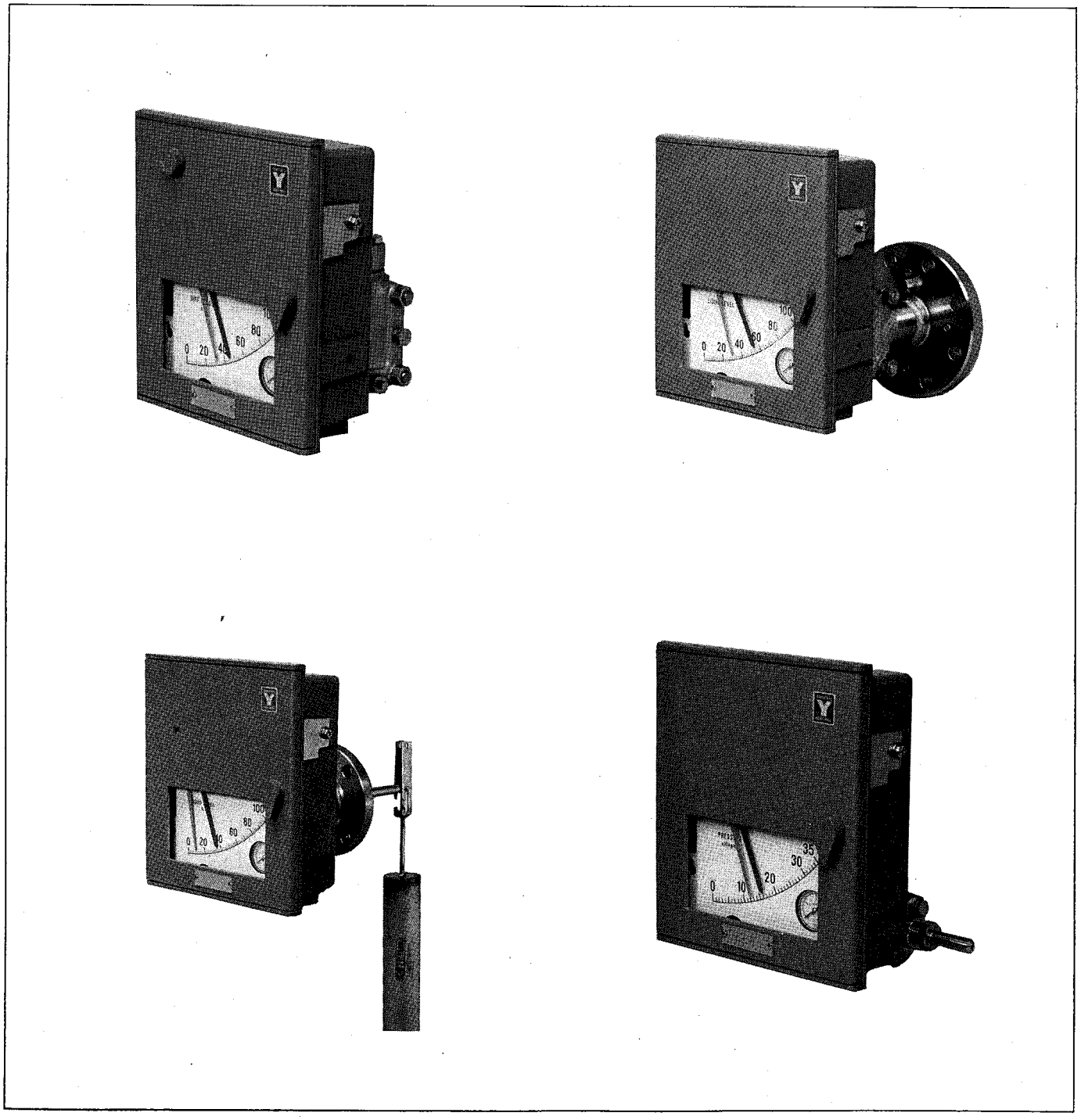
Yamatake-Honeywell

OPERATOR'S MANUAL

KF SERIES (FIELD MOUNTED TYPE) INDICATING CONTROLLERS (ADJUSTABLE RANGE) MODELS: KFD, KFK, KFL

(KFD: DIFFERENTIAL PRESSURE
KFK: PROCESS PRESSURE
KFL: LIQUID LEVEL)



Yamatake-Honeywell Co., Ltd.
Tokyo, Japan

Aug. 1981 Issue 3 (H)

KF SERIES (FIELD MOUNT TYPE)
INDICATING CONTROLLERS (ADJUSTABLE RANGE)
MODEL: KFD, KFK, KFL

MAINTENANCE

SCHEMATIC OF KFD/KFK/KFL INNER PIPING SYSTEM

1. DESCRIPTION

1.1 General

The KF Series Field-mounted Indicating Controllers measure and indicate a process variable (PV) and at the same time they compare the process variable with the set point (SP) and transmit a pneumatic control output signal of 0.2 to 1.0 kg/cm^2.

1.2 Structure

The KF instrument consists of a case, a pneumatic circuit board with indicating control unit, a process detector element and a force balance type transmitter unit.

Functionally, the instrument consists of two major sections, namely, a process variable transmitter section including detector and a receiving and indicating controller section.

Note: This instruction manual explains the transmitter section (excluding the detector) and the indicating controller section. Operator's manuals are issued for individual types of detectors. Refer to the corresponding manual for installation, connection to the process, calibration setup, and preparation for operation of each type of detector.

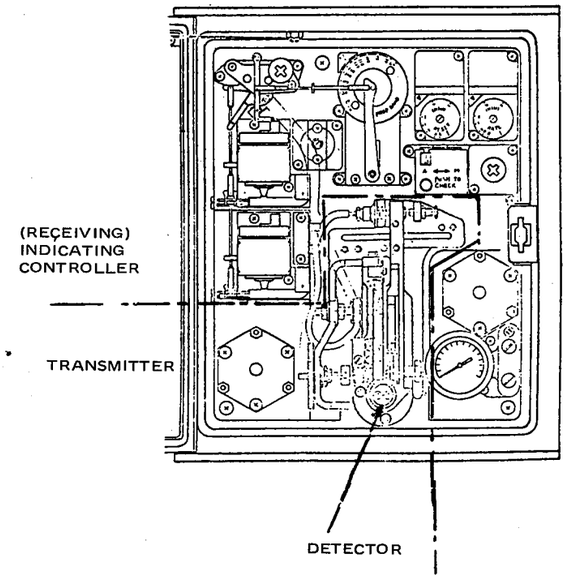


Fig. 1

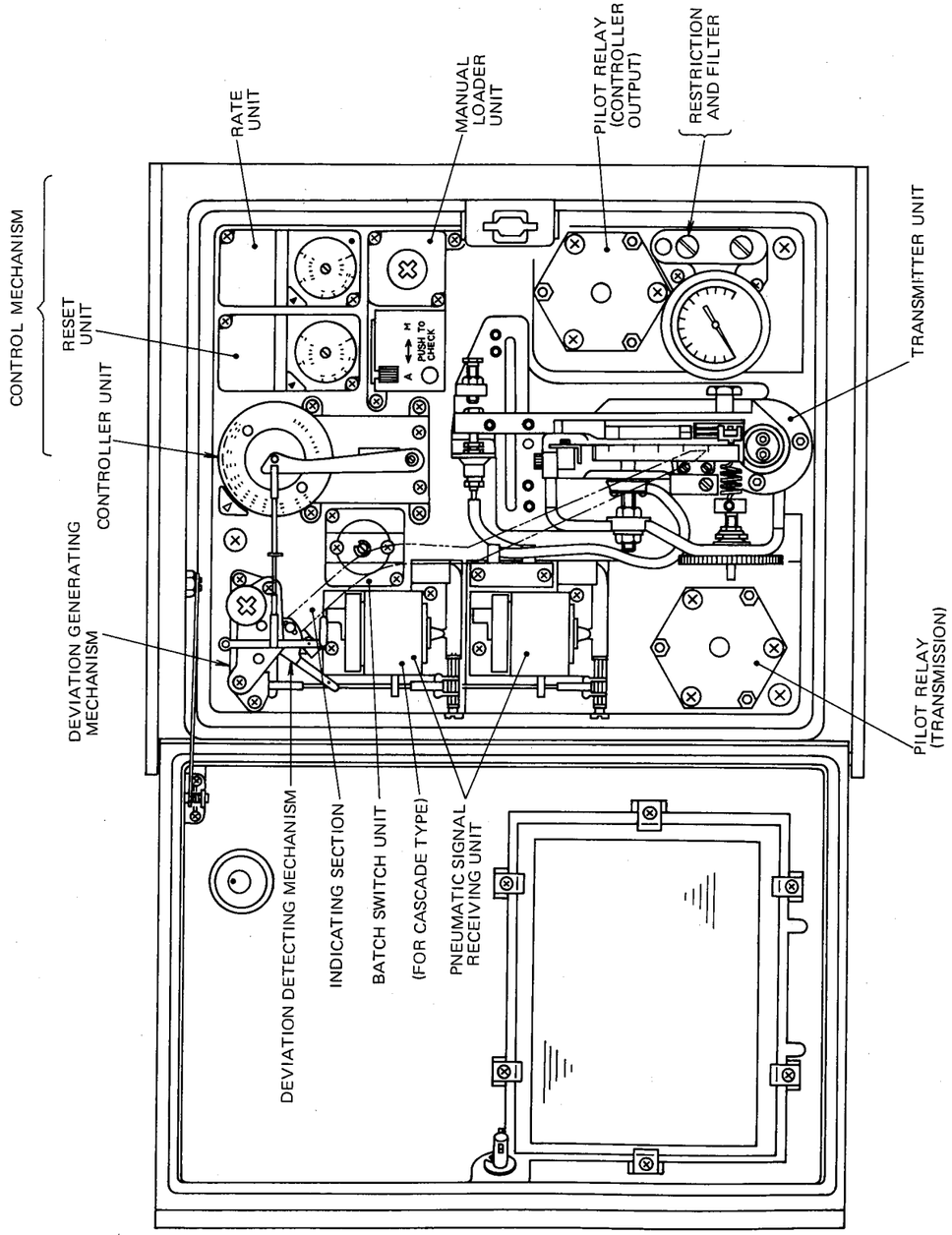


Fig. 2

1.3 Specifications

1.3.1 Specifications of Instrument Section

Performance	Accuracy:	±1% FS
	Repeatability:	0.3% FS or better
	Dead zone:	0.2% FS or less
Indicating section	Indicating angle:	44 deg.
	Scale length:	150 mm
	Pointers:	PV (red), SP (green)
	Output indicator:	Scale range: 0 to 2 kg/cm²
		Indicating accuracy: ± 3% FS
Setting section	Local setting:	Internal or external setting with knob
	Remote setting:	With pneumatic pressure of 0.2 to 1 kg/cm²
	Setting range:	0 to 100% FS
Controller section	Control actions:	P + manual reset, PI, PID, PD + manual reset, PI + batch, on-off, differential gap, P + external reset, and PD + external reset
	Proportional band (P):	5 to 500% (direct or reverse action)
	Integral time (I):	0.05 to 30 minutes
	Derivative time (D):	0.05 to 30 minutes
	Differential gap:	1 to 100% FS, variable
	Batch setting pressure:	0.6 to 1.1 kg/cm²
	External reset pressure:	0.2 to 1.0 kg/cm²
	Manual reset:	0 to 100% FS, variable (by pneumatic pressure setting)
General items	Output:	0.2 to 1.0 kg/cm²
	Minimum load:	Inside diameter 4 (mm) x 3 (mm) + 20 (cm³)
	Air supply:	1.4 ± 0.1 kg/cm²
	Air consumption (when balanced at 50% output):	Indicating transmitter: 4 Nℓ/minute
		Indicating controller: 8 Nℓ/minute
		Indicating controller + pneumatic transmitter: 8 Nℓ/minute

Saturated air capacity	Pneumatic transmission:	40 Nℓ/minute	
	Controller output:	40 Nℓ/minute	
	Manual loader:	30 Nℓ/minute	
Air connections	PT 1/4 or 1/4 NPT internal thread		
Operating temperature range	Meter body (process fluid):	-40 °C to +120 °C	
	Transmitter (ambient):	-30 °C to +80 °C	
Ambient humidity range	10 to 90% RH		
	Case construction:	Waterproof and dustproof	
		JIS F 8001 Class 3 splashproof equivalent	
		NEMA 3 equivalent	
		IEC IP54 equvalent	
Case and door	Material:	Case:	Aluminium die cast
		Door:	Glass-fiber-reinforced polyester resin
		Door glass:	Tempered glass (JIS R 3202, 3mm thick)
	Case finish:	Acryl paint baking finish (Anticorrosion paint and silver paint are available as options.)	
	Finish colors:	Case:	Dark beige
		Door:	Light beige
Mounting:	Panel mount, 2 inch pipe mount, or flange mount		

1.3.2 Specifications of Meter Body Section

Refer to the Operator's Manual of the Meter Body.

2. TRANSMITTER SECTION

2.1 Description

The transmitter section has a pneumatic force balance mechanism and a pilot relay assembly, with which to convert the displacement signal (torque signal received from the detector (meter body) into a pneumatic output signal of 0.2 to 1.0 kg/cm^2. This signal is fed to the receiving unit and then to the controller unit. If the instrument is a type for transmission only (without receiving unit or controller unit), this signal is directly delivered as the instrument output signal.

2.2 Structure

(1) The transmitter mechanism is coupled to the meter body (detector) with a bushing via torque rod. The transmitter mechanism is mounted on a single aluminium diecast base.

(2) The major components of the transmitter section are primary and secondary beam assemblies, a nozzle and flapper, and a feedback capsule. The instrument is delivered with its measuring range adjusted at the instrument manufacturer's factory at the values specified on the order sheet for the instrument. However, the measuring range can be easily changed to other required values in the field by the user simply by changing the position of the span rider on the primary beam. A measuring range scale is provided on the secondary beam. A fine span adjustment screw also is provided on the primary beam. A low limit stopper against overload is provided at the right hand side of the flapper. As for the high limit, the nozzle itself is used as the high limit stopper against overload. Neoprene tubes are used for air tubing inside the instrument.

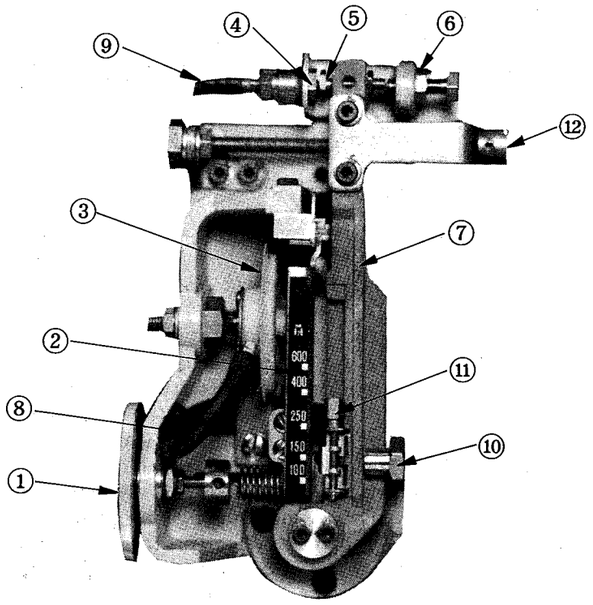
(3) The feedbcak capsule, zero spring, and suppression/elevation spring as well as the torque tube are made of an nickel alloy which is highly stable against temperature change.

(4) A suppression/elevation spring is available as an optional provision. With this spring, the zero point can be largely changed to cope with large measuring range change. The force of the spring is adjustable with a hex-knob screw. The spring can be readily installed in or detached from the instrument in the field.

2.3 Operation

(1) The process variable is detected into mechanical displacement (torque) and this displacement is linked to the primary beam of the transmitter. Displacement of the primary beam (7) causes change in gap between nozzle (4) and flapper (5), thereby causing change in the back pressure of the nozzle (4). The back pressure is boosted by the pilot relay to a pneumatic signal of 0.2 to 1.0 kg/cm^2 which is used as the output signal of the transmitter section. At the same time, this pneumatic signal is applied to the feedback capsule to make up a feedback loop to rebalance the primary beam so that the pneumatic signal stably representing the process variable is transmitted.

(2) The suppression/elevation spring provides an additional balancing force to the primary beam in order to provide an intentional offset of the zero point of measurement.



① Zero Adjustment
② Secondary Beam
③ Feedback Capsule
④ Nozzle
⑤ Flapper
⑥ Overload Stopper
⑦ Primary Beam
⑧ Capsule Tubing
⑨ Nozzle Tubing
⑩ Coarse Span Adjustment
⑪ Fine Span Adjustment
⑫ Elevation/Suppression (Option)

Fig. 1

3. INDICATIONG CONTROLLER SECTION

3.1 General

The free end of the sensor element is displaced in proportion to the measured process value. The displacement is fed through a linkage to the deviation generating mechanism which magnifies and indicates the deviation on the scale. At the same time, through another linkage, the control deviation amount is fed to the controller unit which performs the proportional, reset and rate actions on the deviation amount in order to produce a pneumatic control output signal.

3.2 Descriptions of Mechanism

3.2.1 Deviation Generating Mechanism

The deviation generating mechanism consists of a deviation detecting section and an indicator section. It detects the deviation of the measured value of the process variable (PV value indicated by the measuring pointer on the scale) from the set point value (SP value indicated by the set point pointer) and controls the position of the flapper with respect to the nozzle via a control link.

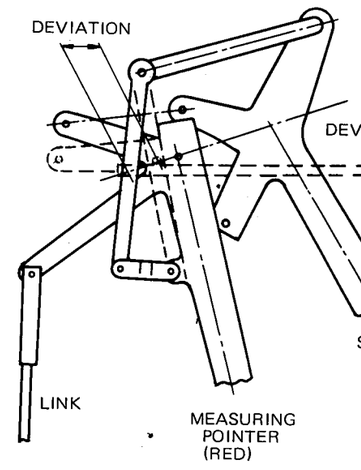
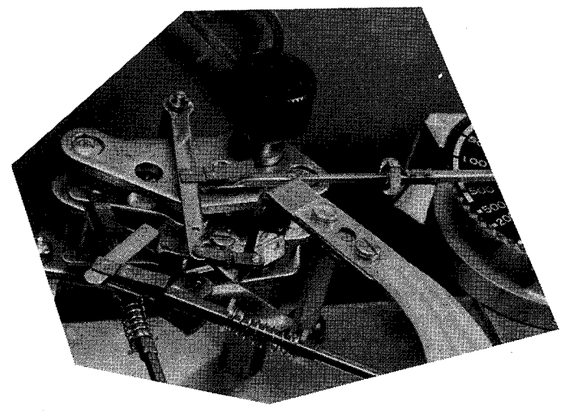


Fig. 1



Fi.g 2

3.2.2 Control Mechanism

The control mechanism consists of a controller unit, a reset unit, and a rate unit. Different combinations of these units are possible to attain different control actions.

(1) Controller Unit

Displacement of the deviation link is fed via the flapper pin of the feedback link to the flapper, so that its gap with respect to the nozzle is varied and consequently the nozzle back pressure is varied. The nozzle back pressure is boosted by the pilot relay and delivered as the pneumatic output signal of the controller. This output signal is led to the feedback chamber in order to return the flapper-to-nozzle gap to that existed before this displacement took place. Ultimately the controller output pressure is balanced at a value in a certain proportion to the deviation.

Setting of proportional band can be done by turning the proportional band dial which varies the crossing angle between flapper and deviation link (feedback link).

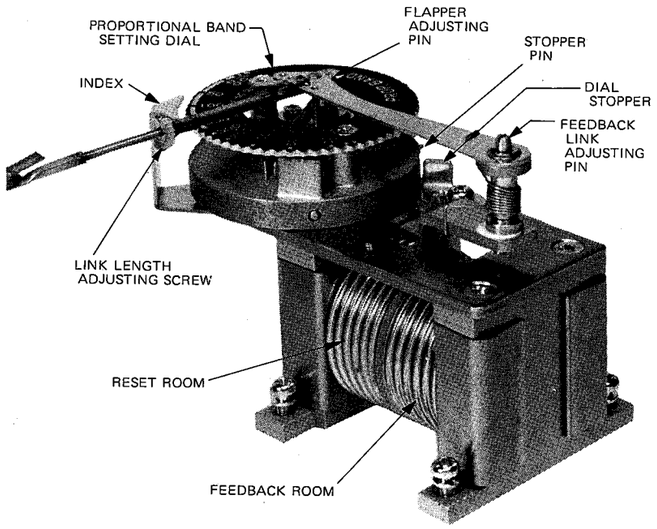


Fig. 3

(2) Reset unit (integrating unit)

Pneumatic pressure of the feedback chamber is fed to the reset chamber through capacity and restriction of the reset unit, thereby attaining a reset action. When the rate unit is provided, a derivative action also can be attained. A bellows is provided in the chamber of the rate unit and part of the controller output pressure is directly led to this bellows to adjust the amplitude of the derivative action.

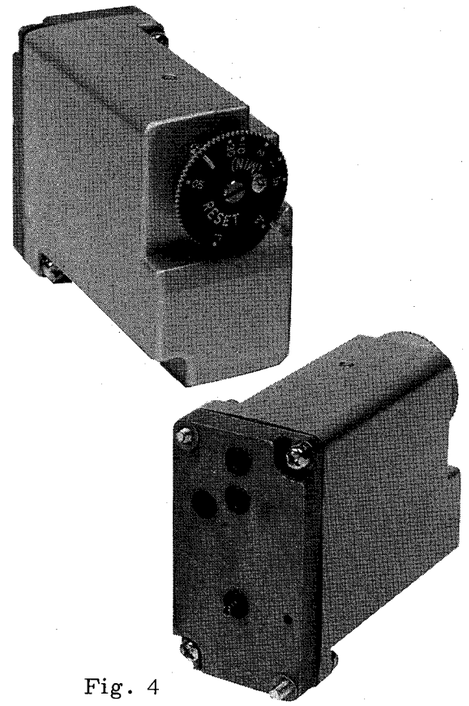
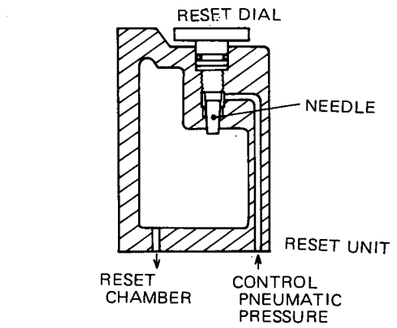


Fig. 4



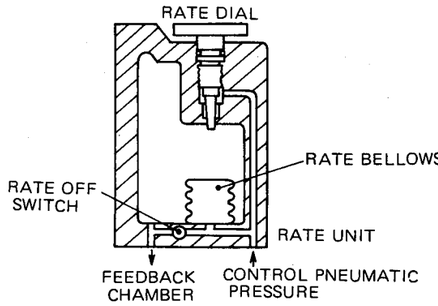


Fig. 5

(3) Other control operations

(a) ON-OFF action
The nozzle back pressure is directly applied to the pilot relay. The control operation is done in an ON-OFF mode in response to the open or closed state of the nozzle.

(b) Differential gap action
The feedback chamber of the controller unit is replaced with a spring-function device and the output pressure is led to the reset chamber. The differential gap width is adjustable as required.

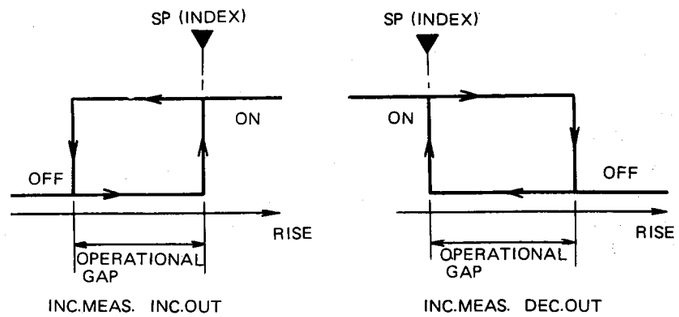


Fig. 6

(c) Addition of manual reset

Such manual reset provisions can be incorporated that the output pressure of the pilot relay is applied to the feedback chamber of the controller unit and the manual reset pressure produced by a pressure regulator is applied to the reset chamber.

(d) Addition of external reset

This provision is such that a reset signal as explained in the above item (c) is applied externally. The external signal can be applied through the RES port of the customer connection block.

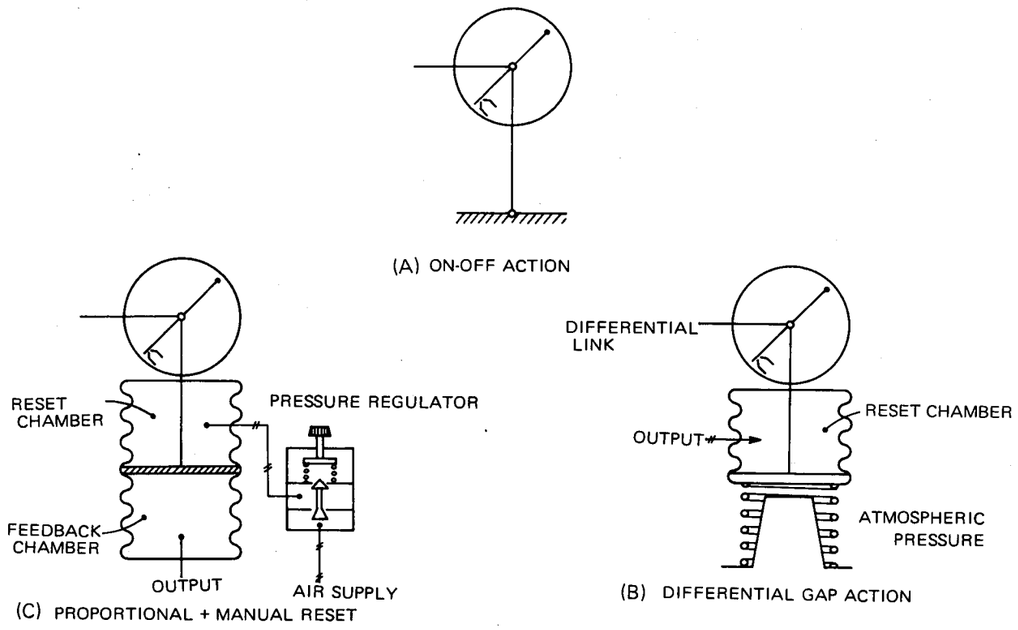


Fig. 7

3.2.3 Manual controller unit

The manual controller unit consists of a pressure regulator for manual pressure setting and an AUTO/MAN transfer switch.

When in the automatic mode (the lever is set in the A position), the output air pressure gauge indicates the automatic control output pressure; when the check button is pressed, the gauge indicates the regulator output pressure (manual controller output pressure).

When in the manual mode (the lever is set in the M position), the output pressure of the regulator is led to the reset chamber of the controller unit and, at the same time, it is indicated by the output pressure gauge and applied to the control valve for remote control operation. If the check button is pressed in this case, the pressure gauge indicates the controller output pressure.

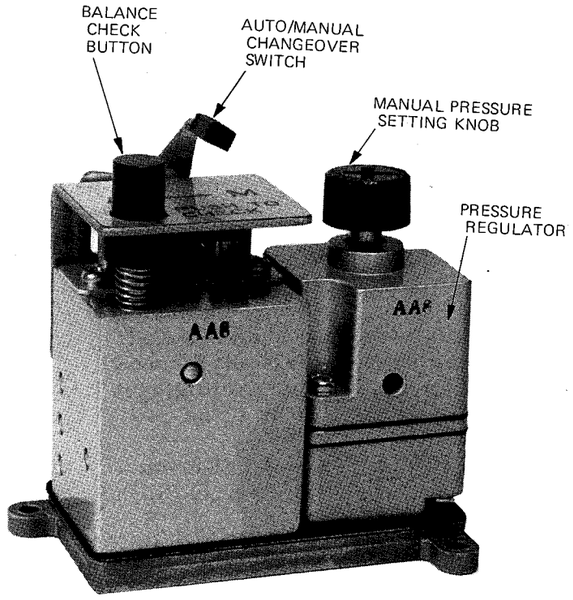


Fig. 8

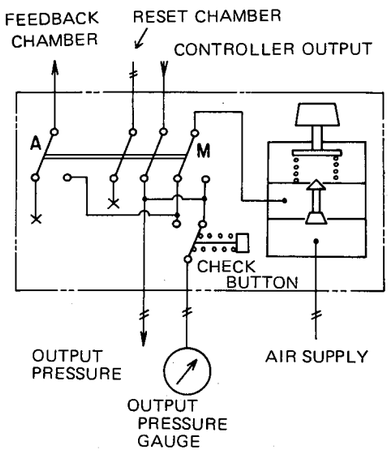


Fig. 9 Diagram of manual controller unit

3.2.4 Pneumatic Signal Receiver Unit (Set Point Pointer)

This unit receives with its bellows an external pneumatic signal of 0.2 to 1.0 kg/cm^2 and converts this pneumatic signal into a mechanical position displacement. This displacement is conveyed via a travel link to the deviation generating mechanism which magnifies the displacement so that the input signal is indicated as a set point signal on the indicator scale.

3.2.5 Batch Switch Unit

When the output has exceeded a preset limit, a relay trips so that the reset pressure cannot increase above the preset limit. This unit is used to prevent abnormal excursion of signal when starting operation of a batch process. (This unit is effective only for control of high limit.)

Preloading for a batch process can be done by applying an external preload pressure to the connector block (RES port) of the instrument.

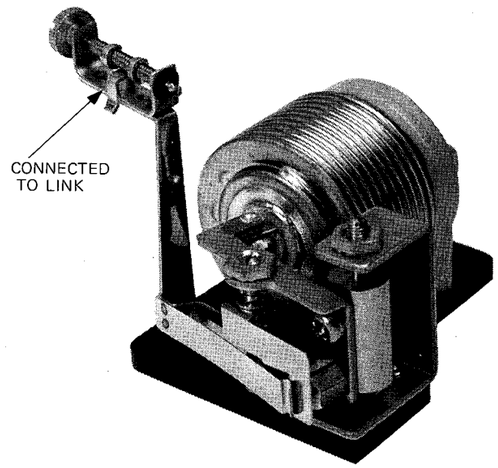


Fig. 10

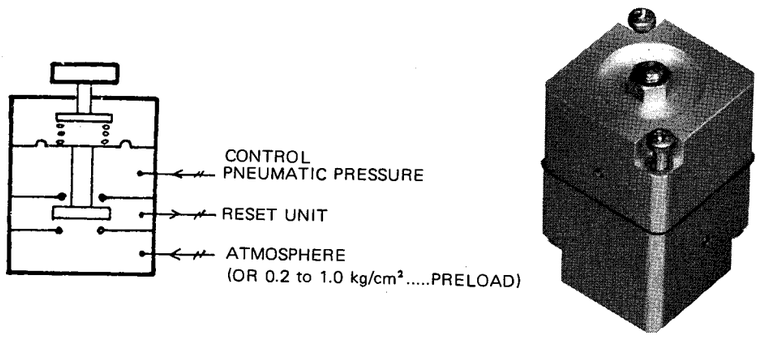


Fig. 11

4. INSTALLATION

For installation and connections of the instrument, see the drawings of instrument mounting dimensions.

4.1 Air Piping

For piping, use copper pipes of OD 6 mm (ID 4 mm) with brass fittings HI-ZEX tubes. (HI-ZEX: Tradename of polyethylene tubes manufactured by Mitsui Petrochemical Ind. Ltd.)

(1) Air supply

(a) The air supply must be clean, dry air of 1.4 kg/cm² ± 0.1 kg/cm². Connect the air supply to the instrument via a filter and a pressure regulator. When two or more instruments are used, provide a filter and a regulating valve for each instrument.

(b) Connect the supply air to the SUP port of the air connection manifold of the instrument.

Note: Use of pipe sealing agent may be harmful to pipes. If sealing agent is required, sparingly apply it to the male connector.

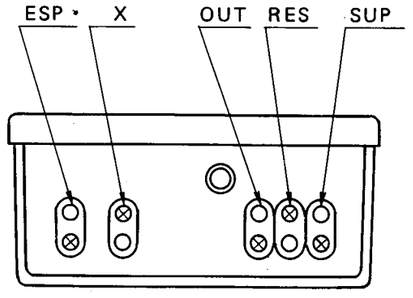
(2) Output air

Connect the pipe for the control valve to the OUT port of the air connection manifold of the instrument.

4.2 Connection Method

(1) The air connection ports at the bottom of the instrument casing are as shown below. Both PT-1/4 thread and 1/4-NPT thread are provided for each connection item. Seal the unused ones with plugs.

(2) If an air set is provided, connect the air supply to the IN port of the air set.



○ : PT 1/4 FEMALE SCREW
⊗ : 1/4 NPT FEMALE SCREW
When in manual reset, the external reset signal connection port is connected to SUP through a pipe.

PNEUMATIC PIPING CONNECTION PORTS

ESP: EXTERNAL SP SIGNAL
X: RECEIVING OR TRANSMITTING PNEUMATIC SIGNAL
OUT: CONTROLLER OUTPUT PRESSURE
RES: EXTERNAL RESET SIGNAL
SUP: SUPPLY AIR PRESSURE

Fig. 1

5. OPERATION

5.1 Preparations for Operation

(1) Check that air piping is correctly done and there is no air leak.

(2) If a manual loader is used, turn the lever to "M" (to the extremely counterclockwise position) to make the regulator output zero.

(3) Drain the filter and set the supply air pressure at 1.4 kg/cm^2.

5.2 Manual Operation

When a manual loader is provided, perform the manual operation according to the following procedure to conform the stability of process.

(1) Set the AUTO/MAN transfer switch in the M position. Adjust the manual loader (regulator) output so that the required process value is obtained.

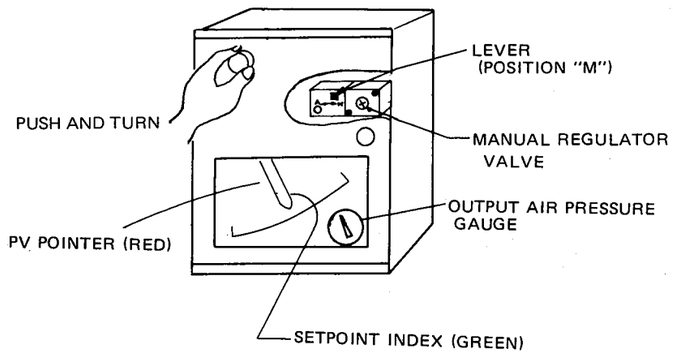


Fig. 1

5.3 Automatic Operation

For a control system for which no set point value is determined, automatic operation is generally started in the procedure mentioned below.

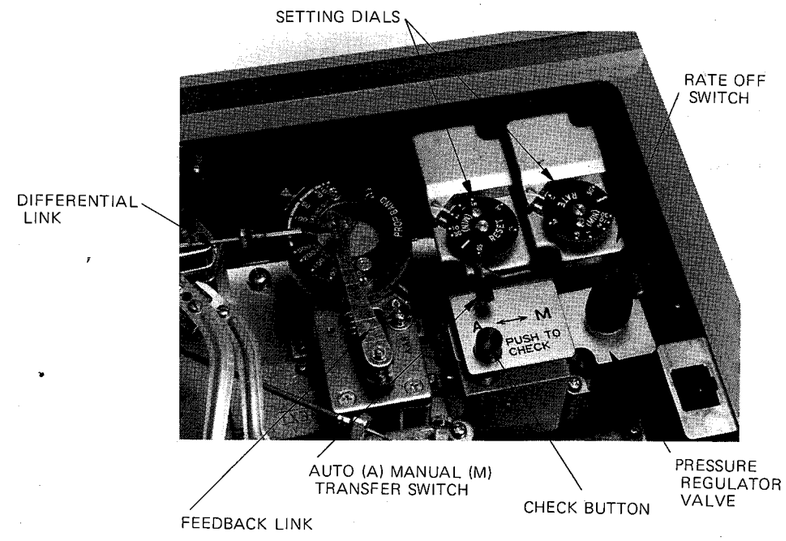
(1) Set the control sections as follows:

Proportional band (P):	Maximum (proportional band setting dial 500%)
Reset time (I):	Maximum (reset dial 3.0 minutes)
Rate time (D):	Minimum (rate dial 0.05 minutes)

(2) When the manual loader unit is provided, operate the pressure regulator so that the desired output value can be obtained with the AUTO/MAN switch set in the M position.

(3) By turning the setting knob, set the set point pointer to the desired value. When the setting knob outside the case is provided, setting can be done by turning the knob, pressing it toward the door.

(4) If the check button is pushed with the AUTO/MAN switch set in the manual (M) position, the output pressure gauge indicates the controller output. If the check button is pushed with the switch set in the automatic (A) position, the pressure gauge indicates the pressure regulator output.



When turning PB setting dial, take are not to touch feedback link or differential link.

Fig. 2

For switching from the manual operation to the automatic operation when the manual loader is provided, make equal the pressure regulator output and the controller output in the manual (M) position, observing the output pressure gauge.

When the pointer of the output pressure gauge has become stable even if the check button is pushed, change the transfer switch lever from manual (M) position to auto (A) position. (Shift the lever quickly and completely until it comes to the end position.)

(5) In auto operation, set P.I.D. to suit the process characteristics.

(6) For switching to manual operation, follow in the reverse order the procedure (4).

5.4 Using the Rate Action

To unuse the rate action with the rate unit mounted, turn the rate off switch on the unit fully counterclockwise. This feature is convenient when adjusting the controller mechanism.

When rate action is required, turn the rate off switch fully clockwise.

5.5 Setting of Batch Switch

(1) Connect the controller output to a mercury column.

(2) Perform the following settings and apply a deviation input to saturate the output.

Proportional Band: 50%

Reset Time: 0.02 min.

(3) Decrease the output to the desired value by turning the setting screw. The output decreases as the screw is turned clockwise.

(4) When the function as a batch controller is not required, turn the setting screw fully counterclockwise.

6. CALIBRATION AND ADJUSTMENT

First, adjust the transmitter section. After adjustment of the transmitter section is complete, adjust the indicating controller section.

When the transmitter unit has been replaced, perform the adjustment procedure starting by 6.1. In other normal cases, perform the procedure starting by 6.2.

6.1 Adjustment of Transmitter Section (Balancing Adjustment)

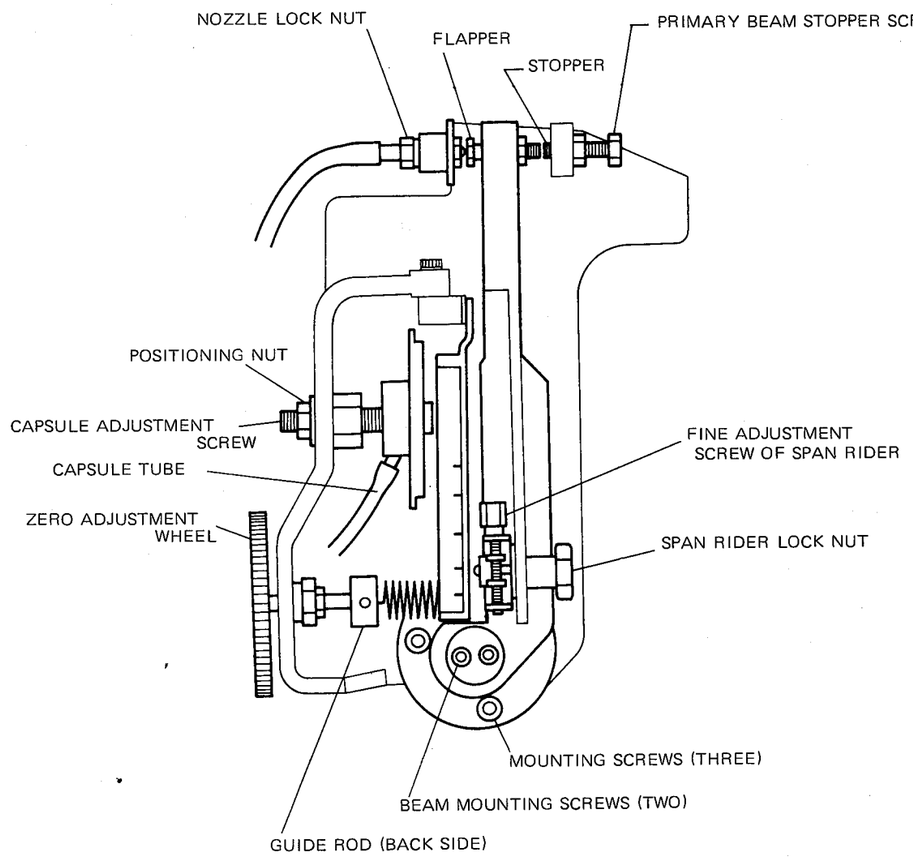


Fig. 1

First, remove the elevation/suppression spring. (Remove the four socket screws.)

(1) Connect an air supply of 1.4 kg/cm^2 to the SUP connection port of the instrument manifold. Remove the blind plug of the X port (output connection port) and connect a mercury manometer to this port. Prepare another pneumatic pressure source which is capable of providing a pressure up to 200 mmHg. Do not apply the input yet.

(2) Disconnect the tube from the capsule and block the tube end. Apply a pneumatic pressure of 100 mmHg to the feedback capsule.

(3) So adjust the zero adjustment control that the zero adjustment guide rod is positioned at a mid-position in the guide groove.

(4) Set the span rider of the primary beam at a mid-position of the secondary beam and tighten the lock nut of the span rider.

(5) Undo the clamping socket screws of the primary beam and the positioning lock nut of the feedback capsule.

(6) Make the primary and secondary beams mutually parallel with the adjusting screw of the capsule and tighten the lock nut of the capsule and the clamping socket screws of the primary beam. (Tighten the clamping socket screws with a tightening torque of 15 to 18 kg-cm.)

(7) Set the span rider at the maximum scale position. Apply a pressure of 170 mmHg to the capsule.

(8) Adjust the output pressure at 250 to 300 mmHg by turning the flapper at the end of the primary beam.

(9) Check the operation of the nozzle and flapper as follows: When the capsule pressure is varied from 165 mmHg to 175 mmHg, the output pressure varies from 0.2 kg/cm^2 to 1.0 kg/cm^2 (from 148 mmHg to 738 mmHg) or for a wider range.

(10) If the output pressure does not become higher than 1.0 kg/cm^2 in Step (9), undo the lock not of the nozzle and so adjust the mounting attitude of the nozzle that the nozzle end surface becomes in parallel with the flapper surface.

(11) Connect the tube to the capsule following the procedure of Step (2) in the reverse order, in order to restore the mechanism to its original state.

(12) Recheck the parallelism of the beams as follows: When the span rider is moved from the maximum scale position to the minimum scale position, output pressure variation is not greater than 150 mmHg.

If the output pressure variation is greater than 150 mmHg, repeat the above adjustment procedure starting by Step (4).

(13) Turn the primary beam stopper screw until it lightly hits the flapper. From this position, retract the screw by a quarter turn and then secure the lock nut in this state.

(14) If the elevation/suppression provision is incorporated, fix the spring assembly with the four socket screws.

6.2 Calibration of Transmitter Section

In order to remove residual stress (which can be a cause of zero point shift) of the sensor element, apply to the transmitter section an overload pressure for several times before starting calibrating the instrument.

6.2.1 When no suppression/elevation provision is incorporated

(1) Connect to the meter body a pressure source which is capable of covering from zero to the maximum measuring range. Connect a 1.4 $\pm$ 0.1 kg/cm^2 air supply to the air supply connection port.

(2) Repeat alternately zero adjustment and span adjustment as explained in the following, until the required accuracies are obtained.

(3) Adjustment procedure

(a) Zero adjustment

With zero input pressure, adjust the output pressure at 0.2 kg/cm^2 (148 mmHg) with the zero adjustment wheel located at lower left on the transmitter section.

(b) Span adjustment

Apply an input pressure of 80 % of the full span and adjust the output pressure at 0.84 kg/cm^2 (620 mmHg).

- Coarse span adjustment

Undo the hex screw of the span rider on the primary beam and slide the rider along the beam. This adjustment primarily is for coarse span adjustment.

- Fine span adjustment

To finely adjust the span, turn the small hex screw of the span rider.

6.2.2 When suppression provision (elevated-zero range provision) is incorporated

(1) After the procedure of 6.2.1 is complete, proceed as explained in the following.

(2) Calculate the pneumatic signal pressure corresponding to the required suppression, so adjust the hex knob of the suppression spring assembly that the instrument without any input pressure being applied to it produces an output pressure corresponding to the calculated value and fix in this state the hex knob with the lock nut.

(3) Repeat alternately zero adjustment and span adjustment as explained in 6.2.1. For the zero point value, however, use the value of Step (2) above.

6.2.3 When elevation provision (suppressed-zero range provision) is incorporated

(1) After the procedure of 6.2.1 is complete, proceed as explained in the following.

(2) Apply an elevation input to the input connection port (to the high pressure chamber in the case of a differential pressure meter), so adjust the hex knob of the elevation spring assembly that the output pressure becomes 0.2 kg/cm² (148 mmHg), and then fix the hex knob with the lock nut.

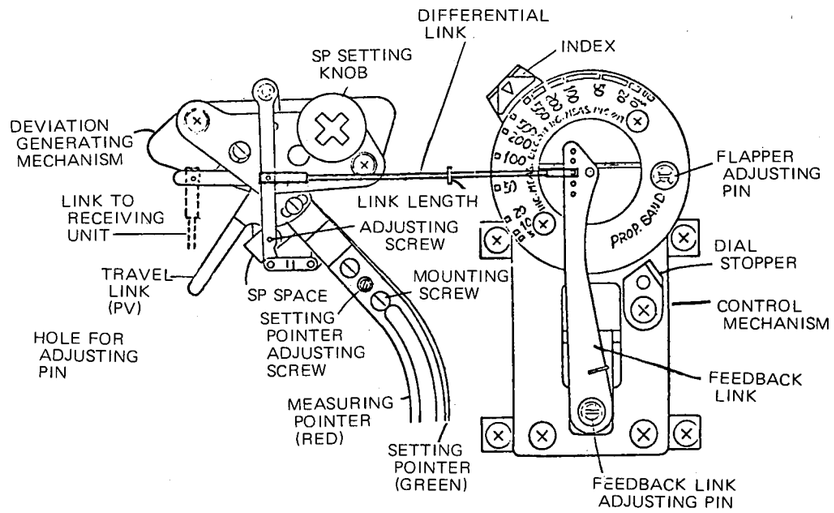
(3) Repeat alternately zero adjustment and span adjustment as in Step (1). For the input value, use a value with the elevation value added to it.

6.3 Range Change

With the calibration procedure of 6.2, the measuring range of the instrument is continuously variable covering from the minimum range to the maximum range. When performing range change procedure, use the range scale of the secondary beam as an reference for coarse span adjustment.

6.4 Deviation Generating Mechanism

By following the procedure mentioned below, accurately align the ends of the measuring pointer and the set point pointer.



(1) Either by disconnecting the link from the receiving unit or by setting measuring input for about 50%, make the measuring pointer indicate approximately 50% point on the scale.

(2) Set the set point pointer at approximately 50% scale position with the setting knob in the case of the local type or with an external set point signal in the case of the cascade type.

(3) Insert the adjusting pin (Standard accessory 1.2 mm dia.) through the adjusting pin hole.

(4) If there is a gap difference between the ends of the set point pointer and the measuring pointer, eliminate the difference by turning the set point pointer adjusting screw.

If the motion is not smooth, temporarily loosen the clamping screw for adjustment. Then, tighten the screw firmly.

Connect a mercury column or a digital manometer to the OUT connection port, and a supply air 1.4 kg/cm² to the SUP connection port.

6.5 Controller Mechanism

6.5.1 Balance Adjustment for Controller Proportional Band

First, remove the dial stopper by loosening its screw.

(1) Set the proportional band at 500%.

(2) Set the set point pointer and the measuring pointer at 50%

(3) With the reset dial set in the full open state (minimum reset time), set the output air pressure at 50% FS (443 mmHg) by adjusting the set point pointer.

(4) When the output pressure is stabilized, fully close (maximum reset time) the reset dial and move both pointer to the 50% position.

(5) So adjust the length of the deviation link that the difference of the output pressures between when the proportial band dial is set at 20% (INC. MEAS, INC, OUT) and at 20% (INC. MEAS, DEC, OUT) is not greater than 6 mmHg.

(6) Adjust the flapper adjusting pin so that the change in the output pressure becomes less than 6 mmHg when the proportional band is changed from 20% to 500%. (Turn the adjusting pin clockwise if the output increases when the band is changed from 20% to 500%.)

(7) Adjust the feedback link adjusting pin so that the output pressure becomes 443 $\pm$ 2 mmHg at 500% proportional band. (The pressure increases as the pin is turned clockwise.)

(8) Repeat steps (5), (6) and (7) so that, in the entire range of the proportional band, the output pressure becomes 443 $\pm$ 9 mmHg in the range of white figures 50 to 500 to yellow figure 50; and 443 $\pm$ 18 mmHg in the other range.

Notes:

1. With step (4), pneumatic pressure of about 443 mmHg is sealed in the controller reset chamber. Since the pressure may change in a prolonged time, complete the above operations as rapidly as possible.

2. For change between INC. MEAS. INC. OUT (direct action) and INC. MEAS. DEC. OUT (reverse action), free the dial stopper by loosening its clamping screw, turn the dial to the opposite action range, and then fix the dial stopper.

6.5.2 Calibration of Reset and Rate Units

Be extremely careful when handling the reset (rate) restriction. Even a minor damage to the needle or valve seat can cause a great change in the characteristics. So, the reset restriction and the dial base are firmly fixed. When the unit has been disassembled for servicing, calibrate it observing the following procedures:

A. Reset Unit

(1) Set the set point pointer (SP) at 50% F.S.

(2) Set the proportional band dial at 100 (% P.B.) of direct action. In this case, fully open (0.05 min. or less) the reset restriction and, if the rate unit is provided, fully open (0.05 min. or less) the rate restriction also.

(3) By adjusting the PV value, balance the controller output (control output pressure) at 350 mmHg.

(4) Fully close the reset restriction (30 min. or more).

(5) By adjusting the PV value, set the controller output at 400 mmHg.

(6) Set the reset dial at 2 min.

(7) Measure the time required by the controller output to change from 400 to 450 mmHg.

(8) Make sure that the measured time is not longer than 120 $\pm$ 60 sec.

(9) Adjust the position of the reset unit dial after loosening its two setscrews, as required.

B. Rate Unit

(1) Set the set point pointer (SP) at 50% F.S..

(2) Set the proportional band dial scale at 100 (% P.B.) of direct action. In this case, fully open (0.05 min. or less) the rate restriction and, if the reset unit is provided, fully open (0.05 min or less) the reset restriction also.

(3) By adjusting the PV value, set the controller output at 300 mmHg.

(4) Fully close the reset and rate dials (30 min. or more).

(5) By adjusting the PV value, set the controller output at 600 mmHg. (Denote this value by n_1.)

(6) Fully open the rate dial (0.05 min or less), measure the residual pressure (denote this value by n_2) and calculate the rate amplitude.

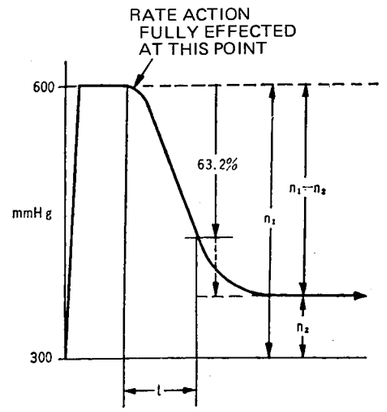
$$\text{Rate amplitude} \quad W = \left(\frac{n_1}{n_2}\right)$$

(7) Repeating the procedure of (2) to (5) so that the controller output becomes 600 mmHg.

(8) Rapidly change the rate dial to 2 min and measure the time t in which the output changes to 63.2% of the value of $n_1 - n_2$.

(9) Make sure that t x W is not longer than 120 $\pm$ 60 sec.

(10) If necessary, adjust the position of the rate unit index.



RATE ACTION CALIBRATION

6.5.3 Other Calibration and Adjustment Procedures

1) On-Off Controller

Before adjustment, perform the following confirmation procedure (confirmation of zero deviation):

(a) Set the set point pointer at 50%.

(b) Disconnect the travel link (PV) from the indicating mechanism, and insert the adjusting pin.

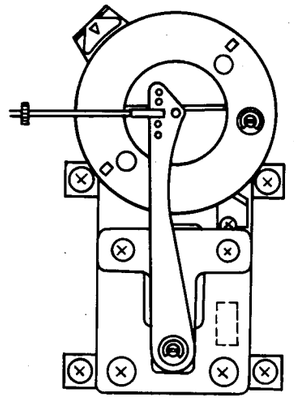
(c) Make sure that there is no deviation between the PV pointer and the SP pointer.
If there is any deviation, eliminate it by using the set point pointer adjusting pin.

(d) Remove the adjusting pin and connect the travel link (PV).

o Adjustment

(1) Turn fully counterclockwise the set point dial and set it to the white edge line of the INC. MEAS. INC. OUT scale. Apply a deviation that will make the output 443 $\pm$ 6 mmHg. Read the deviation by the pointer on the scale.

(2) Turn fully clockwise the set point dial and set it to the yellow edge line of the INC. MEAS. DEC. OUT scale. Then perform a procedure the same as step (1).



(3) Adjust the deviation link length so that the deviation values read in steps (1) and (2) are the same in the value but the reverse in the direction. The link becomes shorter when the deviation link adjusting screw is turned upward.

When the deviation values in step (1) and (2) are of the same direction, if the red pointer shows a higher value than the green pointer, make the link longer. If the green pointer shows a higher value, make the link shorter.

(4) Make the deviation zero, and set the set point dial to the white line. Under this state, adjust the flapper adjusting screw so that the output is somewhere within a range of 0.1 to 1.3 kg/cm^2.

(5) Set the set point dial to the yellow line, and adjust the deviation link length so that the output is somewhere within a range of 0.1 to 1.3 kg/cm^2.

(6) Repeat steps of (4) and (5) so that in each of the cases in which the set point dial is set to the white and the yellow line, the output will be somewhere within the range of 0.1 to 1.3 kg/cm^2.

2) Differential Gap Controller

Before adjustment, perform the following confirmation procedure (confirmation of zero deviation):

(a) Set the set point pointer at 50%.

(b) Disconnect the travel link (PV) from the indicating mechanism and insert the adjusting pin.

(c) Make sure that there is no deviation between the PV pointer and the SP pointer. If there is any deviation, eliminate it by using the set point pointer adjusting pin.

(d) Remove the adjusting pin and connect the travel link (PV).

o Adjustment

(1) Make initial setting of the flapper adjusting pin and feedback link adjusting pin as follows:

(a) The flapper adjusting pin rotates 360°. Make the pin slot horizontal at the side where the flapper rises when the adjusting pin is turned clockwise.

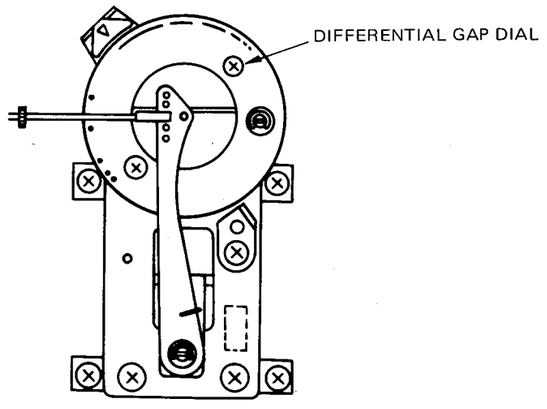
(b) The feedback link adjusting pin also rotates 360°. Make the pin slot horizontal at the side where the link falls when the adjusting pin is turned clockwise.

(2) Set the set point pointer at 50%.

Set the differential gap setting dial at the minimum point (0%) on the INC. MEAS. INC. OUT side. Moving the PV pointer, note the points where the output starts rising and falling and determine the difference between these two points.

(3) Set the dial at the minimum point on the INC. MEAS. DEC. OUT side. Moving the PV pointer, check the points where the output starts rising and falling.

(4) Adjust the deviation link so that the output the rising points of steps (2) and (3) are distribute as equal as possible with the set point as the center of distribution.
If the distribution point is on the plus side, make the link longer. If the distribution point is on the minus side, make the link shorter.



(5) With the flapper adjusting pin, the output rising points recorded in (2) and (3) with the set point.
Repeat actions in (4) and (5) until both rising points conforms with the set point.

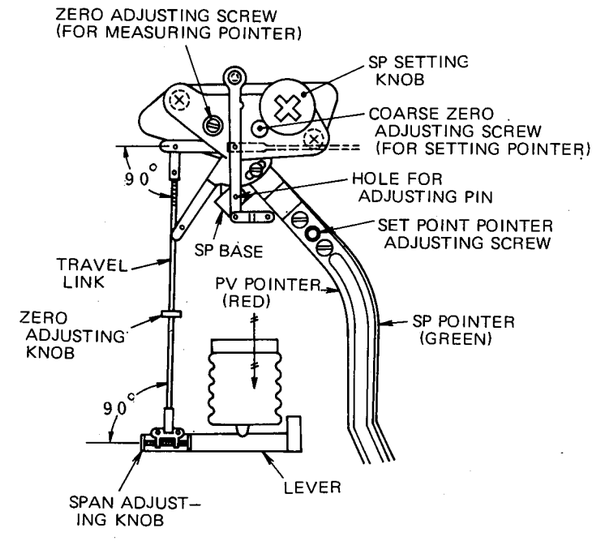
(6) Set the differential gap dial to the 100% position on the right or left side.
Adjust the feedback link adjusting pin so that the output rises at the setting point. (to lower the output for once, slightly open the flapper with the tip of a screw driver.)

(7) Repeat steps (4), (5) and (6) so that the output rising points falls within the gap of set point (SP) ± 1.5% F.S. at entire range of the differential gap dial.

6.6 Adjustment of Indicating Mechanism

Adjustment of the indicating mechanism must be done after that of the deviation generating mechanism and controller mechanism is complete. The indicating mechanism is of the same construction for both the indicating pointer for reading out and the setpoint index for cascade operation.

For adjustment of the indicating mechanism, apply an input to the meter body. To calibrate the setpoint (SP), apply a pneumatic input signal of 0.2 to 1.0 kg/cm² to the ESP connection port of the instrument.



(1) Zero Adjustment

Turn the zero adjusting knob of the travel link so that when the input is 0%, the measuring pointer points at 0. The pointer falls as the knob is turned clockwise as viewed from the bottom of the instrument.

(2) Span Adjustment

Turn the span adjusting screw so that when 80% input is applied, the PV pointer indicates 80%. As the screw is turned clockwise, the span increases.

If a large change in the span is necessary, change the position of connection of the travel link and the hole of the span adjusting screw. As the connection position is set farther from the center of the element, the span becomes larger.

(3) Linearity Adjustment

(a) Check the linearity at the 50% scale point.

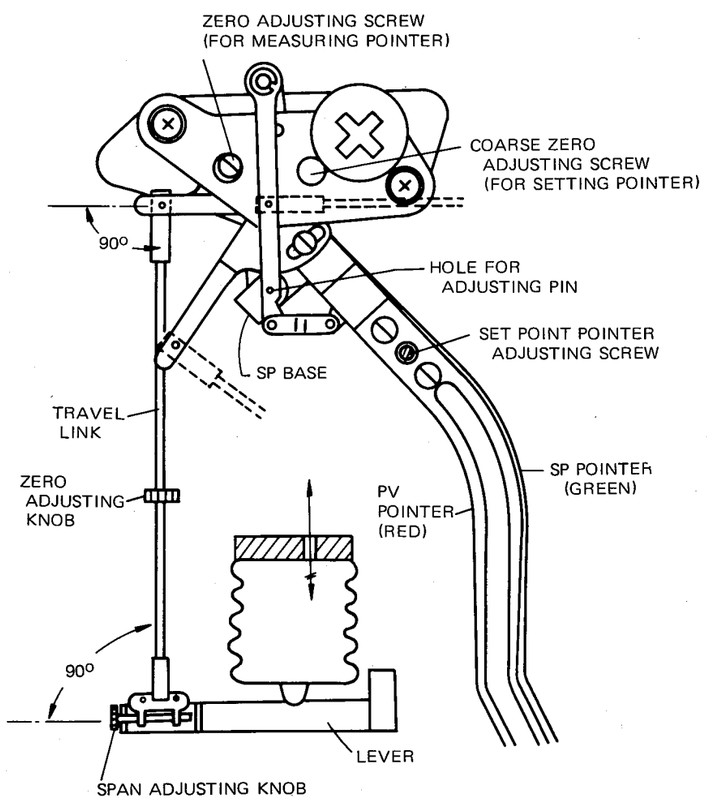
(b) If an error larger than 1% F.S. is detected, change the travel link length by turning the adjusting knob. If the error is plus with respect to the scale, make the travel link shorter (turn counterclockwise as viewed from the bottom.

(c) A change in the travel link length will cause a shisft of zero point. So, loosen the zero adjusting screw, align the pointer to the scale and then fasten the screw.

(d) Check again the zero and span in the method mentioned before.

6.7 Adjustment of Transmitter Unit

The transmitter unit is of a balanced displacement type. When adjusting this unit, check at first that the measuring arm and lever are at the right angle with respect to the travel link. If they are not set the right angle as visually inspected, perform calibration and adjustment of the deviation generating mechanism.



(1) Adjustment of Zero and Span

(a) Set the PV pointer at 0% and turn the zero (linearity) adjusting knob (A) so as to make the transmitted pressure 148 mmHg. The transmitted pressure increases as this knob is turned clockwise as viewed from the case bottom.

(b) Set the PV pointer at 100%, and turn the span adjusting knob (B) so that the transmitted pressure becomes 738 mmHg. The span is decreased as this knob is turned clockwise as viewed from the left side.

(c) Repeat the above procedures so that both zero point and span are correctly set.

(2) Adjustment of Lineality

(a) After adjusting the zero and the span, set the PV pointer at 50% and check that the transmitted output is 433 $\pm$ 6mmHg.

(b) If the output is less than 437 mmHg, turn the zero (linearity) adjusting knob (A) counterclockwise so that the transmitted output increases.

(c) If it is more than 449 mmHg, turn the knob (A) clockwise. In this case, about 10% F.S. movement of the zero point is needed per about 1% F.S. deviation between the PV pointer and the transmitted pressure.

(d) Readjustment for the zero point shift caused as above. If the shift is large, adjust with the coarse adjusting screw (C), and achieve fine adjustment with the zero (linearity) adjusting knob (A). Connect a suitable pressure measuring instrument such as a mercury manometer to the "X" connector on the bottom of case where the transmitted pressure is delivered from.

6.8 Setting of Batch Switch

To set the operation point of the batch switch (if incorporated), proceed as follows:

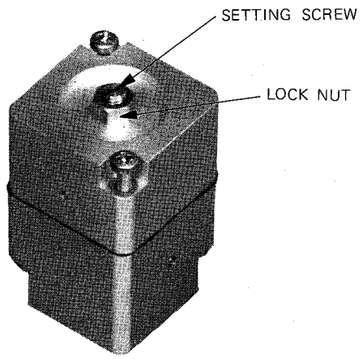
(1) Connect a mercury manometer or a JIS Class 0.5 pressure gauge to the OUT connection port of the instrument.

(2) Set the proportional band setting dial of the controller mechanism in the INC. MEAS. DEC. OUT state and at PB 50%.

(3) Set the reset dial at 0.02 minute position (minimum position).

(4) Apply to the controller mechanism a devication of 10% to 15% FS so that the controller output is increased and saturated.

(5) Turn the setting screw of the batch switch until the desired batch output setting is attained. For this setting, undo the lock nut, turn the setting screw with a screwdriver, and then tighten the lock nut.



(6) When the batch controller function is not required, turn the setting screw to the counterclockwise extreme position.

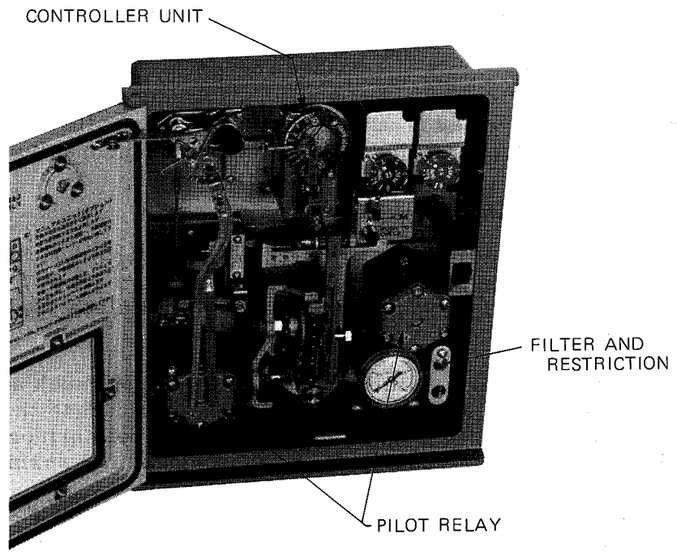
7. MAINTENANCE

7.1 Routine Inspection

(1) Check for any air leakage from the air piping and the connecting joints.

(2) Also check the air supply drain, the filter and compressor, the air cleaning and dehumidifying equipment and the tank.

(3) Check for any clogging of the filter and the restriction inside the instrument. Replace the clogged filter. If the restriction is clogged, clean it with a 0.12 mm wire.



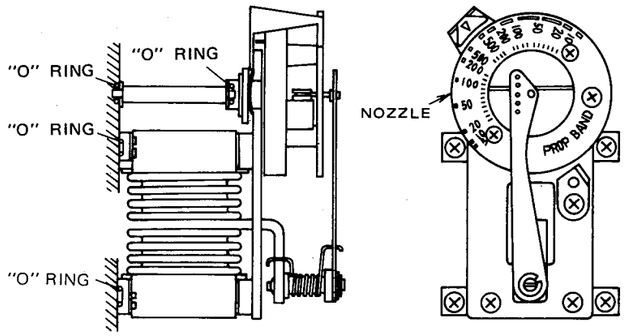
7.2 Controller Unit

(1) Shut off the supply air pressure, and remove the differential link.

(2) Loosen the four clamping-screws of the controller unit, take out the controller unit and clean the nozzle.

(3) For assembly, follow the disassembly procedure in the reverse order. Re-adjust the control unit after re-assembly.

Confirm that the O-rings are placed. Securely tighten the unit with the four screws and check that there is no air leakage.



7.3 Pilot Relay

(1) To remove the pilot relay from the manifold, remove three fastening screws, lock washers and the gasket attached to the manifold.

(2) Servicing the pilot relay

(i) Remove three fastening screws (1), washers (18) and nuts (19).

(ii) Remove parts (3) to (17) in the due order. Unless replacement is required, do not remove parts (2) to (6).

(iii) Clean metallic parts with an appropriate solvent such as petroleum naphtha or chlorosene. Do not apply any solvent to the diaphragms. To let the solvent to pregnate through the sheet surface, push valve system (2) in the direction of compressing conical spring (5).

(iv) Check for any stain on inner exhaust ring (13). If it is stained, clean it with a cloth moistened with solvent.

(v) Fully dry all parts with clean compressed air.

(vi) Replace if diaphragms (16) and (11) are worn or damaged.

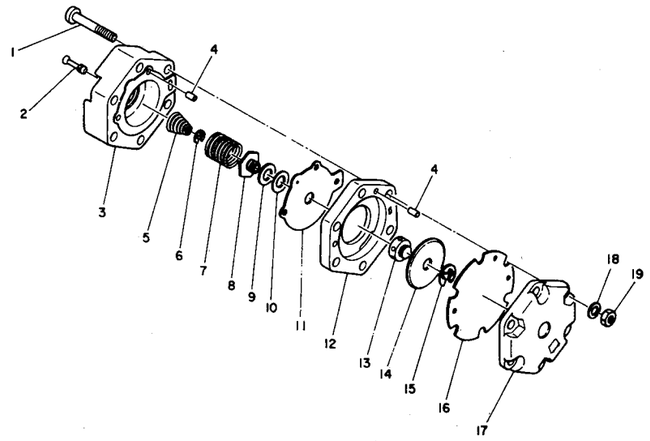
(vii) For reassembly of the pilot relay, assemble all parts in the correct order and fasten them with screws (1), washers (18) and nuts (19).

Tighten all screws to uniform tightness.

(3) Mounting the pilot relay

(i) Place the gasket at the mounting position of the pilot relay.

(ii) Mount the pilot relay to the manifold with the clamping screws and the spring washers. Tighten all screws to uniform tighteness.



Exploded view of pilot relay

No.	Name	Quantity
1	MOUNTING SCREW	3
2	VALVE STEM	1
3	HOUSING	1
4	GUIDE PIN	6
5	CONICAL SPRING	1
6	PIN WASHER	1
7	SPRING	1
8	NOZZLE	1
9	WASHER	1
10	SEAL	1
11	DIAPHRAGM (LOWER)	1
12	EXHAUST RING (OUT)	1
13	EXHAUST RING (IN)	1
14	AREA PLATE	1
15	PIN WASHER	1
16	DIAPHRAGM (UPPER)	1
17	COVER	1
18	WASHER	3
19	NUT	3

7.4 Removing the AUTO Unit when in Manual Operation

(1) Balance the A/M output pressure and transfer operation to the M mode.

(2) Apply a deviation in the direction that the AUTO output pressure decreases. (Turn the SP knob so that SP becomes smaller than PV when in the reverse action or SP becomes larger than PV when in the direct action.)

(3) Set the controller proportional band at the minimum (PB = 5%).

(4) Press the CHECK button of the manual controller unit and check that the AUTO unit output pressure is zero.

(5) Remove the AUTO units (controller unit, rate unit and reset unit). In this case the manual output pressure will slightly fall Re-adjust the manual output pressure as required.

(6) In the case that SP is set in the remote setting mode (cascade type) and cannot be varied, proceed as follows instead of performing the procedure of steps (2) and (3).

(a) Disconnect the link of the element and make zero the AUTO output pressure by moving the PV pointer.

(b) Move the flapper away from the controller so that the nozzle back pressure becomes zero.

7.5 Maintenance of Batch Switch Unit

Periodically clean the vent hole of the unit with a steel wire of 0.8 mm diameter. To detach the batch switch unit from the pneumatic circuit board, remove the two clamping-screws of the batch switch unit. The vent hole is located in the slit at the center on the backs ide of the batch switch unit.

7.6 Maintenance of Meter Body

For maintenace of the meter body, refer to the operator's manual issued separately for the meter body.

7.7 Troubleshooting

For troubleshooting the instrument, see the following table. For adjustment, refer to the preceding chapter.

Symptom	Probable Cause	Remedy
Pilot relay whines.	Valve sheet is stained.	Remove pilot relay, and clean valve sheet.
Little or no control pressure is delivered.	Supply air pressure is off or below 1.4 kg/cm^2. Restriction is clogged.	Provide proper supply pneumatic pressure. Remove restriction and clean it.
	Restriction is not correctly set.	When no transmitter is used, restriction is provided with blind plug. Reattach it to correct position. Correctly set restriction(s) and plug depending on whether the instrument has transmitter or not.
	Filter is badly stained.	Replace filter.
	There is leakage in nozzle circuit of indicating control section.	After making sure that O-rings are properly attached, firmly tighten the controller unit and restriction.
	There is leakage or choking in A/M transfer circuit. (When A/M transfer switch is provided.)	Remove manual control unit and make sure that circuit is correct and that O-rings of connecting section are properly attached. Then, firmly tighten the unit.
	There is leakage from pilot relay diaphragm.	Remove pilot relay, check diaphragm and, in case of leakage, replace diaphragm.

(Cont'd)

Symptom	Probable Cause	Remedy
Control pneumatic pressure is too high.	Nozzle of indicating control section is clogged.	Clean nozzle.
	Restriction screw of indicating control section is not in firm contact with sheet surface.	Tighten so that sheet surface of restriction screw is contacted with the manifold.
	Valve sheet of pilot relay is stained.	Remove pilot relay and clean valve sheet.
Input offset in indication is large.	Set point pointer or measuring pointer is shifted.	Readjust deviation generating mechanism and indicating mechanism. (See section 3.)
	Control mechanism is not properly adjusted. (Proportional band is not properly balanced.)	Adjust the balancing of control mechanism.
Reset rate is abnormal or ineffective.	Needle or sheet is damaged.	Use new needle assembly.
	Dial attaching screw is loose.	Set dial in correct position and fix it firmly with screw.
	Air is leaking from gasket.	Firmly fix it to the base.
Manual control pressure does not rise.	Supply pneumatic pressure is not applied or below 1.4 kg/cm^2.	Supply proper supply air pressure.

(Cont'd)

Symptom	Probable Cuase	Remedy
Manual control pressure does not fall.	Valve stem of manual regulator has collected dirt or dust.	Disassemble and clean manual regulator.
Zero point change unreasonally when range is changed.	Parallelism adjustment of transmitter beam is poor.	Perform parallelism adjustment and calibration.
Output is unstable or pulsates.	Air is leaking.	Tighten pneumatic piping and gaskets.
	Assembly of nozzle flapper is improper.	Reassemble the nozzle.
	Pilot relay is stained.	Remove and clean pilot relay. If necessary, replace it.

SCHEMATIC OF KFD/KFK/KFL INNER PIPING SYSTEM