

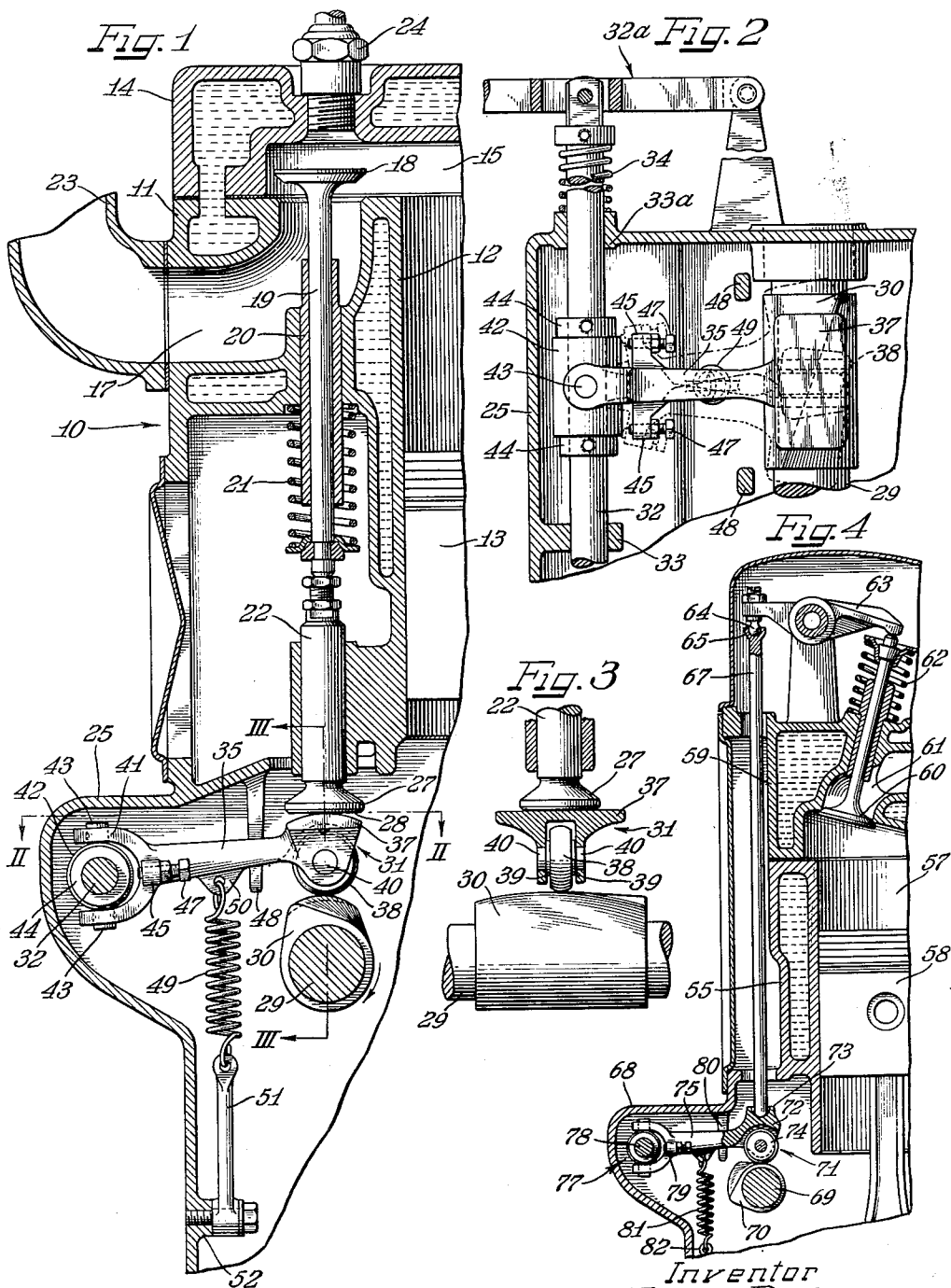
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ADJUSTABLE CAM FOLLOWER

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ADJUSTABLE CAM FOLLOWER

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The present invention relates to improvements in mechanism for controlling the operation of cam actuated valves such as valves of the poppet-type used in internal combustion engines and the like.

It has heretofore been proposed to control the operation of internal combustion engine poppet valves by providing actuating cams of varying size or height to act selectively upon the valves for determining the duration of opening or closing of the valves. One of the principal problems encountered has been that in the transition from one cam area to another, the follower means of the valve and the cam have encountered or been subjected to an inefficient degree of friction and resistance to movement, detrimental not only to the efficient operation of the mechanism, but also subjecting the interengaging relatively frictionally movable elements to undue wear and resultant rapid breakdown in proper operating relationships.

An important object of the present invention is to provide improved means for controlling cam-actuated valves and which is substantially free from frictional losses and wear by reason of affording smooth and easy transition from and between various selective actuating cam areas.

Another object of the invention is to provide a steerable valve-controlling cam follower device.

A further object of the invention is to provide an improved valve-controlling cam and adjustable follower combination.

Still another object of the invention is to provide improved means for controlling the operation of an internal combustion engine, or other piston and cylinder apparatus in which it is desirable to control the admission of fluid to the cylinder or exhaust fluid from the cylinder or the degree of compression to be created within the cylinder by the piston.

Other objects, features and advantages of the present invention will be readily apparent from the following detailed description of certain preferred embodiments taken in conjunction with the accompanying drawings in which:

Figure 1 is a fragmentary, more or less schematic vertical sectional view through a portion of an internal combustion engine showing mechanism embodying the features of the present invention in use therein;

Figure 2 is a fragmental horizontal sectional detail view taken substantially on the line II—II of Figure 1;

Figure 3 is a fragmentary vertical sectional detail view taken substantially on the line III—III of Figure 1; and

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Figure 4 is a more or less schematic vertical sectional view through a modified form of internal combustion engine embodying the features of the present invention.

As shown on the drawings:

By way of illustration, having reference to Figures 1, 2 and 3, the invention is shown as embodied in a more or less conventional internal combustion engine 10 including a water cooled block 11 and having therein a cylinder 12 within which is operable reciprocally a piston 13. A water-jacketed cylinder head 14 closes the cylinder 12 and affords a combustion chamber 15 thereabove. An intake port 17 into the combustion chamber 15 is controlled by a poppet valve 18 having an axial stem 19 slidably reciprocable in a bearing guide 20 and normally maintained under yielding closing pressure by a coiled biasing compression spring 21. At its lower end the valve stem 19 engages with a tappet 22.

Opening of the valve 18 enables a fuel charge from a manifold 23 to enter the combustion chamber 15 through the inlet 17 and after closing of the valve 18 compression of the fuel is effected by the piston 13 and the fuel is then exploded by a spark created by a spark plug 24 for driving the piston 13.

According to the present invention, the interval of opening of the valve 18 is controlled selectively and preferably throughout a uniform range of selective increments for effecting economy at various speeds of operation of, or operating demands upon the engine. In this manner the volume of the fuel charge drawn into the combustion chamber 15 and the cylinder 12 is regulated for economy and efficiency in operation throughout substantially the entire range of operating demands. To this end, the lower end portion of the tappet 22 which extends down into the chamber defined by a lower crank case portion 25 of the engine block is formed with an enlarged foot 27 having a broad lower face 28. Below the tappet foot 27 is a rotary cam shaft 29 carrying a cam 30 upon which rides a cam follower 31 interposed between the tappet foot 27 and the cam 30. As the cam shaft 29 rotates in the direction indicated by the directional arrow in Figure 1, the lobe of the cam periodically raises the follower 31 and thereby the tappet 22 and the valve 18 in opposition to the biasing spring 21 in proper timed sequence coordinated with operation of the piston 13.

In order to control the interval of opening of the valve 18, the lobe of the cam 30 is of varying width throughout a substantial extent longitudinally of the cam shaft 29, the cam being for-

this purpose of elongated form and longitudinally centered with respect to the axis of the tappet 22. Thus, one end of the lobe 30 is quite narrow so that when the follower 31 rides this narrow end of the cam the interval of opening of the valve 18 will be short. From the narrow end the cam gradually widens toward a substantial width at the opposite end, as best seen in Figures 1 and 2. Therefore, by moving the follower 31 lengthwise of the actuating cam 30, the interval of opening of the valve 18 can be controlled by gradual increments from a short interval to a rather long interval.

To accomplish movement of the follower 31 longitudinally of the actuating cam 30, a follower actuating shaft 32 is provided to which the follower 31 is connected, the shaft 32 being mounted in parallel spaced relation to the cam shaft 29 in appropriate bearings 33 in the crank case 25. Any suitable means may be provided for reciprocally moving the follower shaft 32, shown in Figure 2 as comprising an actuating lever mechanism 32a. Biasing means such as a compression spring 34 may be provided to act upon the shaft 32 normally to urge it toward a given position, as for example, the position in which the follower 31 is disposed midway the ends of the valve actuating cam 30.

In a convenient and practical form, the follower 31 comprises an arm 35 provided at one end with a follower head 37 which is transversely elongated to provide a platform upon which the tappet foot face 28 bears. The length of the head 37 is so related to the width of the tappet foot 27 that proper operating contact between the tappet foot and the follower head will prevail throughout the range of control movement of the follower longitudinally of the valve actuating cam 30. Furthermore, since in the rotation of the cam 30 with the cam shaft 29, the follower 31 must move with a rocking movement relative to the tappet foot 27, the upper bearing surface of the follower head 37 is preferably formed convexly transversely of the head so as to maintain adequate contact with the central portion of the tappet foot face 28 in all relative positions of the tappet foot and the follower.

Friction between the valve actuating cam 30 and the follower 31 is minimized in operation by equipping the follower with a roller 38. For this purpose the lower portion of the follower head 37 has a pair of spaced, downwardly extending journal ears 39 within which trunnions 40 of the roller 38 are journaled. Thus, as the cam 30 rotates, the roller 38 rides thereon smoothly and substantially without friction.

Although relative rotation of the valve actuating cam 30 and the follower roller 38 proceeds substantially without friction, relative movement in axial directions of the cam and roller is highly resisted by the friction of the interengaging surfaces thereof. Accordingly, means are provided for steering the follower roller 38 into various positions of adjustment longitudinally of the cam 30 by operation of the follower shifting shaft 32. Such means herein comprise a yoke 41 at the end of the follower arm 35 opposite the follower head 37 having substantially universal connection with the shifter shaft 32 through a collar 42 rotatably engaged about the shaft 32 and having trunnions 43 rotatably journaled in the arms of the yoke 41. The sleeve 42 is held against relative axial movement on the shaft 32 while permitting free rotary movement on the shaft by respective stop collars 44 secured fixedly

on the shaft at the opposite ends of the sleeve. Through this arrangement, the follower arm 35 can rock relative to the shaft 32; and in the axial movement of the shaft 32 for shifting the follower 31 longitudinally of the valve actuating cam 30, the follower arm 35 can swing toward either respective side depending upon the direction of shifting of the shifter shaft, so that follower roller 38 is steered to ride by smooth transition into the desired shifted or adjusted position on the cam 30. Swinging of the follower is indicated by the dot dash and by the dot outline positions thereof seen in Figure 2 which show, respectively, the positions of the follower at the beginning of shifting of the follower from positions toward opposite ends of the actuating cam 30 to the median full line position illustrated. Thus, as the cam 30 rotates, within only a very few revolutions thereof, the follower will attain the adjusted position to which it is steered by actuation of the shifter shaft 32.

In order to assist the steering action of the follower 31 and more particularly the smooth transitional movement of the roller 38 over the cam 30 in the shifting of the follower from place to place longitudinally of the varying width lobe area of the cam 30, the engagement periphery of the roller 38 is preferably convex in cross-section as best seen in Figure 3. Furthermore, the varying width peak of the lobe of the cam 30 is preferably convexly formed both transversely and longitudinally. Thereby, irrespective of the angular relationship of the cam 30 and the roller 38 during operation, friction or resistance to relative rolling movement is eliminated in a practical sense irrespective of the contacting pressures involved due to spring loadings, mass dispositions, operating speeds and the like during operation. During operation, of course, due to the universal joint connection of the follower arm 35 with the shifter shaft 32, the follower arm will normally tend automatically to assume an unbiased position relative to the shifter shaft by reason of the reaction of the surface of the cam 30 and the contacting surface of the roller 38 in the same manner that a freely swivelling wheel on a vehicle normally assumes a straight front to rear position when in relative travelling movement over a surface. Hence, in effecting adjustment of the position of the follower roller 38 longitudinally of the lobe of the cam 30 shifting movement of the shifter shaft 32 effecting angular deviation in the desired direction from the free normal running relationship of the follower causes the follower to be steered into the desired adjusted position as it automatically assumes the free, unbiased running relationship of the roller 38 over the cam 30. It will be appreciated, of course, that the respective convexities of the contacting surfaces of the cam lobe 30 and the follower roller 38 enhance the tendency of the follower to move into any steered adjusted position relative to the cam.

Inasmuch as unsteered relative axial movement of the cam 30 and the follower roller 38 is frictionally resisted to a very high degree, advantage can be taken of this fact to limit the rate of control transition or shifting of the follower 31. This is especially desirable in an internal combustion engine for smoothness and uniformity of operation. To this end means are provided for limiting the swing of the follower arm 35 relative to the shifter shaft or rod 32. To this end the follower arm 35 is provided with

stop means comprising a pair of lateral lugs 45 located at the sides of the bight of the yoke 41 and arranged to respectively engage with the adjacent ends of the swivel or universal sleeve 42 to delimit swinging movements of the follower arm. While for some purposes it may be desirable to permit a full range of swinging movement of the follower arm 35 in both opposite directions as limited by the lugs 45, it may be best under certain circumstances, or in certain engines, or under certain operating conditions of any particular type of engine with which the device is used to further limit or restrict the range of swinging movement in either or both directions, or to effect a differential swinging of the follower arm in opposite directions. For this purpose, stop screws 47 may be provided which are threaded through the respective lugs 45 with their tips projectable beyond the sleeve-opposing faces of the lugs to any desired adjusted extent.

In order to retain the follower 31 and more especially the roller 38 against riding off of the opposite ends of the cam 30 at the extremes of position adjustment of the follower, stop means such as lugs 48 are preferably provided and which may comprise integral or attached members properly located on the adjacent wall of the engine block defining or providing the crank case 25. As best seen in Figures 1 and 2, the stop lugs 48 are located adjacent to the opposite ends of the cam 30 for engagement by the follower arm 35. There is also, of course, a limit upon the respective opposite shifting movements of the shifter rod, or shaft 32, which can be accomplished in any preferred fashion, but in the present instance results from the particular spacing between the journal lugs 33, or between the journal lug 33 nearest the end wall of the crank case and a bearing boss 33a provided for the rod or shaft 32 in said end wall.

Any possibility of slap between the follower 31 and the cam 30 during high speed operation is avoided by the provision of biasing means for holding the follower against the cam 30. Such biasing means comprises a coiled tension spring 49 hooked through an ear 50 on the underside of the follower arm 35. At its opposite, or lower end, the spring 49 is hooked onto the end of a link 51 which is pivotally secured at its lower end to the adjacent wall of the crank case 25 as for example, to a boss 52 provided for this purpose. The total length of the spring 49 and the pivoted link 51 is such as to enable ample accommodation of the biasing structure to the full range of shifting adjustment of the follower 31 and to avoid undue resistance to such shifting. By preference, the biasing spring and link are located to assume a directly vertical position when the follower 31 is at mid-point of adjustment range and which may be the optimum operating relationship of the engine controls for peak normal running efficiency of the engine. By having the biasing spring 49 and the link 51 thus centered, the biasing effect thereof will, in addition to the normal hold-down bias also tend to return the follower 31 normally toward the central operating position relative to the cam 30 following shifting of the follower in either direction from the central position.

In the modification shown in Figure 4 the steered valve control follower is shown as applied to an internal combustion engine employing overhead valves. In such an engine a water jacketed engine block 55 has one or more cylinders 57 within which are reciprocally operable respec-

tive pistons 58. A water jacketed cylinder head 59 carries one or more poppet valves 60 controlling respective ports 61, in the instance shown comprising a fuel inlet port 61. A coil spring 62 normally urges the valve 60 to closed relation. A rocker arm 63 has one end portion thereof in engagement with the end of the valve stem while the opposite end of the rocker arm carries a universal joint ball 64 engaging within a universal socket 65 of a transmission rod 67 which extends down into a crank case 68 wherein is appropriately located a cam shaft 69 having thereon a cam 70 identical with the previously described cam 30. A follower 71 operates between the cam 70 and the transmission rod 67 in the same manner as the follower 31 and embodies the same structural and operating characteristics as the follower 31 except for the slight modification required for adapting the same for overhead valve control.

In order to adapt the follower 71 for cooperation with the transmission rod 67, a head 72 is provided formed with an upwardly-opening, rounded, concave socket 73 within which the rounded lower end of the transmission rod 67 bears. A roller 74 carried by the lower portion of the head 72 rides the cam 70. A follower arm 75 is attached by a universal swivel connection 77 identical with the swivel connection for the follower arm 35, to a shifter shaft or rod 78. Stop lug means 79 may be provided on the arm 75, corresponding to the stop lug means 45. Likewise, end limit stop lugs 80 may be provided on the inside of the crank case 68. A hold-down and centering biasing spring 81 and a pivoting connecting link 82 for the follower 75 may also be provided. Operation of the follower 71 is the same as the follower 31, and the universal connections of the transmission rod 67 with the rocker arm 63 and with the follower head 72 enables the transmission rod to accommodate itself to all shifted and shifting movements of the follower.

While the valve control of the present invention has been specifically illustrated in conjunction with forms of internal combustion engines, since in this field a wide range of usefulness is inherent, it should be understood that the valve control mechanism would also find use in such apparatus as compressors, and in other apparatus where reciprocable, or poppet-type valves are used and in which the interval of valve opening is desirably variable for improved efficiency under various operating conditions and demands.

While for specific illustration, intake or inlet control has been described, it will be appreciated that exhaust control is equally within the contemplation and scope of the present invention. In the same apparatus, both intake and exhaust valve control can be effected by the use of separate control mechanisms according to the present invention.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. Valve control mechanism comprising a rotary cam having an axially elongated lobe of gradually increasing width from one end to the other end of the lobe, a follower member comprising an arm pivotal about an axis substantially parallel to said cam and having a roller riding the cam and a surface above the roller for engagement by a valve actuating member,

a shaft upon which said arm is mounted, means for axially moving said shaft for shifting the follower arm, and means providing a swivel connection between said shaft and said arm for steerably swinging the arm to change the position of the roller axially of the cam.

2. Valve control mechanism comprising a rotary cam having an axially elongated lobe of gradually increasing width from one end to the other end of the lobe, a follower member comprising an arm having a roller riding the cam and a surface above and adjacent to the roller for engagement by a reciprocable valve actuating member, means for shifting the follower arm, means providing a swivel connection between said shifting means and said arm for steerably swinging the arm to change the position of the roller axially of the cam, and means for limiting the swinging range of said arm.

3. Valve control mechanism comprising a rotary cam having an axially elongated lobe of gradually increasing width from one end to the other end of the lobe, a follower member comprising an arm mounted for pivotal movement about an axis parallel to said cam and having a roller riding the cam and an enlarged arcuate surface above the roller for engagement by a valve actuating member, means for shifting the follower arm, means providing a swivel connection between said shifting means and said arm for steerably swinging the arm to change the position of the roller axially of the cam, and means comprising spaced stop abutments located adjacent to the respective ends of the rotary cam for limiting the range of shifting movement of the follower arm with respect to the ends of the cam lobe.

4. In combination in mechanism for controlling the operation of a reciprocable valve, a follower arm having at one end a roller for riding upon a cam having a lobe of progressively varying width and a portion above said roller for engagement by valve actuating means to be reciprocated in the riding of the roller over the cam during rotation of the cam, a shifter rod reciprocably mounted on an axis parallel to the axis of rotation of the cam, a yoke on said arm, a swivel sleeve on said rod and having a universal swivel connection with said yoke, and means for selectively shifting the rod to change the angular attitude of the follower arm relative to the rod and thereby steer the follower roller into selected adjusted position relative to the cam lobe.

5. In combination in mechanism for controlling the operation of a reciprocable valve, a follower arm having at one end a roller for riding upon a cam having a lobe of progressively varying width and a portion above said roller for engagement by valve actuating means to be reciprocated in the riding of the roller over the cam during rotation of the cam, a shifter rod reciprocably mounted on an axis parallel to the axis of rotation of the cam, a yoke on said arm, a swivel sleeve on said rod and having a universal swivel connection with said yoke, and means for selectively shifting the rod to change the angular attitude of the follower arm relative to the rod and thereby steer the follower roller into selected adjusted position relative to the cam lobe, said arm having stop lug means adjacent to the bight of said yoke and engageable with said sleeve to limit the range of angular attitude or swinging movement of the arm with respect to the shifter rod.

6. In combination in mechanism for controlling the operation of a valve, valve actuating means including a follower having a roller for riding upon a cam having a lobe of substantial length and progressively varying width, means comprising a member pivotally connected to said follower on a pivotal axis transverse to the axis of the cam for steering movement of said follower by swinging about said pivotal axis into selected positions with respect to said lobe throughout the length of the lobe, and means for normally yieldably maintaining the follower in a central position relative to the length of the cam lobe.

7. In combination in mechanism for controlling the operation of a valve, valve actuating means including a follower having a roller for riding upon a cam having a lobe of substantial length and progressively varying width, means comprising a member pivotally connected to said follower on a pivotal axis transverse to the axis of the cam for steering movement of said follower by swinging about said pivotal axis into selected positions with respect to said lobe throughout the length of the lobe, and means for normally yieldably maintaining the follower in a central position relative to the length of the cam lobe, said means comprising a tension spring and a link pivoted on a fixed pivot centered with respect to the cam lobe.

8. In combination in valve controlling mechanism, a cam follower arm having a head including means for engagement by a valve actuating member and a roller for riding upon a rotary cam having a lobe of varying effective area, said arm being pivotally mounted on an axially shiftable shaft having an axis substantially parallel to said cam for steering movement longitudinally of the cam while riding on said cam and during movement of said arm when shifted by said shaft, and a spring acting on said arm to urge said roller into positive engagement with the cam.

9. In combination in mechanism for controlling the operation of a poppet valve or the like, a rotary cam having a lobe elongated axially thereof and of progressively varying width from end to end of the lobe, a follower having a head to be engaged by means for actuating the valve and also having a roller riding said cam, said follower including an arm, a shifter adjacent the end of the arm opposite said head, means providing a swivel connection between the shifter and said opposite end of the arm for effecting swinging movement of the arm upon actuation of the shifter to steer said roller into selected position with respect to said cam lobe, and means for normally urging said arm into a centered position with respect to said cam lobe.

10. In combination in mechanism for controlling the operation of a poppet valve or the like, a rotary cam having a lobe elongated axially thereof and of progressively varying width from end to end of the lobe, a follower having a head to be engaged by means for actuating the valve and also having a roller riding said cam, said follower including an arm, a shifter adjacent the end of the arm opposite said head, means providing a swivel connection between the shifter and said opposite end of the arm for effecting swinging movement of the arm upon actuation of the shifter to steer said roller into selected position with respect to said cam lobe, and means for normally urging said arm into a centered position with respect to said cam lobe, said last mentioned means comprising a tension spring

attached to said arm and a link attached to said spring and pivotally secured on a fixed pivot spaced from and centered with respect to said lobe.

11. In combination in mechanism for controlling the operation of a poppet valve, a tappet, said tappet having a foot provided with a broad downwardly facing surface, a rotary cam underlying said foot in spaced relation and having an elongated lobe of progressively varying width, 10 a follower arm having a head underlying said foot and affording a bearing surface for said broad surface of said foot, said head surface being substantially elongated in the direction of elongation of said lobe, a roller carried by said 15 head and riding said cam, a shifter adjacent the opposite end of said arm, and means effecting a swivel connection between said shifter and said opposite end of the arm for imparting steering angularity to said arm with respect to said lobe to cause said roller to ride into selected positions on said lobe to vary the duration of lifting of the tappet, said head slidably shifting 20 relative to said tappet foot during the steering adjustment of the follower.

12. In combination in valve controlling mechanism, a valve actuator, an elongated rotary member of varying peripheral contour, a follower having a roller riding the periphery of the rotary member, said follower having a first 30 portion engaging said valve actuator and a sec-

ond portion projecting clear of said first portion, a member longitudinally pivotally supporting said second portion and carrying transverse pivot means for enabling swinging of said follower about an axis transverse to the axis of rotation of said rotary member for steering the follower into selected positions longitudinally of said rotary member during rotation of said rotary member, and means for effecting relative shifting of said members longitudinally with respect to the axis of said rotary member for steering said follower.

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