

accomplished the building of a-c 440 V winches by Leonard control, a-c electrification of deck machines, that had been a long pending question in shipping circles, has made a rapid development. Such various distinctive features of a-c equipment as not only excellent operating performance, but also reduction of weight and cost of ships are now widely recognized and from year to year the Company is receiving orders for good many numbers of units. This particular apparatus has been also kept improved to reduce the weight. By giving up a d-c generator attached to each common motor-generator for two winches for supplying power to the field and control circuit, only a common d-c supplying generator has been designed to operate for a group of common motor-generators.

For special application, the Company has manufactured a number of whale winches for whale catchers. The kinds were a hunting hoisting $5T \times 30$ M/min. which winds up a rope of the harpoon shot at a whale, a tail hoisting of 15 ton max. to take a shot whale into the ship, a 40 HP motor of 220 V d-c but now an improved new type winch is equipped with a 50 HP motor a whale winch of $6.2T \times 30$ M/min. tail hoisting 20T.

The trawl winch that was delivered to the training ship of Tokyo Suisan (Fisheries) University is of 220 V d-c 120 HP, in which two generator 100 V, 80 kW are installed as a power source, one of them being used as a booster to control speed, thus most smooth speed control being available in fishing.

XII. MEASURING INSTRUMENTS

XII.1. ELECTRICAL METERS

1) Indicating meters

In present day industry, in order to perform rational overall supervision, a demand for the manufacture of small type meters has become more and more important and to meet this demand, a wide-angle type switchboard instrument with long scale length in which the center of rotation of the pointer is located in the center of the instrument was accomplished. There are two sizes, namely 140 mm square and 100 mm square and each type comprises various types of instruments such as d-c ammeters and voltmeters, a-c ammeters and voltmeters, single and 3 phase wattmeters, 3 phase power factor meters, frequency meters, synchroscope, etc. Fig. XII.1

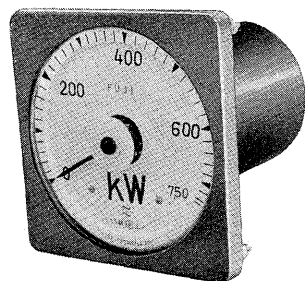


Fig. XII.1.
Wide Angle Type
Switchboard Instrument

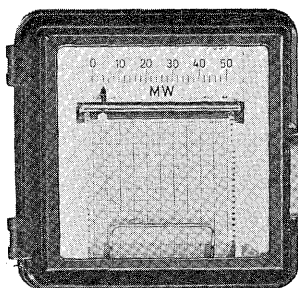


Fig. XII.2.
Ink Recorder

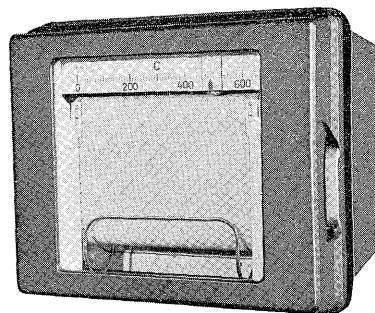


Fig. XII.3.
Self Balancing Type Recorder

illustrates one example of the above products.

The next stage in the manufacture of high precision electrical instrument was to construct a temperature and humidity controlled factory in which temperature is maintained at $20^{\circ} \pm 0.5^{\circ}\text{C}$, humidity between 55~60%, and room pressure maintained higher than the atmospheric pressure by approximately 6 mm of water column to prevent the entrance of dirt and dust. This factory has been now completed and the manufacture of precision instruments within this factory has begun lately.

2) Recording Meters

Although the manufacture of ink recorders was discontinued after the war, a small-sized ink recorder of 258 mm. square in size has been completed. The design by Siemens Co. was selected as an

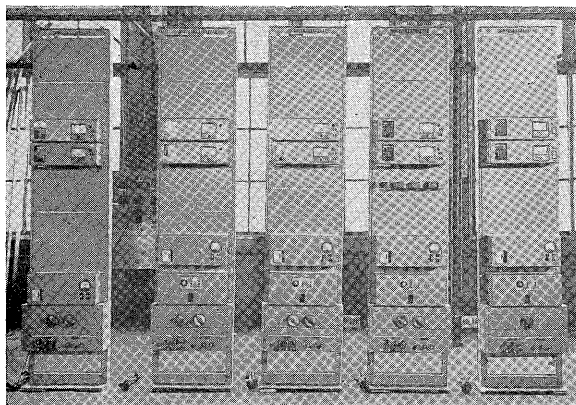


Fig. XII-4. Transmitting Frames
for Telemeter

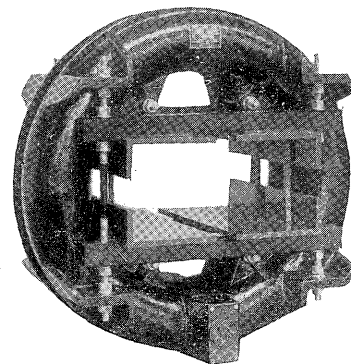


Fig. XII-5. D-c Current Transformer
40,000 A/20 A

example in producing this instrument. Besides the moving coil, rectifier and electrodynamic types for measuring the usual current, voltage, power and reactive power, a moving coil type recorder with a built-in compensating amplifier has been manufactured. This instrument is used in industrial measurements where the input is obtained by a change in electrical resistance or from a very small electromotive force. The recorder is driven by either a synchronous motor, pulse clock, or electrically wound mechanical clock and has a recording width of 120 mm. and recording chart speeds of 20 mm/hr and 60 mm./hr. Special types among the recorders manufactured are two element type capable of recording in 53 mm. width 2 kinds of measured quantities on a single recording chart, and the portable type. At present, a recorder having 3 elements and recording width of 210 mm. and capable of recording two or three different quantities is under production.

The research on electronic self balance type recorder was begun later than that of the other manufacturers; however, in the fall of 1954 the trial production was completed and after making various improvements, this type of recorders were supplied to all districts from early part of 1955. The size of this recorder is 366 mm \times 314 mm with 180 mm recording width and normal speeds of 20, 60, 120 mm/hr. and there are two models, namely, intermittent 6 or 12-point recording and continuous pen 1-point recording. The sensitivity is 0.1% of full scale value, accuracy 0.5% and has an excellent speed response of 3 seconds for full scale range. Besides the standard type recorders mentioned-above, a small sized pen type 1-point recorder of the same size as that of the above-mentioned ink recorder has been developed and is already in the market for telemeter use.

3) Telemetering Equipment

The impulse signal system of telemetering equipment using the integrating wattmeter mechanism and photoelectric cell has been developed after the war, and although several improvements were made, a new torque balance type was selected for production in July 1954. In this equipment, the regulating vane is moved by the input to the measuring element and causes the current in the vacuum tube oscillator to change from zero to maximum. This high frequency current is led through a high frequency transformer and a rectifier to a compensating circuit with compensating moving coil element and to the transmitting circuit to be indicated and recorded. The moving coil element is connected mechanically to the above-mentioned measuring element through a needle coupling. The torques of these two elements are made to oppose each other and current in the compensating coil changes until the two torques are balanced. This current is directly proportional to the value of the quantity to be measured. In measuring active or reactive power, an electrodynamic type element is employed and for measuring water level or other non-electrical quantities, the quantities are first converted to changes in resistance and then to D-C current to be led to the moving coil element.

Our Company has already manufactured approximately 300 units of telemetering equipment and has delivered them to Hokkaido, Tohoku, Tokyo, Hokuriku, Chubu, Chugoku, Kyushu Electric Companies, Electric Power Development KK, and Japanese National Railways. These units are equipment for telemetering voltages, currents, power, reactive power, frequencies, water levels, etc. and are mainly transmitted by communication line carrier system and electric power line carrier system. However, there

are also those transmitted by wireless or by direct line transmission.

Due to the success made in the transmission of indications of gas pressure, flow, tank levels, etc. between Osaka and Kyoto by the Osaka Gas Company with the equipment manufactured by our Company in 1951, telemetering equipment composed of 28 units designed in 1954 and completed in Feb. 1956 is being used at present by the Tokyo Gas Co. in telemetering the quantities mentioned above from 10 different locations of gas plants and compressing factories to the central recording panel in the main office of the company. A plan is being made to install the same type of equipment for the new factories to be built by the gas company and it is possible that in future, operation may be made by telecontrol.

4) D-c Current Transformer and D-c Potential Transformer

In this field, although transformers with ratio error of within $\pm 0.3\%$, an extremely high accuracy, has been manufactured and placed into actual use, an inexpensive and accurate transformer having a ratio error of approximately $\pm 1.0\%$ was manufactured. This was brought about by the special treatment of iron core and the transformers are being highly praised by the users. Both the 0.5 and 1.0 grades of d.c. Current transformers have current ranges of 2,000 to 40,000 amperes and are standardized into 13 classes. D.C. Potential transformers are divided into two classes, namely, 600V/0.2A and 1500 V/0.2 A. Fig. XII.5 shows a d.c. current transformer.

XII.2. WATTHOUR METERS

The notable matters that have taken place in connection with watthour meters for the past two years are the enforcement of the new Japanese Industrial Standards and new Regulation pertaining to the government approval, and also the development of new demand meters.

The following are the retrospect of the past two years, giving account to the matters referred to.

1) Enforcement of New JIS and Regulation Pertaining to the Government Approval

The New Japanese Industrial Standards for Watthour Meters, which had been discussed since 1953, were decided in April 1955 and put into force retrospectively as from February 12 of the same year.

The innovations in this new JIS C1210-1214(1955) are that it provides for wide-range a-c watthour

meters (herein after referred to as wide-range meter) and weather-proof construction of meters for outdoor installation (herein after referred to as outdoor meter), which were not provided for in the previous standards and that it requires narrower allowances of errors for precision watthour meters.

Accompanying this revision of JIS, the Regulations for the Approval of Electric Meters were revised and put into effect on March 30, 1955, which provides that the effective period of the government approval for single-phase wide range meters is 7 years and that for other meters (three-phase wide range meters, precision meters, commercial meter, etc.) is 5 years, the same as that which has been provided for commercial meters.

2) Ink-writing Type Watthour Meters

Automatic or uninhabited power stations or substations have made rapid development of late, and along with this tendency, the distant or remote control has become widely used. However, as there had been no reliable meters that could automatically register the integrated value of electric power, there had been no other way but to resort to human power for supervision of loading conditions. In view of this fact, Fuji Electric had made researches on an ink-writing watthour meter which automatically registers in figure at a given interval the value of electric power measured during that time interval, and completed it to win a good reputation early in 1955.

This Type D2-1 Ink-writing Watthour Meter consists of a power transmitter and a register. The power transmitter is a high precision meter provided with the various characteristics of a precision class, and is especially featured by its impulse current transmitting device. Whereas the system in which, making use of a light source, the photoelectric current is amplified or the system employing an interrupter consisting of segments and brush combined have been widely adopted, the system of using a light source is infeasible as a meter to be sealed because of the comparatively short life of vacuum tube used, and the system employing an interrupter having segments and brush is disadvantageous for maintaining precision because of its high friction torque and an appreciable variation in error given by the transmitter at light load. Using the special transmitter (a mechanical amplifier employing mercury contacts) which overcomes these defects, Type D2-1 has a high durability, and characteristics that meet every requirement for a precision meter, even at light load. The register consists of a clock mechanism, ink-writing mechanism, recording paper winding mechanism, etc. As the clock mechanism uses an electrically wound clock, there is no need

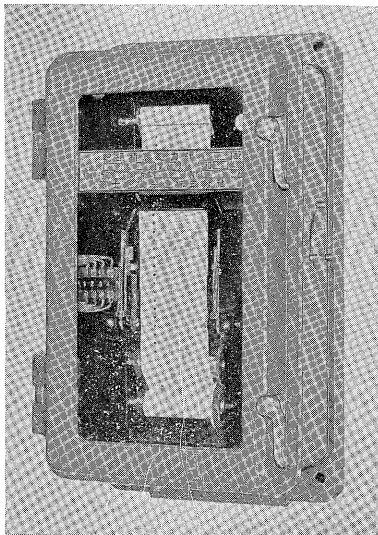


Fig. XII-6.
Printing System Recording
WHM DZ-1

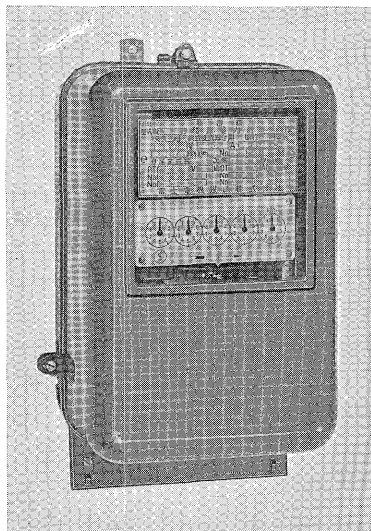


Fig. XII-7.
Precision Integrating
Power Transmitter

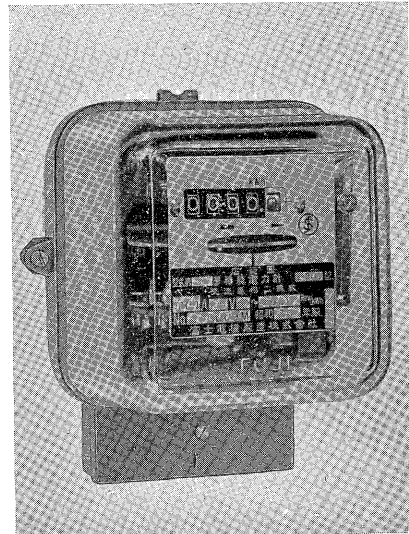


Fig. XII-8.
1-Ph. 2-W. Wide Range
WHM E-20G1

to wind up, and it is unaffected by the change in frequency and continues to work for 20 hours in case of power failure. The register is so constructed that the quantity of power consumed for 22 hours after starting to record can be read from outside at a glance.

3) Wide Range Meter

The wide range meter has a range of operating load current twice as large as that of the ordinary type and has its voltage, frequency, thermal characteristics, to say nothing of its current characteristics, compensated over its whole operating range to have higher precision value within the error limits than those of the ordinary type meter. As compared with the six ratings of 5, 10, 20, 30, 50 and 100 A in case of the conventional ordinary meters, the five ratings of 5 (2-5), 10 (5), 20 (10), 60 (30) and 120 (60) A are provided for the wide range meters. The values in parenthesis of rating are the values corresponding to the ratings of the ordinary meters, and the values outside the parenthesis are the compensated values of the values given in parenthesis. For Fuji Electric's wide range meters, Types E-20, E-20 G, E-20 R, E-20 GR, E-70, E-70 G, E-70 R and E-70 GR are available as single-phase wide range meters, and Types D-10, D-10 G, D-10 R, D-10 GR, D-170, D-170 G, D-170 R, D-170 GR, D-180, D-180 G, D-180 R, and D-170 GR as both single-phase and three-phase three-wire use.

The appearance is shown in Figs. 3 & 4, and the characteristics are given in Table I.

4) Precision Watthour Meter

The demand for the precision watthour meter, which is used in combination with instrument transformer for measuring a large power, has recently been increasing, and to meet this requirement, Our Company had made studies since 1953, and in 1955 and 1956, developed Type D-16 G precision meters which conform to the old JIS and the new JIS, and obtained the government approval respectively.

Some of the principal features are

- 1) Being provided with characteristic which compensate the inherent characteristics of instrument transformers, the overall errors when combined with instrument transformers are very small.
- 2) Load characteristics is compensated for the range of from 2.5% to 200% rated full load current, and the variation in errors is very small.
- 3) Having a second thermal compensator the meter has very little variation in errors to the change of ambient temperature.
- 4) Precipitation hardening Alnico having durability and high stability being used as the braking magnet, the torque is high and the mechanical merit is good.
- 5) Starting current is less than 0.25% of rated full load current.
- 6) The pointer type register has low friction and is easy to read.
- 7) Every error adjustment device has little mutual interference and is of the micrometer system easy to adjust.

The heavy load adjustment device is installed in the braking magnet, and is so designed that it can

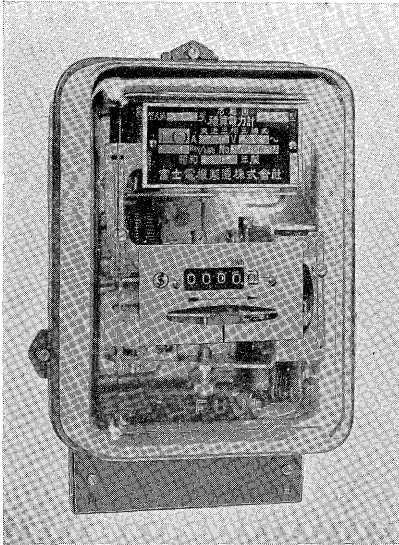


Fig. XII-9.
3-Ph. 3-W. Wide Range
WHM D-10G

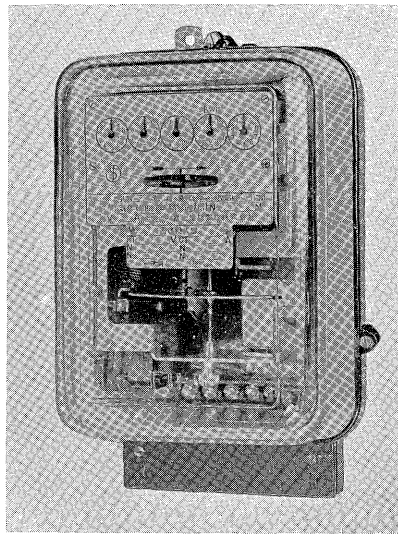


Fig. XII-10.
Precision WHM D-16G

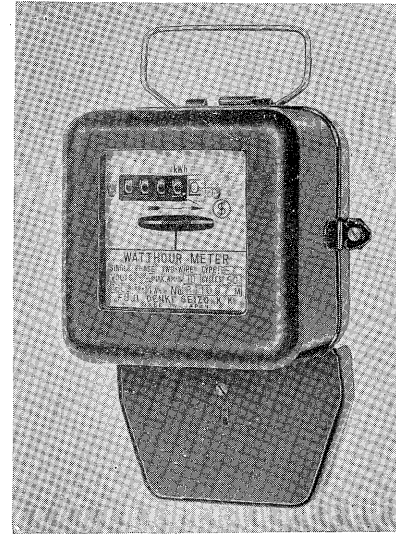


Fig. XII-11.
1-Ph. 2-W. WHM. E-7

regulate by the mere turning of the dial on the side the variation of error at the rated value by 1% for one turn changing linearly. Furthermore an Alnico magnet has coercive force (HC) 10 times as high and residual magnetism 1.2 times as high as those of a chromium-steel magnet. This gives the magnet features of almost insusceptibility of demagnetizing by heat, vibration, shock and external field disturbance and increases remarkably the stability and durability of characteristics of the meter as a whole.

5) Development Made on the Ordinary Type Meters

5-1) Single-phase 2-wire watthour meters.

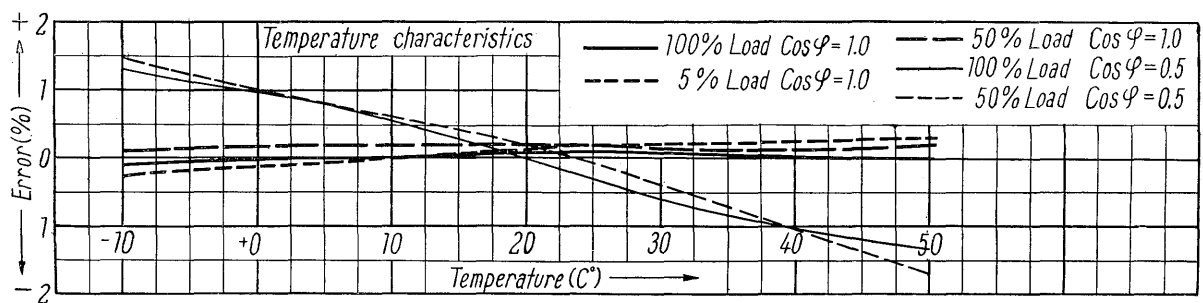
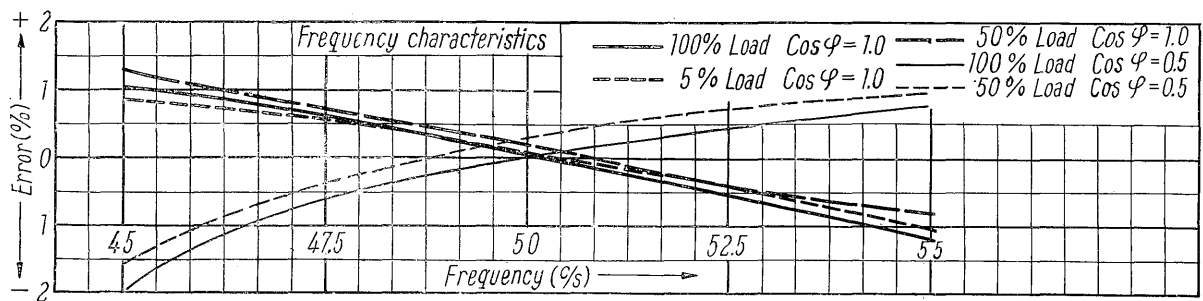
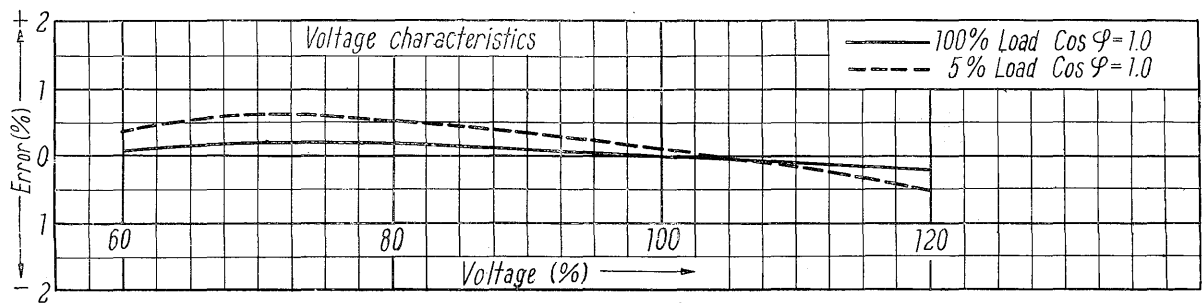
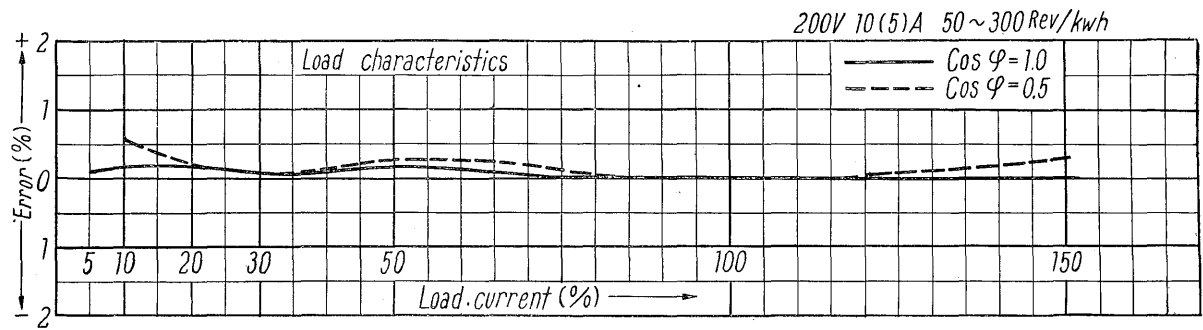
There are 5 representative types of our Company's single-phase 2-wire watthour meters, namely Types E-2, E-7, E-7 A, E-7 B and E-6. On Type E-2 meters that had been manufactured from 1938 to the present, such improvement has been made that the drooping characteristics at overload—inherent to the meter—is compensated to be within $\pm 1\%$ at 200% load by installing laminated type magnetic shunt in the current element. Thus the meter fully meets the electrical and mechanical requirements

which are required for the present day wide range meter. To increase the stability of its characteristics, chromium-steel magnets that had been used were superseded by precipitation hardening MK steel magnets of our Company's make having superior characteristics, and were adopted in 1954, resulting in higher stability of the meters. Also the meter, whose voltage characteristics is compensated by the voltage magnetic shunt core installed in the voltage element, has been completed. MK steel magnets are also adopted for Type E-7 and have proved that the stability is improved.

5-2) Single-phase and three-phase three-wire watthour meters.

There are three types of single-phase and three-phase three-wire watthour meters of our company's make, Types D-1, D-17 and D-18. Type D-1 meter has been improved in the same manner as in the case of single-phase types E-2 and E-7 meters, by replacing with the braking magnet of MK steel. Also, both the types D-17 and D-18, same as D-1, are the meters having the characteristics equal to those required for a wide range meter and are so excellent that they can be used as wide range meters without any modifications other than replacing the name plates.

Table XII.1. Characteristic Curves of WHM



XII-3. INDUSTRIAL METERS

1) Flow Meters, Level Meters, and Pressure Meters.

Our Company's float type flow meter has an indicator with a built-in resistor in the transmission end. The change in resistance occurring in this resistor is utilized to transmit meter indication to a distance or to integrate. However, the indicator does not always has to be in the transmitting end and there are many occasions where the indicating, recording, and integrating have to be done in the central observation post. To meet the requirements, a distant flow transmitter MT model was developed with which the changes in resistance of the slide-wire were obtained by the up and down movement of the float in the mercury U-tube. Since indicator parts and cam mechanism are not necessary for this instrument, only a small torque is required resulting in the reduction of the amount of mercury used to 60%.

As for the receiver, a cross-coil type instrument, capable of also recording and integrating was completed. In this instrument, the flux distribution of the magnetic field, position of the coil and the electric circuit are ingeniously utilized in the receiver in such a way that flow is indicated on a uniform scale.

Next, special mention must be made of the completion of a pneumatic type differential pressure converter which is a flow measuring device without the use of mercury. This is one model of force balance type instrument. The principle used here is the measuring of necessary force required to maintain equilibrium of the balance to which the moment is applied. This is accomplished by applying the pressure produced in the diaphragm mechanism and then by opening and closing the flapper located

opposite the balance shaft and changing the amount of flow. By the nozzle back pressure the balance is restored and this pressure is the scale in measuring the flow. To the distant indicating meter, an ordinary pressure gauge is used and also the pneumatic type pressure regulator, to be mentioned later, can be connected. The fact that mercury is not utilized and that indication is transmitted to a distance by pneumatic pressure are the outstanding points differing from the ordinary types.

New products such as a distant flow integrating meter and a air purge type liquid level meter have been developed. The former integrates electrically the indications transmitted from a distance by a mechanical type integrating meter to which a mercury switch has been attached.

2) Thermometers and Psychrometers

Thermoelectric pyrometers and electrical resistance thermometers have been manufactured by our Company for a long time, but in order to meet the requirements of Japanese Industrial Standards, a new type was developed by completely changing the design to increase the mechanical strength, to decrease the time lag, to make parts interchangeable and to reduce the cost. Also a trial production of thermistor thermometer for industrial use has been completed. The special features of this type are that it is small in size, has high temperature coefficient of resistance and due to high resistance approximately 200 meters of distant measuring is possible without any compensating resistance.

As for the psychrometer manufactured by our Company, the temperature of dry and wet bulb is measured with a temperature measuring resistor. The quantity thus measured is led into a bridge circuit and with a double coil type indicator, humidity is measured. Now the new type Li Cl psychrometer has been completed.

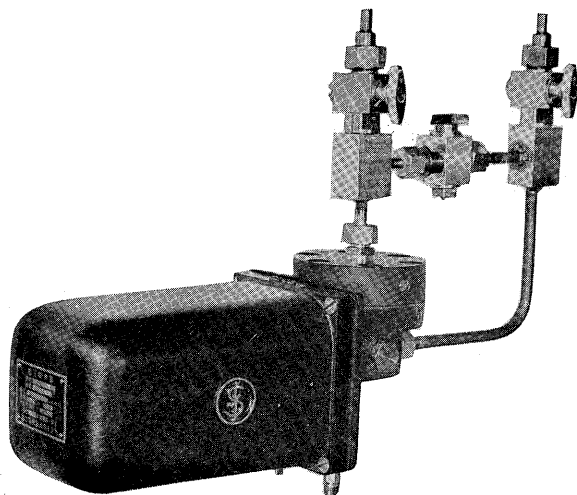


Fig. XII-6.
Pneumatic Differential Converter

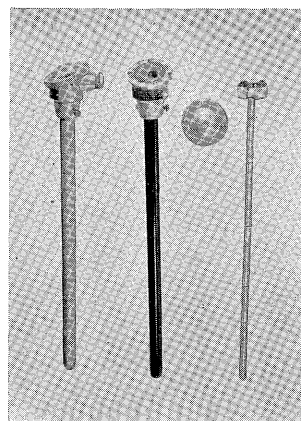


Fig. XII-7.
New Type Thermometers

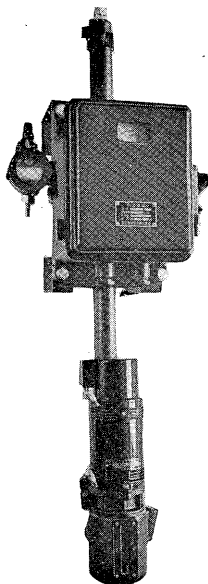


Fig. XII-8.
Magnetic O₂ Meter

3) Gas Analysis Equipment

For gas analysis meter, in order to spread the use of the CO₂ meters and CO+H₂ meters among the small and medium industries, a new design for smaller and simpler type was made, thus reducing the manufacturing cost.

The fact that oxygen is the only gas having magnetic properties it was used in the magnetic type oxygen meter. The increased use of various mixed fuels in boilers has resulted in the former CO₂ analysis meter and CO+H₂ analysis meter to be replaced by this type in the direct measurement of the excess volume of air. Ordinarily, the scales are 0—10% and 0—20%. However, this new type is capable of measuring from 0—5% for minimum range up to 0—100% and is used in chemical, iron industries, etc.

In Japan, this type was first manufactured by our Company and at present, no other Companies have sent this type of gas analysis meter on the market.

Next, the infra-red ray gas analysis meter is a type which is solely our product and as such has been supplied to the users.

However, with the negative filter type, it is very difficult to analyse extremely small quantities of gases and also due to 2 or 3 unsatisfactory parts in the meter, a new type called the positive filter type was recently studied and completed. In future it is planned to standardize the product to this type only.

4) Salinometers and pH Meters

Since the demand for densitometer was relatively small up to the present date, no consideration has been placed on this instrument; however, due to

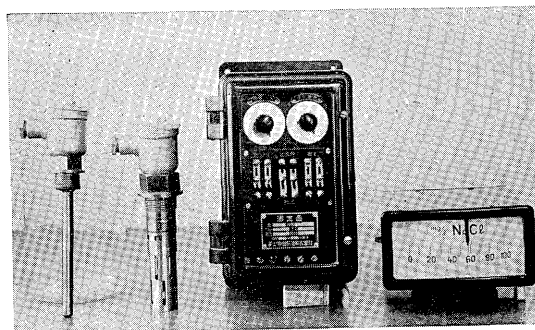


Fig. XII-9. Salinometer

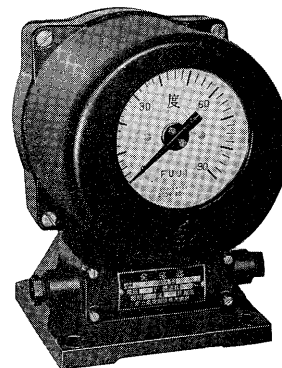


Fig. XII-10. Selsyn Type Angle Transmitter

recent increase in demand, salinometers and pH meters were developed and at present study is being made for the manufacture of sulfuric acid densitometer.

The salinometer uses the changes in electrical conductivity and is chiefly utilized in continuous measurement of salt content in boiler water and also in water used in chemical industry. There are six ranges in scale readings from 0—5 up to 0—500 mg/l NaCl as standard products.

The pH meter uses glass electrode and there are two models, namely immersion model and flow model. Trial samples have been made and found satisfactory and preparation is now being made for regular production.

5) Other Industrial Meters

To replace the mechanical tachometer, eddy current type tachometer was manufactured. This tachometer with built-in ring tubes is mainly used for the measurement of rotation of stokers and is employed in automatic combustion control equipment for transmitting the measured quantity to a distant point. Also Selsyn type and ring tube type of angle transmitters were developed as standard products of our Company. These transmitters are used for indicating angle of damper openings by connecting the rotating shaft directly and also for indicating the positions of any devices by rotating the shaft of the transmitter by any suitable means.