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WHOLE ASPECT OF FUJI FC-SERIES TRANSMITTER

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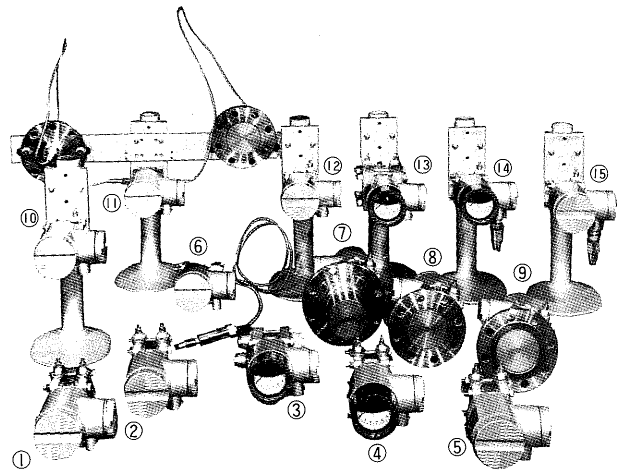
I. INTRODUCTION

Transmitters, which are used widely as industrial sensors for measuring various process variables such as flow, pressure and liquid level, are progressed from the force-balance type (typical type used over a long time) to the open loop slight deflection type which assures remarkably improved accuracy, reliability and maintainability. Starting research on this type very early, Fuji marketed the TELEPERM IS Series Transmitters with semiconductor strain gage in 1971 and has since made remarkable achievements in a variety of processes to establish a technical basis for manufacturing the open loop slight deflection type transmitters.

The recent trend toward digital control of plants, conservation of resources and energy makes it necessary to develop highly accurate transmitters. And higher reliability and maintainability are desired for safe operation of industiral plants which are now constructed on an ever larger scale with more complicated process systems.

In view of such circumstances, Fuji has developed the highly aocurate "Fuji Electronic FC Series Transmitters" based on the measuring principle of electrostatic capacitance (*Fig. 1*) and has completed all the products family mentioned in *Table 1* for commercial use.



① Low differential pressure
② High differential pressure
③ Medium differential pressure (with indicator, material: tantalum)
④ Medium differential pressure (with indicator)
⑤ Very high differential pressure
⑥ Pressure with remote sealing
⑦ Flange liquid level (diaphragm extension type)
⑧ Flange liquid level
⑨ Flange liquid level (Material: Hastelloy C)
⑩ Absolute pressure
⑪ Differential pressure with remote seal diaphragm
⑫ Pressure
⑬ High static differential pressure (with indicator)
⑭ Pressure (flameproof type with indicator)
⑮ Absolute pressure (flameproof type)

Fig. 1 FC series transmitters

Table 1 FC series transmitters

Measuring Item	Type	Measuring range (mmH₂O: 10, 100, 10,000; kg/cm²: 1, 10, 100, 1,000)	Pressure rating (kg/cm^2)
Differential pressure	FFB, FFC, FFF	10 – 30	10, 30, 100, 420
Differential pressure with remote seal diaphragm	FFD	130 – 3.2	10
Pressure	FBC	0.4 – 500	–
Pressure with remote sealing	FBD	0.4 – 500	–
Absolute pressure	FBA	(12mmHg abs) – (3,000mmHg abs)	–
Flange liquid level	FPA	130 – 3.2	10

II. DEVELOPMENT CONCEPT AND FEATURES

Fuji has been making examinations for several years to develop new transmitters of 0.2% accuracy which can meet the requirements enumerated below.

(1) Transmitters offered in wide rangeability and specifications to meet any industrial process requirements.

(2) Transmitters assured high accuracy in actual working conditions in any processes or installation sites.

(3) Transmitters stable enough to assure high accuracy and high performance for a long term.

(4) Transmitters with easy maintenance.

The open loop slight deflection type electronic transmitters are classified depending on measuring principles into three types: ΔR, ΔL and ΔC. Among these types, Fuji has been examining mainly the electrostatic capacitance (ΔC) type and diffused silicon diaphragm strain gage (ΔR) type. The examinations have led to a conclusion that a detector element (cell) which detects deflection of a flat diaphragm as a electrostatic capacitance change elastically floated in an filled liquid or the floating cell construction is the optimum measuring system for meeting all the requirements mentioned above.

1) An important reason for adopting this type of measuring system lies in the fact that the measuring principle of electrostatic capacitance assures a high signal component ratio (ratio of signal component ΔC relative to base capacitance C: $\Delta C/C$) of 30 to 50% about five times as high as that of $\Delta R/R$ of 5 to 10% provided by a diffused silicon straingage.

2) Discussing from the technical aspect, the diffused silicon strain gage is difficult to measure low differential pressures because of machining precision and performances. Further, this type of measuring system (ΔR) requires a complicated compensation circuit and protective device against temperature variation and overpressure. In contrast, the electrostatic capacitance type of measuring system requires a stretched measuring diaphragm at high tension unaffected by thermal expansion, static pressure or bolts tightening torque in order to maintain good pressure-deflection relation in low and medium differential pressure ranges. However, the problem posed by the capacitance measuring system is only structural and can be solved more easily than that of the diffused silicon strain gage type. Fuji has succeeded in solving that problem by its unique technical know-how and adoption of the Floating Cell construction. This is the second reason for selecting the electrostatic capacitance type of measuring system.

Fuji has adopted this type of measuring system and manufactured commercial products which incorporate it.

Now, features of FC Series Transmitters will be introduced below:

1) High accuracy

The electrostatic capacitance measuring system with a measuring diaphragm of high tension has realized a high accuracy of 0.2%.

2) High performance

The Floating Cell construction assures high performance unaffected by variations in static pressure, overpressure, temperature, etc. in actual working conditions.

3) High reliability and excellent long-term stability

The electrostatic capacitance measuring system is highly stable for a long time since it assures a high signal component ratio and uses measuring diaphragm stretched at a stable initial tension. Long-term stability and reliability are further improved owing to the simple, entirely welded construction of the Floating Cell comprising no organic materials.

4) Easy maintainability

The compact, lightweight block construction standardized in external dimensions facilitates handling in the field. All the adjustments are concentrated on the amplifier front panel to allow easy adjustments. In addition, the amplifier unit is usable common with all the types of transmitters and can be replaced with a new one with little performance deviation.

III. MEASURING SYSTEM

Performance of FC Series Transmitters depends chiefly on the factors below:

1) Linearity of the measuring diaphragm
2) Floating Cell construction
3) Detection and caliculation of electrostatic capacitance

1. Linearity of the measuring diaphragm

Pressure-deflection relation of the measuring diaphragm can be approximately expressed as follows (See *Fig. 2*):

$$P = \left\{ \frac{16E}{3(1-\nu^2)} \left(\frac{h}{a} \right)^4 + 4T_0 \left(\frac{h}{a} \right)^2 \right\} \frac{W_0}{h} + \frac{12EA(\nu)}{1-\nu^2} \left(\frac{h}{a} \right)^4 \left(\frac{W_0}{h} \right)^3 \quad \text{.............} \quad (1)$$

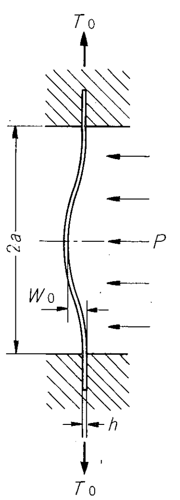


Fig. 2 Deflection of measuring diaphragm

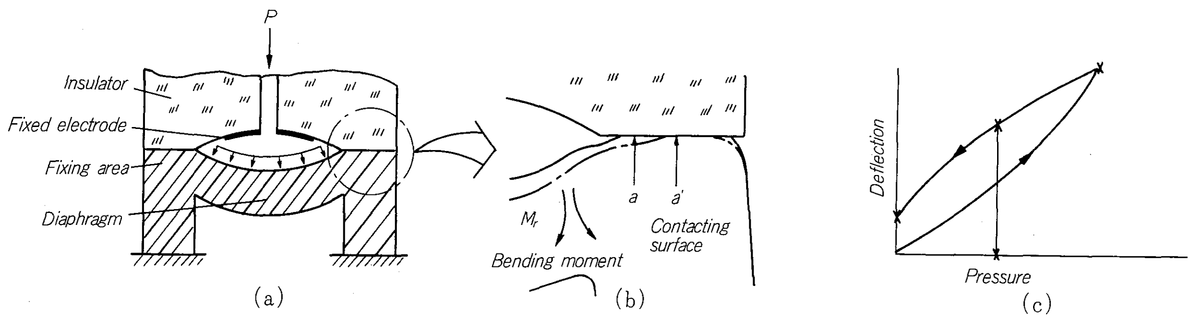


Fig. 3 Deflection of thick diaphragm

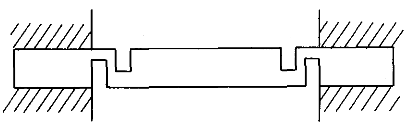


Fig. 4 Measuring diaphragm of pressure transmitter

where E : Young's modulus of diaphragm material
g : Poisson's ratio of diaphragm material
$A(\nu)$: Constant determined by ν

The second term of formula (1) is a non-linear term indicating that the third power of deflection W_0 is proportional to pressure P. This formula proves that linearity is degraded in the thinner region ($h \ll W_0$). It is therefore necessary to give a large initial tension T_0 and increase the first term to have a value large enough to make the second term negligible.

The measuring diaphragm is manufactured by Fuji's unique technique so as to be stretched at a high initial tension. Since the cell in the floating cell construction does not require to withstand static pressure and can easily be made compact, it is possible to manufacture cells having high linearity and little variations. This is the clue to the high accuracy for very low differential pressure down to $0 \sim 10$ mmH_2O with cells having the same diameter.

In the thick region where excellent linearity is obtainable even no intial tension, the characteristic is influenced by outer fixing shape. When a measuring diaphragm is deflected as shown in (a) of *Fig. 3*, the outer fixing area is subjected to a bending moment as shown in (b) of *Fig. 3*, and the surface contacting the insulator is deformed by vertical displacement and radial sliding in the figure. Hysteresis is increased accordingly as visualized in (c) of *Fig. 3.*

In order to correct this defect, the measuring diapharagm of the pressure transmitter is constructed as shown in *Fig. 4*, thereby providing favorable measuring results.

2. Floating cell construction

Structural principle of the differential pressure transmitter with the Floating Cell construction is illustrated in *Fig. 5*.

High and low pressures applied on the seal diaphragms act on the measuring diaphragm through the filled liquid.

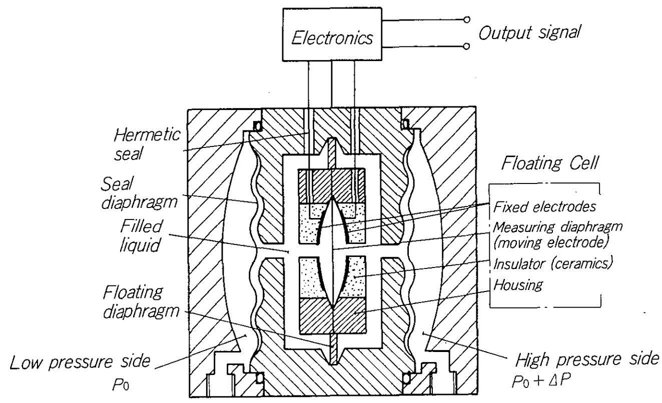


Fig. 5 Principle diagram of differential pressure cell

The measuring diaphragm is deflected by the differential pressure ΔP and produces capacitance change proportional to the deflection of the measuring diaphragm.

As input increases, differential pressure acts also on the floating diphragm to deflect it. When differential pressure exceeds the maximum measuring range, the filled liquid moves to bring the seal diaphragm into close contact with the bed, thereby protecting the measuring diaphragm (the most important element for measurement) from excessive pressure even if differential pressure further increases. Therefore, overpressure error is limited within very narrow.

Since the cell floats in the filled liquid, tension of the measuring diaphragm scarcely changes even when static pressure varies. Therefore, it is possible to make accurate measurement without narrowing the output signal even under a high static pressure.

The floating diaphragm also serves as a cushion between the cell and body, preventing the cell from body thermal expansion due to temperature variation, deformation of body by cover tightening force and external force in mounting or dismounting.

Fig. 6 shows the structural principle of the pressure transmitter. Measuring pressure applied to the seal diaphragm acts on the measuring diaphragm is deflected by the pressure and produces capacitance change proportional to the deflection.

The cell is kept in the floating condition with the pipe. Therefore, the cell is protected from deformation due to high pressure, thermal expansion difference caused by

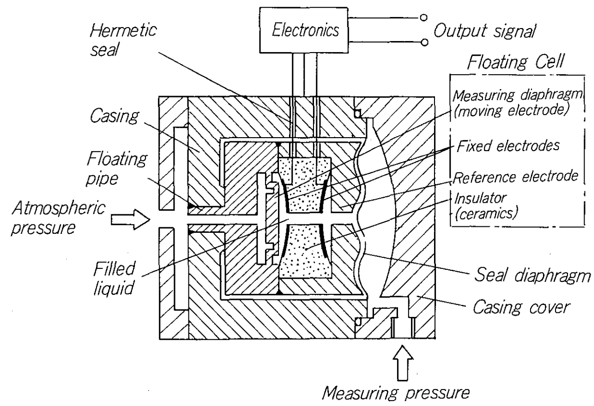


Fig. 6 Principle diagram of pressure cell

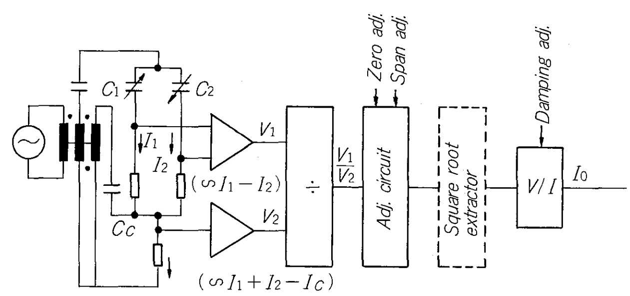


Fig. 7 Block diagram of differential pressure transmitter circuit

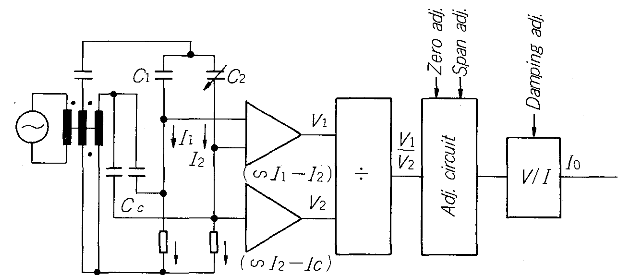


Fig. 8 Block diagram of pressure transmitter circuit

temperature variation or external force applied in tightening the bolts to assure high resistance to environmental conditions and excellent stability.

3. Detection and calculation of electrostatic capacitance

When the measuring diaphragm is considered as a moving electrode, electrostatic capacitance C_1 and C_2 between the moving electrode and fixed electrodes evaporated on the insulator are given by the following equations:

$$C_1 = \frac{\epsilon A}{d_0\epsilon - \Delta d} + Cs \quad \dots\dots\dots\dots (2)$$

$$C_2 = \frac{\epsilon A}{d_0 + \Delta d} + Cs \quad \dots\dots\dots\dots (3)$$

where, d_0 : effective gap between electrodes
Δd : effective deflection of measuring diaphragm ($\propto W_0$)
A : area of electrode
ϵ : dielectric constant of filled liquid
Cs : stray capacitance

From equations (2) and (3) above, we obtain:

$$\frac{C_1 - C_2}{C_1 + C_2 - 2Cs} = \frac{\Delta d}{d_0} \quad \dots\dots\dots\dots (4)$$

Hence, it is possible to obtain a signal equal to $\Delta d/d_0$ through computation by equation (4). Since Δd is proportional to deflection of the measuring diaphragm center, signal proportional to differential pressure ΔP can be obtained. *Fig. 7* illustrates the principle of the electronics circuit for the differential pressure transmitter. A sinusoidal voltage of approx. 60 kHz is added to C_1 and C_2 respectively, whereas its reverse voltage is added to a compensating capacitor Cc (= 2 Cs) corresponding to twice the stray capacitance Cs. When currents there are designated by I_1, I_2 and Ic respectively, these are proportional to capacitance of each capacitor.

Then, computation of $(I_1 - I_2)/(I_1 + I_2 - Ic)$ is performed by a dividing circuit to obtain the required signal by the following equation:

$$V_0 = \frac{V_1}{V_2} = \frac{I_1 - I_2}{I_1 + I_2 - Ic} = \frac{C_1 - C_2}{C_1 + C_2 - Cc} = \frac{\Delta d}{d_0} \dots (5)$$

After performing zero adjustment and span adjustment for signal voltage V_0, it passes through a damping filter circuit to be converted into output signal (DC 4 to 20 mA).

In $\sqrt{\Delta P}$ transmitter for transmitting signal proportional to flow rate, square root is extracted in the circuit enclosed by bloken line.

Since C_1 is kept constant in case of the pressure transmitter, formula (2) above can be transformed as follows:

$$C_1 = \frac{\epsilon A}{d_0} + Cs \quad \dots\dots\dots\dots (6)$$

From formula (3) and (6), we obtain:

From formula (3) and (6), we obtain:

$$\frac{C_1 - C_2}{C_2 - 2Cs} = \frac{\Delta d}{d_0} \quad \dots\dots\dots\dots (7)$$

In the following circuits, these signals are processed in quite the same manner as the differential pressure transmitter to get an output signal proportional to deflection of the measuring diaphragm sown in *Fig. 8*.

IV. MAINTAINABILITY

The FC Series transmitters are designed compact, lightweight and standardized in external dimensions for assuring easy handling. They have a block construction as shown in *Fig. 9*, which allows convenient assembly and disassembly. Each block is sealed with O-rings. All types of transmitters

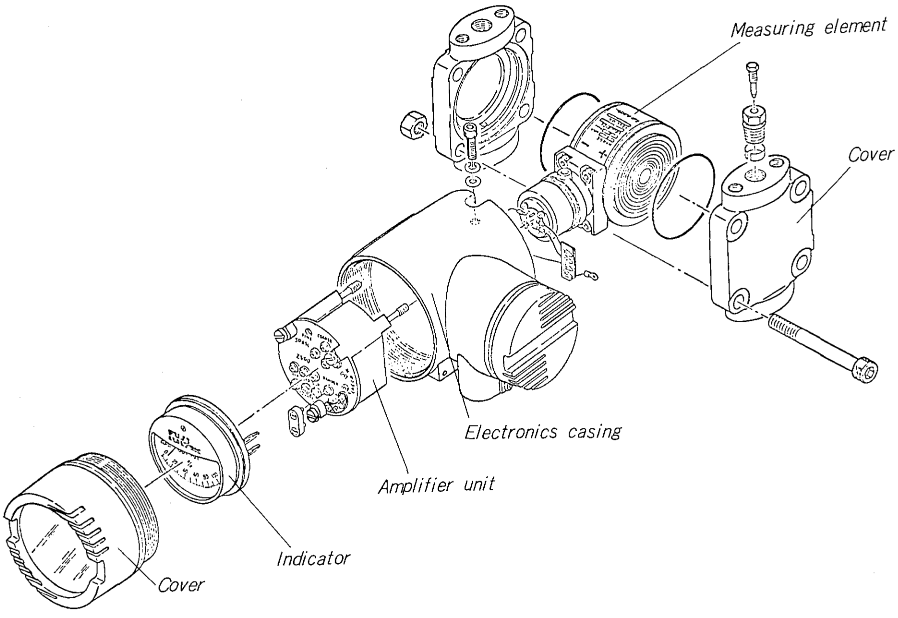


Fig. 9 Construction of transmitter

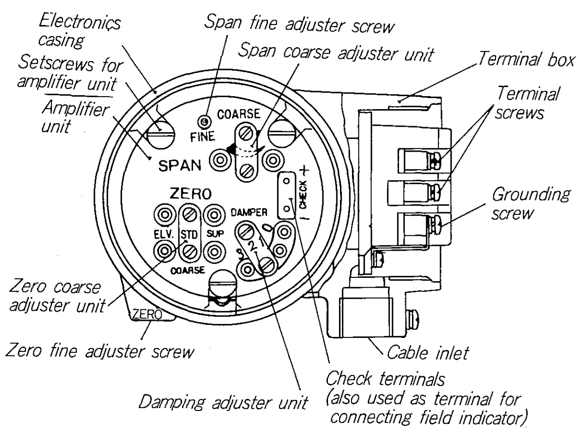


Fig. 10 Internal view of transmitter

have the same construction as that of the differential pressure transmitter exemplified in *Fig. 9*.

All the adjusting are arranged on the front panel of the transmitter as illustrated in *Fig. 10* to allow an easy maintenance. Wide turndown ratio of 1 to 10 is permitted simply by reconnecting a short bar of the span coarse adj., to be easily adjusted on site after the installation. The amplifier unit used in the electronics is interchangeable for all types of FC Series Transmitters (except flow transmitter). That is, the same positioning of zero coarse, span coarse and damping adjuster causes little performance change when replacing with new one.

For simple checks in the field, a field indicator is usable by plug it in the check terminals located on the front panel.

V. SPECIFICATIONS AND TYPES OF FC SERIES TRANSMITTERS

Table 2 lists specifications common to all types of FC

Table 2 General specifications for FC-series transmitters

Standard specifications	Wiring system	Two-wire type
	Output signal	DC4~20mA linear to d.p. (ΔP) DC4~20mA linear to flow rate ($\sqrt{\Delta P}$)
	Allowable maximum load resistance	$R_{max} = \frac{U-12}{20} \times 10^3\,\Omega$
	Power supply U	$12 \leqq U \leqq 45$V.DC
	Ambient temperature	$-30° \leqq Ta \leqq 80°$
	Weather resistance	DIN 40040 HQC
	Water proof	JIS C 0920 submergible type DIN IP54
	Explosionproof	Intrinsic safety JIS i3nG5 Flame-proof JIS ds2G4
	Turndown ratio	1 : 10 (1 : 5 in case of $\sqrt{\Delta P}$)
	Zero shift	-32~100% of maximum span (-20~20% for $\sqrt{\Delta P}$) (-100~100% for FPA)
	Damping time constant	0, 0.8, 2.2, 6 sec.
	Conduit connection	1 x PF½ internal thread
	Electronics casing	Aluminium alloy Epoxy-polyurethane double coating Silver
Additional specifications	Field indicator	Built in electronics casing, 1.5 class, scale length 75 mm, 0 ~ 100% linear scale, square root scale or actual scale (30, 35, 40 or 50 divided linear or square root)
	Arrester	Built in electronics casing, With Z-trap (gapless lightnin arrester element) Protective function Resistance to impulsive discharge 8 x 20 μs 2000A Number of repeated discharges 8 x 20 μs 100A, 400 times Additional error less than 0.1%

Table 3 Specifications for FC-series transmitter

		Type	Measuring range (1)... Unit of mmH_2O (2)... Unit of kg/cm^2 (3)... Unit of mmHg abs	Maximum working pressure (kg/cm^2)	Materials of wetted parts	Fluid temperature (°C)	Weight (approx.) (kg)	Process connection	Special specifications
Differential pressure	Very low differential pressure	FFB11	0~10 ...100(1)	10	Standard: Diaphragm ... stainless steel JIS SUS316L, Others ... stainless steel JIS SUS316 (casing cover of high static pressure type ... Steel), Corrosion resistant materials: Hastelloy C, monel metal, tantalum (available for medium and high differential pressure, differential pressure and pressure with remote seal diaphragm, pressure and flange liquid level)	-30 to 100 (-30 to 180°C for differential pressure and pressure with remote seal diaphragm and flange liquid level)	6.5	PT¼ internal thread (or PT½ internal thread with oval flange)	Specifications for oxygen measurement, chlorine measurement, vacuum and cold areas, etc...
	Low differential pressure	FFB22	0~25 ...250(1)	30					
	Medium differential pressure	FFC	0~130 ...1,300(1) 0~640 ...6,400(1)	100					
	High differential pressure	FFF35	0~3,200 ...32,000(1)						
	Very high differential pressure	FFF36	0~3 ...30(2)						
	High static differential pressure	FFC, FFF	0~640 ...6,400(1) 0~3,200...32,000(1) 0~3 ...30(2)	420			12		
Differential pressure with remote seal diaphragm		FFD	0~130 ...1,300(1) 0~640 ...6,400(1) 0~3,200 ...32,000(1)	10, 30			14~29	Flush type: Flange JIS-80A Diaphragm extension type: Flange JIS-100A	
Pressure		FBC	0~0.4 ...4(2) 0~2 ...20(2) 0~10 ...100(2) 0~50 ...500(2)	–			5	PT¼ internal thread or PT½ internal thread with oval flange	
Pressure with remote sealing		FBD	0~0.4 ...4(2) 0~2 ...20(2) 0~10 ...100(2) 0~50 ...500(2)	–			7.5~11	JIS flange for 4 and 10 kg/cm^2, PF 1 screw type for 100 and 500 kg/cm^2	
Absolute pressure		FBA	0~12 ...120(3) 0~60 ...600(3) 0~300 ...3,000(3)	5			5	PT¼ internal thread or PT½ internal thread with oval flange	
Flange liquid level		FPA	0~130 ...1,300(1) 0~640 ...6,400(1) 0~3,200 ...32,000(1)	10, 30			12~21	Flush type: Flange JIS-80A Diaphragm extension type: Flange JIS-100A	

Series Transmitters.

Though power supply voltage is specified as 12 ~ 45 V, it must be lower than 26 V for intrinsically safe construction and 27 V for transmitter with an arrester.

Ambient temperature should be controlled to 60°C or lower for explosionproof type, and within a range of -10 to 60°C for oxygen or chlorine measurement.

Weatherproof, waterproof constructions are specified as classes according to DIN standard in West Germany. Weatherproof construction class HQC is usable at the maximum humidity of 100% RH and annual average humidity of 80%.

As for the explosionproof construction, the transmitters are prepared in both intrinsically safe type and flameproof type. For flameproof type, cable gland is supplied additionally together with explosionproof shroudings according to specifications.

Zero shift of -100 to +100% is assured for flange type liquid level transmitter.

Table 3 summarizes types and main specifications of FC Series Transmitters.

As for corrosion resistant materials, the transmitters are classified in two types; one has only the seal diaphragm of a corrosion resistant mateial, and the other all the wetted parts of corrosion resistant matierals.

Oxygen or chlorine measurement transmitters are degrease treated and filled with fluorine oil.

Each type of transmitter will be described briefly below.

1. Differential pressure transmitter

The same external dimensions within a remarkably wide range from 10 mmH_2O to 30 kg/cm^2 eliminate the conventional large-scale low differential pressure transmitters.

The high static differential pressure transmitter FFC4 permits the Floating Cell to fully exhibit its excellent static pressure performance, and is optimum for main water supply or main steam flow measurement of boilers in power plants.

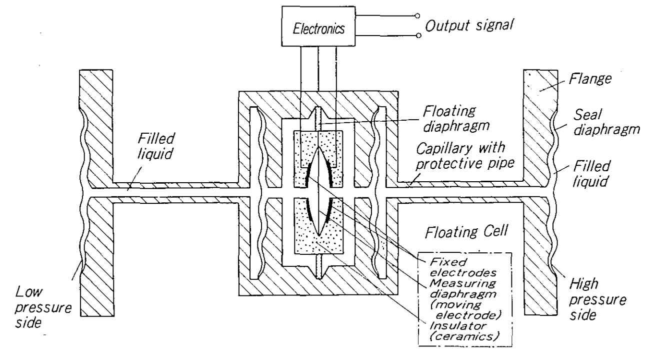


Fig. 11 Principle diagram of differential pressure transmitter with remote seal diaphragm

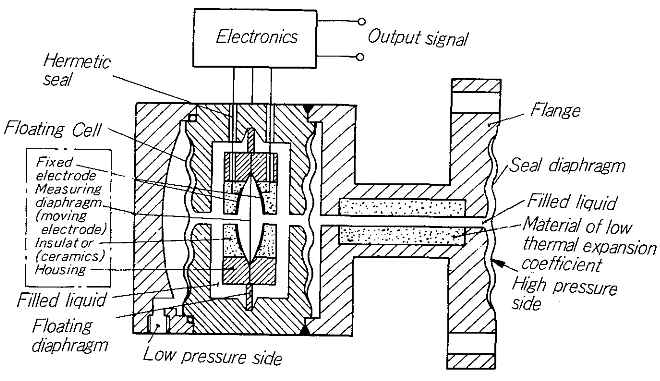


Fig. 14 Principle diagram of flange type level transmitter

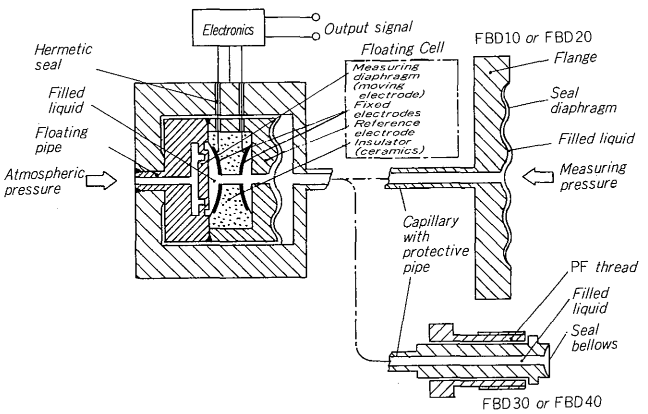


Fig. 12 Principle diagram of pressure transmitter with remote sealing

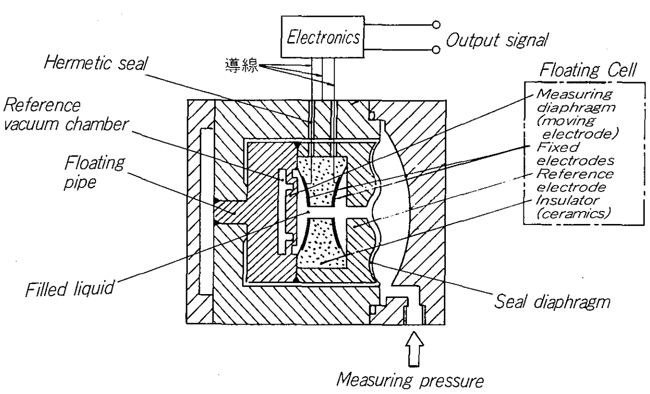


Fig. 13 Principle diagram of absolute pressure transmitter

The process connection is PT½ internal thread when equalizing valve is used. When a PT½ process connection is necessary without an equalizing valve, an oval flange should be employed.

Structural principle of the differential pressure transmitter with a remote seal diaphragm is shown in *Fig. 11*.

2. Pressure transmitter

Four types of pressure transmitters are prepared for covering a wide range from 0.4 to 500 kg/cm^2.

The PT½ process connection is designed for use with an oval flange.

Construction of the pressure transmitter with a remote sealing is illustrated in *Fig. 12*.

3. Absolute pressure transmitter

Construction of the absolute pressure transmitter is visualized in *Fig. 13* in which atmospheric pressure side is sealed to compose a reference vacuum chamber. The absolute pressure transmitters provide accurate measurement in three ranges from 12 to 3,000 mmHg abs. even the lowest pressure transmitter can withstand pressure up to 5 kg/cm^2.

4. Flange type liquid level transmitter

Fig. 14 clarifies the structural principle of the flange liquid level transmitter consisted of a differential pressure transmitter detector with a flange.

On the low pressure side, the process connection has PT¼ internal thread which is the same as with the differential pressure transmitters. An oval flange should be used with a PT½ process connection of internal thread.

5. Related equipment

In addition to the components described above, equalizing valves, intergral orifices, oval flanges, etc. are prepared for use with FC Series Transmitters.

VI. CHARACTERISTICS AND RELIABILITY

This section will introduce some test results on characteristics and reliability of FC Series Transmitters.

1) Linearity

Fig. 15 and *Fig. 16* exemplify linerarity at the maximum, medium and minimum spans of a FC Series Transmitter. Linearity is better as span is narrower.

2) Static pressure effect

Fig. 17 exemplifies static pressure effect of a differential pressure transmitter in which span deviation is minimized at a high static pressure of 350 kg/cm^2 owing to the Floating Cell construction. This effect was measured with a precision manometer manufactured by Exactel Instrument Co..

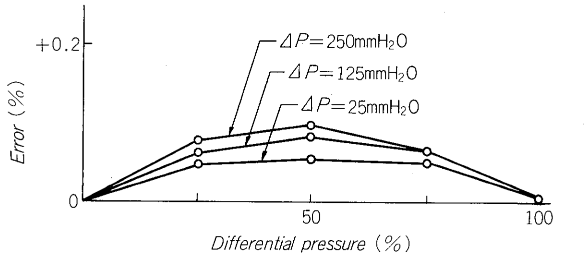


Fig. 15 Linearity curves of differential pressure transmitter type FFB22

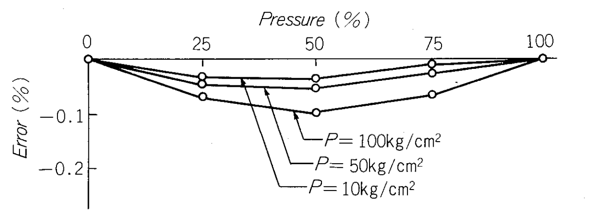


Fig. 16 Linearity curves of pressure transmitter type FBC30

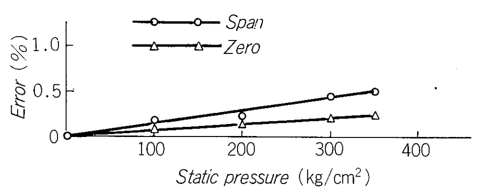


Fig. 17 Static pressure effect

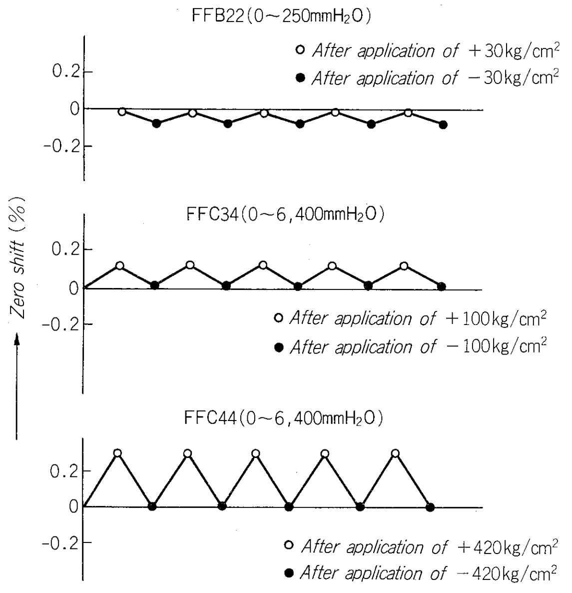


Fig. 18 Overpressure effect

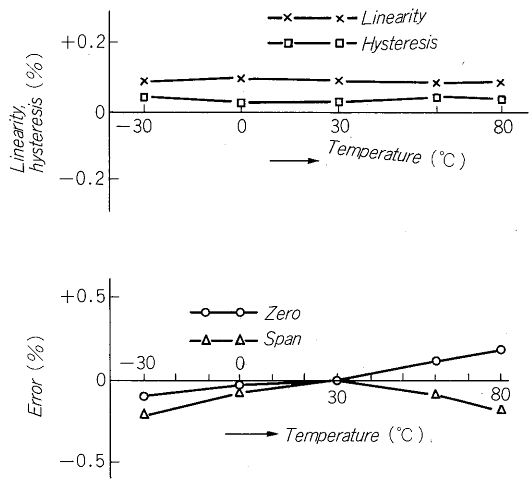


Fig. 19 Temperature effect

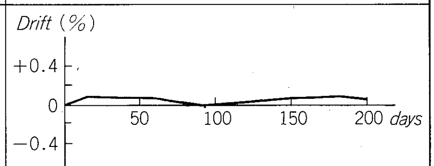
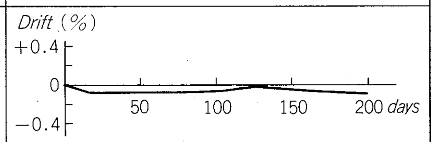
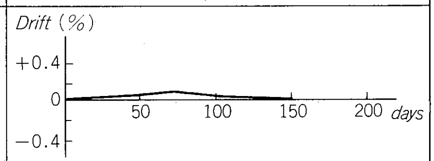
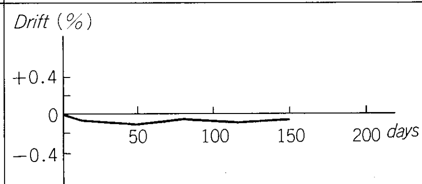
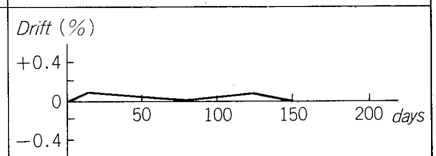
Test conditions	*Zero drift*
Outdoors *Input:* 100kg/cm² *constant* *Measuring range:* 0~100kg/cm² *Type:* FBC30	
Outdoors *Input:* 20kg/cm² *constant* *Measuring range:* 0~20kg/cm² *Type:* FBC20	
Indoors *Input:* 0↔20kg/cm² *Repeating cycle:* 12 *times/min.* *Measuring range:* 0~20kg/cm² *Type:* FBC20	
Outdoors *Input:* 300kg/cm² *constant* *Measuring range:* 0~300kg/cm² *Type:* FBC40	
Outdoors *Input:* 0↔4kg/cm² *Cycle repeating:* 12 *times/min.* *Measuring range:* 0~4kg/cm² *Type:* FBC10	

Fig. 20 Long-term stability of pressure transmitter

3) Overpressure effect

Fig. 18 visualizes an example of zero shift measured immediately after the rated pressures were applied to the positive and negative pressure chambers respectively. This figure shows that output is highly stable all the low, medium and high differential pressure transmitters.

4) Temperature effect

Fig. 19 illustrates how temperature variation deviates the zero, span, linearity and hysteresis. It can be understood that linearity and hysteresis are stable regardless of temperature variation in FC Series Transmitters.

Table 4 Reliability test data

Item	Test Conditions	Results
High humidity	45°C, 95 ~ 100% RH, 1,000 hours	No abnormality, zero drift less than 0.2%
High temperature	100°C, 1,000 hours	No abnormality, zero drift less than 0.2%
Low temperature	-50°C, 1,000 hours	No abnormality, zero drift less than 0.2%
Quick cooling	80°C → 20°C, Splashing water	No abnormality, zero drift less than 0.5%
Cyclic heating	10 cycles of 90°C ↔ -40°C	No abnormality
Repeated differential pressure	0 ↔ maximum span pressure, 10^8 times	No abnormality, linearity variation less than 0.2%
Repeated overpressure	0 ↔ 6 kg/cm^2, 10^6 times	No abnormality, zero drift less than 0.2%
Static pressure	Maximum working pressure x 1.5, 1,000 hours	No abnormality, zero drift less than 0.2%
Influence due to direct sunlight	Exposure to direct sunlight in X, Y and Z directions in summer	Variation in characteristic less than 0.2%
Outdoor	Leaving outdoors for one year	No abnormality, zero drift less than 0.2%
Vibration	16.7 Hz, 1G in X, Y and Z directions for 1,000 hours	No abnormality, zero drift less than 0.2%
Water-proof	JIS C 0920 immersed in water for 24 hours	No abnormality
Influence due to external magnetic field	5 oersteds in X, Y and Z directions	Little variation in characteristic

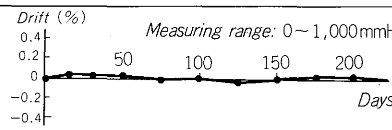
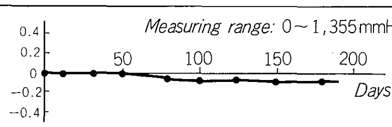
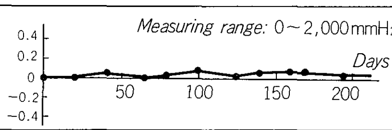
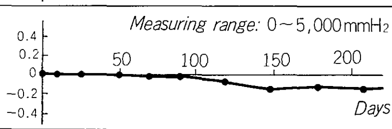
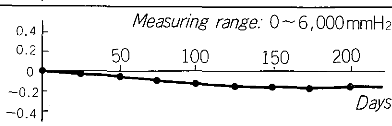
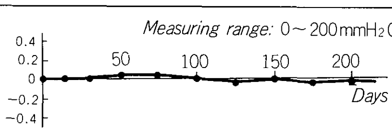
User	*Test and environmental conditions*	*Zero drift*
Petro-chemistry	*Measurement of corrosive gas in environmental-pollution-preventive plant* *Transmitter installed on roof of plant at seashore industrial area where it is badly subjected to heat radiation and corrosive gas.*	 Drift (%) *Measuring range:* 0～1,000 mmH_2O
Petro-chemistry	*Measurement of differential pressure of gas in liquid air manufacturing plant where input level remarkably varies.* *Operated in corrosive atmosphere in seashore industrial area.*	 *Measuring range:* 0～1,355 mmH_2O
Chemistry	*Measurement of highly pulsating flow rate in sea water condensing plant.* *Installed in extremely corrosive atmosphere in seashore industrial area.*	 *Measuring range:* 0～2,000 mmH_2O
Chemistry	*Measurement of flow from boiler.* *Installed in highly corrosive outdoor atmosphere in seashore industrial area.*	 *Measuring range:* 0～5,000 mmH_2O
Steelmaking	*Measurement of trading flow rate between users.* *Installed in corrosive outdoor atmosphere and subjected to counter differential pressure irregularly several times a day.*	 *Measuring range:* 0～6,000 mmH_2O
City water	*Flow rate measurement of city water pumped up to grouped residences on a hill.* *Installed in underground concrete pit which is always filled with water of 10 cm deep.*	 *Measuring range:* 0～200 mmH_2O

Fig. 21 Field test data of differential pressure transmitter

5) Reliability test

Test data on long-term stability of the pressure transmitter are exemplified in *Fig. 20*. It is clear that zero is highly stable regardless of pressure conditions (i.e., scarcely affected by repeated pressure application or constant pressure application).

Table 4 lists reliability test data which have proved that the characteristics of the differential pressure transmitter are highly stable in any process or environmental conditions. *Fig. 21* shows field test data obtained at actual sites of users who ran the tests at Fuji's request.

These test results have clarified the fact that FC Series

Transmitters are excellent in long-term stability and usable in any fields of application.

VII. POSTSCRIPT

Main test data and constructions on FC Series Transmitters has been introduced in this paper. Furthermore, a variety of other tests have been effected on all the types with good results. Since the transmitters have been field-proven as to their excellent resistance to adverse process' and environmental conditions, the instruments will surely provide full satisfaction to each user. It is expected that 'FC Series Transmitters will be increasingly employed in various fields of application.