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OPTICAL-FIBER SIGNAL MULTIPLEX TRANSFER EQUIPMENT (Commodity Name: Remote Terminal)

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1 FOREWORD

Semi-conductor devices and LSI are used not only for electronic equipment but they are widely used in the industries of various sectors exerting a great influence. Recent technological progress in the field of opto-electronics represented by opto-devices and optical fiber equipment is particularly remarkable and their applications are extended to communications and information processing equipment as high-speed data transmission and image transmission.

These evolutions served as an impact and made it possible to electronization and optical-fiberization in the field of wiring works that have been impossible up to now, because of the restriction imposed by economic reasons. A variety of control cables are used in the factory and other buildings and the task of their designing and works for new installation, expansion of facilities and their modification are extremely complex. Furthermore, as the number of signals to be controlled and distance of connection are increased, so are the cost for the work, duct installation charges and cable expenses. So that we are faced with the problems as to how to rationalize all these, as well as shortening of work period, facility of inspection and maintenance and miniaturization of wiring parts.

In the fields of large-scale industries, remote supervisory and control equipment represented by telementers and telecontrollers, have been used from many years now, but in the field of middle and small sectors, it was difficult to use them on account of their cost performance and their transmitting speed.

With this background, Fuji Electric has already commercialized RM 10, 20 and 30 Series using a pair of wire cables for the transmission lines that have been enjoying popularity being adopted for building administrating system, FA (factory automation) system and in various plants. This time, we have developed a new system RM 100 and 200 in which optical fiber is used for the transmission paths. This report outlines this new systems.

2 SYSTEM CONFIGURATION

Remote Terminals are available in two versions: one being 3 series, RM 10, 20 and 30 in which a pair of twist wire cables (CPEV) are used for signal lines, and another, series, RM 100 and 200 in which optical fiber is used for signal lines. In both cases, these transmission systems function as follows: in the transmitting terminal, the paralle

Fig. 1 Remote terminal RM10, 20, and 30

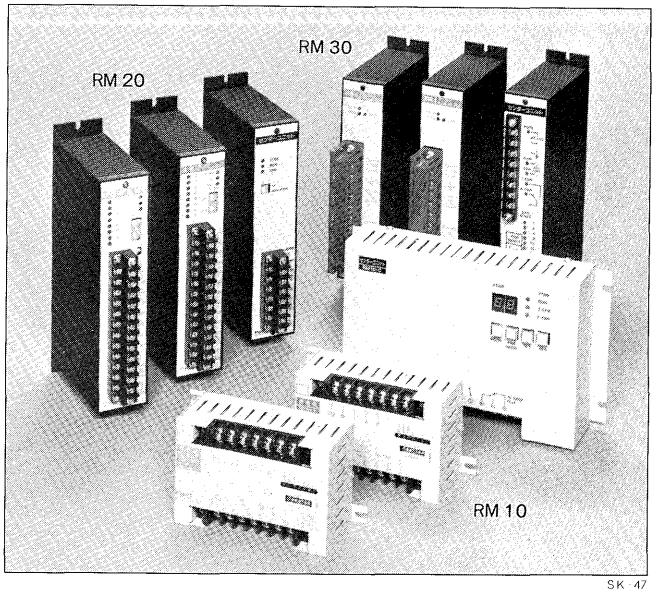

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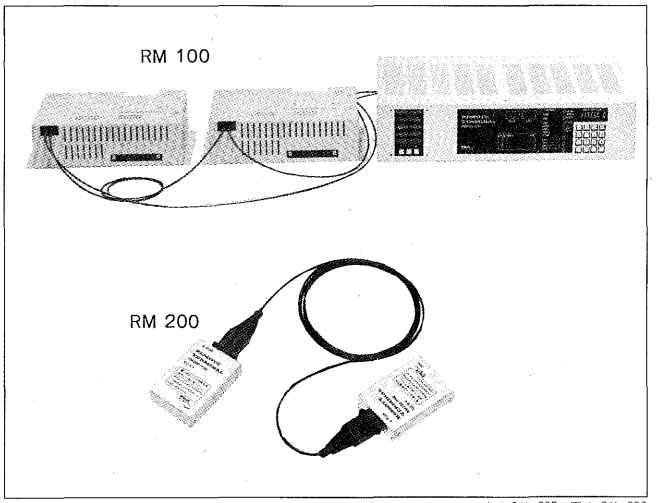
Fig. 2 Remote terminal RM100 and 200



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input signals are read-in and sent over the signal lines as serial data signals, many signals being transmitted at a time by time division, then they are made into parallel signals again in the receiving terminal, then they are output. *Fig 1* and *Fig. 2* show their outer views.

The remote terminals are composed with center and terminal equipment. The center consists of Center Unit carrying out communication control between terminal equipment, Computer Interface using terminal equipment as remote I/O (input/output) for the computer and Center Equipment having communication control function between terminal equipment and interface function for host computer. The center plays a central role of the communication control for the entire system and each system will be provided with one such center, which is able to be connected at any point in the signal line.

The terminals are available in two types: digital and analog. The analog type also transmits and receives data in digital form. The function of the terminals is that of transmitting and that of receiving, and depending on the use of the system, transmitting type, receiving type and transceiving type are combined. Also, depending on the point number scale of I/O, various forms of I/O terminals can be selected.

Each terminal of RM 10, 20, 30 and RM 100 is provided with address setting switch. Data communications between terminals with identical address are effectuated. Also, not only the data communications between these terminals but also the data communications are carried out between center and terminal equipment.

RM200 is developed for a purpose of carrying out data transmission between two points of relatively short distance, and it can transmit and receive data among terminals without a need for the center. The terminal of RM100 can, as in case of RM200, carry out data transmission between terminals without using centers. *Fig. 3* shows system configurations.

Besides these, since transmitted data can be received in various places, if terminals of exclusive use for receiving, it is possible to monitor the operational status in various places as in electric equipment room, supervisory room and office.

3 DIFFERENCE BETWEEN THE SERIES OF REMOTE TERMINALS

Remote terminals can be selected according to the use and scale. The main difference between RM 10, 20, 30, RM 100 and 200 consists in 1. type of signal lines, 2. transfer time, 3. transferable signal numbers, 4. center function, and 5. scale and types of terminals. The comparison of general characteristics is shown in *Table 1* and the relationship

Fig. 3 Remote terminal system configuration

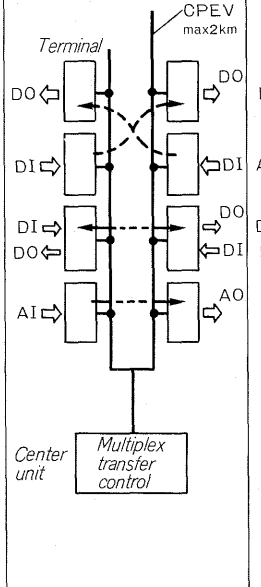
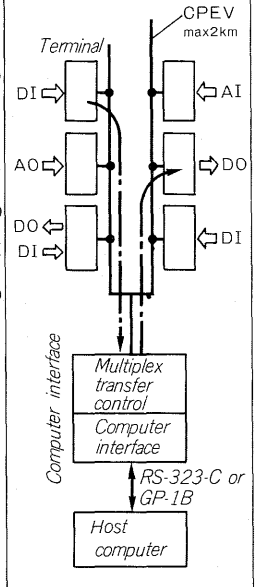
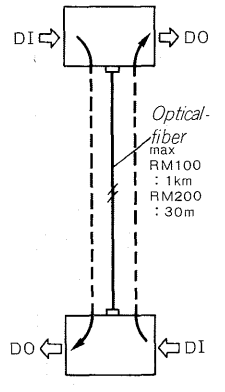
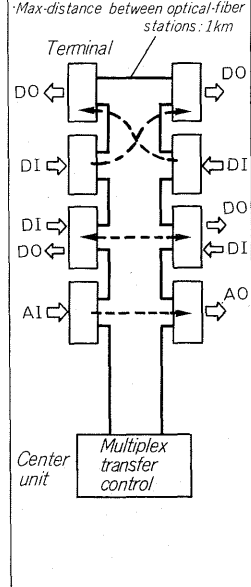
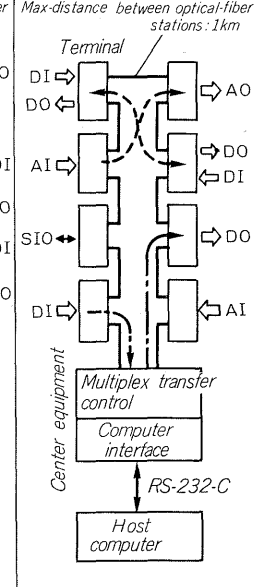
Signal path	*Multi-drop wire connection*		*Optical fiber connection (two cores)*	*Optical-fiber loop connection*	
Transmission form	*N:N terminal-to-terminal transmission system*	*1:N transmission system*	*1:1 point-to-point transmission system*	*N:N terminal-to-terminal transmission system*	*1:N, N:N transmission system*
System configuration					
DI : Digital input *DO : Digital output* *AI : Analog input* *AO : Analog output* *SIO : Serial input output*					
Function	*Communications between terminals identical address*	*Terminal functions as remote I/O for host computer.*	*Communications between two terminals*	*Communications between terminals set to identical address*	*Terminal functions as remote I/O for host computer, and communications between terminals are also possible.*
Equipment type	RM10, 20, 30	RM20, 30	RM100, 200	RM100	RM100

Table 1 Comparison of remote terminal series

Equipment type		Maximum transferable signal number	Transfer time (scanning time)	Maximum transfer distance	Center type	Terminal type	Terminal I/O points	Main characteristics
Milti-drop wire line system	RM10	Digital 256 points	10ms/point (40ms/4 points)	CPEV ϕ0.9 2km	Center unit	Digital type	4 points	4 points are housed in a terminal and it is suitable for small-scale dispersed type plants.
	RM20	Digital 512 points Analog 64 units	1ms/point (64ms/64 points)	CPEV ϕ0.9 2km	Center unit	Digital type	8 points 16 points	Transfer time is as fast as 1 ms/point, and by input signal holding function, when the input lasts more than 20ms, it will can be transferred without fail. It can be used for normal sequence control.
					Computer interface	Analog type	2 units	
	RM30	Digital 1,024 points Analog, 128 units	0.3ms/point (2.5ms/8 points)		Center unit	Digital type	8 points	Transfer time is still faster: as fast as 0.313ms/point, and 64 points can be transferred within 20ms. Suitable for control signal transfer and analog transfer for which high-speed is required.
					Computer interface	Analog type	1 unit 4 units	
Optical-fiber system	RM100	1:N N:N Digital 2,048 points Analog 256 units (per channel)	N:N 16μs/point (4ms/256 points) 1:N 16 μs/point (8ms/DI 256 points) DO256 points)	Multi -component glass fiber terminal distance: 1km Loop total extension 30 km	Center unit Center equipment	Digital type	DI/DO: 16 points each DO: 32points	High-speed and noise free transfer system through use of optical fiber Free system configuration as 1:1 1:N and N:N depending on the use is possible.
						Analog type (under development)	A1: 4 units AO: 4 units	
		1:1 Digital 64 points Analog 8 units	19μs/point (1.2ms/64 points)	Multi-element glass fiber 1 km	———	Serial type (SIO)		Applications for assembly work line in which machine control equipment are dispersed and for various sorts of automaticized systems such as measurement, supervision, FA, are possible.
	RM200	Digital 32 points	30μs/point (0.96ms/32	Plastic fiber 30m.	———	Digital type	DI: 16 points DO: 16 points	Most suitable for high-speed control between machine-tool and control panel, printing machine and other industrial machines and their control panel, as well as control equipment. In compact packing form mounting to print circuit board.

between transfer signal number and transfer time, in *Fig. 4*.

When the characteristics of multi-drop wire connection line type and optical-fiber type are compared, the former excels in the easiness of wire work, the lower cost for signal lines and facility in purchase, while the latter excels in, due to use of optical-fiber, high-speed in transfer, prevention of inductive trouble from power lines, and measures taken for noise.

The transfer speed of optical-fiber system is as high as 500k bits/ sec., more than tens of times faster than the multi-drop wire system, being able to transfer 256 points in about 4ms, that is, about 16 μs per point.

4 ADVANTAGE IN USING REMOTE TERMINALS

As mentioned in the previous section, the remote terminal has been developed with a view to rationalizing the cable installation work, and by adopting the equipment, the following advantages could be expected.

(1) Shortening of work period

Though control sequence is not established, plant layout and signal I/O point are determined, the signal line can be laid out. For this reason, the cable laying plan is made easier and together with reduction of number of man-hour, shortening of the work period is possible.

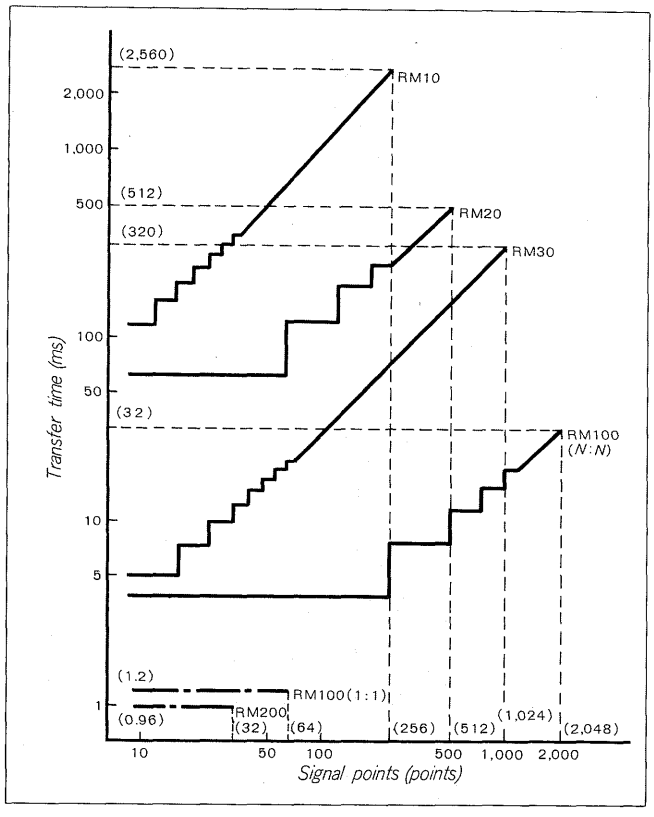
(2) Noise prevention

Since in optical-fiber system, transmitting terminal and receiving terminal are insulated one from another, noise invasion can be prevented, and this makes taking up of measures against noise for the system easy.

(3) Flexibility for modification

Not only manipulation of address setting switch, but also modification in connection is easily done, so that when there came up a problem of changing the sequence and

Fig. 4 Signal point number and transfer (scanning cycle) time



expansion, these problems can easily be solve.

(4) Prevension of wrong wiring and wrong connection

Since there are only two signal lines, erroneous connection and erroneous wiring that have long been problems in works at site in case of laying out of conventional multicore cable, can be avoided. This is particularly advantageous. in case of systems to be exported overseas whose installation work at site is difficult.

(5) Reduction in global cost for cable laying work

The cost for cable installation is mainly determined by cable core number and cable length, so that longer the transfer distance and more the transfer points will be, the advantage of the remote terminal will be greater. Also, up to now, signal lines as sensor have to be installed separated from the power line which is the noise source, making separate duct or making duct larger or giving cables shields, but now all these will become unnecessary if optical-fiber system will be adopted.

5 TRANSFER CONTROL SYSTEM AND FUNCION

As a principle, remote terminal is designed to carry out cyclic communications at a regular interval in accordance with the sequence of address of the terminal units used, irrespective of existence or inexistence, or fluctuation of input signals of transmitting unit.

As for control method on cyclic communications, there are three methods, one being controlling by individual address one by one; second, making several terminals into groups, and lastly, by communicating at a time with all terminals used. Fewer the terminal number to be communicated at a time, the communication procedures could be, in general terms, dispensed with simpler ones, and this has still further advantage of minimumizing the bad effect when the communications should fail. However, when comparing this system with that of communicating with many terminals at a time, the percentage taken up by the time necessary for communication control as address designating and error check in time for transmitting the data, resulting in large transfer delay time.

Therefore, in remote terminal, the best suitable control system for each equipment type is adopted.

(1) Multi-drop wire system remote terminal

RM10: Communications per each individual address

RM20: Communications per block, making 8 terminal units into one block. (Group poll)

RM30: All terminal unit group communications

As for the control system on them, since they are already mentioned previously, the description is omitted here.

(2) Optical-fiber system remote terminal RM100

Various types of system configuration, by combining Center Unit (equipment) with Terminal Units, as shown in *Fig. 3*, that is, 1:1 transfer system, 1:N transfer system and N:N transfer system, are possible for RM100 system. An example of optical multiplex signal transfer system using the center equipment is shown in *Fig. 5*.

For RM100 system, by system configuration, three types of transfer formats are prepared as the fundamental system, whose transfer format is as shown in *Fig. 6*. The designating characters as address and others sent from the center are collating checked in parity check and inversion

Fig. 5 Example of system configuration of RM100 optical multiplex

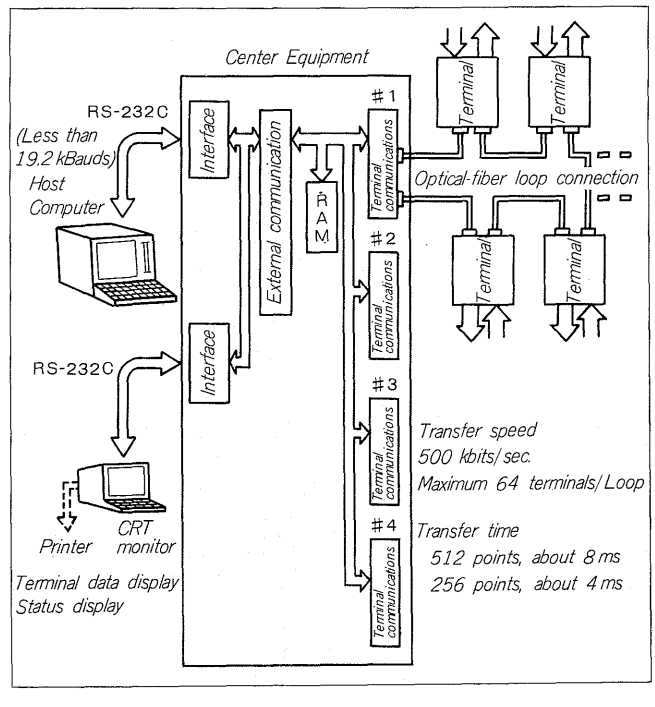


Fig. 6 RM100 fundamental transfer data format

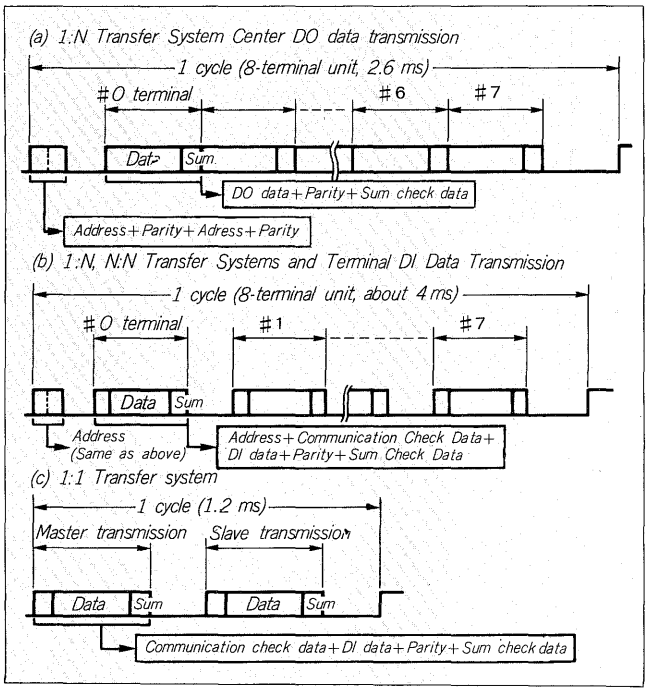


Table 2 RM100 System inspection abnormality process functions

Host computer RS-232C Interface	• Detection of error communication time • Failure data communication • Test communication • Dumping of terminal unit variation data
Center equipment	• Status monitor display • Failure status display • Failure alarm output contact • Forced operation test for terminal unit • Hardware, software watchdog timer • Battery backup (option) • CRT monitor (option)
Terminal unit	• Failure status display • Output selector • Loop holding unit during power failure (option)

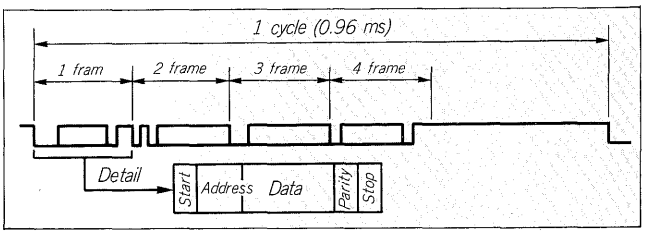
data and sum check data, besides the parity check data are sent to the terminal data.

When communication error continues more than predetermined time, center and terminal equipment emit alarm output and display, and in the center side, the equipment displays abnormal code and abnormal terminal address. And the equipment is provided with function of inspecting and failure processing shown in *Table 2*, for displaying the transfer system status and failre status, as well as inspecting the operational status.

(3) Optical digital link RM200

RM200 is developed for using exclusively for machine equipment incorporating, and is a two way optical multiplex transfer link that can transfer up to the maximum of 30m communicating cyclically with high speed as high as 0.96ms for transmitting 16 points and 16 points of receiving. It has a compact package form that can be mounted

Fig. 7 RM200 transfer format



on a print-circuit board working on DC 5V or on 12V. Its input can be connected to TTL and CMOS, and its output is an open collector. The transfer format is as shown in *Fig. 7*.

6 REMOTE TERMINAL OPERATION

The multi-drop wire system remote terminals RM10, 20 and 30 have, since their debut in 1984, been widely used for plant installation, factory facilities, in-building installations, water supply and sewage, mainly for transferring digital and analog signals for controlling the above mentioned facilities and installations. The main examples of their application are as shown in *Table 3*. These applications can be, roughly divided into 4 typical categories, namely:

(1) Data centralized supervisory control in wide-area

The use of equipment for transferring digital and of conventional wiring for concentrating various operating switches, sensors and control interruptors, pilot lamps and other signalling devices located in the plant and the building into a central control equipment. Suitable number of terminals are located in an adequate number of places and up to terminals, connections are made in a conventional way, and between the terminals, pre-designated signal lines will be used for connecting among terminals. By adopting this method, a number of wiring will be reduced in a large scale. This is a representative way of use.

(2) Data transfer in a wide area

The use of equipment for transferring digital and analog volumes for displaying presence/absence, for example, displaying status data such as temperature, voltage, and current in a plurality of locations in a control room and at work site, is more and more increasing everyday. Furthermore, use in a FA-like method in the factory, plant, building, the remote terminals are widely used for transferring data.

(3) Terminal control from computer

This is a method in which the remote terminals are used as a remote I/O for host computers by connecting terminal with computer through the center equipment using the computer interface.

In particular, through utilization of personal computer, the expansion of use of medium and small scale automatic supervisory control system that has been difficult to use from the point of view of its cost, is remarkable.

(4) Data transfer between 2 points

The system can be used for transferrring control signals between, for example, machine tool and control panel,

Table 3 Example of use of remote terminals

Use	Reason for adoption, ◎ :1st ○ :2nd • 3rd			
	Wire reduction, simplification	Reduction in cost for wire work	Facility in modification of future expansion	Shortening of wire work period
Remote control on lighting	•	◎	○	•
Remote control on air conditioning equipment	◎	•	•	•
Presence/absence display	◎	•	○	•
Remote control and supervision on water treatment equipment	◎	•	○	–
Remote control and supervision on tunnel excavator	◎	•	–	○
Electric power control	•	◎	○	–
Supervision and control on production line	○	•	◎	•
Signal transfer among production line	○	•	◎	•
Signal transfer in vehicles	○	•	◎	•
Supervision and control of equipment on working status	○	•	•	◎
Plant administration	○	•	○	◎
Data transfer between machine-tool and control panel	◎	–	–	○
Display system on lacking of component parts and supply status indication	•	○	◎	•

between printers and other various sorts of industrial machineries and their control panels, as well as between control equipment and power panel. For these, if RM100 terminals are used face-to-face or RM200's are used, many signal lines can be concentrated in a from of two-core optical-fiber.

Also, thanks to development of RM100 and 200 series using high-speed light transfer technology, these can be used for extensive use in various types of automaticization or application to control transfer system. The examples are shown in (5) and (6).

(5) FA system

This is the centralized control and supervisory system, concentrating digital data and analog data of the factory and plant in the host computer, and these concentrated and gathered data will be used for a basis for controls. In order to alleviate the program load for host computers, remote Terminal RM100 is provided with a function of sending automatically terminal data to host computers from the center equipment when terminal data have changed or when certain data condition has attained in the terminal, and also with a function of setting the priority of transmission per each terminal, so that they can be utilized in highly automaticized systems. *Fig. 8* shows an example of FA system configuration.

(6) Control center system (Application of RM20, under development)

An example of using a Remote Terminal for a control center effectuating a centralized control on electric motors is given in *Fig. 9*. The equipment replaces some tens of control cables per 1 unit necessary for controlling electric motors by mere two signal lines. With this, all functions necessary as a control center as ON/OFF control including forward and reverse turning of the motor, switching over the control location (direct/remote), switching over AUTO/MANUAL, as well as operational status display, inching operation, automatic reclosing of the circuit at the time of intantaneous power failure, protection against overload and excessive torque, etc. are incoporated in form of LSI, so that standardization of control center and reduction in large scale of wiring in panels and at work site can be realized. *Fig. 10* shows the outer view of the remote terminal for controling control center.

As we have seen, it is possible to constitute an entirely new control system by adding the function proper to the system, control object, to the remote terminal which would function as the fundamental element of the system.

Also we have developed light repeating unit for multi-drop wire type remote terminal RM20 and for the case where the signal lines and power lines are laid together for a long distance. The light repeating unit is adopted for the case where optical fiber is partially used for signal line of RM20, and by this, the problem of taking countermeasures against the lightning surge and of laying the signal lines in more severe noise environment can easily be solved.
environment can easily be solved.

Since the use of optical fiber is restricted to certain locality, the facility of work, inherent of the multi-drop wire system, as well as the advantage of being low in cost will not be harmed. *Fig. 11* shows an outer view of the light repeating unit.

Fig. 8 Example of FA system configuration

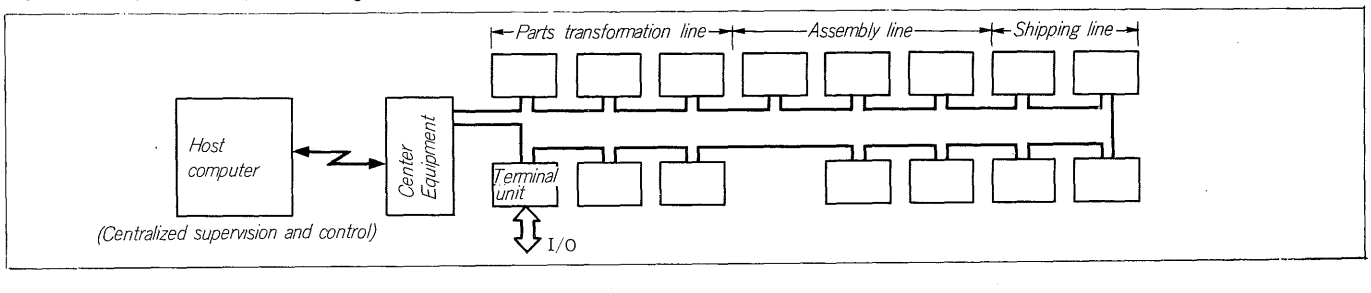


Fig. 9 Control center system

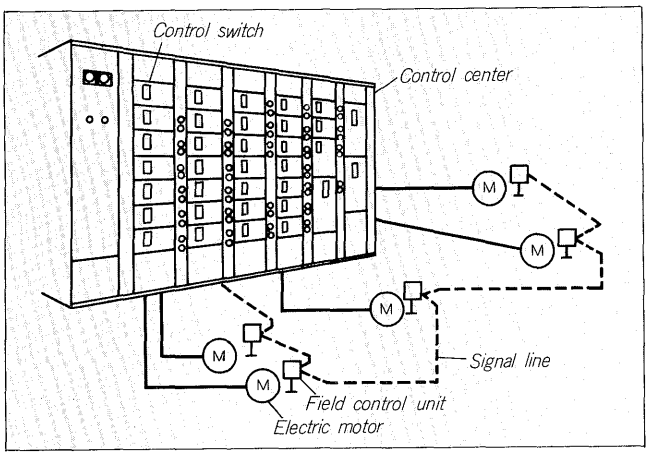


Fig. 10 Terminal unit for control center outer view

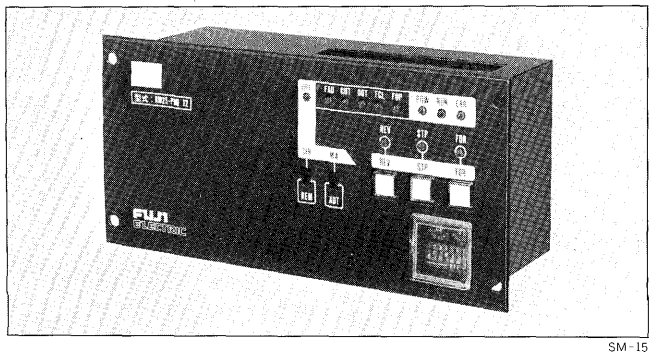


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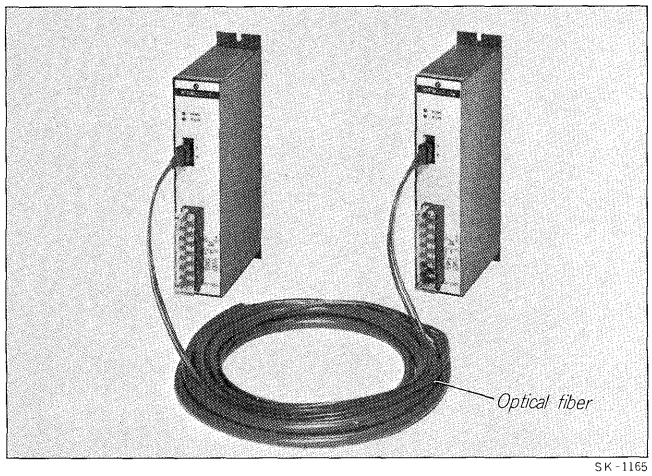
Fig. 11 Light repeating unit-outer view



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7 FEATURES OF REMOTE TERMINAL

(1) Various equipment composition

Remote Terminals are, as shown in *Figs. 3* and *4*, available in 5 fundamental types, so that an adequate selection depending on transfer system and transfer time can be made.

(2) High transfer reliability

By adopting LSI of exclusive use, Remote Terminal tries to reduce its component parts and improve its reliability. And by taking up measures against noise interference on both aspects of hardware and software, good results in various noise tests and field tests in the electric welding workshop have been obtained.

(3) Output selector (fail-safe) function

When abnormality emerges in the communications due to interruption of signalling device, RM10, 20 and 100 will ① maintain the output before the emergence of abnormality for the output of the receiving unit, or ② cut off but reset the receiving units one by one, as their fundamental functions, so that safer system configuration is possible.

(4) Input signal holding function

The transmitting unit of RM20 and 100 can select two operational modes as a method of making up transfer data from digital input signals.

(a) Normal mode: Input data at the time of communication timing is transferred (RM 10, 30 and 200 utilize this system).

(b) Input signal holding mode: Even when communication timing is not being carried out in its own station, when the input data varies more than 20 ms, the signal will be transferred in the next communication. This is advantageous for counting the input signal pulses.

(5) Analog value averaging function (RM20 and 100)

In the anglog transmission unit, reading-in of input analog data is carried out besides the hard filter circuit, in the soft filter function. That is, input data of various times in a certain determined time are read-in and their average values are made to transmission data.

(6) Special functions of RM100

The remote terminal has functions of variable chattering timer for reading-in digital signal and transmitting data compression timer.

8 CONCLUSION

By the use of remote terminals, multiple core control cable can be replaced by a pair of signal lines so that rationalization in large scale in cable laying works, designing, and maintenance is made possible. Also, through adoption of LSI of exclusive use, cost performance per point of transfer signal is improved, and it is expected that the terminals be used for telemeters and remote controls that have been not possible due to their economic feasibility, as well as they can be used for various types of automaticized systems as FA and LA.

In order to make remote terminals easier to use and to improve the practical performance, it will be the future problem to perfectioning the transfer system of exclusive use making terminals speedier, more compact, as well as improvement of center function and combining the control system's proper function. And we intend to perfect and develop more the RM series in compliance with the market needs.