Nov. 14, 1939. A. F. BRECHT 2,179,709

INTERNAL COMBUSTION ENGINE

Original Filed Sept. 12, 1938 3 Sheets-Sheet 1

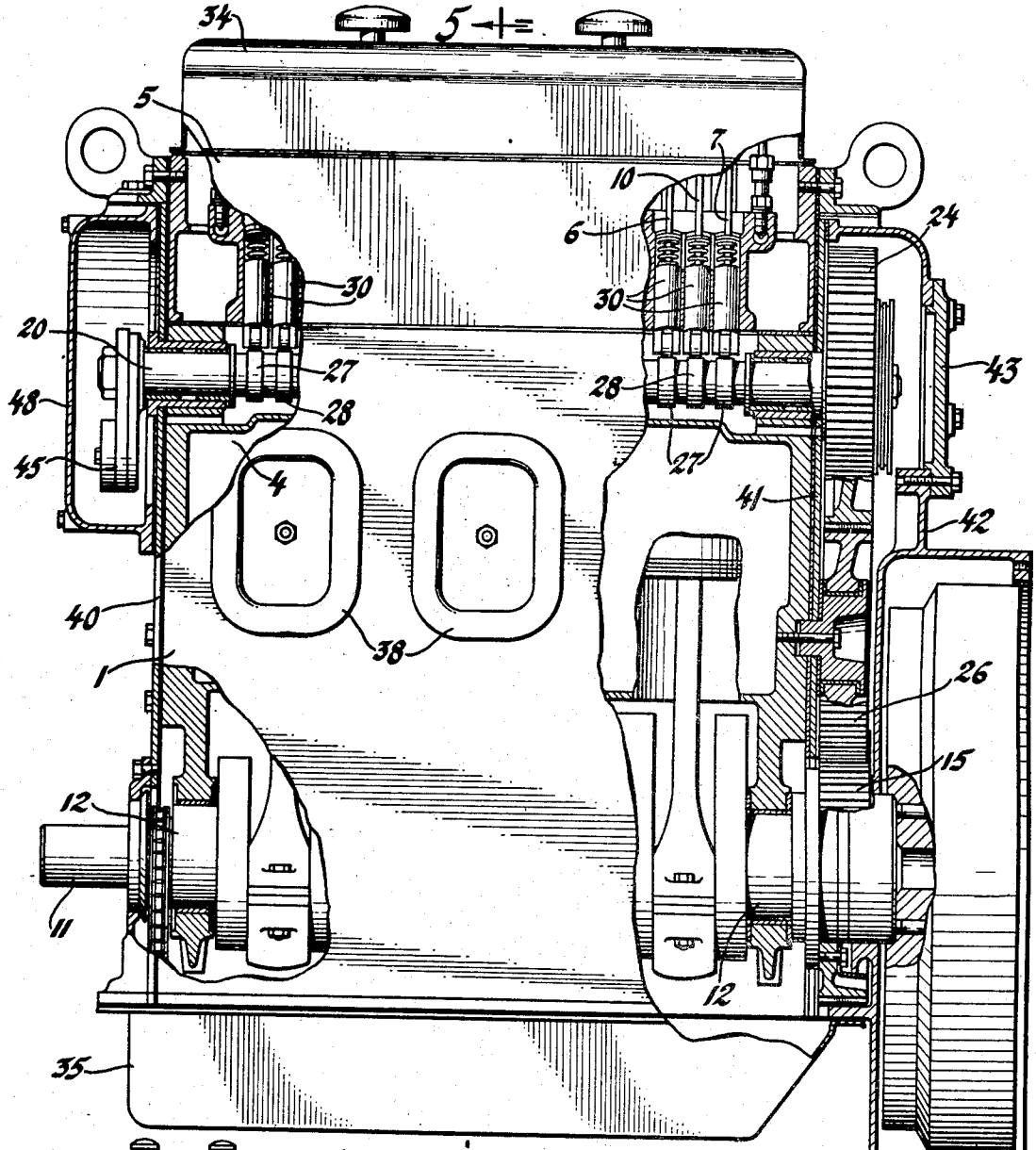



Fig. 1

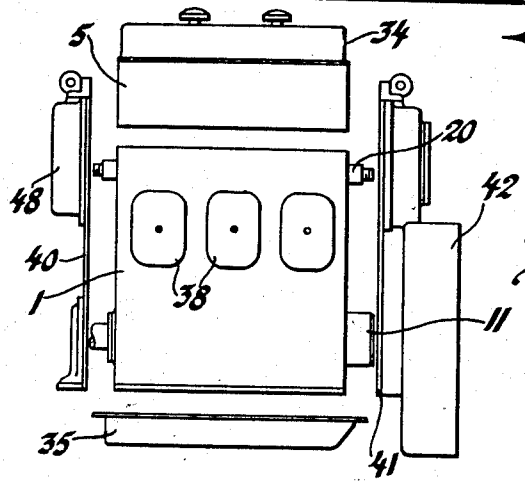



Fig. 2

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INTERNAL COMBUSTION ENGINE

Original Filed Sept. 12, 1938 3 Sheets-Sheet 2

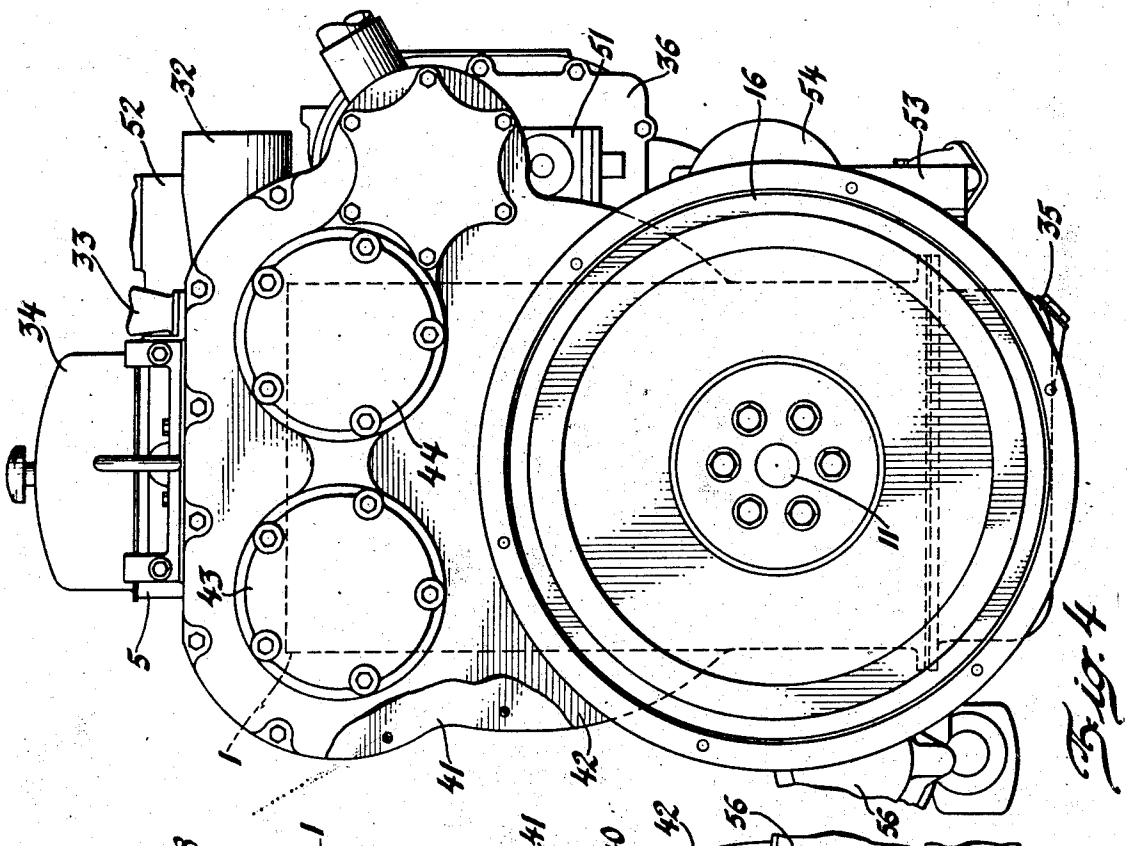



Fig. 4

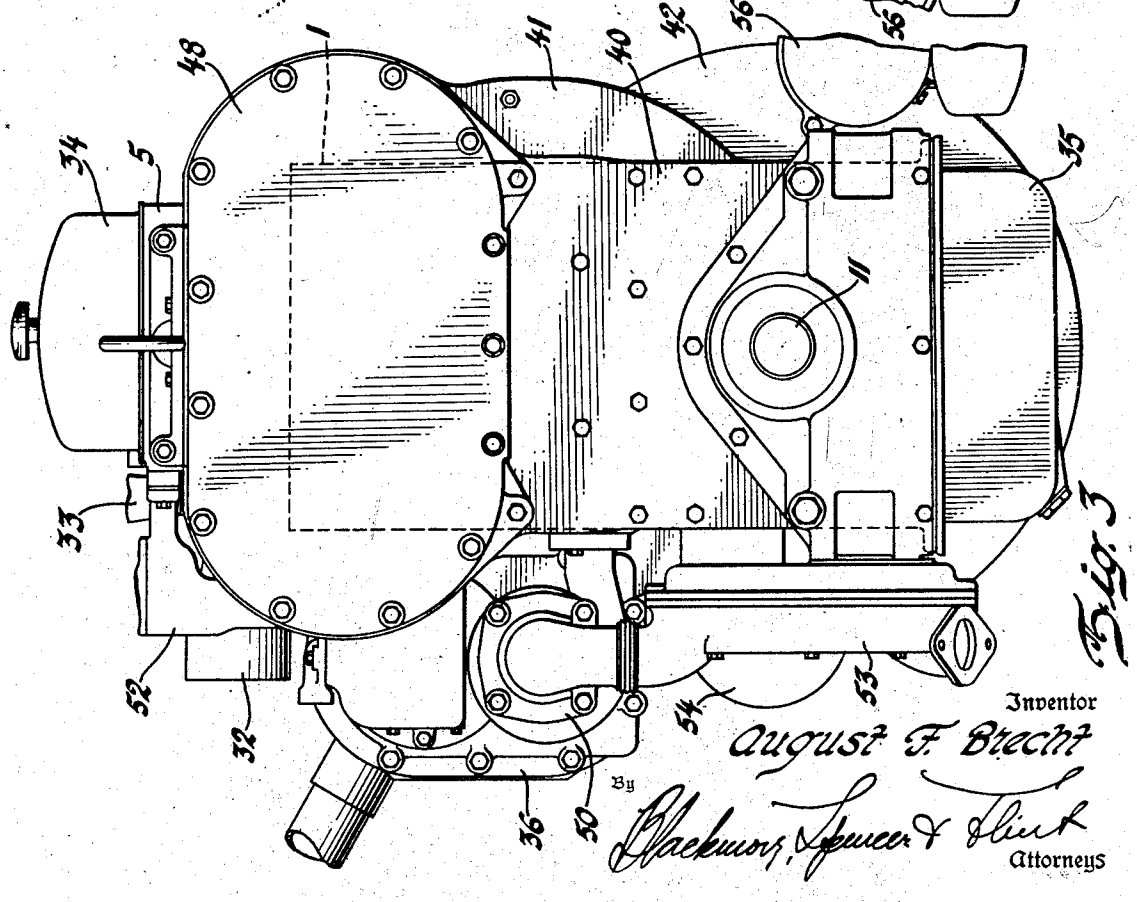



Fig. 3

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INTERNAL COMBUSTION ENGINE

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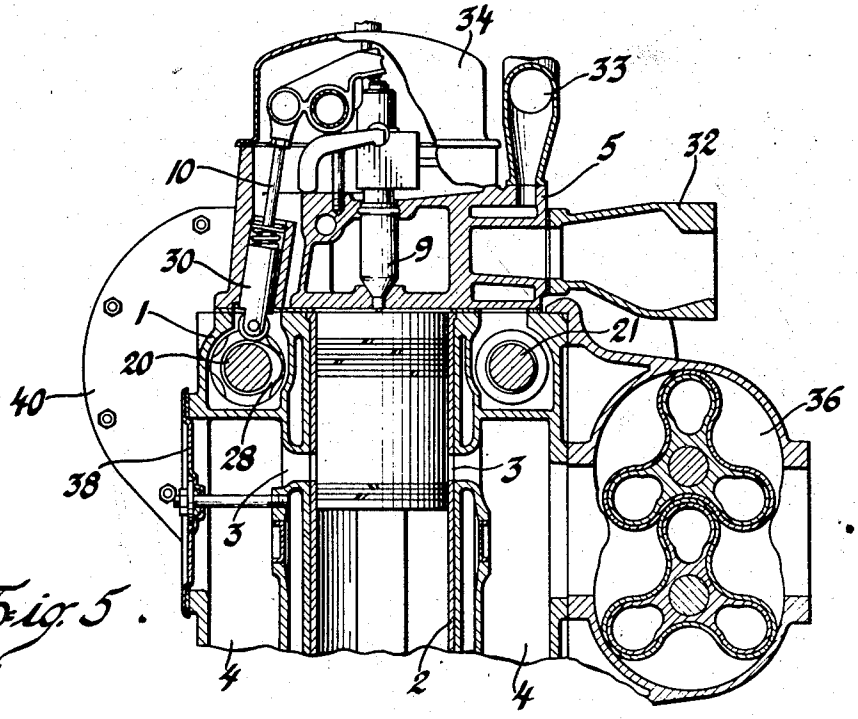



Fig. 5.

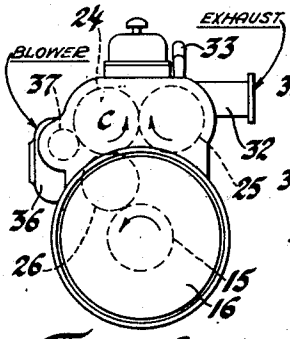



Fig. 6

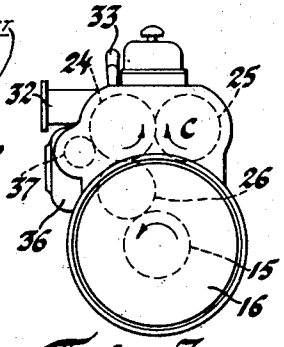



Fig. 7

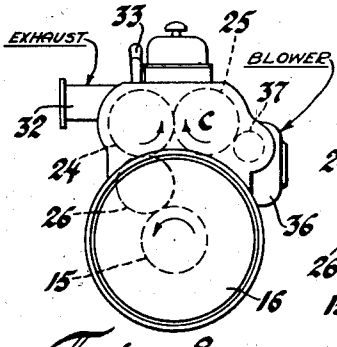



Fig. 8

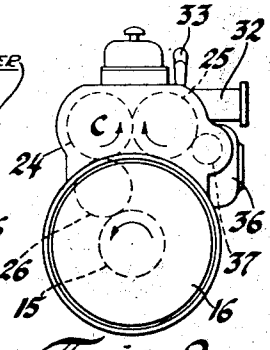



Fig. 9

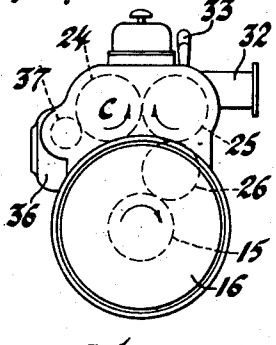



Fig. 10

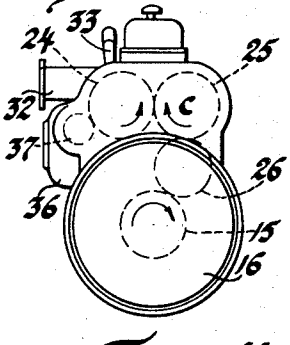



Fig. 11

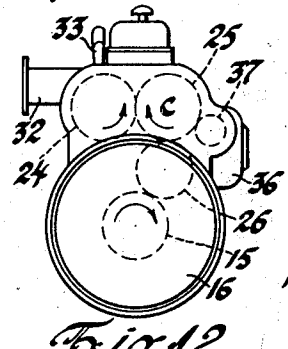



Fig. 12

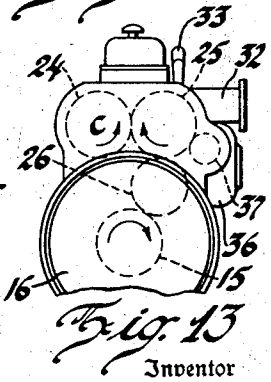



Fig. 13

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2,179,709

# UNITED STATES PATENT OFFICE

2,179,709

## INTERNAL COMBUSTION ENGINE

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Application September 12, 1938, Serial No. 229,484
Renewed February 8, 1939

8 Claims. (Cl. 123—195)

This invention relates to internal combustion engines and the design and construction of the parts thereof, so that the same elements may be assembled in various different relationships to each other, to provide an engine particularly adapted to the circumstances for which it may be required.

In some instances it is desirable that various of the necessary appurtenances should be on one side of the engine and in other instances that they should be on the other side of the engine.

In some cases, as for example when the engines are employed as left and right hand engines for driving twin screws in boats, it is necessary to have the said appurtenances on opposite sides of the respective engines with the crankshafts turning in opposite directions.

The object of the invention is to provide an engine in which as many of the parts as possible may be interchangeably associated in different relationships to each other to provide a diversity of combinations suited to a variety of conditions.

The above and other objects of the invention will be apparent as the description proceeds.

According to the invention the ends of the cylinder block transverse to the crankshaft are identified as seen from those ends, and are provided with fitting faces for various elements interchangeably securable to either end; the cylinder head is geometrically similar end for end with the same spacing and arrangement of bolt holes as seen from either end.

The cylinder block, the cylinder head, and the crankshaft constitute main separable elements each having a number of appurtenances in fixed relationship thereto, including a blower at one side of the cylinder block, water and exhaust pipes at one side of the cylinder head, and a fly-wheel and gear wheel at one end of the crankshaft. Each of the main separable elements is turnable end for end through 180° in relation to one or both of the other main separable elements, to provide four different combinations of parts in which the appurtenances in fixed relationship to the main separable elements may be on either desired side of the engine. The engines of the aforesaid four different arrangements, may be arranged for rotation of the crankshaft in either a clockwise or an anticlockwise direction, as will later be described.

The invention is equally applicable to multi-cylinder engines having either an odd or an even number of cylinders.

The drawings show the application of the invention to a three-cylinder two-cycle Diesel engine, having piston controlled inlet ports and exhaust valves in the cylinder head.

In the drawings:

Fig. 1 is an elevation with parts broken away and in section.

Fig. 2 is a diagrammatic elevational view of some of the parts in associated but disassembled relationship.

Figs. 3 and 4 are views of opposite ends of the engine.

Fig. 5 is a part sectional view on line 5—5 of Fig. 1.

Figs. 6 to 13 are diagrammatic end views showing eight different engine arrangements according to the invention.

Referring now especially to Figs. 1 to 5, the cylinder block 1 is rectangular in shape. Each cylinder is provided with a dry liner such as 2, having air inlet ports 3 controlled by the pistons of the respective cylinders, and opening from an air box 4 surrounding the cylinders.

The overhead exhaust valves, of which there are two per cylinder, are mounted in the cylinder head 5 and operated from a camshaft by push rods such as 6 and 7 and rocker levers.

Fuel is injected into the combustion chamber of each cylinder by a combined fuel pump injector such as 9, mounted in the cylinder head, axially of each cylinder, and between the two exhaust valves, and operated in a manner similar to the exhaust valves, by a push rod such as 10.

The crankshaft 11 is mounted in bearings such as 12 in the lower part of the cylinder block, and carries a gear wheel 15 and flywheel 16 at one end.

Mounted in suitable bearings in the upper end of the cylinder block, are a pair of balancing shafts 20 and 21 to balance a rocking couple due to the primary inertia forces of the reciprocating parts and which tends to rock the engine about a transverse axis. These balancing shafts 20 and 21 are parallel with the crankshaft axis and disposed symmetrically on opposite sides of the plane of the cylinder and crankshaft axes. Mounted on the balancing shafts are appropriate masses, phased 180° apart, at opposite ends thereof. The shafts 20 and 21 are provided with gear wheels 24 and 25 respectively, and are driven at crankshaft speed in opposite directions, from the gear wheel 15 through an idler 26, in a phase relationship such that the horizontal forces of the balancing masses neutralize each other, and the vertical forces thereof are additive, to balance the primary inertia forces of the reciprocating parts, in well known manner.

The balancing shafts 20 and 21 are identical except that the shaft 20 combines the function of a camshaft with that of a balancing shaft, and is provided with cams such as 27 and 28 to actuate the push rods such as 6, 7 and 10, for the exhaust valves and the fuel pump injectors respectively.

The push rods such as 6, 7 and 10, are provided with tubular guides such as 30, sliding in suitable bores along one side of the cylinder head 5. An exhaust manifold 32 and water pipes 33 are provided along the other side of the cylinder head.

A cover 34 encloses those parts of the valve gear projecting above and outside the cylinder head 5, and an oil pan 35 is secured to the bottom of the cylinder block.

Mounted on one side of the cylinder block 1, is a blower 36, for delivering air under pressure to the air box 4. The opposite side of the cylinder block is provided with inspection covers 38. The blower is driven by a pinion 37 from either the gear wheel 24 or the gear wheel 25 of the gear train; in the arrangement of Figs. 1 to 5 it is driven from the gear wheel 25 of the gear train.

According to the invention, the cylinder head 5 is turnable through 180° in relation to the cylinder block 1, to bring the exhaust manifold on the same side, or the opposite side of the engine as the blower 36, and the cylinder block is turnable through 180° in relation to the crankshaft 11 with its flywheel 16, to bring the blower on the right or the left hand side of the engine as seen from the flywheel end of the engine.

Since the valve push rods are moved from one side of the engine to the other as the cylinder head 5 is turned through 180°, it is necessary to transfer the camshaft from one side of the engine to the other. The balancing shafts 20 and 21 are provided with identical bearings and are interchangeable one for the other, the camshaft balancing shaft 20 being also turnable end for end. As a result of this interchangeability it is possible to transfer the same camshaft from one side of the engine to the other, but it must be turned end for end whenever the transfer is made, in order to preserve the same valve operating characteristics of the non-symmetrical cams, with an opposite direction of rotation of the camshaft as seen from the same end of the engine.

End plates 40 and 41 are provided for opposite ends of the engine cylinder block 1. They are not identical, but may be interchangeably secured to either end of the cylinder block, accordingly as the crankshaft is disposed with its flywheel and gear train at one end of the engine or the other.

The gears 15, 26, 24, 25 and 37, are always at the flywheel end of the engine external of the end plate 41, and are enclosed by a cover 42 which also shrouds the flywheel 16. Independent covers 43 and 44 for the gears 24 and 25 are bolted to the cover 42.

The balancing masses on the shafts 20 and 21 consist of weights such as 45, suitably secured to the shafts at that end of the engine opposite to the flywheel, and equivalent weights, phased respectively on each shaft at 180° from the weights such as 45, are embodied in the gear wheels 24 and 25. The masses 45 are exterior of the end plate 40 and are enclosed by a cover 48.

The water pump 50, the fuel transfer pump 51, and the governor 52, are all driven from the blower and are mounted at either end of the blower, accordingly as the blower is on one side or the other of the engine; the oil cooler 53 and the oil filter 54 are mounted on the cylinder block at that end of the blower to which the water pump is connected. A starting motor 56 is mounted on the cover 42 of the flywheel and gear train.

Referring now to the various arrangements shown diagrammatically in Figs. 6 to 13, (Fig. 9 being the arrangement of the engine according to Figs. 1 to 5, and the camshaft being designated by the letter C in all instances) the crankshaft may be assumed to remain undisturbed while the cylinder block and/or the cylinder head is turned end for end through 180° relative thereto. Whenever the cylinder head is turned, the same camshaft, turned end for end and exchanged for the other balancing shaft, may be used for various of the arrangements, later to be described. The camshaft turns in an opposite direction in one position as compared with the other, but being turned end for end, it turns in the same direction as far as its valve operating characteristics are concerned, the only difference being that what was the last cylinder becomes the first, and vice versa.

Thus, in an engine having an even number of cylinders 1, 2, 3, 4, for example, with a crank arrangement for a firing order of 1, 3, 4, 2, when the camshaft is turned end for end and reversed, it actuates the valves of cylinders in the sequence 4, 2, 1, 3, which is actually the same cyclic sequence as 1, 3, 4, 2, leaving the firing order and the direction of rotation of the crankshaft unchanged.

On the other hand, in an engine having an odd number of cylinders 1, 2, 3, for example, with a crank arrangement for a firing order of 1, 2, 3, when the camshaft is turned end for end and reversed, it actuates the valves of cylinders in the sequence 3, 2, 1, which is not the same cyclic sequence as 1, 2, 3, or 3, 1, 2, but a reversed firing order, suitable only for a reverse direction of rotation of the crankshaft.

Figs. 6 to 9 show the various different combination positions of the blower, the exhaust and the camshaft of an engine with anti-clockwise rotation of the crankshaft.

Figs. 10 to 13 are respectively, engines with the same blower, exhaust and camshaft positions as those of Figs. 6 to 9, but arranged for a reverse or clockwise rotation of the crankshaft.

In Figs. 6 to 9, the idler gear 26 transmits the drive from gear 15 to gear 24 of the train, while in the engines of Figs. 10 to 13 for a reverse rotation of the crankshaft, the idler gear 26 is transferred to a position in which it transmits the drive from gear 15 to gear 25 of the train.

In the case of an engine having an even number of cylinders, the camshaft of Figs. 6 and 9, or Figs. 10 and 13, turned end for end, can be used at the other side of the engine as shown in Figs. 7 and 8 or Figs. 11 and 12, respectively; but an entirely different camshaft from that of Figs. 6 to 9, is required for the reverse rotation of the crankshaft of Figs. 10 to 13.

In the case of an engine having an odd number of cylinders, the camshaft of Figs. 6 and 9 or the camshaft of Figs. 7 and 8, turned end for end, can be used at the other side of the engine, for reverse rotation as shown in Figs. 11 and 12 or Figs. 10 and 13, respectively; but an entirely different camshaft from that of Figs. 6 and 9, 11 and 12, is required for the engines of Figs. 7 and 8, 10 and 13.

I claim:

1. An internal combustion engine including as

main separable elements a cylinder block, a cylinder head, and a crankshaft, and a number of elements in fixed relationship to said separable elements respectively at one side of said cylinder block, at one side of said cylinder head, and at one end of the crankshaft; the ends of said cylinder block transverse to the crankshaft being provided with identical fitting faces for various elements interchangeably securable to either end; said cylinder head being geometrically similar end for end; whereby each of said main separable elements is turnable end for end through 180° in relation to one or both of the other main separable elements to provide an engine in which the elements in fixed relationship to said separable elements may be on either desired side of the engine.

2. An internal combustion engine according to claim 1, having an even number of cylinders in line, in which a pair of balancing shafts, parallel with the crankshaft and symmetrically disposed on opposite sides of a plane containing the axes of the cylinders, are driven in opposite directions through gearing from a gear wheel in fixed relationship to one end of the crankshaft; the cylinder head being provided with valves and operating means therefor d'sposed in fixed relationship to one side of said cylinder head, and one of said balancing shafts being provided with cams for actuating the valve operating means; said balancing shaft with cams being turned end for end and exchanged for the other balancing shaft whenever the cylinder head is turned end for end in relation to the cylinder block.

3. An internal combustion engine according to claim 1, having an odd number of cylinders in line, in which a pair of balancing shafts parallel with the crankshaft and symmetrically disposed on opposite sides of a plane containing the axes of the cylinders run in fixed but opposite directions and are driven from a gear wheel in fixed relationship to one end of the crankshaft through an idler gear transferable from a position in which it transmits the drive from the crankshaft to one of the balancing shafts to a position in which it transmits the drive to the other of the balancing shafts; the cylinder head being provided with valves and operating means therefor disposed in fixed relationship to one side of said cylinder head, and one of said balancing shafts being provided with cams for actuating the valve operating means; whereby the engine may be arranged for rotation of the crankshaft in a reverse direction by turning the cylinder head end for end in relation to the cylinder block, turning said balancing shaft with cams end for end and exchanging it for the other balancing shaft and transferring the idler gear in the manner set forth.

4. The combination according to claim 1 in which there is a blower in fixed relationship to the cylinder block, water and exhaust pipes in fixed relationship to the cylinder head, and a flywheel and gear wheel in fixed relationsh'p to the crankshaft.

5. An internal combustion engine having an even number of cylinders in line, and a crankshaft, including as main separable elements, a cylinder block and a cylinder head, there being in the cylinder block a pair of balancing shafts parallel with the crankshaft and symmetrically disposed on opposite sides of a plane containing the axes of the cylinders, said balancing shafts being driven in opposite directions through gearing from the crankshaft; the cylinder head being provided with valves and operating means therefor disposed in fixed relationship to one side of said cylinder head, and one of said balancing shafts being provided with cams for actuating the valve operating means; said cylinder head being geometrically similar end for end, whereby it is turnable end for end in relation to the cylinder block, to provide an engine in which the valves and operating means therefor, and other elements in fixed relationship to said cylinder head, may be on either desired side of the engine; said balancing shaft with cams being turned end for end and exchanged for the other balancing shaft whenever the cylinder head is turned end for end in relation to the cylinder block.

6. An internal combustion engine having an even number of cylinders in line, including as main separable elements, a cylinder block and a crankshaft, and a number of elements in fixed relationship to said main separable elements respectively at one side of said cylinder block and at one end of the crankshaft; the ends of said cylinder block transverse to the crankshaft being provided with identical fitting faces for various elements interchangeably securable to either end; there being a pair of balancing shafts parallel with the crankshaft and symmetrically disposed on opposite sides of a plane containing the axes of the cylinders, said balancing shafts running in fixed but opposite directions and being driven from a gear wheel in fixed relationship to one end of the crankshaft through an idler gear transmitting the drive from the crankshaft to one of the balancing shafts; whereby said cylinder block is turnable end for end in relation to the crankshaft, to provide an engine in which the elements in fixed relationship to the cylinder block, may be on either desired side of the engine; said idler gear transmitting the drive from the crankshaft to the other of the balancing shafts whenever the cylinder block is turned end for end in relation to the crankshaft.

7. An internal combustion engine having an odd number of cylinders in line, and a crankshaft, including as main separable elements a cylinder block and a cylinder head; there being in the cylinder block a pair of balancing shafts parallel with the crankshaft and symmetrically disposed on opposite sides of a plane containing the axes of the cylinders, said balancing shafts running in fixed but opposite directions and being driven from a gear wheel in fixed relationship to one end of the crankshaft through an idler gear transferable from a position in which it transmits the drive from the crankshaft to one of the balancing shafts, to a position in which it transmits the drive to the other of the balancing shafts; the cylinder head being provided with valves and operating means therefor disposed in fixed relationship to one side of said cylinder head, and one of said balancing shafts being provided with cams for actuating the valve operating means; whereby the engine may be arranged for rotation of the crank shaft in a reverse direction by turning the cylinder head end for end in relation to the cylinder block, turning said balancing shaft with cams end for end and exchanging it for the other balancing shaft, and transfering the idler gear in the manner set forth.

8. An internal combustion engine having an odd number of cylinders in line; including as main separable elements a cylinder block and a crankshaft; the ends of said cylinder block transverse to the crankshaft being provided with identical fitting faces for various elements inter-

changeably securable to either end, there being a pair of balancing shafts parallel with the crankshaft and symmetrically disposed on opposite sides of a plane containing the axes of the cylinders, said balancing shafts running in fixed but opposite directions and being driven from a gear wheel in fixed relationship to one end of the crankshaft through an idler gear transferable from a position in which it transmits the drive from the crankshaft to one of the balancing shafts, to a position in which it transmits the drive to the other of the balancing shafts; whereby the engine may be arranged for rotation of the crankshaft in a reverse direction by turning said cylinder block end for end in relation to the crankshaft, and transferring the idler gear in the manner set forth.

AUGUST F. BRECHT.

CERTIFICATE OF CORRECTION.

Patent No. 2,179,709. November 14, 1939.

AUGUST F. BRECHT.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 27, for "identified" read identical; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 30th day of January, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)