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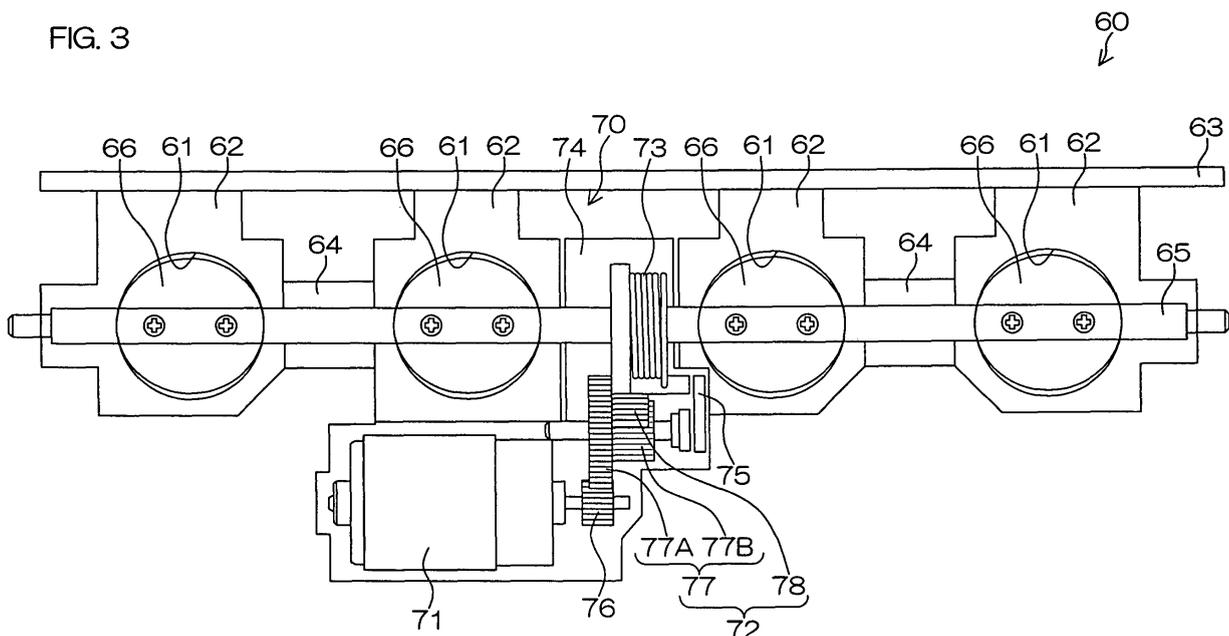
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(54) **Throttle apparatus and motorcycle having the same**

(57) A throttle apparatus (60) includes: a throttle valve (66) disposed in an intake air passage (61) of an engine (3), a throttle shaft (65) connected to the throttle valve (66) and rotatable in a predetermined operational angle range, a motor (71) for rotating the throttle shaft (65), and a reduction mechanism (72) for transmitting, to the throttle shaft (65), the rotation of the motor (71) as

reduced in rotational speed. The reduction mechanism (72) has a plurality of gears (76,77,78) including a first gear (77) rotatable in a rotational angle range greater than the operational angle range of the throttle shaft (65) and smaller than 360 degrees. The throttle apparatus (60) further includes a rotational angle sensor (82, 91, 92) for detecting the rotational angle of the first gear (77).

FIG. 3



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a throttle apparatus for adjusting the throttle opening by driving, by a motor, a throttle shaft connected to a throttle valve, and to a motorcycle having such a throttle apparatus.

2. Description of Related Art

[0002] It is proposed to mount a throttle apparatus of an electronic control type on a motorcycle. For example, the apparatus of prior art disclosed in Japanese Laid-Open Patent Application 2002-256903, has a throttle grip sensor for detecting the operation amount of a throttle grip, a driving motor for opening/closing a throttle valve, and a controller. The controller controls the driving motor based on the detected value of the throttle grip sensor. A first throttle sensor is mounted on a valve shaft (throttle shaft) of the throttle valve, and a second throttle sensor is mounted on the drive shaft of the driving motor, the gear shaft of a speed reduction gear mechanism or the gear shaft of a speed increasing mechanism. The speed reduction ratio of the speed reduction gear mechanism is set such that the throttle valve is rotated between the full closing position (0 degree) and the full open position (90 degrees) when the drive shaft of the driving motor has made three revolutions.

[0003] The first throttle sensor detects the rotational angle of the throttle shaft, and outputs the detected value which linearly changes in the range from the full closing position to the full open position of the throttle valve. The second throttle sensor outputs the detected value which linearly changes in the range of one revolution of the drive shaft of the driving motor, the gear shaft of the speed reduction gear mechanism or the gear shaft of the speed increasing mechanism. Accordingly, the second throttle sensor outputs a detected value which changes significantly with respect to change in throttle opening in a small throttle opening range from 0 to 30 degrees. As a result, it is considered possible to detect, with high precision, a small movement of the throttle valve in the small throttle opening range, thereby improving the traveling feeling.

SUMMARY OF THE INVENTION

[0004] According to the apparatus of prior art as mentioned above, the second throttle sensor detects the rotational angle of the shaft of which whole angle range corresponding to the whole operating angle range of the throttle valve (0 degree to 90 degrees) exceeds 360 degrees. Accordingly, the second throttle sensor cannot detect the absolute angle of the throttle valve. More specifically, the first throttle sensor for directly detecting the rotational angle of the throttle shaft is indispensably re-

quired for detecting the absolute angle position of the throttle valve.

[0005] A motorcycle requires a high responsiveness with respect to the throttle operation. Accordingly, a high resolution is required for detecting the throttle opening. In the prior art above-mentioned, the use of two sensors enables a high resolution. In a motorcycle, however, there are instances where it is difficult to assure a space for disposing two sensors in view of severe restrictions of the vehicle layout. Thus, it is desired to improve the throttle-opening detecting resolution, yet preventing the sensors from being increased in size.

[0006] A throttle apparatus according to the present invention comprises: a throttle valve disposed in an intake air passage of an engine; a throttle shaft connected to the throttle valve and rotatable in a predetermined operational angle range; a motor for rotating the throttle shaft; a reduction mechanism having a plurality of gears including a first gear rotatable in a rotational angle range greater than the operational angle range of the throttle shaft and smaller than 360 degrees, the rotation of the motor being transmitted, as reduced in rotational speed, to the throttle shaft by the plurality of gears; and a rotational angle sensor for detecting the rotational angle of the first gear.

[0007] According to the arrangement above-mentioned, when the motor is rotated, its rotation is transmitted, as reduced in rotational speed by the reduction mechanism, to the throttle shaft, causing the same to be rotated. As a result, the throttle valve connected to the throttle shaft is displaced in the intake air passage and the throttle opening is accordingly changed. The reduction mechanism has a plurality of gears. Of these, the first gear is rotated in an angular range greater than the operational angle range of the throttle shaft. Accordingly, when viewed from the throttle shaft side, the rotation of the first gear is increased in rotational speed as compared with the throttle shaft. Therefore, when the rotational angle of the first gear is detected, the rotational angle of the throttle shaft, i.e., the throttle opening can be detected with high resolution. On the other hand, the rotational angle range of the first gear is less than 360 degrees for the whole rotational angle range of the throttle shaft (from the full closing to the full open). Accordingly, the rotational angle of the first gear corresponds at the one-to-one basis to the absolute rotational angle of the throttle shaft. It is therefore sufficient to detect the rotational angle of the first gear, and not necessary to detect the rotational angle of the throttle shaft itself.

[0008] In this connection, according to the present invention, a rotational angle sensor for detecting the rotational angle of the first gear is provided. Since the rotational angle sensor detects the first-gear rotation as increased in rotational speed as compared with the rotation of the throttle shaft, the rotational angle of the throttle shaft, i.e., the throttle opening can be detected with high resolution. Further, since it is sufficient to detect the rotational angle of the first gear, it is not required to dispose

a plurality of rotational angle sensors. This eliminates the need to provide a large space for installing a plurality of sensors. Therefore, the throttle apparatus can be reduced in size.

[0009] In a motorcycle for example, since an accurate response with respect to the throttle operation is required, a speed reduction ratio as high as possible is required between the motor drive shaft and the throttle shaft. For example, there is proposed a reduction mechanism provided with an intermediate gear having a large-diameter wheel gear portion and a small-diameter pinion gear portion. Further, it is supposed that a pinion gear connected to the motor drive shaft meshes with the wheel gear portion and that a throttle gear fixed to the throttle shaft meshes with the pinion gear portion. In this case, in order to increase the speed reduction ratio and to reduce the installation space, it is preferable to increase the speed reduction ratio between the throttle gear and the pinion gear portion of the intermediate gear. Such an arrangement not only enables the intermediate gear to be reduced in diameter (the diameter of the wheel gear portion), but also achieves an accurate response with respect to the throttle operation. However, if the speed reduction ratio is increased with only the reduction of the intermediate gear in diameter taken into consideration, this causes the intermediate gear to be rotated in an angle range greater than 360 degrees for the operational angle range of the throttle shaft. Accordingly, even though the rotation of the intermediate gear is detected, the absolute angle of the throttle shaft cannot be detected. Therefore, two sensors are required as done in the prior art mentioned earlier, thus requiring a large installation space as a whole.

[0010] According to the present invention, the rotational angle range of the first gear (which is, for example, corresponding to the intermediate gear above-mentioned) is set less than 360 degrees. For example, when the operational angle range of the throttle shaft is about 90 degrees and the first gear meshes with the throttle gear fixed to the throttle shaft, the speed reduction ratio between the throttle gear and the first gear is preferably less than 4. In such an arrangement, the absolute angle of the throttle shaft can be detected with high resolution by disposing a single rotational angle sensor for detecting the rotational angle of the first gear. For example, when the first gear corresponds to the intermediate gear above-mentioned, the pinion gear portion is increased in diameter by relatively reducing the speed reduction ratio. Therefore, even though the wheel gear portion is accordingly increased in diameter, the whole throttle apparatus is reduced in size as compared with an arrangement having two sensors.

[0011] An embodiment of the present invention further comprises an elastic member for imparting, to the throttle shaft, an elastic force in the direction of closing the throttle valve. Further, an elastic force is imparted to the throttle shaft in its whole operational angle range in the direction of closing the throttle valve.

[0012] When the rotational angle sensor is disposed at a gear shaft of the reduction mechanism, this causes trouble of backlash which does not become a problem with an arrangement of directly detecting the rotation of the throttle shaft. The backlash prevents the rotational angle of the throttle shaft from being detected with high precision. To overcome this problem, it is preferable to dispose an elastic member for imparting, to the throttle shaft, an elastic force in the throttle valve closing direction. Since this eliminates the backlash in the reduction mechanism, an accurate throttle opening detection can be achieved by detecting the rotational angle of the first gear.

[0013] There is a conventional throttle apparatus having a return spring mechanism for returning the throttle valve to the idle position. The return spring mechanism has a spring for biasing the throttle valve in the closing direction and another spring for biasing the throttle valve in the opening direction. Normally, the idle opening is set to the position where these two spring forces are in balance with each other.

[0014] According to an embodiment of the present invention, an elastic force is imparted to the throttle shaft in its whole operational angle range in the throttle valve closing direction. That is, the throttle shaft is always biased to the closing direction. In this case, even when the throttle shaft is located in the idle opening position, it is necessary to energize the motor to maintain the throttle shaft as not to be rotated. Accordingly, the power consumption is inevitably increased. It is therefore generally difficult to adopt such an arrangement. However, when an elastic force is daringly imparted to the throttle shaft in the whole operational angle range even though the power consumption is increased, the backlash can securely be eliminated. This enables the rotational angle of the throttle shaft to be detected with high precision.

[0015] According to an embodiment of the present invention, the first gear has a rotary shaft different from the throttle shaft, and the first gear is the gear, out of the plurality of gears, nearest to the throttle shaft in the rotation transmission passage. According to the arrangement above-mentioned, the rotational angle can be detected with the use of the gear of which backlash influence is minimized, enabling the throttle opening to be accurately detected with high resolution.

[0016] An embodiment of the present invention further comprises a full closing switch fixed to the second gear of the reduction mechanism. The full closing switch is sufficient if it is possible to detect whether or not the second gear is in the rotational position corresponding to the full closing position, and the full closing switch is not required to detect a rotational angle. Accordingly, as the full closing switch, an economical switch having a simple structure may be used. When this full closing switch is provided, the throttle valve can smoothly be brought to the full closing position by driving the motor even when the rotational angle sensor is in failure at the worst. More specifically, since the full closing switch can detect that

the throttle valve is brought to the full closing position, the driving of the motor in the full closing direction can be stopped in response to the full closing detection by the full closing switch. This not only restrains or prevents the motor from being overloaded, but also restrains the power consumption from being wasted.

[0017] More specifically, the rotational angle sensor may include: a rotational-angle detecting magnet fixed to the first gear of the reduction mechanism; and a rotational-angle detecting element which is disposed opposite to the rotational-angle detecting magnet and which is arranged to detect the magnetic field thereof, thereby to detect the rotational angle of the first gear. Further, the full closing switch may comprise: a full-closing detecting magnet fixed to the second gear of the reduction mechanism; and a full-closing detecting element for detecting the magnetic field of the full-closing detecting magnet, thereby to detect whether or not the throttle valve is in the full closing position.

[0018] According to the arrangement above-mentioned, the rotational-angle detecting magnet is fixed to the first gear, and the rotational-angle detecting element is disposed opposite to the rotational-angle detecting magnet. By this rotational-angle detecting element, the rotational angle of the first gear is detected in a non-contact manner. Generally, the detecting resolution of the non-contact type rotational-angle detecting element is lower than that of the contact-type rotational-angle detecting element. However, the rotation of the first gear is detected as increased in rotational speed as compared with the rotation of the throttle shaft. It is therefore possible to detect, with high resolution, the rotational angle of the throttle shaft, i.e., the throttle opening. This not only ensures the advantage of high durability of the non-contact type, but also enables the throttle opening to be detected with high resolution. Further, it is enough to detect the rotational angle of the first gear. This eliminates the need to dispose a rotational-angle detecting element to each of a plurality of rotary shafts, thus reducing the cost.

[0019] According to the arrangement above-mentioned, a full-closing detecting magnet is fixed to the second gear, and there is disposed a full-closing detecting element for detecting the magnetic field of this full-closing detecting magnet, thereby to detect whether or not the throttle shaft is fully closed. This full-closing detecting element is sufficient if it can detect whether or not the second gear is in the rotational position corresponding to the full closing position, and is not required to detect the rotational angle. Accordingly, as the full-closing detecting element, an economical element having a simple structure may be used.

[0020] The rotational-angle detecting magnet and the full-closing detecting magnet are respectively fixed to different gears. This is for restraining the magnetic fields of the respective magnets from interfering with each other.

[0021] Further, the present invention is arranged to detect the rotation of a gear in the reduction mechanism. It

is therefore possible to dispose the rotational angle sensor at a lateral side of the throttle shaft and not at a longitudinal end thereof. Likewise, the full closing switch can be disposed at a lateral side of the throttle shaft. This enables the throttle apparatus to be reduced in size in the throttle shaft axial direction.

[0022] For example, there are instances where a plurality of intake air passages are linearly disposed as respectively correspondingly to a plurality of cylinders of an engine and a common throttle shaft is connected to a plurality of throttle valves respectively disposed in the plurality of intake air passages. In this case, the throttle shaft is preferably connected, in between the intake air passages, to the reduction mechanism. Accordingly, both the reduction mechanism and the rotational-angle detecting structure can be disposed at a lateral side of the throttle shaft. This effectively reduces the throttle apparatus in size in the throttle shaft axial direction.

[0023] The second gear may have a magnet attaching portion which extends in the axial direction of the throttle shaft and to which the full-closing detecting magnet is attached. According to this arrangement, the position of the full-closing detecting magnet in the throttle shaft axial direction can be adjusted. This facilitates a common use of a substrate for both the rotational-angle detecting element and the full-closing detecting element.

[0024] The gear shaft of the first gear may have a large-diameter portion to which the rotational-angle detecting magnet is attached. For example, the rotational-angle detecting magnet may be attached to the large-diameter portion such that the two magnetic fields are aligned in the direction at a right angle to the throttle shaft.

[0025] The second gear may be connected to the throttle shaft. More specifically, the second gear may be the throttle gear. According to this arrangement, the full closing switch is fixed to the second gear connected to the throttle shaft, thus assuring the full-closing detection by the full closing switch. As a result, the motor control based on the output of the full closing switch can more suitably be executed.

[0026] According to an embodiment of the present invention, the rotational-angle detecting element and the full-closing detecting element are commonly mounted on a substrate. The rotational-angle detecting element detects the magnetic field of the rotational-angle detecting magnet fixed to the first gear, and the full-closing detecting element detects the magnetic field of the full-closing detecting magnet fixed to the second gear. More specifically, these detecting elements are arranged to detect the magnetic field and therefore can easily be mounted on the common substrate. Thus, the rotational-angle detecting element and the full-closing detecting element are mounted on the common substrate, thus enabling not only the arrangement to be simplified, but also the cost to be reduced. Particularly, the support structure of the rotational-angle detecting element and the full-closing detecting element can be simplified.

[0027] According to an embodiment of the present in-

vention, the full-closing detecting magnet is disposed such that the two magnetic poles thereof are aligned in the throttle shaft axial direction, and the two magnetic poles of the rotational-angle detecting magnet are aligned in the direction at a right angle to the throttle shaft. In this case, along the throttle shaft axial direction, the full-closing detecting element is preferably disposed opposite to the full-closing detecting magnet and the rotational-angle detecting element is preferably disposed opposite to the rotational-angle detecting magnet.

[0028] Further, the rotational-angle detecting element may be arranged to detect the orientation of the magnetic field, and the full-closing detecting element may be arranged to detect the intensity of the magnetic field. According to this arrangement, when the rotational-angle detecting magnet is fixed onto the rotary shaft of the first gear, the rotational-angle detecting element can detect the orientation of the magnetic field of the rotational-angle detecting magnet. This enables the rotational angle of the first gear to be detected by the rotational-angle detecting element. On the other hand, since the full-closing detecting element is to detect the intensity of the magnetic field, the full-closing detecting magnet can be disposed at a position separated away from the rotary shaft of the second gear. This increases the degree of freedom of the positional relationship between the rotational-angle detecting magnet and the full-closing detecting magnet. For example, the full-closing detecting magnet can be so disposed as to be positioned in the vicinity of the rotational-angle detecting magnet when the throttle shaft is in the full closing position. Thus, when the rotational-angle detecting element and the full-closing detecting element are mounted on a common substrate, the substrate can be reduced in size.

[0029] According to an embodiment of the present invention, the first gear and the second gear are directly engaged with each other. Since the first and second gears are directly engaged with each other, the rotational-angle detecting magnet and the full-closing detecting magnet can be respectively fixed to the adjacent gears. This shortens the distance between the rotational-angle detecting element and the full-closing detecting element, thus contributing to the miniaturization of the apparatus. For example, when the rotational-angle detecting element and the full-closing detecting element are mounted on the common substrate, the substrate can be reduced in size.

[0030] According to an embodiment of the present invention, two or more rotational angle sensors are provided, and one full-closing switch is provided. More specifically, two or more rotational-angle detecting elements and one full-closing detecting element are provided. When the outputs of the plurality of rotational angle sensors are matched to one another, it is considered that these rotational angle sensors are normal. On the contrary, if the outputs of the plurality of rotational angle sensors are not matched with one another, it is considered that any of the rotational angle sensors is in failure. Thus,

an abnormality of any of the rotational angle sensors can be detected. Further, if the outputs of the rotational angle sensors are not matched with the output of the full closing switch when the rotational angle sensors are normal, an abnormality of the full closing switch can be detected. It is thus possible to judge whether a failure has occurred in any of the rotational angle sensors or in the full closing switch.

[0031] A throttle apparatus according to an embodiment of the present invention further comprises: a throttle opening computing unit for computing the opening of the throttle valve based on the output of the rotational angle sensor; an accelerator opening detecting unit for detecting the accelerator opening which represents the operation amount of an accelerator operating member; and a motor control unit for controlling the motor based on an accelerator opening detected by the accelerator opening detecting unit, a throttle opening computed by the throttle opening computing unit and an output signal of the full-closing switch, such that the throttle opening corresponds to the accelerator opening.

[0032] According to the arrangement above-mentioned, while the accelerator opening which represents the operation amount of the accelerator operating member is detected, the throttle opening is computed based on the output of the rotational angle sensor, and the motor is then controlled based on these accelerator opening and throttle opening.

[0033] For example, the motor can be feedback-controlled so as to obtain the throttle opening corresponding to the accelerator opening. Further, when the rotational angle sensor is in failure, the motor can for example be controlled, according to the accelerator opening, so as to be rotated in the full closing direction (in the rotational direction of displacing the throttle valve in the full closing direction). In this case, a control processing can be executed such that the energization to the motor is stopped in response to the detection made by the full closing switch that the throttle valve has reached the full closing position.

[0034] The throttle valve preferably further comprises a first failure detecting unit for detecting a failure in the rotational angle sensor. In this case, the motor control unit is preferably arranged such that when the first failure detecting unit detects a failure in the rotational angle sensor, the motor control unit rotationally drives the motor in the full closing direction until the full closing switch detects that the throttle valve is in the full closing position.

[0035] According to the arrangement above-mentioned, the first failure detecting unit detects a failure in the rotational angle sensor. Then, when a failure in the rotational angle sensor is detected, the motor is rotationally driven in the full closing direction. This rotational driving is stopped when the full-closing detecting element has detected the full closing of the throttle valve. This restrains the power consumption of the motor from being wasted.

[0036] A throttle apparatus according to an embodi-

ment of the present invention further comprises a second failure detecting unit for detecting a failure in the full closing switch, and the motor control unit is arranged such that when the second failure detecting unit has detected a failure in the full closing switch, the motor control unit rotationally drives the motor in the full closing direction until the rotational angle sensor detects that the throttle valve is in the full closing position.

[0037] According to the arrangement above-mentioned, when the second failure detecting unit detects a failure in the full closing switch, the motor is rotationally driven in the full closing direction. This rotational driving is stopped when the rotational angle sensor has detected the full closing of the throttle valve. This restrains the power consumption of the motor.

[0038] According to an embodiment of the present invention, a plurality of rotational angle sensors are disposed, and the first failure detecting unit detects a failure according to the output signals of the plurality of rotational angle sensors.

[0039] According to the arrangement above-mentioned, since the plurality of rotational angle sensors are disposed, a failure in the rotational angle sensors can be detected based on the output signals of these rotational angle sensors. That is, by arranging the rotational angle sensors in a so-called multiple system, a failure of any of these sensors can be detected. More specifically, when the deviation among the output signals of the plurality of rotational angle sensors exceeds a predetermined threshold, it can be judged that any of the rotational angle sensors is in failure. Examples of the failure in the rotational angle sensors include not only a failure in the rotational-angle detecting element itself, but also a disconnection failure or a short-circuit failure in the signal lines.

[0040] The provision of a plurality of rotational angle sensors increases the cost. However, the cost is remarkably lower than that incurred by an arrangement in which a rotational angle sensor is provided for each of a plurality of rotary shafts and each rotational angle sensor is made in a multiple system. It is therefore possible to detect a failure in any of the rotational angle sensors with an economical arrangement.

[0041] According to an embodiment of the present invention, a plurality of rotational-angle detecting elements are provided, and the second failure detecting unit is arranged to detect a failure in the full closing switch based on the output signals of the plurality of rotational angle sensors and the full closing switch.

[0042] As mentioned earlier, since the rotational angle sensors are arranged in a multiple system, a failure in any of the rotational angle sensors can be detected. Accordingly, if the output signals of the plurality of rotational angle sensors are not matched with the output signal of the full closing switch when all of the plurality of rotational angle sensors are normal, it can be judged that the full closing switch is in failure. More specifically, it can be judged that the full closing switch is in failure, if the full

closing switch does not detect the full closing position when all of the plurality of rotational angle sensors have detected the rotational angle corresponding to the full closing position. Further, it can be judged that the full closing switch is in failure if the full closing switch detects the full closing when each of the plurality of rotational angle sensors does not detect the rotational angle corresponding to the full closing.

[0043] A motorcycle according to the present invention comprises: an engine; a wheel to which the driving force of the engine is transmitted; and the above-mentioned throttle apparatus arranged to adjust the amount of air taken in the engine.

[0044] These and other features, advantages and operational effects of the present invention will be more fully apparent from the following detailed description set forth below when taken in conjunction with the accompanying drawings.

20 BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

Fig. 1 is a schematic side view of the arrangement of a motorcycle in accordance with an embodiment of the present invention;

Fig. 2 is a view illustrating the arrangement in association with the engine of the motorcycle in Fig. 1;

Fig. 3 is a schematic view of a throttle apparatus;

Fig. 4 is a perspective view illustrating the structure of a driving mechanism for a throttle valve and the layout of a sensor assembly;

Fig. 5 is an exploded perspective view of the arrangement shown in Fig. 4;

Fig. 6 is an enlarged perspective view illustrating the layout of a rotational-angle detecting magnet and a full-closing detecting magnet;

Fig. 7 is a plan view illustrating the arrangement of the sensor assembly;

Fig. 8 is a block diagram illustrating the electric arrangement for controlling the throttle apparatus;

Fig. 9 is a flowchart illustrating a series of processings to be executed by a microcomputer;

Fig. 9A is a flowchart illustrating a series of processings to be executed when a failure has been found in a full-closing detecting element;

Fig. 9B is a flowchart illustrating a series of processings to be executed when a failure has been found in a rotational-angle detecting element; and

Fig. 10 is a graph illustrating changes in accelerator opening and throttle opening with the passage of time when a failure has occurred.

55 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0046] Fig. 1 is a schematic side view of the arrangement of a motorcycle 1 in accordance with an embodi-

ment of the present invention. The motorcycle 1 has a vehicle body frame 2, an engine 3, a front wheel 4 and a rear wheel 5. The engine 3 is mounted on the vehicle body frame 2. The vehicle body frame 2 is provided at the front thereof with a head pipe 6, by which a front fork 7 is transversely swingably supported. The front fork 7 is provided at the lower end thereof with the front wheel 4 journaled. A rear arm 8 is supported by the vehicle body frame 2 at its rear portion. The rear wheel 5 is supported by the rear arm 8 at its rear end.

[0047] A handlebar 10 for steering the motorcycle 1 is fixed to the upper end of the front fork 7. The handlebar 10 is provided at both ends thereof with a pair of grips to be respectively held by the left and right hands of the rider. One of the grips (normally, the right-hand grip) is an accelerator grip 11 (accelerator operating member) to be rotatably operated around the handlebar axis by the rider. The accelerator grip 11 has an accelerator opening sensor 12 (accelerator opening detecting unit) for detecting the operating amount of the accelerator grip 11. In the following description, the operating amount of the accelerator grip 11 will be referred to as the accelerator opening. That is, the accelerator opening sensor 12 detects the accelerator opening. The throttle opening of the engine 3 is adjusted according to an output of the accelerator opening sensor 12, i.e., the accelerator opening. Accordingly, the rider can adjust the speed of the engine 3 by the operation of the accelerator grip 11.

[0048] The engine 3 is for example a water-cooling four-stroke four-cylinder engine. The engine 3 is provided under thereof with a crankcase 15 in which a crank shaft is housed. A cylinder block 16 is connected to the front of the top of the crankcase 15. A cylinder head 17 is fixed onto the cylinder block 16.

[0049] The crankcase 15 incorporates a transmission mechanism (not shown). A chain 19 is wound around the output shaft of the transmission mechanism and a sprocket 18 fixed to the rear wheel 5. Thus, the driving force of the engine 3 is to be transmitted to the rear wheel 5 through the transmission mechanism and the chain 19.

[0050] Disposed on the engine 3 is a fuel tank 20 supported by the vehicle body frame 2. A seat 21 is disposed at the rear of the fuel tank 20. Disposed under the seat 21 is an ECU (Electronic Control Unit) 22 serving as a control device.

[0051] Exhaust ports are opened in the front wall of the cylinder head 17 of the engine 3. An exhaust pipe 23 is connected to the exhaust ports. The exhaust pipe 23 is rearwardly bent and connected to a muffler 24 disposed at a lateral side of the rear wheel 5.

[0052] Air intake ports are opened in the rear wall of the cylinder head 17. A throttle apparatus 60 is connected to these air intake ports.

[0053] Fig. 2 is a view illustrating the arrangement in association with the engine 3. The engine 3 has the crankcase 15, the cylinder block 16 communicating with the crankcase 15, the cylinder head 17 connected to the head portion of the cylinder block 16, and a piston 26

housed in the cylinder block 16. A crank shaft 27 is rotatably journaled to the crankcase 15. The rotor of a generator (ACM) 41 is connected to the crank shaft 27.

[0054] The cylinder head 17 is connected to an air intake pipe 42 and an exhaust pipe 23 which communicate with a combustion chamber 43 above the piston 26. A spark plug 44 is attached to the cylinder head 17, and the discharging unit of this spark plug 44 is located in the combustion chamber 43. A discharging voltage is applied to the spark plug 44 from an ignition coil 45.

[0055] An injector 40 is attached to the air intake pipe 42 at an intermediate portion thereof. Fuel stored in the fuel tank 20 is supplied to the injector 40 by a fuel pump 47. The throttle apparatus 60 is disposed at the air intake pipe 42. This throttle apparatus 60 has throttle valves 66. An intake air temperature sensor 52 and an intake pressure sensor 53 are attached to the air intake pipe 42. The throttle apparatus 60 is arranged to adjust the quantity of the air introduced into the engine 3 by changing, according to the accelerator operation of the rider, the opening of the intake air passages (throttle opening). The throttle apparatus 60 is disposed upstream of the injector 40 in the intake-air inflow direction. The intake air temperature sensor 52 is to detect the temperature of the air introduced into the air intake pipe 42. The intake pressure sensor 53 is disposed between the throttle apparatus 60 and the injector 40 for detecting the atmospheric pressure of the intake air in the air intake pipe 42.

[0056] Further, the cylinder block 16 has a water temperature sensor 54, and the crankcase 15 has a crank angle sensor 55. The water temperature sensor 54 is arranged to detect the temperature of cooling water for cooling the engine 3. The crank angle sensor 55 is arranged to detect the rotational angle of the crank shaft 27.

[0057] The output signals of the sensors above-mentioned are to be given to the ECU 22 (See Fig. 1). The ECU 22 is arranged to control the ignition coil 45 (ignition control), the injector 40 (fuel injection control), the fuel pump 47 (fuel supply control) and the throttle apparatus 60 (intake air quantity control).

[0058] Fig. 3 is a schematic view of the throttle apparatus 60 which is applied to a four-cylinder engine in this embodiment. The throttle apparatus 60 has four throttle bodies 62 each having an intake air passage 61 to be connected to an air intake port. Four throttle bodies 62 are connected and supported, as linearly arranged, to and by a frame 63. Thus, the intake air passages 61 are linearly arranged. A spacer 64 is disposed between each adjacent pair of throttle bodies 62 at both ends, and the distance between adjacent throttle bodies 62 is matched to the distance between adjacent air intake ports. A throttle shaft (valve shaft of the throttle valve) 65 is disposed as passing through these four throttle bodies 62 and two spacers 64. For example, the throttle shaft 65 is axially rotatably supported by bearings (not shown) disposed at the throttle bodies 62.

[0059] Four throttle valves 66 are connected to the throttle shaft 65 at intervals provided in the longitudinal

direction thereof. These four throttle valves 66 are respectively located in the four intake air passages 61. By rotating the throttle shaft 65 around the axis thereof, each throttle valve 66 takes an arbitrary angular position in the range between the full closing position and the full open position. The full closing position refers to a position where each throttle valve 66 is substantially at a right angle to the gas flow direction of each intake air passage 61 (the axial direction of each intake air passage 61). The full open position refers to a position where each throttle valve 66 is substantially parallel to the gas flow direction of each intake air passage 61. For example, when the angular position of each throttle valve 66 is expressed based on the direction at a right angle to the gas flow direction of each intake air passage 61, the full closing position can be expressed as 0 degree, and the full open position, for example, as 90 degrees. The angular position of each throttle valve 66 expresses the throttle opening, i.e., the opening degree of each intake air passage 61 adjusted by each throttle valve 66. The four throttle valves 66 are fixed, in parallel to one another, to the throttle shaft 65. Accordingly, the rotation of the throttle shaft 65 enables the throttle openings of the four intake air passages 61 to be adjusted to the same value in synchronization with one another.

[0060] Disposed between two center throttle bodies 62 or between two center intake air passages 61 is a driving mechanism 70 for rotating the throttle shaft 65 thereby to change the throttle opening. The driving mechanism 70 has a motor 71, a reduction mechanism 72, a restoring spring 73 and a bracket 74 for supporting these members 71, 72, 73. This bracket 74 also supports a sensor assembly 75 for detecting the throttle opening and the throttle full closing.

[0061] Fig. 4 is a perspective view illustrating the structure of the driving mechanism 70 and the layout of the sensor assembly 75. Fig. 5 is a perspective view of the arrangement shown in Fig. 4.

[0062] Disposed in parallel to the throttle shaft 65 is the motor 71 drive shaft, to which a motor pinion gear 76 is fixed. The reduction mechanism 72 has an intermediate gear unit 77 and a throttle gear 78.

[0063] The intermediate gear unit 77 has a large-diameter wheel gear (large-diameter gear) portion 77A which meshes with the motor pinion gear (motor gear) 76, and a small-diameter pinion gear (small-diameter gear) portion 77B integral with the large-diameter wheel gear portion 77A. The intermediate gear unit 77 is fixed to an intermediate gear shaft 80 which is parallel to the throttle shaft 65. This intermediate gear shaft 80 is supported by the bracket 74 (See Fig. 3) so as to be axially rotatable together with the intermediate gear unit 77.

[0064] The throttle gear 78 is fixed to the throttle shaft 65 between two center throttle bodies 62 (See Fig. 3). This throttle gear 78 is provided at the outer periphery thereof with a wheel gear portion 78A which meshes with the pinion gear portion 77B of the intermediate gear unit 77. The wheel gear portion 78A is composed of a teeth

row extending substantially in a 90-degree angular range corresponding to the range between the full closing position and the full open position of the throttle valves 66.

[0065] According to the arrangement above-mentioned, when the motor 71 is driven to rotate the motor pinion gear 76, this rotation is transmitted to the wheel gear portion 77A of the intermediate gear unit 77. This causes the intermediate gear shaft 80 to be rotated together with the intermediate gear unit 77. This rotation of the intermediate gear unit 77 is transmitted from the pinion gear portion 77B to the wheel gear portion 78A of the throttle gear 78, causing the same to be rotated. Accordingly, the throttle shaft 65 fixed to the throttle gear 78 is axially rotated. As a result, the throttle valves 66 are rotated in the intake air passages 61 to change the throttle opening.

[0066] The number of teeth of the motor pinion gear 76 is smaller than that of the wheel gear portion 77A of the intermediate gear unit 77. Accordingly, the rotation of the motor 71 is transmitted, as reduced in rotational speed, to the intermediate gear unit 77. Further, the number of teeth of the pinion gear portion 77B of the intermediate gear unit 77 is smaller than that of the wheel gear portion 78A of the throttle gear 78. Accordingly, the rotation of the intermediate gear unit 77 is transmitted, as reduced in rotational speed, to the throttle gear 78. Thus, the rotation of the motor 71 is transmitted, as reduced in rotational speed by the reduction mechanism 72, to the throttle shaft 65. It is noted that the teeth number of the wheel gear portion 78A is the number on the assumption that the wheel gear portion 78A is formed over the whole periphery of the throttle gear 78.

[0067] For example, the number of teeth of the motor pinion gear 76 is equal to 10, the number of teeth of the wheel gear portion 77A of the intermediate gear unit 77 is equal to 32, the number of teeth of the pinion gear portion 77B of the intermediate gear unit 77 is equal to 14 and the number of teeth of the wheel gear portion 78A of the throttle gear 78 is equal to 55. In this case, the speed reduction ratio between the motor 71 and the throttle shaft 65 is about 12.5. The speed reduction ratio between the intermediate gear shaft 80 and the throttle shaft 65 is 3.9. That is, the rotational angle of the throttle shaft 65 is smaller by about a quarter than the rotational angle of the intermediate gear shaft 80. In other words, the speed increasing ratio of the rotation of the intermediate gear shaft 80 with respect to the rotation of the throttle shaft 65 is 3.9. Accordingly, the rotational angle of the intermediate gear shaft 80 is greater by about four times than that of the throttle shaft 65. More specifically, when the operating angle range (the angle range from the full closing position to the full open position) of the throttle shaft 65 is set to about 90 degrees but less than 90 degrees, the rotational angle range of the intermediate gear shaft 80 is about 360 degrees but less than 360 degrees. Therefore, the rotation of the throttle shaft 65 in the operating angle range is amplified to the rotation of substantially one revolution of the intermediate gear shaft 80.

[0068] As enlargedly shown in Fig. 6, the throttle gear 78 has a magnet fixing portion 78B, in which a full-closing detecting magnet 81 (permanent magnet piece) is embedded. That is, the magnet fixing portion 78B serves as a magnet attaching portion on which the full-closing detecting magnet 81 mounted. The magnet fixing portion 78B is disposed in the vicinity of one end of the wheel gear portion 78A and is made in the form of a column projecting in one direction parallel to the throttle shaft 65. The full-closing detecting magnet 81 is embedded in the tip of the magnet fixing portion 78B. This full-closing detecting magnet 81 is fixed to the magnet fixing portion 78B with its magnetic pole direction (which passes through the N- and S-poles) being in parallel to the throttle shaft 65.

[0069] On the other hand, a magnet fixing member 83 is fixed to the tip of the pinion gear portion 77B of the intermediate gear shaft 80 so as to be rotatably integrally therewith. A rotational-angle detecting magnet 82 (permanent magnet piece) is embedded in the magnet fixing member 83. This rotational-angle detecting magnet 82 is embedded in the magnet fixing member 83 such that its magnetic pole direction is at right angle to the intermediate gear shaft 80. The magnetic pole direction refers to the direction in which two magnetic poles of the rotational-angle detecting magnet 82 are aligned. Accordingly, the two magnetic poles of the rotational-angle detecting magnet 82 are arranged in the direction at a right angle to the throttle shaft 65.

[0070] The magnet fixing member 83 has a large-diameter portion of which diameter is larger than that of the intermediate gear shaft 80, and the rotational-angle detecting magnet 82 is attached to this large-diameter portion. The magnet fixing member 83 may be formed integrally with the intermediate gear unit 77.

[0071] As shown in Fig. 4, the sensor assembly 75 is disposed opposite to the rotational-angle detecting magnet 82 disposed at the tip of the intermediate gear shaft 80. The sensor assembly 75 is so disposed as to face always the rotational-angle detecting magnet 82 and also as to face the full-closing detecting magnet 81 when the throttle valves 66 are in the full closing position. The sensor assembly 75 is held by the bracket 74 (See Fig. 3), thus maintaining the positional relationship of the sensor assembly 75 with respect to the intermediate gear shaft 80 and the throttle gear 78.

[0072] The restoring spring 73 is formed by a torsion spring wound on the throttle shaft 65. The restoring spring 73 has one end held by a predetermined portion of the bracket 74 and the other end fixed to the wheel gear portion 78A of the throttle gear 78. Torsion is previously applied to the restoring spring 73. Thus, the restoring spring 73 elastically biases the throttle shaft 65 through the throttle gear 78 in such a direction as to guide the throttle valves 66 in the full closing position. The main function of the restoring spring 73 is to eliminate backlash between gears. More specifically, under the action of the restoring spring 73, the motor pinion gear 76 and the

wheel gear portion 77A are meshed with each other as always biased in one direction, and the pinion gear portion 77B and the wheel gear portion 78A are also meshed with each other as always biased in one direction. Accordingly, the rotation of the intermediate gear shaft 80 corresponds correctly to the rotation of the throttle shaft 65. Therefore, by detecting the rotational angle of the intermediate gear shaft 80, the angular position of each throttle valve 66 fixed to the throttle shaft 65 can accurately be detected.

[0073] In this embodiment, the restoring spring 73 gives, to the throttle shaft 65 in its whole operating angle range, an elastic force in such a direction as to close the throttle valves 66. That is, the throttle shaft 65 is always biased toward the closing side. In this case, even though the throttle shaft 65 is in the idle open position, it is required to energize the motor 71 to maintain the throttle shaft 65 as not to be rotated. Since this increases inevitably the power consumption, it is normally difficult to adopt such an arrangement. However, even though the power consumption is increased, the daring application of an elastic force to the throttle shaft in its whole operating angle range can securely eliminate the backlash. This enables the rotational angle of the throttle shaft 65 to be detected with high precision.

[0074] Fig. 7 is a plan view illustrating the arrangement of the sensor assembly 75. The sensor assembly 75 is formed by a rotational-angle detecting unit 86 and a full-closing detecting unit 87 which are mounted on a common substrate 88.

[0075] The rotational-angle detecting unit 86 is formed by a pair of rotational-angle detecting elements 91, 92 sealed in a common resin package. The lead terminals of the rotational-angle detecting unit 86 are soldered on the wiring pattern on the substrate 88. Each of the rotational-angle detecting elements 91, 92 is composed of a Hall IC for detecting the magnetic pole direction (magnetic field direction) of the rotational-angle detecting magnet 82. As such Hall IC, there may be used, for example, a magnetic field vector detection-type sensor MLX90316 (Rotary Position Sensor IC) provided by Melexis. The rotational-angle detecting elements 91, 92 formed by such Hall ICs are to detect the direction of the magnetic field, and not the magnitude of the magnetic field. Accordingly, the rotational angle of the intermediate gear shaft 80 can accurately be detected regardless of the size of the gap between the rotational-angle detecting magnet 82 and the rotational-angle detecting elements 91, 92. The rotational-angle detecting magnet 82 and one rotational-angle detecting element 91 form one rotational angle sensor, while the rotational-angle detecting magnet 82 and the other rotational-angle detecting element 92 form another rotational angle sensor.

[0076] On the other hand, the full-closing detecting unit 87 has a full-closing detecting element 93 which is formed by a Hall IC of detecting the magnetic field intensity and which is sealed in a resin package. The lead terminals of the full-closing detecting unit 87 are soldered to the

wiring pattern on the substrate 88. The full-closing detecting unit 87 is disposed in the vicinity of the passage in which the full-closing detecting magnet 81 is moved when the throttle shaft 65 is rotated. Thus, when the throttle valves 66 are in the full closing position, the full-closing detecting unit 87 is opposite to the full-closing detecting magnet 81. The full-closing detecting element 93 is used for detecting whether or not the full-closing detecting magnet 81 is opposite thereto. More specifically, when the full-closing detecting element 93 detects a strong magnetic field (e.g., not less than the threshold), it is judged that the full-closing detecting magnet 81 is located in the opposite position and that the throttle valves 66 are therefore in the full closing position. On the contrary, when the magnetic field detected by the full-closing detecting element 93 is weak (e.g., less than the threshold) or zero, it is judged that the full-closing detecting magnet 81 is not in the opposite position and that the throttle valves 66 are therefore not in the full closing position. Thus, the full-closing detecting magnet 81 and the full-closing detecting element 93 form a full closing switch. Differently from the rotational-angle detecting elements 91, 92, the full-closing detecting element 93 is arranged to detect the intensity of the magnetic field, and not the direction of the magnetic field. Accordingly, the full-closing detecting element 93 can be formed by a Hall IC relatively cheaper than that used for forming each rotational-angle detecting element 91, 92.

[0077] Since the rotational-angle detecting elements 91, 92 are to detect the direction of the magnetic field, the rotational-angle detecting magnet 82 is disposed on the rotary shaft of the intermediate gear shaft 80. On the other hand, since the full-closing detecting element 93 is to detect the intensity of the magnetic field, the full-closing detecting magnet 81 is disposed positionally shifted from the rotary shaft of the throttle gear 78. That is, the full-closing detecting magnet 81 is disposed movably toward or away from the full-closing detecting element 93. More specifically, the full-closing detecting magnet 81 is fixed to the throttle gear 78 so as to be located in a position close to the rotational-angle detecting magnet 82 when the throttle valves 66 are in the full closing position. Accordingly, the rotational-angle detecting unit 86 and the full-closing detecting unit 87 can be disposed in close proximity to each other, thus reducing in size the substrate 88 on which these units 86, 87 are commonly mounted.

[0078] Fig. 8 is a block diagram illustrating the electric arrangement relating to the control of the throttle apparatus 60. The output signals of the pair of rotational-angle detecting elements 91, 92 of the rotational-angle detecting unit 86 are entered into the ECU 22. Further, the output signal of the full-closing detecting element 93 of the full-closing detecting unit 87 is also entered into the ECU 22. Moreover, entered into the ECU 22 is the output signal (accelerator opening) of the accelerator opening sensor 12 arranged to detect the operation amount of the accelerator grip 11.

[0079] The ECU 22 includes a microcomputer 30 having a CPU, a ROM and a RAM, and a motor driving circuit 68 for supplying an electric power to the motor 71. The microcomputer 30 serves as a plurality of function processing units each realized by executing a predetermined control program in the microcomputer 30. These function processing units include a throttle opening computing unit 31, a motor control unit 32 and a failure detecting unit 33.

[0080] The throttle opening computing unit 31 is arranged to compute, based on the output signals of the pair of rotational-angle detecting elements 91, 92, the angular position of the throttle valves 66, i.e., the throttle opening.

[0081] The motor control unit 32 is arranged to generate an instruction of motor voltage to be applied to the motor 71 based on (i) the accelerator opening detected by the accelerator opening sensor 12, (ii) the throttle opening computed by the throttle opening computing unit 31 and (iii) the output signal of the full-closing detecting element 93. A driving signal corresponding to this motor voltage instruction is given to the motor driving circuit 68, which in turn supplies an electric power to the motor 71 for driving the same.

[0082] The failure detecting unit 33 is arranged to execute, based on the output signals of the pair of rotational-angle detecting elements 91, 92 and the full-closing detecting element 93, a failure detecting processing for detecting whether or not any of these elements 91, 92, 93 is in failure. For example, the failure detecting unit 33 judges that any of the pair of rotational-angle detecting elements 91, 92 is in failure when the deviation of the output signals of the rotational-angle detecting elements 91, 92 is not less than a predetermined threshold. Examples of the failure to be detected include not only a failure of each rotational-angle detecting element 91, 92 itself, but also a disconnection failure or a short-circuit failure in the wirings between the rotational-angle detecting unit 86 and the ECU 22. The failure detecting unit 33 is arranged to detect these examples as the failure of the rotational-angle detecting elements. Further, when it has been judged that the rotational-angle detecting elements 91, 92 are normal, the failure detecting unit 33 can detect whether or not the full-closing detecting element 93 is in failure, by checking whether or not the outputs of the rotational-angle detecting elements 91, 92 are matched to the output signal of the full-closing detecting element 93. Examples of a failure to be detected include not only a failure of the full-closing detecting element 93 itself, but also a disconnection failure or a short-circuit failure in the wirings between the ECU 22 and the full-closing detecting unit 87. The failure detecting unit 33 is arranged to detect these examples as the failure of the full-closing detecting element 93.

[0083] At the normal time where no failure is found, the motor control unit 32 executes a feedback-control processing on the motor 71 such that the target throttle opening corresponding to the accelerator opening coin-

cides with the throttle opening (actual opening) computed by the throttle opening computing unit 31. This feedback-control processing may be executed by a proportional-integral-derivative (PID) control.

[0084] When the failure detecting unit 33 judges that any of the rotational-angle detecting elements 91, 92 is in failure, the motor control unit 32 executes a control processing for guiding the throttle valves 66 to the full closing position. At this time, the motor control unit 32 controls the motor 71 with reference to the output signal of the full-closing detecting element 93. Also, when a failure in the full-closing detecting element 93 is detected by the failure detecting unit 33, the motor control unit 32 executes a control processing for guiding the throttle valves 66 to the full closing position. At this time, the motor control unit 32 controls the motor 71 based on the throttle opening computed by the throttle opening computing unit 31 based on the output signals of the rotational-angle detecting elements 91, 92.

[0085] Fig. 9 is a flowchart illustrating a series of processings to be executed by the microcomputer 30. The microcomputer 30 reads in the output values of the pair of rotational-angle detecting elements 91, 92 (Step S1), and then judges whether or not these output values are normal (Step S2). More specifically, when the difference between the output values of the two rotational-angle detecting elements 91, 92 is not less than a predetermined threshold, the failure detecting unit 33 judges that the output values are abnormal and any of the rotational-angle detecting elements 91, 92 is in failure. On the other hand, when the difference between the output values of the two rotational-angle detecting elements 91, 92 is less than the predetermined threshold and each of these two output values is in a normal range, the failure detecting unit 33 judges that the output values are normal. That is, the failure detecting unit 33 judges that both rotational-angle detecting elements 91, 92 are normal.

[0086] When the output values of the two rotational-angle detecting elements 91, 92 are normal (Step S2: YES), the throttle opening computing unit 31 computes, based on the average of the output values of the two rotational-angle detecting elements 91, 92, the throttle opening, i. e. , the angular position of the throttle valves 66 (Step S3). The throttle opening (angular position of the throttle valves 66) may be computed with the use of, instead of the average, the output value of the rotational-angle detecting element 91 or 92, whichever is greater.

[0087] The output values of the rotational-angle detecting elements 91, 92 correspond to the rotational angle obtained by amplifying the rotational angle of the throttle valves 66 by about four (the speed increasing ratio of the intermediate gear unit 77 with respect to the rotation of the throttle gear 78). Accordingly, based on this speed increasing ratio, the output values of the rotational-angle detecting elements 91, 92 are converted into the throttle opening. Since the rotational-angle detecting elements 91, 92 detect the rotation of the intermediate gear shaft 80, this means that the throttle opening can be detected

with the resolution about four times (the speed increasing ratio above-mentioned) the resolution with which the rotational angle of the throttle shaft 65 were detected. Further, since the average of the output values of the two rotational-angle detecting elements 91, 92 is used, a more accurate detection can be achieved. More specifically, the rotational angle of the intermediate gear shaft 80 can be detected with no precise adjustment of the positional relationship between the rotational-angle detecting unit 86 and the intermediate gear shaft 80. Accordingly, an accurate throttle opening can be obtained. Further, the rotational angle range of the intermediate gear shaft 80 corresponding to the operating angle range of the throttle valves 66, is less than 360 degrees. Therefore, only with the use of the output values of the rotational-angle detecting elements 91, 92, the absolute angle position of the throttle valves 66 can be obtained with no other angle sensor required.

[0088] Then, the failure detecting unit 33 judges whether or not the throttle opening obtained by the throttle opening computing unit 31, is the full closing value (which shows that the throttle valves 66 are in the full closing position) (Step S4). When the throttle opening is the full closing value (Step S4 : YES), the failure detecting unit 33 further refers to the output signal of the full-closing detecting element 93. Then, the failure detecting unit 33 judges whether or not the output signal of the full-closing detecting element 93 represents the throttle full closing (Step S5). More specifically, the failure detecting unit 33 judges whether or not the output signal of the full-closing detecting element 93 corresponds to the value which is obtained when the full-closing detecting magnet 81 is opposite to the full-closing detecting element 93. In the affirmative, the failure detecting unit 33 judges that the full-closing detecting element 93 is normal because the output values of the rotational-angle detecting elements 91, 92 are matched to the output signal of the full-closing detecting element 93. According to this judgment, the motor control unit 32 executes a normal motor control processing (Step S6). As mentioned earlier, the normal motor control refers to a processing of feedback-control executed on the motor 71 such that the target throttle opening corresponding to the accelerator opening coincides with the throttle opening (actual opening) obtained from the output values of the rotational-angle detecting elements 91, 92. Therefore, the throttle opening is controlled according to the accelerator operation of the rider.

[0089] When it is judged that the throttle opening obtained from the output values of the rotational-angle detecting elements 91, 92, is not the full closing value (Step S4: NO), the failure detecting unit 33 refers to the output signal of the full-closing detecting element 93. Then, the failure detecting unit 33 judges whether or not the output signal of the full-closing detecting element 93 represents the throttle full closing (Step S7). In the negative, the failure detecting unit 33 judges that the full-closing detecting element 93 is normal because the output values of the rotational-angle detecting elements 91, 92 are

matched to the output signal of the full-closing detecting element 93. According to this judgment, the motor control unit 32 executes a normal motor control processing (Step S6).

[0090] On the other hand, when the judgment at Step S5 is negative and the judgment at Step S7 is affirmative, this means that the output values of the rotational-angle detecting elements 91, 92 are not matched to the output signal of the full-closing detecting element 93. In this case, since it has been judged at Step S2 that the rotational-angle detecting elements 91, 92 are normal, the failure detecting unit 33 judges that a fail occurs in the full-closing detecting element 93, and executes a full-closing detecting-element abnormality processing (Step S8). The full-closing detecting-element abnormality processing is a fail-safe control for guiding the throttle valves 66 to the full closing position, causing the engine 3 to be brought to an idling rotation state. The detail of this processing will be discussed later (Fig. 9A).

[0091] On the other hand, when the difference between the output values of the two rotational-angle detecting elements 91, 92 exceeds a predetermined threshold (Step S2:NO), the failure detecting unit 33 judges that one of the rotational-angle detecting elements 91, 92 is in failure, and then executes a rotational-angle detecting-element abnormality processing (Step S9). This rotational-angle detecting-element abnormality processing is a fail-safe control processing for guiding the throttle valves 66 to the full closing position to cause the engine 3 to be brought to an idling rotation state. The detail of this processing will be discussed later (Fig. 9B).

[0092] Fig. 9A is a flowchart illustrating the full-closing detecting-element abnormality processing (Step S8 in Fig. 9).

[0093] The motor control unit 32 generates a motor control signal for guiding the throttle valves 66 to the full closing position at a predetermined full closing speed (Step S81). Then, the motor 71 is accordingly driven in the full closing direction at the speed corresponding to the full closing speed above-mentioned (Step S82). The full closing speed is determined in view of the reduction in throttle opening caused by the rotation of the motor 71 and in view of the deceleration of the motorcycle 1 resulting from the reduction in throttle opening. That is, in order to prevent this deceleration from giving an excessive discomfort to the rider (having no intention of deceleration), the full closing speed is determined according to the specifications of the motorcycle 1. For example, the full closing speed may be a value corresponding to 0.05 deg/msec which represents the rotational speed of the throttle shaft 65. Fig. 10 shows an example of changes in accelerator opening and throttle opening with the passage of time in such a situation.

[0094] The throttle opening computing unit 31 reads in the output values of the two rotational-angle detecting elements 91, 92 (Step S83), and computes the throttle opening (actual opening) based on the average of the output values thus read (Step S84). The motor control

unit 32 judges whether or not the throttle opening is the full closing value (Step S85). When the throttle opening is not the full closing value (Step S85: NO), the processings on and after Step 81 are repeated. When the throttle opening is the full closing value (Step S85: YES), the motor control unit 32 stops the energization to the motor 71 (Step S86). Thus, when the throttle valves 66 are brought to the full closing position, the motor 71 is stopped.

[0095] Fig. 9B is a flowchart illustrating the rotational-angle detecting-element abnormality processing (Step S9 in Fig. 9).

[0096] The motor control unit 32 generates a motor control signal for bringing the throttle valves 66 to the full closing position at the full closing speed above-mentioned (Step S91). Then, the motor 71 is accordingly driven in the full closing direction at the speed corresponding to the full closing speed (Step S92). In such a situation, the throttle opening and the accelerator opening undergo changes with the passage of time as shown for example in Fig. 10.

[0097] The motor control unit 32 reads in the output signal of the full-closing detecting element 93 and judges whether or not the full-closing detecting element 93 has detected the full closing (Step S93). Until the full-closing detecting element 93 detects the full closing, the processings on and after Step 91 are repeated. When the full-closing detecting element 93 detects the full closing (Step S93:YES), the energization to the motor 71 is stopped (Step S94). Thus, the throttle valves 66 are brought to the full closing position and the motor 71 is stopped immediately thereafter.

[0098] As discussed in the foregoing, the embodiment above-mentioned is arranged such that the rotational-angle detecting elements 91, 92 detect the rotation of the intermediate gear shaft 80 as increased in rotational speed as compared with the rotation of the throttle shaft 65. Accordingly, a throttle opening detection with high resolution can be achieved. It is therefore possible not only to enhance the reliability with the use of the rotational-angle detecting elements 91, 92 of the non-contact type, but also to control the throttle opening with high precision with the use of the throttle opening detected with high resolution. This enables the output responsiveness to the throttle operation to be enhanced.

[0099] Further, the speed increasing ratio of the intermediate gear shaft 80 with respect to the throttle shaft 65 is determined such that the rotational angle range of the intermediate gear shaft 80 corresponding to the operational angle range of the throttle valves 66 is less than 360 degrees. Accordingly, the absolute angle position of the throttle valves 66 can be obtained only with the outputs of the rotational-angle detecting elements 91, 92, and no other rotary shaft angle detecting sensor is required. This reduces the sensor installing space in size, thus enabling the throttle apparatus 60 to be miniaturized. At the same time, cost reduction can be achieved.

[0100] Further, since the embodiment above-men-

tioned is arranged to detect the rotational angle of the intermediate gear shaft 80 of the reduction mechanism 72, the rotational-angle detecting elements 91, 92 can be disposed at a lateral side of the throttle shaft 65 and not at a longitudinal end thereof. This enables the throttle apparatus 60 to be reduced in size in the direction along the throttle shaft 65. Further, the reduction mechanism 72 is disposed between the pair of intake air passages 61, and the whole width of the mechanism 72 is housed in the length range of the throttle shaft 65. This further miniaturizes the throttle apparatus 60 in the direction along the throttle shaft 65.

[0101] Further, this embodiment has the full-closing detecting element 93 for detecting the full closing of the throttle valves 66. Even though any of the rotational-angle detecting elements 91, 92 is in failure, with the use of the output signal of this full-closing detecting element 93, the motor 71 can be driven to bring the throttle valves 66 to the full closing position, and the energization to the motor 71 can be stopped immediately after the throttle valves 66 have been brought to the full closing position. This not only prevents the motor 71 from being overloaded, but also restrains the power consumption from being wasted.

[0102] Further, the full-closing detecting element 93 is not a rotational angle detecting sensor, but an element for detecting the intensity of the magnetic field of the full-closing detecting magnet 81 fixed to the throttle gear 78. Accordingly, this element 93 may be formed by an economical sensor as compared with the rotational-angle detecting elements 91, 92. Further, the full-closing detecting magnet 81 is attached to the throttle gear 78 fixed to the throttle shaft 65, thus enabling to securely detect that the throttle valves 66 have reached the full closing position.

[0103] Further, both the rotational-angle detecting elements 91, 92 and the full-closing detecting element 93 are arranged to detect the magnetic field. Accordingly, the rotational-angle detecting unit 86 and the full-closing detecting unit 87 which incorporate these elements 91, 92, 93 are mounted on the common substrate 88. This not only miniaturizes the apparatus, but also simplifies the support structure of the sensor assembly 75.

[0104] Further, according to this embodiment, a rotational angle detecting mechanism of the double system is applied as the arrangement for detecting the rotational angle of the intermediate gear shaft 80 with use of the two rotational-angle detecting elements 91, 92. It is therefore possible to detect a failure in any of the rotational-angle detecting elements 91, 92. As a result, when any of the rotational-angle detecting elements 91, 92 is in failure, the output signal of the full-closing detecting element 93 is used to bring the throttle valves 66 to the full closing position.

[0105] Further, a failure in the full-closing detecting element 93 can also be detected by comparing the throttle opening obtained based on the outputs of the rotational-angle detecting elements 91, 92, to the output of the full-

closing detecting element 93. Accordingly, when the full-closing detecting element 93 is in failure, the output values of the rotational-angle detecting elements 91, 92 can be used to bring the throttle valves 66 to the full closing position.

[0106] In case of failure occurrence, the throttle valves 66 are not instantly brought to the full closing position by the spring force of the restoring spring 73, but the motor 71 is controlled to bring the throttle valves 66 to the full closing position at a predetermined full closing speed. This prevents the engine 3 from being suddenly reduced in rotational speed to prevent the motorcycle 1 from being suddenly reduced in speed. This in turn restrains a sense of discomfort given to the rider.

[0107] In the foregoing, an embodiment of the present invention has been discussed, but it should be understood that the present invention can be embodied in a variety of forms. For example, shown in the embodiment above-mentioned is the reduction mechanism 72 having the intermediate gear unit 77 and the throttle gear 78. However, there may be used a reduction mechanism having more gears. In this case, the full-closing detecting magnet and the rotational-angle detecting magnet may respectively be attached to gears which are not directly meshed with each other. The full-closing detecting magnet may be attached to other gear than the throttle gear. To avoid any interference of magnetic fields, however, the full-closing detecting magnet and the rotational-angle detecting magnet are preferably fixed to different gears. Further, to reduce the sensor assembly in size, the full-closing detecting magnet and the rotational-angle detecting magnet, are preferably disposed at a pair of gears which are directly meshed with each other, i.e., a pair of adjacent gears.

[0108] Further, according to the embodiment above-mentioned, the full-closing detecting element 93 detects the throttle full closing when the full-closing detecting element 93 is opposite to the full-closing detecting magnet 81. However, provision may be made such that the throttle full closing is detected when the full-closing detecting element 93 is not opposite to the full-closing detecting magnet. For example, an arcuate permanent magnet may be fixed along the wheel gear portion 78A of the throttle gear 78 and may be used as a full-closing detecting magnet. This full-closing detecting magnet is so disposed as not to be opposite to the full-closing detecting element 93 when the throttle valves 66 are in the full closing position, and as to be opposite to the full-closing detecting element 93 when the throttle valves 66 are in other position than the full closing position. Accordingly, when the throttle valves 66 are in other position than the full closing position, the full-closing detecting element 93 detects the magnetic field of the full-closing detecting magnet. Therefore, the full-closing detecting element 93 detects the throttle full closing when the full-closing detecting element 93 is not opposite to the full-closing detecting magnet.

[0109] Further, as the full-closing detecting element,

instead of a Hall IC, other detecting element capable of detecting the magnitude of the magnetic field may be used. For example, as the full-closing detecting element, a proximity switch may be used to be turned on/off each time the full-closing detecting magnet is moved toward/away from the proximity switch.

[0110] Further, according to the embodiment above-mentioned, the sensor assembly 75 is formed by mounting the rotational-angle detecting unit 86 and the full-closing detecting unit 87 on the common substrate 88. However, these detecting units 86, 87 may be respectively mounted on different substrates.

[0111] Further, according to the embodiment above-mentioned, the rotational-angle detecting unit 86 incorporates two rotational-angle detecting elements 91, 92, thus forming the rotational angle detecting mechanism of the double system. However, the rotational-angle detecting unit 86 may include only one rotational-angle detecting element.

[0112] Further, the accelerator operating member may be made in the form of an accelerator lever or an accelerator pedal, instead of the accelerator grip.

[0113] Further, in the foregoing description, a motorcycle has been discussed by way of an example, but the throttle apparatus of the present invention may be applied to other vehicle than a motorcycle, and to an engine to be used as the driving source of other mechanical apparatus. It is a matter of course that the number of engine cylinders is not limited to four.

[0114] Further, various modifications of designing can be made within the scope of the appended claims.

Claims

1. A throttle apparatus (60), comprising:
 - a throttle valve (66) disposed in an intake air passage (61) of an engine (3);
 - a throttle shaft (65) connected to the throttle valve (66) and rotatable in a predetermined operational angle range;
 - a motor (71) for rotating the throttle shaft (65);
 - a reduction mechanism (72) having a plurality of gears (76,77,78) including a first gear (77) rotatable in a rotational angle range greater than the operational angle range of the throttle shaft (65) and smaller than 360 degrees, the rotation of the motor (71) being transmitted, as reduced in rotational speed, to the throttle shaft (65) by the plurality of gears (76,77,78); and
 - a rotational angle sensor (82, 91, 92) for detecting the rotational angle of the first gear (77).
2. A throttle apparatus (60) according to Claim 1, further comprising an elastic member (73) for imparting, to the throttle shaft (65), an elastic force in a direction of closing the throttle valve (66), and where-

in the elastic force is imparted to the throttle shaft (65) in its whole operational angle range in the direction of closing the throttle valve (66).

3. A throttle apparatus (60) according to Claim 1, wherein the first gear (77) has a rotary shaft (80) different from the throttleshaft (65), and the first gear (77) is, out of the plurality of gears (76,77,78), a gear nearest to the throttle shaft (65) on a rotation transmission passage.
4. A throttle apparatus (60) according to Claim 1, further comprising a full closing switch (81,93) fixed to a second gear (78) of the reduction mechanism (72).
5. A throttle apparatus (60) according to Claim 4, wherein the rotational angle sensor (82, 91, 92) includes: a rotational-angle detecting magnet (82) fixed to the first gear (77) of the reduction mechanism (72); and a rotational-angle detecting element (91,92) which is disposed opposite to the rotational-angle detecting magnet (82) and which is arranged to detect a magnetic field of the rotational-angle detecting magnet (82), thereby to detect the rotational angle of the first gear (77), and the full closing switch (81,93) includes: a full-closing detecting magnet (81) fixed to the second gear (78) of the reduction mechanism (72); and a full-closing detecting element (93) for detecting the magnetic field of the full-closing detecting magnet (81), thereby to detect whether or not the throttle valve (66) is in the full closing position.
6. A throttle apparatus (60) according to Claim 5, wherein the second gear (78) includes a magnet attaching portion (78B) which extends in the axial direction of the throttle shaft (65) and to which the full-closing detecting magnet (81) is attached.
7. A throttle apparatus (60) according to Claim 5, wherein the rotary shaft (80) of the first gear (77) has a large-diameter portion (83) to which the rotational-angle detecting magnet (82) is attached.
8. A throttle apparatus (60) according to Claim 5, further comprising a substrate (88) on which the rotational-angle detecting element (91,92) and the full-closing detecting element (93) are commonly mounted.
9. A throttle apparatus (60) according to Claim 5, wherein the full-closing detecting magnet (81) is disposed such that the two magnetic poles thereof are aligned in an axial direction of the throttle shaft (65), and the two magnetic poles of the rotational-angle detecting magnet (82) are aligned in a direction at a right angle to the throttle shaft (65).

10. A throttle apparatus (60) according to Claim 5, wherein the rotational-angle detecting element (91,92) is to detect an orientation of magnetic field, and the full-closing detecting element (93) is to detect an intensity of magnetic field. 5

11. A throttle apparatus (60) according to Claim 5, wherein the first gear (77) and the second gear (78) are directly engaged with each other. 10

12. A throttle apparatus (60) according to Claim 4, wherein two or more of the rotational angle sensors (82, 91, 92) are disposed, and one of the full-closing switch (81, 93) is disposed. 15

13. A throttle apparatus (60) according to Claim 5, wherein two or more of the rotational-angle detecting elements (91, 92) are disposed, and one of the full-closing detecting element (93) is disposed. 20

14. A throttle apparatus (60) according to any one of Claims 4 to 13, further comprising: 25

a throttle opening computing unit (31) for computing an opening of the throttle valve (66) based on an output of the rotational angle sensor (82, 91, 92); 30

an accelerator opening detecting unit (12) for detecting an accelerator opening which represents an operation amount of an accelerator operating member (11);

a motor control unit (32) for controlling the motor (71), based on an accelerator opening detected by the accelerator opening detecting unit (12), a throttle opening computed by the throttle opening computing unit (31) and an output signal of the full-closing switch (81, 93), such that the throttle opening corresponds to the accelerator opening; and 35 40

a first failure detecting unit for detecting a failure in the rotational angle sensor (82, 91, 92), 45

wherein the motor control unit (32) is arranged such that when the first failure detecting unit detects a failure in the rotational angle sensor (82, 91, 92), the motor control unit (32) rotationally drives the motor (71) in a full closing direction until the full closing switch (81,93) detects that the throttle valve (66) is in a full closing position. 50

15. A motorcycle (1), comprising: 55

an engine (3);

a wheel (5) to which a driving force of the engine (3) is transmitted; and

the throttle apparatus (60) arranged to adjust an amount of air taken in the engine (3) and set forth in any one of Claims 1 to 14.

FIG. 1

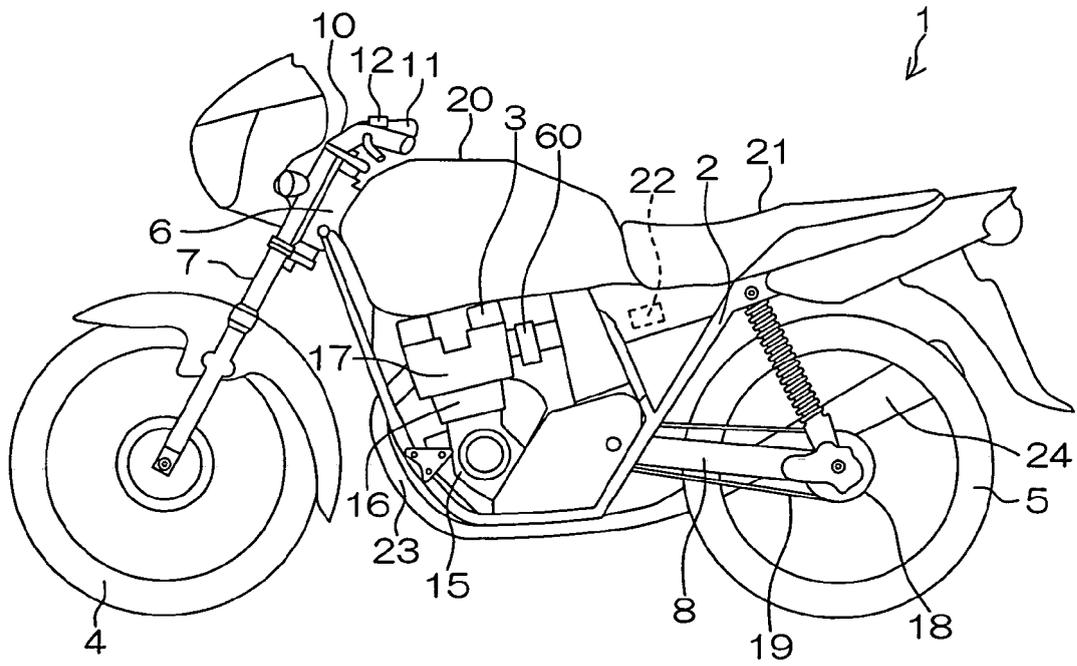
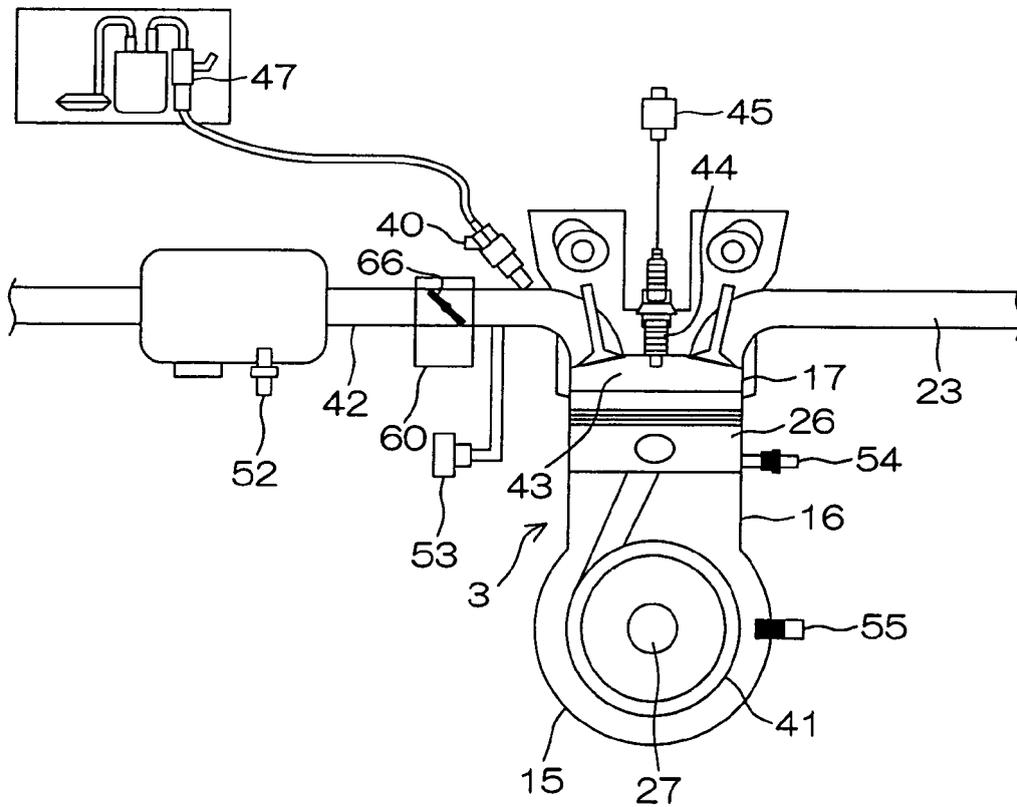


FIG. 2



60 ↓

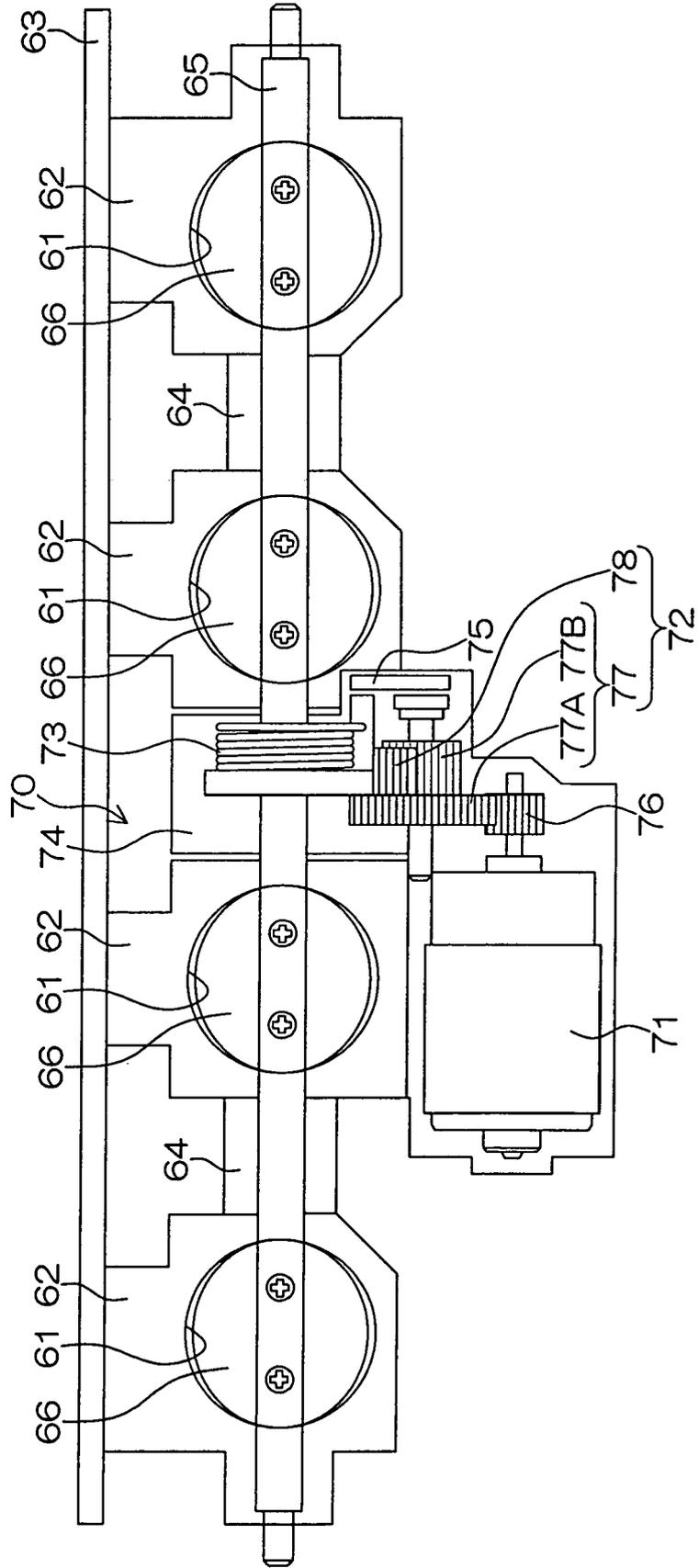


FIG. 3

FIG. 4

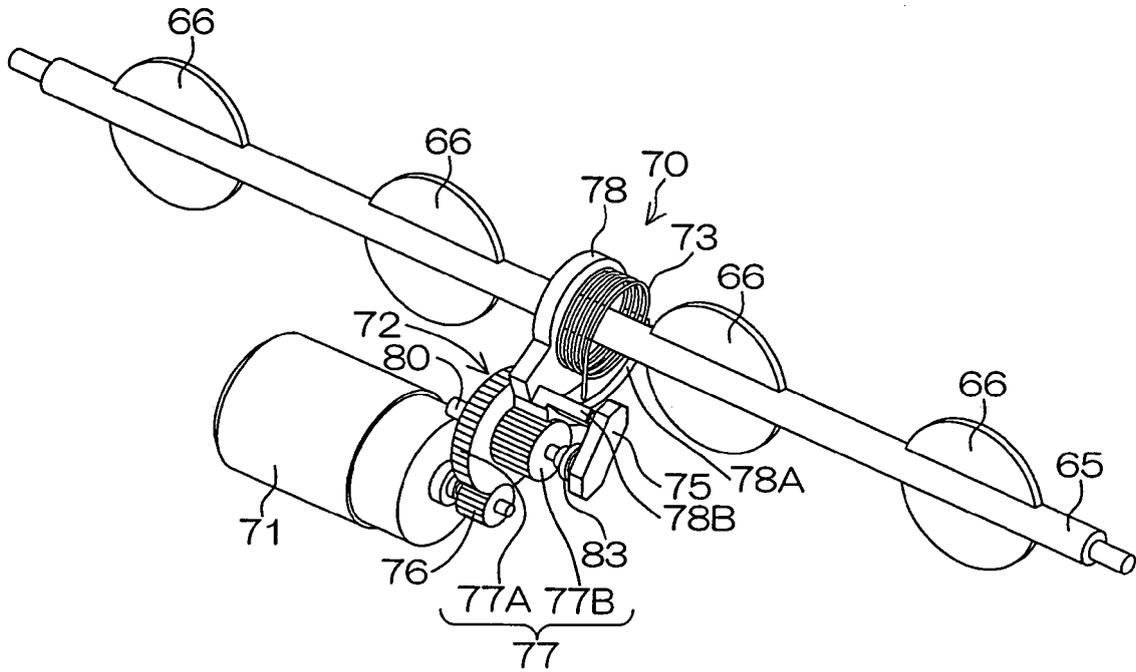


FIG. 5

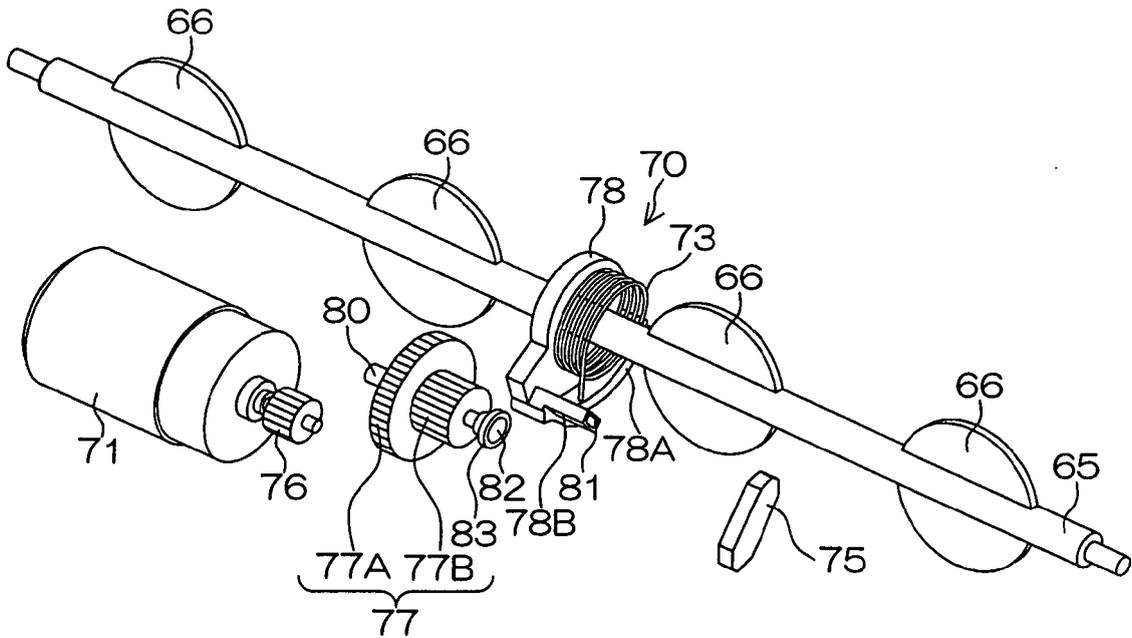


FIG. 6

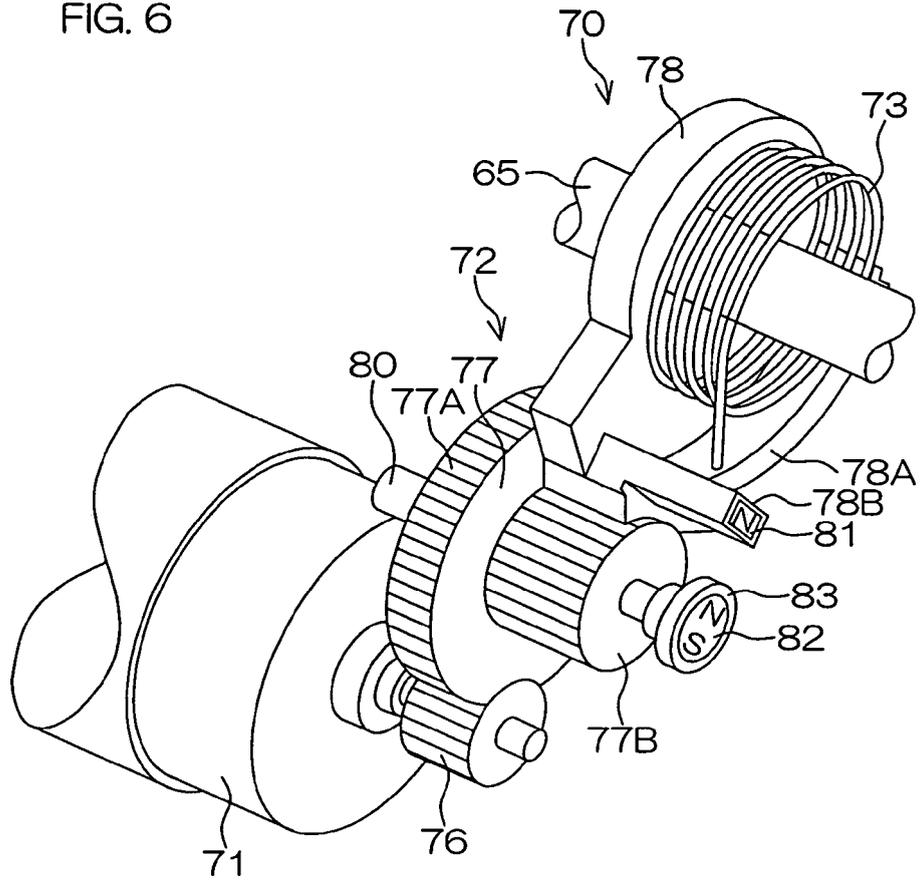


FIG. 7

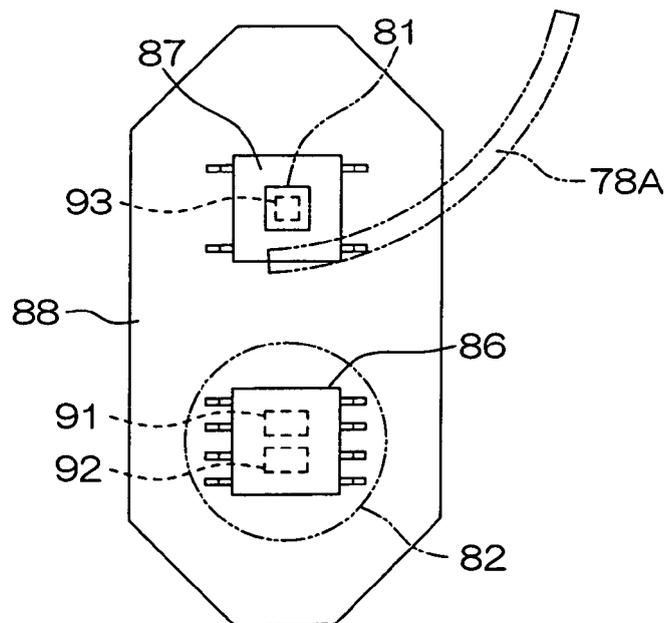


FIG. 8

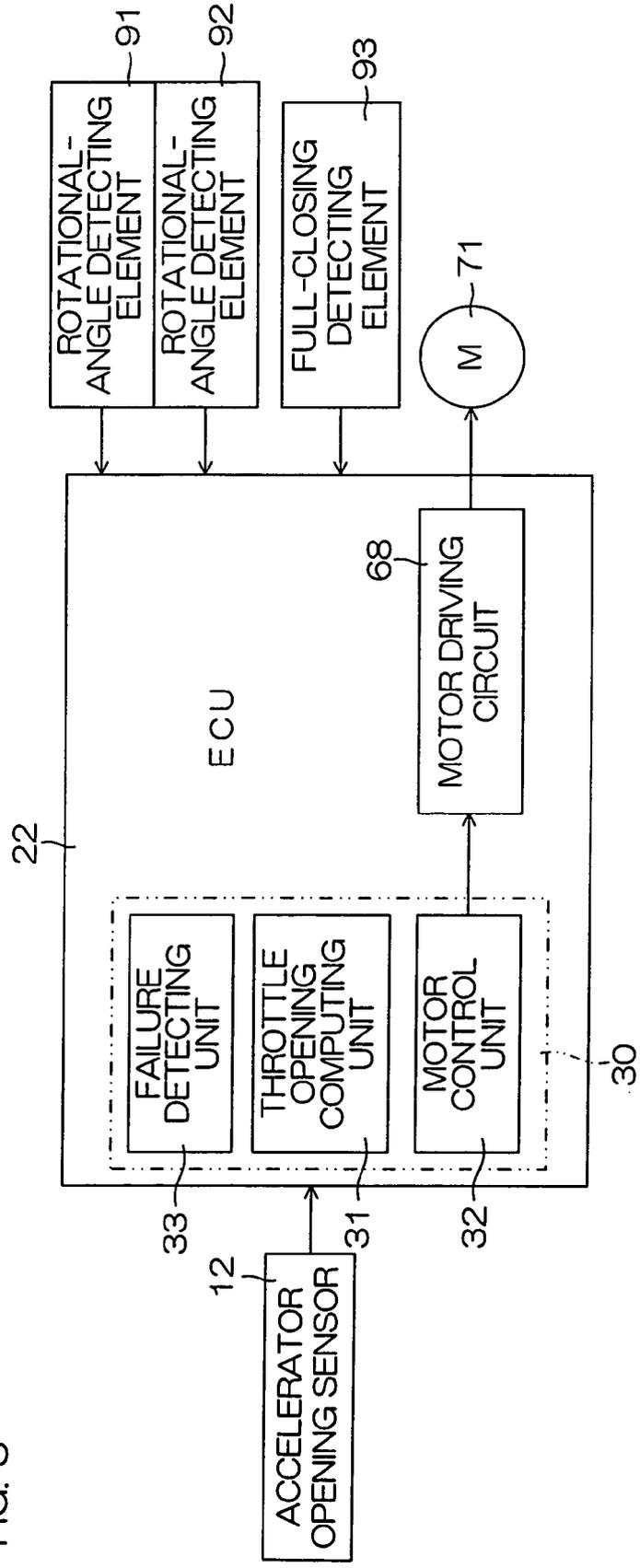


FIG. 9

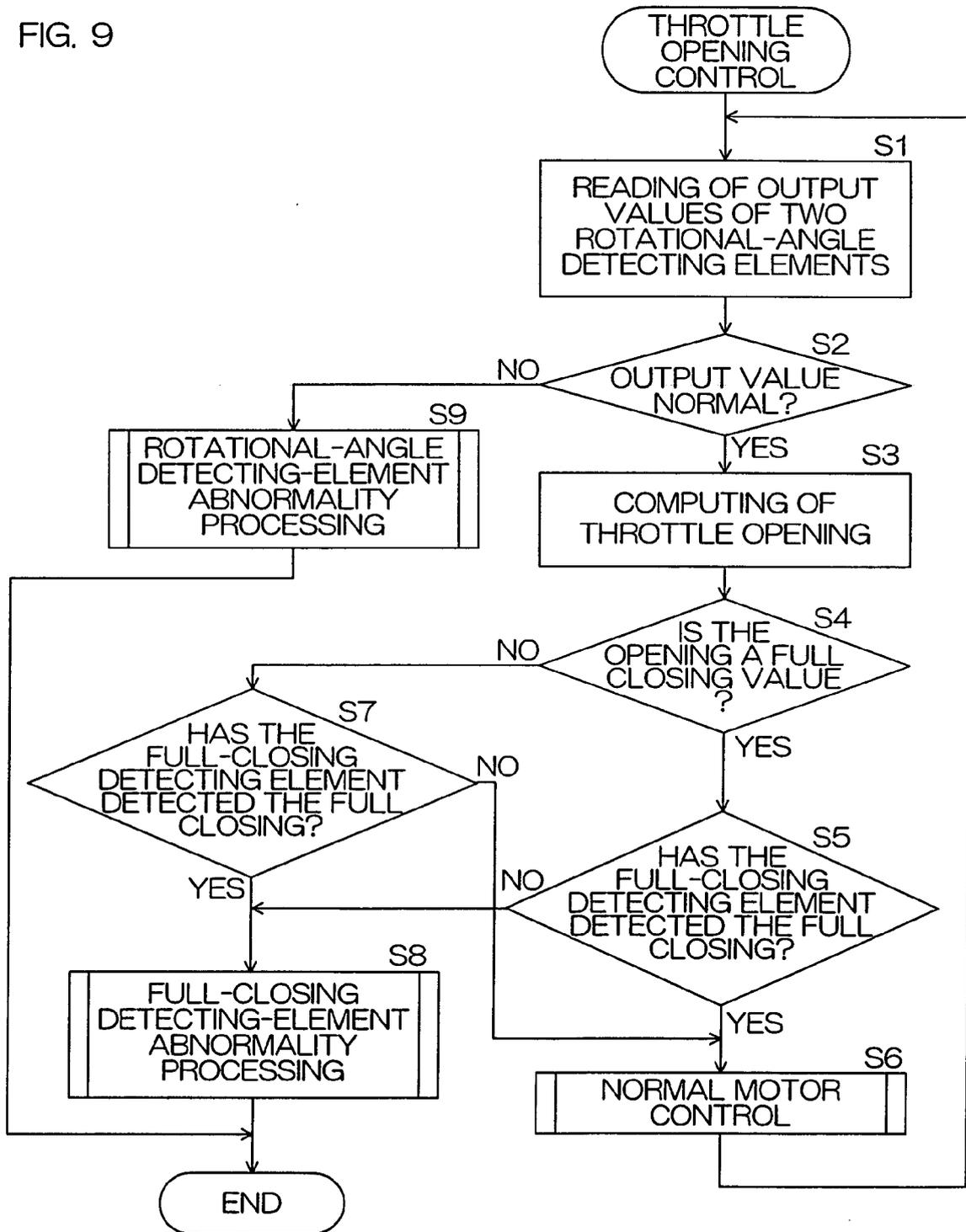


FIG. 9A

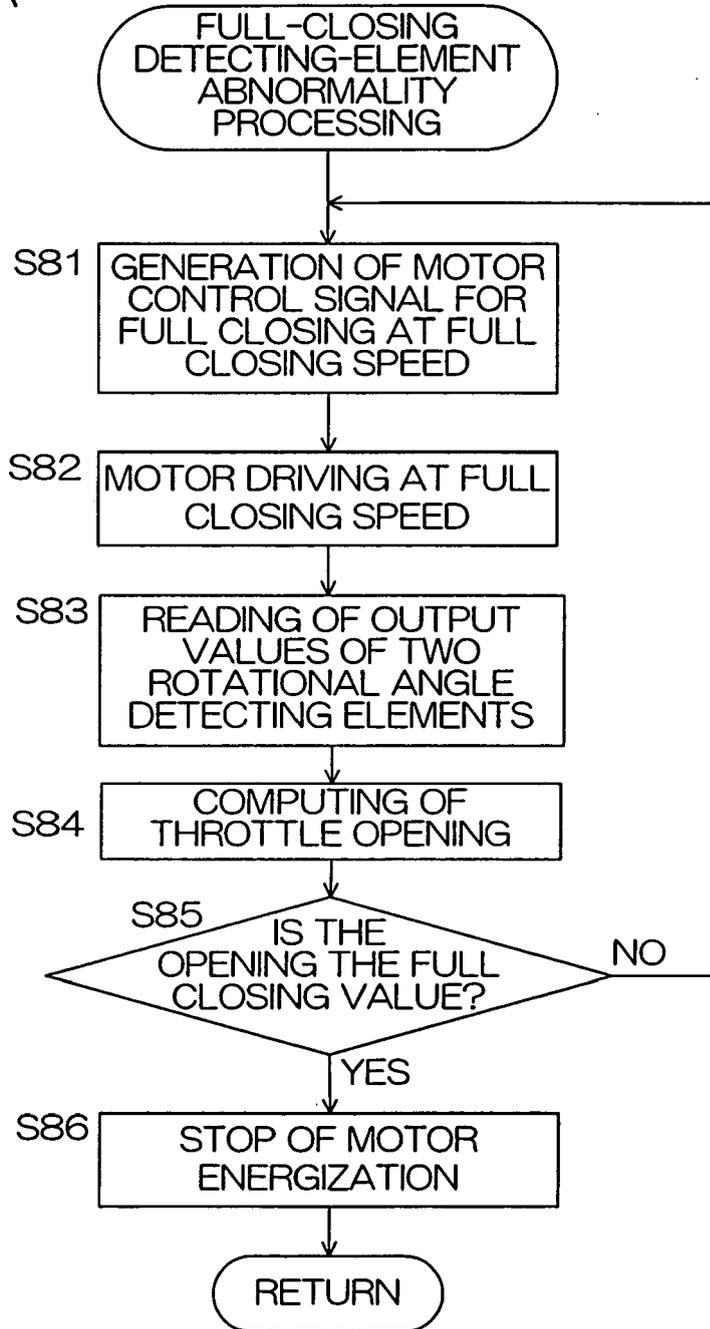


FIG. 9B

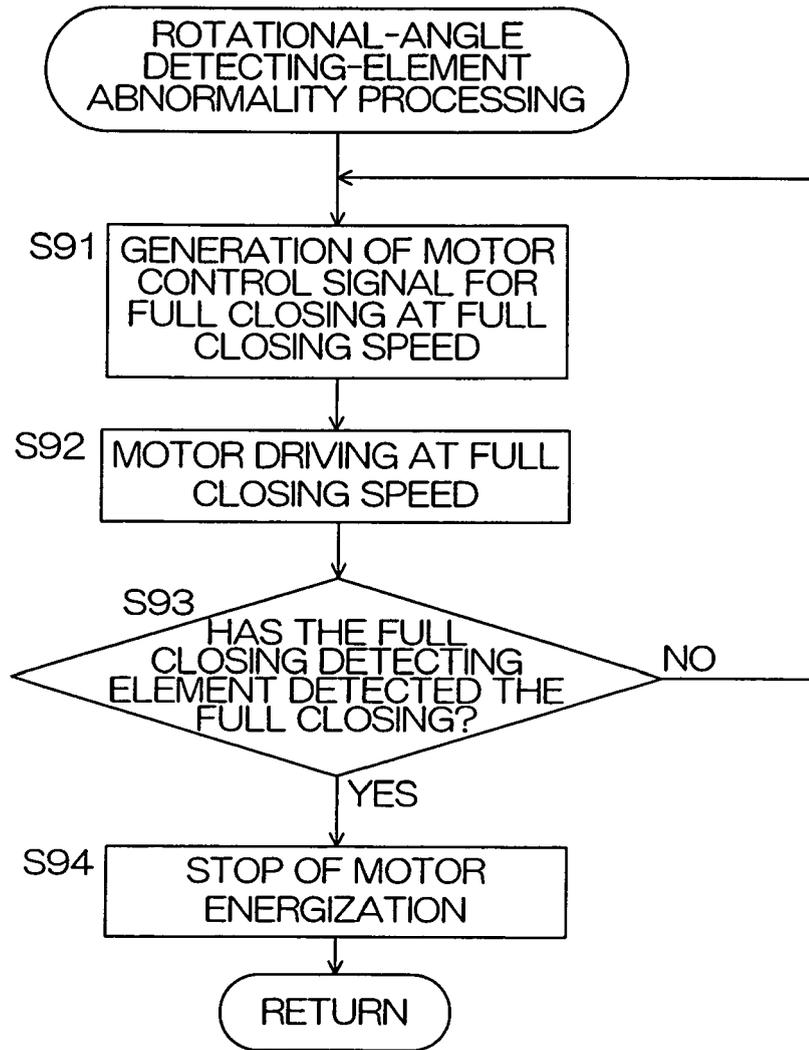
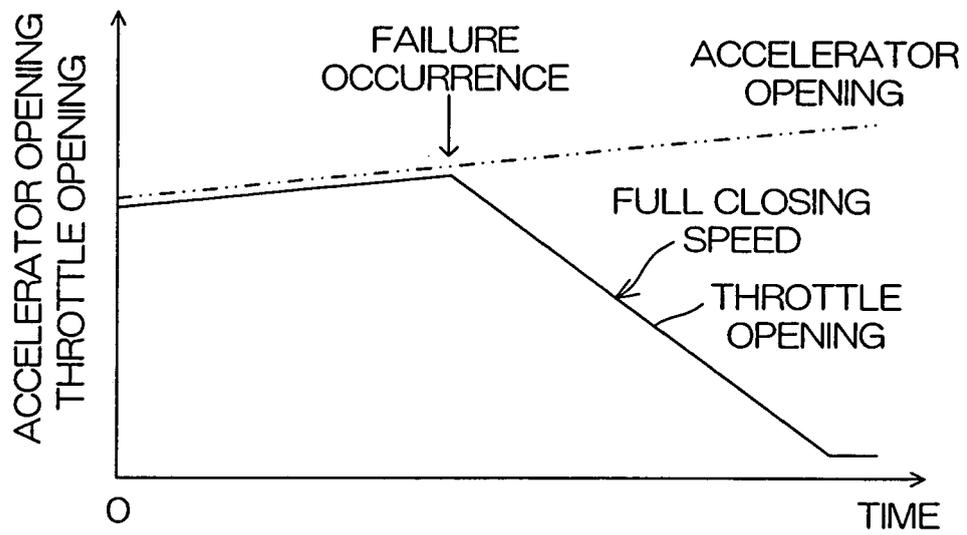


FIG. 10



ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 09 00 8872

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23-09-2009

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|--|------------------|---|--|
| US 2004244772 A1 | 09-12-2004 | DE 102004025926 A1 US 2006124106 A1 | 23-12-2004 15-06-2006 |
| DE 19912231 A1 | 14-10-1999 | JP 11294204 A | 26-10-1999 |
| US 6189507 B1 | 20-02-2001 | DE 19922926 A1 | 25-11-1999 |
| EP 2058489 A | 13-05-2009 | NONE | |
| EP 0572951 A | 08-12-1993 | DE 69326715 D1 DE 69326715 T2 JP 3084929 B2 JP 5332191 A US 5463298 A | 18-11-1999 21-06-2000 04-09-2000 14-12-1993 31-10-1995 |
| EP 0183472 A | 04-06-1986 | DE 3576384 D1 JP 1907404 C JP 6031563 B JP 61129449 A US 4653453 A | 12-04-1990 24-02-1995 27-04-1994 17-06-1986 31-03-1987 |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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Patent documents cited in the description

- JP 2002256903 A [0002]