DESCRIPTION

VALVE OPENING DEGREE DETECTION APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to an apparatus for detecting a full-closure position and full-opening position of a valve body of a valve apparatus and transmitting an ON/OFF control signal for a valve body drive motor, and more particularly to a valve opening degree detection apparatus that can detect the full-closure position and full-opening position of the valve body and easily and reliably determine or change the actuation positions of limit switches for transmitting the ON/OFF control signal for the motor.

BACKGROUND

[0002] Most actuators used for operating valve bodies in valve apparatuses, such as butterfly valves or ball valves, use an electric motor as a drive source. Such an actuator has an output shaft joined to a valve rod that rotates the valve body of the valve apparatus, the full-closure and full-opening position of the valve body is detected by a cam attached to a detection rod synchronized with the output shaft of the valve rod and a limit switch actuated by the cam, the electric motor is switched ON/OFF, and the valve body is set into the full-closure or full-opening position. Such a valve opening degree detection apparatus is disclosed, for example, in Japanese Examined Utility Model Publication No. H 7-10147 (Patent Document 1) and Japanese Patent Application Laid-open No. H 8-21555 (Patent Document 2).

[0003] The apparatus disclosed in Patent Document 1 is so configured that when a limit cam attached to an output shaft driving a valve body rotates through a predetermined angle, a limit dog attached in a position below the limit cam abuts against a striker of a limit switch, and the limit switch can be ON/OFF controlled. However, in such conventional apparatus, the limit switch dog and limit striker are fixed with screws so that fine adjustment of positions thereof is possible, and in

order to adjust the full-closure position of the valve opening degree, the adjustment operation has to be performed by fine adjustment in which the screws are individually loosened or tightened. Moreover, a displacement can occur when the screws are tightened to fix the limit dog. In addition, such an adjustment is a difficult and time consuming operation because the difference between individual components and slight loosening of joints are accumulated and each limit switch has to be adjusted independently. Therefore, faulty adjustment can decrease product quality.

[0004] In the configuration disclosed in Patent Document 2, fine adjustment can be performed by enabling the translation movement of individual limit switches so that the adjustment of fully-closed position or the like can be implemented. However, the problems associated with such a valve opening degree detection apparatus include a large number of parts, a wide space needed if the number of limit switches in the structure is increased, and a troublesome adjustment operation that requires individual adjustment of each limit switch for fine adjustment of a fully-closed position.

Patent Document 1: Japanese Examined Utility Model Publication No. H 7-10147.

Patent Document 2: Japanese Patent Application Laid-open No. H 8-21555.

DISCLOSURE OF THE INVENTION

[0005] The present invention was created to resolve the above-described problems and it is an object of the present invention to provide a valve opening degree detection apparatus that has few parts, requires little space, and makes it possible to adjust a plurality of limit switches by single adjustment, perform ON/OFF control of the switches at the desired angle, and increase the operation efficiency.

[0006] In order to resolve the above-described problems, the present invention provides a valve opening degree detection apparatus including a detection shaft that rotates synchronously with a valve rod rotating integrally with a valve body of a valve apparatus, wherein a tubular member is rotatably fitted onto the detection shaft, a cam that actuates a limit switch so as to match at least a fully closed position and fully open position of the valve body is attached to the tubular member so that rotation directions thereof are identical, and the detection shaft and tubular member are joined to

each other so that the joining position thereof can be changed. For example, in a possible joining configuration of the detection shaft and tubular member, a worm gear is fixed to the detection shaft, a worm wheel that meshes with the worm gear is attached to the tubular member, a relative rotation of the worm gear and the worm wheel is transmitted to the tubular member so that the joining position of the detection shaft and the tubular member can be changed, and the abutment position of the cam and the limit switch can be changed by rotation of the tubular member.

[0007] A slit of a predetermined width is formed in the tubular member in the tubular direction from one end thereof, a cam provided with a protruding portion for insertion into the slit can be fitted externally onto the tubular member, and the cam and the tubular member is integrated in the rotation direction. An actuation position of the limit switch by the cam can be set for each cam by setting the positions of the cam and the protruding portion, and the limit switch can be operated in an actuation position that is different for each cam by externally fitting a plurality of cams that have different actuation positions onto the tubular member.

[0008] The worm wheel that meshes with the worm gear is preferably provided integrally with the tubular member or one cam that is fitted externally onto the tubular member, the tubular member and another cam fitted externally onto the tubular member rotate integrally via the cam provided with the worm wheel, and the abutment position of the cam and limit switch can be changed and adjusted.

[0009] The flat shape of the cam has a large-diameter portion that protrudes outwardly in a radial direction and has a comparatively large radius from the center in a diametrical direction of the hole, and the large-diameter portion is formed so as to press the limit switch to cause ON/OFF actuation.

[0010] Each cam joined to the tubular member so as to rotate integrally therewith is configured so that the formation position of the large-diameter portion in relation to the position of the protruding portion formed in a hole portion of the cam is different for each cam and timings at which the limit switch is ON/OFF actuated by the cam differ from each other.

[0011] Spacers that hold a plurality of cams fitted in the axial direction of the tubular member with a

predetermined spacing are disposed between the cams, and the spacers are preferably plate-shape rising portions provided upright integrally with the cams, but obviously may be a member separate from the cam.

[0012] In accordance with the present invention, a plurality of removable cams are mounted, so as to enable integrated rotation, with respect to the detection shaft having the worm gear and the tubular member that can be rotated independently of the detection shaft coaxially with the detection shaft, and a cam unit is configured by the plurality of cams and the tubular member rotating integrally therewith. Further, a worm wheel that can mesh with the worm gear is formed integrally with at least one cam from among the plurality of cams constituting the cam unit and meshed with the worm gear that rotates integrally with the detection shaft. As a result, by rotating appropriately the worm gear, it is possible to rotate the cam unit integrally with and relatively to the detection shaft coaxially therewith through an appropriate angle. Therefore, a plurality of limit switches can be adjusted by one-degree rotation position adjustment, fine adjustment can be performed in a simple manner if the pitch and teeth of the worm gear and worm wheel are made appropriately small, and no tool is needed for the adjustment.

[0013] In accordance with the present invention, the detection of the full-closure and full-opening position of the valve body of the valve apparatus, detection of the ON/OFF control position of the motor driving the valve body, and determination of the actuation position of limit switch can be performed accurately and reliably.

[0014] Further, the above-described configuration of the valve opening degree detection apparatus makes it possible to decrease the number of parts, reduce installation space, and ON/OFF control the switches at a desired angle. Furthermore, even when the number of limit switches is increased the additional limit switches also can be ON/OFF controlled practically without changes in the number of parts or installation space. Conversely, when the number of limit switches is reduced, a pipe-like spacer can be attached instead of the cam to the tubular member and operation efficiency can be

increased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIG. 1 is a perspective view of the entire valve opening degree detection apparatus of the present embodiment.

FIG. 2 is an exploded perspective view of the aforementioned apparatus.

FIG. 3 is a perspective view of a cam unit of the aforementioned apparatus.

FIG. 4 is a perspective view of a worm wheel cam.

FIG. 5 is a perspective view of a cam other than that of the uppermost stage (second cam from the top).

FIG. 6 is a perspective view illustrating the mutual arrangement of the cam unit and limit switch unit.

FIG. 7 is a plan view illustrating the rotation of the cam unit with respect to the limit switch.

[0030]

1	cam unit
2	limit switch unit
3	valve opening degree detection apparatus
4	casing
5	lid body
6	detection shaft
7	fixing orifice
7a-e	fixing component
8	round hole
9	support component
10	base end portion
11	bolt
12	opening degree indicating needle

13 opening degree display plate

14 terminal unit

15 terminal unit

16a-d limit switch

17 lead wire hole

18 worm gear

19 worm gear attachment component

20 first integrated rotary body

21 tubular member

22a-d cam

23 second integrated rotary unit

24 worm wheel portion

25 handle

26 slit

27a-d insertion hole

28a-d convex portion

29a-d tilting preventing portion

30a-d small-diameter portion

31a-d large-diameter portion

32a-d rising portion

33b-d rising portion

34 bolt

35a-d limit switch body

36a-d roller

37a-d striker

38a-d switch

39a-d terminal

40a-d base end site

BEST MODE FOR CARRYING OUT THE INVENTION

[0015] An embodiment of the present invention will be described below with reference to the appended drawings. In FIG. 1, the reference numeral (1) stands for a cam unit and (2) stands for a limit switch unit. FIG. 1 is a perspective view of the entire valve opening degree detection apparatus (3) in a valve apparatus (not shown in the figure) equipped with the cam unit (1) and limit switch unit (2) that employs the present invention. As shown in FIG. 1, the valve opening degree detection apparatus (3) of the present embodiment has an open-side almost box-like casing (4) that accommodates various components constituting the apparatus (3) and has an open upper side for installation in a desired location and an almost plate-like lid body (5) that closes the opening on the upper side. The cam unit (1) having a configuration including a detection shaft (6) rising vertically from the bottom surface of the casing (4) is installed almost in the central portion of the housing (4) inside thereof. In immediate vicinity of the cam unit (1), the limit switch (2) is installed in close proximity to the cam unit (1), and the limit switches is switched ON/OFF in response to the predetermined operation of the cam unit (1).

[0016] The detection shaft (6), which is the main structural component of the cam unit (1), is fitted in a fixing orifice (7) serving to attach the detection shaft (6) inserted almost in the center of the casing (4) and installed rotatably in a vertical state by fixing components (7a), (7b), (7c), (7d), (7e) on the rear surface side of the bottom portion of the casing (4). A support component (9) of an almost Π-like shape having a round hole (8) in the upper portion thereof and serving to prevent the detection shaft (6) from tilting is attached to the upper portion of the detection shaft (6), and base end portions (10), (10) of the support component are fixed by bolts (11), (11) to the casing (4). An opening degree indicating needle (12) that rotates integrally with the detection shaft (6) is mounted

on the upper end portion of the detection shaft (6), an opening degree display plate (13) that is fixed to the support component (9) is located directly below the opening degree indicating needle (12), and the opening degree of the valve of the valve apparatus can be visually recognized by relative rotational positions of the opening degree indicating needle (12) and opening degree display plate (13). It goes without saying that the entire lid body (5) or part thereof is made transparent to enable visual observations of the opening degree display plate (13) or opening degree indicating needle (12) from the outside.

[0017] A larger terminal unit (14) and a smaller terminal unit (15) are installed inside the casing (4) and configured to enable simple electric connection of limit switches (16a), (16b), (16c), (16d) constituting the limit switch unit (2) to an external power source or an electric motor or the like (not shown in the figure) for driving the valve that is installed in an actuator. Lead wire holes (17) through which the inside of the casing communicates with the outside are formed in predetermined locations in the side wall of the casing (4) to pass lead wires therethrough.

[0018] FIG. 2 is an exploded perspective view of the valve opening degree detection apparatus (3). Referring to FIG. 2, the cam unit (1) has a first integrated rotary unit (20) that includes the detection shaft (6), a worm gear (18), and a worm gear attachment component (19) serving to install the worm gear (18) fixedly with respect to the detection shaft (6) so that the worm gear (18) rotate integrally with the detection shaft (6), those components rotating integrally at all times. The cam unit (1) also has a second integrated rotary unit (23) including a tubular member (21) of substantially C-shaped cross section that can be rotatably fitted onto the detection shaft (6) and a plurality of cams (22a), (22b), (22c), (22d) that are removably fitted onto the tubular member (21) and rotate integrally with the tubular member (21). The tubular member (21) and a plurality of cams (22a), (22b), (22c), (22d), which are constituent elements of the second integrated rotary member (23) rotate integrally at all times, but the second integrated rotary member can rotate relative to the detection shaft (6). Among the cams (22a), (22b), (22c), (22d) fitted onto the tubular member (21), at least one cam (22a) is

formed integrally with a worm wheel portion (24) for meshing with the worm gear (18) that is fixed to the detection shaft (6), and when the second integrated rotary member (23) is attached to the first integrated rotary member (20), the worm wheel portion (24) formed at the cam (22a) is meshed with the worm gear (18). This state is shown in FIG. 3.

[0019] As shown in FIG. 3, the rotation shaft of the worm gear (18) is installed perpendicular to the rotation axis of the detection shaft (6), and the worm wheel portion (24) is installed so as to rotate coaxially with the detection shaft (6). A disk-shaped handle (25) that can rotate about the rotation axis of the worm gear (18) is fixedly attached thereto, and where the handle (25) is rotated, the worm gear (18) rotates coaxially therewith. The rotation of the worm gear (18) is transmitted to the worm wheel portion (24) rotating coaxially with the detection shaft (6). Therefore, with such a configuration, by appropriately rotating the handle (25), it is possible to rotate the second integrated rotary unit (23) relative to the first integrated rotary unit (20) correspondingly to the rotation amount of the handle. Obviously, the detection shaft (6) rotates synchronously with a valve rod constituting the rotation shaft when the valve body in the valve apparatus is opened and closed, and where the valve rod is rotated, the detection shaft (6) also rotates synchronously therewith and correspondingly to the rotation amount thereof.

[0020] As shown in FIGS. 2 to 5, the detection shaft (6) has a round columnar shape having predetermined length and outer diameter, and the tubular member (21) has an almost cylindrical shape having an inner diameter almost equal to the outer diameter of the detection shaft (6) and a length somewhat shorter than the length of the detection shaft (6). A slit (26) of constant width is formed in the tubular member (21) from the lower end to the upper end thereof. The cams (22a), (22b), (22c), (22d) that are detachably fitted externally onto the tubular member (21) and rotate integrally with the tubular member (21) are formed in a three-dimensional shape by press shaping flat metallic plates formed to a predetermined shaft shape, each cam having a flat portion perpendicular to the axial direction of the tubular member (21) and a vertical portion rising vertically

from the flat portion. Insertion holes (27a), (27b), (27c), (27d) of an almost round shape and a diameter almost equal to the outer diameter of the tubular member (21) are drilled in almost central sections of the flat portions of cams (22a), (22b), (22c), (22d), respectively. Convex portions (28a), (28b), (28c), (28d) that are convex and protrude to a certain distance toward the center of the insertion holes (27a), (27b), (27c), (27d) and have a width almost equal to the width of the slit (26) formed in the tubular member (21) are provided in predetermined locations of the insertion holes (27a), (27b), (27c), (27d).

[0021] When the cams (22a), (22b), (22c), (22d) are externally fitted on the tubular member (21), the tubular member (21) is inserted in the insertion holes (27a), (27b), (27c), (27d) of the cams (22a), (22b), (22c), (22d), while the positions of the convex portions (28a), (28b), (28c), (28d) are matched with the slit (26) of the tubular member (21). With such a configuration the cams (22a), (22b), (22c), (22d) can be detachably fitted externally onto the tubular member (21), and the cams (22a), (22b), (22c), (22d) can be rotated integrally with the tubular member (21). Tilting preventing portions (29a), (29b), (29c), (29d) that rise vertically from the flat portion are formed in circumferential edge portions of the insertion holes (27a), (27b), (27c), (27d) of the cams (22a), (22b), (22c), (22d), and after the cams (22a), (22b), (22c), (22d) have been mounted on the tubular member (21), the cams (22a), (22b), (22c), (22d) are prevented from tilting with respect to the tubular member (21). The flat portions of the cams (22a), (22b), (22c), (22d) are of an almost round outer shape and have small-diameter portions (30a), (30b), (30c), (30d) that have a small radius from the center of the insertion holes (27a), (27b), (27c), (27d) and large-diameter portions (31a), (31b), (31c), (31d) that have a large radius. Rising portions (32a), (32b), (32c), (32d) that rise vertically to a predetermined height from the flat portion are provided at the circumferential edge portions extending from the small-diameter portions (30a), (30b), (30c), (30d) to the large-diameter portions (31a), (31b), (31c), (31d), and comparatively small rising portions (33b), (33c), (33d) rising to a predetermined height are also provided in locations equivalent to positions that are diametrically opposite the aforementioned

rising portions, these rising portions serving as spacers.

[0022] There are a total of four cams (22a), (22b), (22c), (22d) in the present embodiment and they are stacked in four stages with respect to the tubular member (21) as a central axis. From among the cams (22a), (22b), (22c), (22d) of such a configuration, the cam (22a) that is positioned at the uppermost stage has the worm wheel portion (24) that is formed as saw teeth in part of the outer peripheral portion of the flat portion of the cam and serves for engagement with the worm gear (18), thereby forming the cam (22a) integrated with a worm wheel as shown in FIG. 4. Obviously, it is not necessary to form the worm wheel portion (24) in the shape of saw teeth at the cams (22b), (22c), (22d) other than the cam of the uppermost stage, and the cams (22b), (22c), (22d) other than the cam of the uppermost stage are formed in a shape such as shown in FIG. 5. In other words, these cams (22b), (22c), (22d) that are thus formed are successively fitted externally onto the tubular member (21) to configure the second integrated rotary unit (23), and while this rotary unit is fitted externally onto the first integrated rotary unit (20), the worm wheel portion (24) of the cam (22a) having a worm wheel shape and positioned at the uppermost stage is meshed with the worm gear (18), and these first integrated rotary unit (20) and second integrated rotary unit (23) are fitted externally so that they can be rotated integrally, while the rotation positions thereof can be shifted with respect to each other.

[0023] In the limit switch unit (2) of the present embodiment, as shown in FIGS. 2, 6, four absolutely identical independent limit switches (16a), (16b), (16c), (16d) are stacked with absolutely identical orientation and fixedly installed in the casing (4) with a bolt (34). Each limit switch (16a), (16b), (16c), (16d) includes a limit switch body (35a), (35b), (35c), (35d) and a striker (37a), (37b), (37c), (37d) having a roller (36a), (36b), (36c), (36d) and installed at one side surface portion of the limit switch body (35a), (35b), (35c), (35d). A terminal (39a), (39b), (39c), (39d) joined to a switch (38a), (38b), (38c), (38d) that opens and closes a circuit by pushing the striker (37a), (37b), (37c), (37d) is provided on the other side surface portion.

[0024] The cam unit (1) and limit switch unit (2) having the above-described configurations are installed in close proximity to each other, as shown in FIG. 6. The cam (22a) in the uppermost position corresponds to the limit switch (16a) in the uppermost position, the cam (22b) in the second highest position corresponds to the limit switch (16b) in the second highest position, the cam (22c) in the third highest position corresponds to the limit switch (16c) in the third highest position, and cam (22d) in the lowermost position corresponds to the limit switch (16d) in the lowermost position.

[0025] The four stacked cams (22a), (22b), (22c), (22d) of the cam unit (1) have different flat shapes. In particular, the relative positions of a base end site (40a), (40b), (40c), (40d) extending from the small-diameter portion (30a), (30b), (30c), (30d) to the large-diameter portion (31a), (31b), (31c), (31d) and the convex portion (28a), (28b), (28c), (28d) formed at the circumferential edge of the insertion hole (27a), (27b), (27c), (27d) are set in advance so as to be different in each cam (22a), (22b), (22c), (22d). As a result, as is clear from FIG. 6, a configuration is employed such that even when the cam (22d) positioned at the lowermost stage is in contact with the roller (36d) of the striker (37d) of the limit switch (16d) positioned at the lowermost stage, the cam (22c), which is the third cam from above, and the limit switch (16c), which is the third limit switch from above and corresponds to this cam, are in a state immediately preceding the contact therebetween and are not in contact with each other, and the cams (22a), (22b) and limit switches (16a), (16b) positioned at the upper stages are in a state without any contact. This state is shown in plan view in FIG. 7. In a state in which the roller (36a), (36b), (36c), (36d) of the limit switch (16a), (16b), (16c), (16d) is positioned at the small-diameter portion of the cam (22a), (22b), (22c), (22d), the cam (22a), (22b), (22c), (22d) and limit switch (16a), (16b), (16c), (16d) are in a drift state and the ON/OFF operation is not performed.

[0026] As shown in FIG. 7, the relative angular shift of the base end site (40b) in which the small-diameter portion (30b) of the cam (22b), which is second from the top, changes to the large-diameter portion (31b) with respect to the base end site (40a) in which the small-diameter portion (30a) of the

cam (22a) positioned at the uppermost stage changes to the large-diameter portion (31a) is about 1°-3°. The relative angular shift of the base end site (40c) in which the small-diameter portion (30c) of the cam (22c), which is third from the top, changes to the large-diameter portion (31c) with respect to the base end site (40a) in which the small-diameter portion (30a) of the cam (22a) positioned at the uppermost stage changes to the large-diameter portion (31a) is 90°. Furthermore, the relative angular shift of the base end site (40d) in which the small-diameter portion (30d) of the cam (22d), which is positioned at the lowermost stage, changes to the large-diameter portion (31d) with respect to the base end site (40a) in which the small-diameter portion (30a) of the cam (22a) positioned at the uppermost stage changes to the large-diameter portion (31a) is 87-89°.

[0027] When the four limit switches are thus employed, the uppermost stage is used as the limit switch (16a) for full closure, the second stage from the top is used as the auxiliary closure limit switch (16b), the third stage is used as the limit switch (16c) for full opening, and the lowermost stage is used as the auxiliary opening limit switch (16d). The limit switches (16a), (16c) for full closure and full opening are used in contact point (b) and the auxiliary closure and auxiliary opening limit switches (16b), (16d) are used in contact point (a). When the valve is fully closed, the cam (22a) positioned at the uppermost stage and the cam (22b), which is second from the top, actuate the limit switches (16a), (16b) corresponding thereto. The limit switch (16a) of the uppermost switch sets the electric circuit for a motor to "Open", no electric current flows to the motor, the display circuit of a full closure display lamp is "Closed", and the full closure display lamp is turned on. The second limit switch (16b) transmits a valve "Closed" signal to other devices.

[0028] In this case, where the motor is caused to rotate in the opening direction, the valve rotates in the opening direction, following the rotation of the motor. Where the valve is actuated from the fully closed state in the opening direction and the cam (22a) of the uppermost stage is withdrawn from the limit switch (16a), the electric circuit of "Fully Closed" lamp display is switched "Off", the lamp is turned off, and the closing electric circuit of the motor is turned "Off" and assumes a standby stand.

Where the valve is rotated through 1-3° from a fully open position, the second cam (22b) is withdrawn from the limit switch (16b), and the transmission of an auxiliary valve "Close" signal is terminated. Where the valve is rotated to a valve opening degree close to 87-89°, the cam (22d) at the lowermost end actuates the limit switch (16d) and an auxiliary "Open" signal is transmitted. Where the valve is rotated to 90°, the cam (22c), which is the third cam from above, actuates the limit switch (16c), opens the motor electric circuit, stops the flow of electric current to the motor, sets the electric circuit for full-closure lamp display, and turns on the full-closure display lamp. The auxiliary switches on the closure side and opening side produce signals that are picked up and used as contact signals for actuating other devices based on the opening degree of the valve.

CLAIMS

1. A valve opening degree detection apparatus comprising a detection shaft that rotates synchronously with a valve rod rotating integrally with a valve body of a valve apparatus, wherein a tubular member is rotatably fitted onto the detection shaft, a cam that actuates a limit switch so as to match at least a fully closed position and fully open position of the valve body is attached to the tubular member so that rotation directions thereof are identical, and the detection shaft and tubular member are joined to each other so that the joining position thereof can be changed.

2. The valve opening degree detection apparatus according to claim 1, wherein a worm gear is fixed to the detection shaft, a worm wheel that meshes with the worm gear is attached to the tubular member, a relative rotation of the worm gear and the worm wheel is transmitted to the tubular member so that the joining position of the detection shaft and the tubular member can be changed, and the abutment position of the cam and the limit switch can be changed by rotation of the tubular member.

3. The valve opening degree detection apparatus according to claim 1 or 2, wherein a slit of a predetermined width is formed in the tubular member in the tubular direction from one end thereof, a cam provided with a protruding portion for insertion into the slit is fitted externally onto the tubular member, and the cam and the tubular member are integrated in the rotation direction.

4. The valve opening degree detection apparatus according to claim 3, wherein an actuation position of the limit switch by the cam can be set for each cam by appropriately setting the positions of the cam and the protruding portion, and the limit switch is operated in an actuation position that is different for each cam by externally fitting a plurality of cams having different actuation positions onto the tubular member.

5. The valve opening degree detection apparatus according to claim 2, wherein the worm wheel that meshes with the worm gear is preferably provided integrally with the tubular member or one cam that is fitted externally onto the tubular member, the tubular member and another cam fitted

externally onto the tubular member rotate integrally via the cam provided with the worm wheel, and the abutment position of the cam and limit switch can be changed and adjusted.

6. The valve opening degree detection apparatus according to any one of claims 1 to 5, wherein the flat shape of the cam has a hole formed in the cam, and a large-diameter portion that protrudes outwardly in a radial direction and has a comparatively large radius from the center in a diametrical direction of the hole, and the large-diameter portion is formed so as to press the limit switch to cause ON/OFF actuation.

7. The valve opening degree detection apparatus according to any one of claims 1 to 6, wherein each cam joined to the tubular member so as to rotate integrally therewith is configured so that the formation position of the large-diameter portion in relation to the position of the protruding portion formed in a hole portion of the cam is different for each cam and timings at which the limit switch is ON/OFF actuated by the cam differ from each other.

8. The valve opening degree detection apparatus according to any one of claims 1 to 7, wherein spacers that hold a plurality of cams fitted in the axial direction of the tubular member with a predetermined spacing are disposed between the cams.

9. The valve opening degree detection apparatus according to claim 8, wherein the spacers are plate-shape rising portions provided upright integrally with the cams.