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THE LATEST COMPUTER CONTROL SYSTEM FOR IRON AND STEEL PLANT

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I. INTRODUCTION

Control techniques in Japanese iron and steel industries have been remarkably advanced and developed, and it has been many years since the Japanese Steel Industry occupied the world leading position.

These control technique innovations are greatly owing to the advancements of computer control systems employed in iron and steel plants.

The computer control system in iron and steel plants composes a large hierarchical system with the top level central management computer and many layers of control computers in each process level, and these computers are operated completely organically as the overall plants based on the production orders.

Recently, not only at the final producting process but also at the raw material handling process, the instructions for production plan are corrected and newly planned on-line, further, the optimum production schedule is established, and at any fields, controls cannot be made without having computers. The operations are also changed for energy saving, resorce saving and efficiency. Managements of the total energy flow in the steel plants are re-examined and enhanced, oilless operation of blast furnace, combination blowing of converter and continuous casting are increased, continuous casting of special steel and continuous casting of multiple steel grades are promoted, and by the direct rolling and the hot charge operations at rolling mill process for improvements of efficiencies and energy saving are strongly proceeded.

Needless to say, for these processes, computer control systems are installed, providing the efficiency improvements.

As described above, control computers are essential in the plant operations, the following factors are regarded as more and more important factors and severe requirements for installation of computers into these processes.

1) Highly reliable design
2) High speed processing
3) Easiness of hierarchical structure system building
4) Easiness in linkage with other systems
5) Flexibility and extensibility
6) Achievement of optimum control performance

On the other hand, computer manufacturers are continuing the every efforts not only to improve processing speeds, reliability and maintainability but also to cope with the expectations by the users at both phases of the hardware and software such as:

1) Response to system scale enlargements
2) Easiness in building a compound system
3) Revision of man-machine interface of CRT, etc.
4) Increase of dataway speed (employment of optical transmission)
5) Practical applications of optimum control theory
6) System maintenance technique

This paper introduces the Fuji Electric's new system composing techniques, ideas, and examples of introduction of control computers into iron and steel plants.

II. TREND OF IRON AND STEEL PLANT COMPUTER CONTROL SYSTEM

1. Trend of system composition

Aiming at distribution of controls and centralization of data, in many cases, the recent iron and steel plant control computer system is composed of three layers of control systems; production planning system, supervisory control system and direct digital control system. (see *Fig. 1*)

1) Direct digital control level computer

The direct digital control level computer in the lowest layer is a combination of those distributed to the extremes such as the recent one loop controller, control system which controls several tens of loops of DDC with one computer, and those having sequence control fucntions. And, mainly, microcomputers are used. In this field, to improve the reliability, controls and functions are distributed, and rapidly increased softwares are entirely made to package programs, so that computers can be used without any particular consciousness.

2) Supervisory control computer system

The supervisory control computer system manages functions of the individual direct digital control subsystems on real-time and provides the optimum control instructions. Conventionally, direct digital control was also made at this

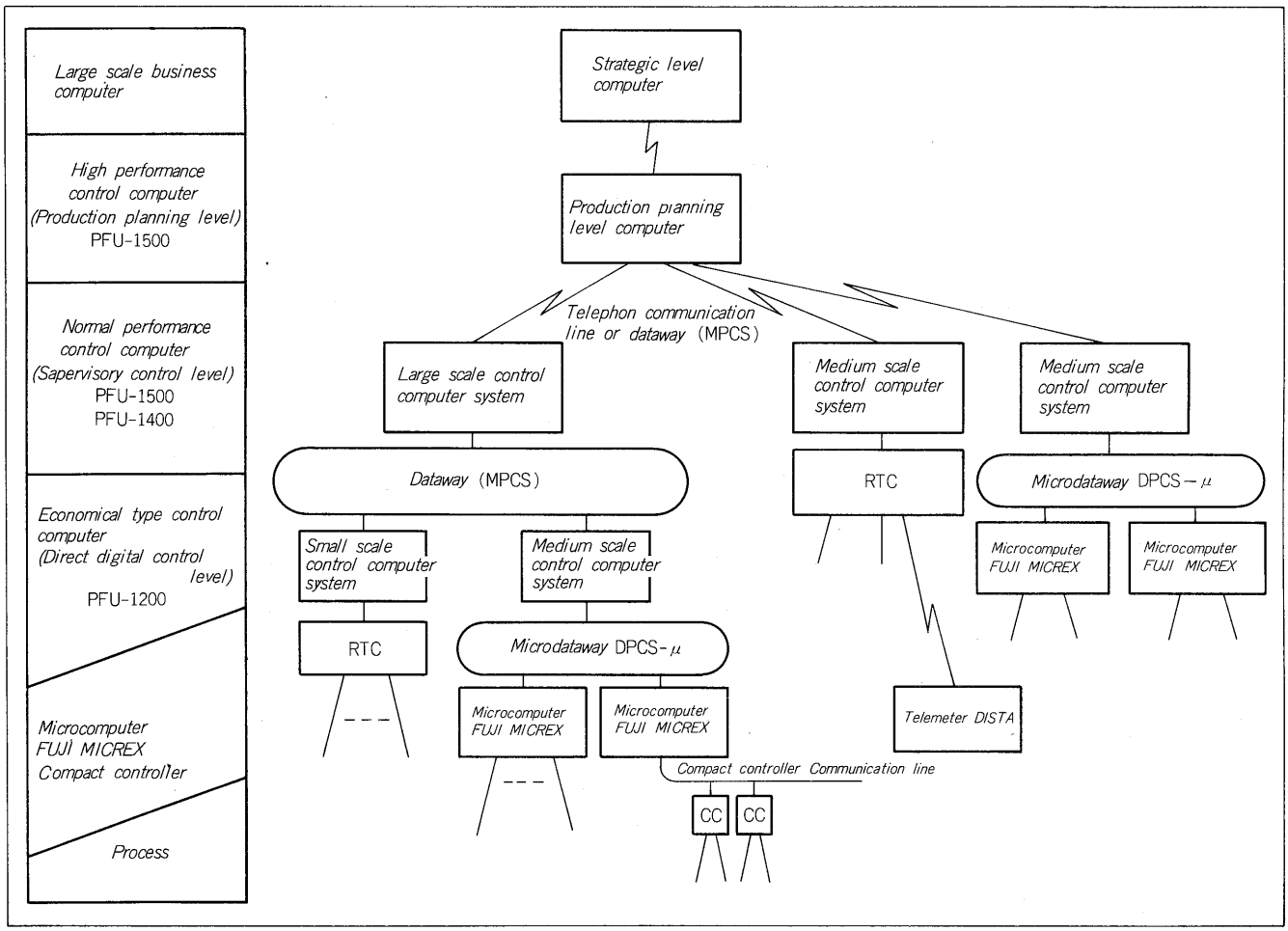

Fig. 1 Configuration of distributed hierarchy system

level. With the development of the direct digital control systems using microcomputers, the directly controlling functions have been separated from the supervisory control level, and instead thereof, the following functions are enhanced as a supervisory control computer.

(1) Enhanced instructions for plant starting, stopping and erroneous operations and guidances for erroneous controls by operators.

(2) On-line supervision and support system for microcontrollers in lower levels.

(3) Perfect process data collections.

(4) The traditional computerized control methods such as real-time optimum controls and prodicted controls.

Especially, in this level, the man-machine interfaces are multiplied by using CRT displays, and high reliability is obtained for the 24 hours continuous operations by composing compound computer systems or dual files, etc. High speed response is being requested, yet software processings for these are becoming more and more complicated and huge.

3) Production planning level computer

Production managements were performed by the use of medium size business computers at this level. However, as functions and performances of the control computer are leveled up, control computers are now installed in the production planning level. The following reasons may be considered.

(1) Also to the computers in this level, high speed response for on-line real-time processing, equivalent to a control computer, has been required.

(2) Also for control computers, hardwares such as high speed large capacity main memory and large capacity auxiliary memory have been developed.

(3) Software supports equivalent to general purpose computers such as a data transfer between control computers and a higher level large size computer and other software packages can now be obtained.

(4) As long as the hardware is concerned, a control computer system is higher in the reliability and more advantageous for the cost.

2. Trend of software technique

The software in a system, especially, that of the user's application software prepared in accordance with the user's individual specifications is rapidly increasing.

As a manufacturer, how to produce such a rapidly

increasing user's application software efficiently, or how the huge software properties accumulated up to this date could be used in the development of new systems in the future, is the largest focus.

For this reason, based on the view point of programming technique, the following matters are actively promoted.

1) Increases of POL and FIF type program and promotion of table look up type program package.
2) Employment of structured programming methods using system describing language, FORTRAN and COBOL language, without relying on the machine.
3) Promotion of interactive program developments.
4) Completely prepared testing tools.

When making a system including the user's application software with full turnkeys, a method of software engineering as a control computer system must be introduced toward the entire processes starting from the stage when the specifications are required by the user planning, designing, testing and up to the practical use of the system.

III. DISTRIBUTED SYSTEM AND HIGH SPEED COMPUTER NETWORK SYSTEM

As application fields of the computer control system are expanded, more economical, more reliable and more extensible control systems are seeked. Further, a total control

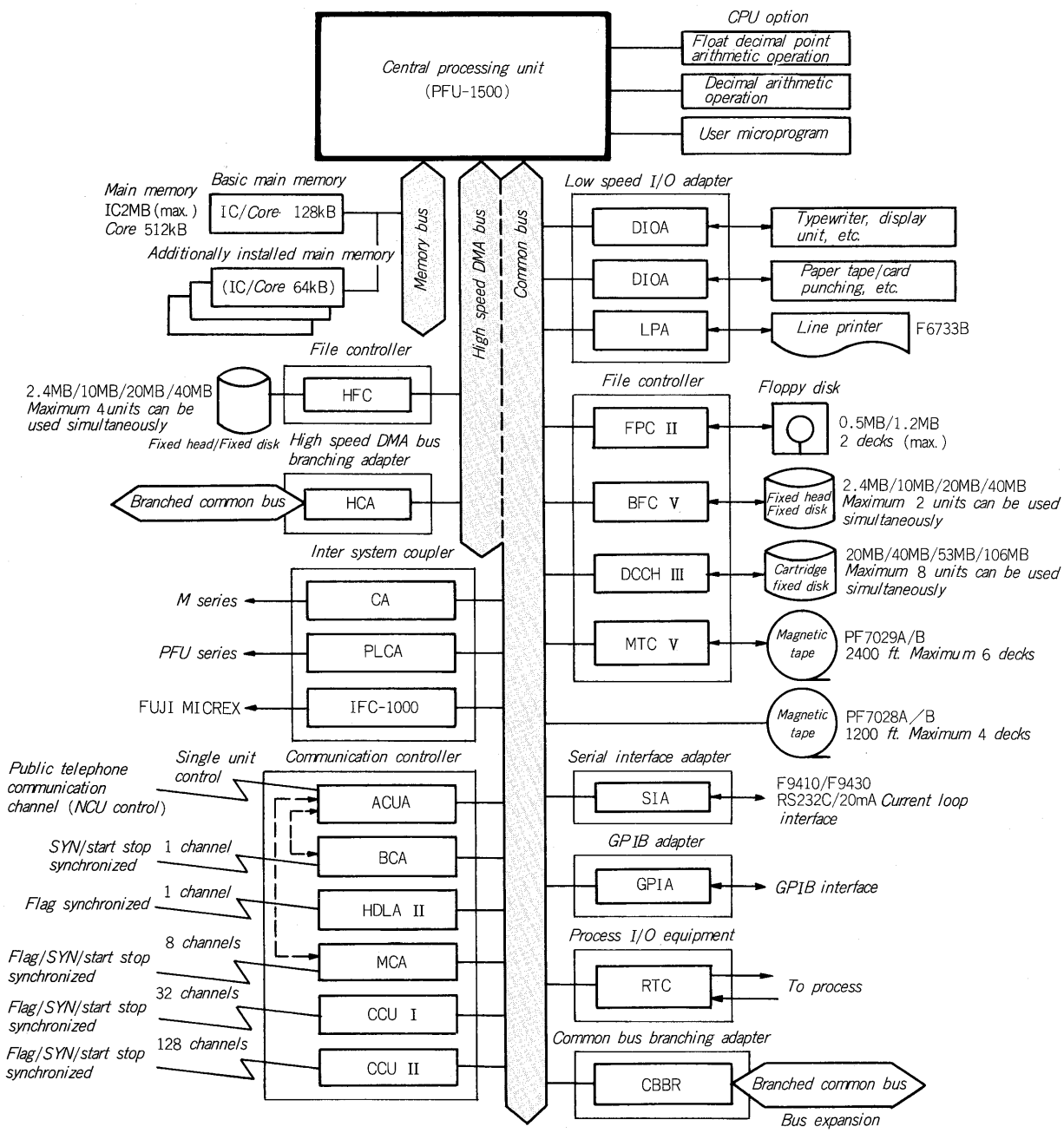

Fig. 2 System configuration of PFU-1500

system which is well harmonized toward the overall process control and plant management is needed because scale of a plant equipment and facility is increasing, various equipment and machines are used, and labor and energy savings are required.

In response to the requests as described above, Fuji Electric has developed and manufactured the distributed control system using microcontrollers "FUJI MICREX System", hierarchy control system which couples the FUJI MICREX with PFU-1000 series computer, multi computer systems using PFU-1000 series computers, etc., which are able to compose the best process control systems and total control systems suited to individual fields. *Fig. 2* shows the system configration of PFU-1500. The FUJI MICREX system distributively installs multiple number of microcontrollers in response each control function, couples the component units with micro-dataway (DPCS), and with this configuration, distributed control system can be formed by realizing distribution of hazard and improvements of control functions.

In addition, PLCA network system which is suited to mutually couple PFU-1000 series computers, and to couple PFU series computers with a higher level management computer and distributed control system using dataway system (MPCS-F), etc. are available.

Distributed control systems and hierarchy systems suited to various processes can be composed by using these network systems.

Computer network systems using these composition elements are introduced in the following paragraphs.

1. PLCA network system

The parallel line communication adapter (PLCA) coupies PFU-1000 series computers installed distributively in a comparatively short distance with simple interfaces (PLC interface), and has the following features.

(1) Data can be transferred under 400k bytes/sec or faster speed.

(2) Various connection modes can be made. *Fig. 3* shows PLCA network system.

1 Opposed connection

Allows mutual connections between PFU-1000 series computers or with a different type computer having process I/O hardware.

2 Branched connection

A master-slave communication of 1:N can be made by making a branched type mutual connections between PFU-1000 series computers. ($N \leqq 8$).

3 Exchanged connection

Using PLCA exchanged connection (option), up to 16 CPUs can be combined and communications can be made in the same level.

4 Expansion of connecting distance

Using PLCA long distance option, PLC interface can be extended to 1km (maximum) per a line.

(3) The hardware is simple and number of signaling lines are minimum (16 bits parallel transfer at 26 lines.)

(4) Communication control procedure can be composed with image of line control.

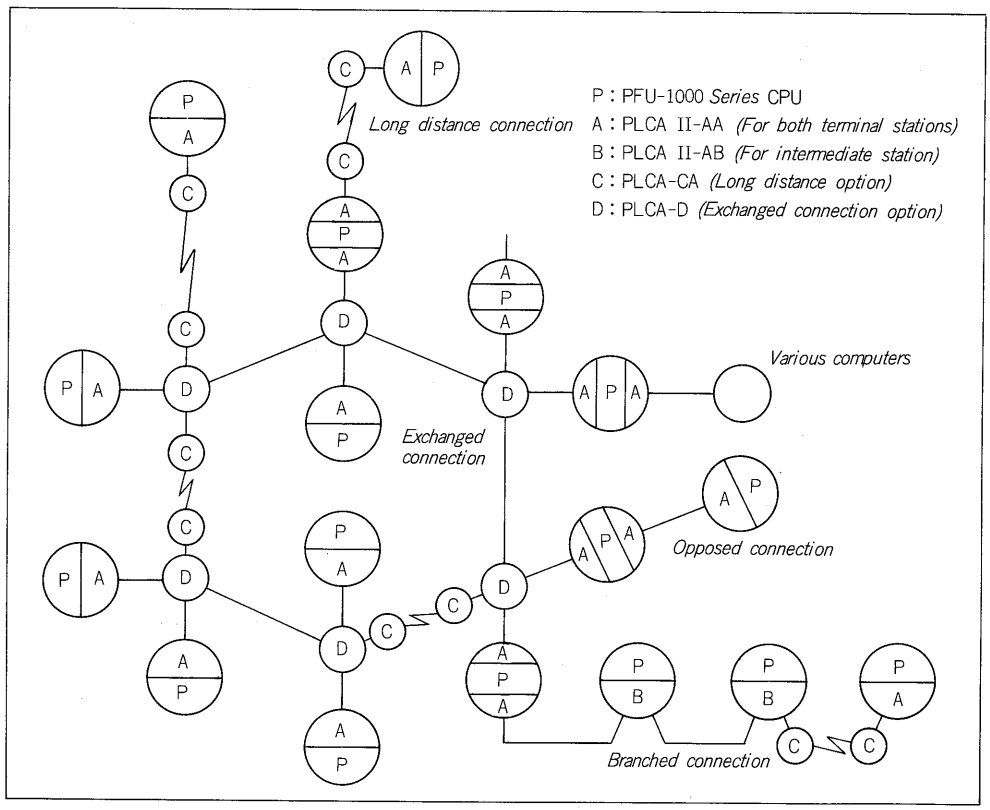

Fig. 3 PLCA network system

2. Fuji optical dataway system (MPCS-F)

Hierarchy composition of a system, distributed system and the system for extended area have caused the volume of data to be transferred by terminal units, controllers, computers and other data processors and process I/O signals to be increased tremendously. For this reason, when a computer control system is of a type which connects computers with other equipment to which data are transferred with cables individually and directly, the wiring and construction costs is considerable, and system design is also complicated. For this reason, dataway systems which connect a set of data communication line in a line or loop to transfer data among individual equipment by time sharing are used in many fields.

Fuji optical dataway system MPCS-F fully uses the features and experience of the conventional MPCS dataway system, and further, uses the latest semiconductor technologies and optical transmission techniques. With the MPCS-F, a high level total system can be realized in wider fields for process control, production managements, etc. *Table 1* shows the specifications, and *Fig. 4* shows the configration.

Fuji optical dataway system MPCS-F has the following features.

Table 1 Specifications of MPCS-F

Application	Computer network system for computer control system
Connected equipment	Computer (CPU): PFU series computer I/O equipment: CRT display, TW Process I/O equipment (PI/O): RTC
Number of coupled ports	Maximum 32 per dataway
Port coupling mode	Closed loop coupling
Communication mode	$N : N$ Port to port communications
When a port fails	The faulty port is automatically disconnected from the dataway
Data length	Maximum 256 words (variable length) 1 word= 16 bits
Error control system	Frame check, CRC check
Retransmitting function	Retransmitted in case of a data error or time out automatically
Transmission speed	12.6 M bits/second
Transmission throughput	Maximum 1,300k bytes/second
Dual construction of transmission path	The standard specifications Automatic reverse circulation in case of a broken line
Transmission path	Step type optical fiber (Attenuation: 4 db/km or less)
Distance between ports	Maximum 1.5km
Total length of transmission length	Maximum 48km

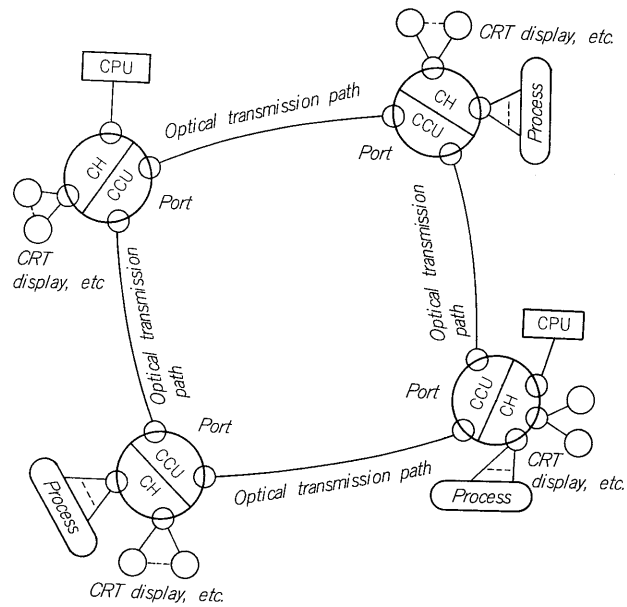

Fig. 4 System configuration of MPCS-F

1) High performance dataway to which optical transmission technique is applied.
2) Transmission efficiency and use efficiency of transmission lines are high.
3) Data reliability is high.
4) A tough dataway to which fault tolerant technique is applied.
5) Remote diagnosis can be made.
6) Remote controls (remote port in/out) can be made.
7) The application field is wide, and extension can be made easily.
8) Varieties of device are available, and installations at the sites are easy.
9) Intelligent device access can be made.

IV. INTRODUCTION OF COMPUTER CONTROL SYSTEM INTO EACH PROCESS

1. Iron making system

Techniques of the computer control system are remarkably developing during the recent years, and even in the fields of process computers, it has been possible to realize the systems having the following features.

(1) Highly reliable multi-computer system using low cost yet high throughput processors.
(2) High class OS and high class language systems promoted by the developments of low cost, high speed and large capacity memories.
(3) High level man-machine systems in response to the realizations of high performance and multi-function man-machine interfaces.
(4) Distributed hierarchical systems realized by intelligent subsystems in response to improvements of micro-

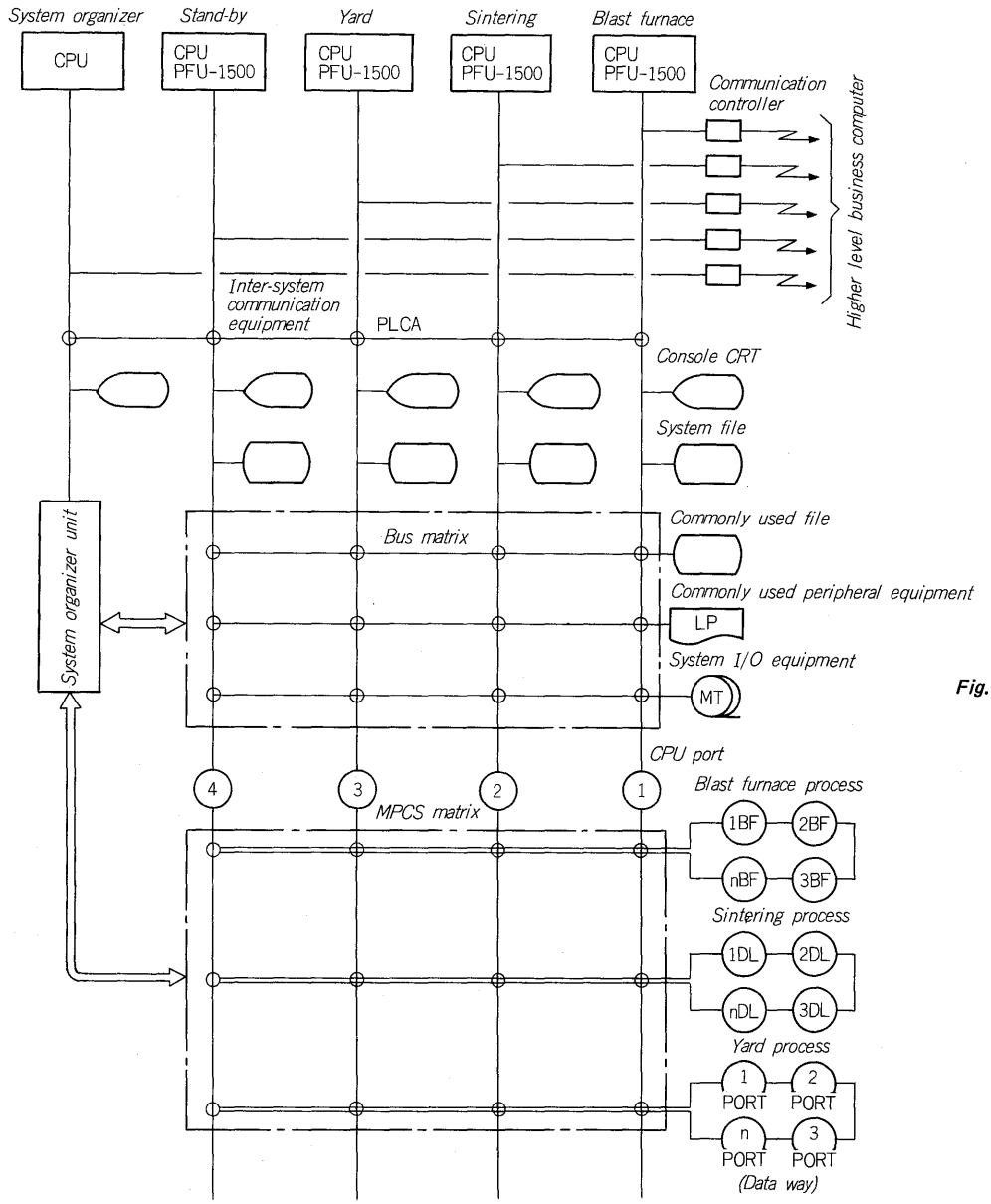

Fig. 5 Total computer control system in iron making plant

computer application techniques.

(5) High level application software systems which are based on the reliability, functionability, maintenability and safety realized by improvements of software engineering techniques.

Also in the iron making processes, these technical accomplishments are actively employed, and total computer control systems of iron making plant have been realized as described followings. (see *Fig. 5*)

This computer system features:

(1) A total iron making system which performs data processings totally for raw material yard, sintering plant and blast furnace.

(2) Constructed to a multi-processor system including a stand-by system, and further, random stand-by system is employed, improving the reliability and reducing MTTR.

(3) With a higher level business computer, software of the lower level process computers can be developed and simulations can be made.

2. Steel making system

Recently, applications of control computers in steel making plants are not limited simply to those for one process, but also to the overall steel making plant. Further, when life cycle costs of control computers are taken into considerations, it has become important that the software can be developed, modified and added easily and safety. As a method to solve these problems, totalized computer rooms, installation of back up computers, and employment of optical dataway have been proceeded. The totalized computer room provides the following merits.

(1) Effective use of resources (commonly used I/O equip-

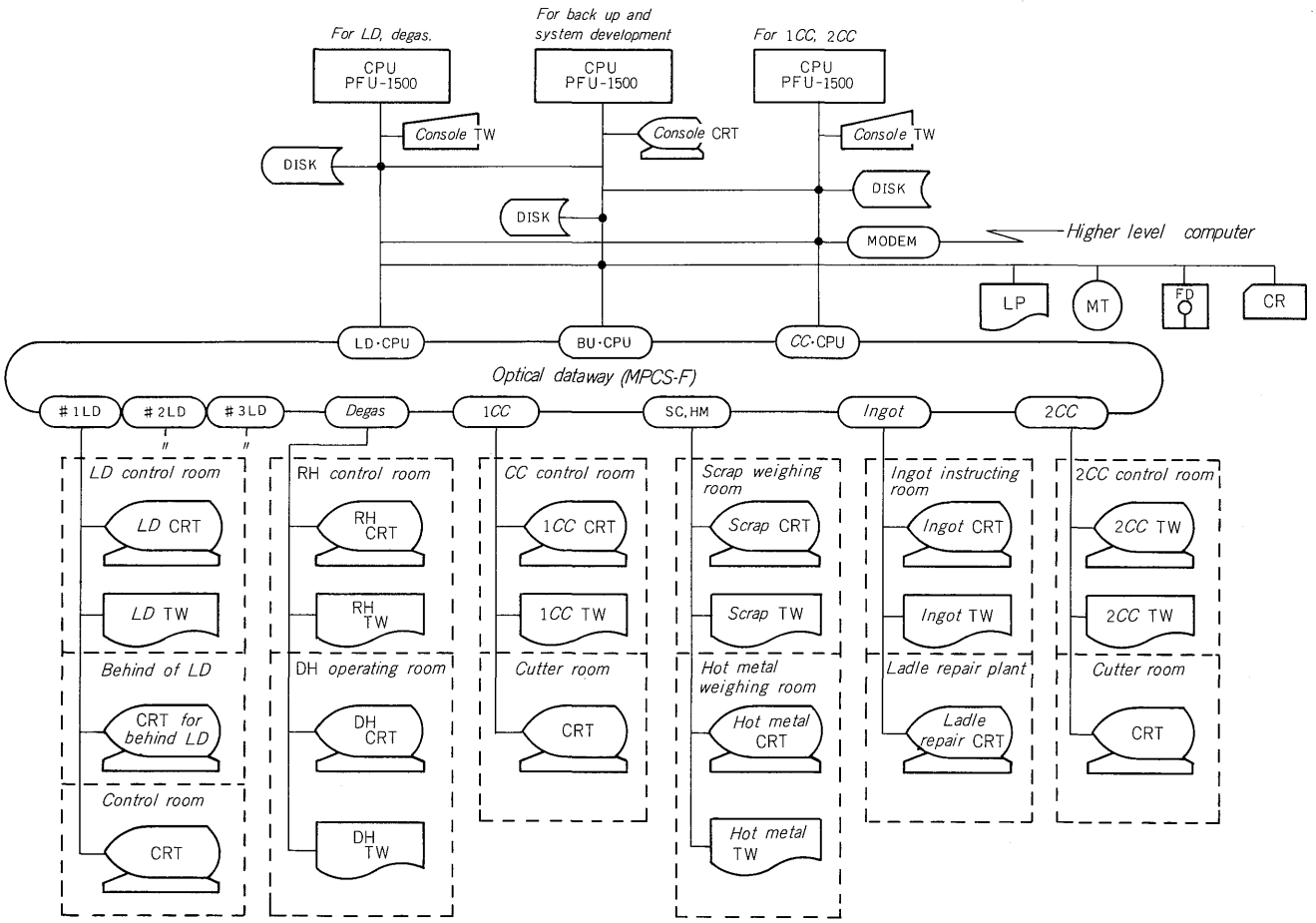

Fig. 6 Total computer control system in steel making plant

ment and stand-by equipment)
(2) Easily installed commonly used back up computers.
(3) Improvement of maintenance work efficiency
(4) Integration of data managements
(5) Improvement of reliability realized by satisfactory environment
(6) Reduction of the construciton cost (including air conditioner and power supply)

With back up computers installed, not only the hardware reliability is improved but also new software developments, debugging, testing, etc. can be made easily.

Integration of computer rooms can be now proceeded advantageously by employing optical dataways. With the optical dataway, construction cost can be reduced, noise-resisting performance can be improved, high speed transmission can be made and compound computer system can be easily composed.

Fig. 6 shows an example of total computer control system in steel making plant. In this example, three computers, namely LD/degas. computer, 1cc/2cc computer and back up computer are joined.

3. Rolling mill Systems

Control systems for rolling mills, finishing or processing lines must process thousands of data regarding the products produced from the lines timely.

Further, in these processes and facilities, improvement of productivity, improvement of the yield rate, quality improvement, and promotions of labor and energy savings are significant, and for this purpose, every efforts have been made to introduce high performance control equipment and automation devices. And, the control system must control the system more precisely, increase processing speed by organically connecting various devices and equipments, and must improve the reliability of the overall composing devices and equipments.

On the other hand, when the economical growth is low, the products produced from these plants are in small quantities but count number of kinds, and high qualities are seeked. For this reason, volume of data handled by the control system increases, and to cope with such tendency, a control system which is capable of providing more fast and precise controls in used, and hierarchy and distributed control system is applied to rolling mills.

Fig. 7 shows an application example of control system in a rolling mill plant. This application example consists of PFU-1500 and FUJI MICREX-E. This control system features the following matters.

(1) Fully utilizing the high speed arithmetic performance and large memory capacity, the computer system operates

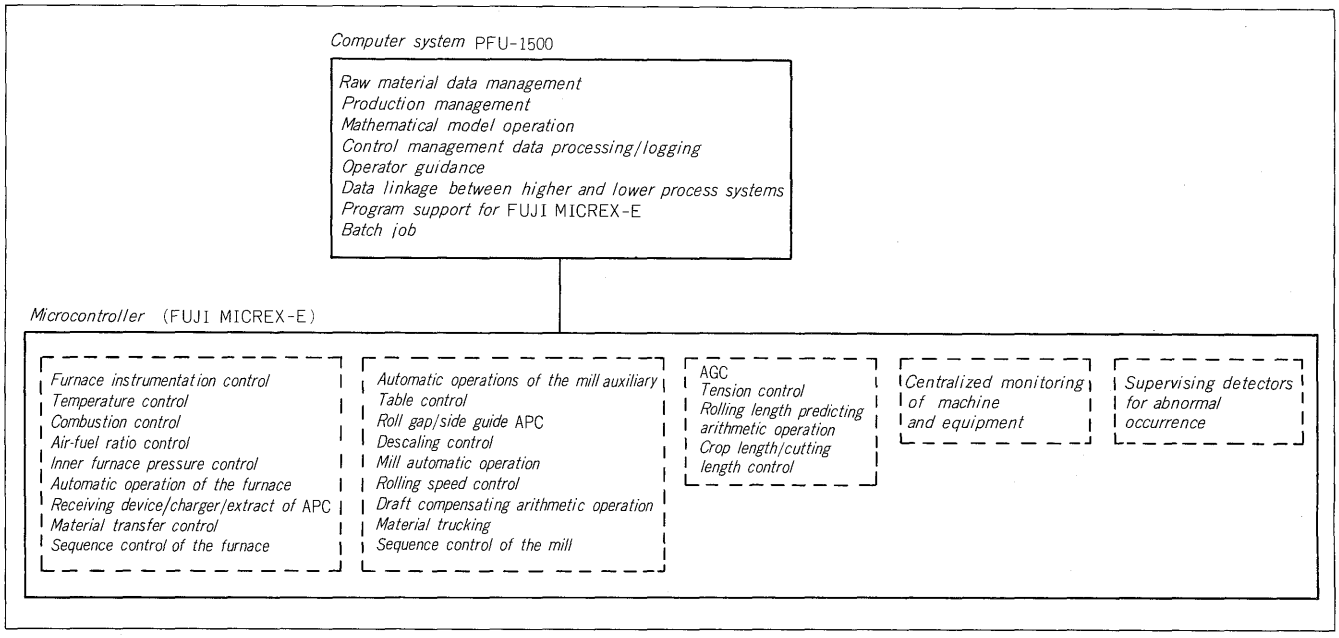

Fig. 7 Computer control system in rolling mill plant

mainly on the data base, and centralizes the data.

(2) DDC level and local control level are unified in the highly functional microcontroller FUJI MICREX-E, enhancing the maintenability.

(3) The main machine control which was conventionally an analogue control is now a part of functions of the FUJI MICREX-E, realizing the high accuracy, cooperation can be made easily with a computer system and operations are very efficient.

(4) Machine and equipment operating status is supervised centrally, and operation of starting and abnormal condition are easied. Further, accumulating data for maintenance, the reliability is improved.

(5) Detectors, etc. are monitored for abnormal occurrences separately from the machine and equipment control sequence, shortening times required in recovery and taking actions for troubles.

4. Energy Center System

The energy center systems planned during recent years have been large scale systems which directly connect the production planning system for the purpose of "Total cost minimum" and use optimum distribution calculations, etc. In response to the expansions and varieties of the required functions, a structure of energy center systems is also moving rapidly to distribution of controls and centralization of data by keeping pace with the developments of digital equipments. As for the method of distributed control, it has moved from the style in which PI/O is simply distributed to one to which intelligent functions are added, and further, a network which organically connects multiple number of computers or hierarchical large scale system has been realized.

An energy center must centralize not only the data for the entire area of the iron and steel works but also those in the outside. For this reason, employment of dataway provides a large merit. Moreover, as the optical dataway is being used practically, more and more optical dataways are introduced because reliability of the data and easiness of securing cable route can be improved.

Based on the functions of a total energy control center system (*Fig. 8*), the system is described below.

1) Data base system

In recent years, in many cases, the systems are composed hierarchically, and these can be classified briefly into the data base system and sensor base system depending on the differences of handled data. Exceeding the range of the conventional process computers, it is necessary to examine the data base system together with the central management computer.

(1) Central management computer

Operations performed by a large scale business computer. These operations are directly related with the production management. The covered operations are statistical anaylsis operations, calculations of large volume data (production plan, long term energy consumption/supply balance, etc.) , etc. production plans planned by the central management computer are reported to the energy center computer. Moreover, from the energy center computer, accomplishments by the energy center are reported, the data are accumulated by the central management computer, and used at the central management center. Most of the handled data are mainly those one month or longer term data.

(2) Energy center computer

The energy center computer processes those data which are for comparatively shorter period than those processed by the central management computer (in the unit of hour or day rather than month). The computer is the core of the energy center, and in many cases, a duplex

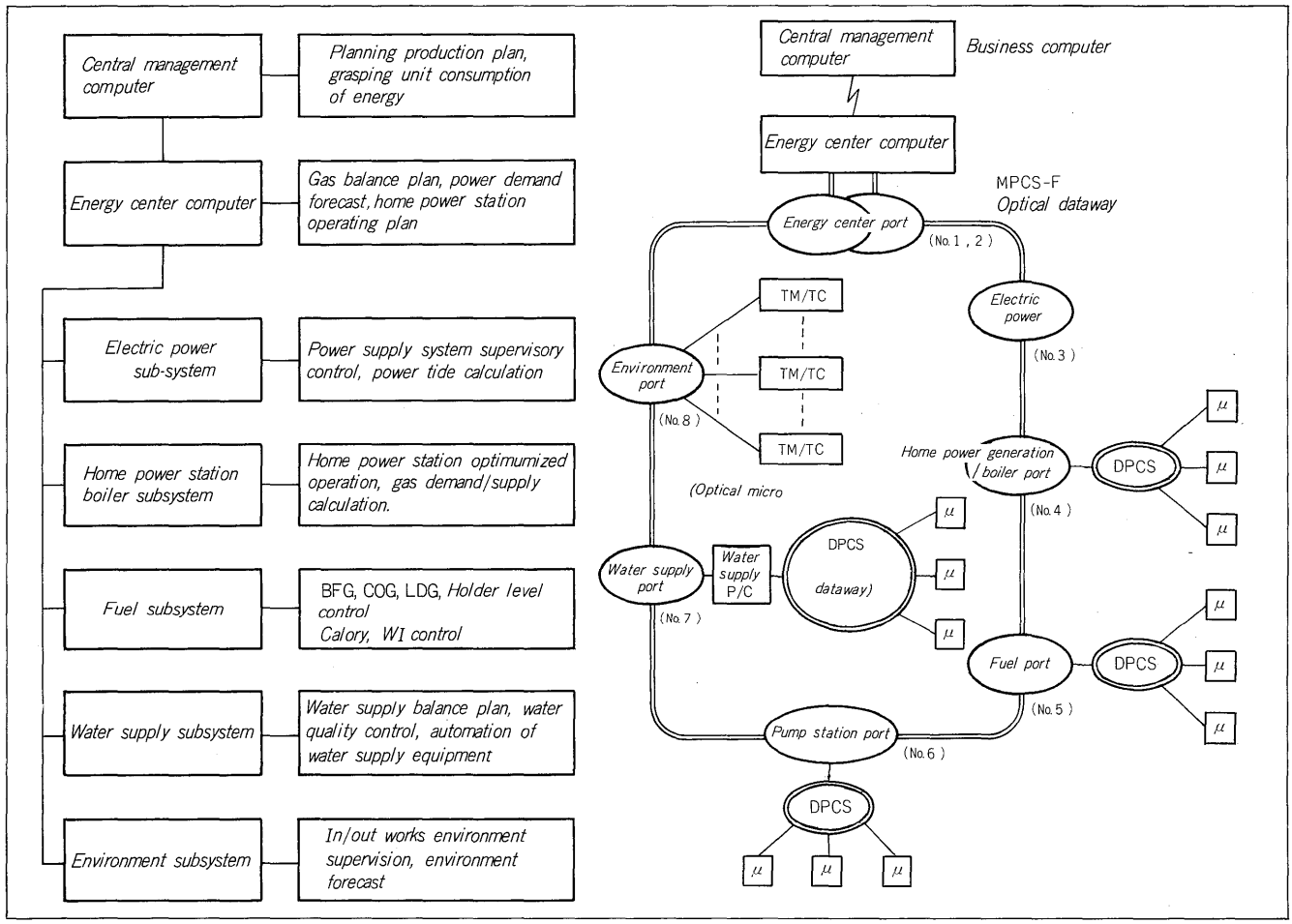

Fig. 8. Functions of total energy control center system

system is employed.

The main function on this computer are adjustments among the individual subsystems, short term energy consumption/supply balancing plan, ordering to each subsystem, acquisition and arrangement of data for accomplishment by each subsystem, etc. The stand-by computer is used for the following purposes also.

1 Backing up the on-line computer to improve reliability

2 Debugging for program development and system modifications

3 Technical calculations.

2) Sensor base system

Against the data base system of the central management computer and energy center computer, each subsystem is called "Sensor base system". Moreover, structure of these individual subsystems vary depending on the scale of energy center system, wideness of the area, control method, etc. The typical structure consists of:

1 Optical dataway (MPCS-F) for data transmissions between the energy center and each subsystem.

2 Microcontroller (FUJI MICREX) and optical micro-dataway (DPCS-F) used to distributively control each subsystem.

3 Remote supervisory control (TM/TC) for wider ranges. The sensor base system performs PI/O processings, control of each equipment, arrangements of each subsystem, etc.

The typical subsystems consists of follows

(1) Electric power subsystem
(2) Home power station/boiler subsystem
(3) Fuel subsystem
(4) Water supply subsystem
(5) Environment supervision subsystem

V. POSTSCRIPT

Fuji Electric's basic idea of the composing techniques of the computer control system for iron and steel plants has described.

Equipment technique and operation technique of iron and steel plants are being advanced remarkably, and advancements and developments of the control equipments and devices are greatly expected. As a manufacturer, Fuji Electric will make best efforts in further improving reliabilities and developing systems of higher functions, and will aim at the developments of new computer control sysetms which are always advancing.