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NEW SYSTEM FOR OVERALL CONVEYER CONTROL

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I. INTRODUCTION

In recent years, the scale of major industrial plants has increased with the expanding scale of the world economy and the processes involved have not only become more complex and diverse but the areas covered have widened and there are greater demands for the long-distance transport of large amounts of resources and raw materials. Under such conditions, Fuji Electric is advancing in research and development by accumulating control technology based on wide experience and new plant-oriented total control systems have been developed. These systems are highly evaluated in the large number of applications where they are now in operation. This conveyer system has several technical features differing from the "sequencers" placed on the market in the past and it is also highly economic. This article describes the various types of plants where conveyer transport is the most basic process and also introduces the technical progress applied in this new system. It also shows future trends in the field of total control technology.

II. CONVEYER EQUIPMENT AND CONDITIONS FOR TOTAL CONTROL

1. Conveyer Equipment from the Standpoint of Total Control

There are two main types of conveyer equipment from the standpoint of overall control:

1) Multi-group conveyers

These are groups of conveyers spread over a large area in ore and coal storage facilities, raw material yards of steel plants, cement plants, etc. The objects of control and monitoring are processes including raw material treatment facilities and loading equipment, *Fig. 1* shows an example of such a plant.

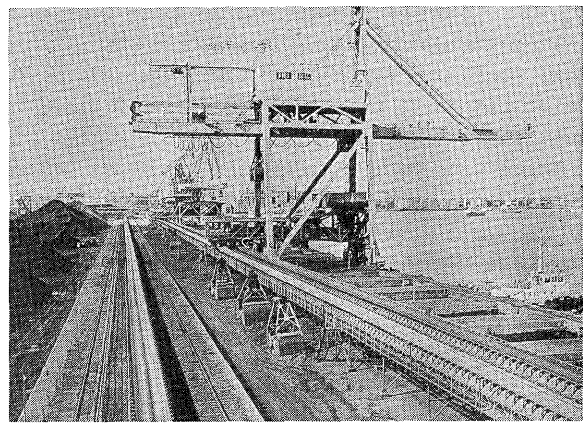


Fig. 1 Multi-group conveyer plant

The features of this process are that there are complex interlocks formed between the central control room and the local electrical rooms, among the various electrical rooms and among the conveyer motors. Specification changes occur frequently and changes in the control interlocks up to the time of test operation are unavoidable.

Therfore, not only does improvement work at the site on the interlock panels, etc. require a long time but control cables must be newly installed or removed and there is the problem of a large amount of time and labor being required.

2) Long-distance conveyer facilities

These conveyers are for the long distance, continuous transport of large amounts of the main industrial raw materials such as ore, limestone, gravel, sand and clinker in the form of lumps, granules of powder. They are used to connect the plant and the raw materials collection point, or the

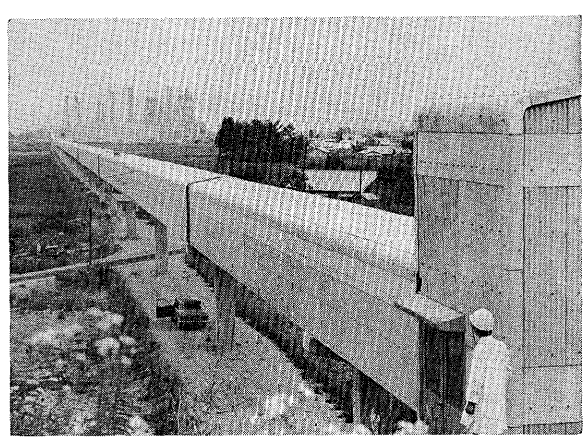
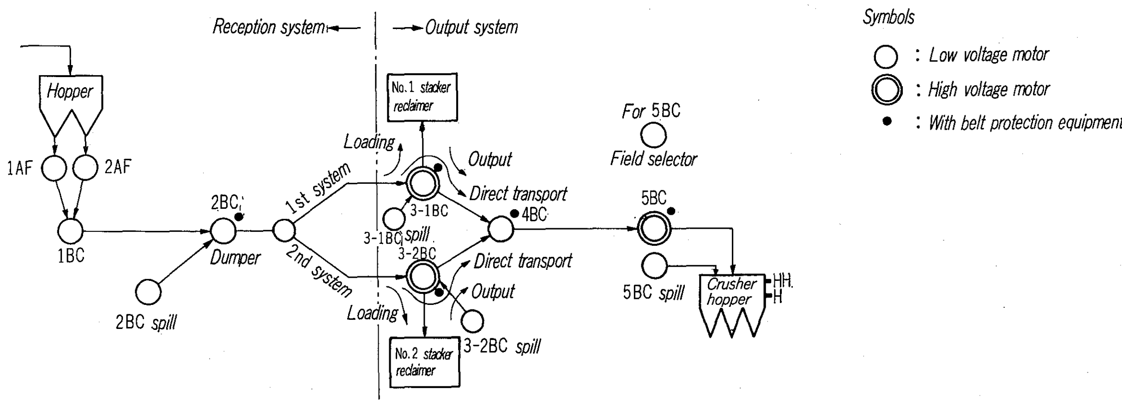


Fig. 2 Long-distance conveyer plant

plant and the loading port, etc. Recently, such conveyers are being used widely to replace roads, railways, etc. which were used formerly. Conveyers have appeared with unit device length of 13 km and total lengths of 200 km. *Fig. 2* shows an example of such facilities.

The feature of long-distance conveyers is the long distance between the central control room and the various local electrical rooms. Each local electrical room is unmanned and it is necessary to be able to monitor from the central control room not only the conditions in the local electrical rooms but also the operating conditions along the length of the converter, and also to take the appropriate measures during emergencies.

Therefore, it is necessary to concentrate on the signal transmission system and have a system which is strong against noise and cheap.



Electrical receiving room	Output electrical room	Central control room
1. *Group and independent changeover of apron feeder,* 1BC, 2BC *and dumper* 2. *Independent operation and stopping* 3. *Transmission of operation display signal to central* 4. *Transmission of accident display signal to central* 5. 2BC *spill is operated and stopped together with* 2BC *during operation*	1. *Group and independent changeover of* No.1 *and* No.2 *stack reamers,* 3-1BC, 3-2BC, 4BC *and* 5BC 2. *Independent operation and stopping* 3. *Transmission of operation display signal to central* 4. *Transmission of accident display signal to central* 5. *Transmission to hopper level* 6. *Each spill and field selector are operated and stopped in common with each* BC *during operation*	1. *Selection of number of operating apron feeders* 2. *Selection of loading, direct transport and output of* 1st *and* 2nd *systems* 3. *Confirmation of starting preparations* 4. *Group starting instruction* 5. *Group stopping instruction* 6. *Operation display* 7. *Accident details display* 8. *Starting and stopping of system according to hopper level*

Fig. 3 Contents of control signals in an example of a multi-group conveyer plant

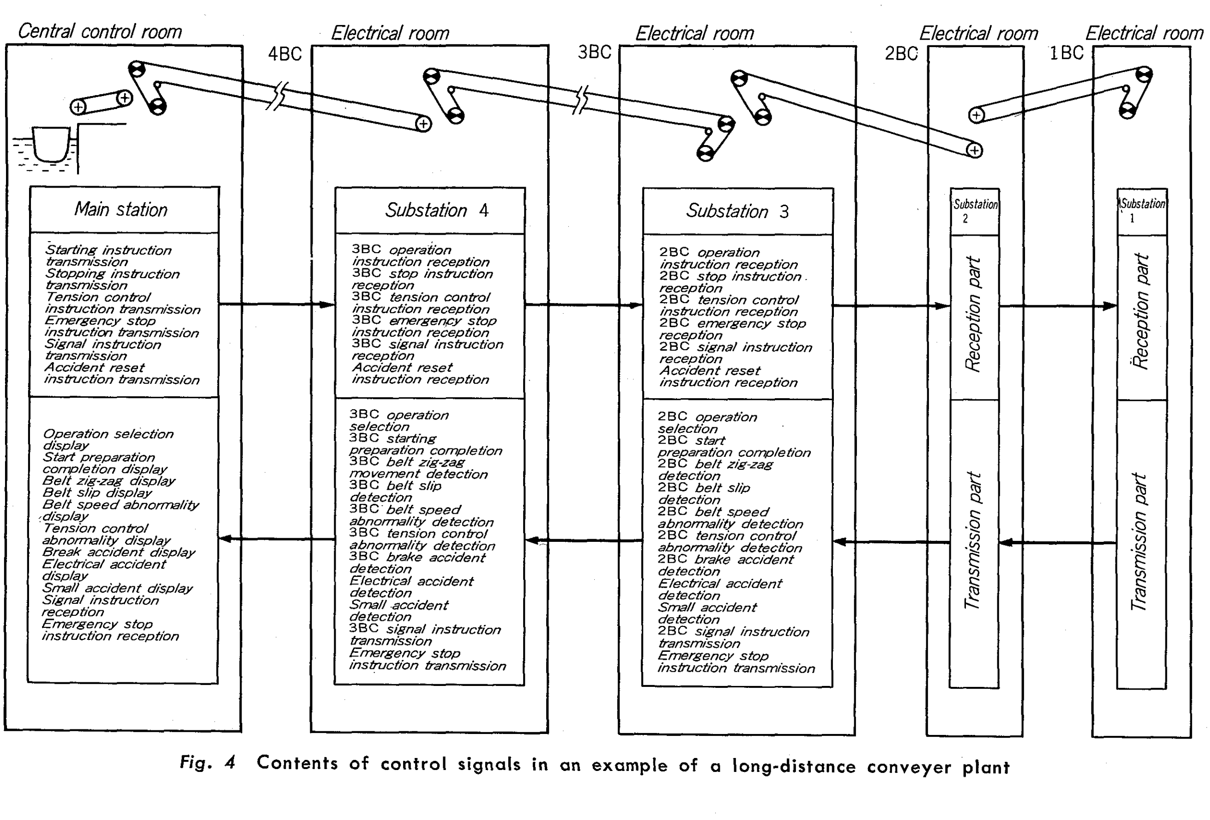


Fig. 4 Contents of control signals in an example of a long-distance conveyer plant

2. Outline of Total Control in Conveyer Equipment

Examples of control systems for the multi-group conveyers and the long-distance conveyers are shown in *Figs. 3* and *4* respectively. The control functions of these systems for the operation locations are as follows:

1) Central control room
   (1) Operation system selection
   (2) Operation starting and stopping control
   (3) Process monitoring and display
2) Local electrical rooms
   (1) Independent start and stop control
   (2) Independent accident protection control

3. Conditions required of the Total Control Equipment

For the total control equipment to have the above functions, the following conditions must be met.

1) Cost/performance

The economy of the equipment requires an evaluation considering the initial cost, running cost, operating efficiency, repair costs, etc. and the final decision is to be made taking into consideration 2) to 8) below. Therefore, it is desirable that the costs for performance be low and the basic cost needed for the equipment also be small. In the case of a system with low performance, the conventional type of equipment with the contact relays can be used as a basis for comparison.

2) Labor savings

Because the electrical rooms located in the processing area are unmanned, it must be possible to understand quickly and accurately the operating conditions of system as a whole, to be able to transmit the required control instructions and, at the time of accidents, to be able to respond automatically and rapidly and prevent the abnormality from spreading throughout the plant.

3) Simplicity of operation

It is necessary that the process be operated according to methods which are the same as those used with existing equipment. In other words, operation of the equipment is not to require any special knowledge or training.

4) Simple erection and wiring work

Since a large amount of information is to be centered in the central control room to save labor, there must be a large number of signal cables and the time and costs required for construction work will be increased. Therefore, it is necessary that the transmission systems employ systems using common signal circuits. A small number of signal cables is also advantageous from the standpoint of maintenance.

5) High flexibility

Many changes are required in improving the systems and adding to the equipment and for the total control equipment, it must be easy to vary the number of input/output points, to change the contents of the sequence control and to make additions or improvements in a short time.

6) Reliability

There are cases when the stoppage of the equipment could result in a major accident and it is desirable that the signal transmission systems be highly reliable, the hardware be provided with self-diagnosis of faults, main parts be duplicated, power interruption countermeasures be provided and software measures be used to deal with signal transmission abnormalities.

7) Easy maintenance

Recent equipment has been employing ICs and the unit system and faults are difficult to find. Therefore, systems should be employed whereby there is self-diagnosis of the fault and partial units can be replaced. From the standpoint of maintenance, it is also necessary that no special knowledge or training be required.

8) Performance display

There are various types of total illuminated display equipment depending on aims but systems which bind all of the units together are commonly used and mosaic systems are often used because they can be adapted to system improvements. However, from the standpoint of human engineering, it is sufficient if the operator understands the minimum essential plant operating conditions and generally, redundant information displays are eliminated and functional display system are employed which give complete displays only in times of emergency. In other words, it is recommended that a display system be used in the total control equipment so that it is easy to perform batch type display of the plant processes employing CRT and EL, separate and casual display for fault systems, operator's guidance during operation and dynamic process simulation.

III. NEW CONTROL SYSTEMS AND THEIR FEATURES

1. Main Points about New Control Systems

It has now become common to introduce computer systems for monitoring and control in manufacturing plants and such systems have made possible a high level of control through improvements in system reliability and the applications of wide-ranging control algorithms. There is great interest in the changes in this technology (*Fig. 5*).

Stage No. 1: the special equipment and circuits in the central control room and the objects of operation and control (hereafter referred to as process points) were connected on a 1:1 basis. The special equipment were individual devices and circuits such as control relays, time limit relays, current rectifiers and special circuits elements in accordance with the required performance and each had to be designed separately. At this stage, there were limitations on the control equipment used. The necessity of com-

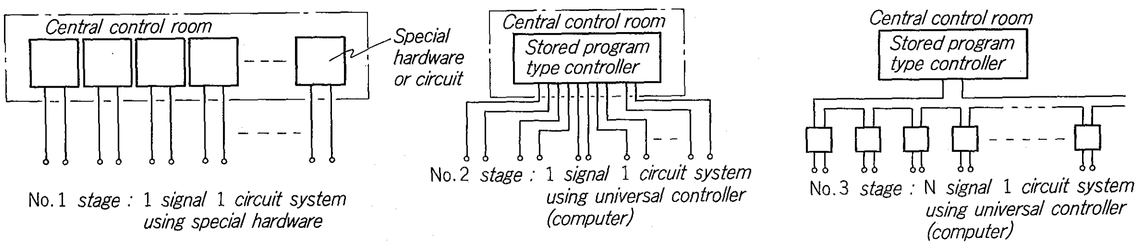


Fig. 5 Development of control system

bining these devices, diversifying technology and having operator's techniques was the main factor in improving system reliability and control performance.

Stage No. 2: the special equipment and devices in the central control room were replaced by a universal stored program type controller. With this system, the same hardware could be employed for completely different control purposes so that from the standpoint of hardware, system reliability was improved and costs were reduced. A high level of control was possible through the use of software for all control objectives and great progress was made over the first stage.

These techniques were made possible by the original development of a control system using a special computer for control. The so-called SCC (Supervisory Computer Control) and DDC (Direct Digital Control) were developed at this stage. Among the control computers the sequencer, a special device which process only logical operations, gained attention as a controller mainly for total and sequence control at this stage.

Stage No. 3: the technology of the second stage presented a great innovations through the use of a universal central controller but in respect to the signal transmission routes in both the first and second stages, it was indispensable that there always be one circuit per signal between the central control room and the process points and in this respect some of the former "order-made" methods still remained. The technology of the third stage developed a universal signal transmission system. The third stage technology which combined a universal signal transmission system and the universal central controller was such that the control system composition was not related to plant conditions and it became possible to lower system component costs considerable and also to develop control functions to a high level which represents remarkable progress. In other words, this simple system is a new system which represents a rational combination of conventional telecontrol technology and recent data highway technology and computer technology such as the SCC and DDC.

Fuji Electric took note of this third stage technology early and made its first announcement concerning this at the 9th Industrial Measurement Exhibition in 1971. Thereafter, efforts have been made to make practical systems and considerable results have been obtained. However, at present, the advanced nature and excellence of this technology has been recognized. The following sections will introduce the technical aspects of this new system and give some actual examples of application.

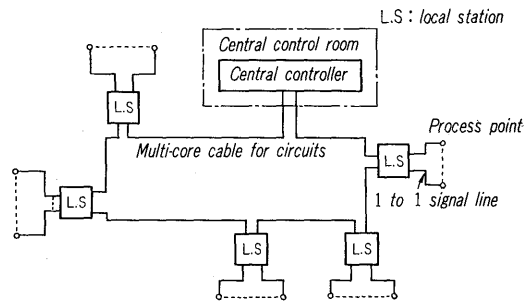


Fig. 6 Diagram of signal sending system for DPCS

2. The New DPCS Control System

The DPCS (Data highway Process Control System)[1] system is a total system consisting of a combination of a data transmission system using line sharing and a master controller of the stored program type adapted to process control.

The DPCS utilizes minicomputers such as the PUC-10 and FACOM U-200 in the master controller and the large number of local stations arranged rationally near the various process points are connected by one multi-core urban telephone cable circuit. Input and output signals from the process point (*Fig. 6*) are processed in the local stations and sequence control is performed between the center and local stations by time sharing of the cable circuit mentioned above. With this universal system, the DPCS is suitable for sequence and feedback control (*Table 1*).

(1) System specifications

Transmission system: Series pulse code unmodulated signals (NRZ)

Synchronization system: External synchronization system

Transmitted signal level: DC 0/24V

Transmitted signal check system: parallel comparison and odd parity system

Transmission distance: about 10 km (however, easy to extend by relay amplification)

Table 1 **Specifications of DPCS**

	Function	Model	Specifications		
Central controller		DPCS-P	Power supply	100V±10% 50/60Hz	
			Outer dimensions	1,400(W)×700(D)×1,900(H)mm	
			Ambient conditions	0~40°C 20~80% R.H.	
		DPCS-U	Power supply	100V±10% 50/60Hz	
			Outer dimensions	700(W)×830(D)×1,800(H)mm	
			Ambient conditions	0~40°C 20~80% R.H.	
Local station	Lacker+ power supply	DPC-LS1	No. of channel units accomodated		1
			Power supply capacity		200VA
			Power supply type	AC 100, 110, 200, 220V±10%, 50/60Hz	
			Outer dimensions	500(W)×410(D)×390(H)mm	
			Weight		20kg
			Ambient conditions	−10~+45°C 85% R.H.	
		DPC-LS2	No. of channel units accomodated		12
			Power supply capacity		1 kVA
			Power supply type	AC 100, 110, 200, 220V±10% 50/60Hz	
			Outer dimensions	620(W)×600(D)×2,350(H)mm	
			Weight		500kg (max.)
			Ambient conditions	−10~+45°C 85% R.H.	
Channel unit	For sequence control	DPC-SC	Input	ON-OFF input, no-voltage contact	12 points
			Output	No-voltage 1C contact (AC 200V, 5A)	12 points
	Only for sequence input	DPC-SM	Input	ON-OFF input, no-voltage contact	12 points
	For feedback control	DPC-FC	Input	Measured value (analog or pulse)	1 point
				Electrically driven valve opening rate (instruction possible only in portable controller)	1 point
			Output	Increase pulse	1 point
				Decrease pulse	1 point
				No-voltage contact (for sequence control)	4 point
	Only for feedback input	DPC-FM	Input	Measured value (analog or pulse)	1 point
				Electrically driven valve opening rate (instruction possible only in portable controller)	1 point
Portable control	For manual operation		Power supply: AC 100V±10% 50/60Hz		
System typewriter	For accident print-out system operation and program loader		Power supply: AC 100V±10% 50/60Hz		

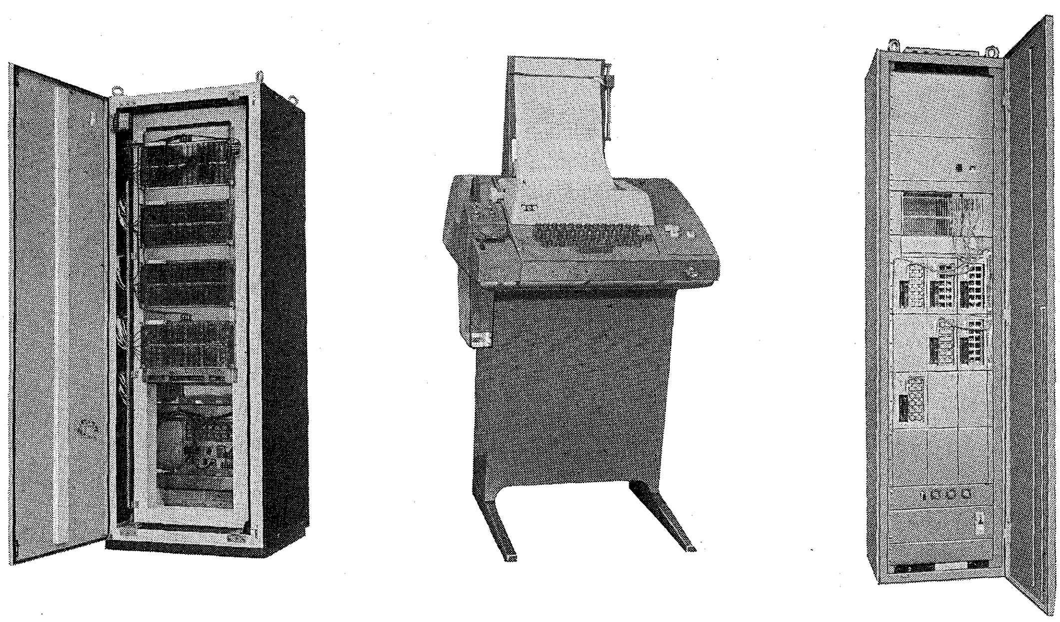


Fig. 7 Hardware for DPCS

No. of control channels: 255 channels (max.)
Scanning speed: 10 channels/sec., 16 channels/sec. (convertible)
Circuit: CPEV-S 0.9ϕ more than 5 P

(2) Master controller
Hardware: PUC-10 system or FACOM U-200 system
Software: PUCS-11 series

(3) Site equipment
The local stations can accomodate up to a maximum of 12 channels in a building block system for each channel.

This system is especially applicable to process points scattered over a wide range such as cement plants and steel mill raw material yards and systems where the process points are separated by considerable distances such as in long-distance conveyer systems.

3. DPCS Features

1) Simple construction work
Since only one multi-core cable is used to connect the central control room and local stations, major savings are possible not only in cable costs but also construction costs. Work design, cable inspection and maintenance, etc. can be accomplished easily. This greatly contributes to the economy of the system.

2) Easy improvement and addition
It is unnecessary to change the hardware of the central controller when adding new control points. Only local stations or building block type channels need be added to the circuits and then the software changed accordingly.

3) Local stations are linked to on-line control
The local stations as terminal stations can accomodated a maximum of 12 control channels in unit form and suitable for on-line control. The site equipment is of strong electrical construction and can withstand adverse environmental conditions such as ambient temperature without the need to air-conditioning, etc.

4) Simple system design
In addition to the basic program, many software groups including sequence control, feedback control and data logging are provided. System design needs no special knowledge since the required data can be easily set in the tables by means of the "Fill in the Blanks" system.

5) High reliability
When the multi-core cable is in the form of a loop, there is no system down-time even when a wire breaks in the circuit. For protection of the circuit against noise and surge, not only are the signal levels basically high but sufficient measures such as parallel comparison and parity check are also provided. There is also no problem with long distance transmission.

6) Self-diagnosis for faults

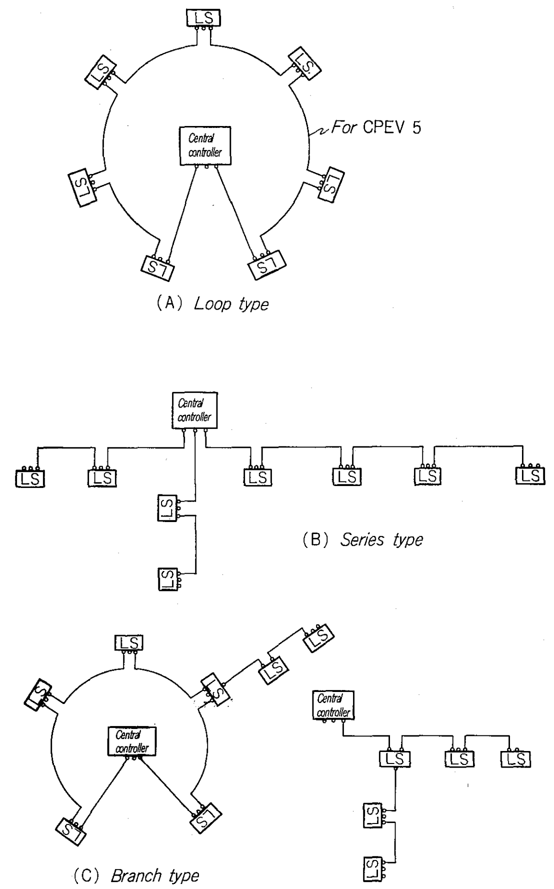


Fig. 8 Three methods for signal sending cable arrangement

When temporary errors in transmission due to noise, etc. are detected, the system maintains correct data transmission by automatically repeating transmission of the same signal.

When the error continues over a long period, a display or print-out alarm is given, the channel is automatically cut off and total channel control is continued. When a fault is discovered in the master controller, a fault alarm is given.

7) Easy system maintenance and inspection
Maintenance and inspection are easy since loop circuit checking channel checking functions are provided and portable consoles and system panels can be used. Since only specified channels can be operated without influencing other control channels, regulations, etc. can easily be performed during operation.

8) Data transmission to external computers
Such data can be sent via two routes, one via a local station and the other directly from the master controller. Data transmission is easy via either route.

4. Total Control Systems Employing the DPCS

The DPCS system with the above features was adopted to total control systems as follows:

1) Distribution plan for signal transmission routes
In the DPCS layout plan, the optimum loop is to be selected in accordance with the distribution

of the large number of process points. Generally, the following systems are considered (*Fig. 8*).

(1) Loop system [*Fig. 8(A)*]

This system is applicable when the process points are distributed comparatively uniformly. The highest reliability is achieved if the signal circuits are doubled by the loop. This does not make the cable too long.

(2) Series system [*Fig. 8(B)*]

This system is suitable when the process points are arranged in a straight line. This system uses time sharing in the signal lines and its major advantage is low cost.

(3) Branched system [*Fig. 8(C)*]

The majority of the process points are connected by systems (1) or (2) but when only a few points do not fit the ordinary pattern, this system can be used by branching from the local stations.

The control table layout can use any one of the above three systems or a combination of them. For this layout plan to be realized freely, it is evident from *Fig. 8* that no matter what the process point distribution, the central controller and local stations need have only 3 control cable connection ports. Therefore, it is easy even for a beginner to compile a suitable cable plan to match future planning.

2) Local station layout plan

The local stations consist of transmission control circuits and channel groupings and as shown in *Table 1*, some have only one channel while others have 12. The channels can be combined optionally in various types of functional units corresponding to the process points. Therefore, the optimum control cable plan and system cost can be achieved by selecting the best channel combination method and local station locations and using two types of local stations.

5. Total Control Software

The following program systems are used as the standard software for total control. An effective control system can be achieved by freely combining these programs.

(1) Sequence control software
- Independent operation program
- Group operation program
- Emergency stop program
- Circuit check program
- Universal sequence control execution program (SQCS)

(2) Feedback control software
- Universal feedback control execution program

(3) Display and monitoring software
- Process data monitoring program
- Process data logging program
- SF print processing program
- Accident display program
- Program for data transmission to external computer
- CRT display coupling program

(4) System service program
- Sequence control (SQCS) compiler
- SQCS test program
- System utility and control service routine

Among these many programs, the universal sequence control execution program (SQCS) is particularly effective in total control systems. This program uses a universal minicomputer in the master controller and it can be used directly to express logical algebra in the same way as a special sequencer. Sequence logic combinations are possible. It is more convenient than former sequence programs in respect to program additions, changes and checks and is very highly evaluated by users. The accident display program does away with annunciator relay panel used for each point in former alarm systems. The lamps can be lighted, flickered or extinguished directly from the central controller which contributes greatly to rationalization. By coupling with CRT display equipment, it becomes easy to centralize the graphic functions of the illuminated panels and functions can be expanded to operator guidance and process simulation.

IV. NEW DEVELOPMENT IN CONVEYER EQUIPMENT

The new DPCS system described above has been used in wide-ranging applications for high level control functions required for various types of conveyer equipment.

1. Time Sharing System for Transporting Many Materials Simultaneously

This system is for the transport of many types of raw materials freely loaded on a long-distance converter with the minimum gap between. The control system automatically distributes and gives out materials efficiently in storage facilities and finishing lines. One conveyer can be used for many purposes.

This system facilitates the selective size transport of crushed rock, selective transport of coal and gravel, weighing and transport of various types of raw materials in steelmills and the transport of different raw materials in suitable amounts. it is also ideal for control of long-distance conveyers for loading of grains, wood chips, clinker, various types of ores, etc. from wharfs to ships.

2. Automatic Monitoring and Control System for Container Conveyers

Container transport utilizing long-distance conveyers is foreseen. This system is completely automatic and unmanned and performs recording and classification of groups of containers for different places in distribution centers located along the conveyer, classification of containers arriving or passing through for various delivery areas, checking of containers passing through, etc. Container tracking can be performed by means of a tracking instruction given from any base and the container conditions can be monitored at any time by means of the monitoring system. This system shows the functions of the series type DPCS at their best.

3. Automatic Storage and Reclaiming System for Raw Materials Yards

With expansions in the scale of steel plants, raw material yards have also become larger and there are many problems in the efficient storage and reclaiming of raw materials. Raw material yards have many transport conveyers and stackers and reclaimers located along the conveyers perform the storage and reclaiming work. This system performs automatic control of storage and reclaiming of raw materials in steel mills by utilizing the DPCS features of few control lines and control of scattered equipment. Combinations of raw material transport operation systems are decided for storage and reclaiming for several raw material yard blocks and the storage and reclaiming are performed according to the most rational schedule. The system also controls the rotation and clearing of the bottom and unloading conveyers, as well as the position and movements of the stackers and reclaimers themselves.

4. Conveyer Monitoring System

As conveyer facilities become longer, faster and more branched, the effects caused by accidents increase and it is necessary to provide an accident forecasting system more advanced than the previous protection systems.

The DPCS also can be used independently to advantage in this field. Detection functions at the preoperation stage can be provided for the various protective devices located along the conveyers and if an abnormality is detected in cyclic repetition of comparisons with standard values in the DPCS, the address and contents are displayed immediately and an alarm is given in the central control room. This is a total system for accident forecasting and protection including all important monitoring items such as analog signals for belt tension, motor load distribution, speed abnormalities in various parts, etc. and hopper level signals, etc.

V. APPLICATION RESULTS

This section introduces typical results of the application of the excellent DPCS system. Features of the applications are also given.

1. Long-distance Conveyer System

The G route conveyer delivered to the Kamiiso plant of the Nihon Cement Co. continuously transports primary crushed limestone from the Garo mine to the plant, a distance of 6.3 km. The equipment then transports the material between the secondary crushing plant and the storage yard via connected groups of conveyers. An outline is shown in *Fig. 9*. Local stations are arranged in three electrical rooms for the G route conveyer, the G route tail part and the crushing system. The master controller is located in the central control room near the G route part. It is a typical series system connected by DPCS transmission cables. The control functions performed by the DPCS for the long distance conveyer are as follows:

(1) Interlock signal transmission among the electrical rooms
(2) Switching control between G route BC main operation and turning operation
(3) Group operation control of G route BC and auxiliary equipment
(4) Automatic group operation control of route conversion of site conveyers
(5) Control of 1-light multi-purpose graphic display system

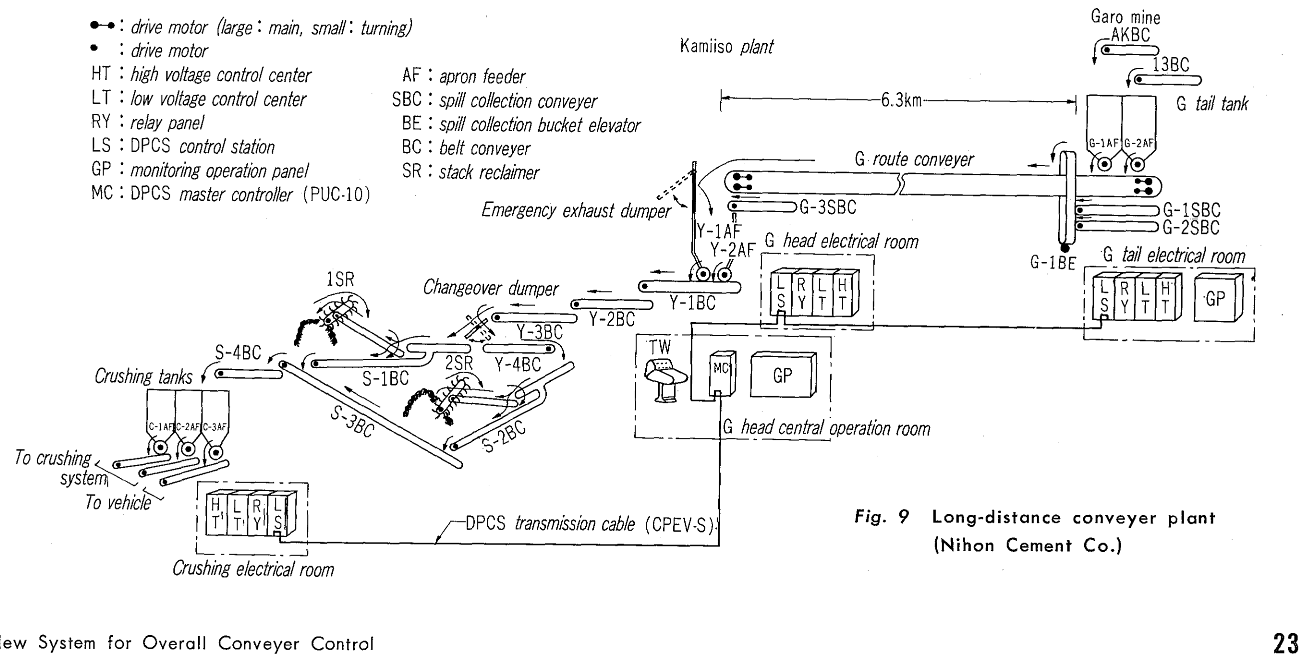


Fig. 9 Long-distance conveyer plant (Nihon Cement Co.)

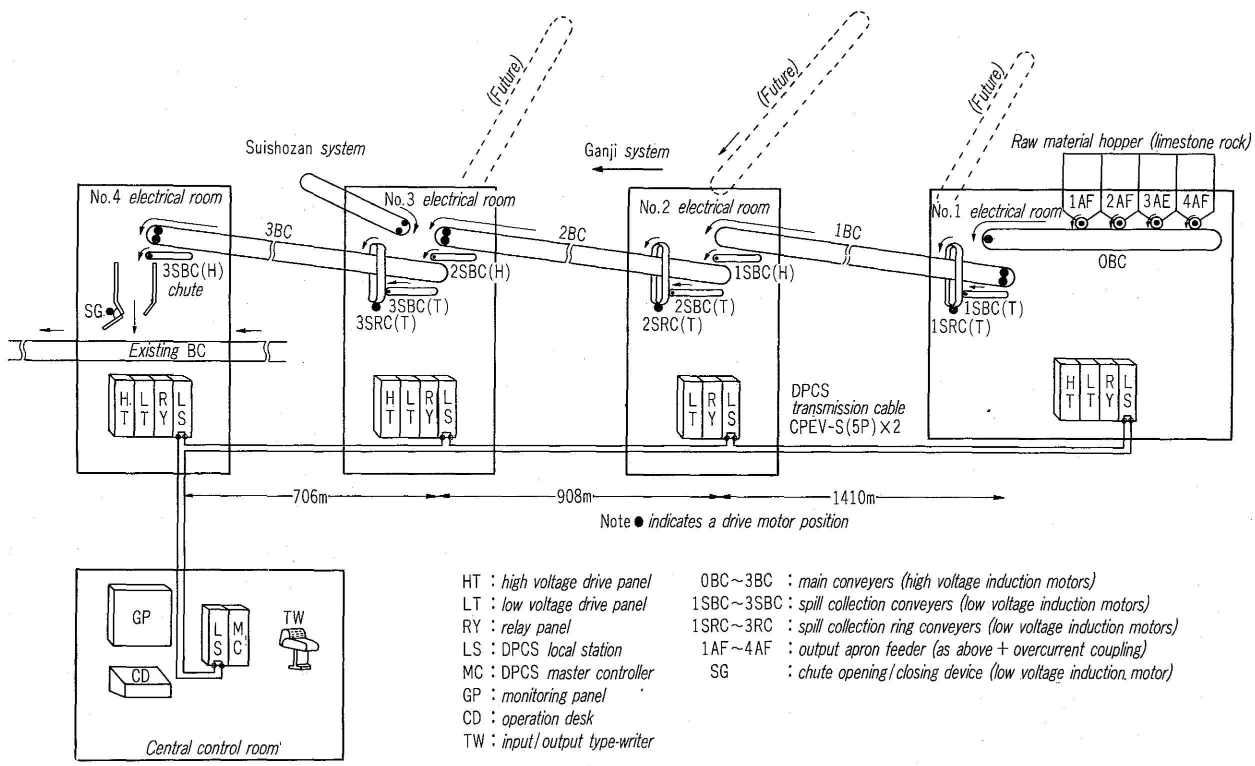


Fig. 10 Long-distance conveyer group (Onoda Cement Co.)

Since processing can be performed internally for circuit checks before operation, operation condition display, accident display and flicker alarm display by means of the central master controller control and monitoring functions, this contributes greately to compactness and simplicity of external circuits and also simplifies the graphic panel. The cyclic illumination system in which the LED attached to each channel in the local stations show the total operation conditions by scanning from the central control room has proven particularly effective. This equipment was installed in March, 1973. As never before, it operated well during the short test period and no trouble have occurred.

2. Long-distance Conveyer Group

These are long-distance conveyer facilities delivered to the Tsukumi plant of Onoda Cement via Furukawa Mining for the transport of limestone. An outline is shown in *Fig. 10*. The facilities consist of 4 main conveyers of a total length of about 4,024 m which connect the Ganji system and the Suishozan system which joints it in the form of a branch and the existing facilities in the plant. In the future it is planned to add branch conveyers to the 4 main conveyers.

The main characteristics required for this project were control of facilities located far apart and easy adaptability to future expansions. The DPCS system was the most appropriate control system for this case. In these facilities, local stations are located in each electrical room along the main Ganji conveyers. The DPCS master controller in the central control room in the plant and the local stations are connected by a loop-type transmission cable for safety.

Attention was also paid to the electrical supply system for the conveyer drive motors and another feature is the use of drive power sources located near the electrical rooms so that long distance power cables are not necessary and there is greater economy. Another point of interest about these facilities is that after the control equipment was installed at

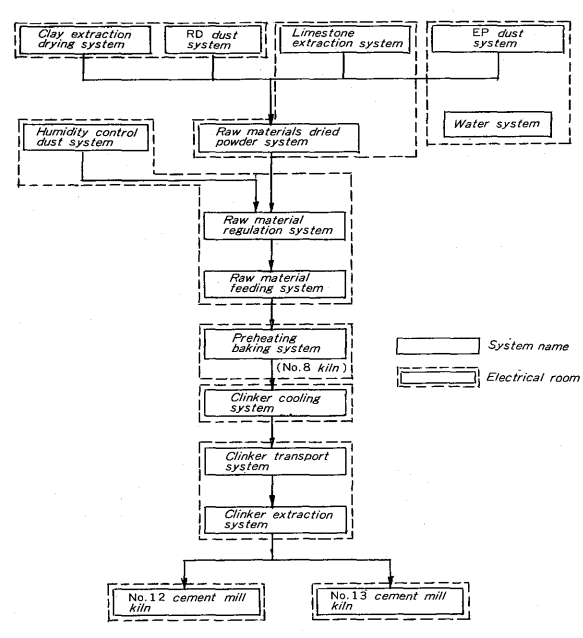


Fig. 11 Flow chart of conveyer lines of No. 8 Kiln, Nihon Cement Co.

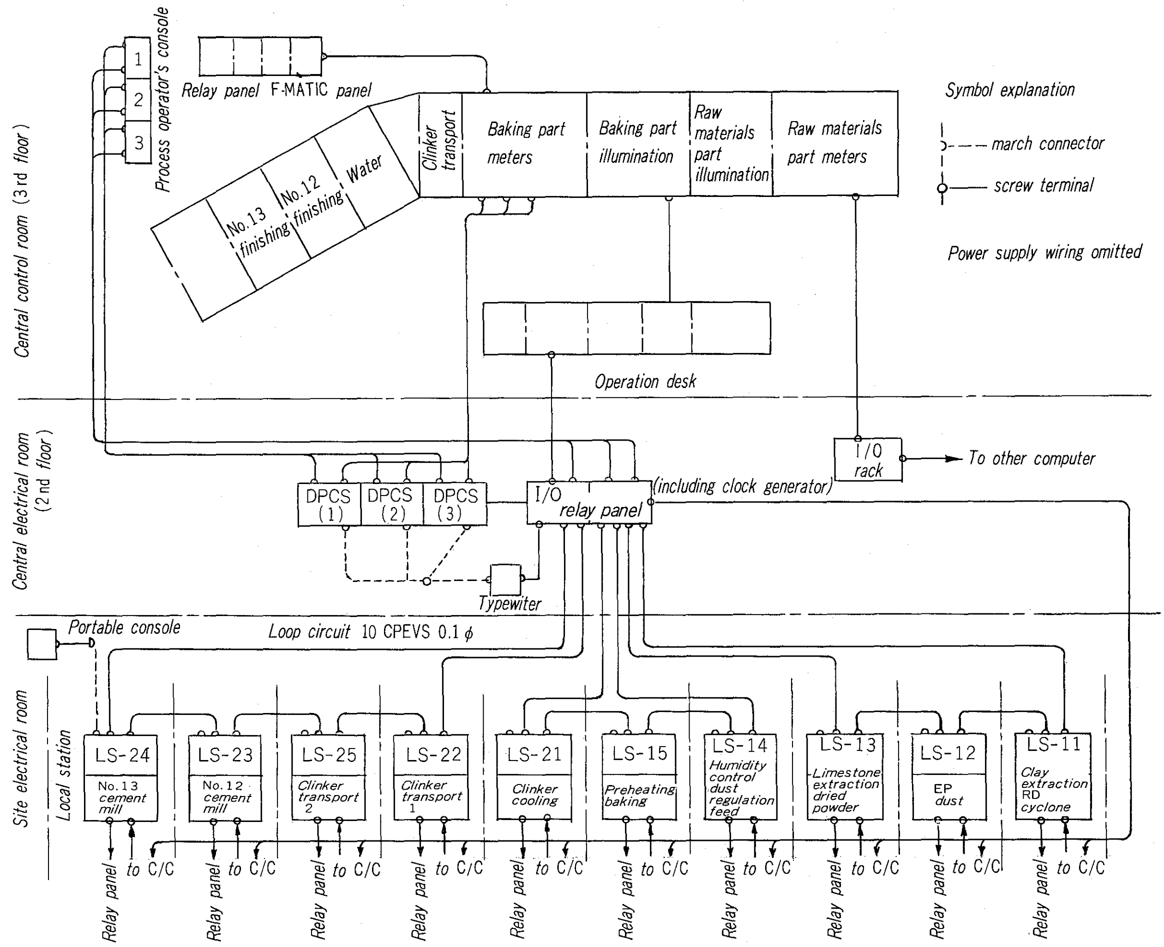


Fig. 12 Construction of hardware and cable distribution system

Table 2 **List of control objects and devices**

Central electrical room / Site electrical rooms for each system	Site devices							Central control room equipment						
	Control object		Panel relations					2nd-floor electrical room				3rd-floor electrical room		
	Motor	Dumper	Branch panel	Control center	Electromagnetic assembly panel	Relay panel	Local station	PUC-10	I/O relay panel	I/O frame	Typewriter	Operator console	Desk	Illumination panel
Clay extraction dried RD dust	47	3	3	3	3	2	1 [11]	1 (including RTC)	2	2	1	1	One set	One set
EP dust transport water	29	1	6	3	1	1	1 [8]							
Limestone extraction raw materials dried powder	51	3	3	3	2	2	1 [10]							
Humidity control dust, raw material regulation and raw material supply	29	1	5	3	2	3	1 [11]	1 (including RTC) PUC-A One for standby				1		
Preheating baking	16	0	3	2	1	2	1 [6]							
Clinker cooling	35	8	2	3	2	3	1 [11]							
Clinker transport and extraction	54	13	3	5	3	3	2 [15]	1 (including RTC)				1		
No. 12 cement mill	35	4	4	3	2	2	1 [10]							
No. 13 cement mill	13	3	3	2	1	2	1 [6]							
Total	304	36	32	27	17	20	16	3 (1)	2	2	1	3	One set	One set

The figures in parentheses show numbers of local station channels.

the site, the operating system was decided by discussion with the customer at the same time as the cable work, etc. and programming and debugging were performed at the site. Operation could be started in only two weeks. This was made possible by the SQCS compiler and the SQCS test program. In this way, a simulation test of the compiled program could be performed at the site using only the master controller and the typewriter without external cable. Since the system is such that program errors can be corrected immediately, the customer was strongly impressed by the convenience and the ease of changing specifications. No repairs have been made after connection to the control objects and the facilities have been operating smoothly since March, 1974.

3. Multi-Group Conveyer Facilities

A DPCS system is also operating in the No. 8 kiln cement manufacturing process in the Kamiiso Plant of the Nihon Cement Co. As can be seen in *Fig. 11*, these facilities connect 15 system and are controlled from electrical room in 9 locations. The system performs monitoring and control from the central control room located near the kiln. The plant consists of (1) a raw material processing area where various types of raw materials are dried, crushed and mixed and then stored in tanks, (2) an area where the clinker formed by preheating and kiln baking using the kiln exhaust gas for high preheating efficiency after moisture control and feeding, is cooled, and (3) an area for transporting the clinker from the tanks, mixing it with lime, producing cement by final milling and storing the finished product in cyclones. This is a large scale process system with a total of 340 control objects as shown in *Table 2*.

There is one master controller for each of these processes and plant operation is monitored by a total of 3 DPCS systems. *Fig. 12* shows an overall outline of the plant. The nine electrical rooms are all located within a radius of 400 m from the central control room and since the several thousand signal lines for control and monitoring in this equipment are collected into one multi-core cable, this lead to a great savings in construction work time and expense. In addition, considerable efforts were also made to improve system reliability and achieve maximum operation safety by (1) employing the loop type DPCS transmission cable, (2) preventing an accident in one part from spreading the plant as a whole by using the operation division system whereby the control system can be divided into 3 parts, one for each area, and (3) shortening the recovery time after an accident by the use of a back-up master controller. This plant was put into operation from June, 1973 as a continuation of tee G route conveyer mentioned in tee previous section. Everything went as to the original plan and the equipment has been highly evaluated.

4. Multi-group Conveyer Facilities for a Raw Material Yard

Via the Nihon Conveyer Co., an order was received from Brazil CSN for a total control system employing DPCS for blast furnace raw material transporting and handling equipment. There are to be two plants, a limestone yard plant with 140 control points and an iron ore yard plant with 300 points. The first DPCS for export is now being manufactured.

For both plants, a large range of equipment is spread at various points, a large range of equipment is spread at various points over large raw materials years. This equipment includes conveyer groups of various sizes, stackers and reclaimers, crushing equipment, raw material bunker groups and shuttle conveyers crossing these, sounding equipment for level detection, dumper gates, and various types of detectors for conveyer protection. Therefore, in order to minimize power and control cable construction costs, and to achieve functionally centralized control, it was suggested to locate electrical rooms at several places in the yards and to arrange local stations and control centers.

VI. CONCLUSION

The data highway system has been successfully adapted for industrial use in process control and by combining with the software (SQCS) effective for sequence control, a total control system, long considered to be the most difficult, has not only been achieved but its effectiveness has been confirmed in practice.

As has been shown in actual examples, this system is an advance over previous total control systems in respect to shortening the time required for plant planning and the adjustments leading to operation, ease of changing software, system reliability, etc. The system introduced here is not limited only to total control and can also be used in other fields and many orders and requests concerning its use in water treatment plants, steel mills, etc.

Naturally, technology is advancing rapidly and Fuji Electric intends to incorporate technical innovations in this system. All criticisms are gladly accepted.

The following information has been completed for the DPCS. Please make use of it.

(1) Process monitor and control equipment DPCS KC–PS01B
(2) DPCS system specifications KE–PS01B
(3) Long-distance conveyer monitoring and control equipment KE–PR02B
(4) Results table KS–PS01B