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# NEW SERIES FUJI ULTRASONIC FLOWMETER

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## 1 INTRODUCTION

To achieve energy and resource savings by operating plants efficiently, it is desired to manage plant operations more precisely, and as a method to realize it, the measurement and management of flow at each section of a plant are needed to expand.

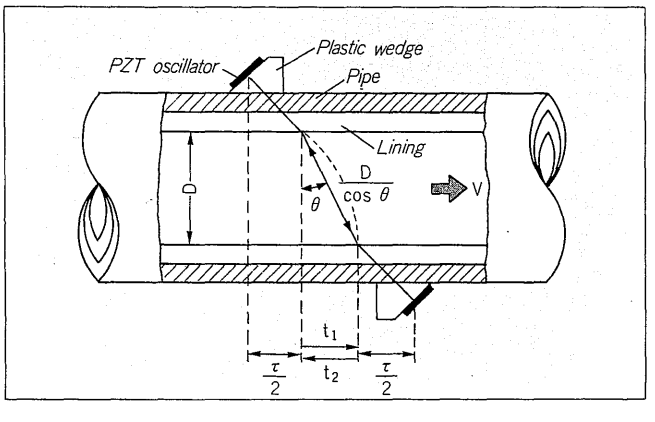
In comparision with various types of flowmeter, the most attractive feature of an ultrasonic flowmeter is that it is capable of measuring flow from the outside of a pipe. Drilling or cutting is not required on a pipe, the flowmeter can be installed easily during the plant operation, and therefore, the ultrasonic flowmeter is most suited to measure flow of the already existing pipe.

Based on the technologies of the conventionally sold Fuji Ultrasonic flowmeters, Fuji Electric has developed [Fuji Ultrasonic Flowmeter MARK-2] and [New Portaflow] as a series. The MARK-2 fully uses the most advanced technologies of electronics and New Portaflow features its easy handling.

## 2 MEASURING PRINCIPLE

Construction of the detector of the ultrasonic flowmeter is so simple that ultrasonic oscillator elements are adhered on wedges which transmit ultrasonic wave diagonally. (See *Fig. 1*.)

*Fig. 1* Measuring principle




Each one of the detectors are installed on the upper and lower streams of a pipe, and these detectors alternately transmit and receive ultrasonic pulses.

The transmitter circuit measures the time $T_1$ required in propagating ultrasonic pulse from the upper stream to the lower stream and the time $T_2$ required in propagating pulse from the lower stream to the upper stream, and after completing an arithmetic processing, converts the pulses to flow signals.

The propagation times $T_1$ and $T_2$ contain propagation times $t_1$ and $t_2$, and other propagation times $\tau$ of the wedges, pipe material, etc., and they are related as indicated below.

$$T_1 = t_1 + \tau \qquad T_2 = t_2 + \tau$$

On the other hand, propagation times $t_1$ and $t_2$ in the fluid are expressed as follows.

$$t_1 = \frac{D/\cos\theta}{C + V\sin\theta} \qquad t_2 = \frac{D/\cos\theta}{C - V\sin\theta}$$

Where, $V$ : Velocity of flow

$C$ : Velocity of ultrasonic wave within the liquid

This equation indicates that a time difference occurs depending on the flow. The ultrasonic flowmeter uses the differential propagation time of ultrasonic pulse.

Flow $Q$ in a pipe is obtained in the form of a product of cross-sectional area and mean flow velocity, and it can be obtained by solving the following equation.

$$Q = \frac{1}{k} \cdot \frac{\pi D^2}{4} \cdot \frac{D}{\sin 2\theta} \cdot \frac{T_2 - T_1}{(T_0 - \tau)^2}$$

In other words, flow value can be obtained with dimensions, angle, propagation time at each part of ultrasonic wave propagation path and the time difference.

$T_0$ represents propagation time of static fluid, and when the fluid is flowing, it can be approximated as $T_0 = (T_1 + T_2)/2$.

$k$ represents coefficient for compensation calculated from Reynolds number of the fluid, which is a ratio between diameter of cross section of pipe and mean flow velocity.

- The most important point of the functions required

*Fig. 2* Composition of transmitter circuit unit

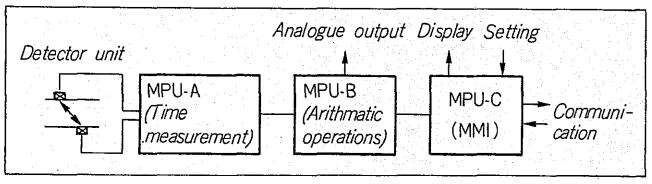



*Table 1* Outanding features of new series

| Features | Fuji FLG/FLF, FLH, FLB |
|---|---|
| 1. Clamp-on type: | |
| - Is it clamp-on detector? | Yes |
| - Is it easy to change measuring points from place to place? | Yes |
| - What's pipe size to be measured? | 2" to 200" |
| - How many kinds of detector does it need to cover from 1" to 200" pipe size? | 2 kinds |
| 2. Higher temperature/higher accuracy version: | |
| - Is it available to measure high process temperature up to 500°C with ±0.5% accuracy in, for example, boiler feed water flow measurement? | Yes |
| 3. Universal electronics: - processor built-in | (built-in) |
| - Is the transmitter able to compute signals from various pipe dia/pipe thickness/pipe material? i.e. Is it universal type? | Yes |
| - Is auto-zero calibration possible? | Yes |
| - Is auto-temperature calibration possible? | Yes |
| 4. Smart Instrument: type FLH & FLB | |
| - Can it dialogue through man-machine interface with LCD display? | Yes |
| - Does it give you the mounting information of detector? | Yes |
| - Is span adjustment possible? | Yes |
| - Is it easy to adjust by keys? | Yes |
| - Is trouble shooting possible? | Yes |
| 5. Portable: type FLB | |
| - Is portable transmitter available? | Yes |
| - Is the portaflow connected with wall mounted transmitter, FLF, as HHT (Hand Held Terminal)? | Yes |
| 6. Automatic switching: (w/doppler option) | |
| - Is it automatically switched to doppler meter when liquid migles air or higher turbid? | Yes |
| 7. Outstanding applicability: (with option) | |
| - Is multi-points scanning possible? (w/scanner) | Yes |
| - Can it solve possible eccentric flow? (w/multi-beam mounting method) | Yes |
| - Is it available to monitor and data logging? | Yes |
| 8. Easy installation, handling, maintenance: | |
| - Does it need specialist(s) or special tools to mount the detector? | No need |
| - Is it so designed as to minimize spare parts? | Yes |
| - Is it easy to select right ordering code? | Yes |

in the transmitter circuit is resolution of time measurement. For example, in case of a 25 mm diameter tube, the ultrasonic propagation time is about 20 μs, and time difference at 1 m/s flow velocity is only about 10 ns. The transmitter circuit of the new series ultrasonic flowmeter accomplishes 0.1 ns or less time difference resolution, making it possible to measure flow of small diameter tube extremely precisely.

The transmitter circuit unit of New Portaflow consists of three CPUs. (See *Fig. 2*.)

The New Series which is aiming at a conversational input processing of piping conditions, easily used data memory and communicating functions, high accuracy and maintenance ease, is expected to respond to the future needs of flow meterings.

## 3 OUTSTANDING FEATURES OF NEW SERIES

Now series Fuji ultrasonic flowmeter has more atractive features than other flowmeters, as shown in *Table 1*.

## 4 SPECIFICATIONS AND APPEARANCES

For the New Series, type S for small diameter, type L for large diameter and type X for high temperature clamp type detectors (Type FLG) are available.

For the transmitters, standard type FLF for process installation, type FLH with a dialogue style man-machine-

*Fig. 3* Small type detector of ultrasonic flowmeter

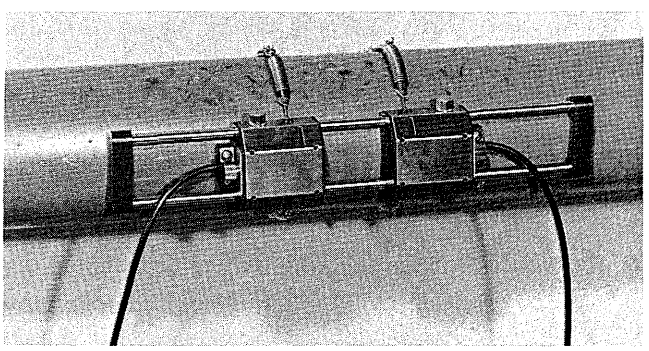


*Fig. 4* Transmitter of ultrasonic flowmeter (MARK-2)

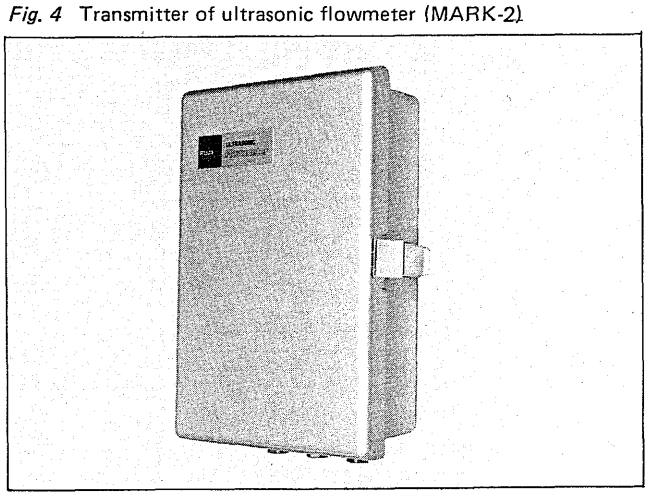
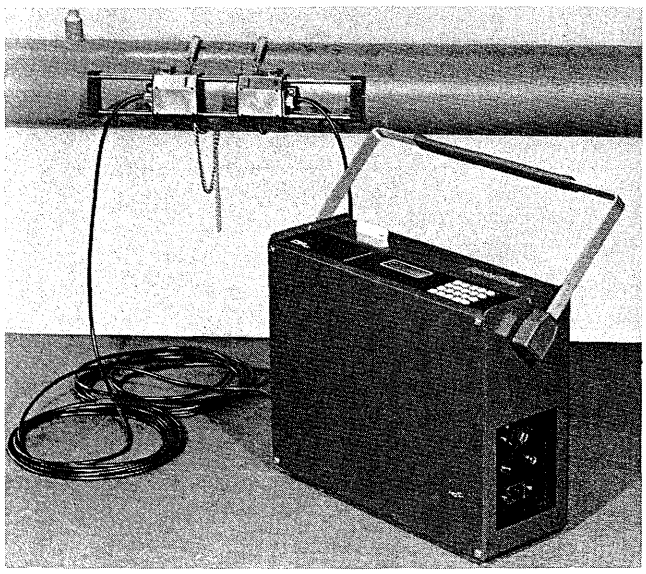


*Table 2* Specifications of detectors

| Type | FLG-S and L | FLG-X |
|---|---|---|
| Functional Specifications | | |
| Measurable fluid: | | |
| Kind of fluids | Homogeneous liquids (Gas contained liquids are applicable by Doppler option.) | Same as left. |
| Turbidity | Less than 10000 degree (mg/*l* or p.p.m.) | |
| Process Temperature | −40°C - +100°C | 0°C - +500°C |
| Applicable pipe: | | |
| Diameter | FLG-S . . . 25mm - 500mm<br>FLG-L . . . 200mm - 5000mm | 100mm - 500mm<br>(25mm - 80mm: available, contact Fuji) |
| Material | Steel, Cast iron, Stainless steel, & PVC | Steel, Stainless steel |
| Inner surface | Smooth coating/lining, epoxy or, cement mortar | Thin coating or smooth surface |
| Thickness of the lining | Less than 30mm and air-gap should not be formed between the pipe and the lining. | Less than 1mm |
| Mounting method | To be mounted to outer wall of existing pipe | Same as left |
| Ambient temperature | −40°C to +60°C | |
| Ambient humidity | Less than 95% RH | |
| Distance to transmitter | Max. 100m | |
| Performance Specifications | | |
| Accuracy (with transmitter combined) | ±1% of rate<br>Note: ±0.01 m/s: velocity less than 1m/s, in dia. more than 250mm<br>±0.02 m/s: velocity less than 2m/s, in dia. less than 250mm | ±0.5% of FS |
| Physical Specifications | | |
| Materials: | | |
| Compound to surface of the pipe | Silicone compound/or silicon grease | Thin metal film |
| Wedge | Epoxy resin | Stainless steel |
| Oscillator | PZT ceramic | $LiNbO_3$ crystal |
| Housing | FRP/SUS 304 | SUS 304 |
| Cable connection to transmitter | coax. cable $\phi 6/\phi 10$, 50Ω | BNC/M connector |
| Water proof structure | submergible JIS0920/NEMA4 | proofless |
| Weight | FLG-S . . . approx. 1 kg<br>FLG-L . . . approx. 2 kgs | 5 kg + α (depending on pipe dia.) |

*Fig. 5* Portable type ultrasonic flowmeter



interface (MMI), and portable type FLB are available.

*Table 2* and *Table 3* shows tha general specifications, and *Figs. 3* through *5* show their appearances.

## 5 DESCRIPTION FOR APPLICATION

**1) What are the homogeneous liquids through which ultrasonic wave goes?**

Water can be measured regardless if it is river water, well water or city water.

Drain water can also be measured as long as it does not contain large volume of air bubble.

Generally, it is easier to measure flow of fluid having less foreign matters (including air bubble). However, it is difficult to know inside of a pipe. First try to measure with Portaflow. When the fluid is other than water, it is necessary to know sound velocity of that fluid and attenuation rate of ultrasonic wave for a more accurate flow measurement. Portaflow also functions to make such a survey.

**2) When air bubble exists in water, what happens?**

When air bubbles are mixed, measurement cannot be made because ultrasonic wave does not go through. When

*Table 3* Specifications of transmitters

| Type | FLF | FLH | FLB |
|---|---|---|---|
| Functional Specifications | | | |
| Measuring method | TDP method (Time-difference Digital Processing) | Same as FLF | Same as FLF |
| Velocity span | Min. span 1 m/s<br>Max. span 16 m/s (standard) | Same as FLF | Same as FLF |
| Output signals - Analog output | 4 - 20mA DC<br>(allowable lead: 600Ω, insulation withstand 500V DC). | Same as FLF | Same as FLF |
| - Digital output | | Integration pulse<br>Flow direction<br>Auto 3 range<br>Abnormal alarm | Digital printer built-in |
| Power supply | 90 - 120V AC<br>180 - 240V AC<br>DC 10 - 30V (option) | Same as FLF | Same as FLF but<br>DC 10~30V is standard. |
| Indication/Display | LED indications<br>• normal signal receiving<br>• self-diagnostic normal<br>• functional checking | LCD digital display<br>• measured values<br>• setting values<br>• dialogue response | Same as FLH |
| Adjustment for various applications | Adjustable by MMI (option) | Dialogue style MMI (built-in) | Same as FLH |
| MMI (Man-Machine-Interface) functions | | • Dialogue style setting and adjustments by keyboard LCD display<br>• Multi-points measurement function with scanner<br>• Analog signal input for<br>- automatic change to Doppler option<br>- comparison with reference flowmeter<br>- built-in memories (Temp. Pressure), etc. | |
| Connection to detectors | Can be combined with either Clamp-on type (FLG) or Pipe mounted type (FLE) or Open channel type (FLX) | Same as FLF | Same as FLF |
| Ambient temperature | −10°C - +50°C | Same as FLF | Same as FLF |
| Ambient humidity | Less than 90% RH | Same as FLF | Same as FLF |
| Performance Specifications | | | |
| Basic measuring cycle | 0.2 sec. | Same as FLF | Same as FLF |
| Resolution of time difference | Less than 0.1n sec. | Same as FLF | Same as FLF |
| Power consumption | 12VA | 15VA | 15VA |
| Physical Specifications | | | |
| Housing structure | Wall mount type | Same as FLF | Portable type |
| Housing material/finish | Steel/Silver epoxy | Same as FLF | Steel and soft case |
| Weight | Approx. 10 kgs | Approx. 11 kgs | 7 kgs |

mixture of air bubble is of a temporary one, however, there is no problem because the self-diagnostic function holds the output.

Air bubble is likely to be mised in water in the following cases.

(1) Air suction due to dropped down water level in pumped well.
(2) Occurrence of cavitation
(3) Negative pressure applied to the pipe exposed to the air air, causing air leaking into the pipe.

**3) What are the specifications for input piping? How is it done?**

The piping specifications concerned are outer diameter (or circumference), material, thickness, material of lining, thickness of the lining, etc.

As for the input method, the transmitter questions by each item of the specifications. In case of dimensions, numbers come out or in case of material, etc., menues come out. Proper numbers and/or menues are selected and input.

In case of a piping under the JIS specification, specifications are determined based on the bore and material, and standard values have been stored in the memory. Therefore, the specifications can be input simply by designating as JIS.

Further, when normally measured piping is known in advance, it is registered in the user memory domain, and it is not necessary to input each time. Up to eight kinds can

be registered.

**4) How can it be handled when piping specifications are unknown.**

When the specifications are within the range of Portaflow, flow can be measured by inputting the designated value. In this case, however, the accuracy cannot be guaranteed.

- Diameter can be found by measuring the circumference.
- Thickness can be found by using a thickness gauge (option).
- Generally, lining material and lining thickness can be estimated based on the above specifications and standard specifications.

**5) How is the measurement affected by exterior finishing of the pipe, etc.?**

Generally, when the pipe has rust, dirt, foreign matters and/or peeled off paint on the interior or exterior, and the detector cannot be attached to the pipe tightly or there is a gap between the pipe and detector, measurement cannot be made because ultrasonic wave does not go through. In a case like this, the detector must be installed after eliminating them.

There will be no problem when the pipe is painted evenly.

Even if the pipe is painted heavily and the thickness exceeds several millimeters, measurement can be done without any problem. In this case, however, thickness of the paint should be added to the lining thickness for a more accurate measurement.

When the pipe is wrapped with a tape, etc., it should be removed.

**6) How is the measurement affected by scale inside the pipe?**

Even if scale exists, measurement is possible. However, reduction of the cross-sectional area due to the scale causes an error. The displayed flow is slightly more than the actual flow.

If thickness of the scale is known, it can be compensated by adding it to the lining thickness. Generally, however, existence of scale in an old pipe is not even, but an unbalance is anticipated. Therefore, it is difficult to find correct cross-sectional area, flow is uneven, and accurate measurement cannot be expected.

**7) Is it possible to measure flow in a pipe not filled with water, or open channelflow?**

Primarily, this flowmeter has been designed for pipe filled with water. However, it still can be used for velocity measurement by purchasing a special detector.

# TOPICS

## THE 5TH SOUTH EAST ASIA AGENT CONFERENCE

The Export Group of Asia Department organized the conference for three days from November 28 to 30, 1983 at Osaka Hotel Plaza and Kobe Factory. As a sort of "Summit", the purpose of this important conference were to establish a sales policy for the Fuji's standard products and to discuss sales expansion strategy.

In this conference, Mr. Gondaira, Managing Director and other top managements of the Export Group attended from Fuji Electric side. From the agent side, the president of each agent in Hongkong, Indonesia, Malaysia, Philippines, Singapore and Thailand and representatives of the relative trading companies, and the total attendents reached 30.

The main theme was "Movement from single unit sales to system equipment sales". Fuji Electric introduced the new products such as inverters, new VCB panel, distribution board, etc., and discussions were made actively for the sales methods. Further, at New Kobe Factory where the


VCB panels and inverters are being manufactured, the productions were introduced by using the actual products, and the participants indicated their strong interests.