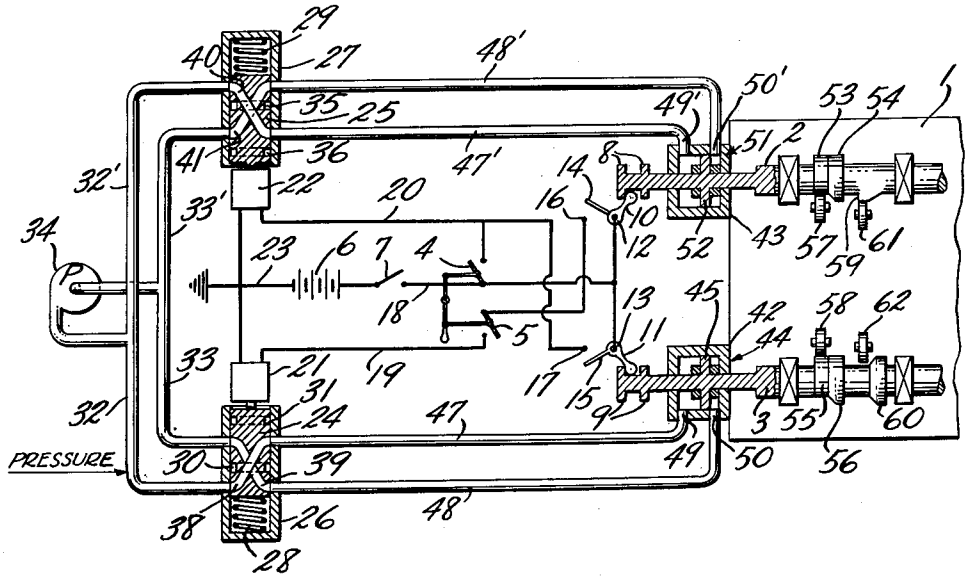
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POWER PLANT

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POWER PLANT

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This invention relates to power plants, and has particular reference to dual cycle internal combustion engines whereby the engine may operate at will on either a two- or four-stroke cycle, such as with alternative fuel oxidants.

Numerous types of dual cycle internal combustion engines have been proposed heretofore, some of which operate with a hydrocarbon fuel and air on one cycle and with steam on the other, others operate with a hydrocarbon fuel on either a two- or four-stroke cycle while still others operate on a four- or six-stroke cycle, and the like. Virtually all prior dual cycle internal combustion engines rely on selective operation of various inlet and exhaust valves by shifting valve camshafts or cam followers to selectively render certain cams operative and other cams inoperative in accordance with requirements. Such prior valve cam selecting mechanisms have inordinately increased the length and weight of the engines, rendered the operations uncertain because the shifting mechanism had to rapidly accommodate high valve loads and resulted in overlap of inlet and outlet valve operations which sometimes caused explosion in the outlet manifolds or mufflers or other damage where fuels or oxidants were allowed to pass out of the cylinder owing to the overlap.

In accordance with the present invention, a dual cycle internal combustion engine is provided in which selective change from two-cycle to four-cycle operation, and vice versa, may be effected at will without any increase in the normal size of the engine and with reliability, notwithstanding the necessary accommodation of the high valve loads to a new set of cams.

In a preferred embodiment of the invention, fluid pressure means supplied from the engine oil pump are sequentially controlled to shift the intake and exhaust valve camshaft endwise for aligning new cams thereon with the cam followers and with means controlled by the movement of the camshafts to insure coordination of the new cams with the former cams so that intake and outlet valve overlap does not occur.

It will be seen that the dual cycle engine with the novel cam selecting mechanism of this invention does not necessitate material increase in the size or weight of the engine and enables the use of shorter and stronger camshafts with more closely-spaced bearings accommodating the high valve loads encountered in high speed and high pressure engines.

For a more complete understanding of the invention, reference may be had to the accompanying drawing illustrating semi-diagrammatically the camshaft control mechanism of a dual cycle engine.

Referring to the drawing, numeral 1 indicates an internal combustion engine capable of operating with a hydrocarbon fuel and either air or hydrogen peroxide or other oxidant, such as liquefied oxygen, for use in submarine boats and torpedoes, for example. Such engines are known, and usually involve the use of separate valves for air and the alternative oxidant, such as hydrogen peroxide, although with the mechanism of the present invention the same intake valve may be used to draw in either air or decomposed hydrogen peroxide during the suction stroke.

The camshafts 2 and 3 of the engine 1 are shown in position for operation of the engine on one of the running cycles, say the four-cycle operation, with means being provided to shift therefrom to two-cycle operation, for example, and back again at will. This shifting means includes electrical switches 4 and 5 which are mechanically interconnected as shown, so as to open and close simultaneously. The source of electrical power may be the battery 6 with a main circuit switch 7 interposed between it and the switches 4 and 5 and appurtenant electrical mechanism.

The ends of the camshafts 2 and 3 are provided with spaced collars 8 and 9, respectively, between which lodge the free ends of correspoding levers 10 and 11 which are pivoted at their other ends 12 and 13, respectively, and carry respective switches 14 and 15 which they are adapted to move to closed position in engagement with corresponding fixed contacts 16 and 17. Switches 14 and 15 are connected to one terminal of the power source 6 by wire 18 containing main switch 7. Fixed contacts 16 and 17 of respective switches 14 and 15 are connected by wires 19 and 20 to solenoids 21 and 22, respectively, whose other terminals are connected to the other terminal of power source 6 by the common supply wire 23 as shown.

The armatures of solenoids 21 and 22 are connected to respective valves 24 and 25 slidably mounted in corresponding cylinders 26 and 27 and normally urged to the positions shown in the drawing by springs 28 and 29, i.e., with diagonal passages 38 and 39 of valve 24 registering with respective pressure and return lines 32 and 33 leading from and to the engine driven oil pump 34. Similarly, diagonal passages 40 and 41 in valve 25 are normally in registry with respective pressure and return lines 32′ and 33′.

When solenoids 21 and 22 are energized by closure of switches 4 and 5, the solenoids advance corresponding valves 24 and 25 against the pressure of springs 28 and 29 to a position such that straight passages 30 and 31 in valve 24 are aligned with the respective pressure and return lines 32 and 33 and straight passages 35 and 36 of valve 25 are aligned with the respective pressure and return lines 32′ and 33′. In the advanced position of valves 24 and 25, diagonal passages 38 and 39 in valve 24 and 40 and 41 in valve 25 are disconnected from the corresponding pressure and return lines.

Solenoid-operated valves 24 and 25 control the operation of hydraulic servo-motors 42 and 43, respectively. Servo-motor 42 comprises the cylinder 44 secured to the engine 1 in axial alignment with the camshaft 2 which carries the piston 45 mounted for reciprocation in cylinder 44. The movement and position of piston 45 is controlled by the pressure fluid supplied thereto through valve 24 to which pipes 47 and 48 are connected in alignment with pressure and return lines 32 and 33, respectively. Pipe 47 is connected to port 49 in the wall of servo-motor cylinder 44 at one side of piston 45, whereas pipe 48 is connected to port 50 on the other side of piston 45.

Similarly, pipes 47′ and 48′ aligned with respective pressure and return lines 32′ and 33′ are connected to respective ports 49′ and 50′ in cylinder 51 of servo-motor 43. Fixed to camshaft 3 is a piston 52 adapted to reciprocate within cylinder 51 between ports 49′ and 50′. The direction of movement and position of piston 52 are controlled by the pressure fluid supplied to cylinder 51 through valve 25.

The camshafts 2 and 3 are of generally conventional construction, except that they are provided with two adjacent cams for the selected valve, one cam for two-cycle operation, and the other cam for four-cycle operation, in the example given. As is shown more or less diagrammatically in the drawing, camshaft 2 carries two cams 53 and 54 for alternative operation of the fuel injector valve and cam 59 for operation of the air inlet

valve. Camshaft 3 carries two cams 55 and 56 for alternative operation of the exhaust valve and cam 60 for operation of a hydrogen peroxide valve. Either of cams 53 or 54 is adapted to cooperate with the same cam follower 57 and either cam 55 or 56 is adapted to cooperate with cam follower 58, depending upon the axial position of the corresponding camshafts 2 and 3. Likewise cam 59 is adapted to cooperate with follower 61 and cam 60 is adapted to cooperate with follower 62.

Accordingly, when pistons 45 and 52 and corresponding camshafts 3 and 2 are in the positions shown, cams 53, 55 and 59 are connected to respective followers 57, 58 and 61. Alternatively, when the pistons 45 and 52 move corresponding camshafts 3 and 2 to the left-hand position, cams 53, 55 and 61 are disengaged from respective followers 57, 58 and 61 and cams 54, 56 and 60 are engaged with respective followers 57, 58 and 62. An example of a suitable camshaft construction suitable for axial movement is shown in Peterson Patent No. 1,792,028, although it is to be understood that various other forms of camshaft construction affording the results described herein may be used with equal facility.

In operation of the dual cycle engine as controlled by the mechanism of this invention, let it be assumed that the engine is operating on the four stroke air cycle of operation and it is desired to shift to the two stroke operation, the operator closes main switch 7 and then closes switches 4 and 5 simultaneously. Solenoid 22 is immediately connected to power source 6 through closed switches 4 and 7 and wires 20 and 23 and is energized to move valve 25 against the pressure of spring 29 so as to connect straight passages 35 and 36 with respective pressure and return lines 32′ and 33′ and disconnect diagonal passages 40 and 41 therefrom.

Pressure fluid accordingly flows from pump 34, pressure line 32′ through straight passage 35, pipe 48′ and port 50′ behind piston 52 of servo-motor 43. Accordingly, piston 52 is moved to the left as seen in the drawing to disengage cam 53 and engage cam 54 with cam follower 57 and disengage cam 59 from follower 61.

As the piston 52 is moved to the left, the fluid in front of piston 52 is forced through port 49′, pipe 47′, and straight passage 36 to return line 33′.

The aforementioned movement of piston 52 to the left also causes lever 10 to engage switch 14 with fixed contact 16, thereby closing the circuit to solenoid 21 from power source 6, closed switches 5 and 14 and wire 19.

Solenoid 21 moves cylinder valve 24 against spring 28 to connect pressure line 32 through straight passage 30 with pipe 48 and port 50, whereby piston 45 of servo-motor 42 is moved to the left and the fluid in front of the piston is returned through port 49, pipe 47, straight passage 31 of valve 24 and return line 33 to the intake side of pump 34.

Piston 45 accordingly moves camshaft 2 axially to the left, thereby disconnecting follower 58 from cam 55 and connecting it with cam 56, and also connecting cam 60 with follower 62. At the same time, lever 11 is moved to close switch 15, thereby setting up a holding circuit for solenoid 21.

The movements of camshafts 3 and 2 are sequential and if they are respective air and peroxide intake valve camshafts as previously indicated, the air valve is closed before the peroxide valve opens, and hence there is no overlap between the opening and closing of the valves and no combustible or other damaging mixture is discharged to the inlet manifold at the time of the shift from one cycle to the other cycle of operation.

In order to revert to the original four-cycle operation, switches 4 and 5 are simultaneously opened by means of their common control, but simultaneous shifting of camshafts 2 and 3 does not occur, but the foregoing sequential operation occurs in the reverse order. Thus, the opening of switch 5 results in the deenergization of solenoid 21 notwithstanding that switch 14 remains closed, so that spring 28 restores valve 24 to its original position

aligning its diagonal passages 38 and 39 with lines 32, 47 and 33, 48, respectively. Thus, pressure from line 32 is supplied to the left-hand side of piston 45 as seen in the drawing, so as to force piston 45 and the corresponding camshaft 2 to the right to the position shown in the drawing where cam 56 is shifted from contact with cam follower 58 which then contacts with cam 55 and cam 60 is shifted from contact with cam follower 62, as shown.

Opening of switch 5 had no immediate affect on solenoid 22 because its circuit was maintained through closed switch 15 until the latter is opened by the aforementioned movement of camshaft 3 to the right, which then opens switch 15 to open the circuit through solenoid 22. Deenergization of solenoid 22 enables spring 29 to restore valve 25 to the position shown in the drawing, with its diagonal passages 40 and 41 thereof aligned with pipes 32′, 47′, and 33′, 48′, respectively. Pressure fluid accordingly forces piston 52 to the right to shift cam 54 from and cam 53 to cam follower 57 and restore switch 14 to open position. Cam 59 is simultaneously shifted from contact with follower 61. Accordingly, the closing of the peroxide and air intake valves again are sequential without overlap.

Although hydraulic operating pressure has been illustrated and described herein, it will be understood that any other fluid pressure, such as pneumatic pressure may be used with equal facility, and that other changes in form and detail may be made within the scope of the invention as defined by the appended claims.

I claim:

1. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, means for activating one of said motive means, and means responsive to the resulting relative shifting of the corresponding plural cams and follower means for activating said other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves.

2. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, a source of power for said motive means, means for connecting said source of power to said motive means, and means responsive to the resulting relative shifting of the corresponding plural cams and follower means for activating said other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves.

3. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, a source of power for said motive means, switching mechanism interposed between said power source and each of said motive means, means for actuating one of said switching mechanisms to energize the corresponding said motive means, and means responsive to the resulting relative shifting of the corresponding plural cams and follower means for actuating said other switching mechanism to energize the other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves.

4. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, a source of power for said motive means, electrical switching mechanism interposed between said power source and each of said motive means, manual means for actuating one of said switching mechanisms to energize the corresponding said motive means, and means responsive to the resulting relative shifting of the corresponding plural cams and follower means for actuating said other switching mechanism to energize the other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves.

5. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of fluid pressure motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, a source of fluid pressure for said motive means, valve mechanism interposed between said fluid pressure source and each of said motive means, means for actuating one of said valve mechanisms to activate the corresponding said motive means, and means responsive to the resulting relative shifting of the corresponding plural cams and follower means for actuating said other valve mechanism to activate the other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves.

6. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of fluid pressure motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, a source of fluid pressure for said motive means, valve mechanism interposed between said fluid pressure source and each of said motive means, several electrical means for actuating said valve mechanisms to activate the corresponding said motive means, manual means for energizing one of said electrical means, and means responsive to the resulting relative shifting of the corresponding plural cams and follower means for energizing the other of said electrical means to cause the other valve mechanism to actuate the other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves.

7. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, a source of power for said motive means, switching mechanism interposed between said power source and each of said motive means, manual means for actuating one of said switching mechanisms to activate the corresponding said motive means, means responsive to the resulting relative shifting of the corresponding plural cams and follower means for actuating said other switching mechanism to energize the other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves, and means responsive to a second actuation of said manual means for reactivating said switching mechanisms to energize said one and said other motive means in reverse sequential order to restore said plural cams and corresponding cam follower means to initial position.

8. In an internal combustion engine having a pair of valves and corresponding actuating mechanism therefor including relatively shiftable plural cams and cam follower means, the combination of a pair of fluid pressure motive means for relatively shifting said plural cams and followers of corresponding valves to alternatively place one of said plural cams for each valve into operation, a source of fluid pressure for said motive means, valve mechanism interposed between said fluid pressure source and each of said motive means, manual means for actuating one of said valve mechanisms to activate the corresponding said motive means, means responsive to the resulting relative shifting of the corresponding plural cams and follower means for actuating said other valve mechanism to energize the other motive means, whereby said one and said other motive means act in sequence to successively shift the plural cam and cam follower means of the corresponding valves, and means responsive to a second actuation of said manual means for reactivating said valve mechanisms to energize said one and said other motive means in reverse sequential order to restore said plural cams and corresponding cam follower means to initial position.

9. In an internal combustion engine having two different valves and corresponding actuating mechanism therefor, including longitudinally shiftable camshafts each having one of said cams and a corresponding cam follower connected to the corresponding valve, the combination of a motive means for shifting each camshaft relatively to the corresponding cam follower to alternatively place one of said cams in operative relation with the corresponding cam follower, means for initially actuating one of said motive means, and means responsive to the resulting relative shifting of the corresponding camshaft for actuating the other motive means, whereby said one and said other motive means shift said camshafts in sequence.

10. In an internal combustion engine having two different oxidant intake valves and corresponding actuating mechanism therefor, including longitudinally shiftable camshafts each having one of said cams and a corresponding cam follower connected to the corresponding valve, the combination of a motive means for shifting each camshaft relatively to the corresponding cam follower to alternatively place one of said cams in operative relation with the corresponding cam follower, means for initially actuating one camshaft motive means, and means responsive to the resulting relative shifting of said one camshaft for actuating the other camshaft motive means, whereby said motive means disables said one oxidant intake valve before rendering effective said other oxidant intake valve.

11. In an internal combustion engine having valves and corresponding actuating mechanism therefor, including longitudinally shiftable camshafts each having a plurality of cams and cam followers connected to a corresponding valve, the combination of a motive means for shifting each camshaft relatively to the corresponding cam follower to alternatively place one of said cams in operative relation with a corresponding cam follower, a source of power for said motive means, switching mechanism interposed between said power source and each of said motive means, manual means for initially actuating one of said switching mechanisms to energize the corresponding motive means, and means responsive to the resulting relative shifting of the corresponding camshaft for actuating the other switching mechanism to energize the other motive means, whereby said one and said other motive means shift said camshafts in sequence.

12. In an internal combustion engine having valves and corresponding actuating mechanism therefor, including longitudinally shiftable camshafts each having a

plurality of cams and cam followers connected to the corresponding valve, the combination of a motive means for shifting each camshaft relatively to the corresponding cam follower to alternatively place at least one of said cams in operative relation with a corresponding cam follower, a source of power for said motive means, switching mechanism interposed between said power source and each of said motive means, manual means for initially actuating one of said switching mechanisms to energize the corresponding motive means, means responsive to the resulting relative shifting of the corresponding camshaft for actuating the other switching mechanism to energize the other motive means, whereby said one and said other motive means shift said camshafts in sequence, and means responsive to a second actuation of said manual means for reactivating said switching mechanism to energize said one and said other motive means in reverse sequential order to restore said camshafts to initial position relatively to the corresponding cam followers.

13. In an internal combustion engine having at least two intake valves and corresponding actuating mechanism therefor, including longitudinally shiftable camshafts each having a cam and a corresponding cam follower connected to the corresponding valve, the combination of a motive means for shifting each camshaft relatively to the corresponding cam follower to place the corresponding cam in operative relation with the corresponding cam follower, manual means for initially actuating one intake valve camshaft motive means, means responsive to the resulting relative shifting of the said one intake valve camshaft for actuating the other intake valve camshaft motive means, whereby said motive means shift said intake valve camshafts in sequence, and means responsive to a second actuation of said manual means for reactivating said motive means to shift said one intake valve camshaft and then said other intake valve camshaft in reverse sequential order.

14. In an internal combustion engine having at least two intake valves and corresponding actuating mechanism therefor, including longitudinally shiftable camshafts each having a cam and a corresponding cam follower connected to the corresponding valve, the combination of a motive means for shifting each camshaft relatively to the corresponding cam follower to place the corresponding cam in operative relation with the corresponding cam

follower, a source of power, switching mechanism interposed between each motive means and said power source, manual means operatively connected to one of said switching mechanisms for initially actuating one intake valve camshaft motive means, means responsive to the resulting relative shifting of said one intake valve camshaft for actuating the other switching mechanism and the other intake valve camshaft motive means, whereby said motive means shift said intake valve camshafts in sequence, and means responsive to a second actuation of said manual means for reactivating said respective switching mechanisms to cause the corresponding motive means to shift said one intake valve camshaft and then said other intake valve camshaft in reverse sequential order.

15. In an internal combustion engine having at least two intake valves and corresponding actuating mechanism therefor, including longitudinally shiftable camshafts each having a cam and a corresponding cam follower connected to the corresponding valve, the combination of a fluid pressure-operated motive means for shifting each camshaft relatively to the corresponding cam follower to alternatively place the corresponding cam in operative relation with the corresponding cam follower, a source of fluid pressure, valve mechanism interposed between each motive means and said source, electrical means operatively connected to each of said switching mechanisms for initially actuating the exhaust valve camshaft motive means, electrical switching means for energizing one of said electrical means, means responsive to the resulting relative shifting of the corresponding valve camshaft for actuating the other switching means and the corresponding valve mechanism and other intake valve camshaft motive means, whereby said motive means shift said intake camshafts in sequence, and means responsive to a second actuation of said switching means for reactivating said respective valve mechanisms to cause the corresponding motive means to shift said one intake valve camshaft and then said other intake valve camshaft in reverse sequential order.

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