

[54] CAM SHAFTS FOR FOUR CYCLE REVERSIBLE INTERNAL COMBUSTION ENGINES  
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 Oct. 9, 1971 Japan..... 46-92966

[52] U.S. Cl..... 123/90.18; 123/41 R; 123/75 R  
 [51] Int. Cl..... F011 1/34  
 [58] Field of Search..... 123/41, 90.18, 75 E, 75 R

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[57] **ABSTRACT**  
 In a cam shaft for actuating suction and exhaust valves of a four cycle reversible internal combustion engine of the class wherein the cam shaft is provided with a plurality of cams and the cam shaft is moved axially to select two cams for actuating suction and exhaust valve operating rods for effecting forward or reverse rotation of the engine, there are provided three spaced apart cams on the cam shaft, an intermediate cam of which serves as, for example, a cam for actuating the suction valve upon forward rotation and for actuating the exhaust valve upon reverse rotation, the spacing between adjacent two cams being made equal to the spacing between adjacent operating rods for suction and exhaust valves of the engine whereby the inclination angle of the inclined surfaces between the two adjacent cams can be reduced.

1 Claim, 6 Drawing Figures

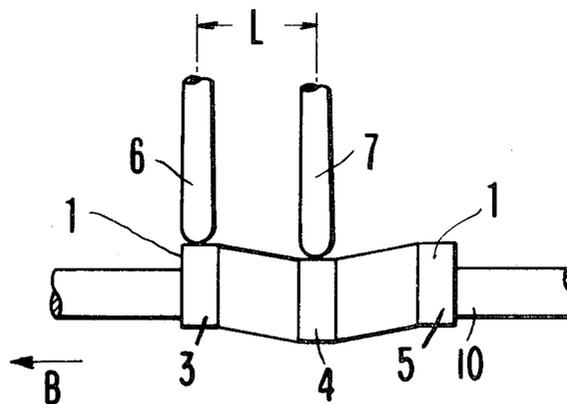


FIG. 1

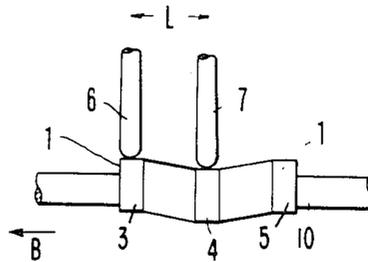


FIG. 2

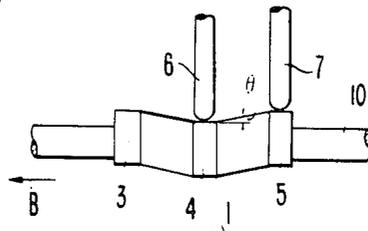


FIG. 3

PRIOR ART

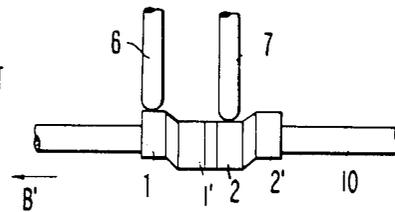


FIG. 4

PRIOR ART

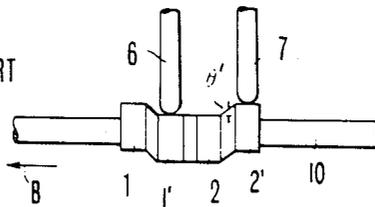


FIG. 5

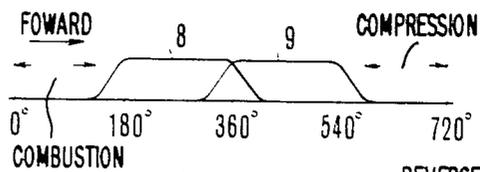
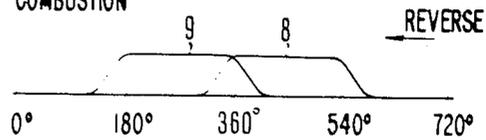


FIG. 6



## CAM SHAFTS FOR FOUR CYCLE REVERSIBLE INTERNAL COMBUSTION ENGINES

### BACKGROUND OF THE INVENTION

This invention relates to a cam shaft for actuating suction and exhaust valves of a four cycle reversible internal combustion engine where a cam shaft makes one revolution every two revolutions of a crank shaft.

As shown in FIGS. 3 and 4 prior art cam shaft 10 for actuating suction and exhaust valves of a reversible internal combustion engine includes a pair of cams 1 and 2 for actuating operating rods 6 and 7 of exhaust and suction valves, not shown, for forward rotation and another pair of cams 1 and 2 for reverse rotation. Accordingly, when the cam shaft is moved axially for the purpose of reversing the direction of rotation of the engine, the length of the axial movement is very short so that the inclination angle  $\theta'$  of the inclined surfaces of the cam shaft between adjacent cams which engage valve operating rods 6 and 7 is large thus requiring large force to move axially the cam shaft. If an attempt of reducing the inclination angle  $\theta'$  is made, it results in the increase in the axial length of engine. Moreover, if two cams are provided for actuating suction and exhaust valves independently for forward rotation and for reverse rotation, it is necessary to provide a total of four cams which increases the cost of the cam shaft.

### SUMMARY OF THE INVENTION

It is an object of this invention to provide a new and improved cam shaft for actuating suction and exhaust valves of a four cycle reversible internal combustion engine capable of reducing the number of cams.

Another object of this invention is to provide an improved cam shaft capable of reducing the inclination angle of the inclined surfaces between adjacent cams so as to be moved axially with a small force for reversing the direction of rotation of the engine.

According to this invention there is provided a cam shaft for actuating suction and exhaust valves of a reversible internal combustion engine of the class wherein the cam shaft is provided with a plurality of cams and the cam shaft is moved axially to select two cams for actuating suction and exhaust valve operating rods for effecting forward or reverse rotation of the engine, characterized in that there are provided three spaced apart cams on the cam shaft, an intermediate cam of which serves as, for example, a cam for actuating the suction valve upon forward rotation and for actuating the exhaust valve upon reverse rotation, the spacing between adjacent two cams being made equal to the spacing between adjacent operating rods for suction and exhaust valves of the engine whereby the inclination angle of the inclined surfaces between the two adjacent cams can be reduced.

### BRIEF DESCRIPTION THE DRAWING

Further object and advantages of the invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawing in which:

FIG. 1 shows a diagrammatic side view of a cam shaft embodying the invention in the forward rotation position;

FIG. 2 shows a view similar to FIG. 1 but showing the shaft in the reverse rotation position;

FIG. 3 shows a diagrammatic side view of a prior art cam shaft in the forward rotation position;

FIG. 4 shows a view similar to FIG. 3 but showing the shaft in the reverse rotation position; and

FIGS. 5 and 6 are diagrams to explain the forward and reverse rotation operations, respectively.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the accompanying drawing FIG. 1 shows a cam shaft 10 for actuating suction and exhaust valves (not shown) of a four cycle reversible internal combustion engine, the cam shaft 10 being shown in the position for forward rotation. The cam shaft 10 is provided with cams 3, 4 and 5 for actuating the exhaust and suction valves through operating rods 6 and 7 and the cam shaft is disposed to be movable in the axial direction. As shown in FIG. 1, the rod 6 of exhaust valve engages the cam 3 and the rod 7 of suction valve the cam 4, thereby opening an exhaust valve and closing a suction valve.

FIG. 5 is a diagram showing the valve opening and closing intervals (crank angle) for forward rotation wherein curve 8 shows the valve opening interval of the exhaust valve and curve 9 that of the suction valve.

To reverse the direction of rotation of the engine cam shaft 10 is moved by a distance L in a direction designated at symbol B as shown in FIG. 1 so that intermediate cam 4 actuates the exhaust valve operating rod 6 whereas righthand cam 5 actuates the suction valve operating rod 7. Then, as shown in FIG. 6, the operating timings of the suction and exhaust valves are varied.

As above described, the cam shaft is provided with only three cams so that it is possible to increase the length B of the axial movement of the cam shaft over that of the prior design. Accordingly, it is possible to decrease the angle of inclination  $\theta$  of the inclined surface interconnecting adjacent cams, whereby the force necessary to move axially the cam shaft is decreased greatly. In addition, since there is no exclusive cam for the reverse rotation between the valve operating rods it is possible to reduce the spacing L between these rods if the inclination angle  $\theta$  is allowed to be slightly larger. Further, as the number of cams for reverse rotation is decreased from two to one, the cam shaft can be manufactured at a less cost.

Although the invention has been shown and described in terms of a preferred embodiment thereof wherein numeral 6 designates the exhaust valve rod and 7 the suction valve rod it will be evident that many changes and modifications may be made wherein, for example, the rods 6 and 7 operates as the suction valve rod and exhaust valve rod, respectively.

I claim:

1. In a four cycle reversible internal combustion engine having spaced valve operating rods, a cam shaft for actuating suction and exhaust valves, said cam shaft comprising three spaced apart cams, an intermediate cam of which is disposed eccentrically with respect to the cams on opposite sides thereof and inclined surfaces are formed between said intermediate cam and the other two cams, said intermediate cam actuating the suction valve upon forward rotation and actuating the exhaust valve upon reverse rotation, the spacing between adjacent pairs of cams being equal to the spacing between said operating rods for adjacent suction and exhaust valves of said engine for reducing the inclination angle of said inclined surfaces between said adjacent pairs of cams.

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UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 3,884,198

DATED : May 20, 1975

INVENTOR(S) : Takashi Ito

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 17, after "movement" insert -- & --

**Signed and Sealed this**

*second Day of March 1976*

[SEAL]

*Attest:*

**RUTH C. MASON**  
*Attesting Officer*

**C. MARSHALL DANN**  
*Commissioner of Patents and Trademarks*