.

According to this invention and as shown in the engine in FIGURES 4 and 5 there may be separate slide end plates 4 which are attached to the slides 2. The attachment may be made by means of set-screws as shown. This form of construction has the advantage that if desired different materials can be used for the slides and the slide end plates.

According to this invention and as shown in the engine in FIGURE 4 if each of the slides 2 are as shown separate components suitably attached to the slide end plates 4 then each slide 2 may be in one piece.

But if desired and according to this invention if each of the slides are separate components suitably attached to the slide end plates then each slide may consist of any desired number of separate pieces suitably attached together.

According to this invention and as shown in the engine in FIGURES 4 and 5 if each of the slide end plates 4 are as shown separate components suitably attached to the slides 2 then each slide end plate 4 may be in one piece.

But if desired and according to this invention if each of the slide end plates are separate components suitably attached to the slides then each slide end plate may consist of any desired number of separate pieces suitably attached together.

According to this invention and as shown in the engine in FIGURES 1 and 2 and in the air-compressor in FIGURES 7 and 8 the peripheral surfaces of a slide end plate or slide end plates 4 as shown may be flush with the bounding surfaces of the outsides of the slides 2. In this case the width of each of the slide end plates 4 is the same as the outside width of the slides 2 as shown in FIGURES 1 and 7; and the depth of each of the slide end plates 4 is the same as the depth of each of the slides 2 as shown in FIGURES 2 and 8. This form of construction has the advantage of simplifying the manufacture of the inside of a barrel and the manufacture of the slides and slide end plates.

In the engine shown in FIGURES 1 and 2 the swept volume of each of the two charging and scavenging variable volume spaces situated between the slide end plates 4 and barrel end covers 5 is the same as the swept volume of each of the two working variable volume spaces situated between the slides 2.

In the air-compressor shown in FIGURES 7 and 8 the swept volume of each of the two first-stage variable volume spaces situated between the slide end plates 4 and barrel end covers 5 is larger than the swept volume of each of the two second-stage variable volume spaces situated between the slides 2.

According to this invention and as shown in the engine in FIGURE 4 a slide end plate or slide end plates 4 as shown may be of greater width than the outside width of the slides 2. With this form of construction the depth of a slide end plate or slide end plates 4 is the same as the depth of the slides 2 as shown in FIGURE 5. This form of construction has the advantage of enabling the swept volume of each of the two charging and scavenging variable volume spaces situated between the slide end plates 4 and barrel end covers 5 to be considerably larger than the swept volume of each of the two working variable volume spaces situated between the comparatively thin slides 2 as shown in FIGURES 4 and 5. This form of construction also has the advantage of enabling a number of small additional variable volume spaces to be obtained within a barrel which could be used for any desired purpose.

According to this invention and as shown in the engine in FIGURE 4 a barrel 1 may be of stepped internal cross sectional shape at one end or at both ends as shown. With this form of construction the barrel 1 is of constant depth throughout its axial length as shown in FIGURE 5. This form of construction has the advantage of enabling a slide end plate or plates to be of greater width than the outside width of the slides.

According to this invention and as shown in all the drawings from FIGURES 1 to 9 inclusive there may be a piston 3 which consists of a piston crown 61 at each end which are joined together by a longitudinally extending joining plate 62. A piston 3 may be any suitable bearing fit in a barrel 1 between the slides 2.

According to this invention and as shown in the engine in FIGURES 4, 5 and 6, and in the air-compressor in FIGURES 7, 8, and 9, there may be a longitudinally extending joining plate 62 between the piston crowns 61 which is as shown of rectangular or substantially rectangular external cross sectional shape throughout the whole or most of its axial length. This form of construction has the advantage in the case of a crankshaft slider-block mechanism of enabling the two inner crankwebs 11 to be situated in the two spaces between the slides 2 and a joining plate 62 as shown in FIGURES 4 and 6; and thereby making for extreme compactness and light weight.

According to this invention and as shown in the engine in FIGURES 1, 2, and 3, there may be a longitudinally extending joining plate 62 between the piston crowns 61 which is of I external cross sectional shape throughout the whole or most of its axial length. This form of construction has the additional advantage in comparison with a joining plate of rectangular external cross sectional shape of providing a larger area of bearing surface in contact with the barrel walls.

But if desired a longitudinally extending joining plate between the piston crowns may be of any other suitable external cross-sectional shape.

According to this invention and as shown in all the drawings from FIGURES 1 to 9 inclusive the piston crowns 61 may be as shown of rectangular or substantially rectangular peripheral shape. Such piston crowns have the advantage that they may be accommodated within a barrel of square or rectangular internal cross sectional shape, and may be situated between slides of

rectangular external cross sectional shape; and also have the advantage of a large area of bearing surface disposed to resist the cyclical rocking action that a piston is subjected to by a crankshaft slider block or eccentric slider-block mechanism, thereby making for maximum durability.

But if desired the piston crowns may be of any other suitable peripheral shape.

According to this invention a longitudinally extending joining plate as described may have recesses of any desired geometrical form in some or all of its bounding surfaces. Such recesses would be of advantage if it was desired to reduce the weight of a piston to a minimum.

According to this invention and as shown in the engine in FIGURES 1 and 2 and in the air-compressor in FIGURES 7 and 8 a piston 3 which has a piston crown 61 at each end of a longitudinally extending joining plate 62 may be in one piece. This form of construction has the advantage of providing a piston of maximum strength and rigidity for a given reciprocating mass.

According to this invention and as shown in the engine in FIGURES 4 and 5 the piston crowns 61 and a longitudinally extending joining plate 62 may be separate components suitably attached together. The attachment may be made by means of set-screws as shown. This form of construction has the advantage that if desired different materials can be used for the piston crowns and a longitudinally extending joining plate.

According to this invention and as shown in the engine in FIGURES 4 and 5 if a longitudinally extending joining plate 62 is as shown a separate component suitably attached to the piston crowns 61 then a longitudinally extending joining plate 62 may be in one piece.

But if desired and according to this invention if a longitudinally extending joining plate is a separate component suitably attached to the piston crowns then a longitudinally extending joining plate may consist of any desired number of separate pieces suitably attached together.

According to this invention and as shown in the engine in FIGURES 4 and 5 if each of the piston crowns 61 are as shown separate components suitably attached to a longitudinally extending joining plate 62 then each piston crown 61 may be in one piece.

But if desired and according to this invention if each of the piston crowns are separate components suitably attached to a longitudinally extending joining plate then each piston crown may consist of any desired number of separate pieces suitably attached together.

According to this invention and as shown in the air-compressor in FIGURES 7 and 8 the piston crowns 61 may be flat at each end of a piston 3.

But if desired and according to this invention and as shown in the engine in FIGURES 4 and 5 the piston crowns 61 may each have a recess in them at each end of a piston 3.

According to this invention and as shown in the engine in FIGURE 1 and in the air-compressor in FIGURE 7 there may be blending radii between the piston crowns 61 and some as shown or all of their flat peripheral surfaces. In these cases these blending radii correspond with the blending radii of the slide-end plates 4. This form of construction has the advantage as shown of enabling the piston crowns to be brought into close proximity to slide end plates which have corresponding blending radii.

According to this invention and as shown in the engine in FIGURES 1 and 2 there may be a hemispherical recess 63 as shown or a substantially hemispherical recess in the inside of each slide end plate 4 and a hemispherical recess 64 as shown or a substantially hemispherical recess in each of the piston crowns 61 which are so disposed as to form spherical as shown or substantially spherical combustion chambers when the piston crowns 61 and the insides of the slide end plates 4 are in close proximity to one another at the inner dead-centre positions. A very small clearance may be used between each piston crown

61 and the inside of each slide end plate 4. There may be inclined projections 65 which are integral with the piston crowns 61 as shown or are suitably attached to the piston crowns and which are in close proximity to the surfaces of the hemispherical recesses 64 as shown or the substantially hemispherical recesses in the piston crowns 61 and which inclined projections 65 fit into corresponding inclined recesses 66 in the insides of the slide end plates 4 and which inclined recesses 66 merge into the surfaces of the hemispherical recesses 63 as shown or the substantially hemispherical recesses in the insides of the slide end plates 4. A very small clearance may be used between the bounding surfaces of each inclined projection 65 on each piston crown 61 and the bounding surfaces of each inclined recess 66 in the inside of each slide end plate 4. There may be recesses 67 in the piston crowns 61 and recesses 68 in the slide end plates 4 which may be used to bring injection nozzles (not shown) into cyclical communication with the combustion chambers in the inner dead-centre position.

A combustion chamber with an accompanying inclined projectoin as described and used in a compressor-ignition internal combustion engine has the following advantages. By using very small clearances between the various surfaces, violent ejection of the charge takes place from between the clearance space substantially tangentially into the main combustion chamber; thereby causing a high velocity rotational swirl to take place which makes for rapid and complete combustion. This makes for a high output per unit of working swept volume and a high thermal efficiency.

According to this invention and as shown in the engines in FIGURES 1 and 2 and in FIGURES 4 and 5 and in air-compressor is FIGURES 7 and 8 there may be sealing strips 69 set transversely to the central axis of a barrel 1 and retained in grooves in the flat peripheral surfaces of the slide end plates 4. These sealing strips 69 are held in sliding contact with the flat surfaces of the walls of a barrel 1 by means of springs which are not shown. The sealing strips 69 are shown in cross section. Preferably the ends of these sealing strips are of diagonal form and are in close proximity to one another to form gaps in the vicinity of the corners of a barrel.

There may as shown in FIGURE 1 and in FIGURES 4 and 5 be peripheral grooves 70 in the flat peripheral surfaces of the slide end plates 4 and which grooves 70 are in close proximity to the sealing strips 69 and are merged into the grooves which retain the sealing strips 69. These grooves being for lubricating oil and scraping purposes.

According to this invention and as shown in the engine in FIGURE 1 there may be scraper strips 71 set transversely to the central axis of a barrel 1 and retained in grooves in the flat bounding surfaces of the slides 2 as shown and or in the flat peripheral surfaces of the slide end plates. These scraper strips 71 have grooves in their sliding contact surfaces and have holes or slots through them; and are held in sliding contact with the flat surfaces of the walls of a barrel 1 by means of springs which are not shown. The scraper strips 71 are shown in cross section.

According to this invention and as shown in the engine in FIGURE 5 there may be sealing strips 77 set transversely to the central axis of a barrel 1 and extending across those portions of the periphery of each slide end plate 4 which extends transversely between the longitudinally disposed slides 2 and which sealing strips 77 are retained in grooves in these flat portions of the peripheral surfaces and which sealing strips 77 are held in sliding contact with the flat surfaces of the walls of a barrel 1 by means of springs which are not shown.

According to this invention and as shown in the engines in FIGURE 3 and in FIGURE 6 and in the air-compressor in FIGURE 9 there may be longitudinally disposed sealing strips 75 retained in grooves in the flat upper and

lower bounding surfaces of the slides 2. These sealing strips 75 are held in sliding contact with the flat surfaces of the walls of a barrel 1 by means of springs which are not shown. The sealing strips are shown in cross section. Preferably these sealing strips extend from end to end of the slides. If these longitudinally disposed sealing strips are separate components then preferably each end of these strips is brought into close proximity to a sealing strip which is set transversely to the central axis of a barrel to provide gaps which are reduced to a minimum.

According to this invention and as shown in the engine in FIGURES 2 and 3 the sealing strips 69 which are set transversely to the central axis of a barrel 1 may be integral with the longitudinally disposed sealing strips 75. This form of construction has the advantage of eliminating gap leakage losses.

According to this invention and as shown in the engines in FIGURES 1 and 2 and in FIGURES 4 and 5 and in the air-compressor in FIGURES 7 and 8 there may be sealing strips 72 set transversely to the central axis of a barrel 1 and retained in grooves in the flat peripheral surfaces of the piston crowns 61. These sealing strips 72 are held in sliding contact with the flat surfaces of the walls of a barrel 1 and with the flat bounding surfaces of the slides 2 by means of springs which are not shown. The sealing strips 72 are shown in cross section in these drawings. Preferably the ends of these sealing strips are of diagonal form and are in close proximity to one another to form gaps in the vicinity of the corners of the piston crowns.

There may as shown in FIGURE 1 and in FIGURES 4 and 5 be peripheral grooves 73 in the flat peripheral surfaces of the piston crowns 61 and which grooves 73 are in close proximity to certain of the sealing strips 72 and are merged into certain of the grooves which retain the sealing strips 72. These grooves being for lubricating oil scraping purposes.

According to this invention and as shown in the engine in FIGURE 1 there may be scraper strips 74 set transversely in the central axis of a barrel 1 and retained in grooves in the flat peripheral surfaces of the piston crowns 61. These scraper strips have grooves in their sliding contact surfaces and have holes or slots through them; and are held in sliding contact with the flat bounding surfaces of the slides 2 as shown and or with the flat surfaces of the walls of a barrel by means of springs which are not shown. The scraper strips 74 are shown in cross section.

Some or all of the sealing strips may be of square or rectangular or of substantially square or rectangular cross sectional shape and which form of construction is shown in the engine in FIGURES 1, 2, and 3, and in the air-compressor in FIGURES 7, 8, and 9, in which there may be sealing strips 69, 72, 75, and 77, which are of rectangular cross sectional shape.

Some or all of the sealing strips may be of wedge cross sectional shape and which form of construction is shown in the engine in FIGURES 4, 5, and 6, in which there may be sealing strips 69, 72, 75, and 77, which are of wedge cross sectional shape.

Some or all of the scraper strips of a geometrical form as described in the foregoing may be parallel sided or may be of wedge cross sectional shape.

Sealing and scraper strips of wedge cross sectional shape have the advantage of reducing strip gumming tendencies to a minimum at high temperatures in internal combustion engines.

According to this invention there may be longitudinally disposed sealing strips 78 of L cross sectional shape as shown in the air-compressor in FIGURE 9 or of substantially L cross sectional shape as shown in the engine in FIGURE 6 and which sealing strips are retained in grooves in the vicinity of the longitudinally extending edges of the slides 2. This form of construction has the advantage of enabling the flat sliding sealing surfaces of

the sealing strips to be in very close proximity to the longitudinally extending edges of the slides whilst still maintaining adequate strength of the slides in the vicinity of these edges; and thereby of enabling more satisfactory fluid sealing to be obtained.

Sealing strips of a form and used as described in the foregoing have the advantage of making for efficient sealing of the variable volume spaces, which is of particular importance in the case of internal combustion engines and air-compressors.

Scraper strips of a form and used as described in the foregoing have the advantage of enabling the lubricating oil to be controlled and thereby of bringing about a satisfactorily low oil consumption in the case of an internal combustion engine.

According to this invention and as shown in the engines in FIGURES 2 and 3 and in FIGURES 5 and 6 there may be longitudinally disposed strips 79 retained in grooves in the flat upper and lower bounding surfaces of a longitudinally extending joining plate 62 of a piston 3 and which strips 79 are held in sliding contact with the flat surfaces of the walls of a barrel 1 by means of springs which are not shown. The strips 79 are shown in cross section in FIGURES 3 and 6. Preferably these longitudinally disposed strips extend from end to end of a joining plate. These strips may as shown be separate from or may be integral with the sealing strips which are set transversely to the central axis of a barrel and retained in grooves in the flat peripheral surfaces of the piston crowns.

According to this invention and as shown in the engine in FIGURE 3 there may be longitudinally disposed strips 80 retained in grooves in the longitudinally extending edges of the joining plate of 1 external cross sectional shape 62 of a piston 3 and which strips 80 are held in sliding contact with the flat bounding surfaces of the slides 2 by means of springs which are not shown. The longitudinally disposed strips 80 are shown in cross section. These strips may be separate from or integral with the sealing strips which are set transversely to the central axis of a barrel and retained in grooves in the flat peripheral surfaces of the piston crowns.

Such strips used in an internal combustion engine have the advantage of improving the thermal linkage and thereby of improving the cooling of a piston.

Some or all of the longitudinally disposed strips may be of square or rectangular or of substantially square or rectangular cross sectional shape and which form of construction is shown in the engines in FIGURES 3 and 6 in which there may be longitudinally disposed strips 79 which are of rectangular cross sectional shape, and is shown in the engine in FIGURE 3 in which there may be longitudinally disposed strips 80 which are of square cross sectional shape.

Some or all of the sealing strips mentioned in the foregoing may be of such a depth that they contact the base of the grooves in which they are situated and protrude from those grooves and which form of construction is shown in the engine in FIGURES 2 and 3 in which there may be sealing strips 69 and 75 which are of such a depth that they contact the base of the grooves in which they are situated and protrude from those grooves by a minute amount and thereby function as load carrying bearing surfaces. The minute amount by which these sealing strips protrude is not shown.

According to this invention and as shown in the engine in FIGURE 1 there may be flat bearing plates 81 retained in recesses in the flat bounding surfaces of the slides 2 and in sliding contact with the flat surfaces of the walls of a barrel 1. The thickness of each flat plate 81 is greater than the depth of the recess in which it is situated such that it protrudes from the recess. The minute amount by which these bearing plates protrude is not shown. Some or all of these flat bearing plates may be held in sliding contact with the flat surfaces of the barrel

walls by means of springs which are not shown. Such springs used in an internal combustion engine have the advantage of improving the thermal linkage and thereby of improving the cooling of the slides. Some or all of these flat bearing plates may have apertures of any desired geometrical form through them which are not shown. Such apertures have the advantage of enabling flat bearing plates to have their weight reduced to a minimum.

This form of construction has the advantage that by this means the surfaces of the slides are brought out of contact with the surfaces of the barrel walls and thereby of enabling light alloys to be used for the barrel and slides.

According to this invention and as shown in all the drawings from FIGURES 1 to 9 inclusive a barrel 1 may be in one piece.

But if desired and according to this invention a barrel may consist of any desired number of separate pieces suitably attached together.

A barrel may have walls locally shaped to any other desired suitable internal and/or external shape. For example it might be desired to make a barrel of increased overall dimensions and/or of a different shape in the vicinity of a crankshaft or a shaft carrying eccentrics to enable an increased length of crank-throw or eccentric-throw to be accommodated. Or again for example it might be desired to accommodate an oil sump within a barrel and thereby necessitate a different internal and external local shape.

According to this invention and as shown in the engine in FIGURES 1, 2, and 3, and in the air-compressor in FIGURES 7, 8, and 9, a barrel 1 may have peripheral fins 82 on it. In these examples the entire exterior surfaces of the walls of a barrel 1 are used to carry integral peripheral fins 82. This form of construction has the advantage of providing the necessary area of cooling surface together with the maximum peripheral strength and rigidity throughout the entire axial length of a barrel.

According to this invention a barrel may have longitudinal fins on it. This form of construction is of advantage if the central axis of a barrel is parallel with the air flow direction, as then the air flows comparatively smoothly through the fins.

According to this invention and as shown in the engine in FIGURES 1, 2, and 3, a finned air-cooled barrel 1 may be situated inside a duct 83. The construction of this duct may be as follows. Each end of the duct 83 may be welded to a ring 84 which is spigoted onto a barrel end cover 5. In the vicinity of the bearings there may be circular apertures into which circular rings 85 and 86 are welded. The rings 85 and 86 may be spigoted in position on the bearing carrier 44 and on the closure plate 57 respectively. The cooling air intakes 87 may be welded to the duct 83. The cooling air may leave the duct through apertures on the opposite side of the barrel 1 to the cooling air intakes 87. These apertures are not shown. This form of construction has the advantage of constraining all the cooling air to flow through the fins and around the entire periphery of the fins.

According to this invention a barrel may be situated inside a jacket. This jacket may be integral with a barrel or may be a separate component as shown in the engine in FIGURES 4, 5, and 6, in which a barrel 1 may be inside a jacket 88. The construction of this jacket may be as follows. Each end of the jacket 88 may be welded to a ring 89 which is spigoted onto a barrel end cover 5. In the vicinity of the bearings there may be circular apertures into which circular rings 90 and 91 are welded. The rings 90 and 91 may be spigoted in position on the bearing carrier 44 and on the closure plate 57 respectively. The coolant inlet and outlet pipes which are not shown in these drawings may be welded in position on the jacket 88. This form of construction which is suitable for either a liquid or evaporatively-cooled internal

combustion engine has the advantage of enabling the coolant spaces to be readily cleaned when overhauling.

According to this invention and as shown in the engine in FIGURES 1 and 2 and in the air-compressor in FIGURES 7 and 8 the barrel end covers 5 may be separate components each in one piece attached to the ends of a barrel 1. Although not shown the barrel end covers may have inwardly projecting portions. This form of construction has the advantage of enabling a barrel which is in one piece to be used.

According to this invention and as shown in the engine in FIGURES 4 and 5 the barrel end covers 5 may each consist of two separate covers 5 which are attached to the ends of a barrel 1. The barrel end covers may as shown have inwardly projecting portions. This form of construction has the additional advantage of enabling disc valves to be accommodated between the two separate covers.

In these particular examples the barrel end covers 5 are attached to the ends of a barrel 1 by means of set-screws.

But if desired and according to this invention each barrel end cover may consist of any desired number of separate pieces suitably attached together and to the ends of a barrel.

But if desired and according to this invention a barrel end cover or covers may be integral with a barrel. This form of construction has the advantage of completely eliminating any barrel end cover fixing troubles.

According to this invention and as shown in the engine in FIGURES 1 and 2 the barrel end covers 5 may have recesses 92 in their inside surfaces and into which fit corresponding projections 93 which are suitably attached to or are as shown integral with the outsides of the slide end plates 4. This form of construction has the advantage of enabling hemispherical combustion chamber halves to be accommodated in the insides of comparatively thin slide end plates.

But if desired the barrel end covers may be of any other suitable geometrical form.

According to this invention and as shown in the engines in FIGURES 1 and 3 and in FIGURES 4 and 6 there may be mounting lugs 94 which are suitably attached to or as shown are integral with the barrel end covers 5. This form of construction has the advantage that it provides a strong, light, and compact, method of mounting.

According to this invention a disc valve or valves may be carried by and their port or ports contained by a barrel end cover or covers and or by a wall or walls of a barrel and which form of construction is shown in the engine in FIGURES 4 and 5 in which at each end of a barrel 1 there may be automatic inlet disc valves 95 which are accommodated in recesses and between two separate covers 5 which are clamped together to form a barrel end cover 5. In this case the disc valves 95 have scalloped peripheries which allow the induction air or mixture to flow through them when they are in the open position. By way of example the valves on the left-hand side are shown in the open position and the valves on the right-hand side are shown in the closed position. In this case each of the disc valves 95 has a boss at its centre which has a hole through it into which is hooked an extension spring 96. The opposite end of each extension spring 96 is hooked into a hole through a spring anchor bar 97 which is retained in a recess in the inlet port wall 98. In this case for each inlet disc valve 95 there is a corresponding inlet port 99 in each of the two separate covers 5 which are clamped together to form a barrel end cover 5. In this case there are flat annular seats on each side of each disc valve 95 which are formed on the two separate covers 5. Disc valves have the advantage that they are particularly suitable for use as pneumatically actuated inlet valves because of their light reciprocating weight.

According to this invention a poppet valve or valves may be carried by and their port or ports contained by a barrel end cover or covers and or by a wall or walls of

a barrel and which form of construction is shown in the air-compressor in FIGURE 8 in which there may be automatic delivery poppet valves 100 carried by a wall of a barrel 1. In this case each delivery poppet valve 100 has a stem which reciprocates in a valve guide 101 which is fixed to a wall of a barrel 1. In this case each delivery poppet valve 100 has a conical face which seats on a conical valve seat formed directly on a wall of a barrel 1, and are each controlled by a compression coil spring 102. To each delivery poppet valve 100 there is a corresponding delivery port 103 in a wall of a barrel 1. Poppet valves have the advantage that they are particularly suitable for use as pneumatically actuated delivery valves for air-compressors, as they make for the maximum degree of fluid tightness when closed combined with small percentage clearance volume spaces.

But if desired any other suitable valve mechanism may be carried by a barrel end cover or covers and or by a wall or walls of a barrel.

According to this invention there may be a port or ports in a slide or slides and which form of construction is shown in the engine in FIGURES 1 and 2 in which there may be transfer ports 104 in the slides 2 and is shown in the engine in FIGURES 4 and 5 in which there may be exhaust ports 107 in the slides 2.

According to this invention there may be a port or ports in a wall or walls of a barrel and which form of construction is shown in the engine in FIGURES 1 and 2 in which there may be transfer ports 105 and exhaust ports 113 and inlet ports 120 in the walls of a barrel 1; and is shown in the engine in FIGURE 4 in which there may be exhaust ports 108 in the walls of a barrel 1; and is shown in the air-compressor in FIGURES 7 and 8 in which there may be inlet ports 116 in the walls of a barrel 1.

In the engine in FIGURES 1 and 2 as the slides 2 reciprocate so the transfer ports 104 are brought into cyclical communication with the transfer ports 105, and as the piston 3 reciprocates so the exhaust ports 113 are subjected to a cyclical opening and closing action. In the engine in FIGURES 4 and 5 as the slides 2 reciprocate so the exhaust ports 107 are brought into cyclical communication with the exhaust ports 108. In the air-compressor in FIGURES 7 and 8 as the slides 2 reciprocate so the inlet ports 116 are subjected to a cyclical opening and closing action. These forms of construction have the advantage of enabling the variable volume mechanism to act as valve gear.

According to this invention and as shown in the engine in FIGURE 1 there may be transfer ports 104 in the slides 2 which are surrounded by sealing rings 106 retained in grooves in the flat bounding surfaces of the slides 2 and which sealing rings 106 are held in sliding contact with the flat surfaces of the walls of a barrel 1 by means of springs which are not shown. The sealing rings are shown in cross section. This form of construction has the advantage of improving the sealing of the working variable volume spaces.

Some or all of the sealing rings may be of square or rectangular or of substantially square or rectangular cross sectional shape and which form of construction is shown in the engine in FIGURE 1 in which there may be sealing rings 106 of rectangular cross sectional shape.

According to this invention and as shown in the engine in FIGURE 4 there may be exhaust ports 107 in the slides 2 which are bushed by exhaust port bushes 109. In this case each exhaust port bush 109 has a flange 110 at one end which is situated in a recess; and which flange has a peripheral bevel over which the slide material is peened, which has the advantage of preventing each bush from moving axially in the event of its working loose.

According to this invention and as shown in the engine in FIGURES 1 and 2 there may be exhaust ports 113 in the walls of a barrel 1 which are bushed by means of exhaust port bushes 114. In this case each exhaust port bush 114 has a flange 110 at one end which is situated in a recess.

Bushed exhaust ports have the advantage that each bush may be made in a hard corrosion and erosion resisting alloy steel, thereby enabling light alloys to be used for the slides and a barrel.

According to this invention and as shown in the engine in FIGURE 4 there may be exhaust ports 111 situated along the sides of the walls of a barrel 1 and which have bounding walls 112 which as shown may be integral with the walls of a barrel 1. The exhaust ports 111 being joined to the exhaust ports 108 in the walls of a barrel 1.

According to this invention and as shown in the engine in FIGURES 4 and 5 and in the air-compressor in FIGURES 7 and 8 there may be a transfer recess or as shown recesses 115 in a wall or as shown walls of a barrel 1. As the slide end plates 4 reciprocate the transfer recesses 115 are subjected to a cyclical opening and closing action. This form of construction has the advantage of extreme simplicity.

Such arrangements of transfer ports and or recesses and exhaust ports for use in two-stroke cycle internal combustion engines as described in the foregoing have the advantage of enabling end to end scavenging to be used.

According to this invention and as shown in the air-compressor in FIGURE 7 there may be inlet ports 117 situated along the sides of the walls of a barrel 1 and which have bounding walls 118 which as shown may be integral with the walls of a barrel 1. The inlet ports 117 being joined to the inlet ports 116 in the walls of a barrel 1. The bounding walls 118 may as shown have integral fins 123 on them.

Inlet and exhaust ports situated along the sides of the walls of a barrel have the advantage of compactness.

According to this invention a rotary inlet valve or inlet valves may be combined with a crankshaft and which form of construction is shown in the engine in FIGURE 1 in which there may be a crankshaft 6 which has a rotary inlet valve combined with it and formed by a crank-web 119 which is of partially circular shape viewed along the central axis YY of a crankshaft 6 and is situated in a circular recess in a wall of a barrel 1. In this case there is a small radial clearance which is not shown between the crank-web 119 and the recess in which it is situated. In this case there are inlet ports 120 which have bounding walls 121 which are integral with a wall of a barrel 1. In this case there is a recessed portion 122 in the periphery of the crank-web 119. The inlet port 120 on the left-hand side is shown opened by the recess 122 and the charging and scavenging variable volume space on that side is thereby shown as being brought into communication with the interior of the central zone of the engine; and the inlet port 120 on the right-hand side is shown closed by the partially circular crank-web 119. As the rotary inlet valve formed by the crank-web 119 rotates so the inlet ports 120 are subjected to a cyclical opening and closing action.

According to this invention a rotary inlet valve or inlet valves may be combined with a shaft carrying eccentrics. Such a valve may be integral with or suitably attached to such a shaft. Such a rotary inlet valve may be of a form and may operate in a manner substantially as described in the foregoing for a crankshaft rotary inlet valve.

Rotary inlet valves have the advantage of being suitable for high shaft rotative speeds together with high volumetric efficiencies. They also have the advantage of extreme compactness.

According to this invention there may be an inlet port or ports into the interior of the central zone of a barrel. Such ports have the advantage that they may if desired also be used as breathers for a barrel.

In this mechanism there may be four separate variable volume spaces within a barrel. For this reason a barrel which envelops a given total swept volume may

be of minimum overall dimensions and weight; and thereby enables the overall dimensions and weight of a given engine and a pump and the like to be reduced to a minimum.

Also because of the small overall dimensions great rigidity can be obtained; and thereby enables elastic vibration troubles to be reduced to a minimum, and ensures that the mechanism operates under the best possible conditions of alignment and minimum frictional losses.

Again because of the small overall dimensions a very short crankshaft or shaft carrying eccentrics can be used, which has the advantage of enabling maximum torsional and flexural rigidity to be obtained and thereby of enabling torsional vibration and whipping troubles to be reduced to a minimum.

The total length of the volume varying stroke in the two variable volume spaces between the slides is equal to the sum of the stroke of a piston and the stroke of the slides. This enables a long total length of stroke to be obtained in each of these two variable volume spaces but with a mechanical stroke of a short length. This has the advantage of enabling a high rotative speed of a crankshaft or of a shaft carrying eccentrics to be obtained without unduly high mean linear and rubbing speeds of a piston and slides. This has the advantage of reducing the inertia loading and making for maximum durability.

Because the area of oil film to be sheared can be reduced to a minimum, because of the very small overall dimensions for a given total swept volume, this mechanism has the advantage of minimum frictional losses, and therefore of a high mechanical efficiency.

This mechanism arranged as a double-acting internal combustion engine operating on the two-stroke cycle provides two evenly spaced expansion strokes per piston per barrel per revolution of the output shaft. This has the advantage that an engine with a given number of barrels has the most uniform torque output and torque recoil possible; and this together with the perfect dynamic balance, and the great all round rigidity that can be obtained, makes for very smooth operation.

This mechanism arranged as a double-acting internal combustion engine operating on the two-stroke cycle has the advantage that the timed positive displacement charging and scavenging pumps may be contained in each barrel; thereby obviating the necessity for separate external pumps and their attendant pipes. This makes for minimum overall dimensions and weight for a given working swept volume.

This mechanism arranged as a double-acting internal combustion engine operating on the two-stroke cycle as described in the foregoing has the advantage that the dynamic loading acting on the main reciprocating components is opposed by the fluid loading acting on the main reciprocating components at each end of each stroke. This has the advantage of enabling the mean combined loading acting on the crank-pin and slider-block bearings to be reduced to a minimum for an engine of a given total swept volume, and thereby of enabling these bearings to be of small overall dimensions whilst still retaining adequate durability.

This mechanism arranged as a combined single-acting internal combustion engine operating on the two-stroke cycle and as a single-acting single-stage or two-stage air-compressor has the advantage of the power being transmitted directly from one piston crown to the other through the joining plate and of being transmitted directly from one slide end plate to the other through the slides. The crankshaft slider-block mechanism in this case merely performing the function of a synchronizing mechanism that causes the slides and a piston to reciprocate in the correct relationship to one another.

This mechanism arranged as a double-acting internal combustion engine operating on the two-stroke cycle as

described in the foregoing has the advantage that the loads produced by the high pressure working fluid in the working variable volume spaces and acting on a crankshaft always cancel out; and therefore the main bearings are not subjected to these loads. If such a mechanism has the main moving components within a barrel in perfect balance for inertia forces and couples and for centrifugal forces and couples in a manner as described in the foregoing; then the main bearings are not subjected to dynamic loading. The main bearings will then only be subjected to the light loading produced by the low pressure air or mixture in the charging and scavenging variable volume spaces. This has the advantage of making for maximum reliability and durability of the main bearings.

This mechanism arranged as a power gas generator for compounding with a gas turbine has the advantage that end to end scavenging may be obtained, which together with the fact that the transfer and exhaust ports may open simultaneously enables a much larger volume of air to be passed from end to end through each working variable volume space than is defined by their swept volumes. The timed positive displacement pumps which may be contained within a barrel are very suitable for supplying this much larger volume of air against a very high exhaust back pressure.

This mechanism arranged as an internal combustion engine and or a pump may be charged completely, or additionally, by means of any desired form of positive displacement pump(s) or kinetic pump(s) which could be driven by the engine and or exhaust gas turbine(s).

This mechanism arranged as an internal combustion engine and a pump and the like may have the four variable volume spaces per barrel utilised in any other desired suitable manner. For example the two-stroke or four-stroke cycle could be performed in any or all of the four variable volume spaces.

A mechanism in accordance with this invention may also be arranged to function as a simple or compound steam engine. It may also be arranged to function as a combined internal combustion engine and a simple or compound steam engine.

This mechanism may be arranged as a single or multiple-stage pneumatic or hydraulic pump or motor; or as a vacuum pump.

This mechanism as described in the foregoing may be integral with or may be attached to any other mechanism(s).

From the foregoing it will be realised that an engine and a pump and the like in accordance with this invention can be provided which will be in keeping with the objects of this invention as stated at the beginning of this specification.

I claim:

1. In a reciprocating engine, a barrel, said barrel extending longitudinally, slides situated in said barrel, said slides disposed longitudinally to said barrel, said slides so disposed that there is a space between them, each of said slides disposed along a portion of the periphery of said barrel such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, said slides reciprocate in said barrel, a piston situated in said barrel in said space between said slides, said piston engages said slides, said piston engages said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston engages said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides, said piston engages said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides, said piston reciprocates in said barrel in said space between said slides, slide end plates situated in said barrel, said slide end plates disposed transversely to said slides, said slides joined together at their ends by said slide end plates,

said slide end plates and said slides reciprocate as a unit in said barrel, said piston has a movement of opposite directional sense to said slides and said slide end plates, barrel end covers at the ends of said barrel.

2. In a reciprocating engine, according to claim 1, a rotatably mounted crankshaft situated in said barrel, said crankshaft has three crank-pins, the outer two of said crank-pins being co-axial and extend through apertures in said slides situated in said barrel, said slide end plates situated in said barrel and disposed transversely to said slides, said slides so disposed that there is a space between them are joined together at their ends by said slide end plates, each of said slides disposed along a portion of the periphery of said barrel such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, and the outer two of said crank-pins being opposite to an inner one of said crank-pins which extends through an aperture in said piston, said piston situated in said barrel in said space between said slides, said piston engages said slides, said piston engages said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston engages said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides, said inner crank-pin and said outer two crank-pins joined together and joined to main-shafts by four crank-webs, two of said crank-webs each situated between said piston and a said slide, and two of said crank-webs situated outside said slides, said slides connected to said outer two crank-pins by slider-blocks and said piston connected to said inner crank-pin by a slider-block, said slider-blocks have bearings in them which operate on said outer two crank-pins and have flat faces on their outsides which move between flat parallel faces of said apertures in said slides, a said slider-block has a bearing in it which operates on said inner crank-pin and has flat faces on its outsides which move between flat parallel faces of said aperture in said piston.

3. In a reciprocating engine, according to claim 1, a rotatably mounted shaft carrying three eccentric-sheaves situated in said barrel, said shaft carrying three eccentric-sheaves extends through apertures in said slides situated in said barrel, said slide end plates situated in said barrel and disposed transversely to said slides, said slides so disposed that there is a space between them are joined together at their ends by said slide end plates, each of said slides disposed along a portion of the periphery of said barrel such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, and said shaft carrying three eccentric-sheaves extends through an aperture in said piston, said piston situated in said barrel in said space between said slides, said piston engages said slides, said piston engages said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston engages said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides, the outer two of said eccentric-sheaves being co-axial and being opposite to an inner one of said eccentric-sheaves, said slides connected to said outer two eccentric-sheaves by slider-blocks and said piston connected to said inner eccentric-sheave by a slider-block, said slider-blocks have bearings in them which operate on said outer two eccentric-sheaves and have flat faces on their outsides which move between flat parallel faces of said apertures in said slides, a said slider-block has a bearing in it which operates on said inner eccentric-sheave and has flat faces on its outside which

move between flat parallel faces of said aperture in said piston.

4. In a reciprocating engine, according to claim 1, said barrel is of rectangular internal cross sectional shape, said slides situated in said barrel and so disposed that there is a space between them are each of rectangular external cross sectional shape to correspond with said rectangular internal cross sectional shape of said barrel, each of said slides of rectangular external cross sectional shape disposed along a portion of the periphery of said barrel of rectangular internal cross sectional shape such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, said slide end plates situated in said barrel and disposed transversely to said slides are of rectangular peripheral shape to correspond with said rectangular internal cross sectional shape of said barrel, said slides joined together at their ends by said slide end plates, said piston situated in said barrel in said space between said slides, said piston consists of a piston crown at each end joined together by a longitudinally extending joining plate, said piston crowns are of rectangular peripheral shape to correspond with rectangular internal cross sectional shape of space between said slides which are each of rectangular external cross sectional shape within said barrel of rectangular internal cross sectional shape, said piston crowns of rectangular peripheral shape engage flat vertical inner bounding surfaces of said slides, said piston crowns of rectangular peripheral shape and said longitudinally extending joining plate engage flat horizontal surface of upper wall of said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston crowns of rectangular peripheral shape and said longitudinally extending joining plate engage flat horizontal surface of lower wall of said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides.

5. In a reciprocating engine, according to claim 1, said slide end plates are integral with said slides, said slide end plates and said slides situated in said barrel, said slide end plates disposed transversely to said slides, said slides so disposed that there is a space between them are joined together at their ends by said slide end plates, each of said slides disposed along a portion of the periphery of said barrel such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, said piston situated in said barrel in said space between said slides, said piston which is in one piece consists of a piston crown at each end joined together by a longitudinally extending joining plate, said piston crowns engage said slides, said piston crowns and said longitudinally extending joining plate engage said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston crowns and said longitudinally extending joining plate engage said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides.

6. In a reciprocating engine, according to claim 1, separate said slide end plates attached to said slides, said slide end plates and said slides situated in said barrel, said slide end plates disposed transversely to said slides, said slides so disposed that there is a space between them are joined together at their ends by said slide end plates, each of said slides disposed along a portion of the periphery of said barrel such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner

edges of said slides, said piston situated in said barrel in said space between said slides, said piston consist of a piston crown at each end joined together by a longitudinally extending joining plate, said piston crowns and said longitudinally extending joining plate are separate components attached together, said piston crowns engage said slides, said piston crowns and said longitudinally extending joining plate engage said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston crowns and said longitudinally extending joining plate engage said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides.

7. In a reciprocating engine, according to claim 1, said barrel is of rectangular internal cross sectional shape, said slides situated in said barrel and so disposed that there is a space between them are each of rectangular external cross sectional shape to correspond with said rectangular internal cross sectional shape of said barrel, each of said slides of rectangular external cross sectional shape disposed along a portion of the periphery of said barrel of rectangular internal cross sectional shape such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, said barrel is of stepped internal cross sectional shape at ends, said barrel is of constant depth throughout its axial length, said slide end plates situated in said barrel and disposed transversely to said slides are of greater width than outside width of said slides to correspond with said barrel of stepped internal cross sectional shape at ends, depth of said slide end plates is the same as depth of said slides to correspond with said barrel of constant depth throughout its axial length, said slide end plates are of rectangular peripheral shape to correspond with said rectangular internal cross sectional shape of said barrel, said slides joined together at their ends by said slide end plates, said piston situated in said barrel in said space between said slides, said piston consists of a piston crown at each end which are joined together by a longitudinally extending joining plate, said piston crowns are of rectangular peripheral shape to correspond with rectangular internal cross sectional shape of space between said slides which are each of rectangular external cross sectional shape within said barrel of rectangular internal cross sectional shape, said piston crowns of rectangular peripheral shape engage flat vertical inner bounding surfaces of said slides, said piston crowns of rectangular peripheral shape and said longitudinally extending joining plate engage flat horizontal surface of upper wall of said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston crowns of rectangular peripheral shape and said longitudinally extending joining plate engage flat horizontal surface of lower wall of said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides.

8. In a reciprocating engine, according to claim 1, a hemispherical recess in inside of each said slide end plate and a hemispherical recess in each of the crowns of said piston, said slide end plates situated in said barrel and disposed transversely to said slides, said slides situated in said barrel and so disposed that there is a space between them are joined together at their ends by said slide end plates, each of said slides disposed along a portion of the periphery of said barrel such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, a piston situated in

said barrel in said space between said slides, said piston engages said slides, said piston engages said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston engages said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides, said hemispherical recess in inside of each said slide end plate and said hemispherical recess in each of said crowns of said piston are so disposed as to form spherical combustion chambers when said piston crowns and the insides of said slide end plates are in close proximity to one another, inclined projections on said piston crowns which are in close proximity to surfaces of said hemispherical recesses in said piston crowns, said inclined projections fit into corresponding inclined recesses in insides of said slide end plates, said inclined recesses merge into surfaces of said hemispherical recesses in insides of said slide end plates.

9. In a reciprocating engine, according to claim 1, said barrel is of rectangular internal cross sectional shape, said slide end plates situated in said barrel and disposed transversely to said slides are of rectangular peripheral shape to correspond with said rectangular internal cross sectional shape of said barrel, said slides joined together at their ends by said slide end plates, sealing strips set transversely to central axis of said barrel and retained in grooves in flat peripheral surfaces of said slide end plates, said sealing strips are held in sliding contact with flat vertical and horizontal surfaces of walls of said barrel by means of springs, said slides situated in said barrel and so disposed that there is a space between them are each of rectangular external cross sectional shape to correspond with said rectangular internal cross sectional shape of said barrel, each of said slides of rectangular external cross sectional shape disposed along a portion of the periphery of said barrel of rectangular internal cross sectional shape such that there is a space between the upper longitudinally extending inner edges of said slides and a space between the lower longitudinally extending inner edges of said slides, longitudinally disposed sealing strips retained in grooves in flat horizontal upper and lower bounding surfaces of said slides, said sealing strips are held in sliding contact with flat horizontal surfaces of upper and lower walls of said barrel by means of springs, scraper strips set transversely to central axis of said barrel and retained in grooves in flat vertical outer bounding surfaces of said slides and retained in grooves in flat peripheral surfaces of said slide end plates, said scraper strips have grooves in their flat sliding contact surfaces and have holes through them, said scraper strips are held in sliding contact with flat vertical surfaces of walls of said barrel by means of springs, said piston situated in said barrel in said space between said slides, said piston consists of a piston crown at each end joined together by a longitudinally extending joining plate, said piston crowns are of rectangular peripheral shape to correspond with rectangular internal cross sectional shape of space between said slides which are each of rectangular

external cross sectional shape within said barrel of rectangular internal cross sectional shape, said piston crowns of rectangular peripheral shape engage flat vertical inner bounding surfaces of said slides, said piston crowns of rectangular peripheral shape and said longitudinally extending joining plate engage flat horizontal surface of upper wall of said barrel along that upper portion of the periphery of said barrel not occupied by a said slide in said space between said upper longitudinally extending inner edges of said slides, and said piston crowns of rectangular peripheral shape and said longitudinally extending joining plate engage flat horizontal surface of lower wall of said barrel along that lower portion of the periphery of said barrel not occupied by a said slide in said space between said lower longitudinally extending inner edges of said slides, sealing strips set transversely to central axis of said barrel and retained in grooves in flat peripheral surfaces of said piston crowns, said sealing strips are held in sliding contact with flat horizontal surfaces of upper and lower walls of said barrel and with flat vertical inner bounding surfaces of said slides by means of springs, scraper strips set transversely to central axis of said barrel and retained in grooves in flat peripheral surfaces of said piston crowns, said scraper strips have grooves in their sliding contact surfaces and have holes through them, said scraper strips are held in sliding contact with flat vertical inner bounding surfaces of said slides by means of springs, longitudinally disposed strips retained in grooves in flat horizontal upper and lower bounding surfaces of said longitudinally extending joining plate of said piston, said strips are held in sliding contact with flat horizontal surfaces of upper and lower walls of said barrel by means of springs, flat bearing plates retained in recesses in flat vertical outer bounding surfaces of said slides, said flat bearing plates in sliding contact with flat vertical surfaces of walls of said barrel, thickness of each said flat bearing plate is greater than depth of said recess in which it is situated such that it protrudes from said recess, said flat bearing plates are held in sliding contact with flat vertical surfaces of walls of said barrel by means of springs.

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