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INSTRUMENTATION SYSTEMS FOR INDUSTRIAL THERMAL POWER PLANTS

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1. FOREWORD

The change of the energy situation after the oil shock and change of the economic situation due to the rise in the value of the yen have also led to large changes in the thermal power plant field, which is the main source of energy in the industrial world, and rationalization corresponding to this has become a pressing need.

On the other hand, the noticeable development of digital technology in recent years has been accompanied by popularization of advanced functions, high reliability digital control systems and the activation of their introduction and the pushing ahead of rationalization even in thermal power plants.

Fuji Electric supplies the distributed digital control system MICREX to the market and has delivered many thermal power plant digital control systems both domestically and overseas based on our abundant achievements in the process control field.

The technical trends and concretes examples of the instrumentation and control system for industrial thermal power plant are introduced.

2. TREND OF INSTRUMENTATION AND CONTROL SYSTEM FOR INDUSTRIAL THERMAL POWER PLANT

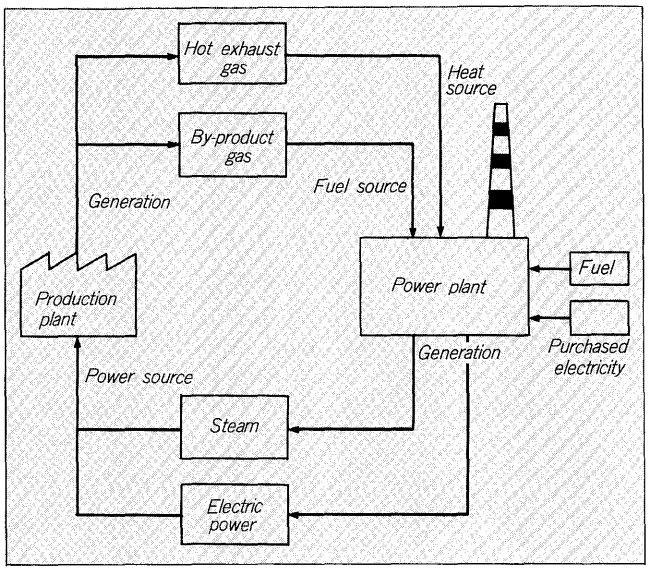
2.1 Positioning of instrumentation and control system for industrial thermal power plant

An industrial thermal power plant supplies power for factory operation. Its features are:

1) The main force is the co-generation type, which supplies electric power and steam simultaneously.
2) Used and operated together with electric power purchased from an electric power company.
3) Effective use as a combustible by-product and high temperature gas energy source.

That is, as shown in Fig. 1, an industrial power plant is said to have a mutually dependent relationship as one link of the factory energy cycle and as a power source and heat source interrelated with the factory production facilities. Its operation is closely related to the factory operating state and stable operation is also indispensable in securing factory operation.

Fig. 1 Energy interdependence of industrial power plant and production facility



2.2 Operation trend

The changes in industrial power plant operation accompanying changes in the energy and economic situations are discussed below.

2.2.1 Diversification of fuel

Regarding boiler fuel centered about heavy oil in the past, from the standpoint of securing a stable supply and cost reduction, the energy shock was taken as an opportunity to convert to alternate fuels and advance the mixing of fuel and boiler fuel is diversifying.

These alternate fuels are coal, which is distributed abundantly around the world, combustible by-products (gas, oil) generated during factory operation, etc. However, using these are boiler fuel raises handling problems and creates such problems as coping with calorie fluctuations, the complexity of control due to fuel mixing, etc.

2.2.2 Diversification of operation

The supply and consumption of the electric power and steam necessary for factory operation and the combustible by-products produced at industrial power generation corresponding to changes of the plant operating state is an important problem in rational use of plant energy.

Therefore, application for optimal load distribution, electric power demand application according to purchased electric power restrictions, and extensive automatic operation of industrial power plants is implemented and low-load operation and other diverse operations which expand the operating range of these are demanded.

That is, totalization of a industrial power generation control system which allows control of everything from management to coordination of boiler and turbine control by one system is indispensable.

2.2.3 Energy saving

Energy saving aimed at optimization of combustion control and reduction of auxiliary machine power has been carried out for some time separately from total energy rationalization by optimization of control, and results have been achieved. A typical example is speed control of the combustion system low excess air control and feed water pump and FDF and other large auxiliary machines.

2.2.4 Labor saving

Fuel diversification and diversification of operation and other high-level control, complexity, and extension of industrial power plant application have reached the limit of operation monitoring by an operator. Therefore, the aim is lightening of the operator's burden and improving operability by promoting automation by mechanization of operation and the trend is toward realization of by integration and centralization.

The road to realization relative to the changes of operation described above is impossible without instrumentation and control technology and equipment function improvements. Its role is becoming increasingly large.

3. INSTRUMENTATION AND CONTROL TECHNOLOGY VERSUS INDUSTRIAL POWER PLANT OPERATION TRENDS

3.1 Instrumentation and control technology topics

Figure 2 shows the topics and background technology of instrumentation and control technology associated with industrial power plant operation trends.

These are arranged below.

3.1.1 Improvement of control functions

Promotion of more complex, advanced, and automated control was accompanied by a demand for substantial improvement of the functions of the instrumentation and control system by which they are realized.

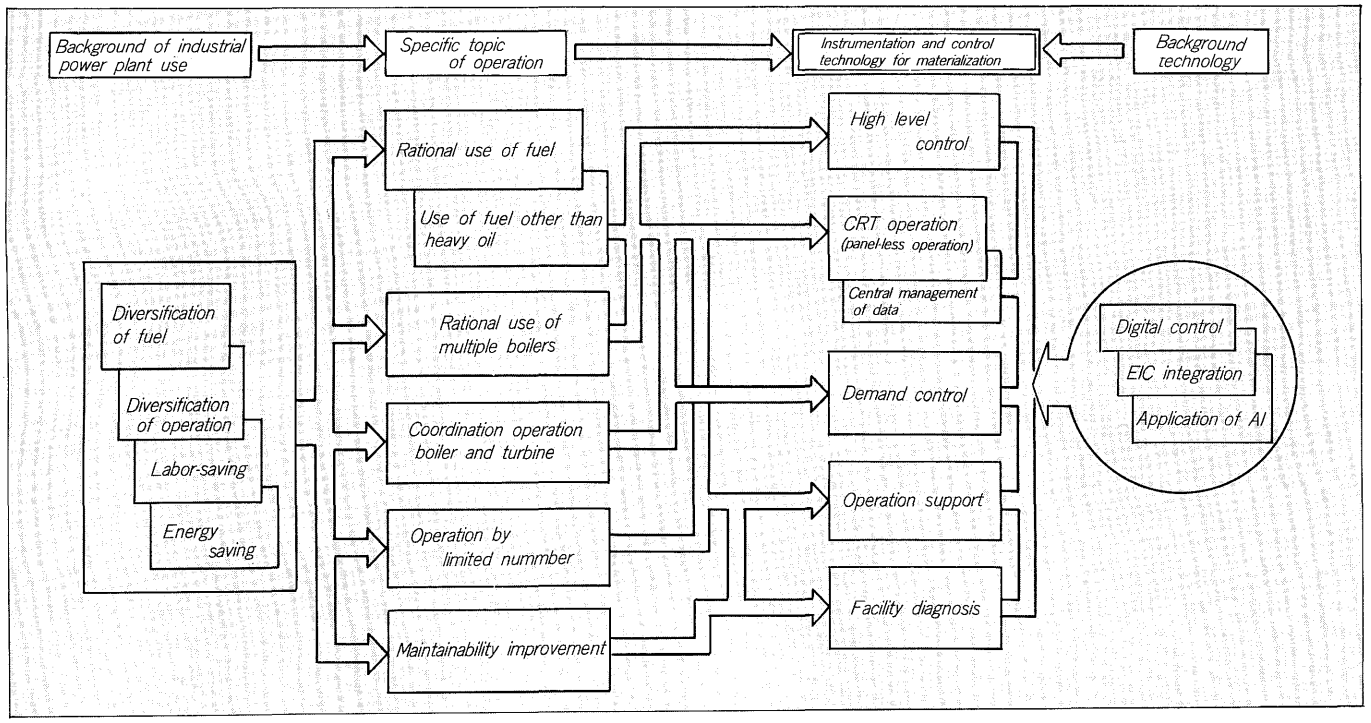
That is, the introduction of nonlinear control and advanced control and other abundant control operation functions, composite control functions which fuse feedforward control and sequence control, and AI technology which has grown noticeably in recent years.

3.1.2 Hierarchy total systemization

The facilities which make up an industrial power plant (boiler, turbine, generator, electromachinery facility...) must operate in coordination according to the plant operating state. On the other hand, however, the trend is toward independence and distribution of control equipment from the standpoints of the functions required and the distribution of risk.

Accompanying this, the distributed control system

Fig. 2 Technical trend at industrial thermal power plant



and general management system must be organically interconnected and, from the standpoint of system configuration, the construction of a hierarchical total system must be possible. That is, a function which integrates the electromachinery system (E), instrumentation system (I), and computer system (C) becomes an essential industrial power plant instrumentation and control technology condition. Moreover, integration and centralization of the control room is also indispensable from the standpoint of rationalization of operation.

3.1.3 Improvement of monitoring operation functions

Regarding extension of the range of operation monitoring operation accompanying the increased complexity and sophistication of operation and integration of systems, improvement of the monitoring operation is a big problem from the standpoint of the importance of the humanity of the operator and stable operation of the plant and establishment of a monitoring operation system that uses a CRT with excellent features was demanded.

The superiority of the CRT as a man-machine interface presents a large volume of information systematically, selectively, and in time series from overall to partial conditions and is the point which is connected easily to judgment and operation. An operation support function called operation support, and a facility diagnosis function can also be incorporated. Its superiority is unshakable.

3.1.4 Improvement of reliability and operability

Control system trouble has a large effect on shutting down of the power plant and plant operation accompany it. Therefore, redundant functions, back-up functions, self-check functions, on-line maintenance functions, and other reliability improvements and additions were demanded.

Hardware and software flexibility capable of coping easily with operation method changes and the addition and renovation of facilities also became a necessary function.

3.2 Introduction of digital technology to industrial power plant instrumentation system

The introduction of digital technology into the industrial power plant instrumentation system must be considered in solving the technical problems described above. Fuji Electric has accumulated experience and established control technology for automation, integrated and general management, optimal operation, and other operation changes through the offering of digital control systems centered about the distributed control system MICREX.

The features of the MICREX system are described below.

1) Realization of EIC integration.

The controller line, from instrumentation controller (PCS) to high-speed sequencer for electromachinery (HDC) and telemeter telecontrol system (SAS), was filled out and direct connection to the same dataway (DPCS), including computer system, was made possible and flexible hierarchical total systemization was realized.

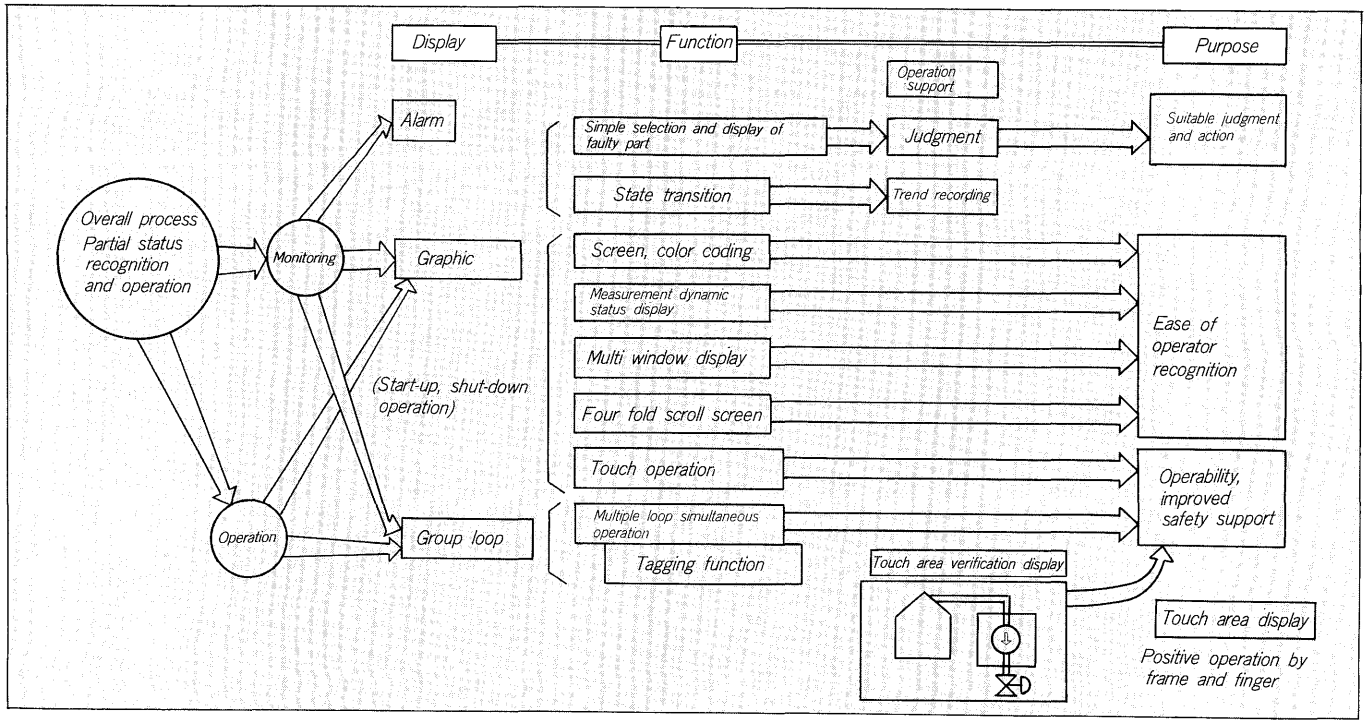
2) Strengthening of man-machine interface

The CRT operator station (OCS) for standardizing the CRT of the electromachinery, instrumentation, and computer systems based on the EIC integration concept substantially improved the touch operation. dynamic keyboard, screen interrupt, voice alarm, and other functions.

The functions of the CRT operation station are shown in *Fig. 3*.

3) Realization of a highly reliable system

Fig. 3 CRT operation functions



An extensive redundant configuration, from control unit to power supply unit and PIO unit, is possible. It was made highly reliable system with duplicate unit on-line maintenance function, etc.

4) Interactive format engineering

The use of an interactive graphic function and engineering work station (EWS) allow engineering in interactive format without the need for a programming expert.

5) Completion of AI tools

Various process control field oriented AI tools are available. An advanced control and operation support system structure is possible by combining with a computer system mounting these.

4. DOMESTIC INDUSTRIAL POWER PLANT INSTRUMENTATION SYSTEM DELIVERY EXAMPLE

Based on the severe economic situation, the construction and expansion of domestic industrial power plants has decreased substantially from its peak in 1970 and is advancing around replacement aimed at rational operation of existing facilities.

That is, instrument aging countermeasures and restarting of shutdown facilities is taken as an opportunity for the extensive introduction of a digital instrumentation system. Automation and optimization are advanced and operability is improved without substantial renovation of the facility itself by integrating and generalizing the control room.

A typical example is described below.

4.1 Integrated optimal operation system

A energy optimal operation plan was established from the energy supply and demand forecast based on the production plan for an industrial power plant with multiple power stations that use the combustible by-product generated by plant operation and optimal automatic operation of the industrial power plant and integration of the control room linked to this are realized.

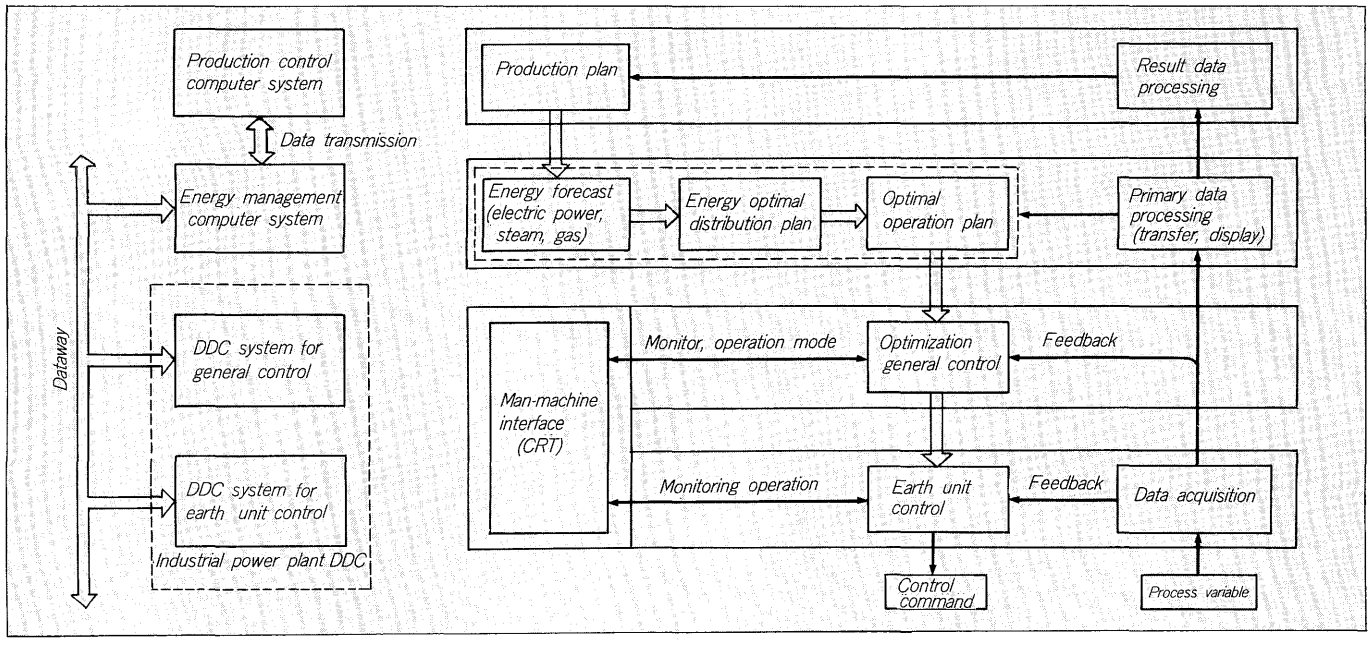
Fig. 4 shows the function concept of this system.

The management computer system forecasts the combustible by-product, etc. energy supply and demand based on the production plan and operation plan. It also makes the industrial power generation optimal operation plan from the purchased electricity cost, industrial power plant running cost, the operating conditions, performance, and capacity of the facility, and the purchased electricity demand forecast.

This operation plan is sent to the general management control system in the form of distribution commands and control priority commands to the fuel and load facilities. The general management control system judges the actual operating state and the operation restrictions of each power station and outputs control commands to each power station controller in control order.

The CRT operation station provided as the man-machine interface for these has a function which centrally displays the operation command and operation state simultaneously with normal monitoring operation and an operator guidance function for the operations necessary from the standpoint of operation. It is a which sets operation commands independently for power stations and allows automatic operation thereafter. This system was delivered to a domestic steel plant. This system has achieved labor saving by integrating industrial power plant optimal operation and the control room and is currently operating favorably as an on-line system, from management computer to general management control system and power station system.

Fig. 4 Industrial thermal power plant optimal control system functions



4.2 AI application turbine optimal control system.

The co-generation system is the main constituent. With an industrial power plant operated together with purchased power, in the past, suitable operation by corresponding the electric power and steam load, which change with the season and time, to the power receiving amount (purchased power amount), depend on the experience of an experienced operator and complex operation. This system extensively automates and improves controllability and reduces the operator load by applying AI technology.

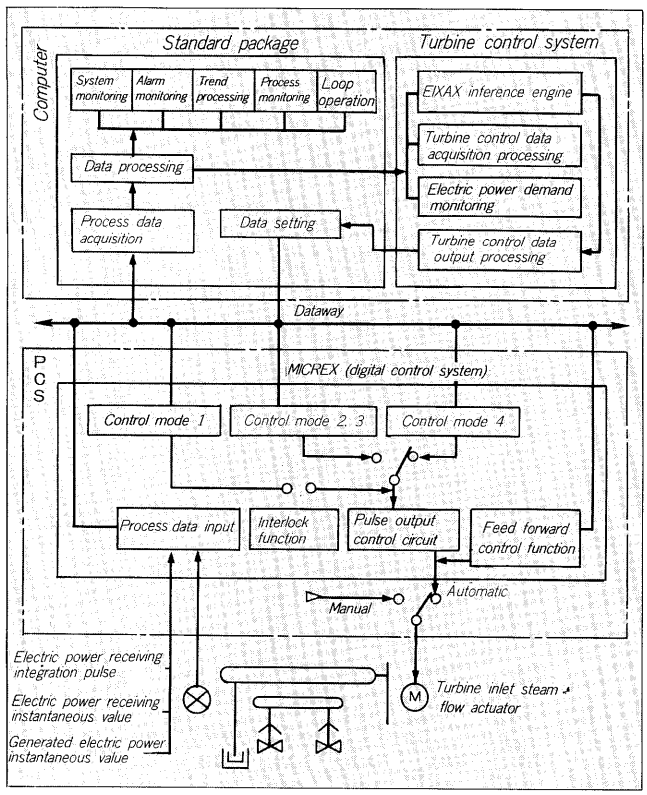
The functional block diagram is shown in *Fig. 5*.

The AI system used by this system defines the rules of operation know-how and formulates the process characteristics and performs forward reasoning. It is the process automatic operation expert system construction tool EIXAX, and selects the control mode (demand over, demand under, exhaust steam pressure control) based on the 30 minute power receiving demand forecast and adjusts the power generation amount and maintains the power receiving demand within the specified range.

This system was delivered to a domestic oil refinery and has improved the operating accuracy several ten times relative to the conventional management standard.

Besides the above, automation of temperature rise and pressure rise at boiler start-up and automation of operation at boiler emergency stop and automation of back-up at partial shutdown of fuel and steam facilities, etc. are implemented and delivered.

Fig. 5 AI applied turbine optimal control system functions



5. EXAMPLES OF OVERSEAS DELIVERY OF INDUSTRIAL POWER PLANT INSTRUMENTATION SYSTEM

Overseas, new construction and expansion of industrial power plants, centered about NIES, is active. Regarding their plan, the trend is toward the introduction of the latest digital control system and the widespread use of automation.

An overview of an instrumentation system for overseas industrial power plant delivered by Fuji Electric is introduced below.

5.1 Overview of unit

This thermal power plant is a co-generation system which supplies electric power and steam to a steel making plant. The load is operated by general command from the energy center for coordinated operation with the existing industrial power plant. The main technologies used at this unit to satisfy the operating conditions in the steel making plant are:

(1) Wide range of automation of start-up operation from boiler ignition to turbine synchronization and target load and up to boiler shutdown.
(2) Use of pressure change operation system to allow low load operation (with conventional technology, 30% load is the limit) down to 5% and improve unit efficiency at partial load by installation of a boiler circulation system.
(3) Use of a discrete order control system for beneficial use of the multiple fuels generated by a steel plant based on steel plant energy mangement.
(4) Use of a boiler and turbine coordination control system which controls the boiler and turbine as one electric power and steam generation facility to secure unit electric power and steam load trackability.

5.2 Overview of automation system

The block diagram of the automation system of this unit is shown in *Fig. 6*.

It is a functions distribution type hierarchical structure which uses an APC (Automatic Plant Control) system as a sub loop and sequential sub loop control system according to the functions of the control objective of each, centered about an APS (Automatic Plant start-up, shut-down) system. The monitoring operation is performed by arranging the conventional BTG panel around a CRT. Operation from panel instruments is also possible. Concerning turbine abnormality monitoring, a dedicated computer is provided as a trouble diagnosis system and turbine life diagnosis and various other diagnostic functions are provided.

5.3 Features of automation system

The automation system has the following features centered about the distributed digital control system MICREX:

Fig. 6 Industrial thermal power plant automation system block diagram

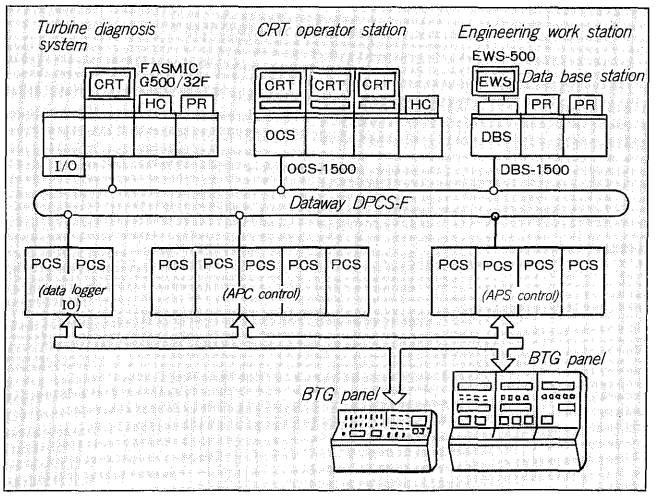
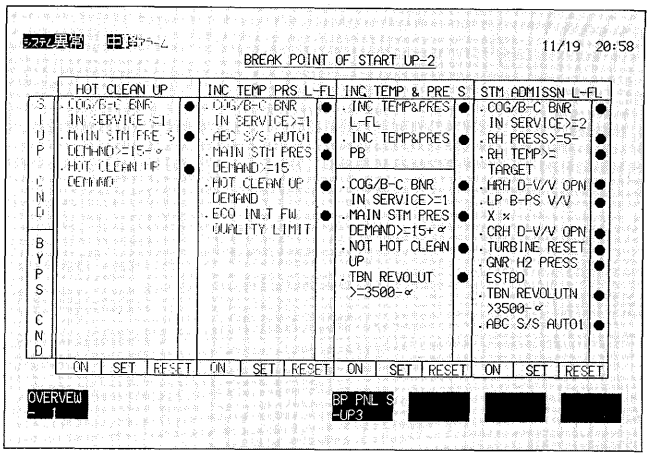


Fig. 7 Break point display screen example



(1) Utility thermal power plant class automation functions are incorporated and limited number of operators is possible as an industrial power plant.

(2) Abundant display screens, including sequence control progress state and plant operation and control function status display and other graphic displays are available at the CRT screen and are supported so that the facility operating status can be grasped positively. A break display example is shown in *Fig. 7*.

(3) To strengthen system reliability, the common parts of the process station (PCS) are duplicated and back-up operators are provided in control loop units, etc. so that operation can be continued even if a device making up the system fails.

6. CONCLUSION

The technical trend of industrial power plant instrumentation and Fuji Electric corresponding examples for them were introduced above. The role of instrumentation technology in industrial power plants is effective use of energy and rational operation, and is said to be integration of optimal operation and monitoring operation. Efforts aimed at completion of this will also be made in the future.