

April 18, 1961

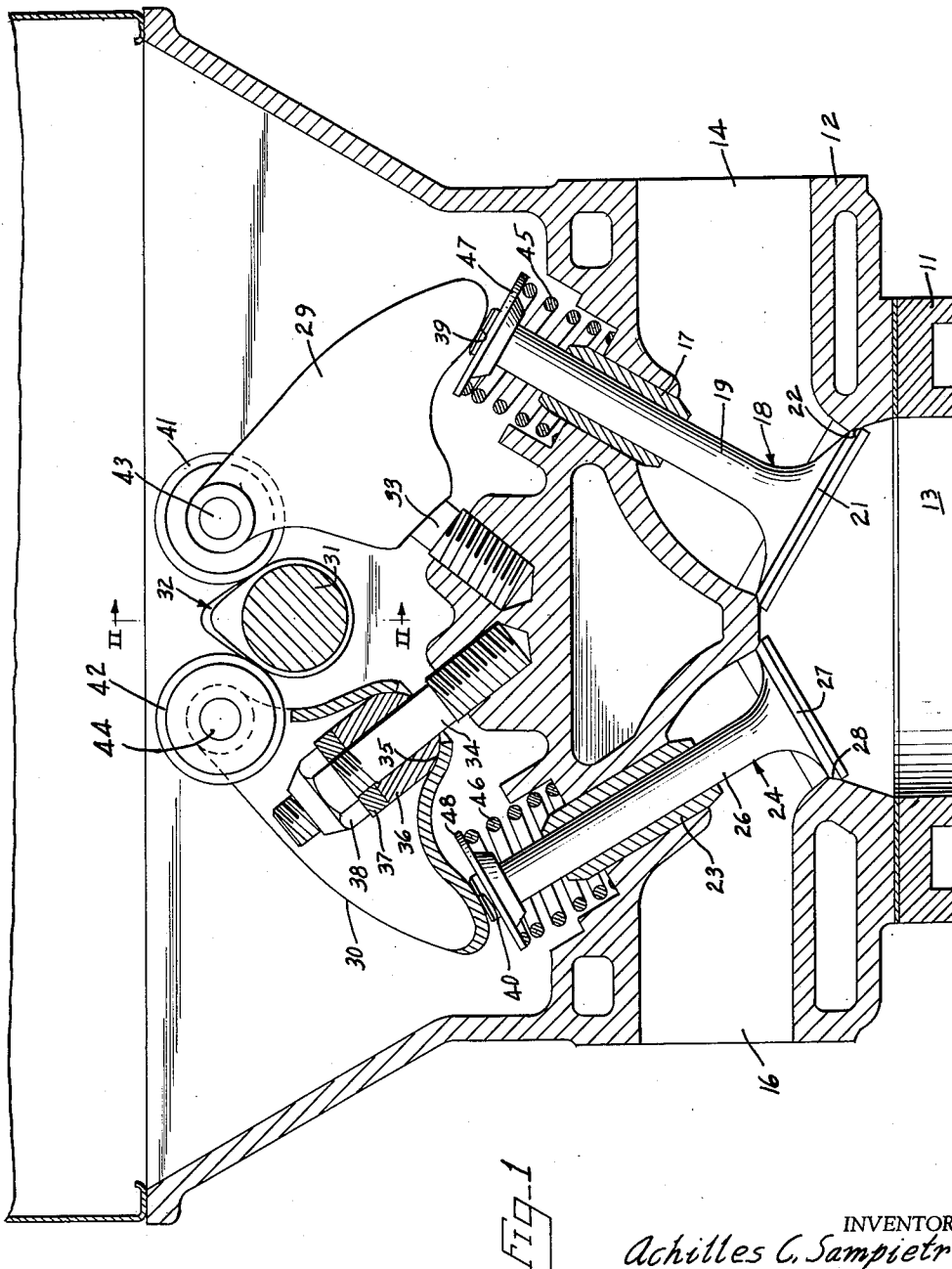
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2,980,089

VALVE OPERATING MEANS AND CONTROL

Filed Aug. 26, 1959

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

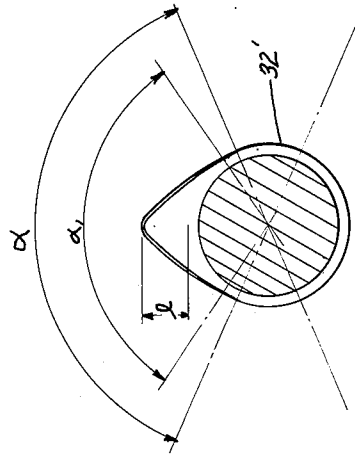
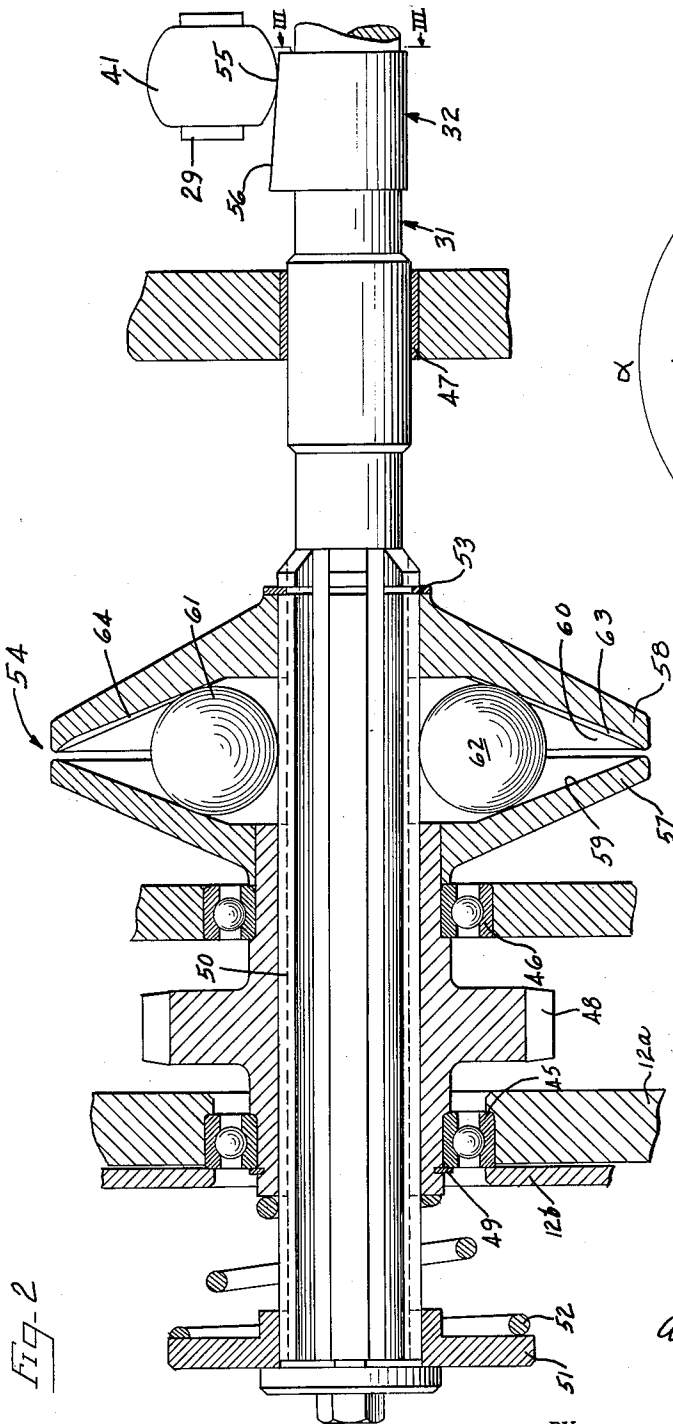


FIG-2

FIG-3

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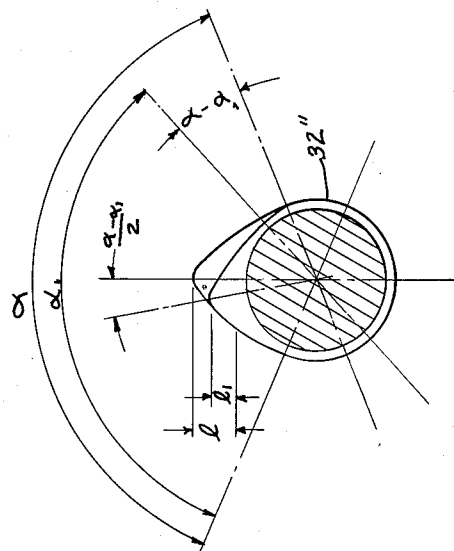
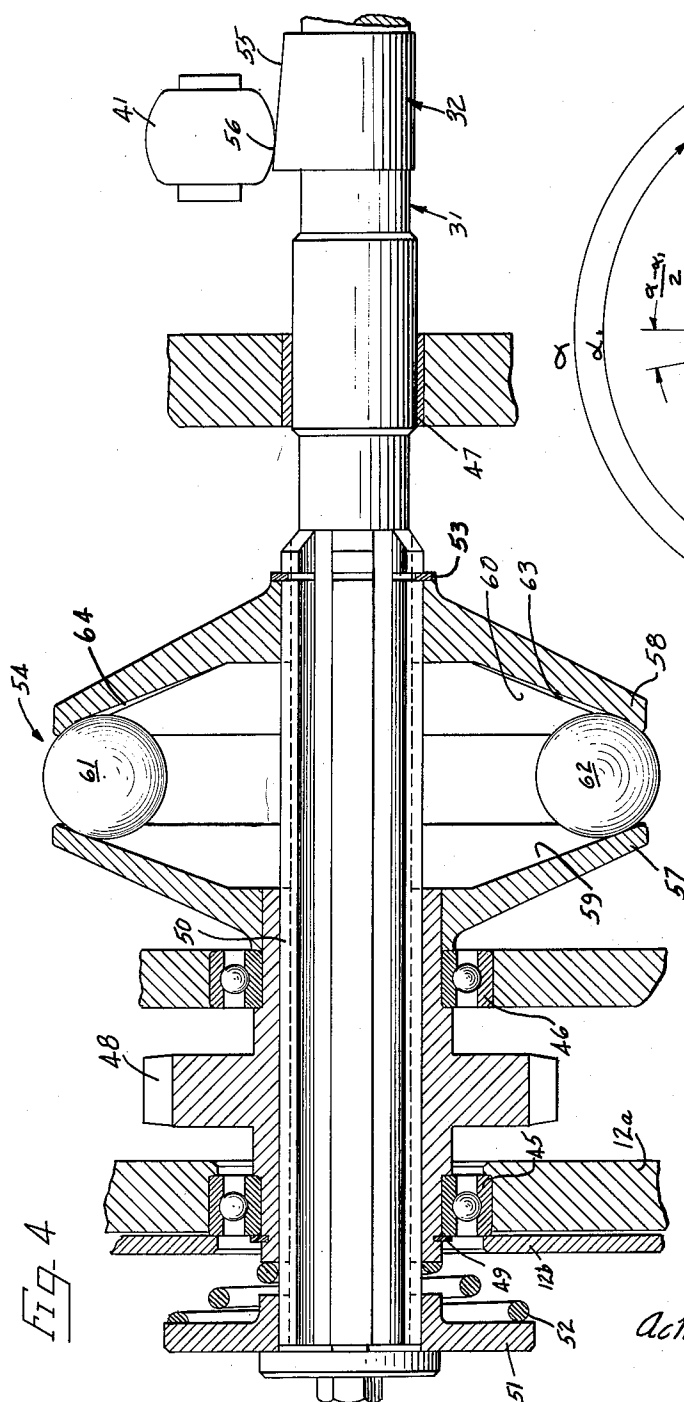
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VALVE OPERATING MEANS AND CONTROL

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3 Sheets-Sheet 3



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VALVE OPERATING MEANS AND CONTROL

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11 Claims. (Cl. 123—90)

The present invention relates to improvements in mechanism for operating valves of an engine and particularly to mechanism for changing valve operation while the engine is running.

The present invention contemplates the provision of a valve operating mechanism in an internal combustion engine having overhead inlet and exhaust valves operated by rocker arms pivotally supported on the engine. In a preferred form the rocker arms extend laterally outwardly and downwardly to operate the intake and exhaust valves and at their inner ends engage a cam on a single cam shaft. The cam has a changing profile along its axial length to vary the valve events such as the valve timing and the valve lift during operation by shifting the cam shaft axially relative to the rocker arms. The cam shaft is preferably shifted in response to changing engine speed but can be changed in response to other engine operating factors to obtain optimum valve operation throughout the engine speed range.

An object of the present invention is to provide an improved valve operating mechanism for an internal combustion engine or the like which operates to change the valve events.

Another object of the invention is to provide an improved valve operating gear for controllably changing valve events such as valve timing and valve lift for optimum valve operation at low idling speeds, for maximum torque throughout the speed range, for increased power, and for improved fuel economy.

A still further object of the invention is to provide an improved valve operating gear utilizing a single cam for operating rocker arms for intake and exhaust valves and changing the operation of both valves simultaneously as a function of engine speed or other factors affecting engine operation.

Other objects and advantages will become more apparent with the teaching of the principles of the invention in connection with the disclosure of the preferred embodiments thereof in the specification, claims, and drawings in which:

Figure 1 is a vertical sectional view taken through a cylinder of an internal combustion engine provided with a valve operating mechanism in accordance with the principles of the present invention;

Figure 2 is a vertical sectional view taken substantially along line II—II of Figure 1 illustrating details of a mechanism for axially shifting the cam shaft;

Figure 3 is a vertical sectional view taken substantially along line III—III of Figure 2 to illustrate the design of the cam;

Figure 4 is a vertical sectional view similar to Figure 2 but illustrating the position of the parts when the engine is operating at a high speed, with Figure 2 showing the parts when the engine is not operating; and

Figure 5 is a vertical sectional view similar to Figure 3 showing another arrangement of the cam.

As shown on the drawings:

In Figure 1 there is illustrated in a fragmentary manner

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a valve in head type of engine to which the valve operating mechanism of the invention may be adapted. The internal combustion engine illustrated includes a cylinder block 11 and a cylinder head 12. The head 12 is provided with an intake passage 14 from a suitable manifold and an exhaust passage 16 leading to a suitable manifold, with the manifolds not being shown. The intake of the fuel air mixture into a cylinder 13 is controlled by an intake valve 18 shown to be of the poppet type with a valve stem 19 slidable in a stem guide 17 mounted in the head 14. The valve 18 has a head 21 which coacts with a valve seat 22 to open or close the intake passage 14 as the intake valve 18 is opened and closed.

The exhaust passage 16 is provided with an exhaust valve 24 having a valve stem 26 slidable in a valve guide 23 in the head. The valve 24 has a valve head 27 which coacts with a valve seat 28 formed in the engine head in order to control the flow of exhaust gases from the cylinder 13 as the poppet type valve 24 is opened and closed.

The valves 18 and 24 are opened and also closed by rocker arms 29 and 30 respectively for the intake and exhaust valves 18 and 24. The rocker arms are actuated by a single cam shaft 31 carrying a cam 32. The cam 32 has a changing or differing profile axially along its length and the cam shaft shifts axially and is controllably positioned relative to the rocker arms 29 and 30 to change the valve events relative to the operation of the engine for optimum performance of the engine.

The rocker arms 29, 30 are pivotally mounted on the engine head 12 on a post 33, 34 respectively, which are threaded into the engine head. The rocker arms are illustrated as being formed of a depressed shaped fragmentary section of sheet metal with a spherically shaped concave central bearing surface, shown at 35 for the rocker arm 30. Since rocker arms 29 and 30 are similar in detail only rocker arm 30 need be described. The bearing surface 35 coacts with a lower fragmentary spherical surface of a bearing member 36 mounted on the post 34 and held in adjusted position by a threaded nut 37 and a lock nut 38, threaded to the top end of the post, and adjusted to obtain the proper valve operating clearance for the rocker arm. The outer ends of the rocker arms 29, 30 have surfaces 39, 40 which engage the upper ends of the valve stems 19, 26 for forcing the valves open with pivotal movement of the rocker arms 29, 30. The rocker arms are pivoted by rollers 41, 42, rotatably mounted on roller shafts 43, 44 on the rocker arms 29, 30 respectively, the rollers engaging the outer surface of the cam 32. The rollers 41 and 42 are crowned so as to engage the tapered cam 32 as illustrated by the roller 41 in Figures 2 and 4, so that the rollers will have substantially point engagement with the cam to travel in a plurality of paths depending upon the relative axial position of the cam.

As illustrated in Figures 2 and 4, the cam shaft 31 is driven by the engine by a gear 48 connected to the cam shaft 31 by splines 50. The gear 48 and the splines 50 permit the shaft to be shifted axially with respect to the gear and engine head and the gear is rotatably supported with its hub mounted on ball bearing units 45 and 46. The ball bearing units support the shaft and the shaft is directly supported on a sleeve bearing 47. The gear 48 will be driven by a meshing gear driven from the engine, and is held against axial shifting by being locked to the ball bearing 45 by a radially contracting snap ring 49 with the ball bearing axially mounted in the member 12a and held therein by a plate 12b which may be parts of the engine head 12.

The cam shaft 31 is urged axially, to the left as shown in Figures 2 and 4, by a coil compression spring 52

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bearing against a plate 51 secured to the end of the cam shaft 31, with the other end of the spring bearing against the hub of the gear 48. The axial movement of the cam shaft from the spring 52 is limited by a snap ring 53 which snaps into a groove in the cam shaft and engages a member of a speed responsive shaft control mechanism shown generally at 54.

The cam shaft is shifted axially from the position of Figure 2 which it occupies when the engine is not operating to the position of Figure 4 which it occupies at full engine speed. In the non-operating or low speed position of Figure 2, the cam follower rollers 41 and 42 engage the cam surface 32 at 55, and at the high or full speed operating position the rollers engage the cam surface at 56, as shown in Figure 4. At speeds between idling speed and full speed the cam followers will engage various axial portions of the cam 32, that is, they will follow various tracks around the cam dependent on the axial position of the cam which is controlled by the speed responsive mechanism 54.

The speed responsive mechanism 54 includes a first plate 57 which is mounted on the hub of the gear 48 to rotate therewith, and includes a second plate 58 which is secured to the splines on the shaft 31 to move axially with the shaft. The plate 57 has an inner segmental conical surface 59 and the plate 58 has an inner segmental conical surface 60, and between the surfaces are located balls 61 and 62. The balls are guided in grooves 63 and 64 formed in the surface 60. The balls of course will be subjected to centrifugal force with rotation of the shaft 31 and as the shaft gains speed the balls will move outwardly between the surfaces 59 and 60 forcing the plate 58 to the right as shown in Figures 2 and 4, compressing the spring 52, and shifting the cam 32 to the right with respect to the cam followers.

The arrangement permits providing cams with changing profiles along their axial lengths and with the profiles changed in accordance with the characteristics of the engine and use to which the engine is adapted for optimum engine operation. As illustrated in Figure 3, the length of valve events (the length of time the valves are open) may be α at one end of the cam and may be a smaller value α_1 at the other end of the cam. The cam 32' of Figure 3 shows the difference between α and α_1 as being equally split between the two sides of the cam. The cam 32'' of Figure 5 shows the difference between α and α_1 all on one side of the cam, and the difference may be unequally divided in accordance with valve operating requirements.

The cam 32' of Figure 3 illustrates substantially the constant lift l for the length of the cam. The cam 32'' of Figure 5 illustrates a change in lift along the cam from l to l_1 . The cam 32 of Figure 1 shows a change in lift and a change in length of events along the cam.

When the difference in length of the events between α and α_1 is taken all on one side of the cam, as illustrated by the cam 32'' of Figure 5, the peak of the cam surface will vary by an angle

$$\frac{\alpha - \alpha_1}{2}$$

In operation during cranking speeds and idling the cam follower rollers 41 and 42 will engage one end of the cam 32. With increase in speed the balls 61 and 62 will move outwardly forcing the cam shaft 31 to the right so that the cam followers will successively engage a different portion of the cam 32 between points 55 and 56. At full speed the followers will engage the cam at 56.

Thus it will be seen that I have provided an improved valve operating mechanism which meets the objectives and obtains the advantages hereinabove set forth. The mechanism operates automatically during engine operation to obtain the best valve timing for all engine speeds. This achieves improved operational characteristics at low

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idling speeds, maximum torque throughout the speed range, increased power, and improved fuel economy. Further, as it is not necessary to compromise the requirements of good torque in the middle range of speed, consistent idle, good power, and good fuel economy in a single cam profile, it is possible to use power cam accelerations with longer events at high speed shortening the events as required at lower speed.

The speed responsive mechanism 54 represents a control which varies the cam position in accordance with factors which affect engine operation. The axial motion of the cam can be controlled by a load responsive speed modulator. Furthermore, the axial position could be controlled by a hand operated mechanism, either directly or through a servo device.

The drawings and specification present a detailed disclosure of preferred embodiments of the invention, and it is to be understood that the invention is not limited to the specific forms disclosed, but covers all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by the invention.

I claim as my invention:

1. A valve operating mechanism for an engine having intake and exhaust poppet valves with valve stems mounted at an angle in an operating plane comprising a rotary cam shaft having a cam thereon differing in profile along its axial length, means rotatably supporting said cam shaft for axial shifting movement, a first pivotally supported rocker arm extending outwardly and downwardly from the cam shaft in said operating plane with the inner end in engagement with the cam for operating the intake valve of the engine, a second pivotally supported rocker arm extending outwardly and downwardly from the cam shaft opposite to said first rocker arm and in said operating plane with the inner end in engagement with the cam for operating the exhaust valve of the engine, shifting means connected to said cam shaft to axially position the cam with respect to said rocker arms, and speed responsive means driven by the engine connected to said shifting means for controlling the axial operating position of the cam with respect to the followers for different valve operating characteristics.

2. A valve operating mechanism for an engine comprising a cam follower for operating a valve of an engine, a valve operating cam in engagement with the follower having a cam surface differing in profile to provide a plurality of different follower paths having different characteristics, means for driving said cam surface at a speed which is a function of the speed of the engine, and means for axially shifting said cam surface so that the follower will follow one of said different follower paths to operate the valve in accordance with the path engaged by the follower.

3. A valve operating mechanism for an engine comprising a cam follower for operating a valve of an engine, a rotary cam shaft having a cam surface thereon in engagement with the follower differing in profile along its axial length for change in operating characteristics, means for rotating said cam shaft at a speed which is a function of the speed of the engine, and means for shifting said cam shaft axially so that the follower will be located at different axial positions along the cam for change in operating characteristics.

4. A valve operating mechanism for an engine comprising a cam follower for operating a valve of an engine, a valve operating cam in engagement with the follower having a cam surface differing in profile to provide a plurality of different follower paths having different characteristics, means for driving said cam surface at a speed which is a function of the speed of the engine, and speed responsive means to be driven as a function of engine speed for axially shifting said cam surface so that the follower will engage one of said different follower

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paths to operate the valve in accordance with the relative positions of the cam and follower.

5. A valve operating mechanism for an engine comprising a cam follower for operating a valve of an engine, a rotary cam shaft having a cam surface thereon in engagement with the follower differing in profile along its length for change in operating characteristics, means for rotating said cam at a function of engine speed, and speed responsive means to be driven at a function of engine speed shifting said cam surface axially so that the follower will engage different axial locations of the cam surface to operate the valve in accordance with the position of the cam.

6. A valve operating mechanism for an engine comprising a rotary cam shaft having a cam thereon, said cam differing in profile along its axial length, a cam follower in engagement with the cam for operating a valve of an engine, means for driving the cam shaft in rotation at a function of engine speed, means for shifting said cam shaft axially to cause the follower to engage the cam at different axial locations, and condition change responsive means responsive to change in engine operating conditions connected to said shifting means for controlling the relative axial operating position of the cam and follower.

7. A valve operating mechanism for an engine comprising a rotary cam shaft having a cam thereon, said cam differing in profile along its axial length, a first cam follower in engagement with the cam for operating an intake valve of an engine, a second cam follower in engagement with the cam for operating an exhaust valve of the engine, means for driving the cam shaft in rotation at a function of engine speed, and means for shifting said cam shaft axially relative to said followers to cause the followers to engage the cam at different axial locations for different valve operating characteristics.

8. A valve operating mechanism for an engine comprising a rotary cam shaft having a cam thereon, said cam differing in profile along its axial length, a first rocker arm at one side of the cam shaft with a follower at the inner end in engagement with the cam for operating an intake valve, a second rocker arm at the other side of the cam shaft with a follower at the inner end in engagement with the cam for operating an exhaust valve, means for driving the cam shaft in rotation at a function of the speed of the engine, and means for shifting said cam shaft axially to cause the followers to engage the cam

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and operate at different axial locations for different valve operating characteristics.

9. A valve operating mechanism for an engine comprising a rotary cam shaft having a cam thereon, said cam differing in profile along its axial length, a first rocker arm at one side of the cam shaft with a follower at the inner end in engagement with the cam for operating an intake valve, a second rocker arm at the other side of the cam shaft with a follower at the inner end in engagement with the cam for operating an exhaust valve, means for driving the cam shaft in rotation at a function of the speed of the engine, means for shifting said cam shaft axially to cause the followers to engage the cams and operate at different axial locations for different valve operating characteristics, and speed responsive means to be driven by the engine connected to said shifting means for controlling the relative axial operating position of the cam and followers.

10. A valve operating mechanism for an engine comprising a rotary cam shaft having a cam thereon, said cam differing in lift along its axial length, means for driving the cam shaft in rotation at a function of the speed of the engine, a cam follower in engagement with the cam for operating a valve of an engine, and means for shifting said cam shaft axially to cause the follower to engage the cam and operate at different axial locations for different valve operating characteristics.

11. A valve operating mechanism for an engine comprising a rotary cam shaft having a cam thereon, said cam differing in the rotational location of maximum lift along its axial length to change valve timing, a cam follower in engagement with the cam for operating a valve of an engine, means for driving the cam shaft in rotation at a function of the speed of the engine, and means for shifting said cam shaft axially to cause the follower to engage the cam and operate at different axial locations for different valve operating characteristics.

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