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AUTOMATIC METER READING SYSTEM

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1. PREFACE

Research and development on automatic meter reading systems in Japan was started about 1965 by The Tokyo Electric Power Co., Inc., Tokyo Gas Co., Ltd., Tokyo Waterworks Bureau, and other large public corporations.

The automatic meter reading system is a telemetering system which collects numeric data distributed over a wide area. It automates meter reading consumption of a watt-hour meter installed at the customer by these public corporations from manual collection. The development of a cheap transmission line architecture and hardware from the standpoint of system composition is a large practical problem.

Recently, from the standpoint of the stable supply of energy to customers, securing of safety, and improvement of other service to the customer, development of an automatic reading system with various functions, beginning from simple data collection of the past, is being restudied. As for the transmission line, the construction of a transmission network that organically connects multiple transmission lines is becoming possible by the implementation of full-scale Nippon Telegraph and Telephone Corp. (NTT) no ringing service system, laying of transmission lines by totalized distribution automation system plan of each utility, etc. An environment incorporating such an automatic meter reading system is quickly taking shape and tremendous development toward practicalization is opening.

The recent technical trends of automatic meter reading systems and the state of development at Fuji Electric are introduced.

2. AUTOMATIC METER READING SYSTEM RESEARCH AND DEVELOPMENT PROCESS

At the beginning of automatic meter reading system research, the securing of labor and coping with the steep rise of labor costs were the main motives.

However, currently, a system with load control function added to not only read electricity consumption, but to also provide more advanced service to customers and contribute to improvement of the load factor, one of the important topics of the electric power industry, is being studies, as previously mentioned, and the original aims have changed considerably.

Fig. 1 Automatic meter reading system research and development

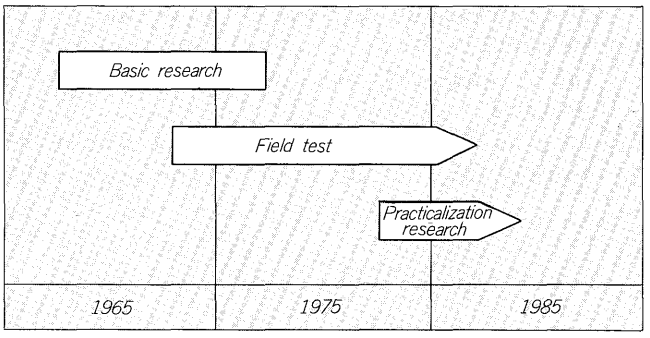


Fig. 1 outlines the automatic meter reading system research and development process. The transmission line, meter, and system development process is outlined below.

2.1 Transmission line

Transmission line development was mainly centered about existing distribution lines and telephone networks from the standpoint of cost-performance.

Distribution lines are centered about the electric power company, and their technical possibilities were proved from the first half of the decade starting from 1975 through investigation of the transmission characteristics, basic research on hardware, and experiments in the field from the decade starting from 1965.

The development of telephone networks was centered about city gas companies, the waterworks bureau, and NTT. Research on a system that has no affect on subscriber talk was completed in the decade starting from 1975 and was test operated thereafter and no ringing communication service is now being offered by NTT.

2.2 Meter

A pulse generating meter with mechanical contacts

was developed in the decade beginning from 1965. Thereafter, a microprocessor was built into the meter by practicalization of the low-power microprocessor and high energy density lithium cell by CMOS technology and a multifunction meter or electronic meter with more advanced functions than the conventional mechanical meter was researched and some are in use.

2.3 System

A central meter reading system for mass housing, which was considered the first step of an automatic meter reading system was practicalized in one half of the decade starting from 1965.

The Ministry of Posts and Telecommunications inaugulated a "Society for the Study of Telemeter Systems" in 1975 to prepare necessary legislation and to develop a standard automatic meter-reading system for electric power, gas, and water utilizing telephone networks.
In 1978, this society was expanded into the "Totalized Telemetering System Development Conference" and development was completed in March 1982.

3. TECHNICAL TRENDS OF AUTOMATIC METER READING SYSTEM

Electricity meter reading is described here.

3.1 System functions

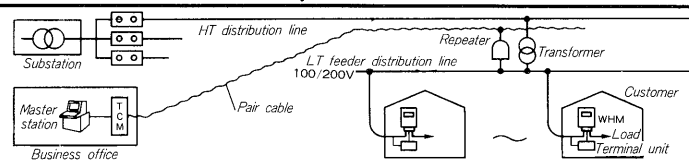
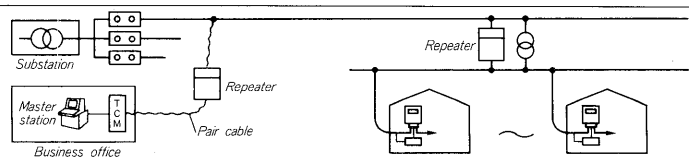
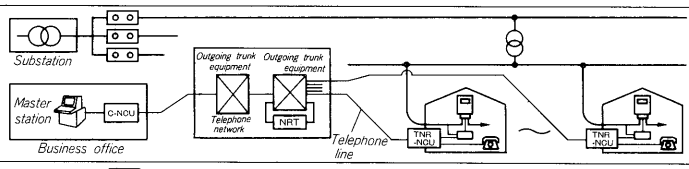
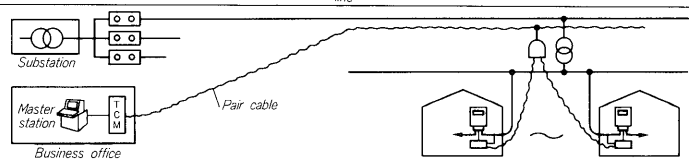
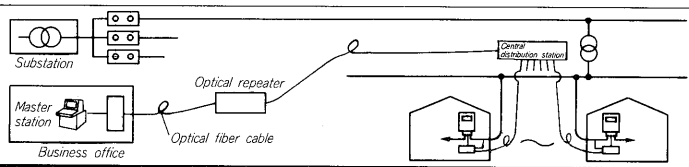
The automatic meter reading system collects and processes the data metered by watt-hour meters (WHM) located at numerous customers distributed over a wide area at a master station installed at a business office, etc. via a transmission line and is used for various purposes.

The original purpose of automatic meter reading is the automatic performance of meter reading work currently done manually. However, various functions can be incorporated by using this system. The functions of the system being studies are summarized in *Table 1*. According to this table, besides the original metering function, it has load control and load survey functions for improving power facility load efficiency, customer information and security monitoring for improving customer service, etc.

Table 1 Functions of automatic meter reading system

Basic functions	(1) Monthly meter reading (2) Incidential meter reading (separately) (3) Incidential meter reading (simultaneously)
Expansion functions	(1) Load control: water heater, air conditioner, etc. (2) Remote control of breaker: On-off service entrance breaker (3) Load survey (4) Reset of demand meter
Additional functions	(1) Information service: Consumption, charges, power interruption work, etc. (2) Security monitoring: Leak, etc.

Table 2 Comparison of various transmission lines for automatic meter reading

Transmission line	System outline	Features of transmission line
Distribution line — LT distribution line		Since distribution line carrier uses an existing distribution line unchanged, it is convenient economically. On the other hand, since the noise level is higher and the signal attenuation is greater than a transmission line, the transmission speed and transmission distance are limited to the point at which transmission reliability is secured.
Distribution line — HT-LT carrier		HT (6kV) systems mainly use a ground return system and LT systems mainly use a line transmission system. Its feature is that most transmission lines made up of distribution lines. It is a system which is considered to be applicable to cities where the distance from the business office is comparatively long.
Telephone line		This uses a telephone circuit in meter reading without affecting the original telephone service. It is a so-called no ringing system which operates the connector without ringing the telephone at meter reading.
Pair cable		This system is considered applicable when building a new communication line. The transmission characteristic is excellent because of exclusive use and the transmission speed is increased up to about 1200 bits/sec. The recent practicalization of a feeder automation system is being accompanied by the installation of pair cable communication lines, centered about cities, and sharing of these lines for automatic meter reading has become possible.
Optical fiber cable		Since communication by optical fiber cable is broadband transmission and non-inductive, it features high speed, large volume transmission, no affect of noise, etc. In a customer information system, the transmission of character or image data uses the high speed, large volume transmission feature of optical fiber cable.

3.2 System composition

Automatic meter reading systems are systems in which the center master station collects the data value of WHM installed at customers, and are classified into various kinds by transmission media used. *Table 2* compares the systems by typical transmission line. The features of each system are used and the system is selected by (1) transmission line length, (2) number of customers, (3) data amount which is transmitted, (4) whether or not there is an existing transmission line, etc. at the actual system architecture.

3.3 Features of various transmission lines

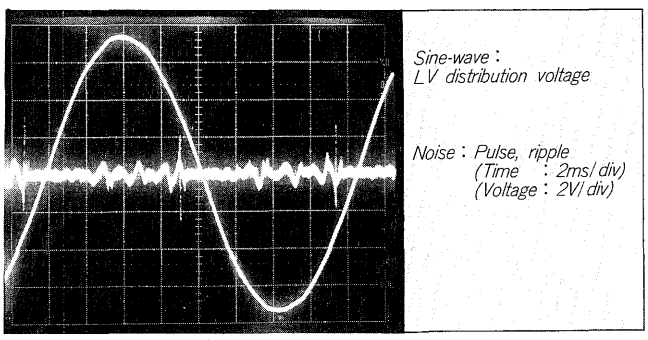
The features of each transmission line are used and the transmission line best suited to the particular system is selected. Multiple transmission lines which can mutually compensate for their disadvantages will be used. The features of each transmission line are summarized in *Table 2*.

3.3.1 Distribution line carrier

The biggest merit of using a distribution line as a transmission line is economy, that is, an existing distribution line can be used unchanged. Moreover, because the line configuration is multidrop connection, it is suitable for simultaneous control, simultaneous reporting. However, since a distribution line is originally installed to supply electric power, the line constants may not be suitable as a transmission line. That is, the line impedance is low and the customer load is connected directly to the line. Besides, since it is used freely by customers, the line impedance changes. Therefore, the signal attenuation is large and the noise level is high. For this reason, the transmission speed and transmission distance are limited. However, if looked at microscopically, since distribution line electric power supply changes with the commercial frequency of the distribution line, the transmission characteristic differs at the high part and low part of the voltage in one half cycle. Therefore, a system locked to the power supply frequency and other technology was developed so that each bit of the data is transmitted under the same line conditions.

Fuji Electric, in cooperation with electric power companies, is studying the characteristics of LT distribution lines, pulse and ripple noise are seen. An example of the noise waveform is shown in *Fig. 2*.

Fig. 2 LT distribution line noise waveform



Since HT (6.6kV) systems are non-grounded systems, the 3-phase ground return system is used widely and it has already been practicalized in the feeder automation.

3.3.2 Telephone line

The rate of telephone subscription exceeds 90% in cities. This also applies to distribution lines from the standpoint that they run widely to general homes. Moreover, since transmission quality is also secured, they are, naturally, an objective of study as an automatic meter reading system transmission media.

A precondition of this system is that telephone service have priority, and it must have a function which accesses the terminal unit without ringing the bell when automatic meter reading is performed. The system developed by NTT for this purpose is the no ringing communication service. This system has the following features:

(1) Use of existing telephone lines
(2) No ringing calling
(3) Priority function for telephone call
(4) Prevention of instantaneous ringing at termination

To implement the functions of (1) to (4), a no ringing trunk (NRT) is installed at the termination side exchange and a center network control unit (C-NCU) is installed at the center and a telemeter network ringing network control unit (TNR-NCU) is installed at the customer.

When the customer is called from the center through the NRT, access without ringing the customer bell is possible by means of an NRT function which prevents ringing of the bell. The TNR-NCU monitors calling from the customer telephone and when a call is originated during meter reading, meter reading is stopped immediately and telephone service is given priority.

3.3.3 Pair cable

The cost of laying pair cable is high. Therefore, in an automatic meter reading system it is the system that is used mainly in the trunk line system from master station to substation and in the branch line system from substation to repeating equipment. With an automatic meter reading system, since the data density on the transmission line increases as the line nears to the center, use of a pair cable at this part is considered to be beneficial from the standpoints of high speed transmission, transmission reliability, and the protection of privacy.

Recently, implementation of the feeder automation system has been accompanied by installation of pair cable in each area. Therefore, system cost cutting by sharing this transmission route with automatic meter reading is also being studied.

3.3.4 Optical fiber cable

The broad-band transmission and non-induction features of optical fiber cables are used and the transmission lines are used in large data volume trunk line systems in the same way as exclusive-use, as lines high-speed and large-capacity transmission and high-reliability transmission media.

Therefore, automatic meter-reading systems are not used independently in these transmission lines; however, in the systems which deliver character and picture infor-

mation to customers, the data obtained by automatic meter reading may be delivered through these transmission lines as one of the information items.

3.4 Meter reading devices

3.4.1 Center master station

The master station sends the meter read command signal and receives the data returned from the terminals and processes the received data.

The meter read command polls the repeater at a fixed time and after collecting the meter reading data, it transfers them to the high-level host computer for charge calculation.

Efficient system operation is possible by installing service terminal workstations to deal with house moving processing, customer service, and other business that requires immediacy.

3.4.2 Repeater

Repeaters are installed in the transmission line between the master station and terminal equipment, and have transmission speed conversion, signal system conversion, transmission loss compensation, amplification, and other functions. These functions differ with the composition of the transmission line described in paragraph 3.3, but making the data format and transmission format the same is desirable.

Transmission speed conversion performs speed conversion between low speed transmission line and high speed transmission line.

Two frequencies simultaneous transmission, power supply synchronization, and other signal systems are used with distribution line carrier and, therefore, repeaters which are installed between different transmission lines must have a signal system conversion function.

Since there are many cases in which the repeater is installed on the outdoor pole, weather-proofing and surge resistance must also be considered.

3.4.3 Terminal unit

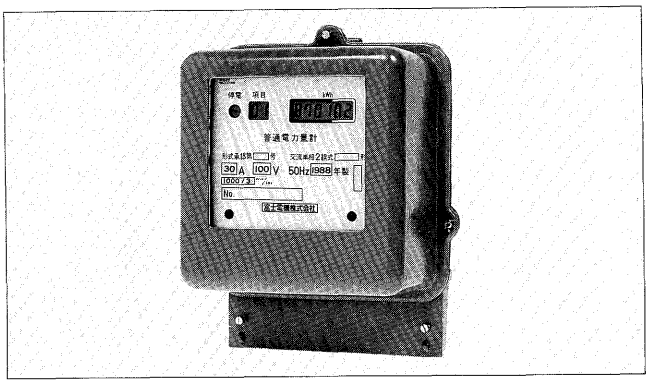
The terminal unit detects the electric power amount of the customer watt-hour meter, converts it to a signal, and sends this signal to the high-level device of repeaters and the master station. It has signal sending-receiving, signal modulation-demodulation, and message restructuring functions. However, these functions differ with the composition of the transmission line. Since it is desirable that the data format and transmission format be made the same even when the transmission line composition is changed, the recent trend is toward sharing of the function load so that these formats are created at the watt-hour meter side with the advent of the electronic watt-hour meter and the terminal unit only performs signal sending and receiving, modulation and demodulation, and protocol related transmission control and the transparency of the watt-hour meter information is maintained.

Load control, information service to the customer, etc. are being studies as additional functions.

3.4.4 Automatic reading function watt-hour meter

In the beginning, an automatic reading function watt-hour meter which transmits metering pulses for each unit metering was developed. Recently, a seasonal power rate system was introduced and an electronic demand meter was practicalized for large customers. The electronic meter has made it possible to transmit signals with the terminal unit by meter data instead of by unit metering pulse.

Fig. 3 Automatic reading function watt-hour meter



In the future, application of the seasonal power rate system to general customers also is considered. However, when this is done, an electronic watt-hour meter for home use will become necessary and demand by time frame metering, metered value display at power interruption, matching of the interface with the terminal unit, and other functions will be demanded. The automatic read function watt-hour meter developed cooperatively with The Tokyo Electric Power Co., Inc. is shown in *Fig. 3*.

4. PRACTICALIZATION PROBLEMS

As previously described, research on an automatic meter reading system was started to secure labor and cope with spiraling labor costs and to make meter reading work more efficient in a high growth period and field tests were conducted in each area from a small scale. Problems in the transmission line, including the meter, terminal unit, and repeater, center equipment, and other technical areas and problems from the standpoint of laws regarding electric communication, etc. are being solved by the efforts of public enterprises and manufacturer research and development through this research. However, the biggest reason why it has not been practicalized until now is cost. When the cost of terminal unit installation, transmission line construction, business office central equipment, etc. is compared to the cost of manual meter reading, at the present point, the automatic meter reading system is not beneficial from the standpoint of cost. However, a hole to practicalization is being opened by raising the additional value of the system in a totalized automation system including load control, load management, customer service, etc. intended from these.

On the other hand, the seasonal power rate system approach is incorporated in the power charging system and is being applied from large customers. Its application in the future to general customers also is considered and the development of a multifunctional electronic watt-hour

meter for general customers necessary for it will become an immediate problem. When a multi-functional electronic watt-hour meter is practicalized, with the automatic meter reading system accompanying the increase of the terminal unit functions, the amount of data sent to the business office will increase substantially. Moreover, studies are being made on additional functions such as monitoring safety and furnishing information for customers, and centralized load control to improve a load factor. These will also increase the amount of data per customer. In the future, establishment of a transmission system which efficiently transmits a large data amount and construction of a network combined with distribution line carrier, telephone line, pair cable, optical fiber cable, coaxial cable, and other media, and from the hardware standpoint, development of a multi-function electronic watt-hour meter and transmission terminal unit are problems.

5. CONCLUSION

The technical trends and problems, etc. of automatic meter reading were outlined. Cost reduction and the securing of reliability of the system, transmission line, hardware, and organization are the keys to practicalization of automatic meter reading.

Fuji Electric has been conducting research and development on automatic meter reading for many years. In the future, we will make further efforts on the technology accumulated up to now and will participate in the practicalization of automatic meter reading, ask for the guidance of the concerned parties.