UDC 621-525+621. 317. 39

S-SERIES IPSOPNEU CONTROLLER

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I. PREFACE

In the field of industrial process control, the trend is toward more centralized control based on a unified signal system. On the other hand, there is also a high demand for a local loop control system. Process variables which can be represented electrically such as temperature, various types of component analyzer values, etc., are transmitted directly to the meter room.

Fuji Electric has recently developed a new IPSOPNEU direct electropneumatic controller in the TELEPNEU S-SERIES. An outline of this new device follows.

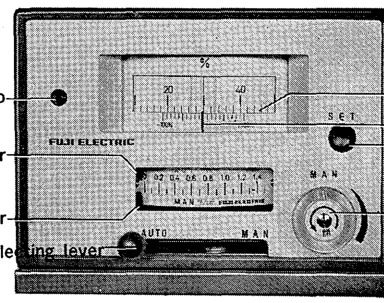

Fig. 1 Front view of IPSOPNEU Controller

II. GENERAL DESCRIPTION

This S-SERIES IPSOPNEU Controller controls electric input and pneumatic output used in the regulation of process variables which can be represented electrically such as temperature, humidity, various types of component values, and various types of process variable variations—all measured electronically.

This controller has pull-out construction, and all operations can be performed at the front of the equipment. A special operating principle and new mechanical concept insure high precision stability, high versatility due to measuring system features, and economical operation. Detailed features of the equipment are as follows.

1) High sensitivity is obtained. Hence, it is possible to make use of low-level signals from thermocouples, resistance thermometer bulbs, resistance bulbs, etc., as direct input signals.
2) With low-level signals used as direct input, it is possible to make an intrinsic safety type transducer and transmission line.
3) High sensitivity and high precision are guaranteed by the elimination of all mechanical play and hysteresis. This is accomplished by a special electrical arrangement and the use of the ABGRIFF electropneumatic spanband.
4) This unit is equipped with a spanband moving coil type indicator which can be used separately as an indicating controller.
5) By attaching a PH-relay, the unit can be used as a proportional controller which switches integral action when the output pressure has become greater than the relay set value. Hence, it is possible to eliminate overshooting caused by integral saturation.
6) Auto-manual switching can be carried out rapidly and smoothly.
7) All operations, including setting of the PID, can be made on the front of the panel.
8) A wide variety of setting units is provided. The set knobs are all one-touch types which are designed to project from the surface of the panel only when the setting is to be changed.
9) The equipment forms a compact unit so that parts replacement, control changeover, and maintenance are greatly simplified. If the control section is removed during operation, manual operation is possible.

Fig. 1 shows the front view of the unit.

III. OPERATING PRINCIPLES

Fig. 2 shows PID operation for a controller with a PH-relay attached.

1. Auto-circuit

The difference between the measured value and the set value can be detected electrically by the setting device. The resulting deviation current is applied to the highly sensitive spanband moving coil type indicator to indicate the deviation and simul-

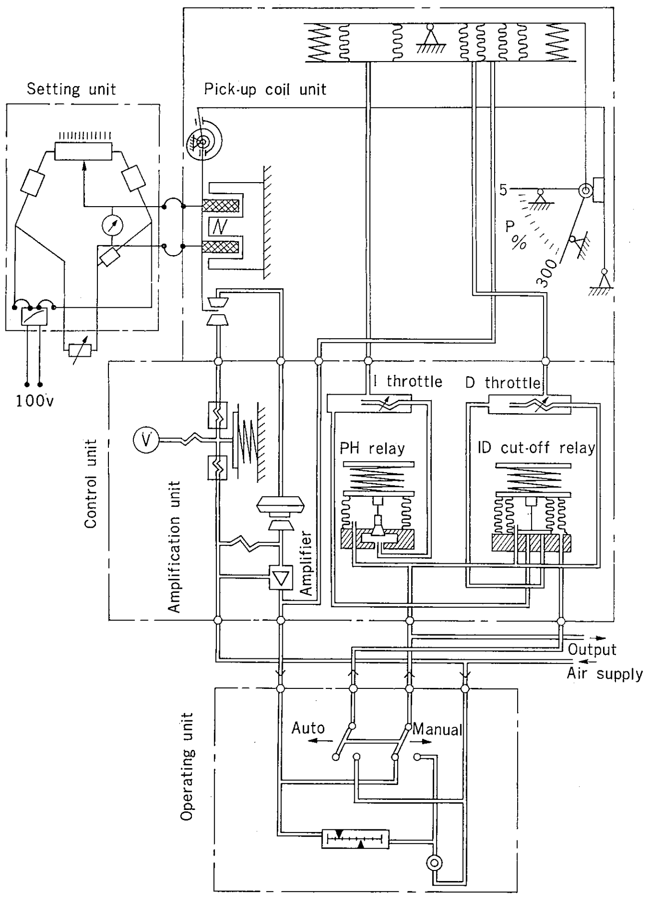

Fig. 2 Operating diagram of IPSOPNEU Controller

taneously to the spanband pick-up coil in the control section. Power corresponding to the polarity and magnitude of the deviation current is transferred to this pick-up coil located within the magnetic field of a permanent magnet, thereby causing displacement of the flapper attatched to the pick-up coil and located between the opposing nozzles. Consequently, the internal pressure in the inlet nozzles is altered.

The injection nozzle constantly injects a set pressure from the pressure divider contained in the preamplifier. The internal pressure in the inlet nozzle is controlled by flapper displacement. In other words, when the flapper is located between the opposing nozzles, the internal pressure in the preamplifier diaphragm decreases. The distance between the nozzles facing the diaphragm grows wider and consequently air is discharged into the atmosphere in larger quantities so that the output decreases. When the pilot valve is not in use, the input signal is amplified approximately 150 times by means of the preamplifier and becomes direct output. When it is necessary to increase the amplification and output flow, the input signal should be further amplified by the pilot valve. If this is the case, the pressure in the injection side of the opposing nozzles is decreased by means of the throttle attached to the preamplifier. The output is fed back directly to the bellows P, integral bellows I, and differential bellows D simultaneously, by means of the throttle and capacitor. A value corresponding to the movement of the balance end which has a fixed plate fulcrum is fed back by means of the feedback bar and spring to the pick-up coil as power with amplification determined by the position of the proportional band lever.

2. Manual Circuit

When the automatic circuit is switched to manual, the interlocking switch lever is actuated and consequently a pressure of 1.4 kg/cm^2 is applied to the outside bellows of the ID-relay. The valve provided on the inside bellows of the ID-relay is then opened so that manual operating pressure bypasses the I and D throttles and is applied directly to the I and D bellows. However, the output of the pilot valve is applied to the P bellows. To balance the force-balance device, the manual and automatic operating pressures must be equal to each other. Hence, if there is no control deviation, the automatic output follows the manual operating pressure and becomes equal.

Therefore, the switchover from manual to automatic operation is done smoothly if there is no control deviation.

3. Output Limited Proportional Control

When desiring to minimize the amount of overshooting in process control if the set value has been changed in a batch process, etc., output limited control can be brought about by merely adding a PH-relay to the equipment.

The output of the pilot valve is connected to the I throttle through the PH-relay. However, when output of the pilot valve has become larger than the relay set value, output overcomes tension of the spring and consequently the valve is closed. In this case the I throttle no longer operates and the control is switched to P or PD action.

The output control point can be adjusted over a range of 0.2～1.0 kg/cm^2 by changing tension of the spring.

IV. UNITS AND CONSTRUCTION

Fig. 3 shows the internal construction of the IPSOPNEU Controller.

The S-SERIES IPSOPNEU Controller consists of a setting unit, an operating unit, a control unit, and a dc power unit. All of these units are installed on the same base and can be pulled out from the front of the instrument as a unit. When mounting the controller body, all operations except wiring and piping can be performed on the front of the panel. Since the control unit pneumatic circuit is automatically sealed by merely removing the pneumatic connector, it is possible to operate the controller manually even after removing the control unit from the controller body.

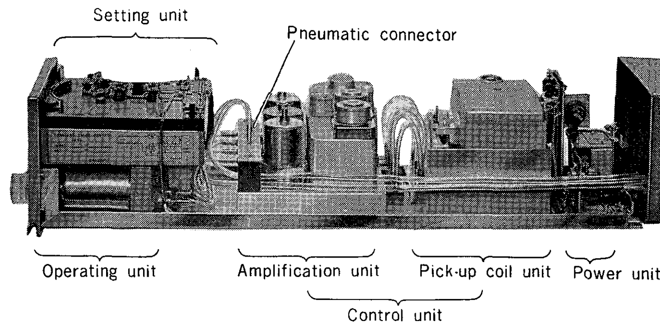

Fig. 3 Internal view of IPSOPNEU Controller

Table 1 **List of Amplification Unit Components**

	P	PI	PID	PD
Pneumatic Canal Plate	○	○	○	○
Pneumatic Connector	○	○	○	○
Preamplifier	○	○	○	○
Power Amplifier	○	○	○	○
ID Cut-off Relay	—	○	○	○
I-throttle	—	○	○	—
D-throttle	—	—	○	○

1. Setting Unit

The setting unit consists of a setting potentiometer, deviation indicator, and potential difference circuit. There are approximately forty types of setting units manufactured as standard units. Among them are those which make use of a TELEPERM unified current input, or direct input from a thermocouple or resistance thermometer bulb.

The setting scale interlocking with the setting potentiometer moves and the setting value is taken as the scale mark indicated by the line in the setting value indicating window. Two potentiometers can be included in this setting unit. With two potentiometers a ratio control circuit and a fixed value control circuit are possible; therefore the controller can function either as a ratio or fixed value controller without using an external setting unit.

The deviation indicator shows a deviation of ±20% on the setting scale when using a TELEPERM signal as input, while it shows a deviation of ±100% in the case of direct input (resistance thermometer bulb or thermocouple).

2. Operating Unit

The operating unit consists of an output indicator, miniature reducing valve, and switching valve. Auto-manual switching can be made as a single action without changing balance or seal position.

3. Control Unit

The control unit consists of the pick-up coil unit and amplification unit. The amplification unit components are compactly assembled to form a complete unit. Hence, a control changeover can be easily carried out by merely changing to a different type of control unit. *Table 1* shows the amplification unit component arrangements in accordance with control desired.

The pilot valve should be used when amplification and output flow rate are necessary. If desired, output can be measured by the preamplifier alone. It is also possible to have PI and PD operations automatically started at greater values than the desired relay setting value by adding a PH-relay as required to the PI and PD controllers.

1) Pick-up coil unit

The pick-up coil unit consists of the ABGRIFF mechanism for handling deviation current transmitted by the setting unit, a force balance device, and a proportional mechanism.

The ABGRIFF mechanism consists of the pick-up coil, spanband (for suspension of the pick-up coil), coupling spring, feedback spring, stopper and adjusting screw, magnet and shielding plate, and nozzle support with two nozzles, two tubes, and a zero adjusting screw. The pick-up coil is balanced by means of deviation current, the feedback spring, or the spanband tension.

The force-balance device is provided with an adjusting screw and consists of three bellows, two springs, a spring tension adjusting worm, and worm

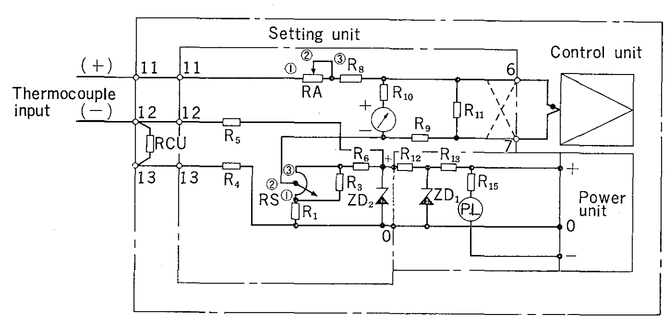

Fig. 4 Constant-value-control circuit of input thermocouple

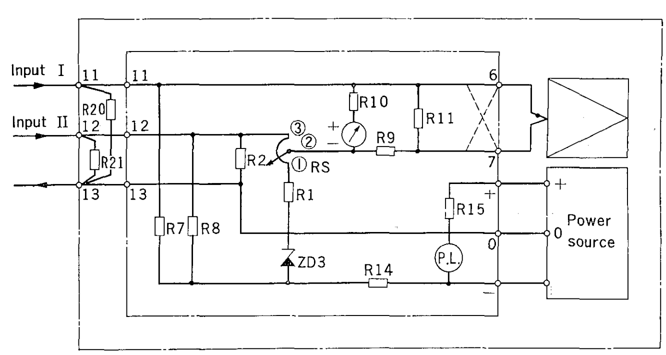

Fig. 5 Ratio control circuit

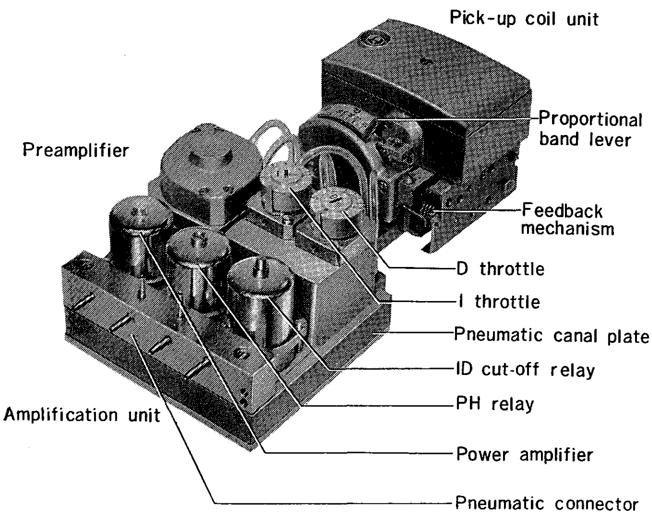

Fig. 6 External view of control unit

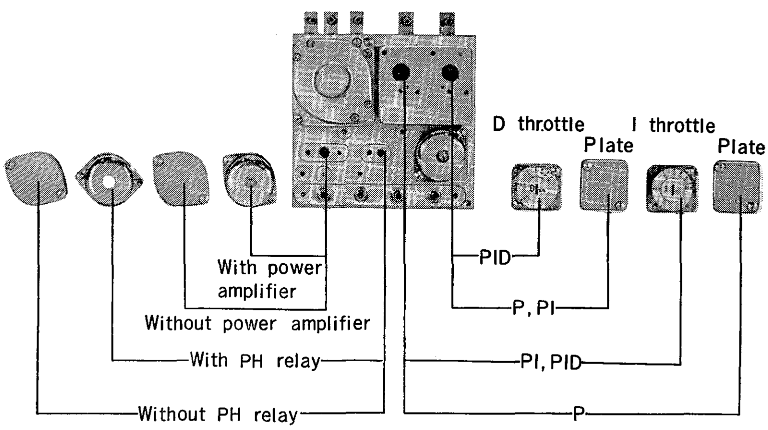

Fig. 7 Amplification unit

gear. This force-balance mechanism serves to convert feedback pressure to displacement. The force-balance unit adjusting screw is used not only for adjusting the tension of the spring when P or PD action is switched to PI or PID action, but for manual resetting and balance adjustment of proportional drift during P or PD action.

The proportional mechanism consists of the proportional scale, lever, link mechanism, and feedback bar. The moving ratio of the feedback bar to the feedback spring shaft can be changed considerably by merely moving the lever.

The relation of the movement *(Y)* of the proportional band link mechanism to the movement *(X)* of the balance plate of the force balance device can be shown by the following formula.

$$(X+l\sin\theta)^2+(Y-l\cos\theta)^2=l^2$$

The feedback gain can be changed depending on the lever position *(θ)*, as shown by the above formula, and hence the proportional band can be changed by adjusting the position of the lever.

2) Preamplifier

The preamplifier consists of a pressure divider (a kind of reducing valve) which furnishes the injection side of the opposing nozzles with a fixed pneumatic pressure, a diaphragm which can amplify minute input pressure up to 150 times, a nozzle, 0.8 ϕ mm and 1.2 ϕ mm fixed throttles, a 0.85 ϕ mm insert throttle 0.4 ϕ mm, and 0.5 ϕ mm threaded throttles, and capacitor.

The pressure divider consists of the silicon diaphragm, the nozzle facing the diaphragm, and a spring. The output pressure can be set as required by merely adjusting spring tension. The pressure divider is specially designed to have a high stability against fluctuation of the air supply.

Fig. 11 shows the relation of the pressure divider output to air supply. When attaching the pilot valve to the after stage, preamplifier gain is reduced by decreasing the range over which the internal

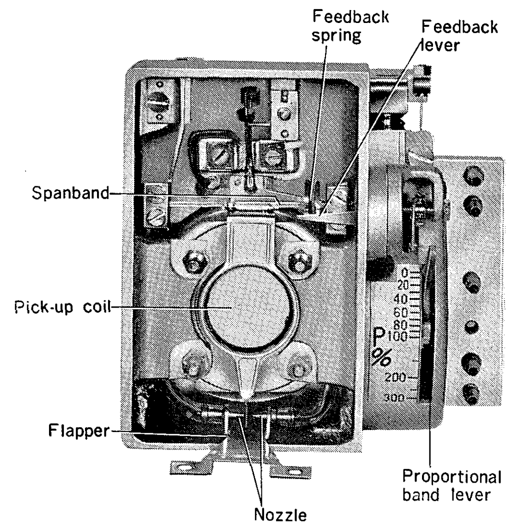

Fig. 8 Internal view of pick-up coil unit

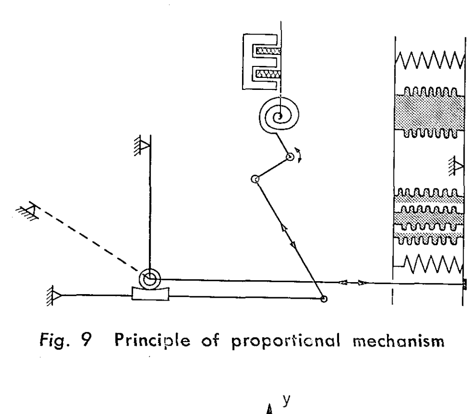
Fig. 9 Principle of proportional mechanism

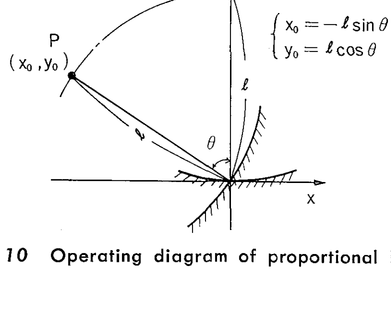

Fig. 10 Operating diagram of proportional band

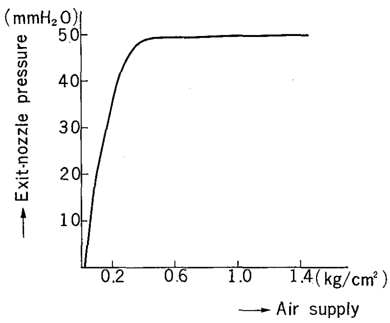

Fig. 11 **Characteristics of pressure divider**

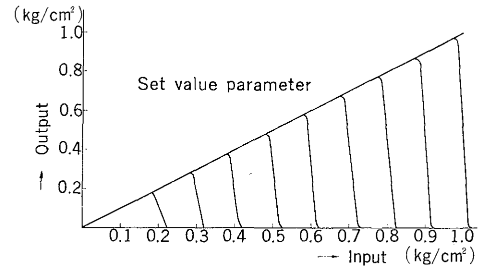

Fig. 15 **Characteristics of PH-relay**

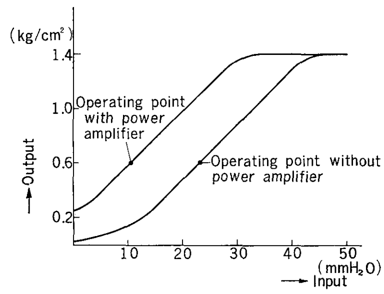

Fig. 12 **Characteristics of preamplifier**

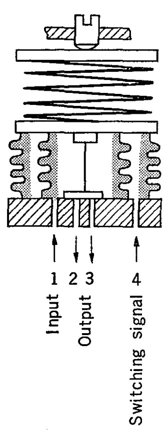

Fig. 13 **Operating diagram of ID cut-off relay**

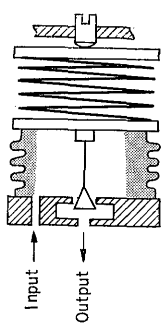

Fig. 14 **Operating diagram of PH-relay**

pressure in the inlet nozzle can vary with a constant flapper displacement volume of the ABGRIFF electropneumatic unit with 0.85 ϕ mm insert throttle placed in the injection nozzle pressure supply.

The preamplifier nozzle diaphragm should be operated at the position shown in *Fig. 12*. The reason why the operating position must be changed by inserting and removing the pilot valve is because output of the preamplifier does not exceed a maximum of 20 mm H_2O because of the insertion of the 0.85 ϕ mm insert throttle.

3) ID cut-off relay

The auto-manual switching circuit is switched by means of pneumatic valve. This valve consists of a spring, two bellows, a valve, and a valve seat. When a 1.4 kg/cm^2 shift signal is applied to the outer bellows, overcoming spring force, the flange is raised, lifting the valve from the valve seat. Pilot valve output which has reached is then connected to the circuits of (2) and (3). *Fig. 13* shows the operating diagram of this ID cut-off relay.

4) PH-relay

This relay is used when output limited proportional control action is required. It consists of a spring, bellows, valve, valve seat, and case. When input has become greater than a set pressure (preset by spring tension), the valve is closed and consequently the output is sealed off.

V. STANDARD SPECIFICATIONS

Input:	Dc 10∼50 ma, or dc 0∼10 mv
Output:	0.2∼1.0 kg/cm^2
Air delivery:	50 N l/min (with pilot valve)
Control constants	
Proportional band:	3∼300% (200%)
Reset time:	0.1∼50 min, or 0.01∼5 min
Rate time:	0.05∼25 min
Zero error	
Air supply fluctuation:	0.2%/± 0.1 kg/cm^2
Proportional band variation:	0.5%
Ambient temeprature:	0∼45°C
Limited proportional action:	(Upper limit) 0.2∼1.0 kg/cm^2
Air supply:	1.4 kg/cm^2
Power source:	100 v ac 50/60 cps