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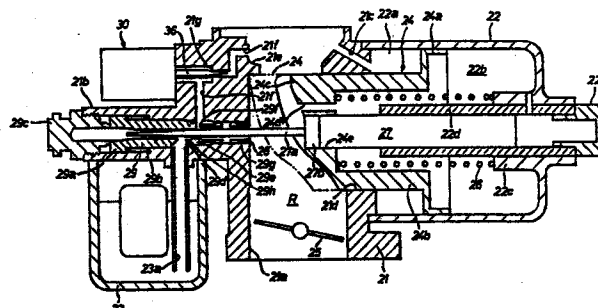
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⑥④ **Electric air bleed control system for carburettor.**

⑥⑦ An electric air bleed control system for a carburetor of the type which comprises a main throttle valve (25) in an induction passage, a throttle piston (24) located upstream of the throttle valve and axially displaceable to form a variable venturi, a pneumatic actuator (22) arranged to be activated by a vacuum depending on the flow of air in the induction passage for effecting axial displacement of the piston, a fuel passage (29) arranged to permit the flow of fuel from a fuel reservoir into a mixing chamber (R) between the piston and the throttle valve and being provided therein with a fuel metering jet (29e), a needle valve element (27a) integral with the piston for controlling the cross-sectional area of the fuel metering jet, and an air bleed passage (21f) arranged to permit the flow of atmospheric air into the fuel passage. The control system is arranged to determine one of plural learning regions in accordance with the axial displacement of the needle valve element, the plural learning regions corresponding with a plurality of subdivided displacement regions of the needle valve element, to learn an instantaneous air-fuel ratio of the mixture in relation to oxygen concentration in exhaust gases of the engine, to determine an optimum amount of air based on a resultant of the learning for supply of an optimum amount of fuel into the mixing chamber, and to produce an output signal indicative of the optimum amount of air and apply it to an electrically operated valve mechanism (30) disposed within the air bleed passage.



- 1 -

ELECTRIC AIR BLEED CONTROL SYSTEMFOR CARBURETTOR

The present invention relates to a carburetor of the variable venturi type, and more particularly to an electric air bleed control system for the carburetor wherein a fuel passage is provided to permit

5. therethrough the flow of fuel from a float chamber into an induction passage, and an air bleed passage is provided to permit the flow of air into the fuel passage for controlling an amount of the fuel supplied into the induction passage.

10. In Japanese Patent Early Publication No. 59-221449, there has been proposed a carburetor of the variable venturi type which comprises a carburetor body formed therein with an induction passage, a main throttle valve disposed in the induction passage, an
15. auxiliary throttle piston located upstream of the main throttle valve and axially displaceably mounted on the carburetor body to form a variable venturi, a pneumatic

- actuator mounted on the carburetor body to be activated by a vacuum depending on the flow of air in the induction passage for effecting axial displacement of the throttle piston, a fuel passage formed in the
5. carburetor body to permit therethrough the flow of fuel from a float chamber into a mixing chamber between the throttle piston and the main throttle valve and being provided therein with a fuel metering jet, a needle valve element integral with the throttle piston for
10. controlling the cross-sectional area of the fuel metering jet in accordance with the axial displacement of the throttle piston, and an air bleed passage formed in the carburetor body to permit the flow of air into the fuel passage substantially at the atmospheric
15. pressure. In carburetors of this kind, the cross-sectional area of the fuel metering jet is controlled in accordance with axial displacement of the throttle piston to control the amount of fuel supplied into the mixing chamber so as to maintain the mixture at
20. an optimum air-fuel ratio. In axial displacement of the throttle piston, however, the needle valve element is inevitably defaced by frictional engagement with the fuel metering jet, resulting in an increase of the cross-sectional area of the fuel metering jet and
25. resulting in an increase of the amount of fuel supplied into the mixing chamber. For this reason, the air-fuel ratio of the mixture deviates from the optimum air-fuel

ratio, resulting in an increase of toxic component in exhaust gases, deterioration of fuel economy and driveability of the vehicle.

- It is, therefore, a primary object of the
5. present invention to provide an electric air bleed control system for a carburetor of the variable venturi type capable of maintaining the mixture at an optimum air-fuel ratio in spite of defacement of the needle valve element.
10. According to the present invention, the primary object is attained by providing an electric air bleed control system for the above-described carburetor which comprises first detecting means for producing a first signal indicative of axial displacement of the needle
15. valve element, second detecting means for producing a second signal indicative of oxygen concentration in exhaust gases discharged from the engine, means responsive to the first signal for determining one of plural learning regions in accordance with the axial
20. displacement of said needle valve element, the plural learning regions corresponding with a plurality of subdivided displacement regions of the needle valve element, learning means responsive to the second signal for learning an instantaneous air-fuel ratio of the
25. mixture in relation to the oxygen concentration in the

- exhaust gases at the determined learning region, means for determining an optimum amount of air based on a resultant of the learning for supply of an optimum amount of fuel into the mixing chamber through the fuel passage, and means for producing an output signal indicative of the optimum amount of air and applying it to an electrically operated valve mechanism which is arranged to control the amount of air flowing into the fuel passage through the air bleed passage.
- 5.
10. In operation of the air bleed control system, the determination of the learning region is useful to learn change of the actual air-fuel ratio of the mixture caused by the axial displacement of the needle valve element. As a result, undesired influences on the
15. actual air-fuel ratio of the mixture caused by defacement of the needle valve element can be determined as a compensation value for supply of the optimum amount of fuel into the mixing chamber through the fuel passage. Thus, the amount of air flowing into the fuel
20. passage can be controlled by the output signal to maintain the mixture at the optimum air-fuel ratio.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

25.

Fig. 1 is a schematic block diagram of an air

bleed control system for a carburetor of the variable venturi type adapted to an internal combustion engine;

Fig. 2 is a sectional view of the carburetor;

Fig. 3 is a partially plan view of the

5. carburetor;

Fig. 4 is a partially enlarged sectional view of the carburetor;

Fig. 5 depicts graphs defining characteristic curves ℓ_1 , ℓ_2 and ℓ_3 , the characteristic curve ℓ_1

10. showing a cross-sectional area formed between a head portion of a piston and a protruded portion of a carburetor body in relation to outward displacement of the piston, the characteristic curve ℓ_2 showing change of a diameter of a needle valve element in relation to
15. outward displacement of the piston, and the characteristic curve ℓ_3 showing change of an annular cross-sectional area formed between the needle valve element and a fuel metering jet in relation to outward displacement of the piston;

20. Fig. 6 is a partially sectioned view of an electric drive mechanism adapted to the carburetor shown in Fig. 2

Figs. 7 and 8 illustrate a flow chart of a main control program for a microcomputer shown in Fig. 1;

25. Fig. 9 illustrates a flow chart of a first interruption control program for the microcomputer;

Fig. 10 illustrates a detailed flow chart of a routine for calculating a learning correction value shown in Fig. 8;

Fig. 11 illustrates a detailed flow chart of a routine for calculating a feedback correction value shown in Fig. 8;

Fig. 12 illustrates a detailed flow chart of a
5. learning routine for learning values shown in Fig. 8;

Fig. 13 illustrates a flow chart of a second interruption control program for the microcomputer; and

Fig. 14 is a graph showing a relationship
between a stroke length of the piston and an amount of
10. air flowing into an induction conduit of the carburetor body.

Referring now to the drawings and particularly to Fig. 1, there is illustrated an electric air bleed control system for a carburetor 20 of the variable
15. venturi type adapted to an internal combustion engine 10. The carburetor 20 comprises a carburetor body 21 which is interposed between an intake manifold 12 connected with a cylinder block 11 of engine 10 and an air duct 14 provided thereon with an air cleaner 13. As
20. shown in Fig. 2, the carburetor body 21 is formed therein with an induction or intake conduit 21a which contains, upstream of a main throttle valve 25 operated by the driver, an auxiliary throttle element 24. The auxiliary throttle element 24 is in the form of a spring
25. loaded throttle piston arranged to form a mixing chamber R defined by the main throttle valve 25 and the throttle piston 24. The throttle piston 24 has a small diameter

portion 24b axially slidably supported at 21d on a peripheral wall of the carburetor body 21 and has a head portion 24c of a V-letter shaped cross-section, as shown Fig. 3. Thus, the head portion 24c cooperates with an

5. internally protruded portion 21e of carburetor body 21 to provide a variable venturi for controlling the flow of air into the intake conduit 21a. In this case, a cross-sectional area formed between the head portion 24c and the protruded portion 21e changes in accordance with

10. outward displacement of piston 24 as shown by a characteristic curve ℓ_1 in Fig. 5.

A hollow cylindrical casing 22 is hermetically fixed to the peripheral wall of carburetor body 21 to contain therein a cylindrical large diameter portion 24a

15. of piston 24. The interior of casing 22 is subdivided by the large diameter portion 24a of piston 24 into an atmospheric chamber 22a and a vacuum chamber 22b which are respectively in open communication with the atmosphere through an air passage 21c in the peripheral

20. wall of body 21 upstream of the throttle piston 24 and in open communication with the mixing chamber R through a suction passage 24d in piston 24. A guide rod 27 is fixedly inserted at its inner end into a central hole 24e of throttle piston 24 and is axially slidably

25. supported by a guide sleeve 22d which is fixedly mounted at its outer end on the cylindrical casing 22.

The guide sleeve 22d is arranged coaxially with the throttle piston 24 and is closed by a closure plug 22e secured thereto. A compression coil spring 26 in surrounding relationship with the guide sleeve 22d is

5. engaged at one end thereof with an annular inner wall 22c of casing 22 to bias the throttle piston 24 toward the internally protruded portion 21e of carburetor body 21.

The carburetor body 21 is formed at one side

10. thereof with a cylindrical portion 21b which is arranged coaxially with the throttle piston 24 to contain therein a needle valve element 27a. The valve element 27a extends from a holder 27b which is fixedly inserted into the central hole 24e of throttle piston 24 coaxially

15. with the inner end of guide rod 27. In this case, a diameter of valve element 27a changes in accordance with outward displacement of piston 24 as shown by a characteristic curve ℓ_2 in Fig. 5. As shown in Fig. 4, the holder 27b includes a cylindrical casing 27c which

20. is pressedly inserted into the central hole 24e of throttle piston 24 and faced at its open end to the inner end of guide rod 27. The holder 27b further includes a support member 27d and a coil spring 27e which are assembled in the casing 27c. The coil spring

25. 27e is interposed between an annular flange of support member 27d and a cover plate 27g to bias the support

- member 27d toward the bottom of casing 27c. The support member 27d has an annular boss into which the inner end of valve element 27a is fixedly inserted through a loose hole in the bottom of casing 27c. The flange of support
5. member 27d is engaged at its upper portion with an upper bottom portion of casing 27c and also engaged at its lower portion with an inwardly protruded portion 27f of the bottom of casing 27c to maintain the valve element 27a in a downwardly inclined position. In addition,
10. the cover plate 27g is secured to the open end of casing 27c to support the coil spring 27e thereon.

- A cylindrical nozzle 28 is fixedly coupled within a stepped bore of cylindrical portion 21b and arranged in surrounding relationship with the needle
15. valve element 27a. A stepped sleeve 29 is disposed within the stepped bore of cylindrical portion 21b of carburetor body 21 through axially spaced sealing members 29g and 29h. The sleeve 29 is loaded by a compression coil spring 29b outwardly and engaged at its
20. outer end 29a with the inner end of a closure plug 29c threaded into the cylindrical portion 21b. The sleeve 29 is formed at its intermediate portion with a radial hole 29d which is connected to the interior of a float chamber 23 through a vertical fuel pipe 23a. The inner
25. end portion of sleeve 29 is formed therein with an annular fuel metering jet 29e which receives

- 10 -

an intermediate portion of the needle valve element 27a at its lower portion (see Fig. 4) and cooperates with the same to control an amount of fuel flowing therethrough. The inner end portion of sleeve 29 is

5. further formed with a radial air hole 29f which connects the fuel metering jet 29e to the upstream of internally protruded portion 21e through an air bleed passage 21f. Thus, fuel in the float chamber 23 is fed into the interior of sleeve 29 through the vertical fuel pipe 23a

10. and mixed with the air from air bleed passage 21f. The air-fuel mixture is fed into the mixing chamber R through the nozzle 28 after it is metered by an annular cross-sectional area between the needle valve element 27a and the fuel metering jet 29e. The annular

15. cross-sectional area between needle valve element 27a and fuel metering jet 29e changes in accordance with outward displacement of piston 24 as shown by a characteristic curve ℓ_3 in Fig. 5. This means that the annular cross-sectional area defined by characteristic

20. curve ℓ_3 is substantially in proportion to the cross-sectional area defined by characteristic curve ℓ_1 .

The carburetor 20 is provided with an electric drive mechanism 30 which is attached to the peripheral wall of carburetor body 21. As shown in Fig. 6, the

25. drive mechanism 30 includes a stepper motor 30a and an axially displaceable plunger 30b. The stepper motor 30a

- comprises a stator 31 secured to an end wall of carburetor body 21 at a place adjacent the air bleed passage 21f, and an annular field winding 31a mounted within the stator 31 in surrounding relationship with a
5. cylindrical rotor 33 which is fixed to a hollow shaft 33a. The hollow shaft 33a is rotatably supported by a pair of axially spaced ball bearings 32, 32 carried on stator 31. The plunger 30b has a male screw portion 35 threadedly engaged with a female screw portion 34 formed
10. in the inner periphery of hollow shaft 33a, and a needle valve element 36 extending into the air bleed passage 21f from the male screw portion 35. The plunger 30b is guided by an internal portion of the stator 31 in such a manner as to be axially displaceable but not rotatable
15. about its axis. The plunger 30b is loaded by a compression coil spring 37 toward the air bleed passage 21f. The needle valve element 36 is arranged to cooperate with an annular valve seat 21g in the air bleed passage 21f for controlling an amount of air
20. flowing from the upstream of passage 21f into the fuel metering jet 29e. In the above arrangement, axial displacement of the needle valve element 36 is effected by rotation of the rotor 33 caused by activation of the stepper motor 30a.
25. As shown in Fig. 1, the air bleed control system for the carburetor 20 comprises analog-to-digital

- or A-D converters 50a, 50b, 50c and 50d each connected to an air temperature sensor 40a, a throttle position sensor 40b, a negative pressure sensor 40c and a cooling water temperature sensor 40d; a wave shaper 50e
5. connected to a rotational angle sensor 40e; and a comparator 50g connected to an exhaust gas oxygen sensor 40f and a standard signal generator 50f. The air temperature sensor 40a is disposed within the air duct 14 to detect a temperature of air flow in the duct 14
10. for producing an analog signal indicative of the air temperature. The throttle position sensor 40b is operatively connected to the main throttle valve 25 to detect the opening degree of throttle valve 25 for producing an analog signal indicative of the opening
15. degree of throttle valve 25. The negative pressure sensor 40c is arranged to detect a negative pressure in the intake manifold 12 for producing an analog signal indicative of the intake manifold negative pressure. The cooling water temperature sensor 40d is arranged to
20. detect a temperature of water in the cooling system of engine 10 for producing an analog signal indicative of the cooling water temperature. The rotational angle sensor 40e is arranged to detect a rotational angle of a cam member in a distributor 15 attached to the engine 10
25. for producing an angular signal indicative of the rotational angle of engine 10. The exhaust gas oxygen sensor 40f is arranged to detect concentration of

the oxygen in exhaust gases flowing through an exhaust pipe 16 of engine 10 for producing an analog signal indicative of the oxygen concentration in the exhaust gases.

5. The A-D converters 50a - 50d each are applied with the analog signals from the sensors 40a - 40d to convert them into digital signals respectively indicative of the air temperature, the opening degree of throttle valve 25, the intake manifold negative
10. pressure, and the cooling water temperature. The wave shaper 50e is applied with the angular signal from rotational angle sensor 40e to reform it into a rectangular wave signal indicative of the rotational angle of engine 10. The standard signal generator 50f
15. is arranged to produce a standard signal indicative of a predetermined oxygen concentration for a stoichiometric air-fuel ratio. The comparator 50g is arranged to compare the analog signal from exhaust gas oxygen sensor 40f with the standard signal from signal generator 50f
20. thereby to produce a high level signal when the level of the analog signal is higher than that of the standard signal and to produce a low level signal when the level of the analog signal is lower than that of the standard signal. The high level signal from comparator 50g
25. represents the fact that the concentration of the air-fuel mixture is higher than that defined by

the stoichiometric air-fuel ratio, and the low level signal represents the fact that the concentration of the air-fuel mixture is lower than that defined by the stoichiometric air-fuel ratio.

5. A microcomputer 60 includes a read only memory or ROM which previously stores therein a main control program defined by flow charts shown in Figs. 7, 8, 10, 11 and 12 and also stores therein first and second interruption control programs defined by flow charts
10. shown in Figs. 9 and 13, respectively. The microcomputer 60 cooperates with the A-D converters 50a - 50d, waveform shaper 50e and comparator 50g thereby to execute the main and first interruption control programs for control of the stepper motor 30a and to execute the
15. second interruption control program for control of a relay 70. The computer 60 is connected to a DC voltage source in the form of a vehicle battery B through an ignition switch IG of the engine 10. The computer 60 is further connected to a back-up random access memory or
20. RAM arranged to be maintained in its activated condition by power supply from a back-up power source 60a. The microcomputer 60 is arranged to initiate execution of the first interruption control program at each time when a timer provided in computer 60 completes measurement of
25. a predetermined time duration, for instance, 1msec. The computer 60 is further arranged to initiate execution of

the second interruption control program in response to opening of the ignition switch IG. The relay 70 is interposed between the DC voltage source B and the microcomputer 60, which relay 70 includes an

5. electromagnetic coil 71 and a normally open switch 72 to be closed by energization of the electromagnetic coil 71.

- Hereinafter, the mode of operation of carburetor 20 under control of the microcomputer 60 will
10. be described in detail. Under inoperative condition of the engine 10, the main throttle valve 25 is maintained in its minimum open position, the auxiliary throttle piston 24 is located in its minimum stroke end to fully close the intake conduit 21a, and the needle valve
 15. element 36 of drive mechanism 30 is positioned to fully close the air bleed passage 21f. Assuming that the ignition switch IG is closed to start the engine 10, the level of vacuum in the mixing chamber R increases in response to operation of the engine, and in turn, the
 20. level of vacuum in the vacuum chamber 22b increases to cause axial displacement of the throttle piston 24 against the compression coil spring 26. Thus, the air is drawn from the air cleaner 13 into the mixing chamber R and is mixed with the fuel drawn into the mixing
 25. chamber R from the fuel metering jet 29e through nozzle 28. In this instance, the amount of air flowing into

induction passage 21a is controlled by the axial displacement of throttle piston 24, and the amount of fuel is controlled by the axial displacement of needle valve element 27a. The air-fuel mixture formed in such a condition is supplied into the internal combustion engine 10 through the main throttle valve 25 and intake manifold 12.

When the ignition switch IG is closed, as previously described, the microcomputer 60 is activated to initiate execution of the main control program at step 80 in accordance with the flow charts of Figs. 7 and 8, and simultaneously the timer of microcomputer 60 starts repetitive measurement of the predetermined time duration of 1msec. Upon repetitive completion of measurement in the timer, the computer 60 initiates execution of the first interruption control program in accordance with the flow chart of Fig. 9 to increment a timer count value T by one repetitively.

When the main control program proceeds to the following step 81, the computer 60 determines as to whether a state value F memorized in the back-up RAM prior to closing of the ignition switch IG is changed at this stage or not. If the answer is "Yes", the main control program proceeds to step 81a where the computer 60 sets respective learning values GK(0) - GK(7) as

- a standard value K_o . In this embodiment, the standard value K_o is equal to, for instance, one. The learning values $GK(0) - GK(7)$ each fluctuate on a basis of the standard value K_o and represent a compensation value for
5. correcting the actual air-fuel ratio of the mixture to the optimum air-fuel ratio. In this case, the learning values $GK(0) - GK(7)$ each may correspond with first to eighth stroke widths $\Delta L, \dots, \Delta L$ which are respectively determined by $1/8$ of the entire length between the
10. minimum and maximum stroke ends of piston 24. The first stroke width ΔL corresponds to the minimum stroke of piston 24, and the eighth stroke width ΔL corresponds to the maximum stroke of piston 24.

- After a "No" answer at step 81 or execution at
15. step 81a, the main control program proceeds to step 82 where the computer 60 acts to set a feedback correction value A_f as the standard value K_o , to set the timer count value T as zero and to produce an energization signal for the electromagnetic coil 71 of relay 70. In
20. the present invention, the feedback correction value A_f fluctuates on a basis of the standard value K_o and represents a value for correcting the actual air-fuel ratio of the mixture to the optimum air-fuel ratio in consideration with oxygen concentration in exhaust
25. gases.

- When applied with the energization signal from computer 60, the electromagnetic coil 71 is energized to close the switch 72 thereby to hold the power supply from DC voltage source B to computer 60 through switch
5. 72. When the main control program proceeds to step 83 shown in Fig. 8, the computer 60 calculates a rotational speed EGR of engine 10 in response to rectangular wave signals from wave shaper 50e and temporarily memorizes the rotational speed EGR therein. Thereafter, at step
10. 84 the computer 60 receives digital signals respectively from A-D converters 50a - 50d and a low or high level signal from comparator 50g to temporarily memorize values of the digital signals as the air temperature
15. THA, intake manifold pressure PIM, throttle opening degree SRT and cooling water temperature THW and to temporarily memorize a level of the high or low level signal as an oxygen concentration level OHL.

- Subsequently, at step 85 of the main control program, the computer 60 calculates an amount Q of the
20. air flow on a basis of the following equation (1) in accordance with the memorized rotational speed EGR and intake manifold negative pressure PIM to temporarily memorize the calculated amount Q of the air flow.

$$Q = K \cdot PIM \cdot EGR \quad \dots (1)$$

25. where K is a propotional constant. Thereafter, the computer 60 calculates a stroke length LFT of piston 24

- on a basis of a characteristic curve ℓ_4 (see Fig. 14) in accordance with the calculated amount Q of the air flow and temporarily memorizes the calculated stroke length LFT. In this embodiment, the characteristic curve ℓ_4
5. represents a relationship between the amount Q of the air flow and the stroke length LFT of piston 24 which is previously stored in the ROM of computer 60. Thus, when the piston 24 is in its minimum stroke end, the stroke length LFT is calculated as zero, and the amount Q of
10. the air flow is substantially proportional to the cross-sectional area defined by the characteristic curve ℓ_1 of Fig. 5 since the intake manifold negative pressure PIM is substantially maintained in a constant value.

- Furthermore, at step 85 the computer 60
15. calculates a water temperature compensation value Aw in accordance with the memorized water temperature THW and temporarily memorizes the compensation value Aw . In this instance, the water temperature compensation value Aw represents a value for correcting the actual air-fuel
20. ratio of the mixture to an optimum air-fuel ratio and fluctuates on a basis of the standard value Ko . When the main control program proceeds to the following step 86, the computer 60 determines on a basis of the memorized throttle opening angle SRT, intake manifold
25. negative pressure PIM, cooling water temperature THW and oxygen concentration level OHL as to whether a condition

- 20 -

for feedback control of the air-fuel ratio is satisfied or not. In this instance, the condition for feedback control of the air-fuel ratio is satisfied by the fact that the exhaust gas oxygen sensor 40f is maintained in

5. its activated condition at a higher range of water temperature SRT during operative condition of engine 10 except the full load and idle conditions.

If the answer at step 86 is "No", the computer 60 acts at step 87 to set the feedback correction value

10. Af equal to the standard value Ko and causes the main control program to proceed to a routine 88 for calculation of a learning correction value GK, as shown in Figs. 8 and 10. After the routine 88 is started at step 88a, the computer 60 acts at step 88b to divide the

15. stroke length LFT by the stroke width ΔL thereby to set the divided value $(LFT/\Delta L)$ equal to a value LFN. AT the following step 88c, the computer 60 corrects the value LFN into an integer INT (LFN) to set the same integer equal to a stroke width number N. This means that the

20. stroke width number N defines one of the first to eighth stroke widths ΔL . In this instance, $N = 0, N = 1, \dots, N = 7$ each correspond to the first, second, ..., eighth stroke widths $\Delta L, \dots, \Delta L$.

If the stroke width number N is smaller than 7,

25. the computer 60 determines a "No" answer at step 88d to

calculate the learning correction value GK based on the following equation (2) at step 88e.

$$GK = GK(N) + \{ GK(N + 1) - GK(N) \} \cdot (LFN - N) \dots\dots (2)$$

5. where GK(N) corresponds to one of GK(0) - GK(7) and where $\{ GK(N + 1) - GK(N) \} \cdot (LFN - N)$ acts a role as interpolation for GK(N) to thereby ensure smooth change of GK even if the number of all the stroke widths ΔL , $\dots\dots$, ΔL is small. In addition, if the answer is "Yes"
10. at step 88d, the computer 60 sets $GK = GK(7)$ at step 88f.

After execution of the routine 88, the main control program proceeds to the following step 89 where the computer 60 calculates an optimum rotary step number

15. So of stepper motor 30a on a basis of the following equation (3) in accordance with a standard amount SB of air bleed, the feedback correction value Af (=Ko), the learning correction value GK obtained at routine 88, and the water temperature Aw obtained at step 85.

$$20. \quad So = K1 \cdot (SB + Af + GK + Aw - 3Ko) \dots\dots (3)$$

- In the equation (3), the standard amount SB of air bleed indicates a standard amount of air flowing through the air bleed passage 21f. The optimum rotary step number So of motor 30a corresponds with an optimum amount of
25. air bleed flowing into the fuel metering jet 29e through the air bleed passage 21f. This means that the optimum

amount of air bleed corresponds with an optimum air-fuel ratio of the mixture to be adjusted in the carburetor 20. The reference character K1 indicates a constant which is available for converting each of the standard

5. amount SB of air bleed, feedback correction value Af, learning correction value GK and water temperature Aw into a rotary step number of motor 30a. In addition, 3Ko acts a role as a correction factor for rendering into the standard value Ko the total 4Ko caused by

10. addition of the standard amount SB of air bleed, feedback correction value Af, learning correction value CK and water temperature Aw.

After the above-described calculation, the computer 60 causes the main control program to proceed

15. to step 90. At this step 90, the computer 60 produces a rotation signal the value of which represents a difference between the optimum rotary step number So and the actual rotary step number S. In this instance, the actual rotary step number $S = 0$ means the fact that the

20. plunger 30b of drive mechanism 30 is in an initial position where the needle valve element 36 cooperates with the annular valve seat 21g to fully close the air bleed passage 21f. It is, therefore, noted that an increase of the actual rotary step number S corresponds

25. with an increase of axial displacement of the needle valve element 36 against the coil spring 37. When

applied with the rotation signal from computer 60, the motor 30a of drive mechanism 30 is activated to rotate the rotor 33 in a forward direction in accordance with the value of the rotation signal thereby to cause axial displacement of the needle valve element 36 against spring 37. This results in an increase of the cross-section of the air bleed passage 21f at valve seat 21g. Thus, the amount of air flowing into fuel metering jet 29e through air bleed passage 21f is controlled in accordance with the axial displacement of needle valve element 36.

When the answer at step 86 becomes "Yes" during repetitive execution of the main control program passing through the steps 83 - 90, the computer 60 causes the main control program to proceed to a routine 91 for calculation of the feedback correction value A_f (see Figs. 8 and 11). Then, the computer 60 initiates execution of the routine 91 at step 91a to determine at the following step 91b as to whether or not the timer count value T is larger than a predetermined value T_1 previously memorized in the ROM of computer 60. If the answer is "No" at step 91b, the computer 60 ends execution of the routine 91 at step 91c.

When the answer at step 91b becomes "Yes", the computer 60 determines at the following step 91d as to

- whether or not the oxygen concentration level OHL is high or not. If the answer at step 91d is "Yes", the routine 91 proceeds to step 91e where the computer 60 adds a value $\Delta Af1$ to the latest feedback correction value Af to update Af equal to $(Af + \Delta Af1)$. If the answer at step 91d is "No", the routine 91 proceeds to step 91f where the computer 60 subtracts a value $\Delta Af2$ from the latest feedback correction value Af to update Af equal to $(Af - \Delta Af2)$. In this embodiment, the values $\Delta Af1$ and $\Delta Af2$ are previously stored in the ROM of computer 60. The value $\Delta Af2$ is predetermined larger than the value $\Delta Af1$. After execution of one of steps 91e, 91f, the computer 60 resets $T = 0$ at step 91g to end execution of the routine 91 at step 91c.
15. Subsequently, measurement of the timer of computer 60 is restarted on a basis of $T = 0$.

- After execution of the routine 91, the main control program proceeds to the following step 92 at which the computer 60 determines as to whether or not the actual load acting on engine 10 is maintained in a predetermined learning range. In this case, the predetermined learning range is defined by the fact that a water temperature THA is higher than a predetermined temperature and that an air temperature THA is lower than a predetermined temperature. If a water temperature THA newly obtained at step 84 is lower than

- or equal to the predetermined temperature or an air temperature THA newly obtained at step 84 is higher than the predetermined temperature, the computer 60 determines a "No" answer at step 92 and causes the main
5. control program to proceed to the routine 88.

- Subsequently, at step 89 of the main control program, the computer 60 calculates an optimum rotary step number So in consideration with the feedback correction value Af, obtained at the routine 91, to
10. generate a rotation signal at step 90 so as to drive the driving mechanism 30. This means that an amount of the air bleed is controlled by the driving mechanism 30 in relation to the feedback correction value Af, obtained at the routine 91, to adjust the actual air-fuel ratio
15. of the mixture to an optimum value. In other words, when the mixture is rich, the computer 60 advances the routine 91 through steps 91b, 91d, 91e and 91g repetitively to increase the optimum rotary step number So so as to render the mixture lean. When the mixture
20. is lean, the computer 60 advances the routine 91 through steps 91b, 91e, 91f and 91g repetitively to decrease the optimum rotary step number So so as to render the mixture rich. Additionally, owing to $\Delta Af_2 > \Delta Af_1$, a speed in control of making the mixture rich is maintained
25. higher than that in control of making the mixture lean. This is effective to prevent deterioration in exhaust gas components.

When a water temperature THW newly obtained at step 84 exceeds the predetermined temperature and an air temperature THA becomes lower than the predetermined temperature, the computer 60 determines an "Yes" answer

5. at step 92 caused the main control program to proceed to a learning routine 93 for learning values GK(0) - GK(7). Thus, the computer 60 initiates execution of the learning routine 93 at step 93a to determine a value LFN and a stroke width number N respectively at steps 93b,

10. 93c in the same manner as those at steps 88b, 88c of Fig. 10. Subsequently, the learning routine 93 proceeds to the following step 93d where the computer 60 calculates the learning value GK(N) on a basis of the following equation (4) in accordance with the value LFN,

15. stroke width number N and feedback correction value Af respectively obtained at steps 93b, 93c and routine 91.

$$GK(N) = GK(N) + K2 \cdot (N + 1 - LFN) \cdot (Af - Ko)$$

..... (4)

where K2 is a weighted constant necessary for

20. determining the changing rate of the learning value GK(N). In other words, the computer 60 subtracts the standard value Ko from the feedback correction value Af to multiply the subtracted value (Af - Ko) by a difference (N + 1 - LFN). Subsequently, the computer 60

25. multiplies the multiplied value (Af - Ko) · (N + 1 - LFN) by the weighted constant K2 and adds the multiplied value K2 · (Af - Ko) · (N + 1 - LFN) to the previous

learning value $GK(N)$ to set the added value equal to $GK(N)$.

- If the stroke width number N obtained at step 93c is smaller than 7, the computer 60 determines a "No" answer at step 93e to calculate at step 93f the learning value $GK(N + 1)$ on a basis of the following equation (5) in accordance with the value LFN , stroke width number N and feedback correction value Af respectively obtained at steps 93b, 93c and routine 91.

$$10. \quad GK(N + 1) = K2 \cdot (LFN - N) \cdot (Af - K0) + GK(N + 1) \dots (5)$$

- In other words, the computer 60 subtracts the standard value Af from the feedback correction value Af to multiply the subtracted value $(Af - K0)$ by a difference $(LFN - N)$. Subsequently, the computer 60 multiplies the multiplied value $(Af - K0) \cdot (LFN - N)$ by the weighted constant $K2$ and adds the multiplied value $K2 \cdot (Af - K0) \cdot (LFN - N)$ to the previous learning value $GK(N + 1)$ to set the added value equal to $GK(N + 1)$.

20. From the above description, it will be understood that even if $(N + 1) > LFN > N$, the difference $(Af - K0)$ is proportionally allotted by $(N + 1 - LFN)$ and $(LFN - N)$ in the equations (4) and (5) respectively to reduce errors in calculations of $GK(N)$ and $GK(N + 1)$.

25. Thereafter, the leaning routine 93 proceeds to step

- 93g. When the computer 60 determines an "Yes" answer at step 93e, the learning routine 93 proceeds to step 93g. After execution of the learning routine 93, the main control program proceeds to the routine 88 where the
5. computer 60 calculates an optimum rotary step number S_o in consideration with the learning values $GK(N)$ and $GK(N + 1)$ obtained at the routine 93 thereby to adjust the actual air-fuel ratio of the mixture to an optimum air-fuel ratio.
10. From the above description, it will be understood that when the value LFT changes in accordance with an axial displacement of piston 24 caused by various engine loads, the learning values $GK(0) - GK(7)$ are selectively learned on a basis of $LFT/\Delta L$ to
15. determine an optimum rotary step number S_o . This means that even if the annular cross-sectional area between the fuel metering jet 29e and the needle valve element 27a increases irregularly due to defacement of the needle valve element 27a caused by frictional engagement
20. with the fuel metering jet 29e, the learning value $GK(N)$ corresponding to the defaced portion of valve element 27a will be learned in relation to changes of the feedback correction value A_f so that an optimum rotary
25. step number S_o can be determined to adjust the air-fuel ratio of the mixture to an optimum value. It will be also understood that the above-described advantage is

- realized even if the annular cross-sectional area between the fuel metering jet 29e and the valve element 27a changes due to sudden change in the axial displacement of piston 24. Furthermore, since the first
5. to eighth stroke widths are determined equal to each other, alternative selection of the learning values $GK(0) - GK(7)$ may be easily effected, and learning in computer 60 may be precisely effected in relation to the characteristic curve l_1 of Fig. 14.
10. When the ignition switch IG is opened to stop the engine 10 during arrest of the vehicle, the computer 60 is maintained in its activated condition by power supply across the switch 72 to execute the second interruption control program shown in Fig. 13. In this
15. instance, the computer 60 starts execution of the second interruption control program at step 110. At the following step 111, the computer 60 adds complement of $GK(0)$ to the renewed learning value $GK(0)$ to memorize the resultant value of the addition as a state value F.
20. At step 112, the computer 60 produces a rotation signal for rotating the stepper motor 30a toward the initial position. Thus, the stepper motor 30a is activated by the rotation signal from computer 60 to displace the needle valve element 36 to the initial position. When
25. the second interruption control program proceeds to step 113, the computer 60 puts out the energization signal to

- deenergize the electromagnetic coil 71 so as to open the switch 72. Finally, the computer 60 stops execution of the control programs at step 114. In such a condition, the back-up RAM of microcomputer 60 is maintained in its
5. activated condition by power supply from the back-up source 60a to memorize therein the renewed learning values GK(0) - GK(7) and the state value F. In the carburetor 20, the auxiliary throttle piston 24 is returned to its minimum stroke end under the biasing
10. force of compression spring 26.

- While in the above embodiment one of the learning values GK(0) - GK(7) is selected in accordance with the value of stroke length LFT, it may be also selected in accordance with an amount Q of air flow
15. corresponding to the stroke length LFT.

CLAIMS:

1. An electric air bleed control system for a carburetor, for an internal combustion engine, of the type comprising a carburetor body formed therein with an
5. induction passage for connection to the engine, a main throttle valve disposed in said induction passage for controlling the flow of an fuel-air mixture to the engine, an auxiliary throttle piston located upstream of said main throttle valve and axially displaceably
10. mounted on said carburetor body to form a variable venturi, a pneumatic actuator mounted on said carburetor body to be activated by a vacuum depending on the flow of air in said induction passage for effecting axial displacement of the throttle piston, a fuel passage
15. formed in said carburetor body to permit therethrough the flow of fuel from a fuel reservoir into a mixing chamber between said throttle piston and said throttle valve and being provided therein with a fuel metering jet, a needle valve element integral with said throttle
20. piston for controlling the cross-sectional area of said fuel metering jet, an air bleed passage formed in said carburetor body to permit the flow of air into said fuel passage substantially at the atmospheric pressure, and an electrically operated valve mechanism mounted on said
25. carburetor body for controlling the amount of air flowing into said fuel passage through said air bleed passage,

- 32 -

the electric air bleed control system
comprising:

- first detecting means for producing a first
signal indicative of axial displacement of said needle
5. valve element;
- second detecting means for producing a second
signal indicative of oxygen concentration in exhaust
gases discharged from the engine;
- means responsive to said first signal for
10. determining one of plural learning regions in accordance
with the axial displacement of said needle valve
element, said plural learning regions corresponding with
a plurality of subdivided displacement regions of said
needle valve element;
15. learning means responsive to said second signal
for learning an instantaneous air-fuel ratio of the
mixture in relation to the oxygen concentration in the
exhaust gases at the determined learning region;
- means for determining an optimum amount of air
20. based on a resultant of the learning for supply of an
optimum amount of fuel into said mixing chamber through
said fuel passage; and
- means for producing an output signal indicative
of the optimum amount of air and applying it to said
25. electrically operated valve mechanism.

2. An electric air bleed control system as
claimed in Claim 1, wherein said first detecting means

- comprises means for detecting a rotational speed of the engine, means for detecting a negative pressure in said induction passage, means for calculating an amount of air flowing into said induction passage based on the
5. detected rotational speed and negative pressure, and means for calculating an amount of axial displacement of said needle valve element based on the calculated amount of air.

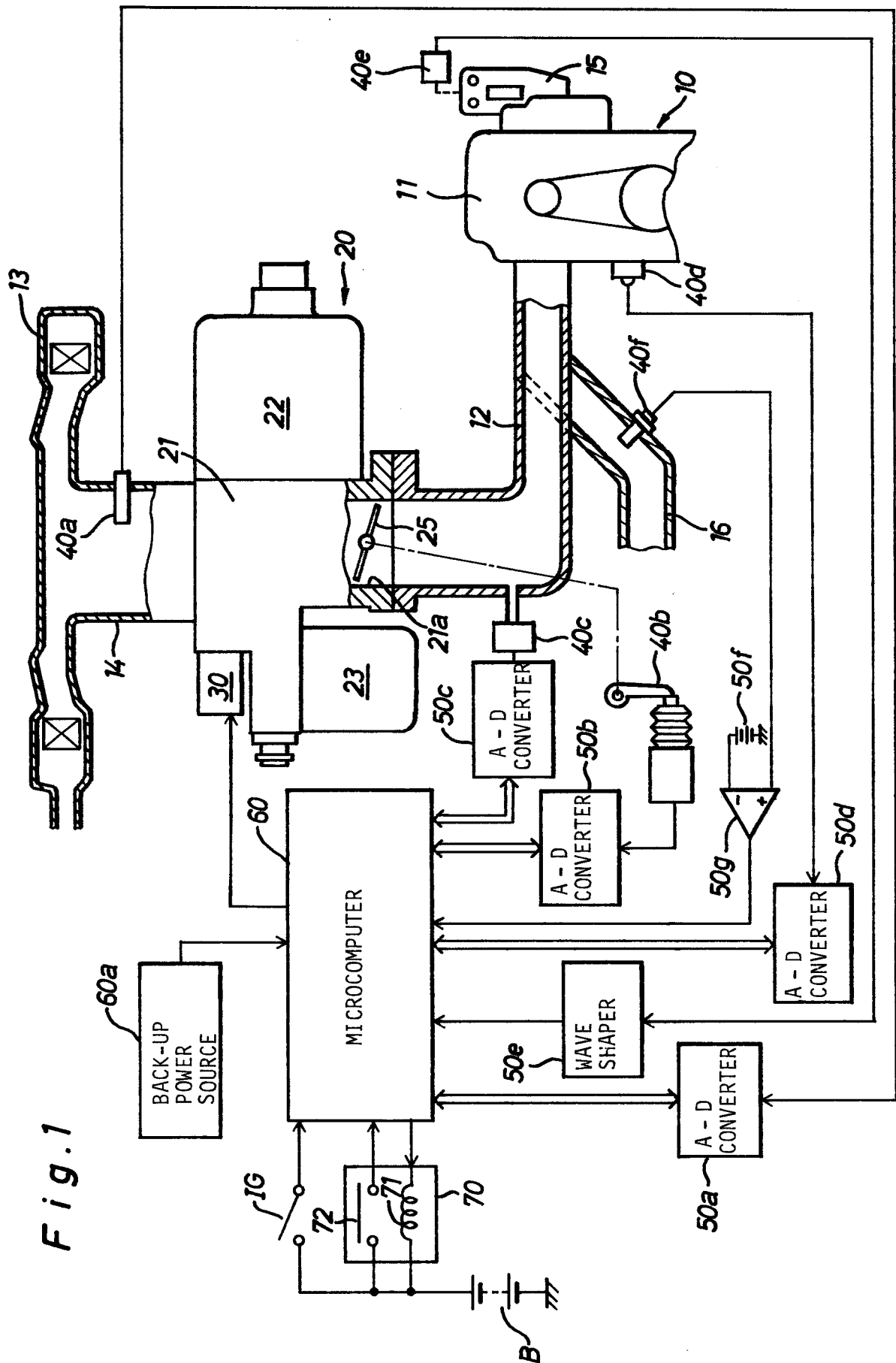


Fig. 2

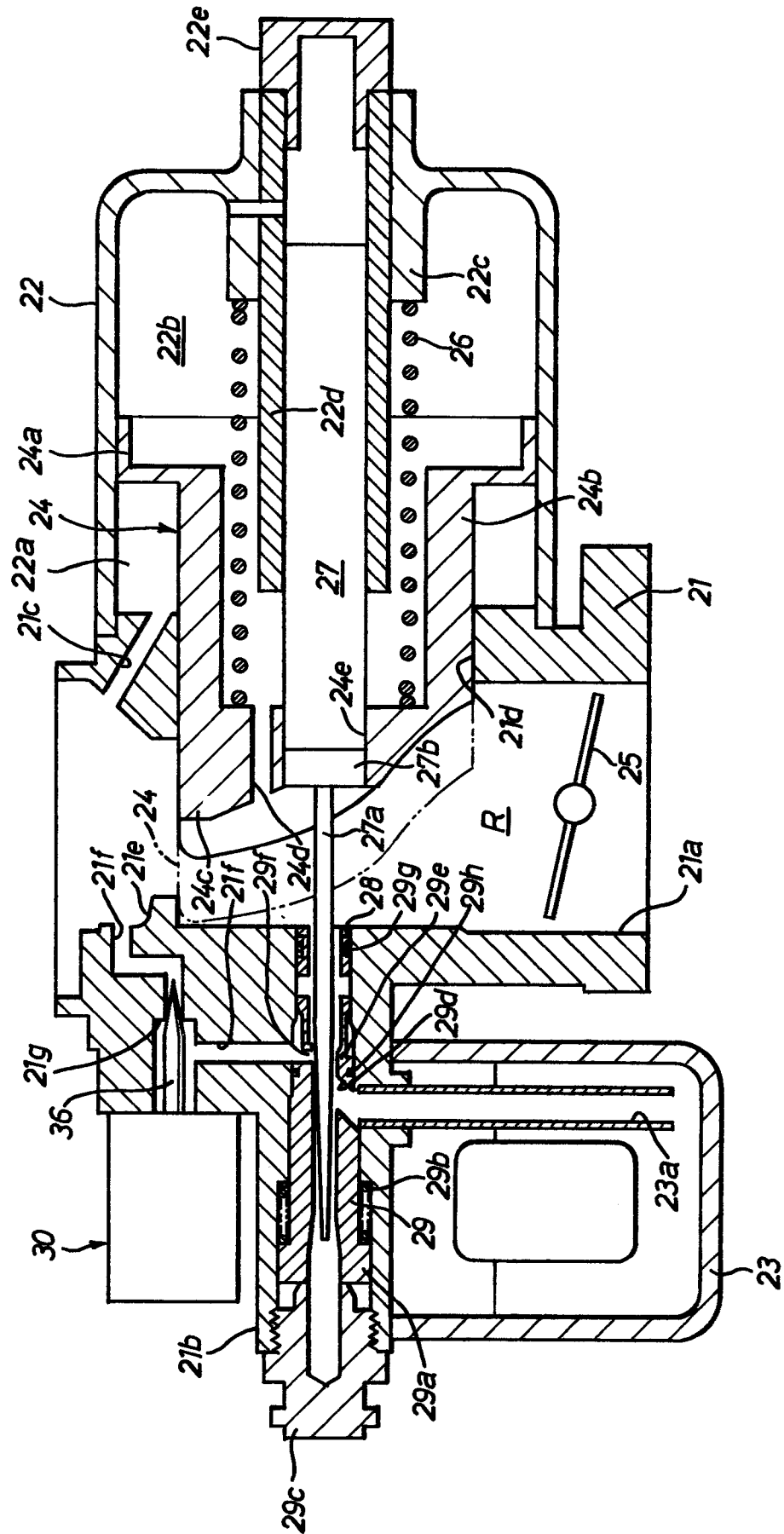


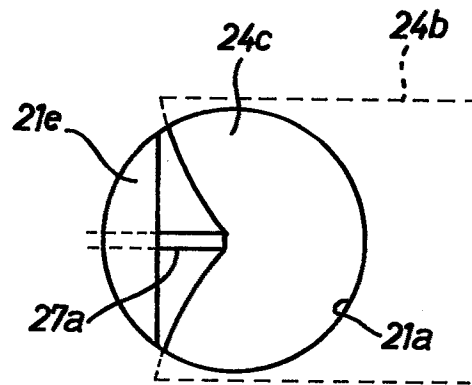
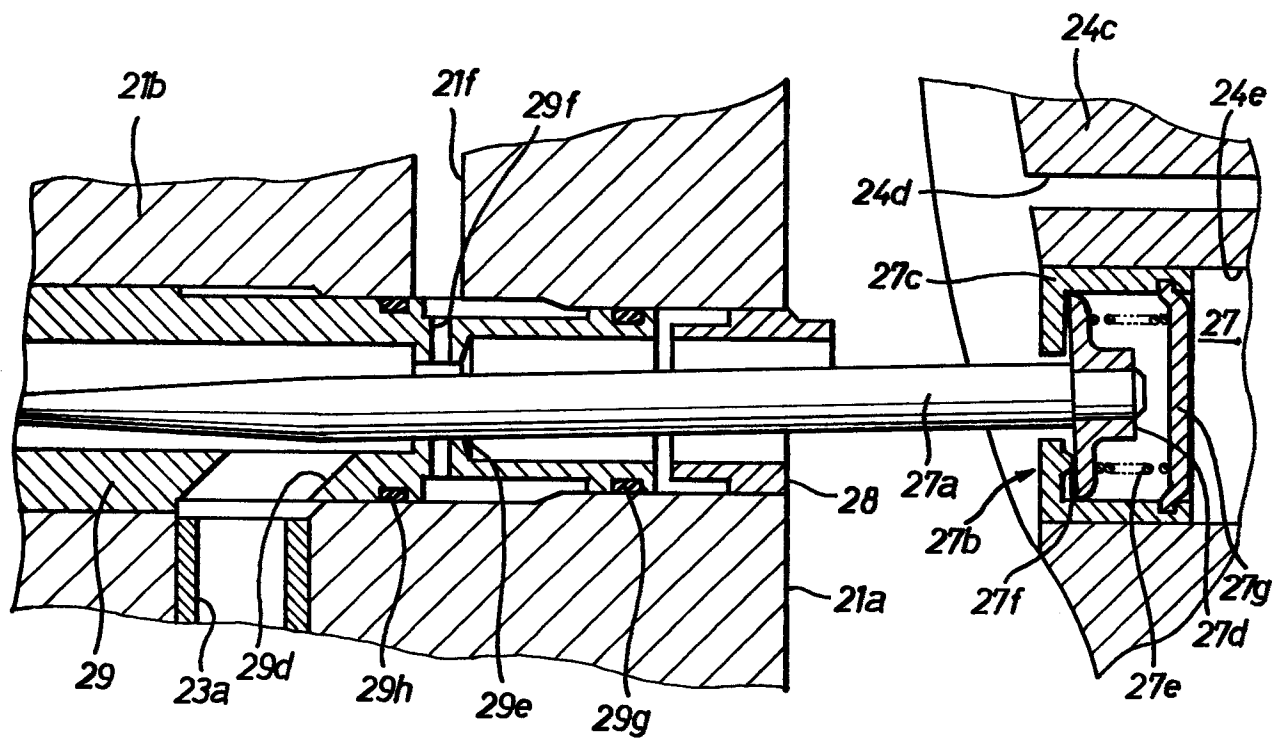
Fig. 3*Fig. 4*

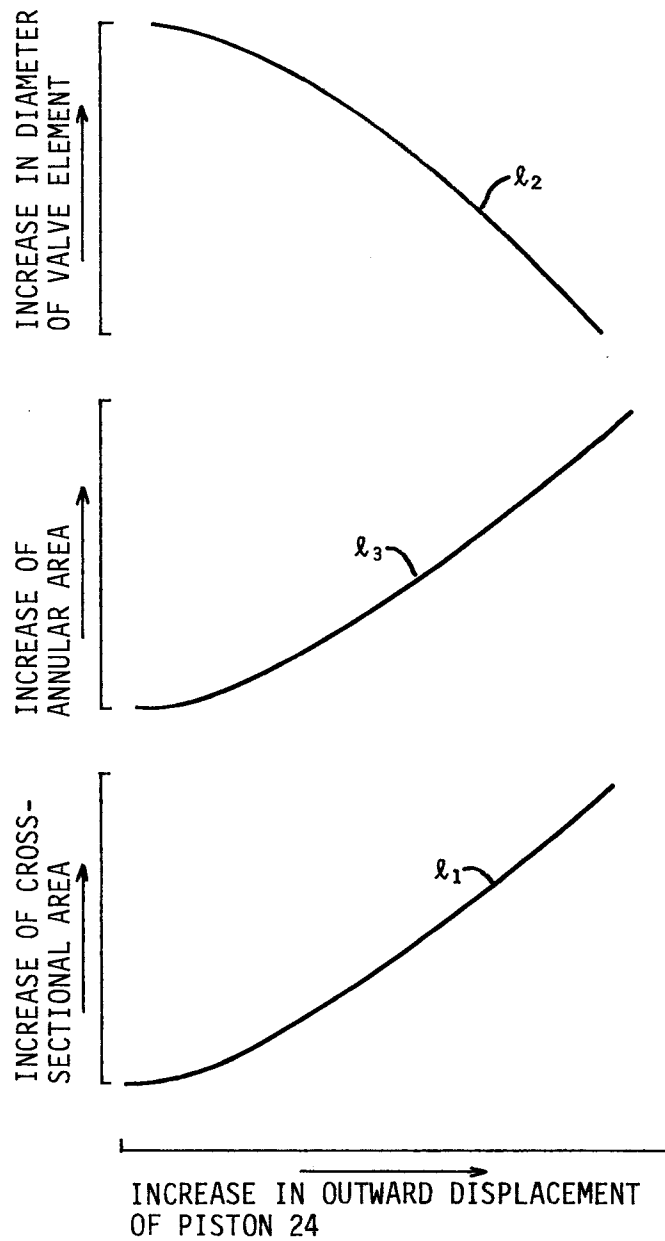
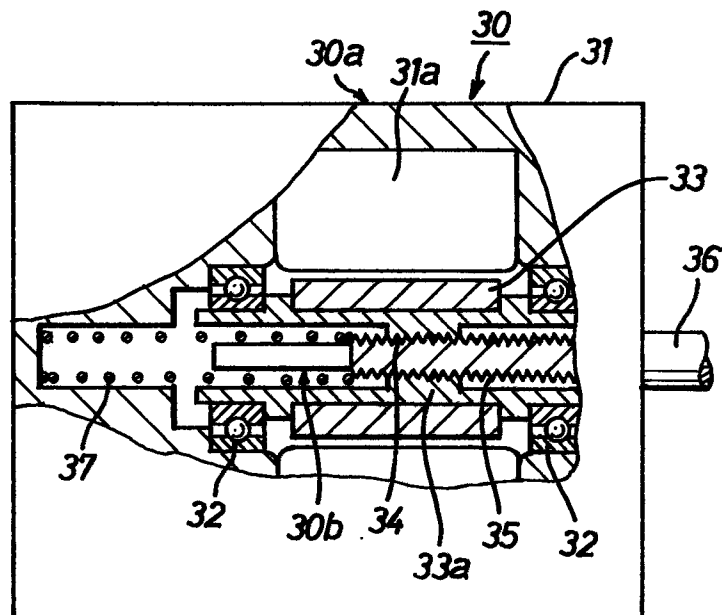
Fig. 5*Fig. 6*

Fig. 7

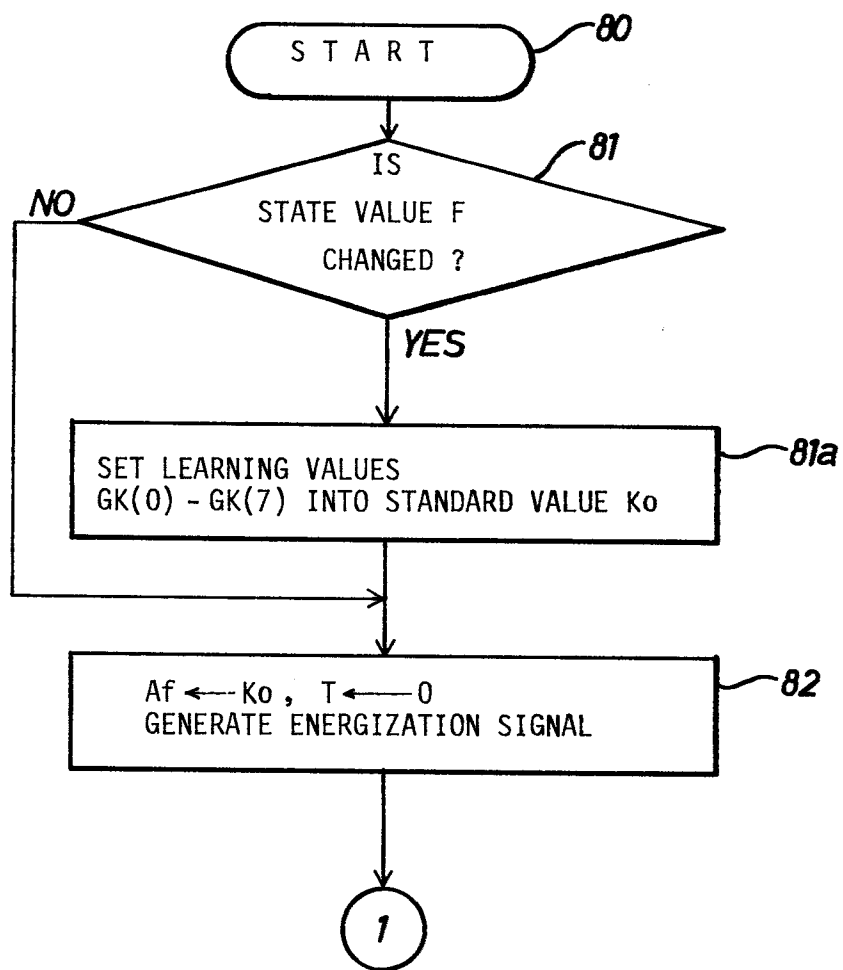


Fig. 8

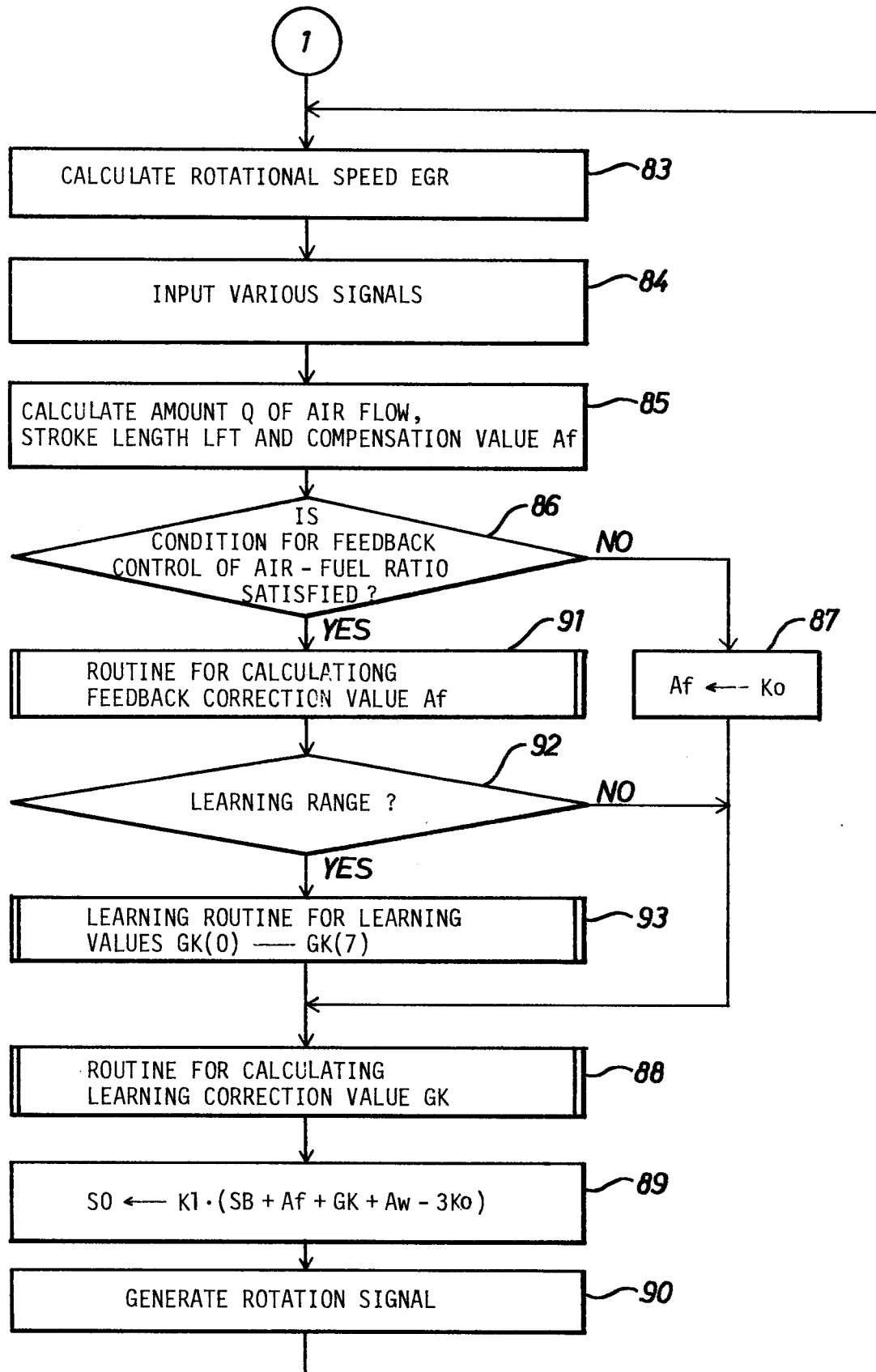


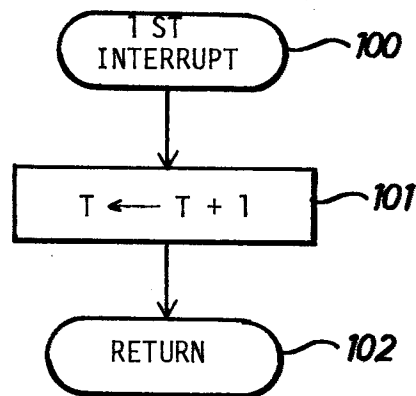
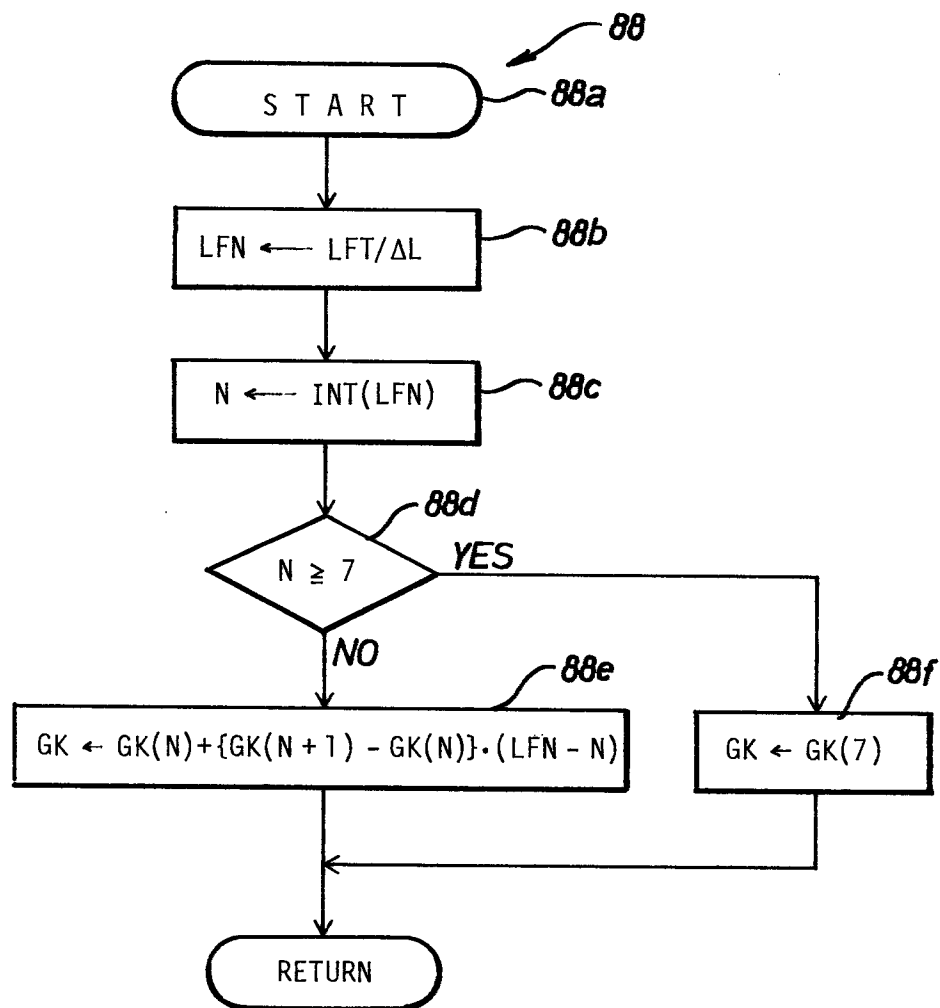
Fig. 9*Fig. 10*

Fig. 11

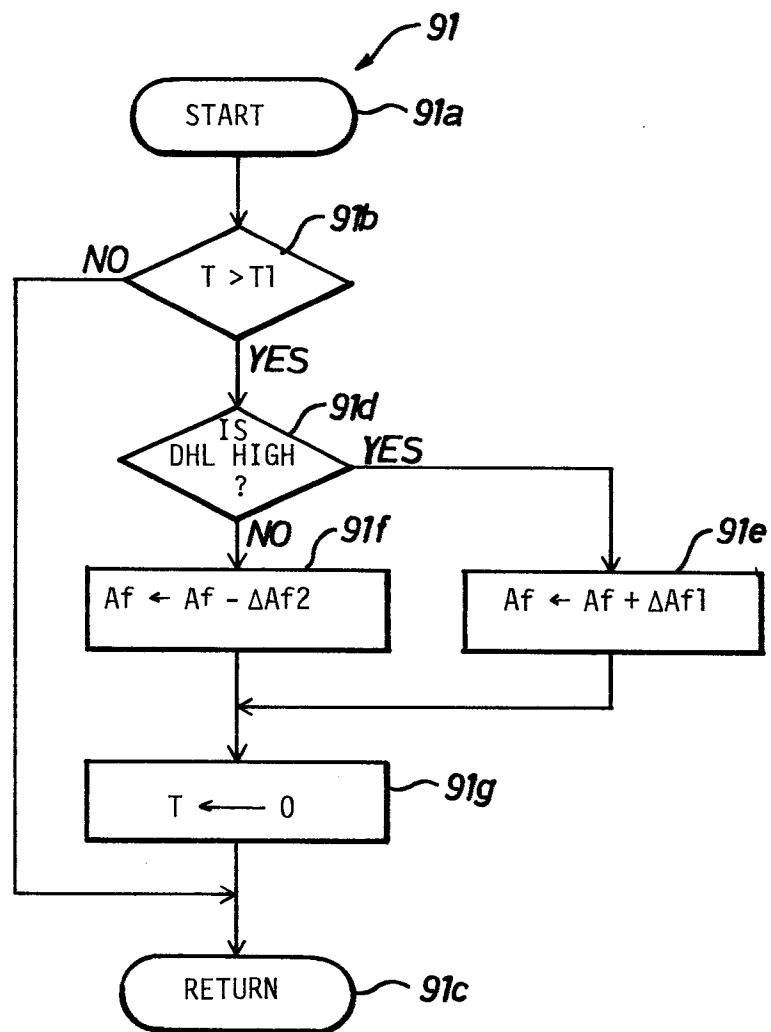


Fig. 12

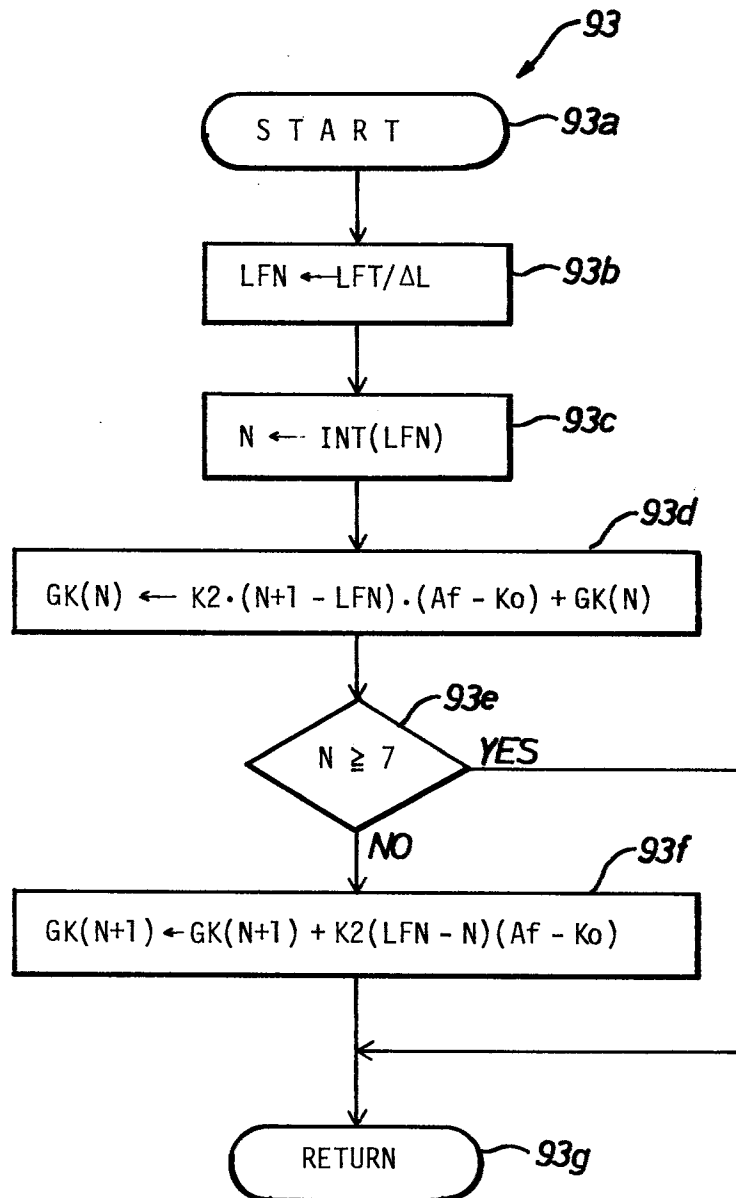
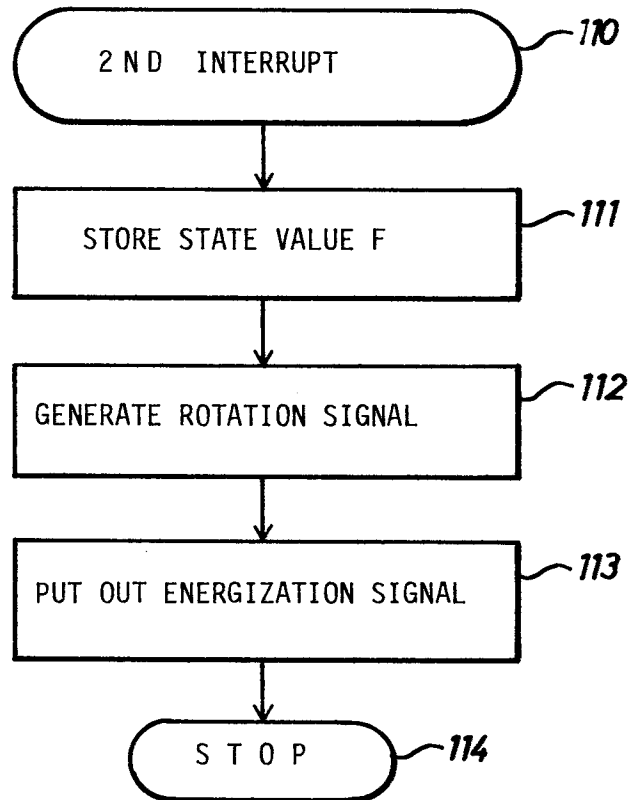


Fig. 13**Fig. 14**