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APPLICATION OF FFI SYSTEM TO PROCESS INSTRUMENTATION

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1 FOREWARD

Sensor and panel instrument data transmission techniques are advancing from pneumatic type to electronic type and to optical type to meet the needs of responseability, noise resistance, remote maintenance, etc.. Regarding optical transmission, which has various merits, such as noise resistance and large capacity transmission, fiber, connectors, sensors, etc. are being developed vigorously. The development of intelligent sensors aimmed at upgrading of the functions of the sensor itself is also flourishing. The FFI (Fuji Fiber Optic Field Instrumentation) system sold by Fuji Electric is the first field instrumentation system in the world with optical fiber transmission and intelligent field instruments. FFI has gained the concern of customers ever since the ISA announcement in 1985 and deliveries have progressed orderly. FFI large scale system application examples are introduced.

2 OVERVIEW OF FFI SYSTEM

The FFI system consists of a star coupler, which collects and distributes optical signals with intelligent field instruments, and a master station, which is the interface unit with a high-level system. It is a comprehensive field instrumentation system with each device interconnected by digital transmission using an optical fiber.

2.1 System specifications

2.1.1 Interface with high-level system

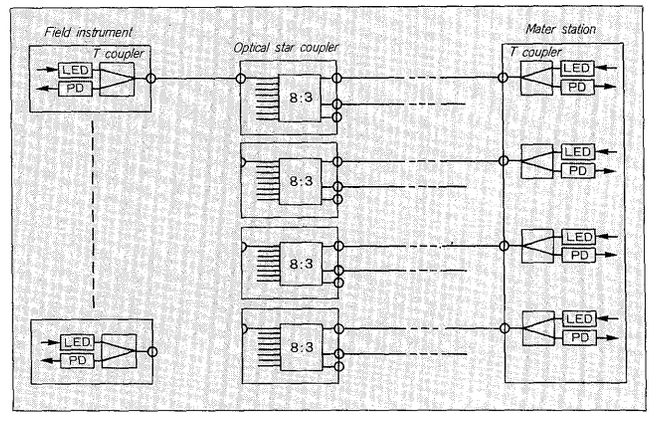
(1) MICREX dedicated master station (abbreviated MS hereinafter) which connects directly to MICREX-P
(2) Panel type master station with general-purpose RS-232-C interface and process input/output signals.
(3) Optic/voltage (or current) converter capable of 1:1 transmission with field instruments

The three interfaces listed above are available. The system of (1) is called the MICREX-P/FFI system. The optical transmission system is shown in *Fig. 1*.

2.1.2 Number of devices connectable

(1) Connection of up to 8 field instruments per star coupler

Fig. 1 Optical transmission system



(2) Connection of up to 4 star couplers per MS

Therefore, up to 32 field instruments per MS can be connected.

2.1.3 Transmission distance

Maximum 1.2 km between field instrument and MS

2.1.4 Transmission cycle

1 time/32 field instruments in 0.2 second

2.2 MICREX dedicated master station (MS)

The MS is the interface between a high-level monitoring control system and the star coupler.

2.3 Optical star coupler

The optical star coupler is an 8:3 distributor and collector using a large diameter quartz fiber as the mixing rod which distributes light equally. Field instrument and MS relay can be performed. Monitoring of field instruments by handheld communicator is also possible.

2.4 Field instruments

The FFI system field instruments consist of a sensor part and a transmission part with built-in electronic circuit and battery.

Exterior views of the field instruments are shown in *Fig. 2*. A menu of FFI field instruments is shown in *Table 1*.

Fig. 2 Field instruments and star coupler 外観

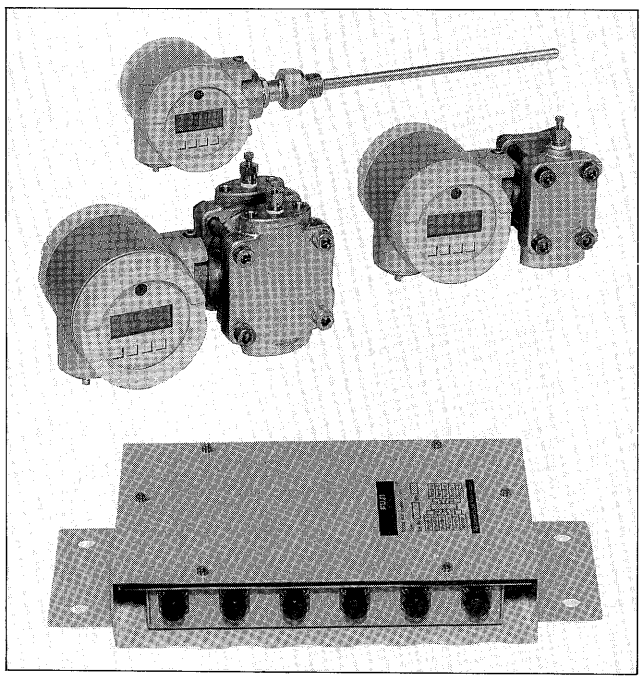


Table 1 FFI field instruments series

Name	Model
Optical platinum resistance bulb temperature transmitter	FUL
Optical thermocoupler temperature transmitter	FUK
Optical gauge pressure transmitter	FBL
Optical gauge pressure transmitter with remote seal diaphragm	FBM
Optical absolute pressure transmitter	FBK
Optical differential pressure/flow transmitter	FFK
Optical differential pressure transmitter with remote seal diaphragm	FFM
Compact electromagnetic flowmeter	FMK
Optical flange type liquid level transmitter	FPK
Optical signal converter	FRK
Optical star coupler	FXN
Handheld communicator (HHC)	FXL
Optical receiving converter (panel mount type)	PRN
Master station (panel mount type)	PMH
Optic/pneumatic converter	ZLD
Optical multichannel temperature converter	FRL
Optical injected liquid level/pressure transmitter	FQM
Optical tank gauge transmitter	

3 FFI APPLIED SYSTEM

This plant produces the new carbon material "KMFC" (Kawasaki Mesophase Fine Carbon) by using the coal tar pitch generated during coke production. This new carbon material is used as electric furnace insulation, motor bearing, nuclear reactor parts, by using it light weight, conductivity, heat resistance, corrosion-resistance, and other merits. Its production process is shown in *Fig. 3*.

3.1 Preliminary study for system selection

The following items were preconditions for studying which instrumentation system to use for this plant:

(1) Explosionproof system from the standpoint of safety

(2) Panel-less operation

Can cope flexibly with pictures changes even for future process changes.

(3) Improvement of site work efficiency

Labor-saving, including maintenance.

(4) High system expandability

Easy and quick coping with process expansion and rebuilding.

As a result of various studies on these needs, the MICREX-P/ FFI system was used.

When applying FFI to this plant, a comparison with conventional electronic sensors was made and the superiority of the FFI system from the standpoints of possibilities, safety, etc. was confirmed. This comparison is shown in *Table 2*.

3.2 System architecture

The architecture, number of units, and wiring distance of the FFI system applied to this plant are shown in *Fig. 4*.

3.2.1 Number of FFI loops

Monitoring loops: 57

Control loops: 12

3.2.2 Site – center transmission

On-site maintenance was considered and the star couplers were centralized at one place. The wiring between the site and center (between MS and star coupler), which consists of 64 metal cables for the conventional electronic system, could be connected with 10 single core optical fiber cables.

3.2.3 Operation

Panel-less operation is realized by using the MICREX-P

Fig. 3 Carbon material production process

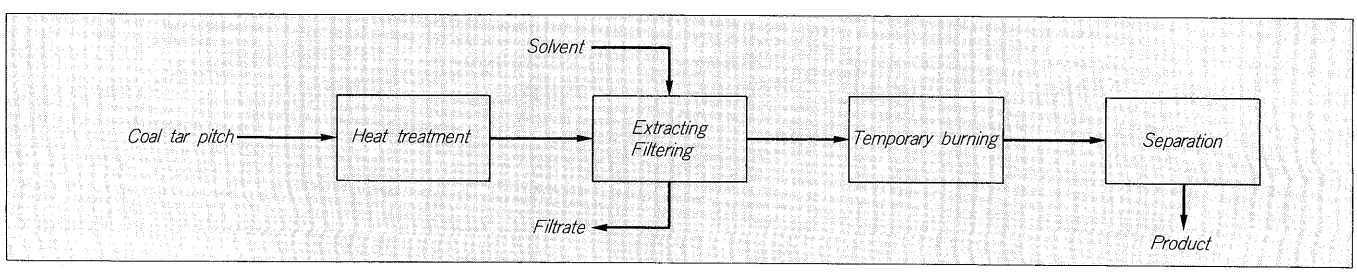
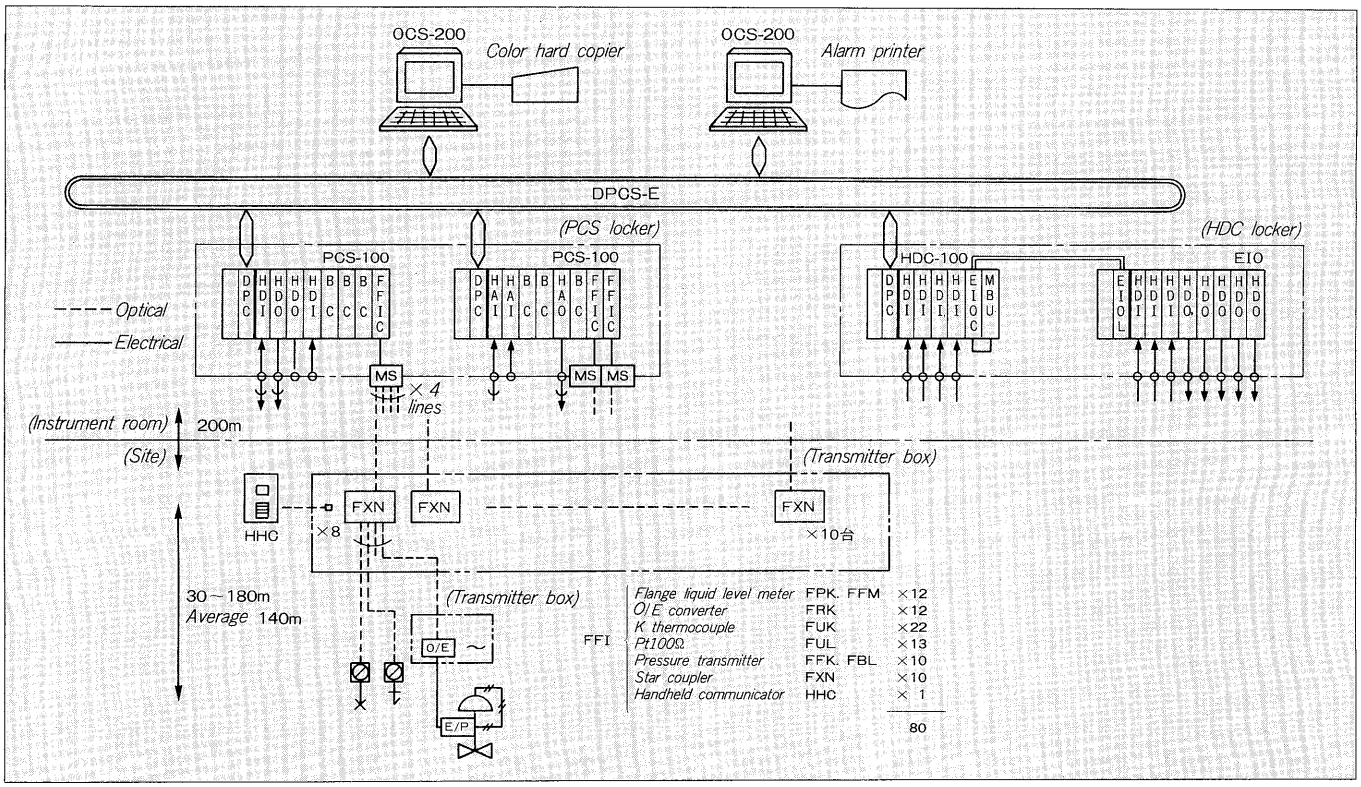


Table 2 FFI and electronic sensor comparison

No.	Item		Optical type (FFI)	Electronic system (FC series)	FFI seen from electronic type
1	Use in explosionproof areas	Cost	○	△	Flameproof packing pressure, special box unnecessary, explosionproof work unnecessary, realization of intrinsically explosionproof system (no spark generation causes)
		Specifications	○	△	
2	Noise by electromagnetic interference		◎	△	No thunder surge noise, noise effect → free selection cabling route
3	Remote maintenance		◎	–	Intelligent self-diagnosis function improvement
4	Accuracy		○	△	Digital transmission, no converter error
5	Power transmission		○	△	Since FFI has a battery power supply, power transmission is unnecessary.
6	Work duct restrictions and work design		◎	△	Work design simplification (by No. 1 and 2), connection list unnecessary, special duct unnecessary
7	Cable unit price		×	△	High because it is not for general-purpose use. However, there is only one kind of cable and stocking is easy.
8	Number of cables		◎	△	Reduction of number of cables → reduction of number of panels, distributor unnecessary
9	Number of field work processes		○	△	Lightening of cable, simplification of loop test, simplification of wiring checks

Symbols: ◎ (excellent), ○ (good), △ (possible), × (poor) – (impossible)

Fig. 4 System architecture



distributed digital control system. All operations are performed from two duplexed CRT operator stations (OSC-200). A CRT picture example is shown in *Fig. 5*. The optical digital signals from the field instruments are connected to an FFI control card (FFIC) inside the PCS-100 and control calculations are performed.

3.2.4 Maintenance

(1) Remote maintenance

Zero point check, span range modification, and damping setting can be performed from the CRT operator station.

CRT panel display examples and the remote maintenance concept are shown in *Fig. 6* and *Fig. 7*.

(2) FFI simulation function

The field instruments and calculation contents can be simulated by disconnecting the input/output signals between the field instruments and controller from the actual circuit and performing input by writing process signals from the keyboard and performing output by forced writing of the calculated result.

Fig. 5 CRT picture example

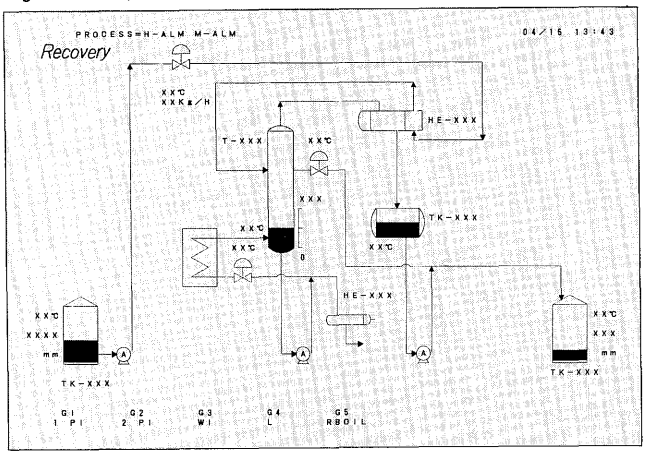
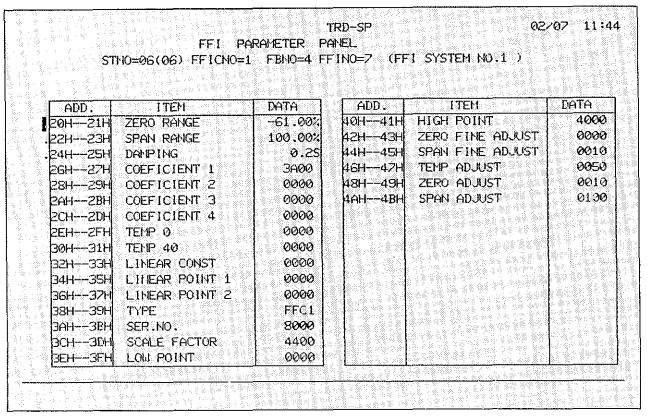


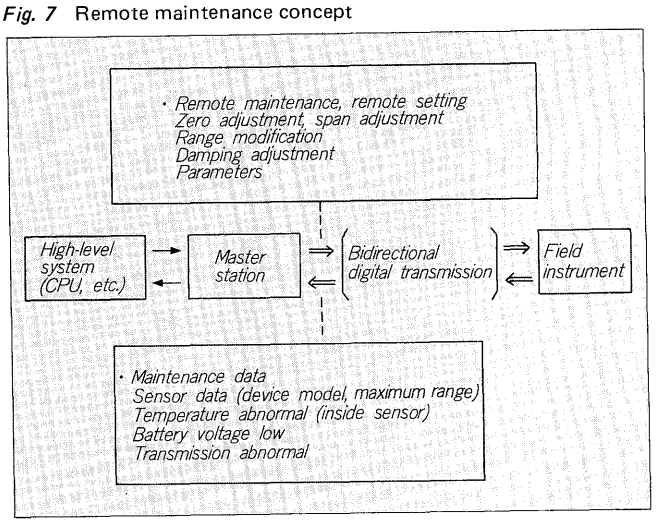
Fig. 6 CRT remote maintenance panel display example



ADD.	ITEM	DATA
20H--21H	ZERO RANGE	-61.00%
22H--23H	SPAN RANGE	100.00%
24H--25H	DAMPING	0.2S
26H--27H	COEFICIENT 1	3A00
28H--29H	COEFICIENT 2	0000
2AH--2BH	COEFICIENT 3	0000
2CH--2DH	COEFICIENT 4	0000
2EH--2FH	TEMP 0	0000
30H--31H	TEMP 40	0000
32H--33H	LINEAR CONST	0000
34H--35H	LINEAR POINT 1	0000
36H--37H	LINEAR POINT 2	0000
38H--39H	TYPE	FFC1
3AH--3BH	SER.NO.	8000
3CH--3DH	SCALE FACTOR	4400
3EH--3FH	LOW POINT	0000

ADD.	ITEM	DATA
40H--41H	HIGH POINT	4000
42H--43H	ZERO FINE ADJUST	0000
44H--45H	SPAN FINE ADJUST	0010
46H--47H	TEMP ADJUST	0050
48H--49H	ZERO ADJUST	0010
4AH--4BH	SPAN ADJUST	0100

Fig. 7 Remote maintenance concept



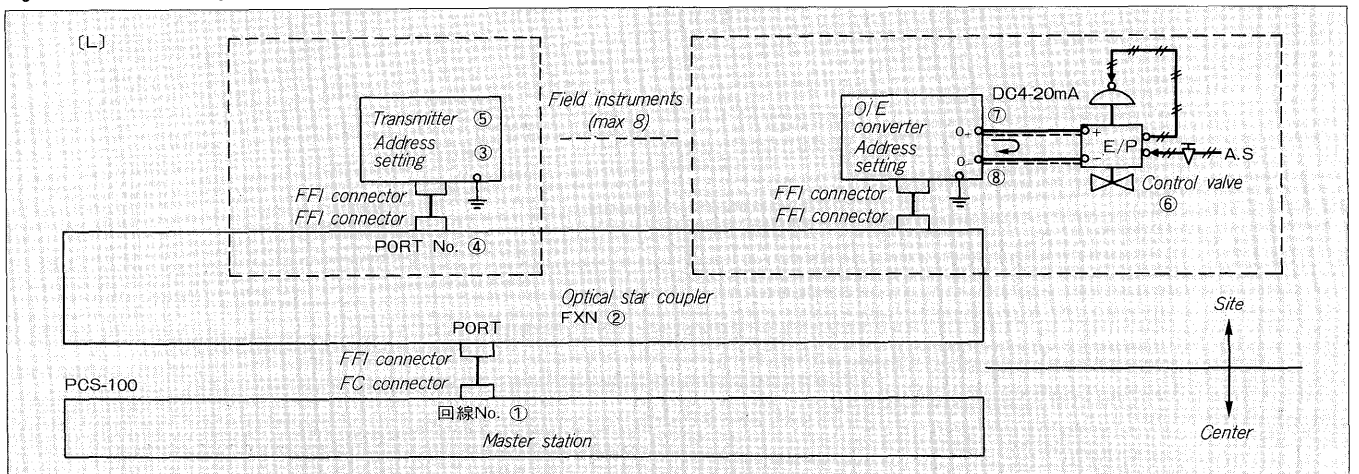
(3) Handheld communicator

In addition to maintenance from the center CRT operator station, field instrument maintenance is performed easily and quickly by using the handheld communicator. The star coupler has maintenance terminals for it.

4 EVALUATION AND PROBLEMS AFTER FFI INTRODUCTION

This system is currently operating favorably one year

Fig. 8 Connection diagram



Line No. / No.	FXN / POS.	Address setting	PORT No.	Name (max 13)	Field instrument: Instruments TAG. No	Instruments Model	Instruments POS.	Control valve TAG. No.	Control valve Model	Control valve POS.	O/E-control valve O+ Wire No.	O/E-control valve O- Wire No.
1	10001	0	8-1	Level	LT-	FPK	101					
		〃	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃
		8	8-8	Temperature A	TY-	FRK	571	TICV-A	ACV	551	01	02
〃												
4	10001	0	8-1	Pressure	PT-	FFK	915					
		〃	〃	〃	〃	〃	〃	〃	〃	〃	〃	〃
		8	8-8	Temperature 1	TT-	FUK	201					
		③	④		⑤			⑥			⑦	⑧

Table 3 Evaluation and problems after FFI operation

Classification	Evaluation	Item	Specific contents	Evaluation	Action
Hardware	○	Reliability	A/D and D/A converter and other errors eliminated by digital signal processing including the site.	Improved precision	–
	○	Expandability	Since the capacity of FFIC is large, allocation is easy and expansion in the star coupler allowance does not require cabling between star coupler and master station.	Lower of costs at expansion	–
	○	Maintainability	Remote maintenance possible.	Increased efficiency by OCS batch management. Shorter adjustment time.	–
	○		Site indication functions, including temperature gauge, all added.	Easier site work.	–
Engineering	○	System design	Interfaces are concentrated by star coupler and design, including DDC, can be managed one dimensionally. Efficiency increased by document concentration.	Reduced design man days	–
	○	Hard sequence design	Distributor unnecessary, signal common line and other wiring unnecessary, document simplification		
	○	Installation design	Wiring table unnecessary. Noise, etc. do not have to be considered at cable selection.		
Site testing	○	Loop test	Since there are no signal conversion sites, field instrument and CRT console direct connection loop test is sufficient. Individual checking of converters, distributors, etc. is unnecessary.	Reduced testing man days.	–
	△	Wiring check	Check of single cable from both directions and total margin check between site and center performed.		Unification of check method, check method improvement
Site installation	△	Cable handling	There are optical fiber bend radius, length, etc. restrictions.		Loosening of restrictions by making cable flexible (cable outside diameter 9 mm → 6 mm)
	△	Connector processing	Special tools and special know-how necessary.		New type connector commercialization, crimping tool improvement, processing order, manual clarification.
					Use of prefabricated cable (connector processing unnecessary)
	○	Duct	Mixing with power cable possible.	Improve installation work efficiency, reduced cost.	–
Schedule	○	Schedule	Reduced design, site testing, and installation man-hours.	Shortening of time other than manufacturing time.	–

after the start of operation. Evaluation of FFI and problem points at plant construction and after operation are shown in *Table 3*.

The merits of introducing FFI are reduction of the number of engineering man-days and number of company testing mandays and, especially, reduction of site testing and other site processes.

These merits shortened the time between the start of design and shipment by about one month compared to conventional systems and also shortened the site schedule by about one month. Such merits attract attention from the standpoint of showing the future direction of instrumentation systems. A connection diagram format such as that shown in *Fig. 8* can be given as a specific reduction of engineering man-hours. This diagram represents the field instruments – center interface for 32 field instruments per one MS and was realized because it is an FFI system in which signal converters, common line, etc. do not have to be considered.

Table 4 Future topics

Item	Contents	Target
Optical fiber cable and star coupler	• Multi-core optical fiber cable • Smaller star coupler	Cost reduction
FFI power supply	• Higher battery power • Lower power transmitter	Longer battery life cycle
FFI menu expansion	• Completion of FFI series including other companies (several types are currently under development)	Unification by optical sensor

5 FUTURE TOPICS

Future topics for developing FFI further are shown in *Table 4*.

6 CONCLUSION

Optical transmission is quickly spreading even outside the communication and data processing fields. It future popularity is expected to be accompanied by further expansion of the cost merits related to optical communication. In the future, the optical instrumentation system will be used in all areas accompanying the expansion of the need for greater data transmission capacity, improved functions, compactness, etc.. We will increase our efforts for this.

The architecture and features of FFI were introduced above, based on actual plant application examples of the optical instrumentation system. The authors will be happy if these features are understood well and serve as reference at system implementation aimmed at a wider range and larger scale.

The authors wish to thank the Kawasaki Steel Corp. Chiba Steel Works for there guidance and cooperation in bringing together this system.

TOPICS

SATECH 87 EXHIBITION in USA from September 14 to 17

SATECH is the largest conference and exhibition in U.S., for professionals working in power electronics, motion control and integrated manufacturing. SATECH represents Systems Automation Technology. This year, it was held on the Queen Mary in Long Beach, California. Collmer Semiconductor Inc., Fuji's agent in the U.S., displayed its semiconductor products, such as new "Z" series, power transistors, high-voltage silicon diodes, schottky diodes, and so on.

Mavy visitors called at our booth during the four day period.