

New Technologies for Measuring Instruments

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1. Introduction

Fuji Electric's measuring instruments have a history of 50 years. During this time, Fuji Electric has developed new technologies and offered new products to lead the industry. Recently in the field of measuring instruments, in addition to improvements in performance and functionality, the following features are being requested: compatibility with various applications, low added installation and maintenance costs, and measures for dealing with environmental problems including the requirements of ISO 14000.

Under these circumstances, Fuji Electric has been developing new unique products for various product groups, based on the following principal concepts.

- (1) To supply products that are well timed to meet the needs of the market timely
- (2) To develop distinctive products by means of evolutionary and unique technology
- (3) To propose a product line for international markets

New specifications have been added to Fuji Electric's field instrument transmitters, which are widely accepted internationally. These new features include a sanitary model, required especially in the food and medical industries, and a small flange model required for level meters in the petroleum and petrochemical industries and also for general use. The total system cost for these products has been revised.

Among the different types of flowmeters, demand for ultrasonic flowmeters is especially expected to increase. Fuji Electric has developed a fixed installation model in addition to the portable model. To satisfy diversified customer's needs, the measuring precision and response characteristics have been improved, as well as performance and functionality, including multi-path and multi-pipe measurement. The electromagnetic flowmeter will be applied to various fields including the water treatment, food processing and petrochemical industries. To support these areas, Fuji's product line has been enriched by developing, in addition to the wafer and flange models, new models such as the sanitary, explosion-proof and surface mount models.

In the field of receiving instruments, Fuji Electric's economical temperature controller has undergone a model change. The new model achieves the following improvements.

- A fuzzy logic control function is attached to improve and extend functionality.
- A smaller front size has been adopted corresponding to the recent smaller size of cubicles and machines.
- The PXZ series, compliant with the NEMA4 waterproof standard, has been developed for the food processing field.

In the recorder market, at the same time as functions are advancing and becoming more varied, user needs remain strong for more economical, and easy to use models. Fuji Electric has developed the "Microjet Recorder-E" series, an industrial-use hybrid recorder that is economical and can be used in the same manner as an analog recorder. This series has been added to the family of inkjet recorders that are able to record and print clearly with high quality, a continuing effort by Fuji Electric.

The market for analyzer devices has become active as these devices are used as a means to reduce the dioxins generated in an incineration plant or are used in relation with ISO 14000. In response, Fuji Electric has developed a new infrared gas analyzer. Its small module construction enables the measurement of a maximum of five components simultaneously by a single unit and is suitable for measuring concentrations of many kinds of gases, including exhaust gas.

This paper will describe details of the above mentioned types of measuring instruments.

2. Field Instruments

2.1 FCX-A series of small flange type transmitters

In recent years, there has been strong customer demand for reduced installation and maintenance costs of devices that measure pressure, flow and fluid levels. To reduce costs, small flange type transmitters, have been mounted directly on small equipment, making instrumentation possible that does not use impulse piping. To meet such requirements of the

Fig.1 Small flange remote seal type differential pressure transmitter



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Table 1 Specifications of the FCX-A small flange transmitter

Item \ Group	Level trans-mitter	Remote seal type	
		Differential press. transmitter	Pressure transmitter
Flange sizes		$\frac{1}{2}$ B, $\frac{3}{4}$ B, $1\frac{1}{2}$ B, 2B	
Flange rating		JIS 10, 20, 30K ANSI/JPI 150, 300LB	JIS 10, 20, 30, 63K ANSI/JPI 150, 300, 600LB
Measuring span		3 to 130 kPa 12.5 to 500 kPa	0.05 to 3 MPa 0.25 to 10 MPa
Material of the wetted parts		316L stainless steel, Hastelloy	
Capillary length	—	1.5, 3, 5 (m)	
Ambient temperature		- 15 to +65 °C	
Liquid temperature		- 40 to +120 °C	
Rated accuracy		0.25%	
Temperature effect (zero drift)		$\pm 1\%$ / 55°C (Measuring span: larger than half of the maximal span)	

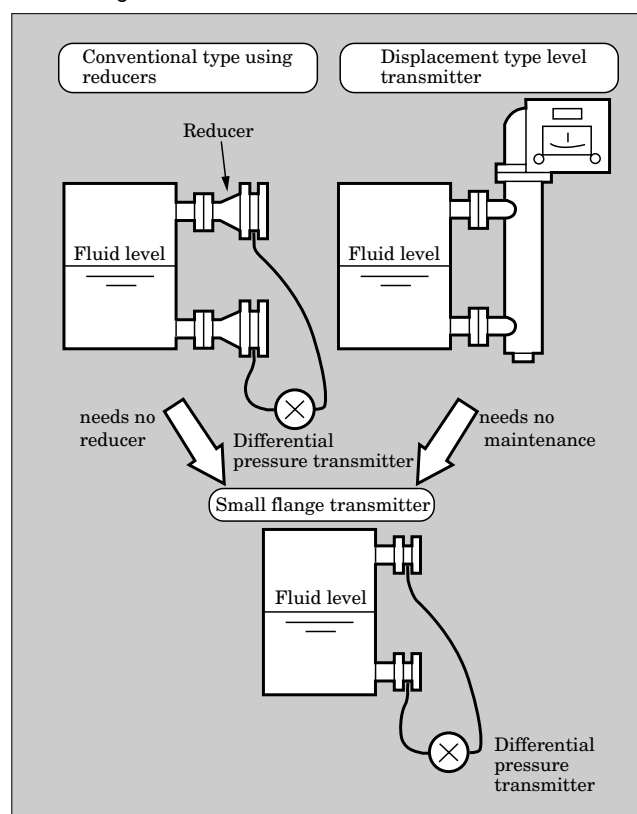
customer, Fuji Electric has developed transmitters with smaller flanges ($1\frac{1}{2}$ B, 2B, $\frac{1}{2}$ B, and $\frac{3}{4}$ B), although most of the conventional flange mount type transmitters have flanges of 3B or 4B.

The following items have either been solved technically or have evolved with the product development.

- (1) By simply changing conventional wetted parts to smaller flange sizes, the highly linear operating range of the seal diaphragm would become too small to be used. Therefore, construction of the wetted part has been optimized, to maintain the necessary linear operating range.
- (2) The wetted part has been constructed such that commercially available gaskets can be used.
- (3) $1\frac{1}{2}$ B and 2B are standard flange sizes. Adapters are applied for smaller size flanges. The application of adapters also enables compatibility with various processes having other dimensions.

Figure 1 shows the external view of the remote seal

Fig.2 Example of fluid level measurement using the small flange transmitter



type differential pressure transmitter, the most commonly used model among small flange type transmitters.

2.1.1 Specifications

The specifications of FCX-A, the small flange type transmitter, are shown in Table 1. Corresponding to such various applications as direct mounting on small equipment or the replacement of impulse pipes, many flange sizes are available.

2.1.2 Example of fluid level measurement using a small flange type transmitter

An example of fluid level measurement using a small flange transmitter is shown in Fig. 2. $1\frac{1}{2}$ B and 2B flanges are generally applied to small tanks. To mount a transmitter having 3B flanges to such small tanks, it was necessary to use a reducer for the connection. However, the newly developed small flange transmitter can be mounted using no reducer, thereby eliminating the reducer cost. To measure fluid levels in a small tank, the displacement type level transmitter has been generally used. The displacement type level transmitter requires regular maintenance because it has a mechanically sliding part. By replacing the installed displacement type level transmitter with the small flange remote seal type, such regular maintenance required for the displacement type transmitter as disassembling and cleaning becomes unnecessary, resulting in reductions of those corresponding costs.

Fig.3 New ultrasonic flowmeter



Table 2 Specifications of the new ultrasonic flowmeter

Item	Specification
Applicable pipe dia.	13 to 6,000 mm (according to the type of sensor used)
Measuring path	Max. 4 measuring paths (according to the type of transmitter used)
Measurable fluid	Homogenous fluid with a turbidity < 10,000mg/L
Measuring range	0 to 0.3 ... 32m/s
Accuracy rating	±1.0% of the rate
Power source	100 to 240 V AC ±10%, 50/60Hz
Input/output signals	4 to 20 mA DC, Integrated output, Input/output status, each 1 point
Indicator display	16 columns × 2 rows, LCD with backlight

2.2 New ultrasonic flowmeter

Following the introduction of the “Portaflow-X” portable type ultrasonic flowmeter in 1995, a new fixed installation type flowmeter has been developed. This new type of flowmeter is summarized below.

2.2.1 Features

(1) Small size and lightweight

Adoption of state-of-art electronics and digital signal processing has reduced the size and mass of the transducer to half that of our conventional products.

(2) Improved anti-bubble characteristics

The application of digital signal processing has improved the anti-bubble characteristics to more than 10 times higher than that of our conventional products.

(3) Excellent temperature characteristics

Excellent temperature characteristics are realized by real-time measurement of the propagation path of the ultrasonic waves and the speed of sound in the liquid to be measured, and by compensating for the affects of liquid temperature and pressure.

(4) A wide variety of products

Fuji Electric has developed 2 types of transducers, a standard type having a single path with a single function and a high performance type capable of multi-

Fig.4 New electromagnetic flowmeter



Table 3 Specifications of the new electromagnetic flowmeter

Item	Specification
Applicable pipe dia.	2.5A to 300A
Electrode material	316L stainless steel, Tantalum, Hastelloy, Platinum, Iridium
Lining material	Teflon (PFA mold), Polyurethane rubber
Measurable fluid	Conductive fluid with a conductivity > 3μS/cm
Measuring range	0 to 0.1 ... 15m/s
Rated accuracy	±0.5% of the rate
Power source	100 to 240V AC ±10%, 50/60 Hz.
Input/output signals	4 to 20 mA DC, Integrated output, Input/output status, each 1 point
Indicator display	16 columns × 2 rows, LCD with backlight

Fig.5 Temperature controller PXZ series



path or multi-pipe measurement.

2.2.2 Specifications

Table 2 shows the main specifications of the new ultrasonic flowmeter of Fig. 3.

2.3 New electromagnetic flowmeter

The new developments in electromagnetic flowmeters have entirely revised this product series. A summary is listed below.

2.3.1 Features

(1) Varied products line

In addition to the wafer type and flange type, the

sanitary type, explosion-proof type and surface mount type have been added to the product line.

(2) Optimized magnetic field design

An optimized magnetic field design minimizes the effect on measurements due to the flow velocity distribution and material composition of adjacent pipes.

(3) Safety for water condensation and submersion

The integrated electronics housing and the terminal box of separate type detectors have two airtight chambers that protect against water condensation and submersion.

(4) Class 3 (JIS) grounding is possible with the explosion-proof type

The housing construction is separated by insulation and a built-in barrier to reduce the cost of class 3 (JIS) grounding for the explosion-proof type flowmeter (patent for new practical design).

2.3.2 Specifications

Table 3 shows main specifications of the new electromagnetic flowmeter of Fig. 4.

3. Receiving Instruments

3.1 PXZ series of temperature controllers

In recent years, temperature controllers have progressed from relatively simple temperature control up to the area conventionally known as process control. Temperature controllers are classified as economic, medium and high performance types. As the application area of the temperature controller widens, greater functionality is required of the controller, including the economic type. Recognizing this tendency in the temperature controller market, Fuji Electric has completely reengineered the economical temperature controller. Specifically, based on the following principals, new models have been introduced for all types including PYZ, which has been the most important model of the Z series temperature controller, PYV and PYW. (See Fig. 5.)

- (1) To enrich functionality and expand the models, while maintaining continuity with conventional models
- (2) To equip all models with fuzzy logic control to prevent overshoot
- (3) To realize easy operability
- (4) To acquire UL, CE-marking and NEMA4X (waterproof standard) certification

Specific developments of the above principle are described below.

3.1.1 Features

(1) Function enrichment and model expansion

(a) Installation of a ramp soak function

For temperature control, sometimes simple program control is desired rather than an exclusive program controller, as has been applied conventionally. This can be achieved at a relatively low price by enriching the functionality.

(b) Model expansion

Adding the PXV3 model, having front dimensions of 48×24 (mm), to the series, has enabled the reduction in size of the control equipment panel, making the entire control equipment more compact. Further, all models have been made compatible with a 24V power source, enabling the use of equipment for which a lower voltage power source is desired.

(2) Fuzzy logic control function as standard equipment

By equipping economical models with the fuzzy logic control function, which has already been well accepted by the market, overshoot has been drastically reduced.

(3) Easy operability

As the functionality of temperature control increases, negative effects have also appeared, such as a drastically increased number of parameters that hinder operability. To prevent this effect, “display” or “non-display” can be selected for each parameter. This provision has dramatically reduced the complexity of operation by selecting “non-display” for unnecessary parameters.

(4) NEMA4X, UL, and CE-marking certification

Approval for such important foreign standards as UL and CE marks has already been obtained. Recently, approval for the waterproof standard, NEMA4X, has been acquired, greatly expanding the applicable fields of the instruments.

3.2 Recorder

Market size of the industrial strip chart recorder is estimated to be approximately 13 billion yen in Japan and 40 billion yen world-wide. In the last few years, this figure has tended to decrease slightly. The recorder has developed, supported also by the advance of technology, from a simple tool for recording to become an important component of the plant operation system. However, currently it is being replaced by PC based control and monitoring systems, which have been driven by recent developments in personal computers and also by the wide spread use of helpful software. Simple operability of the recorder function is desired more than complicated functions.

Fuji Electric's industrial type recorder has a history of approximately 40 years. Especially noteworthy is the “Microjet Recorder”(trade name) which we developed and then introduced to the market in 1991. The Microjet Recorder attracted the attention of users and suppliers of measuring instruments throughout the world. Today, because the inkjet method is superior in several aspects that are difficult for other recording methods to realize, the inkjet method is used widely in many applications including printers for personal computers, plotters for CAD, and industrial printing systems. The inkjet method is a suitable recording technology for multi-point, multi-color and high speed

recording, and because it directly records on chart paper, it can record data clearly and with high quality. The inkjet printing mechanism has a very simple construction and can record and print all types of data using only a single ink cartridge. High-speed ink ejection makes it possible to trace many continuous records with solid lines, the same as with a convention-

Fig.6 Microjet Recorder-E



Table 4 Specifications of the Microjet Recorder-E

Item		Specification
Input system	Recording points	1 or 2 continuous, 6 dotting
	Input signals	12 kinds of thermo-coupling, RTD Pt100, JPt100 DC voltage $\pm 50\text{mV}$ to $\pm 50\text{V}$ DC current 4 to 20mA 10 to 50mA
Recording system	Recording method	Inkjet method
	Recording cycle	Continuous type: 2 to 40 s Dotting type: 30 s
	Paper feed speed	10, 20, 24, 30, 50, 120, 200, 300, 400, 1,000, 1,200, 1,500 (mm/h)
	Chart paper	Z fold 15.08m
	Digital printing	Periodic printing, Scale printing, Channel No. printing, Alarm printing, Burnout printing
	Recording color	1 continuous: violet 2 continuous: channel 1 red, channel 2 blue 6 dots: channel 1 orange, channel 2 green, channel 3 violet, channel 4 red, channel 5 black, channel 6 blue
Digital display		LED, 7 segments \times 6 columns
Display accuracy		$\pm(0.3\% + 1 \text{ digit})$ (per recording range)
Recording accuracy		Display accuracy $\pm 0.2\%$ (per recording range)
Alarm relay output (option)		1 continuous: 2 points, 2 continuous: 4 points 6 dots: 6 points
External control input (option)		Selection of chart speed (including recording start and stop)
Power source		85 to 132 V AC, 180 to 264 V AC
Case construction		Plastic mold
External dimensions, mass		Continuous type: 144 \times 144 \times 175 mm, ca 1.2 kg Dotting type: 144 \times 144 \times 197 mm, ca 1.5 kg

al pen recorder. This small recorder realizes multi-pen recording easily by using only a single cartridge, making it possible to trace several records on the same time axis without relative pen offsets. The above features have made the inkjet method the most important recording technology. Fuji Electric has continuously developed this unique inkjet technology and is pursuing additional developments to meet the market needs of the future.

Fuji electric has now introduced a new model, the "Microjet Recorder-E", to the market (Fig. 6, Table 4). The Microjet Recorder-E is an industrial use hybrid recorder that utilizes inkjet recording technology and is also economical. Since the introduction of the hybrid recorder, every recorder manufacturer has been pursuing higher and a greater number of functions. This has undoubtedly brought much convenience to users. However, on the other hand, we regret not having paid enough attention to the market, where users request conventional models that are economical and easily to use.

The Microjet Recorder-E, based on the concept of providing an economical and easy to use hybrid recorder, has been developed to meet just such requests of the users.

Main features of the Microjet Recorder-E are listed below.

- (1) The Microjet Recorder-E is a conventional analog recorder, that incorporates the hybrid function, and the inkjet method is utilized as in conventional recorders. Therefore, the the Microjet Recorder-E can easily perform not only clear recording, but also various kinds of digital printing.
- (2) Before delivery, various recorder parameters shall have already been set as specified by the user. There is no need for the user to perform complicated start up procedures.
- (3) By utilizing a plastic mold case, this recorder is ultra lightweight, an epoch-making achievement for this class. The Microjet Recorder-E is optimal for mounting in machines and equipment.

4. Analyzer

4.1 Infrared gas analyzer

The infrared gas analyzer is an instrument for measuring gas concentrations utilizing the correlation between the specific infrared wave length that is absorbed by each kind of gas and the rate of absorption proportional to the gas concentration. Infrared gas analyzers are used widely in many areas, including atmosphere control in industrial furnaces or measurement of environmental pollutant components in combustion exhaust gas. Recently, the number of components to be measured at one measuring point have increased according to intensified regulations for environmental protection. Accordingly, the analyzer has been increasing its measuring components. On the

Fig.7 Infrared gas analyzer



Table 5 Specifications of the new infrared gas analyzer

Item	Specification
Measurable components	CO, CO ₂ , NO, SO ₂ , CH ₄ , etc.
Min. measuring range	0 to 100 ppm (CO ₂ : 0 to 50 ppm, CH ₄ : 0 to 500 ppm)
Repeatability	±0.5%FS
Output signal	0 to 1V DC or 4 to 20mA DC
Concentration display	LCD (320 × 240 dots)
Optional functions	Automatic calibration O ₂ concentration display, O ₂ correction output Mean value output for 1 h or 4 h H/L alarm contact output, Range ID contact output, etc.
External dimensions	435 (W) × 177 (H) × 400 (D) mm
Mass	Approx. 20kg

other hand, requirements for smaller instruments have also increased due to lack of installation space.

Fuji Electric, long since an industry leader in the areas of infrared gas analyzers and developing new products for the world, has now developed a new model of the infrared gas analyzer having a smaller size and more components to satisfy the above requirements (Fig. 7). A summary is presented below.

4.1.1 Composition

The infrared gas analyzer consists of an analyzing

unit (optical unit) and a signal processing/displaying unit. Analyzer sensitivity increases with a higher temperature (brightness) of the infrared light source that forms the analyzing unit and a longer optical path in the cell in which gas to be measured is conducted. The analyzing unit of the new analyzer is reduced to 1/10 in volume of Fuji's conventional model by means of the following measures: utilization of a newly developed small and bright light source constructed from a new fine ceramic, utilization of a miniaturized multi-reflectional cell which is constructed from precisely machined parts such that alignment of the optical axis is unnecessary, and utilization of a highly sensitive mass flow sensor.

4.1.2 Performance and specifications

The miniaturized analyzing unit is designed as a module containing a preamplifier that is 70 mm wide, 150 mm high and 300 mm long. A maximum of 3 modules can be mounted on a 19 inch rack type case that is 435 mm wide, 177 mm high and 400 mm long. A maximum of two components can be measured by each module and a maximum of 5 components can be measured by an analyzer simultaneously. It is also possible, with a signal input from an external oxygen sensor, to display the oxygen concentration and to compute the output value, corrected for the measured gas concentration, at standard O₂ concentration.

Dramatic downsizing of the analyzing unit has made downsizing of the entire analyzing unit possible, increased portability, as well as enabled flexible design for a variety of applications. Fuji Electric will continue to expand the application area of this analyzing unit.

5. Conclusion

New Fuji Electric technology and products for measuring instruments has been introduced above. We are convinced that each product, having several advantages due to their unique technology, will be able to meet the needs of domestic and overseas users and to contribute to the world market.

Fuji Electric will continue to develop excellent technology and products to meet future user needs.





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