

INSTRUCTION
BOOK

16

NS-732
AUTOMATIC INDICATING
CONTROLLER



NAKAKITA SEISAKUSHO CO., LTD.

Head Office : Factory : 1-1 Fukonominami-machi, Daito-shi, Osaka 574-8691, JAPAN.
Telephone: +81-72-871-1341
 +81-72-871-7871
Facsimile : +81-72-874-7501

MODEL NS732 AUTOMATIC INDICATING CONTROLLER

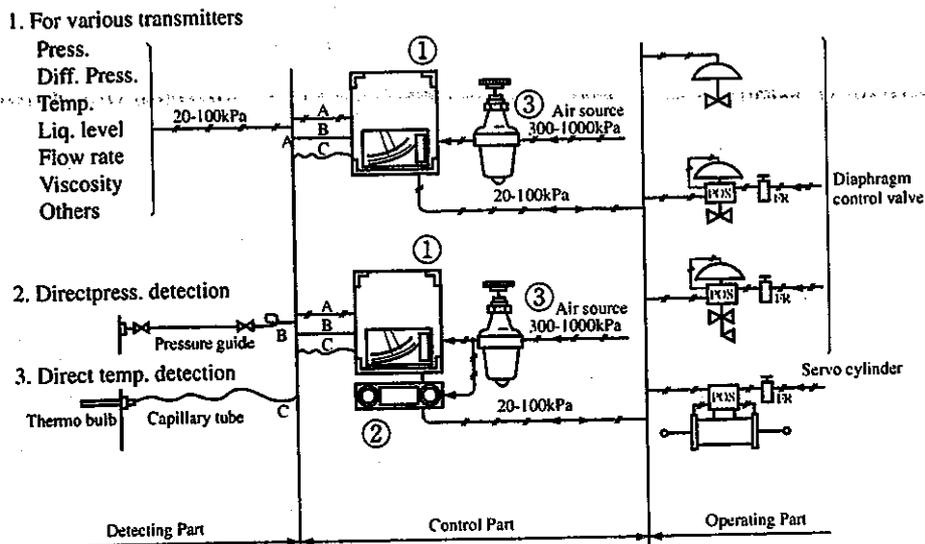
Contents

1. Outline	C- 2
2. Construction and specification	C- 3
3. Performance	C- 3
4. Installation	C- 6
5. Air supply and connection	C- 7
6. Preparation for operation	C- 8
7. Adjustment for operation	C-10
8. Maintenance	C-11
9. Troubles, investigation of causes and counter-measures ...	C-13
10. Correction of measuring link	C-14
11. Adjustment of controller	C-15
12. Order of disassembly	C-17

1. Outline

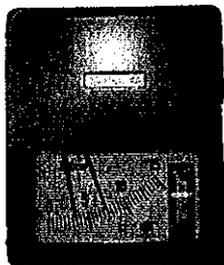
This controller can be applied to all possible fields of process control such as pressure, differential pressure, temperature, liquid level, flow rate, viscosity etc. When used in combination with diaphragm control valves at the operating end. It is a pneumatic controller which can automatically regulate various process conditions at the optimum level.

It is constructed compactly and weights light, incorporating least possible number of parts. Its control, handling and maintenance is therefore simple and yet it has considerable durability. It is an instrument most suitable not only for fixing on graphic panel but also for local control, having usage in versatile fields.



- ① Model NS732 Indicating controller
- ② Model NS743 Auto/man. selector (Manual Loader)
- ③ Model NS770C Filter regulator

For various transmitters and direct pressure detection



Model NS P 732

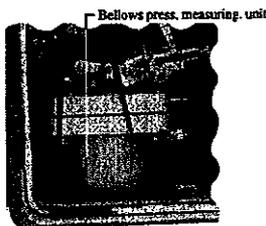
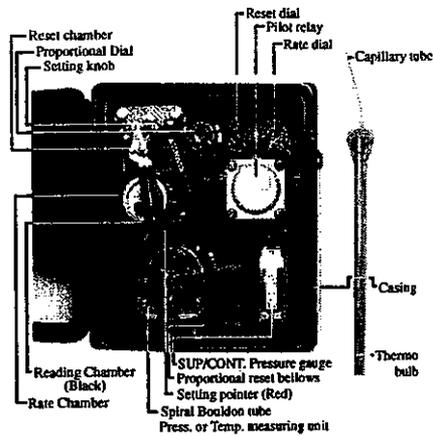
For direct temperature detection



Model NS TM 732

2. Construction and specification

1. Construction



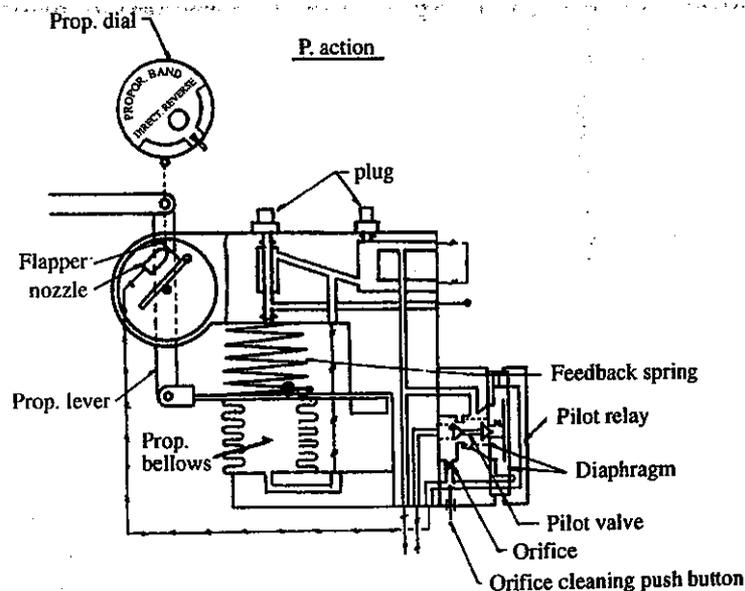
2. Specifications

- 1) Control air pressure(output) :20-100kPa
- 2) Supply air press :140kPa
- 3) Control operation
 Proportional band : 10 - 250%
 Reset time : 20 - 0.1 Min.(std.)
 Rate time : 10 - 0.05 Min.
- 4) Both direct and reverse action are available
- 5) Accuracy : Within 1% of full scale
- 6) Method of fixing : Panel mount or wall mount Type.
- 7) Casing : Drip-proof and dust-proof type
- 8) Mass : ca. 5kg. (When detecting element is thermo bulb, ca. 6kg.)
- 9) Air consumption : Normal : 1Nℓ/min.
 Maximum : 30Nℓ/min.
- 10) Connection for control and supply air : Rc 1/4
- 11) Pressure measuring connection : Rc 1/4

3. Performance

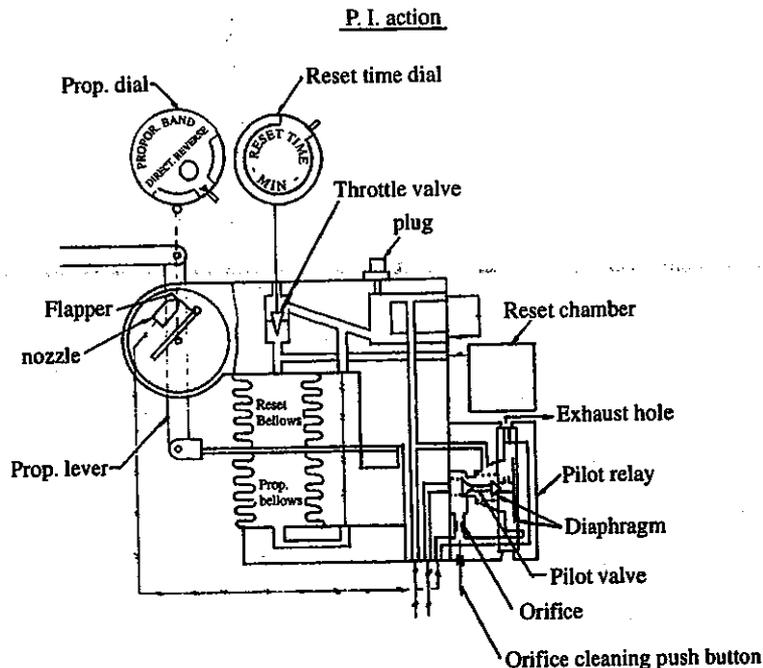
1. P. action

When measured value becomes higher than the set value (deviation), the upper end of proportional lever shifts to the right. Thus the flapper approaches to the nozzle and the back pressure of nozzle i.e., the pressure charged upon pilot relay, increases. Consequently valve in pilot relay opens and supply pressure flows into control side to increase the pressure. At the same time, this pressure in charged



upon proportional bellows and lifts up proportional lever and thus flapper is detached from the nozzle and control pressure is set in proportion to such deflection. All of the aforesaid actions occur simultaneously in the actual operation. When both pointers overlap (deviation "0") control pressure becomes 60kPa (20-100kPa).

2. P. I. action



Assuming that the controller is acting properly and measured value and set value are in equilibrium, (that is, the deviation is "0"), and the same pressure as control pressure is sealed in the proportional bellows and reset bellows. If measured value becomes too high as in the above case, P. action immediately takes place and control pressure increases. Thus control pressure flows into the reset bellows through reset throttle valve.

As the pressure inside reset bellows increases, proportional lever comes down and flapper approaches to the nozzle and back pressure increases. Consequently pilot relay valve in opens to increase the control pressure and the increasing pressure inside proportional bellows lifts up the proportional lever and causes the flapper to detach from the nozzle again. This resetting effect continues until control pressure increases to such extent that the control valve opening enables the reversion of measured value to the set value (that is, until deviation becomes zero). Pressure of proportional bellows and reset bellows thus balances and the original balance condition is established.

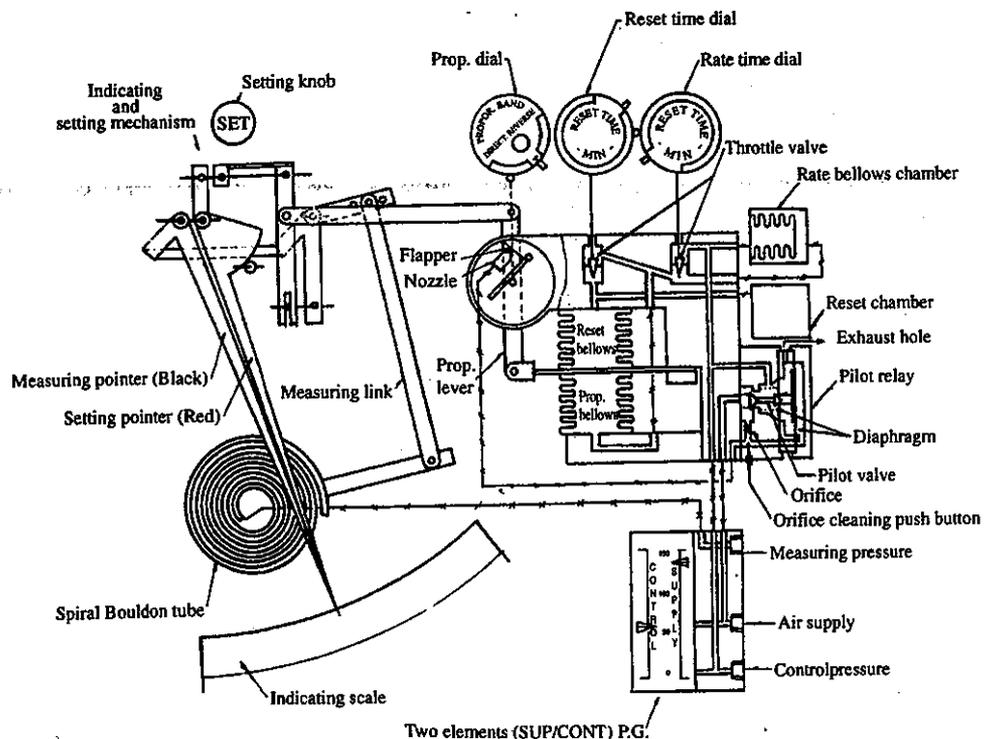
3. P. I. D. action

Rate throttle valve and rate bellows chamber are connected in parallel between the pilot relay and proportional bellows. In the aforesaid P. and P. I. action, the inside pressure of proportional bellows is in proportion to the amount of deviation. Therefore, when the measured value changes, control pressure flows in or out with the speed corresponding to such changes, so that the pressure inside the proportional bellows will synchronize with the change of measured value. Since the pressure reduction taking place as it passes through the rate throttle valve is in proportion to the speed of fluctuation of measured value, pilot relay output i.e., control pressure also becomes larger or smaller than the internal pressure of proportional bellows to the extent of the differential pressure at the rate throttle valve.

Rate bellows chamber is provided to transmit control pressure to the proportional bellows utilizing the volume change of rate bellows caused by its elasticity and to give stability the system.

Therefore, when rate action is utilized, control valve opening can be adjusted more quickly and it certainly gives convenience especially to the process where time lag is great.

P. I. D. action



4. Installation

1. Controller

⚠ CAUTION Please install it at the place where it is least affected by temperature, humidity, dust and vibration. When it is installed at the place where vibration is unavoidable such as in a ship, vibration should be within such tolerance that the total amplitude of measuring pointer and two elements (sup/cont) pressure gauge pointer are within 1 graduation of the scale.

2. Pressure leakage of air piping and joints

⚠ CAUTION When there is leakage at the connecting joints of the piping, perfect regulation is not possible. Therefore after completion of piping, conduct complete leakage test.

Especially make strict checking of the joint between controller and control valve.

3. Measuring unit

⚠ CAUTION The temperature of detecting fluid comes to this measuring unit should not exceed 80°C.

In the case of steam, provide a siphon tube in order to lead the cooled drain to the controller. When pressure pulsates, provide noise damper or noise damper and when detecting piping vibrates, provide flexible tube in the detecting pipe.

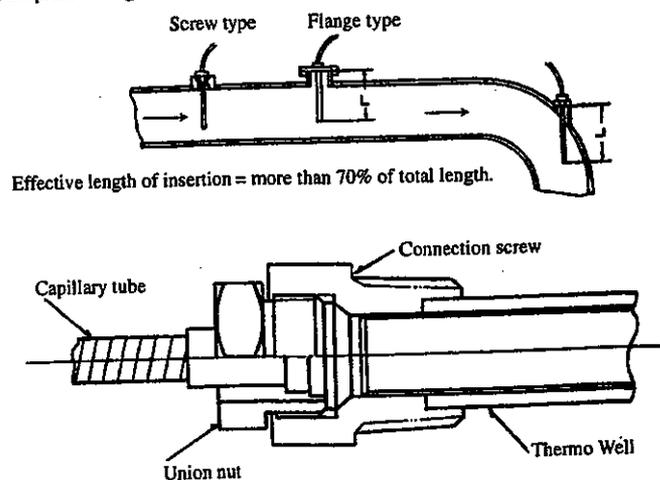
4. Temperature measuring unit (Thermo Element)

⚠ CAUTION 1) Do not install the thermo bulb in the pipe line of which has high speed of fluid.

If the flow is too fast, it gives undue stress on the mechanical strength of the measuring part. Therefore ordinary flow rate is appropriate. Effective length of insertion must be more than 70%.

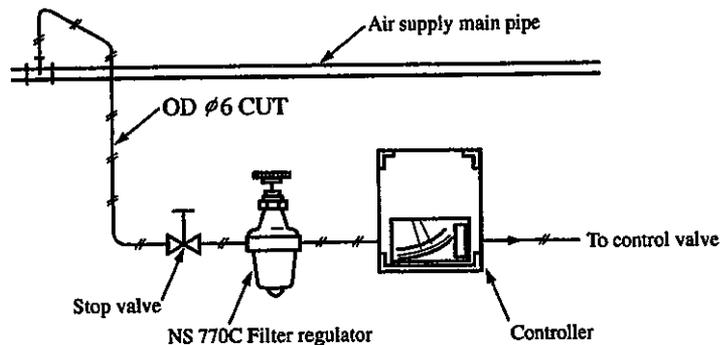
And be sure to pour attached the heat conductive liquid into the gap between the thermo-well and the thermo-bulb.

Method of fixing temp. measuring unit



⚠ CAUTION 2) To be care not to twist or pull capillary tube or hit it against hard object when it is installed. To turn the connecting screw, loosen the union nut first. Do not twist the capillary tube when connecting screw is turned. Install capillary tube at a safe place so that it does not get damaged. Moreover, capillary tube should be installed firmly without any needless trembles.

5. Air supply and connection



1. Supply air source

Pressure of supply air should be 300-1000kPa and air should be free from scales and oiliness. In any season or at any time of the day there should be no drain in the pipe. For piping, use white gas pipe or copper pipe. Stop valve must be bronze stop valve. Install supply air main pipe as close as possible to the controller. Before connecting it to the controller, pass air of about 200kPa through pipe to remove scale and drain.

2. Signal control circuit

O.D. $\phi 6 \times 1$ copper pipe is usually used. When corrosion resistance and seamless pipe are required, vinyl or polyethylene or nylon tube are applied. But since these plastic tubes lack heat resistance and mechanical strength, provide appropriate protection.

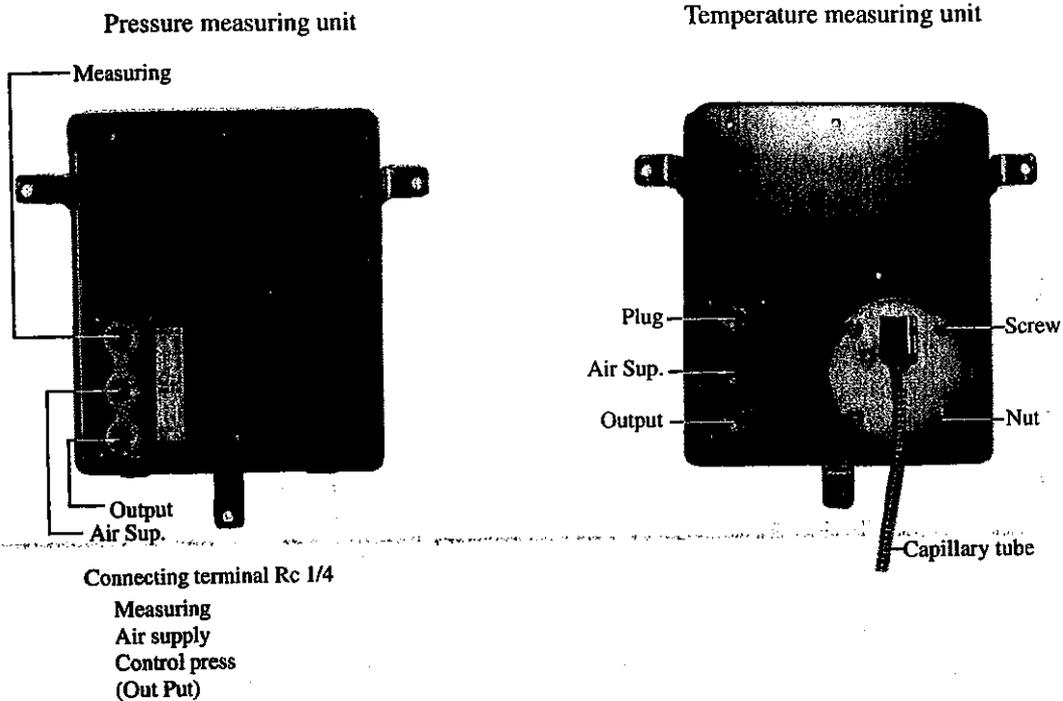
Piping should be install for the shortest distance in principle.

Use long pipe and minimize joints so that maintenance and inspection are easy.

Leakage will affect accuracy of control. Therefore prevent leakage by all means.

Leakage test is conducted by setting filter regulator at 100kPa and pressurize the entire circuit and check each connection with soap water.

3. Connection of controller (Back side)



6. Preparation for operation

Check again if the adjusting devices are properly installed according to the plan. Also check if they function properly. To change it into automatic control from manual control, be care not to disturb the process.

1. Steps for change over from "Manual" to "Auto"

- 1) Fully close front and rear stop valves of the control valve and by-pass valve.
- 2) Send supply air to the controller.
- 3) Gradually open the by-pass valve and while watching the movement of pointer of the controller, bring the measuring pointer closer to the setting point.
- 4) Fully open a rear stop valve of the control valve.
- 5) While watching the action of control valve, gradually open the front valve and simultaneously close the by-pass valve. If valve opening is changed too radically, balance of the process is disturbed and it can not be stabilized.

2. NS743 Auto/Manual selector

Auto/Manual selector is attached below the NS 732 indicating controller. It is used for the manual control at the start of the operation or for checking of controller or for repairing.

It can be adjusted manually without stopping the operation of the control valve.

- 1) Control of change-over cock (Auto-Manual Selector)

AUTO (Automatic control)

Control pressure coming from controller is charged upon the control valve through the change-over cock. It is adjusted automatically.

MANUAL (Manual control)

Control pressure which was set by the filter regulator at an optional position will remote-control the opening of control valve through this change-over cock. In the actual operation, adjust the regulator while watching the measuring pointer of the controller so that the objective value can be maintained.

2) Control valve becomes fully open to fully close in accordance with the movement of SUP/CONT pressure for the span of 20 to 100kPa and 50% opening is obtained at the indication of 60kPa.

3) Control of AUTO and MANUAL

Transition from manual control to automatic control.

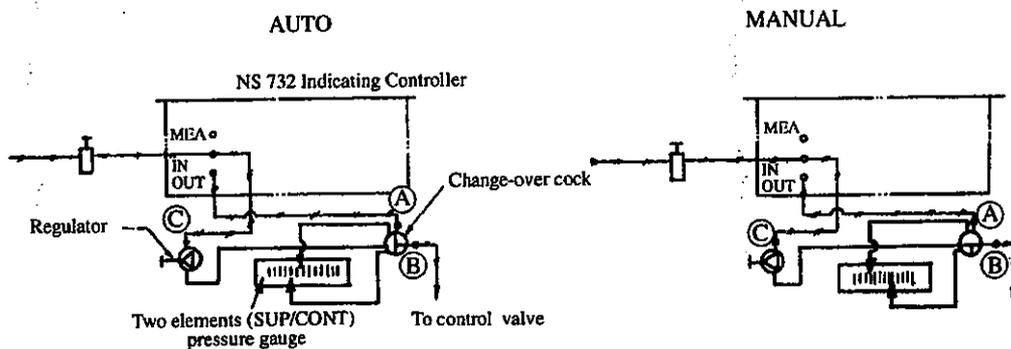
A. The pointer of AUTO of two elements (SUP/CONT) pressure gauge starts to move when the measuring pointer of the controller is made to overlaps the setting pointer by manual control.

B. Then gradually it shifts in the same direction as AUTO pointer and at the instance when the latter matches with the MANUAL pointer set the change over cock to AUTO.

Transition from automatic control to manual control.

Match the MANUAL pointer with AUTO pointer of two elements (SUP/CONT) pressure gauge by operating the regulator for manual control and then set the changeover cock to MANUAL.

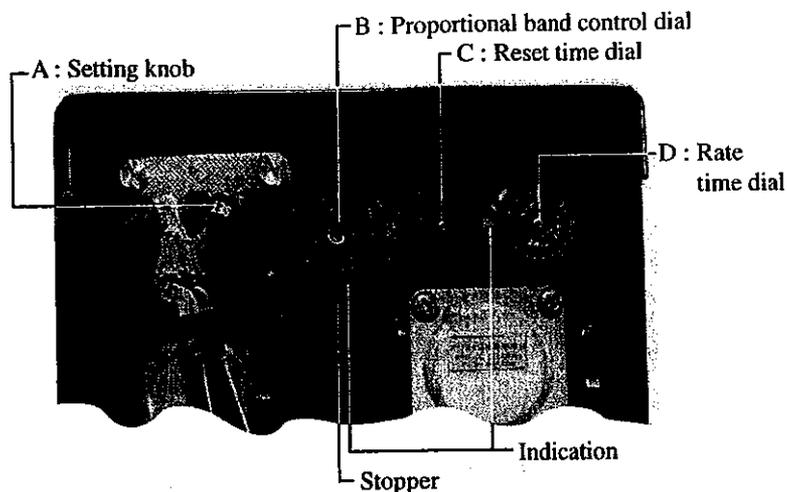
Note : Before changing over from MANUAL to AUTO or from AUTO to MANUAL, be sure to control the change-over cock so that the pointers of AUTO and MANUAL of two elements (SUP/CONT) pressure gauge will overlap. If this is not done beforehand the operating of the pointer may cause temporary disturbance of the process.



connecting thread Rc 1/4
A form control pressure of controller
B to control valve
C Supply air

7. Adjustment for operation

1. How to adjustment



Remarks: In case no rate function is provided, apply the plug at the rate time dial.

A. Setting knob

Set the setting pointer (red) to the desired graduation on the scale by setting knob.

B. Proportional band control dial

The smaller the value on the dial (i.e., Proportional band becomes narrower), it becomes sensitive. But if it becomes too sharp, hunting occurs. When the value on the dial becomes too dull, deviation of measured value from the set value, in the case of load change, becomes excessive.

C. Reset time dial

When reset time is shortened, the time required for balance point is shortened. But when it becomes too short, stability is lost and it apt to cause hunting. When reset time is made too long, it consumes too long time before balance is established at the set value.

D. Rate time dial (This dial is not given in the case of proportional + integral action)

It is used for the process which involves much time lag (delay). When rate time is made too long (to much lead) it causes hunting. Whereas if it is too short, satisfactory effect is not obtained.

E. Change over of direct-reverse action

Direction of operation of control valve is determined by the nature of the process. It is determined by whether the control valve is a direct operation or a reverse. For example, in the case of the above photograph, it acts in Reverse. To change the set up into Direct action (i.e., the action where increase of input causes increase of output), turn the proportional dial to the right for $3/4$ turns.

2. Adjustment

The optimum adjustment of controller can be obtained by the following steps.

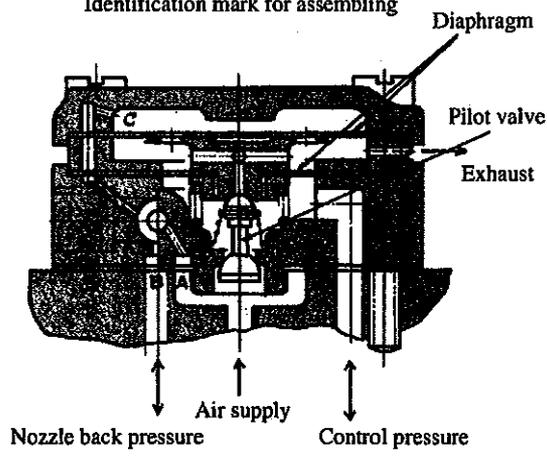
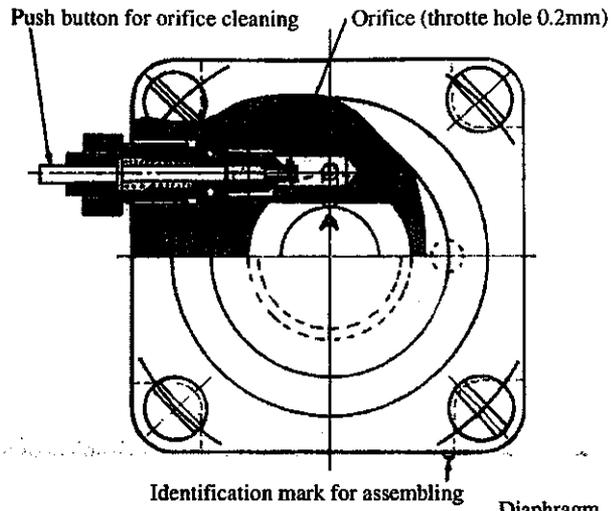
- 1) Set the reset time dial at max. (20 min.) and when there is a rate time dial, set it at minimum value (0.05min.).
- 2) Starting from 250%, gradually reduce the proportional dial from 250% to 10%, while checking the result of adjustment. It causes hunting when it comes to a certain proportional zone. The optimum value is at 2 - 4 times of such proportional zone.
- 3) Gradually reduce the reset time by turning reset time dial. When it becomes less than the marginal value, it causes hunting.
So reverse it slightly from such point and then fix it.
- 4) Fix the rate time dial at about 1/4 of the ultimate reset time or about 1/2 of the time delay of the process and control device. In this case, proportional zone can be made slightly smaller.

8. Maintenance

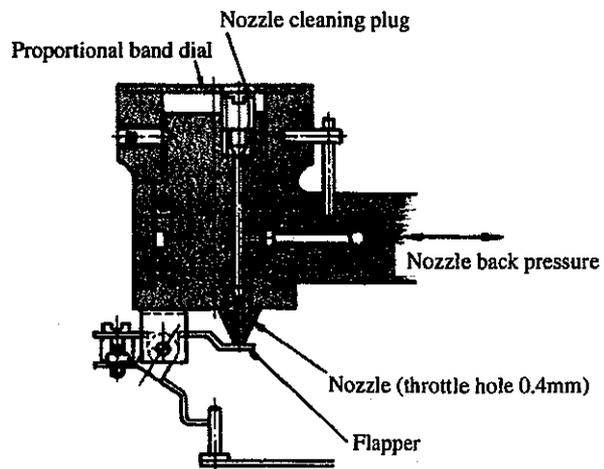
 CAUTION When the controller is installed properly, perform the following maintenance periodically according to a preset program.

1. Remove drain deposited in the air supply tube by loosening the drain plug the bottom of filter regulator.
2. Be care to maintain the supply air pressure always at 140kPa. When the performance of filter regulator is unstable, repair or replace it.
3. According to the conditions of supply air, inspect the orifice holes of nozzle or pilot relay.
 - 1) In case when orifice is clogged. Press the orifice cleaning push button to clean it. When it is necessary to take out orifice out of pilot relay, disassemble it according to the following procedures.
 - a. Stop air supply to the controller.
 - b. Carefully remove the entire orifice at the left end of the pilot relay by a spanner.
 - c. After taking off the orifice, clean the surface with thinner etc. if oil or grease is sticking to it. Dry thus disassembled orifice and then reassemble it.
 - 2) When the nozzle is clogged, disassemble and clean according to the following procedures.
 - a. Same as 1) a. above.
 - b. Carefully disassemble nozzle cleaning plug of proportional dial by a driver.
 - c. Clean the nozzle with a wire having thickness of less than 0.4mm.
 - d. Clean dusts etc. deposited on the flapper surface (to which the nozzle is contacting).

Details of Pilot Relay



Details of Nozzle and Flapper



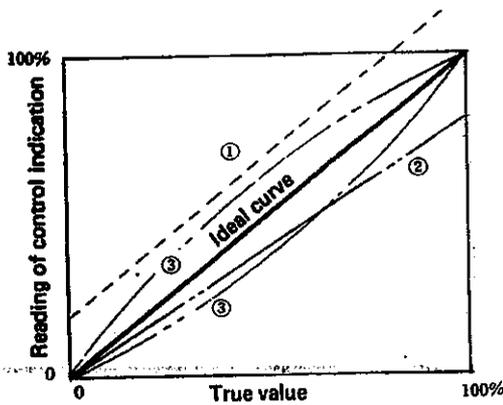
9. Troubles, investigation of causes and counter-measures

Troubles	Causes	Counter-measures
<p>[CONTROLLER]</p> <p>Output air pressure of controller does not increase or decrease inspite of the change of detection input.</p>	<p>When it does not increase.</p> <p>(1) Supply air pressure is abnormal.</p> <p>(2) Orifice of pilot relay is clogged.</p> <p>(3) Leakage at the air piping at output side (due to cracking), or leakage at soldered joint or damage of diaphragm of control valve.</p> <p>(4) Inferior connection (or disconnection) of link systems inside the controller.</p> <p>(5) Leakage of various pipings (tubes) inside the controller.</p> <p>(6) Damage of element at measuring part.</p>	<p>(1) Adjust it into normal conditions.</p> <p>(2) Press the cleaning push button.</p> <p>(3) Adjust it into normal conditions.</p> <p>(4) Adjust it into normal conditions.</p> <p>(5) Replace the tube.</p> <p>(6) Replace element.</p>
	<p>When it does not decrease.</p> <p>(1) Nozzle at the flapper is clogged.</p> <p>(2) Clogging of piping from pilot relay to piping from down of tube).</p> <p>(3) Loosening of pilot relay orifice.</p> <p>(4) Inferior connection (or disconnection) of link mechanism inside the controller.</p> <p>(5) Leakage at various pipings (or tubes) inside the controller.</p>	<p>(1) Clean it with a wire of less than 0.4mm.</p> <p>(2) Adjust it into normal conditions.</p> <p>(3) Retighten it.</p> <p>(4) Adjust it into normal conditions.</p> <p>(5) Replace the tube.</p>
<p>[CONTROL VALVE]</p> <p>Control valve life does not change due to the increase or decrease of output pressure of controller.</p>	<p>Sticking of valve guide and valve stem.</p> <p>(1) When positioner is provided sticking of positioner pilot.</p> <p>(2) disconnection of diaphragm stem and positioner.</p>	<p>Inspection by disassembly. When weding scale or other foreign matters are caught into the parts, remove them and repair any possible damage.</p> <p>(1) Repair the damage caused by sticking using fine mesh grinding paper or file.</p> <p>(2) Adjust it into normal conditions.</p>
<p>[FILTER REGULATOR]</p> <p>Pressure does not increase even when setting knob is turned to increase pressure. Or pressure increase is abnormal or pressure does not go down.</p>	<p>When pressure does not increase.</p> <p>(1) Damage of diaphragm.</p> <p>(2) Damage of setting spring.</p> <p>(3) Sticking of pilot valve.</p> <p>(4) Leakage at air piping at secondary side.</p>	<p>(1) and (2) Replace the parts.</p> <p>(3) Repair the damage caused by sticking using fine mesh grinding paper or file.</p> <p>(4) Adjust it into normal conditions.</p>
	<p>When pressure does not come down.</p> <p>(1) Sticking of pilot valve.</p> <p>(2) Clogging of exhaust hole of the cover.</p>	<p>(1) Repair the damage caused by sticking using fine mesh grinding paper or file.</p> <p>(2) Clean it.</p>

10. Correction of measuring link

Measuring pointer is driven by the link connected to the measuring element. Before beginning correction, check if the moving parts of this unit move smoothly and lightly.

1. Three basic adjustment.



(1) Zero adjustment:

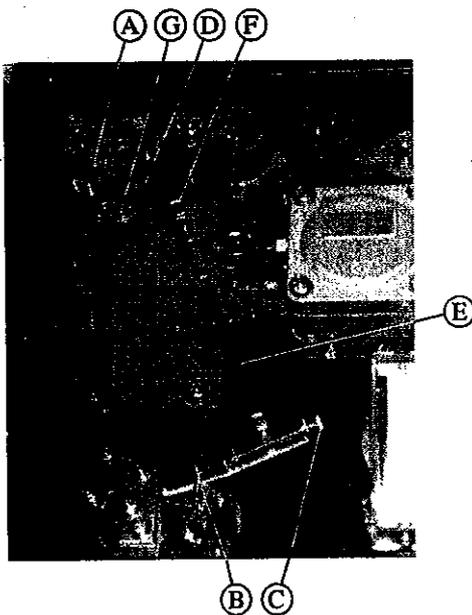
Shift the entire scale by the same band. It means that the point of origin is changed but inclination and shape of the curve do not change.

(2) Adjustment of amplification rate:

It changes the slope angle of the curve without changing the shape or point of origin of the curve.

(3) Angle adjustment:

Point of origin is unchanged but the shape of the curve is changed. That means the change of indication at both ends of the scale is made steeper or flat.



2. Actual correction

(1) Zero point adjustment

This is the most common adjustment which is performed by fine tuning screw (B) of measuring element.

(2) Adjustment of amplification ratio

Ratio of length of (C) and (D) levers is changed. In the actual practise, it is performed by the fine tuning screw on the (C) lever.

(3) Angle adjustment

The length of the link, (B) & (C) is adjusted by loosening the set screw (F), so that the (C), (D) levers and measuring link (E) make right angle at the median point of the full scale.

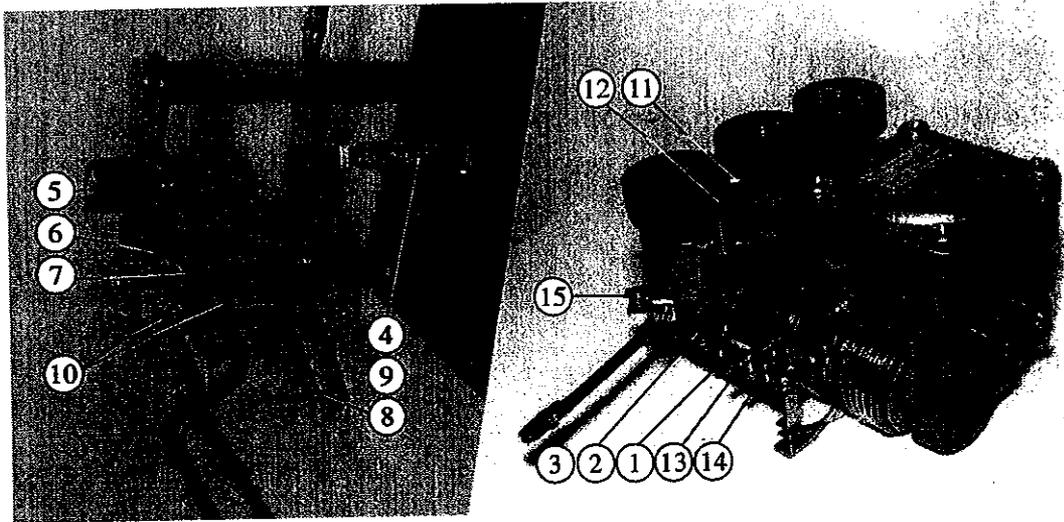
Procedures of correction

1. Conduct angle adjustment (3) by calculating the measured value corresponding to the median reading of the scale.
2. Conduct zero adjustment (1) by calculating the measured value corresponding to the minimum reading of scale.

3. Conduct amplification ratio adjustment (2) by calculating the measured the measured valve corresponding to the maximum reading of the scale.
4. Repeat the steps 1., 2. and 3. before page until satisfactory result is obtained.
5. Check the vaues at several reading of the scale. Do angle adjustment if necessary, but it is rarely needed.

11. Adjustment of controller

⚠ CAUTION Since the adjustment of controller is accurately done at the manufacturing plant when it is assembled, do not touch adjusting screw of respective link and lever unless it is absolutely necessary. Disassembly of proportional and reset bellows should be absolutely refrained from.



Hereunder are given the procedures of on the spot adjustment and checking of this instrument. The purpose of this adjustment is to bring the function pin ② on the proportional lever ① on the same vertical plane with the nozzle flapper setting shaft ③ (proportional dial shaft), so that control pressure does not change even when proportional band is altered when the controller is operating in equilibrium conditions (i.e., when control pressure is stabllized).

1. Set the supply air pressure at 140kPa.
2. When control valve is not connected the CONTROL side, apply R 1/4 plug to the connetion hole. When it has NS 743 Auto/Manual selector, set it to MANUAL.
3. Loosen the adjusting screw ④ of measuring link and retighten the measuring pointer at the central position of indicating dial.
4. Turn the setting knob ⑤ to make the setting pointer overlap with the measuring pointer at the center of indicating scale. By turning the fine turning knob ⑩, make the pointer set plates ⑥ and ⑦ completey overlap with restitution levers ⑧ and ⑨ when hey are viewed from the front, and the pointer of restitution lever becomes roughly vertical at the center of the scale.

5. Turn the reset dial to the right until it hits the stopper and then loosen the set screw at the center of dial for 3 - 4 turns. Then draw out the knob straight forward, turn it to the left for 90° and tighten the screw again.
6. Turn the reset dial anti-clock-wise until it hits the stopper. When it has the rate dial, turn it to the left until the stopper is engaged.
7. Disassemble the stopper ⑪ of proportional band.
8. Set the proportional dial at around 50%, and turn the setting knob to the right and left and maintain the control pressure at 60kPa. Then leave it for sometime to see how it settles and repeat adjustment until equilibrium is established. When reset dial is turned to the right under such conditions, reset valve will fully close before it hits the stopper because it is in the course of shifting according to step 5. above. In such case only lightly tighten it by finger tip. By this adjustment, 60kPa air is sealed into the reset bellows and it functions in the same way as P. action. When the system performs P. action only, (When it has no reset) the aforesaid adjustment is not necessary.
9. Set the mark at the center of the dial of proportional band to indicator ⑫, then the proportional band becomes infinitely large and even when setting pointer is shifted for full scale by turning the setting knob, variation of control pressure shall remain to be minimum. The system is so adjusted as above at our company, but just for confirmation sake, try it again to see if it is so set. Under such condition, turn the fine turning screw ⑬ on the proportional lever ① to set control pressure at 60kPa.
10. Make both pointers completely agree at the center of the indicating dial. (If possible fix them by cellophane tape, etc.) Then turn the proportional dial to the right and left and adjust it with fine tuning screw ⑭ in such way that the control pressure indication moves to both sides of the mark for even distance; for example, at Direct 10% control pressure becomes 30kPa and at reverse 10% it also becomes 30kPa.
11. Adjust the fine tuning screw ⑬ located at the mark of proportional lever to set the control pressure at 60kPa. Then at 10% position (either Direct or Reverse, in the case of Reverse, driver shall not fit in unless it is at around 25%) set the control pressure at 60kPa also by using fine tuning screw of the flapper ③. Repeat this procedure until the control pressure becomes $60\text{kPa} \pm 3.5\text{kPa}$ at any point of the dial.
12. This will complete the adjustment. But once again check it by the steps from 6 to 11.
13. Lastly return the reset dial to the original position.
Turn the reset dial to the left until it hits the stopper and loosen the set screw and draw out the dial. Then pick up the reset dial shaft by finger and turn it to

the right until it stops and turn it back a little. The point where the set mark of the shaft meets the set mark on the circumference, is the point of longest reset time (20min.). So set the dial according to the indication.

12. Order of disassembly

⚠ CAUTION If by any chance this instrument should be damaged, you can disassemble the unit and repair or exchange the damaged parts as far as such damage occurs to the following 3 parts.

If trouble occurs to the parts other than these three, please do not disassemble or repair it by yourself but inquire our company about it or send it to us for repair or repair it under the presence of our service engineer.

1. When Bouldon tube is damaged.

- 1) Stop the air supply to the controller.
- 2) a. Close the main valve of the instrument when damage occurs to the pressure controller.
b. Remove temperature measuring terminals when damage occurs to the temperature controller.
- 3) Open the cover of the unit and remove two screws and dismount the scale plate.
- 4) Confirm that at left underneath of the instrument is the mechanism shown in Fig. 1 or 2.

Fig.1 Pressure controller

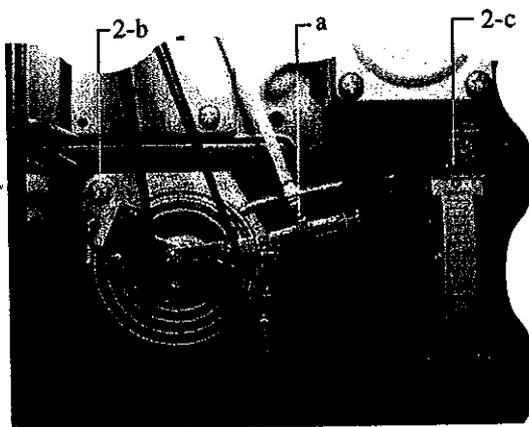
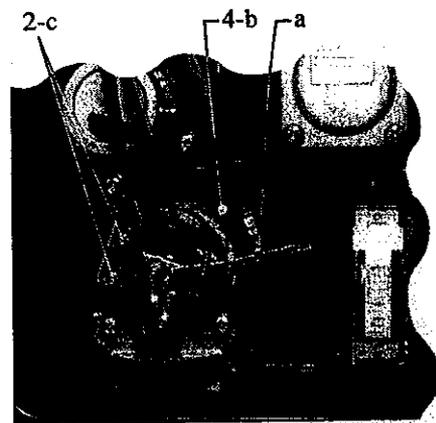


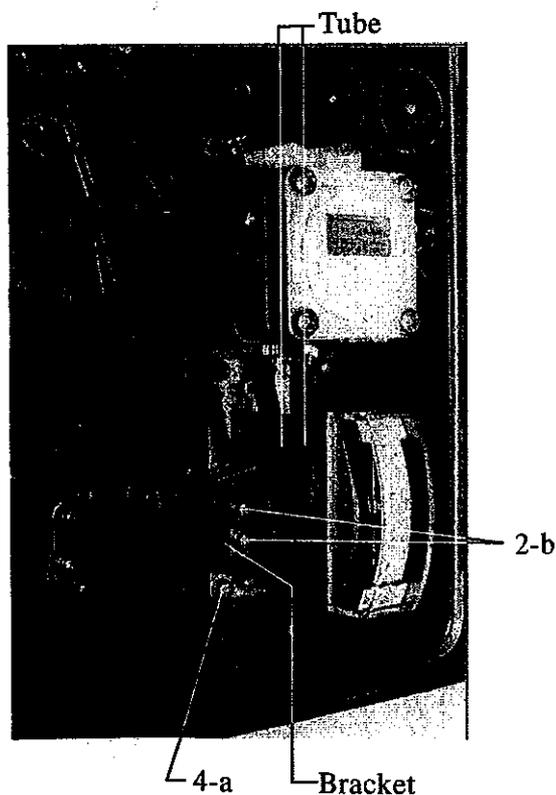
Fig.2 Temperature controller



- 5) a. When it is the pressure controller, disconnect the joint of "a" link, by removing the locking band. Then remove 2 screws "b" and "c" by a driver. Then Bouldon tube can be easily removed.
b. In the case of temperature controller, disassemble the connection of "a" link by removing locking band. Then you can see the terminals of 4 screws b. Remove these screws from the back side of the casing. Then you can easily dismount the Bouldon tube.

- 6) Fix a new Bouldon tube in the reverse order of the above.
 - 7) Perform the adjustment of scale plate according to the procedures described in "Item 10. Correction of Measuring Link".
- 2. When two elements (SUP/CONT) air pressure gauge is damaged.**
- 1) Reduce the supply air pressure to 0kPa by the filter regulator.
 - 2) a. In the case of the temperature controller, disconnect the joint of air pipe at the back of the casing.
 b. In the case of the pressure controller, first close the pressure detecting main valve and then disconnect the air pipe joint and pressure detecting pipe joint at the back side of the casing.
 - 3) Open the cover of the instrument, remove 2 screws and disassemble the scale plate.
 - 4) Confirm that at right underneath the instrument is the mechanism as shown in Fig. 3.
 - 5) Take off the two clips which are fixing the black hyparon tube and disconnect the joint of the tube. At this time pay attention not to damage the elasticity of the clip. Then remove 4 screws "a" and lift the pressure gauge straight upward, then it comes off easily.
 - 6) Fix the new pressure gauge in the reverse order of the above.

Fig.3



3. When the diaphragm inside of the pilot rely is damaged.

- 1) Stop air supply to the controller.
- 2) Open the cover of the instrument and confirm that the mechanism shown in Fig. 4 exists at the right center of the instrument.
- 3) Remove 2 screws "A".
- 4) Then it is possible to dismount the unit of pilot relay from the reversing mechanism as shown in Fig. 5.
- 5) Pilot relay unit can be take out as illustrated in Fig. 6, when two screws "B" shown in Fig. 5 are removed.
- 6) Assembly is done in the reversed order of the above.

Fig.4

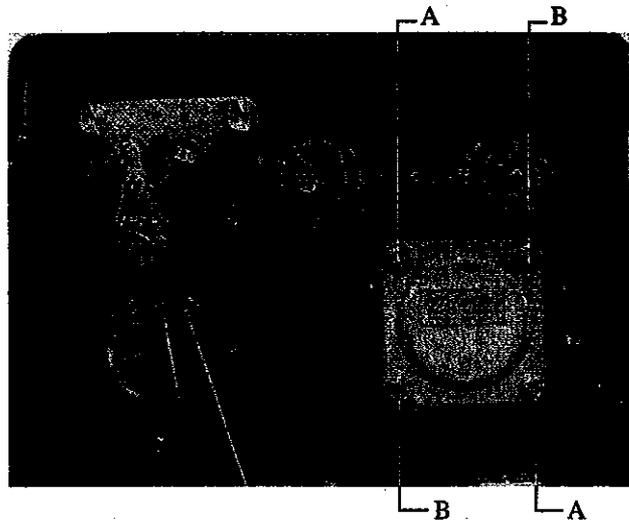


Fig.5

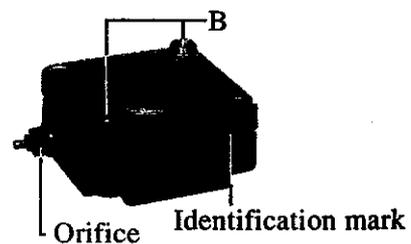


Fig.6

