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⑦ Applicant: **Birchall, Stanley, 45 Hawksbury Road, Leicester (GB)**

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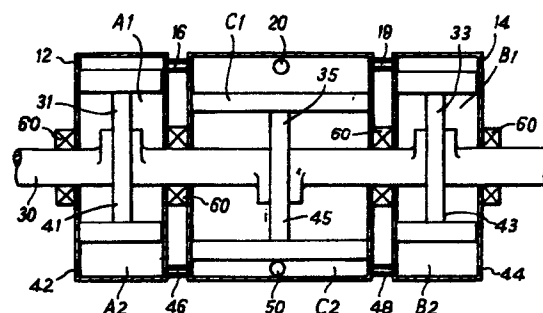
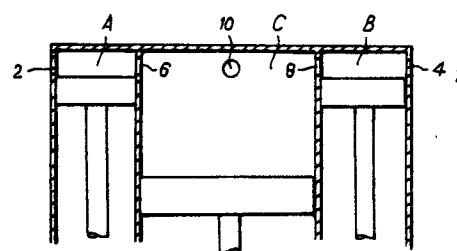
⑦ Inventor: **Birchall, Stanley, 45 Hawksbury Road, Leicester (GB)**

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⑦ Representative: **Hallam, Arnold Vincent et al, E.N. LEWIS & TAYLOR 144 New Walk, Leicester LE1 7JA (GB)**

⑤ Internal-combustion engine with additional expansion.

⑤ The present invention relates to an internal combustion engine having at least one primary cylinder (A, B) operating on the Otto cycle and an associated secondary cylinder (C) which cylinders are operatively coupled to a common crankshaft (30); and wherein the secondary cylinder (C) is operatively coupled to the primary cylinder (A, B) such that exhaust gas from the primary cylinder (A, B) is exhausted into the secondary cylinder (C) where it expands, driving the piston of the secondary cylinder subsequently exhausts the exhaust gas to atmosphere.



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Title: Improvements in or relating to Otto Cycle Internal Combustion Engines.

The invention relates to Otto cycle internal combustion engines.

A conventional reciprocating internal combustion engine utilising the Otto cycle employs four strokes. The first is an induction stroke, wherein the size of the combustion chamber is increased by inducing a fuel air mixture thereinto; a compression stroke, wherein the size of the combustion chamber is decreased thereby compressing the fuel air mixture; a power stroke, wherein the size of the combustion chamber is again increased after combustion of the compressed fuel air mixture; and an exhaust stroke, whereby the size of the combustion chamber is again decreased expelling exhaust gasses therefrom. It will be noted that there is only one power stroke in every four strokes of the engine.

A disadvantage of the Otto cycle is that the power and exhaust strokes are the same length as the induction and compression strokes, thus limiting the thermal efficiency to about 20%.

The present invention seeks to provide an improved, internal combustion engine.

The invention provides an internal combustion engine characterised in that there is provided at least one primary cylinder operating on the Otto cycle and an associated secondary cylinder, which cylinders are operatively coupled to a common crankshaft; and wherein the secondary cylinder is operatively coupled to the primary cylinder such that exhaust gas from the primary cylinder is exhausted into the secondary cylinder where it expands, driving the piston of the second cylinder, said secondary cylinder subsequently exhausts the exhaust gas to atmosphere.

Preferably, the ratio of the working volumes of the or each primary cylinder and the associated secondary cylinder are such that said exhaust gas from said primary cylinder expands into said secondary cylinder substantially to atmospheric pressure.

Conveniently, the length of the strokes of the pistons of the primary and secondary cylinders are substantially the same.

It will be noted that the secondary cylinder operates on a two-stroke cycle. It is advantageous to provide one secondary cylinder fed alternately from each one of two primary cylinders, the secondary cylinder performing two two-stroke cycles during the four-stroke cycle of either primary cylinder, the primary cylinders

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being 180 degrees out of phase one with respect to the other.

The internal combustion engine may work by spark ignition or by compression ignition.

Auxilliary services for the internal combustion engine are driven from the or each crank shaft in the usual manner, such services being pumps for fuel oil, lubricating oil and/or air, generators and the like.

One form of engine according to the present invention has a non-return inlet valve in the head of the or each primary cylinder for induction of fuel/air mixture into said cylinder, and a valve controlling the exhausting of exhaust gas from the or each primary cylinder to the associated secondary cylinder and also the exhausting of said exhaust gas from said secondary cylinder.

The controlling valve is conveniently a rotary valve although it may alternatively be provided by a suitable arrangement of poppet valves in known manner.

The invention will now be described further, by way of example, and with reference to the accompanying drawings in which:-

Figures 1a to 1d are schematic diagrams showing the principle of operation of an engine according to the invention; and

Figure 2 is a schematic longitudinal sectional view of an engine according to the invention.

Figures 1a to 1d show in schematic form an engine comprising a single thermodynamic assembly of two primary cylinders A and B and a single secondary cylinder C. Valves 2 and 4 control inlet of fuel/air mixture to cylinders A and B respectively. Valve 6 controls passage of combustion gases from cylinder A to cylinder C, and valve 8 controls passage of combustion gases from cylinder B to cylinder C. Valve 10 controls exhaust of spent gases from cylinder C. The pistons associated with the cylinders A, B and C are connected to a common three-throw crankshaft (not shown in the drawings).

In Figure 1a the cylinder A has just reached T.D.C. with valve 2 closed and valve 6 open, combustion gas being transferred from cylinder A to cylinder C, valves 10 and 8 being closed. At this point in time cylinder C has also reached T.D.C. and the fuel/air mixture therein has been ignited, the valve 4 being closed. The piston of cylinder C has been driven down to B.D.C. by the exhaust gas from cylinder A. The pistons of cylinders A and B now move

downwardly and the piston of cylinder C upwardly until the position shown in Figure 1b is reached, cylinder B moving under its power stroke and cylinder A moving under its induction stroke.

Referring now to Figure 1b the piston of cylinder A has reached B.D.C., valve 2 having been open during its downstroke with valve 6 closed thus allowing fuel/air mixture to be drawn into cylinder A, and at the point shown valve 2 has just closed. During the downstroke of the piston of cylinder B both valves 8 and 4 have been closed and at the point shown valve 8 is just about to open. During the upstroke of piston of cylinder C the valve 10 has been open and at the point shown has just closed, spent gas being exhausted through valve 10 to the atmosphere. The pistons of cylinders A and B again start to move upwards and the piston of cylinder C starts to move downwards, the gas in cylinder A being compressed and that in cylinder B being transferred to cylinder C.

In Figure 1c the piston of cylinder A has reached the end of its compression stroke at T.D.C. and the gas therein is ignited. Piston of cylinder B has also reached T.D.C. and the gas therefrom has been transferred to cylinder C. During the upstroke of cylinder A the valves 2 and 6 have been closed. During the upstroke of the piston of cylinder B valve 4 has been closed and

valve 8 open and during the downstroke of cylinder C the valve 10 has been closed. At the point shown in Figure 1c valves 4 and 10 are about to open, and valve 8 about to close, valves 2 and 6 being closed. The piston of cylinder A is driven down under its power stroke, the piston of cylinder B moving down in its induction stroke, fuel/air mixture being drawn in through valve 4. The piston of cylinder C moves upwardly exhausting the spent gas through valve 10.

In Figure 1d the piston of cylinders A and B have both reached B.D.C. The valve 6 of cylinder A is about to open to transfer gas therefrom into cylinder C pushing down the piston thereof with valves 10 and 8 closed. The piston of cylinder B is about to start its compression stroke with valves 4 and 8 closed. The pistons of cylinders A and B therefore move upwardly and the piston of cylinder C moves downwardly until the position shown in Figure 1a reoccurs.

The above described cycle of operation is then repeated.

Figure 2 shows a schematic sectional view of a further form of an engine according to the invention, comprising two of the thermodynamic assemblies shown in Figures 1a to 1d. A pair of primary cylinders A1 and B1

are operatively linked to a secondary cylinder C1 by means of valves 12, 14, 16, 18 and 20 which correspond respectively to valves 2, 4, 6, 8 and 10 of the engine shown in Figures 1a to 1d. The pistons A1, B1 and C1 are linked to a crankshaft 30, by connecting rods 31, 33 and 35. A second pair of primary cylinders A2 and B2 are operatively linked with a second secondary cylinder C2 by means of valves 42, 44, 46, 48 and 50 which correspond to the valves, 2, 4, 6, 8 and 10 in the engine shown in Figures 1a to 1d. The pistons of cylinders A2, B2 and C2 are linked to the crankshaft 30 by means of connecting rods 41, 43 and 45, the latter all being slave connecting rods co-operating with the crankshaft 30 and also with the connecting rods 31, 33 and 35 which are the master connecting rods operating in known manner. Bearings 60 are provided between each crank of the crankshaft 30. Operation of the engine is similar to that shown in Figures 1a to 1d, the set of cylinders A1, B1 and C1 being 90° out of phase with the cylinders A2, B2 and C2.

The valves shown schematically in Figures 1a to 1d and Figure 2 are preferably provided by poppet valves in the case of valves numbers 2, 4, 12, 14, 42 and 44 the remainder of the valves being preferably rotary sleeve valves or alternatively poppet valves. The engines shown in the figures may be made of any suitable materials particularly metal.

Auxiliary services for the engines shown in the figures may conveniently be driven by the crankshaft, such services being pumps for fuel and lubrication etc.

In the engine shown in Figure 1 the crankshaft receives one power impulse per crankshaft revolution whereas in the engine of Figure 2 it receives two power impulses per revolution. The duration or time of application of each power stroke to the crankshaft is doubled and in a practical engine the demand for flywheel effect is reduced in proportion.

An engine according to the present invention provides a simplified structure over the conventional engine and is therefore potentially less costly.

The thermal efficiency of the engine may be improved over that for conventional engines. By suitably selecting the ratio of the cross sectional area of each primary cylinder with the secondary cylinder the working gas (combusted fuel/air mixture) may be fully expanded to ambient pressure and temperature in the secondary cylinder thereby extracting more of the heat energy generated during combustion and converting it into mechanical energy.

An engine according to the present invention may also be capable of accepting supercharging without a

significant reduction in thermal efficiency provided the supercharging is at the level dictated by the ratio in cross-sectional areas between each primary cylinder and the secondary cylinder specified in the engine design.

An engine according to the present invention may also provide a greater specific power. (Here specific power is defined as the power delivered at a preselected r.p.m. of the crankshaft by an engine of specific capacity.) For a given power output an engine according to the present invention has a reduced capacity. It is therefore physically smaller than equivalent conventional engines. It may also accept supercharging without substantial reduction in thermal efficiency. The engine stroke can therefore be shortened allowing the maximum r.p.m. of the crankshaft to be raised.

CLAIMS:-

1. An internal combustion engine characterised in that there is provided at least one primary cylinder (A,B) operating on the Otto cycle and an associated secondary cylinder (c) which cylinders are operatively coupled to a common crankshaft (30); and wherein the secondary cylinder (C) is operatively coupled to the primary cylinder (A,B) such that exhaust gas from the primary cylinder is exhausted into the secondary cylinder where it expands, driving the piston of the secondary cylinder, and said secondary cylinder subsequently exhausts the exhaust gas to atmosphere.

2. An engine as claimed in claim 1 characterised in that the ratio of the working volumes of the or each primary cylinder and the associated secondary cylinder are such that said exhaust gas from said primary cylinder expands into said secondary cylinder substantially to atmospheric pressure.

3. An engine as claimed in claim 1 or 2 characterised in that the length of the strokes of the pistons of the primary and secondary cylinders are substantially the same.

4. An engine as claimed in any of claims 1 to

3 characterised in that there are provided two primary cylinders associated with said secondary cylinder and operably coupled to said common crankshaft such that said primary cylinders are 180° out of phase with one another and exhaust alternately into said secondary cylinder.

5. An engine as claimed in any of claims 1 to 4 characterised in that there is provided a non-return inlet valve (2, 12, 42, 4, 14, 44) in the head of the or each primary cylinder for induction of fuel/air mixture into said cylinder, and a valve (6, 8, 16, 18, 46, 48) controlling the exhausting of exhaust gas from the or each primary cylinder to the associated secondary cylinder and also the exhausting of said exhaust gas from said secondary cylinder.

6. An engine as claimed in claim 5 wherein said controlling valve is a rotary sleeve.

E. N. Lewis & Taylor,
Chartered Patent Agents,
144 New Walk,
Leicester, LE1 7JA,
England.

Agents for the Applicants

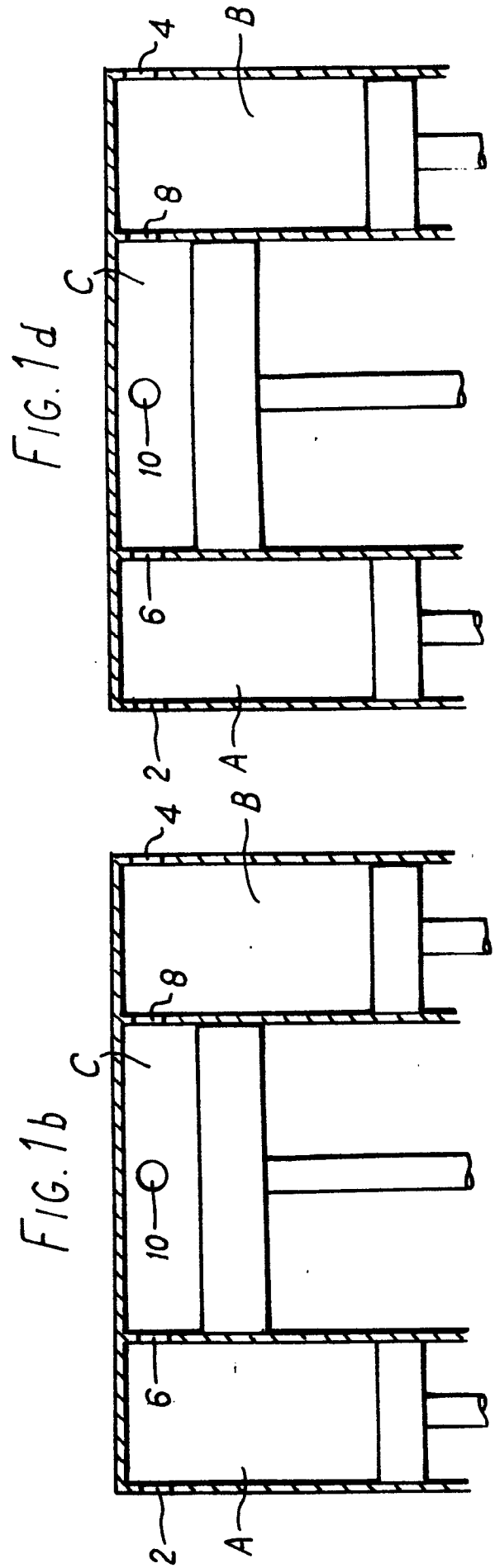
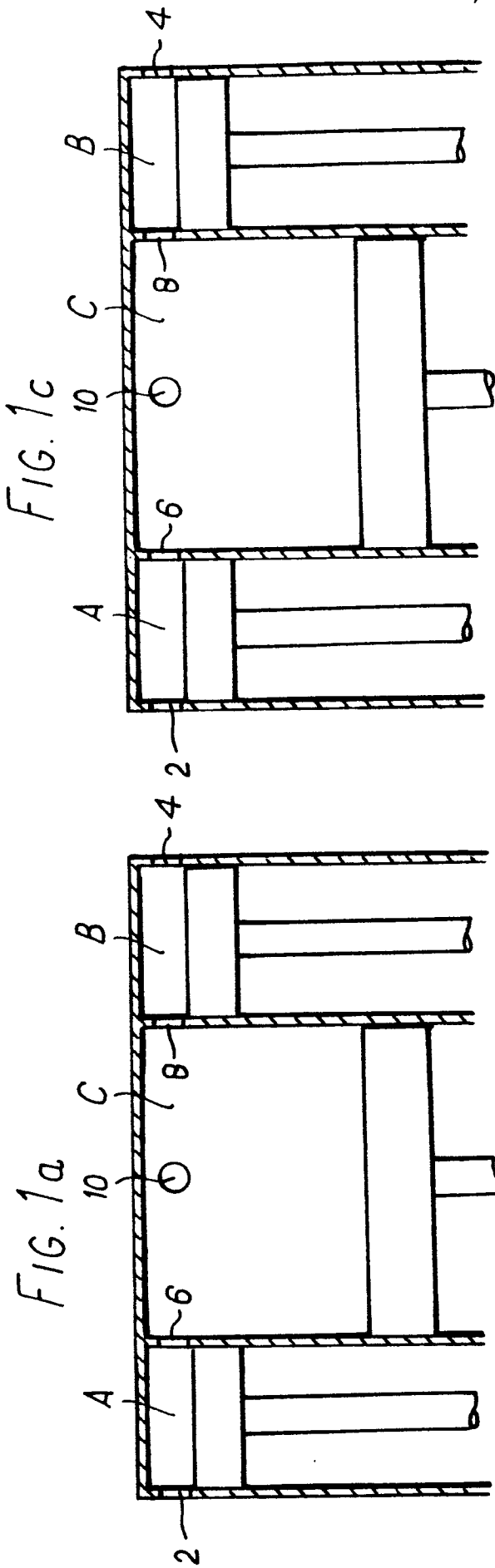
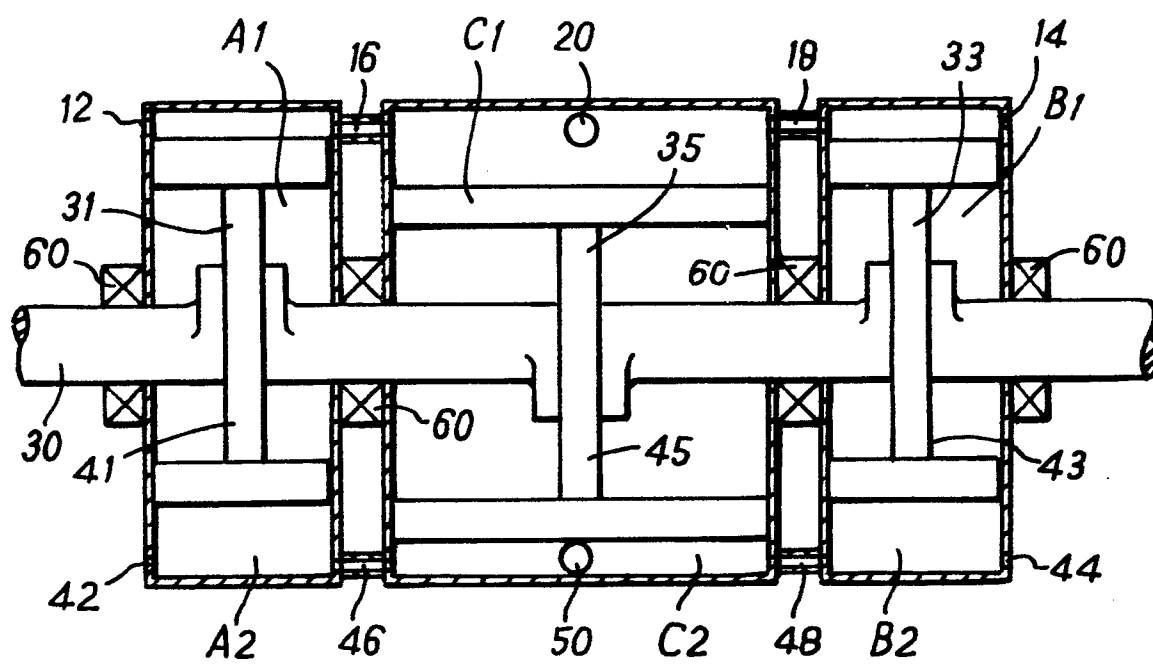


FIG. 2





European Patent
Office

EUROPEAN SEARCH REPORT

0006747

Application number

EP 79 301 218.8

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	<u>FR - A- 823 706</u> (JULLIEN) * page 1, line 43 to page 2, line 29; fig. 1* --- <u>FR - A - 693 316</u> (MOREAU) * claims; fig. 1 and 2 * --- <u>FR - A - 649 467</u> (WOYCIEKOWSKI) * claims; fig. 1 and 2 * ---	1-5 1,2 1	F 02 B 41/02
			TECHNICAL FIELDS SEARCHED (Int. Cl.)
A	<u>AU - B- 465 877</u> (HUBERS) * page 2, paragraph 2 to page 3, paragraph 1 * ---		F 02 B 41/00
A	<u>DE - C - 728 109</u> (HEYLANDT) * page 1, lines 1 to 69 * ---		
A	<u>DE - C - 316 250</u> (WIMPLINGER) * page 3, lines 36 to 38 and 53 to 56 * ----		
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
			&: member of the same patent family, corresponding document
X	The present search report has been drawn up for all claims		
Place of search		Date of completion of the search	Examiner
Berlin		25-09-1979	STÖCKLE