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EXPANSION OF FCX SERIES TRANSMITTERS AND FIBER-OPTIC FIELD INSTRUMENTATION SYSTEMS

Tadanori Yuhara
Yoshimi Watanabe

1. FOREWORD

Fuji Electric field instrumentation systems are roughly divided into electronic systems and optical systems. The electronic systems are centered about FCX Series transmitters. The optical systems consist of fiber-optic field instrumentation system FFI (Fiber Optical Field Instrumentation System). Both systems take advantage of their respective features and are used in the world field and are highly evaluated by users in PA (Process Automation) and FA (Factory Automation) alone or mixed.

This paper describes the series expansion (line up addition of new products) of the two field instrumentation systems above.

2. EXPANSION OF FCX SERIES TRANSMITTERS

The new generation electronic transmitters FCX Series is a new development concept of ±0.1% high accuracy on all ranges and smart ⇔ compatible never seen before and appeared at the International Measurement Industry Exhibition (JEMIMA) held in October 1989 and INTERKAMA'89 (Dusseldorf) and attracted much attention from engineering manufacturers and measurement equipment manufacturers, not to mention world users. The FCX Series, the shipment of which began at the beginning of 1990, has accumulated a record of 40,000 units over two years. High-temperature, high-vacuum specifications transmitters were added to the FCX Series line up, which gained the high acclaim and trust of world users in an extremely short time. The remote seal type differential pressure transmitter for high-temperature and high-vacuum service is outlined here.

2.1 Transmitter composition and principles of operation

The remote seal type differential pressure transmitter is shown in *Fig. 1*. Its principles of operation and construction are shown in *Fig. 2*. The remote seal type transmitter consists of a body containing a silicone sensor which detects the differential pressure as an electrostatic capacitance change and a pressure receiving flange with liquid diaphragm and a capillary tube (filled with silicone oil) which connects these. The sensor is an electrostatic capacitance amount type sensor with a single-crystal silicone diaphragm as the measuring diaphragm and is common to the FCX Series. The measurement pressure acts on the measuring diaphragm of the silicone sensor through the remote seal section liquid diaphragm and sealed in fluid. The measuring diaphragm is displaced in proportion to the pressure difference (differential pressure) which is applied to the two liquid diaphragms and the electrostatic capacitance (differential capacitance) generated between the two fixed electrodes provided at both sides of the measuring diaphragm is changed. Needless to say, the −DC4 to 20mA conversion circuit (electronics) is common to the FCX Series.

Fig. 1 High-temperature and high-vacuum remote seal type differential transmitter

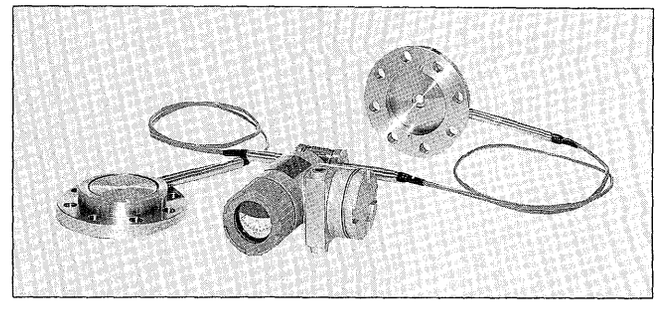
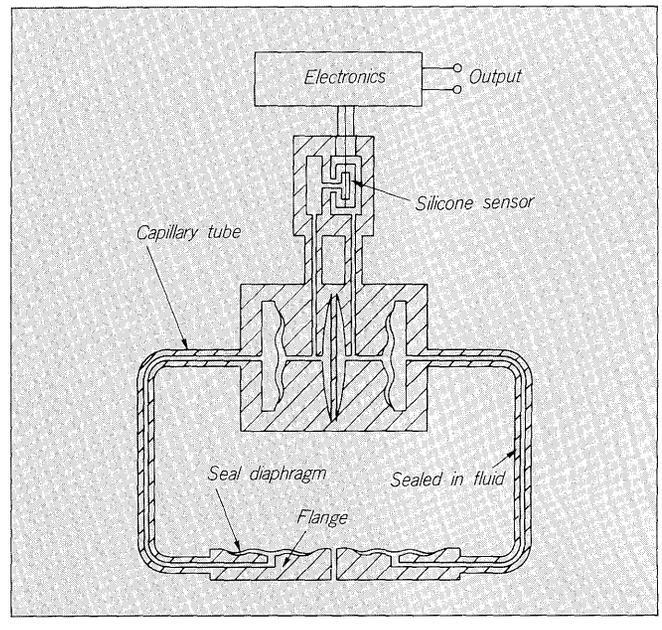


Fig. 2 Construction and principles of operation of remote seal type differential pressure transmitter



2.2 High-temperature and high-vacuum specifications transmitter manufacturing technology

When a transmitter is used at a high-temperature and high-vacuum process, gas is generated at the temperature sealed in fluid section by the following causes:

(1) Thermal breakdown of the sealed in fluid
(2) Breakdown of the gas dispersed in the sealed in fluid
(3) Breakdown gas of oil, grease, etc. on the metal surface of the sealing container

The generated gases cause the pressure of the measurement chamber to rise and the output signal is change.

The manufacturing technology applied to solve these problems are shown below.

(1) Selection of superior heat-resistant methyl phenyl-siloxane silicone oil as the sealed in fluid
(2) Removal of dirt on the material surface by strengthening of parts cleaning and baking under a high temperature and high vacuum
(3) Degassing of silicone oil under high temperature and high vacuum
(4) Screening of inside of sealing container under high temperature and high vacuum

2.3 Specifications of remote seal transmitter for high-temperature and high-vacuum service

The main specifications of the remote seal transmitter for high-temperature and high-vacuum service added to the FCX Series transmitters line up are shown below.

(1) Accuracy rating: ±0.2% (including linearity and hysteresis)
(2) Flange rating: JIS 10 K/30 K, 80 A/100 A
ANSI/JPI, DIN
(3) Measurement span: 0~0.32 . . . . . 3.2 mH_2O
0~0.64 . . . . . 6.4 mH_2O
0~1.3 . . . . . 13 mH_2O
0~5 . . . . . 50 mH_2O
(4) Liquid end diaphragm material: SUS316L
(5) Diaphragm projection length: 9, 50, 100, 150, 200 mm
(6) Negative pressure allowable limit: 2 Torr (200°C)
(7) Liquid end temperature: −15~200°C

The remote seal type differential pressure transmitter for high-temperature and high-vacuum service was outlined above. Remote seal type pressure transmitter and flange level transmitter were lined up simultaneously as transmitters for high-temperature and high-vacuum service.

3. EXPANSION OF FFI SYSTEM

The FFI system is a new generation fiber-optic instrumentation system with

(1) smart field equipment
(2) Use of field bus
(3) fiber-optic transmission

as the three basic concepts. Since its announcement in 1985, many have been used in various plants both inside and outside Japan and have received favorable comment. The devices which make up the FFI system include cooperative research with many measuring equipment manufacturers and completion of the field devices product line and expansion of the interface with the higher level system have progressed and the current general system architecture has become possible.

Fig. 3 FCX/FFI transmitters

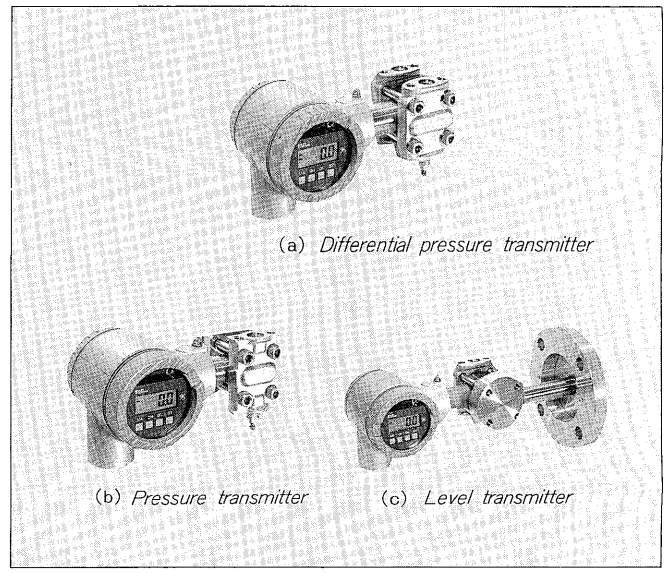
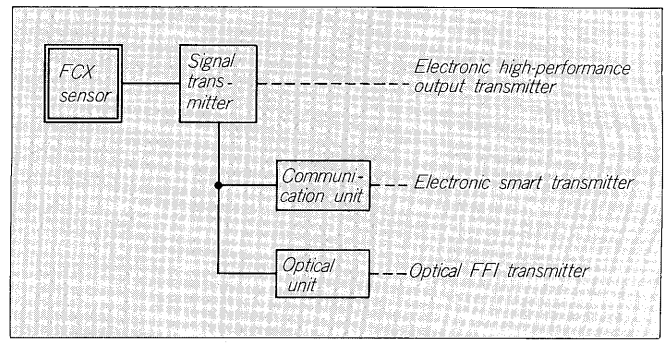


Fig. 4 Fuji Electric transmitter family composition



This section introduces the optic FCX/FFI of the Fuji Electric FCX Series transmitters and some of the cooperatively developed products recently added to the FFI family.

3.1 FCX Series transmitter optical FCX/FFI

FFI of the FCX Series transmitter using the Fuji Electric acclaimed microcapacitance silicone sensor was completed. The FCX/FFI differential transmitter, pressure transmitter, and level transmitter are shown in *Fig. 3.*

The FCX/FFI transmitters maintain the high accuracy, high stability, wide variation, small size and light weight, and other features of the FCX Series transmitters while superimposing the optical featured of FFI. By the completion of FCX/FFI, the three series of

(1) electronic high-performance analog transmitter (4–20 mA)
(2) electronic smart transmitter (4–20 mA + digital communication)
(3) FFI transmitter (optical digital communication)

Fuji Electric transmitters could be built by using the same

Table 1 FCX/FFI transmitter specifications

Specification \ Format		Differential pressure			Level	Pressure	Absolute pressure
		Low range	Medium range	High range			
Measurement range		2 models 0.....100mmH$_2$O 0.....600mmH$_2$O	3 models 0.....3,200mmH$_2$O 0.....6,400mmH$_2$O 0.....1.3kgf/cm^2	3 models 0..... 5kgf/cm^2 0.....20kgf/cm^2 0.....30kgf/cm^2	4 models 0.....3,200mmH$_2$O 0.....6,400mmH$_2$O 0.....1.3kgf/cm^2 0..... 5kgf/cm^2	5 models 0.....0.64kgf/cm^2 0..... 5kgf/cm^2 0..... 30kgf/cm^2 0.....100kgf/cm^2 0.....500kgf/cm^2	4 models 0...0.16kgf/cm^2 abs 0... 1.3kgf/cm^2 abs 0... 5kgf/cm^2 abs 0... 30kgf/cm^2 abs
Accuracy rating (including linearity and hysteresis)		Up to 1/6 range ±0.1%, 1/6–1/10 range ±0.2%			1/10 maximum span or greater ±0.25%	Up to 1/6 range ±0.1% 1/6–1/10 range ±0.25%	1/10 maximum span or greater ±0.2%
Temperature characteristic (total error at maximum span)		±0.8%/55°C	±0.5%/55°C		±1.5%/55°C ±0.8%/55°C*	±0.5%/55°C	±0.8%/55°C
Static pressure characteristic	Zero (maximum span)	0.2%/10kgf/cm^2 0.2%/32kgf/cm^2	0.2%/160kgf/cm^2		0.2%/flange rating	–	
	Span	0.2%/32kgf/cm^2	0.2%/100kgf/cm^2		0.2%/flange rating		
Overpressure characteristic (at maximum span)		0.3%/10kgf/cm^2 0.3%/32kgf/cm^2	0.3%/100kgf/cm^2 0.3%/160kgf/cm^2 0.5%/420kgf/cm^2		0.3%/flange rating	0.2%/allowable overpressure	
Output, power requirement		Optical digital signal, internal lithium battery (life approximately 2 years)					
Zero point drift		–100% to +100% of maximum measurement range (URL)					
Damping		Variable from 0 to 51.2 seconds					
Operating ambient temperature range		–30 to +70°C					
Working pressure		32kgf/cm^2	100, 160, 420kgf/cm^2		Flange rating	–	
Allowable maximum pressure		Up to working pressure				0.64~30kgf/cm^2 300% of URL 100, 500kgf/cm^2 150% of URL	5kgf/cm^2 or 300%URL
Outer case construction		IEC IP65, NEMA 4					
Explosionproof construction		Intrinsically safe explosionproof JIS, FM BASEEFA					

* Option

sensor. The Fuji Electric transmitter family is shown in *Fig. 4.*

3.1.1 Specifications of FCX/FFI transmitters

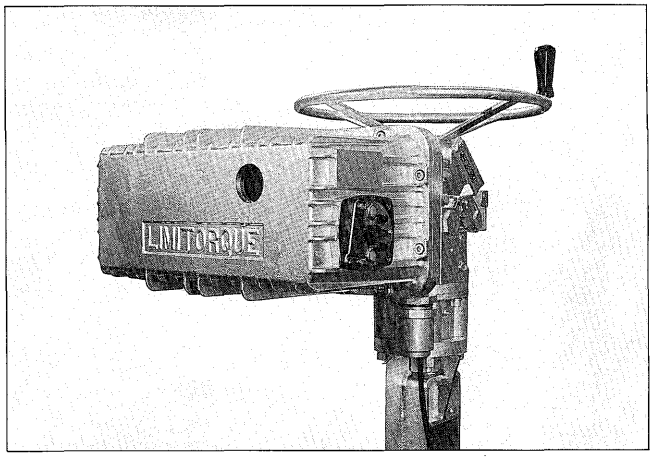
The specifications of the FCX/FFI transmitters are shown in *Table 1.*

The aims were expansion of the measurement range as compared to conventional FFI transmitters, improvement of accuracy, improvement of various characteristics, expansion of the operating ambient temperature range, and other improvements. In *Table 1*, the specifications of only the differential pressure, level, pressure, and absolute pressure transmitters are given, but FFI of the all the FCX Series transmitters, including the remote seal type differential pressure and pressure transmitters and transmitters for high-temperature and high-vacuum service, is complete.

3.2 FFI electric valve actuator LIMITORQUE

The FFI electric valve actuator LIMITORQUE (NIPPON Gear Co., Ltd. product developed cooperatively by Fuji Electric and NIPPON GEAR Co., Ltd., called FFI/limitorque hereinafter) was added to the final control equipment of the FFI system. It is shown in *Fig. 5.*

Fig. 5 FFI/LIMITORQUE electric valve actuator



A electric actuator with a three-phase motor as the power source makes drive source is used for valve drive at various large plants because drive source procurement is easy, a large operating force can be obtained, and its self-lock characteristics and other features. Because of the

Table 2 Specifications of FEI/LIMITORQUE electric valve actuator

Type	Control	Position sensor	Valve opening data	Alarm data
(1)	Open, close, stop	Geared limit switch	Full open, full close	Overtorque thermal relay tripping
(2)	Open, close, stop	RC encoder	Full open, full close Valve position	Overtorque thermal relay tripping
(3)	Open, close, stop, Closed loop control	RC encoder	Full open, full close Valve position	Overtorque thermal relay tripping

demand for rationalization, centralized management, etc. due to the labor shortage of recent years, the demand for automation of existing manual valve, etc. is increasing steadily.

The features obtained by FFI of the electric valve actuator can provide the following merits, in addition to noise resistance, lightening resistance, remote maintenance, and other common features of the FFI system:

(1) Cable-saving, work cost reduction

An electric system requires several ten signal wires between the control room and field to receive open, close, and stop command signals from the control room and opening position limit switch signals, opening torque limit switch signals, valve opening signal, and other status signals from the motor actuator. The FFI motor actuator not only make signal reception of all these possible with a single-core optical fiber cable (single-core two-way communication), 1:8 multiplex transmission is realized by using a field bus and makes a large contribution to reducing work material costs and work costs.

(2) Simplification of instrumentation design and work inspection

Instrumentation design (sequence creation) and wiring check, test run, and other post-work processes can be reduced by the cable-saving and duplex multiplex communication described previously.

(3) Long-distance transmission

Since the FFI electric actuator uses an optical fiber for signal transmission, there is no need to fear transmission range restrictions, etc. due to the stray capacitance between the wires like those seen with the electric system and long-distance transmission up to 1.2 km without repeating and up to 10.2 km if an optical repeater is used is possible.

3.2.1 Types and specifications of FFI/LIMITORQUE

The FFI/LIMITORQUE consists of the following three types:

(1) With open, close, stop command, without valve position feedback

(2) With open, close, stop command and valve position feedback

(3) With open, close, stop, intermediate opening command and valve position feedback

The simple specifications of these three types are shown in *Table 2*. The specifications unique to the motor actuator are omitted.

The new family of the FFI system was introduced above.

4. CONCLUSION

Expansion of the FCX Series electronic transmitters and fiber-optic field instrumentation systems was described above. The construction of electronic transmitters and optical transmitters with a common sensor was realized and flexible field application and maintenance without being aware of the differences between the electronic (analog/smart) and optical transmission systems was made possible by completion of FFI and FCX/FFI of the FCX series transmitters.

We are confident that these new products added to the line up will contribute to expansion of new application areas of field instrumentation and hope that they become an aid in instrumentation planning by instrumentation engineers and designers.

The expanded FCX Series and FFI system will be exhibited at the International Measurement Industry Exhibition (JEMIMA) to be held in Tokyo in October.