Nov. 2, 1937. J. L. BOGERT 2,097,583

OPPOSED PISTON INTERNAL COMBUSTION ENGINE

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Fig. 1

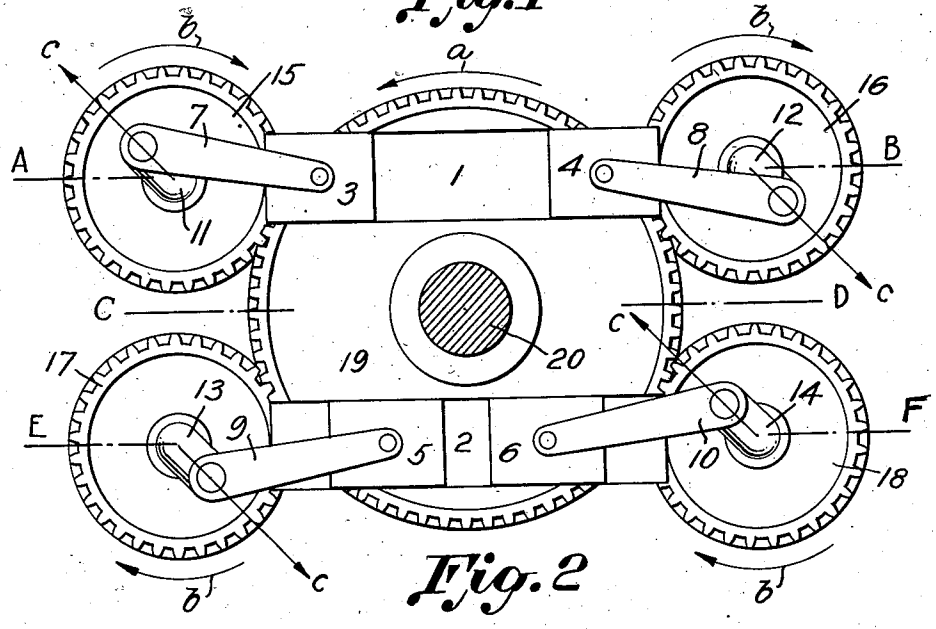


Fig. 2

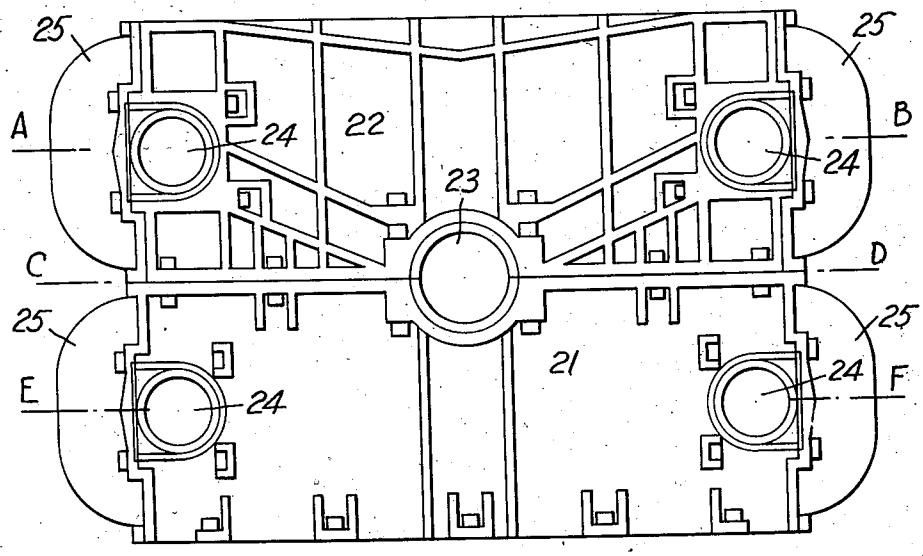


Fig. 9

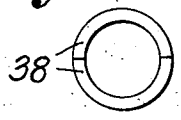
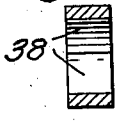


Fig. 10



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Fig. 3

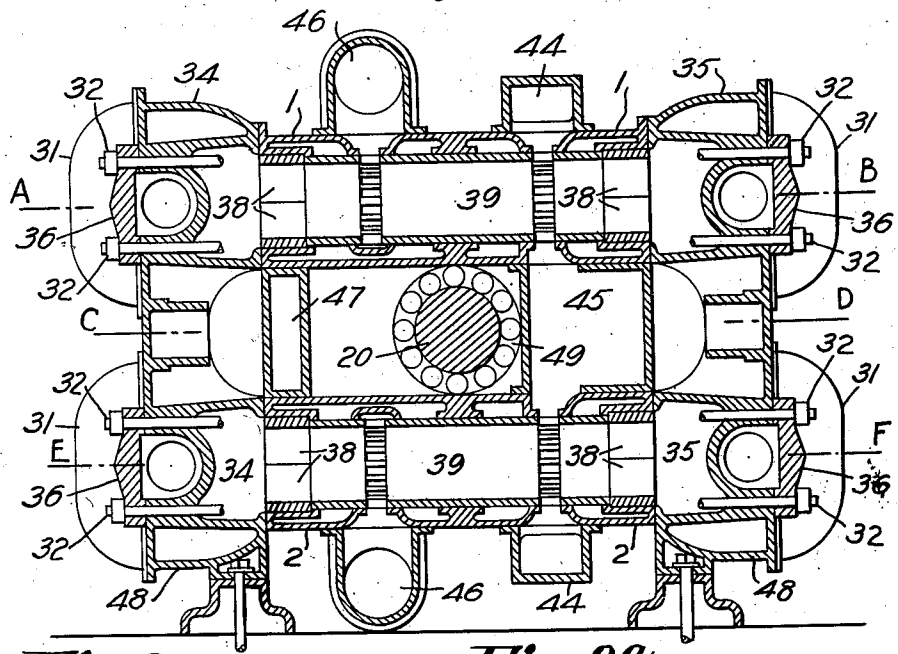


Fig. 8

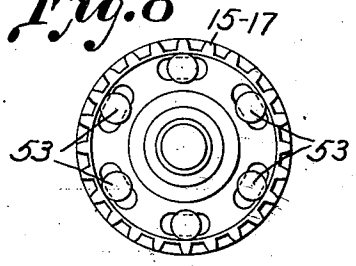


Fig. 8a

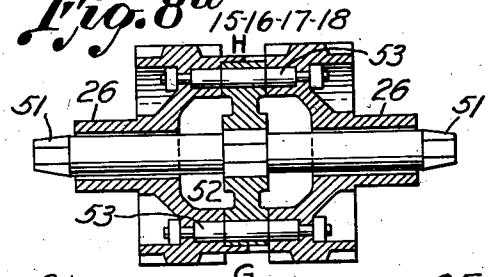


Fig. 7

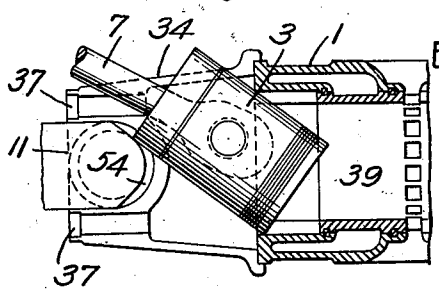
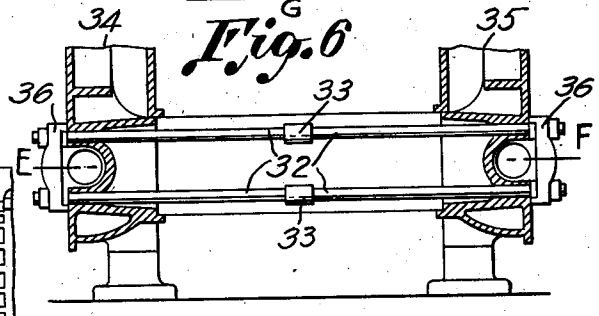


Fig. 6



Inventor:

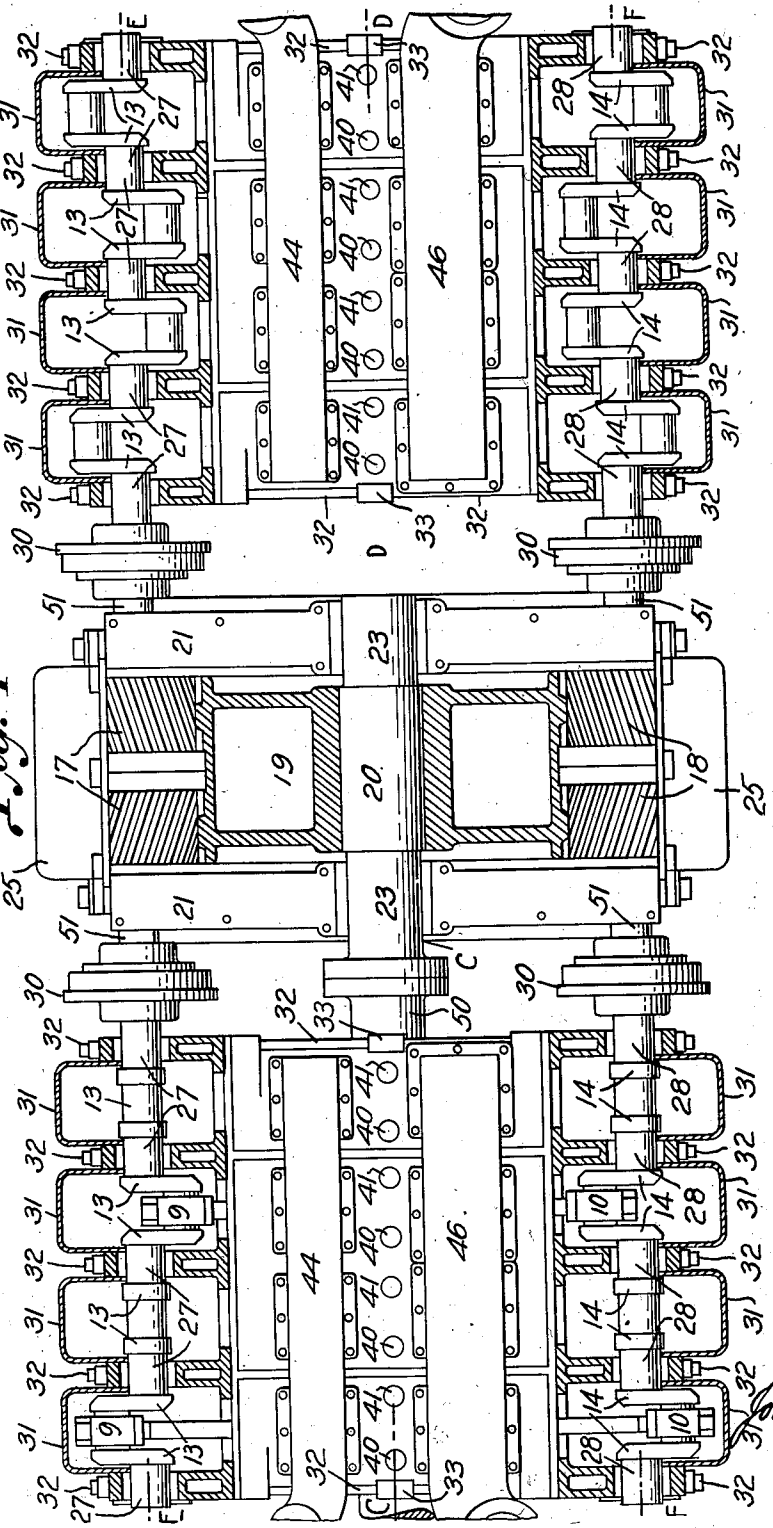
John Lawrence Bogert.

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Fig. 4



Inventor:
John Laurence Bogert

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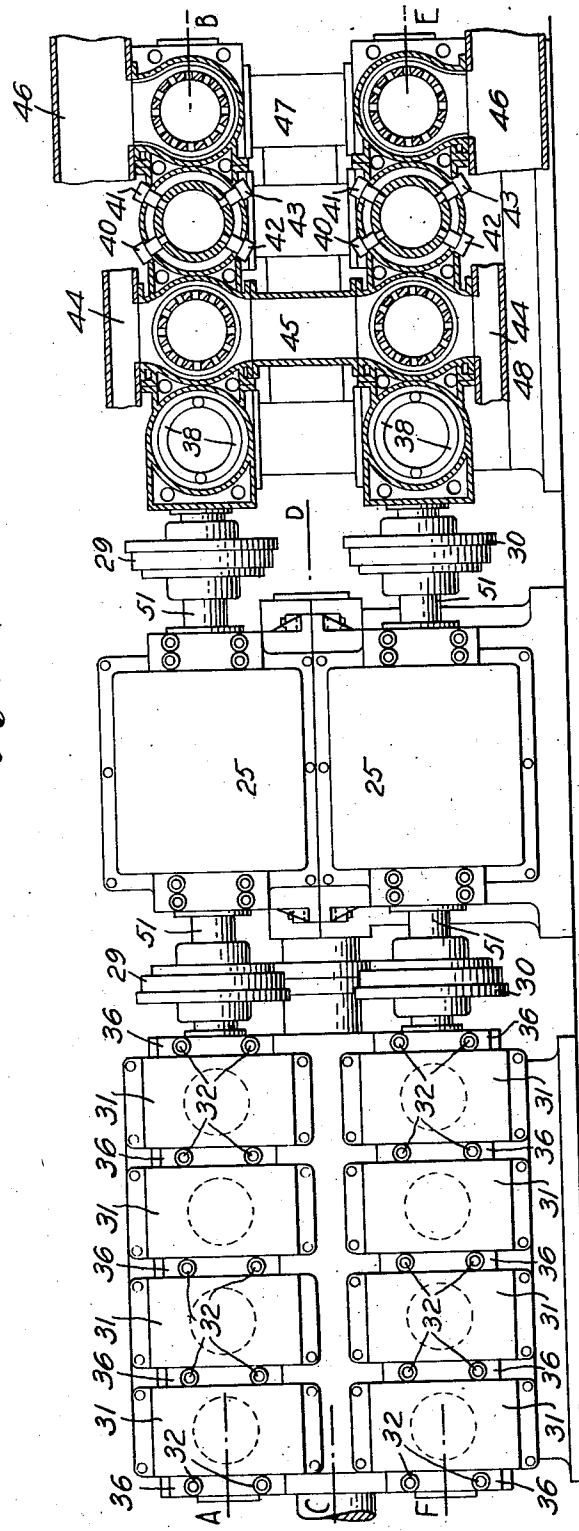


Fig. 5

Inventor:

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OPPOSED PISTON INTERNAL COMBUSTION ENGINE

John Lawrence Bogert, Brooklyn, N. Y.

Application November 8, 1934, Serial No. 752,095

4 Claims. (Cl. 123—51)

My invention relates to that form of internal combustion engine where two power-producing pistons reciprocate together simultaneously in the same cylinder, approaching each other during compression strokes and separating under the expanding force of the burning compressed fuel and air during power strokes.

The Oechelhauser, Junkers and Doxford engines belong to this class and are well known to all skilled in the art. The majority of them are constructed with but a single crank-shaft, the power producing pistons being link-connected with cranks set 180 degrees apart.

However, engines have been constructed with two crank-shafts, these crank-shafts being geared together so that they rotate at exactly the same speed, and the pistons are link connected with cranks out of phase by 180 degrees. Whether these crank-shafts rotate in the same or opposite directions, so long as their speed of rotation is the same, these pistons will approach and recede simultaneously in accordance with the fundamental principle of this type of engine. In one case the connecting-rods swing together in the same direction across the axis of the cylinder, in the other in opposite directions. In both cases balance weights attached to the webs of the cranks are necessary if disturbing forces in the plane of the swing of the connecting-rods are to be balanced.

Furthermore, with normally long pistons and short connecting-rods, there is too little room between the crank-shaft and the end of the cylinder to permit the withdrawal of the piston whether balance weights be attached to the crank webs or not. This is a most serious defect.

In an opposed piston engine, as normally constructed, which must be reversed, as is the case with marine engines, it is difficult to supercharge the engine since the exhaust ports remain open after the scavenge ports have been covered.

The objects of my invention are:—

1.—To secure more perfect balance of the disturbing forces set up by the motion of the reciprocating parts in the plane of their reciprocation without resorting to the use of crank-shaft balance weights.

2.—To secure a more compact engine taking into consideration the large number of power-producing pistons employed.

3.—To produce an engine of large power but low height and low center of gravity—on shipboard and a main propelling unit wholly below the water line.

4.—To render it easy to withdraw any power-producing piston without removing a crank-shaft.

5.—To make possible supercharging without resorting to the use of supplemental valves in the exhaust passages.

These objects I attain by the peculiar structure I employ and the arrangement of its several parts, which are fully set forth in the accompanying drawings which constitute part of this specification. Numerals of reference refer to like parts in all the figures.

Fig. 1 is a kinematical drawing which shows the basic reason for my improvements over the existing state of the art. At the same time it also shows the gearing and mechanism that are fundamental to my invention.

Fig. 2 is an end elevation of the gear case which encloses the gearing shown in Fig. 1.

Fig. 3 is a vertical transverse section of one of my improved engines along the axes of any pair of upper and lower cylinders.

Fig. 4 is a composite drawing of one of my improved engines, part plan and part sectional, showing the lower crank-shafts, the main driving gear and part of the two lower pinions that mesh with the main driving gear, besides the upper exhaust and scavenge air manifolds or conduits.

Fig. 5 is also a composite drawing of one of my improved engines, a vertical longitudinal elevation showing the crank-case and gear-case covers on the left, and vertical transverse sections through the pairs of cylinders at different points on the right show the removable bushings, the scavenging air ports and passages, the fuel injection, relief and air-starting valve locations and the exhaust ports and passages.

Fig. 6 is a vertical transverse section through the lower half of the engine housing, showing the right and left hand coupling nuts that bind together the through bolts that join the right and left crank-cases. These through bolts take the entire explosive stresses developed by each pair of opposed pistons.

Fig. 7 shows a vertical transverse section through a portion of one cylinder and its liner, together with a vertical transverse section of a crank-case bearing, with a tilted piston being withdrawn between the webs of a crank.

Fig. 8 is an end elevation of a pinion showing oblong driving slots and the binder bolts which bind the two halves of the pinion together.

Fig. 8*a* is a longitudinal section through the pinion and its driver, which latter detail is keyed to a shaft which is coupled to a crank-shaft at

one or both ends, and transmits the power of these cranks to the pinion.

Fig. 9 is an end elevation of one of my removable bushings, whose removal permits the tilting of the piston so that it can be withdrawn between the inner edges of the webs of its crank and the enlarged bore of the cylinder. These bushings are split along a diametral plane.

Fig. 10 is a vertical longitudinal section of one of these bushings.

1 is an upper and 2 a lower cylinder; 3 is an upper left-hand piston, 4 an upper right-hand piston, 5 a lower left-hand piston and 6 a lower right-hand piston; 7 is an upper left-hand connecting-rod, 8 an upper right-hand connecting-rod, 9 a lower left-hand connecting-rod and 10 a lower right-hand connecting-rod; 11 is an upper left-hand crank, 12 an upper right-hand crank, 13 a lower left-hand crank and 14 a lower right-hand crank; 15 is an upper left-hand pinion. 16 an upper right-hand pinion, 17 a lower left-hand pinion and 18 a lower right-hand pinion. 19 is the main driving gear with which all the pinions, both upper and lower mesh, and 20 is the main driving shaft which carries main driving gear 19. It is evident that when the main gear 19 turns anti-clockwise all the pinions, as indicated by the arrows turn clockwise. As remarked previously, it is not new to gear together two crankshafts at the opposite ends of a cylinder in which reciprocate two opposed pistons.

The arrows *c*, which represent in length and direction the centrifugal force acting at the cranks and the crank-pin ends of the connecting-rods, show clearly the vibratory unbalance of the centrifugal forces developed in either the upper or the lower pair of cranks and connecting-rods. When, however, they are combined together in the manner shown in Fig. 1 these out of balance forces balance. As indicated by arrows *c*, the upper pair of cranks and connecting-rods developed a clockwise rocking force which was best balanced by an equal anti-clockwise rocking force developed by the lower pair of cranks and connecting-rods. It should be noted that the upper pair of cranks are in-phase angularly with each other but out-of-phase with the pair of lower cranks which are also in-phase with each other, the angular displacement being 180 degrees.

Taken together, cylinders 1 and 2 with their pistons, connecting-rods and geared together crank-shafts constitute a single double-acting opposed piston unit, pistons 3 and 4 compressing while pistons 5 and 6 are expanding.

The gearing shown in Fig. 1 is all mounted in the gear case shown in Fig. 2, of which 21 is the lower and 22 the upper half. 23 are the bearings for the main gear shaft 20, and 24 are the bearings for the pinion shafts 26 which are shown as integral with the pinions in Fig. 8. The gear case covers 25 are shown in Figs. 2, 4, and 5. 27 and 28 are the lower crank-shaft bearings and are shown in Fig. 4.

It will be noted that all four crank-shafts are represented as divided into two parts by the interposition of the gearing. This is indicated in Figs. 4 and 5, but is not essential. It makes for greater torsional rigidity of the crank-shaft, and permits the use of smaller diameters. The normal arrangement would be for each eight cranks to be integral with one crank-shaft, the gear case and its gearing being at one end instead of in the middle.

29 and 30, shown in Figs. 4 and 5, are the upper and lower flexible couplings which relieve the pinions of lateral constrain. As in Fig. 4 the gear case is shown parted at horizontal plane C—D, only the four lower flexible couplings 30 appear. 31 are the crank housing covers, which can be removed separately without disturbing the bearing bolts 32. These latter are a unique constructional feature of my improved engine. They extend across to the middle of the cylinder where they are tapped into nuts 33 shown in Figs. 4 and 6. As these bolts have collars on them which fit into counterbores 37 shown in Fig. 7, it is evident that they by means of their coupling nuts 33, constitute ties which bind together the right and left hand crank-shaft housings and the cylinders interposed between into one solid, rigid structure. At the same time their outer threaded ends, which are beyond their collars serve as crank-shaft bearing bolts. These bolts 32 crossing from crank-shaft housing 34 to crank-shaft housing 35 through the medium of nuts 33 are a very important detail, since the explosive force of the burning fuel and air, transmitted by the pistons through their connecting-rods to the right-hand and left-hand crank-shafts, calls for the resiliency that only the length of bolt can give. 36 are the caps that retain the crank-shaft bearings. The bolts that retain the bearings 24 for the pinion shafts 26 might likewise be carried across from one side to the other. Pinion covers 25 can be removed without disturbing the gearing bearings. It is thus possible to run the engine with all the moving parts exposed. 38 is a split removable cylinder bushing, which supplements the main cylinder liner 39 at both ends. This feature of my construction is of the utmost importance, since the easy removal of every piston without disturbing the crank-shafts is a practical necessity. Piston rings require replacement frequently, and one of the great objections to the normal double-acting engine is the necessity of breaking cylinder-head joints.

Taken in conjunction with Fig. 3, Fig. 7 shows very clearly how, by removing split bushings 38 and constructing the cranks without balance weights but with their inside faces beveled as at 54, the piston can be tilted and withdrawn with its connecting-rod. The cylinder liner 39 carries, as usual, the exhaust and scavenge port openings and at its middle the openings for the fuel valves, the air starting valve and the relief valve. On Fig. 4 two of these valves are shown at 40 and 41, and in Fig. 5 four of them are shown for each cylinder marked 40, 41, 42, and 43. The scavenge air trunks or manifolds are shown at 44 in Figs. 3, 4, and 5, and 45 is a chamber or conduit connecting each upper row of scavenge ports with the scavenge ports of its lower companion cylinder. The object of this device is to permit greater freedom of access for the scavenge air to the ports. Inasmuch as the upper and lower cranks are substantially 180 degrees apart, the upper scavenge ports are always closed when the lower are open and vice versa. 46 are exhaust trunks or manifolds which need no communication between the exhaust ports of the upper and lower cylinders, since the exhaust ports are longer than the scavenge ports and are open longer. So 47 is simply a distance piece, binding the upper and lower cylinders together. These upper and lower cylinders can each be cast integrally or built up in sections; the same is true of scavenge-air chamber 45 and distance piece 47. 48 are the bed-plates through which the crank-shaft housings 34 and 35 are secured to the foundations, double-bottom or framing of the

ship. 49 is the coupling through which main driving gear-shaft 20 transmits power and motion to shaft 50. 51 are the shafts that are driven through the flexible couplings 29 and 30, and which in turn drive the pinions 15, 16, 17, or 18 through the disc 52 and the pinion bolts 53. This combination is normally known as a "quill drive", and where the pinions are of small diameter in proportion to their length is valuable in reducing torsional twist. Here, however, it serves an additional purpose when modified in its construction as I have indicated in Fig. 8. By making the holes through the driving disc 52 for the pinion bolts 53 as shown in the drawings, it is possible to give the exhaust port opening "lead", both in forward and backing drive. The pinions on the scavenging side of the engine have reamed holes for bolts 53 while those on the exhaust side have holes which permit an angular movement of the pinion in relation to disc 52. As soon as starting air is introduced between a pair of pistons, such as 3 and 4 or 5 and 6, the pistons on the exhaust side of the engine move out more rapidly than the pistons on the scavenge side, and thus establish an exhaust "lead". While these oblong holes are not absolutely essential to the successful operation of my engine they constitute an important improvement, permitting supercharging, since the exhaust ports, owing to "lead" will close earlier. The pinions are made in halves, separating on plane H—G. There should be no slackness about the fitting of disc 52 within the rim of the pinions, and preferably friction discs should be interposed between the sides of disc 52 and the inner faces of the pinion, so that there may be no shock when bolts 53 come in contact with the ends of the slotted holes in the disc.

Having clearly shown and described the nature of my improvements what I desire to claim as new and useful is:—

1. In an opposed piston engine having crank-shaft housings separated by a cylinder, counterbores in said housings, tie-bolts having collars that fill said counterbores, coupling nuts that join said tie-bolts together, threads on the outer ends of said tie-bolts beyond their collars, and adjusting nuts on the outer ends of said tie-bolts bearing against a cap of a crank-shaft bearing, substantially as represented and for the purpose set forth.

2. In the cylinder of an opposed piston engine in which two power-producing pistons reciprocate simultaneously in substantially opposite directions, counterboring both ends of said cylinder, fitting said counterbores with bushings divided longitudinally into halves, together with means for securing and releasing said bushings, substantially as represented and for the purpose set forth.

3. In the cylinder of an opposed piston engine, a liner in which said pistons reciprocate, said liner having admission, exhaust and fuel-valve openings through its wall, in combination with removable bushings fitted in counterbores at each end of said cylinder, substantially as represented and for the purpose set forth.

4. In an internal combustion engine, a cylinder, removable bushings in the ends of said cylinder, a piston which reciprocates within said cylinder, a crank-shaft and crank-webs for said cylinder, means beveling the inner faces of said crank-webs to facilitate the removal of said piston when tilted.

JOHN LAWRENCE BOGERT.