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NEW TYPE ELECTROMAGNETIC FLOWMETER <CERAMICS & SMART>

Ken'ichiro Tago
Etsuro Itoh

1. FOREWORD

The electromagnetic flow meter is the flowmeter must generally used in the field of flow measurement because of the basic principle that "there is no pressure loss and a signal which is proportional to flow over the entire measurement range is obtained". Higher quality and multiple functions are being aimed at through many technological innovations, including electronics, and its demand field is spreading rapidly.

In 1986, Fuji Electric placed a compact electromagnetic flowmeter with detector and converter integrated construction aimed at the use of low frequency excitation which improved the zero point stability tremendously and making the meter intelligent by a microcomputer on the market. This flowmeter was favorably received. This year, the experience with the market and needs obtained with this compact electromagnetic flowmeter were concentrated and a new compact electromagnetic flowmeter that uses a ceramic measuring tube at the censor and has high accuracy, pulse output, and other multiple functions and a mode communication function at the converter was placed on sale.•

The features, specifications, construction, functions, etc. of this flowmeter are introduced here.

2. FEATURES

(1) High quality, high reliability construction

Improvement of chemical resistance and wear resistance by the use of a ceramic measuring tube.

(2) High accuracy

High accuracy of 0.5% of rate by improvement of linearity

(3) Small size and light weight compact size and abundant variations

Detector and converter integrated construction or separate type, wafer, type, or flange mounting possible

(4) Easy setting and adjustment

Range modification, etc. can be set easily by key switch operation and automatic calibration of zero point by one-push operation from the outside.

(5) Remote communication possible

Smart specifications were made possible by adding a communication module and display and setting by remote operation is possible by using a hand held communicator.

(6) Smart family with FCX transmitter

Same HHC as FCX transmitter can be used.

Table 1 New electromagnetic flowmeter specifications

Item		Specification
Measurement objective		Industrial water, service water, sewage, contaminated water, chemical, other conductivity 5μs/cm or greater liquids
Measuring range and accuracy		Flow 0–0.3.....Under 1m/s: ±1% of rate ....25% indication or greater ±0.25%FS.....Up to 25% indication Flow 0–1.....10m/s: ±0.5% of rate...25% indication or greater ±0.125%FS...Up to 25% indication
Meter size		2.5A, 6A, 15A, 25A, 50A, 80A, 100A, 150A, 200A
Fluid pressure		–1–40kgf/cm² .....size 2.5–80A –1–20kgf/cm² .....size 100, 150A –1–20kgf/cm² .....size 200A
Fluid temperature		–10–+120°C
Material	Measuring tube	Ceramics (Al_2O_3)
	Electrode	Platinum
	Earthing	SUS316, hastelloy C or tantalum
Input/output signal	Current output	DC4–20A (load resistance 0–600Ω)
	Pulse output	Open collector (capacity DC30V, 0.2A)
	Status output	Same as above.
	Status input	No voltage contact
Communication signal		Smart communication signal (super-imposed on 4–20mA) Load resistance: 250–600Ω Load capacitance: 0.22μF or less Load impedance: 3.3mH or less
Functions		• Span setting: Flow rate or flow velocity • Multi range: Automatic 2 range change over ◦ Forward/reverse flow measurement: Reverse flow selectable ◦ 0% signal lock: Arbitrary flow locked at 0% ◦ Flow switch: Status output at set flow • Low cutoff: Output at low flow locked at 0% ◦ Non-fluid detecting: Detection of non-fluid inside pipe, etc.
Power source		AC90–264V, 50/60Hz
Power consumption		10W or less
Ambient temperature		–20–+60°C
Ambient humidity		95%RH or less

3. MAIN SPECIFICATIONS

The main specifications of the new electromagnetic flowmeter are shown in *Table 1*.

4. DETECTOR CONSTRUCTION

The new ceramic electromagnetic flowmeter is shown in *Fig. 1*.

It consists of a detector that detects the electromotive force proportional to the flow velocity of the measurement fluid and a converter which signal processes this and converts it to DC4–20mA, etc. output. The figure shows an example of the integrated construction of both. The construction of the detector is shown in *Fig. 2*. It consists of a measuring tube, electrode, core, coil, magnetic path plate, and case.

The measuring tube uses 99.7% pure ceramics Al_2O_3. As shown in *Table 2* and *Table 3*, the ceramic has excellent

Fig. 1 New electromagnetic flowmeter

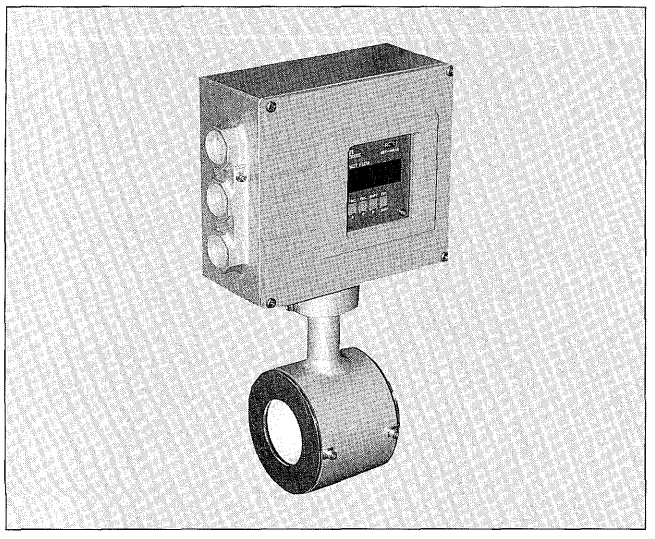


Fig. 2 Detector construction

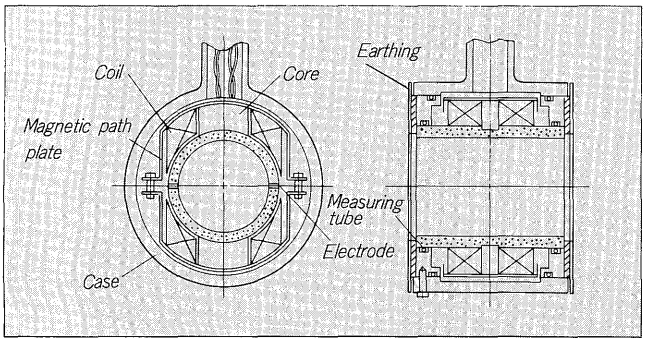


Fig. 3 Electrode construction

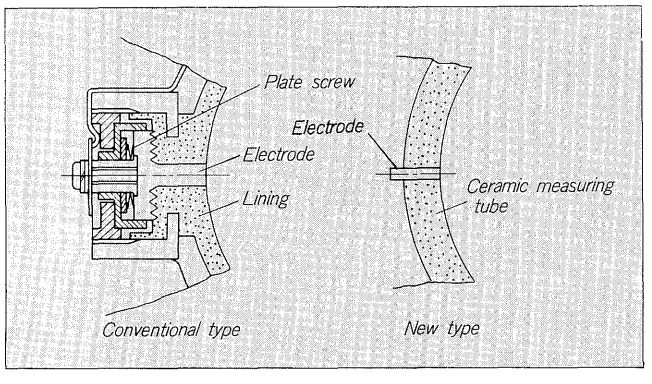


Table 2 Ceramic characteristics comparison

Characteristic item		Measuring tube material		
		Polyurethane	Teflon	Ceramic
Mechanical properties	Bending strength (kg/cm²)	0.43~6.3	–	33
	Compression strength (kg/cm²)	14.1	1.2	240
	Hardness Hv	490	400	1,800
Thermal property	Coefficient of linear expansion	10~20 x 10^{-5}/°C	10 x 10^{-5}/°C	7 x 10^{-6}/°C
Chemical resistance	Weak acid	○	◎	◎
	Strong acid	×	◎	◎
	Weak alkali	○	◎	◎
	Strong alkali	△	◎	◎
	Organic solvent	△	◎	◎

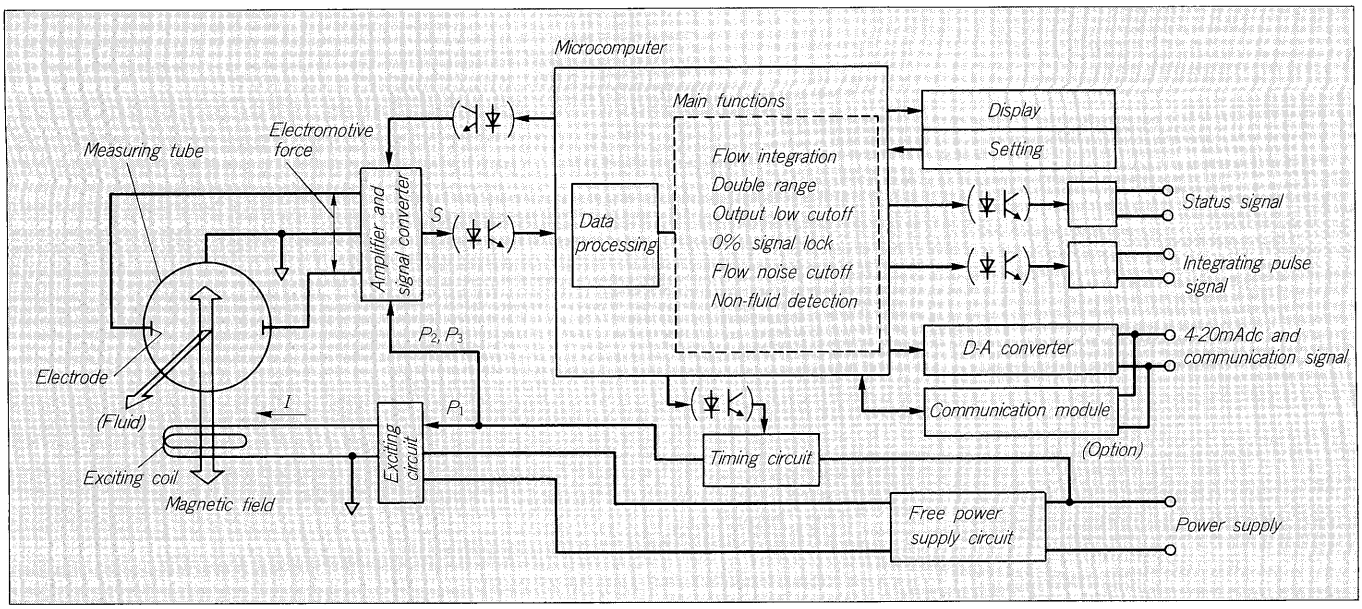
◎: Almost no absorption ○: Worst than ○ △: Some absorption
×: Use impossible

Table 3 Ceramics Al_2O_3 and teflon corrosion resistance

Chemical	Density (%)	Temperature (°C)	Corrosion resistance	
			Teflon	Al_2O_3
Glycerine		175	◎	◎
Acetoaldehyde		25	△	◎
Formic acid	87	90	◎	◎
Acetic acid		70	◎	◎
Phenol	5	70	◎	◎
Cresol		140	◎	◎
Acetone	25	25	◎	◎
Methyl Ethyl Ketone	90	90	○	◎
Chloroform		25	○	◎
Trichloroethylene		80	△	◎
Sulfurous acid	75	25	◎	◎
Hydrochloric acid	37	175	◎	◎
Chlorine		25	○	◎
Hydrogen Peroxide	30	25	◎	◎
Nitric acid		25	◎	◎
HF	50	25	◎	×
Hydrogen Sulfide		160	◎	◎
Sulfuric acid	96	100	◎	◎
H_3PO_4	85	175	◎	○
Ammonia		25	◎	◎
Sodium Chloride		160	◎	◎
Ethyl Alcohol	95	25	◎	◎
Benzene		100	×	◎
Trichloroethylene		25	○	◎
Carbon Disulfide		25	◎	◎

(Note) According to Corrosionproof material selection from New Technology Development Center Co. Ltd. and SANPLATE Corp. general catalog.

Fig. 4 Circuit block diagram



chemical and wear resistance and expansion of its usage field can be expected to expand as compared to conventional polyurethane and teflon lining type. The electrode uses platinum and has excellent air-tightness (10^{-7} atm. cc/s or less) and simplified construction shown in *Fig. 3*. The new electromagnetic flowmeter was integrated as a high quality and high reliability detector by combining this ceramic measuring tube and platinum electrode.

Linearity was improved by optimized design of the magnetic circuit by the Finite element method and a 0.5% of rate high accuracy was achieved.

5. CONVERTER CONSTRUCTION AND FUNCTION

5.1 Construction

The component blocks are shown in *Fig. 4*.

Classified functionally, the convereter is roughly divided into an analog input processor, digital signal processor, and signal transmitter.

The analog input processor decides the basic functions of the flowmeter. The technological points of the circuits included here are:

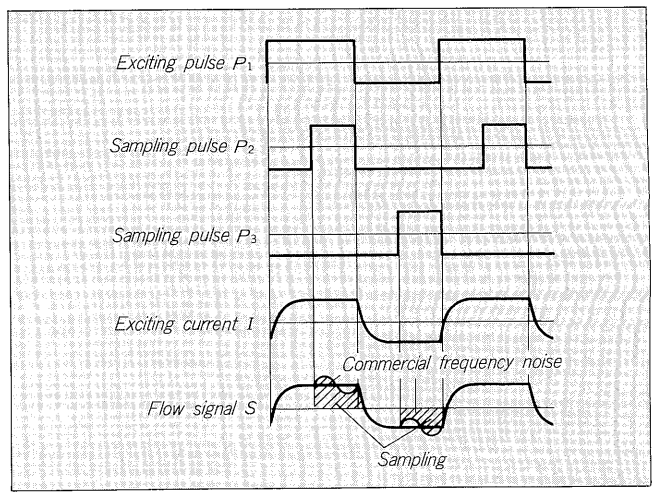
(1) Exciting circuit

This circuit sends a square wave low frequency current to the exciting coil. With this instrument, a constant current system is used. The reason for this is for its features, including that it is not affected by power supply voltage changes and exciting coil impedance changes and short exciting current settling time.

(2) Amplifier and signal converter

The electromotive force of the electromagnetic flowmeter is a low level signal of 1mV or less per 1m/s flow velocity. The basic technology of the circuit for making measurements at a stable accuracy of ±0.5% with this as full scale was established already so that zero point stability

Fig. 5 Operation waveforms



was also obtained. With this instrument, an innovation was made which adds a function which switches the exciting frequency according to the state of the fluid.

(3) Timing circuit

This circuit controls the exciting period and flow rate signal sampling period and is made low frequency by dividing the power line frequency. Since it is synchronized to the commercial frequency power source, the affect of the commercial frequency in the flow rate signal is removed. The operation waveforms are shown in *Fig. 5*.

The digital signal processor is centered about a single-chip microcomputer. Memory uses an EEPROM and a back-up battery is unnecessary.

It is isolated from the analog input processor by a photocoupler. The flow rate signal is sent to the digital circuit as a time signal by pulse period. A–D conversion is performed by a time counter. After being pulse width

Table 4 Functions of new electromagnetic flowmeter

Item	Description
Display function (Measurement mode) (Measurement mode) (Measurement mode)	Display: LCD max 6 digits (units display: LED) (1) Momentary flow rate value (2) Integrated flow rate value (3) Momentary-integrated interchange Alarm item symbol display at alarm generation. Setting item symbol and set value
Range setting (Meter size) (Type of range) (Double range switching) (Range units) (Fall scale value)	 Nominal size of detector (1) Single range (2) Large/small double range (3) Forward/reverse double range (1) Automatic switching (2) Contact input switching (1) m^3/h (2) l/h (3) m/s (flow velocity) Flow velocity 0.3~10m/s equivalent value
Integrating function (Type of integration) (Pulse rate) (Type of integration pulse)	 (1) Forward flow rate integration (2) Reverse flow rate integration 1~3,600/PS (1) Pulse width 100ms (2) Pulse width 30ms
Damping function	Time constant 0~60s
Low flow rate cutoff function	Momentary flow rate low cutoff and integrated flow rate low cutoff
Flow noise cutoff function	Exciting frequency selection and rate limit setting
Flow switch function	(1) Momentary flow rate switch (2) Integrated flow rate switch
Status input function	Range switching signal, zero adjustment, 0% signal lock, etc. by external contact input
Status output function	Range switching signal, alarm, etc. by open collector
Diagnosis function	Input overflow, input underflow, ROM abnormal, circuit operation stop, setting abnormal, non-fluid detection
Others	Flow rate direction selection, constant flow rate, etc.

modulated, the digitally processed signal is converted to a DC4–20mA measurement signal and transmitted. Many of the functions introduced in this instrument are software processed by this digital signal processor.

Besides DC4–20mA transmission corresponding to the instantaneous flow rate, the signal transmitter simultaneously transmits the integrating pulse signal and status signal. The transmission circuit and power supply circuit are isolated.

The addition of a communication function (smart specification) is given as one of the features of this instrument. This is achieved by incorporating a communication module and providing an HHC.

Upgrading to smart specifications which increase the additional value at maintenance, monitoring, etc. is realized easily at the user's site. This concept follows the development concept of the Fuji Electric FCX series transmitter. The communication module and HHC are shared with the FCX transmitter.

5.2 Functions

The main functions of this instrument are shown in *Table 4*.

Extensive multi-functionalization was planned for the conventional integrated type FMK and all these functions are standard equipment.

The main innovations are described below.

(1) The site display is a large LCD (character height approximately 13mm) that emphases reading ease. The momentary flow rate and integrated flow rate are

Fig. 6 Actual flow rate characteristic

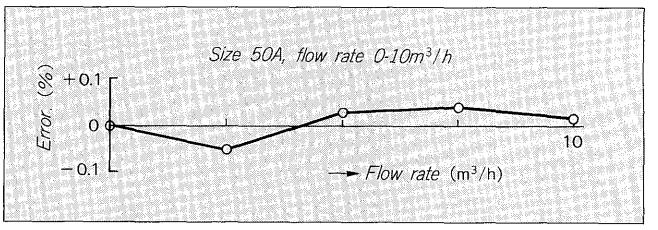


Fig. 7 Converter temperature characteristic

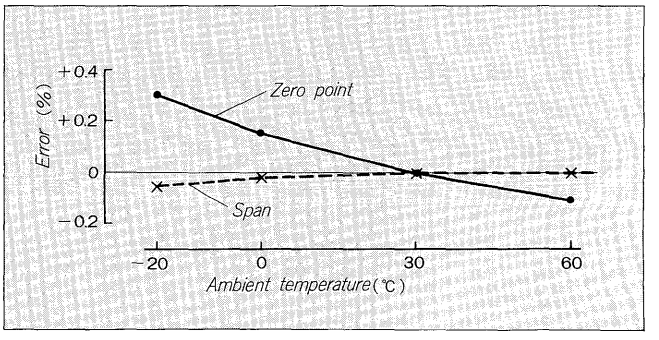


Fig. 8 Zero point change characteristic at running test

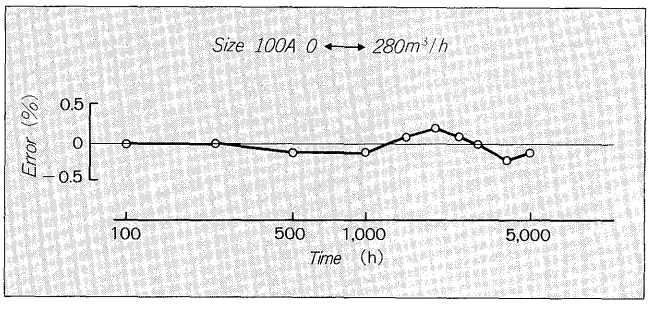


Table 5 Noise resistance

Type of noise	Noise impressed part	Noise resistance
Common mode noise	Between power source–earth Between output–earth	264V
High frequency noise (1 ns x 1 μs square wave)	Between power lines Between power source–earth	2 kV
	Between output–earth	1.5 kV
Transceiver noise	Distance 30 cm	27,154,488(MHz)/ 1W or less
	Distance 1 m	154,468(MHz)/5W
Electrostatic noise	Case, operating part	12 kV
Lightning surge	Between power source – earth	100A (8 x 20 μs)
	Between output – earth	
Radiation interference	Distance 3 m	VCCI Class 1 standard*

*VCCI: Voluntary Control Council for Interference by Data Processing Equipment and Electronic Office Machines

displayed alternately on one screen. (One only can also be displayed)

(2) Integrated display is not simple pulse count, but can be made m^3 or 1 units integrated amount.

(3) Regarding range setting, besides conventional flow velocity span setting, flow rate span setting is possible and a double range is also used.

(4) Four kinds of flow noise cutoff are available, in addition to noise cutoff action by microcomputer, so that the optimum exciting frequency can be selected according to the state of the fluid.

For smart specifications with communication function added, besides the basic merit that industry value measurement, adjustment, and setting can be performed at an arbitrary place at the center-site, additional value is increased as follows in addition to the management standpoint and use ease:

(1) Tag No. write and read are possible.

(2) Type format and serial number write and read are possible.

(3) HHC display is 16 characters, 4 digits and messages are abundant and setting operation is interactive system and easy to understand.

(4) Regarding the flow rate range units, not only m^3/h and 1/h, but also volumetric units, including gallon and barrel, and hours, minutes, and seconds time units abundant combinations are possible.

(5) Set data can be printed out.

6. CHARACTERISTICS

Part of the running test results are shown in *Figs. 6* to *8*.

Fig. 6 is the basic actual flow rate characteristic, *Fig. 7* is the converter temperature characteristic, and *Fig. 8* is the result of the actual flow running test at the Fuji Electric outdoor test site. Regarding the noise resistance which becomes a problem at the user's installation site, the results shown in *Table 5* were obtained. All cases were satisfied.

7. CONCLUSION

The development concept of this instrument which integrates multiplex multiple specifications lining material and electrode material into ceramics and platinum and with abundant functions made standard is intended for type integration.

Smart specifications with the FCX transmitter made the initiative were also used in this instrument. Currently, this function is not does not exceed additional value of the single product level, but is expected to become the mainstream in development to a center-site integrated distributed control system in the future.