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ENERGY CENTER EQUIPMENT FOR USE IN IRON AND STEEL PLANTS

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I. INTRODUCTION

Fuji Electric has delivered many units of Energy Center equipment for use in the iron and steel industry. One complete set of such equipment has been installed in the Sakai Steel Works, Yawata Iron and Steel Co., Ltd. This plant was put into operation in June, 1965, and uses the most modern methods and equipment available.

This equipment is designed to facilitate:
(1) The supervision of energy flow.
(2) The determination and control of the most economical flow distribution.
(3) The streamlining of operations

Various meters and instruments pertaining to electric power, mechanical power, water supply, etc., are concentrated in the Energy Center. There, correct decisions may be made promptly, based on information obtained through these meters. At the same time, control computers forecast demands for electric power and calculate an economical gas balance for the proper operation of substations, gas stations, heavy oil pumps, and various other pumps and valves. Thus, it is the function of the Energy Center to achieve a comprehensive and economical use of energy.

Some features of this equipment are:
(1) Substations, gas stations, and various pump rooms require no attendants and are all supervised and controlled by remote-control equipment.
(2) Control computers provide accurate and prompt answers to problems so that appropriate instructions may be given to achieve an economical use of energy.
(3) Use of the new TELEPERM system to detect various measurements and provide remote transmissions.

Features of the new TELEPERM system:
(a) All converters and transmitters are dc two-wire types; no external power supply is required at the location so wiring is simple.
(b) All measurement values are converted into a dc 10~50 ma signal current. Hence, receiving meters are interchangeable and the system is resistant to induction troubles otherwise common in long-distance transmission.
(c) The allowable load resistance of all converters and transmitters is 0~450 ohms and no adjustment of line resistance is required. This feature makes

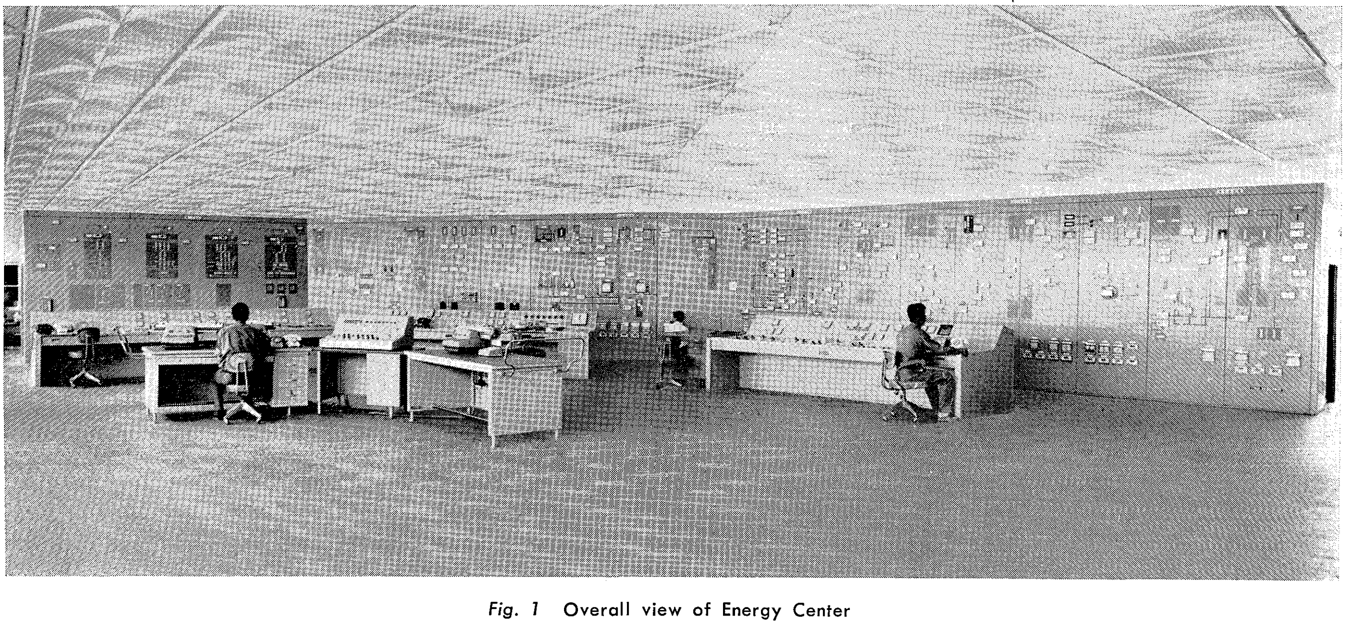

Fig. 1 Overall view of Energy Center

the equipment suitable for long-distance transmission of measuring signals. The new system, therefore, in view of its economy and ease of maintenance, is highly suitable for use in an energy center.

II. EQUIPMENT FOR ELECTRIC POWER

The equipment shown in *Fig. 3* supervises and controls the power facilities at the Energy Center. The East, Central, West, and North substations are installed in such a manner that a 70 kv loop is laid between the Matsuya Substation of the Kansai Electric Power Co., and the Cooperative Steam Power Station. As shown in *Fig. 2*, each substation has 70/10 kv, 20 mva and 10/3 kv, 4.5 Mva transformers, and supplies power to 10 kv and 3 kv loads. As indicated in *Fig. 2*, the Central, West, and North substations are connected to 10/3 kv, 4.5 Mva transformer rooms.

The following explains the use of the equipment:

1. Long-distance Measuring Equipment

The straight forward system was adopted for the remote-control transmitters because of the following reasons:

(1) The distance between the points measured and points supervised is short, averaging 2∼3 km.
(2) The position of other types of equipment necessitates the installation of new link lines.
(3) An excess number of link lines are available.

A minimum number of meters are used for operation and maintenance. The instruments and meters used perform the following functions:

(1) Routine recording of the following:
(a) Flow of 70 kv receiving lines and link lines (w+var), synthesis of one or two line circuits.
(b) Voltage of the 70 kv bus line (v).
(c) Secondary and reactive power of the 70/10 kv transformer (w+var), 10 kv bus-wise synthesis.
(d) Secondary power of the 10/3 kv transformer (w), 3 kv bus wire synthesis.
(e) Frequency (F) of the 70 kv receiving points (East and North substations).

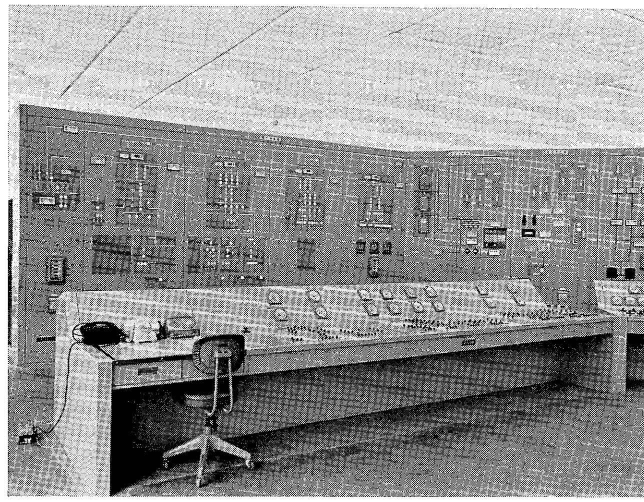

Fig. 3 Graphic panel for electric power system

(f) Power generated at the cooperative steam power station (w).
(g) Flow in the link line between the cooperative steam power station and the Matsuya Substation of the Kansai Electric Power Co. (w).
(2) Routine indication of the following:
(a) Flow of the 70 kv receiving lines and link lines (w), synthesis of one or two lines.
(b) Power generated at the cooperative steam power station (w).
(c) Flow in the link line between the cooperative steam power station and the Matsuya Substation of the Kansai Electric Power Co. (w).
(d) Total power consumption of the Sakai Steel Works (whr).
(e) Total power consumption of each substation (whr).
(f) Maximum total power consumption of the Sakai Steel Works during a 15-minute duration (w).
(g) Maximum power consumption of 70 kv power receiving points (east and north substations), 15 minutes, (w).
(h) Total reactive power consumption of the Sakai Steel Works (var hr).
(3) Selective indication, as need arises, of the following:
(a) Voltage of each bus line (signal phase). (The 70 kv bus line uses a recording meter).
(b) Current of each line (single phase.)

Ac voltage and current is converted to dc current for transmission because direct transmission of ac involves PT and CT burden, induction to other equipment, phase errors due to impedance of transmission line, and abnormal voltages generated when CT circuit is opened. The conversion of the transmission cur-

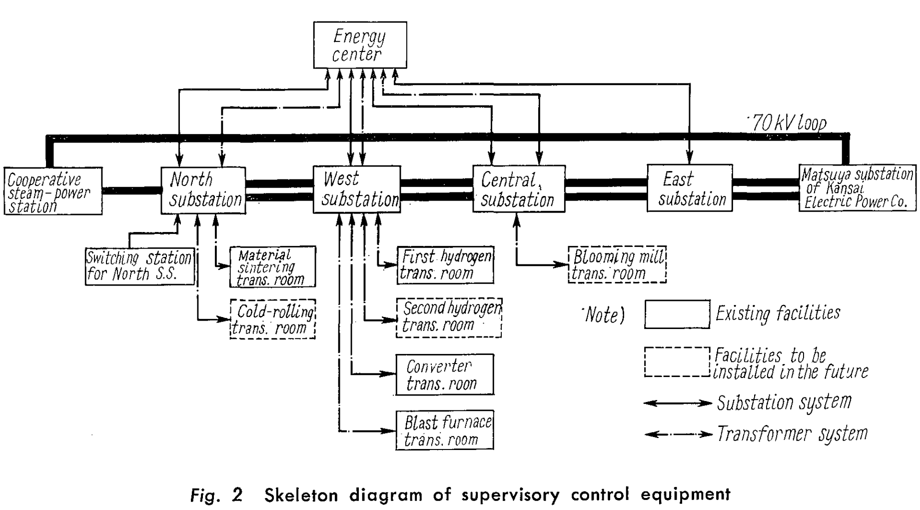

Fig. 2 Skeleton diagram of supervisory control equipment

rent to a 10～50 ma signal current results in the standardization of equipment required.

1) Electric power and reactive power measuring system.

There are 29 points of measurement for electric power, and 11 points of measurement for reactive power. The secondary output of PT, CT is converted into 0～50 mv dc by means of a power converter (HGCW II-1), using a charged body and reactive power converter (HGCBW II-1). The dc voltage is then converted into 10～50 ma by an electrical converter (EETI-P) for transmission.

2) Voltage and current measuring system.

Points of measurement are : 4 for routine voltage recording, 45 for selective voltage measuring and 203 for current measurement. The secondary output of PT and CT is converted by a voltage converter (MUGV-S type for routine recording, MUGV-1 type for selective indication) and current converter (MUGA-1 type for selective indication) into dc 0～50 mv, which is then converted by an electrical converter 10～50 ma for transmission.

3) Frequency measuring system

There are two points of measurement. The PT secondary output is converted into 0～50 mv by a frequency converter (FDC) using transistorized switching circuits and a saturable transformer. The dc voltage is then converted by an electrical converter into 10～50 ma for transmission.

4) Watt-hour and reactive volt-ampere-hour measuring system

There are 8 points of measurement for watt-hour and 4 for reactive volt-ampere-hour. A precision energy meter (D 16 PW TeR type), and reactive volt-ampere-hour meter (D 24 BW TeR type) are equipped with a pulse transmitting mechanism (K_3 type) to convert pulses for transmission.

5) Receiving system

(1) Routine recording

To facilitate the arrangement of recording paper, the 70 kv bus line voltage uses a one-pen recording system, the others a two-pen system. (Electronic automatic balancing recorders S-ERS-1P and S-ERS-2P are used respectively.) These recording system are provided with an external current transformer to match the two inputs of the recording meters.

(2) Routine indication

Power is connected in series to the recording meters, which drive moving-coil indicators (S-EIM2) at a common current of 10～50 ma.

Total power and reactive power comsumed at the Sakai Steel Works is measured at the 70 kv receiving points. Receiving and transmitting pulses may be fed into a 4-input pulse adding and subtracting computer (SUMI-4K) for combined indication of power consumption.

The pulse adding and subtracting computer transmits pulses corresponding to the total power consumption. This pulse is fed to a separate utility wattmeter (PMD-2 Te) to indicate the total power consumption. Power demand at 70 kv receiving points may be indicated by feeding the pulse of each into a separate demand indicating wattmeter in parallel with the pulse adding and subtracting computer.

Total power consumption of each substation is measured at each receiving point, and pulses transmitted are indicated by a pulse integrating meter (S-ESP). A total of 12 cumulative signals are fed in parallel to the control computers.

(3) Selective indication

A wide-angle dc ammeter (DWK) is used as an indicator. Voltage is indicated on a double scale (0～15 kv/0～4.5 kv) and current on a single scale (0～100% graduations). A lamp indicating the proper multiplication factor is located below each meter.

2. Remote Supervisory Control Equipment

The equipment in this system is designed to meet the following factors :

(1) Operation is almost entirely independent of other equipment in the system. Because of this, the extent of possible trouble is limited to a minimum.

(2) Because many sets of equipment are controlled at the Energy Center, the subjects to be controlled are numerous.

(3) The items to be operated and indicated at each substation are also numerous.

Therefore, all controlled equipment utilizes highly compact and reliable, transistorized circuits that permit a 1 : 1 ratio between the control station and the controlled stations.

The overall network involves each substation and transformer room. Each substation has a master-slave relationship with the Energy Center. Each transformer room, however, may be controlled by either the Energy Center or a substation. Thus, relationships between components of the overall network may be likened to the relationship that exists between parents (Energy Center), children (each substation), and grandchildren (each transformer room). Selection of the control location is based on the belief that it should be as near as possible to the remote equipment. Equipment near the control location is fitted with selective switches. Equipment other than 70 kv is individually provided with selective switches at the location, so that units may be operated independently in addition to collective selection at the control station. *Table 1* shows the contents of signals in each controlled station.

A standard pulse code (UR type) is used.

This device takes full advantage of modern components. Wire-spring relays and transistors constitute the main components of this equipment.

The equipment at each substation and transformer

Table 1 **Supervisory and Control Signal Categories in Each Station**

Supervised and Controlled Equipment	No. of Signals Required		Present Mountings		Future Mountings		Model of Equipment	No. of Conductors Required			
	Operation	Indication	Operation	Indication	Operation	Indication		Control operation	Measurement	Telephone	Total
East Substation	41 (6)	63 (6)	50	70	50	30	TC-100UR	4	29	2	35
Central Substation	43 (13)	68 (16)	60	90	40	10	TC-100UR	4	25	2	31
West Substation	31 (5)	52 (6)	40	60	20	0	TC-60UR	4	21	2	27
North Substation	26 (6)	49 (8)	40	60	20	0	TC-60UR	4	31	2	37
First Hydrogen Trans. Room	12 (0)	26 (0)	20	30	40	30	TC-60UR	4	5	2	11
Converter Trans. Room	9 (4)	21 (5)	20	30	40	30	TC-60UR	4	5	2	11
Blast Furnace Trans. Room	10 (4)	22 (5)	20	30	40	30	TC-60UR	4	5	2	11
Material Sintering Trans. Room	16 (4)	30 (6)	40	40	20	20	TC-60UR	4	7	2	13

Note: Values in parentheses represent future plans.

room uses a standard dc voltage dividing system (dc 220 v). Power for the Energy Center is supplied by a no-break ac power source (220 v) using MG in consideration of the large power consumption and resulting economy.

For link lines, 0.65 mmϕ, PE-insulated PVC sheath, electrostatically shielded, local communication cable (CPEVS) is used. The number of conductors required is indicated in *Table 1*.

3. Overall Control Panel, Operating Desk, and Controlled Panel

1) Overall control panel

Located on the surface of the control panel are indicators pertaining to long-distance measuring equipment, recording meters, energy meters, lamps to indicate the condition of remote control equipment, and trouble indicators. The panel on which these meters are located is a graphic illustration of the entire network. The Overall Control Panel consists of five phases:

East substation panel (1200 mm wide)
Central substation panel (1200 mm wide)
West substation panel (1200 mm wide)
North substation pannel (1200 mm wide)
Cooperative steam power station panel (600 mm wide)

Each substation and transformer room panel has a different color to indicate its area. Interdependence of equipment is indicated on the panel by means of appropriate colors and markings.

The flow indication wattmeter is located inside the graphic panel. The integrating meter of each substation is installed in the upper portion of the substation panel. Integrating meters relating to the reception of power are located at each receiving point on the appropriate panel (east substation and cooperative steam power station panel). Recording meters are attached to the lower portion of corresponding panels. Indication lamps which monitor the condition of individual equipment are arranged in a block diagram representing the entire network. Circuit breakers are represented by squares, and disconnect switches by circles. The equipment number is placed above the appropriate symbol. The method of indication is a one-lamp system: when the circuit is open, the lamp lights; when the circuit is closed, the lamp is off. In the event of a change in the automatic circuit, the corresponding lamp flickers, indicating the location of the change.

As shown in *Fig. 4*, the reverse side of the panel houses 11 remote control units (600 mm wide). Three of these units are intended for future use. These units are compatible with the arrangement on the graphic panel. The reverse side of the control panel is fully enclosed.

2) Operating desk

As shown in *Fig. 5*, the Operation desk has selective meters which monitor remote equipment. These meters are located on the slope of the operation desks. Located on the upper side of the operation desk, in graphic arrangement, are switches pertaining to the selection, operation, and warning systems of

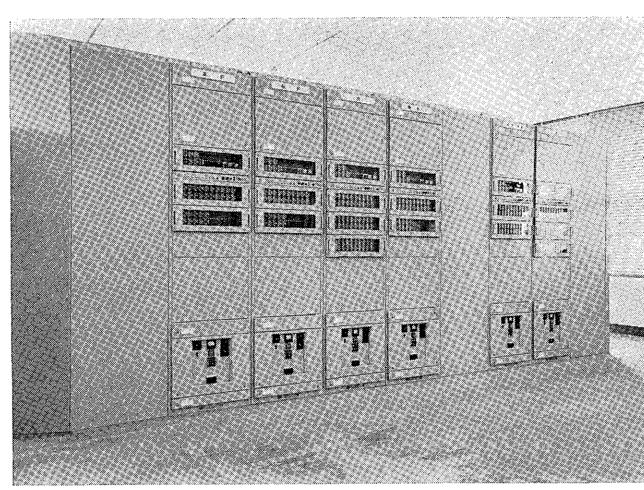

Fig. 4 Supervisory control sets (Energy Center)

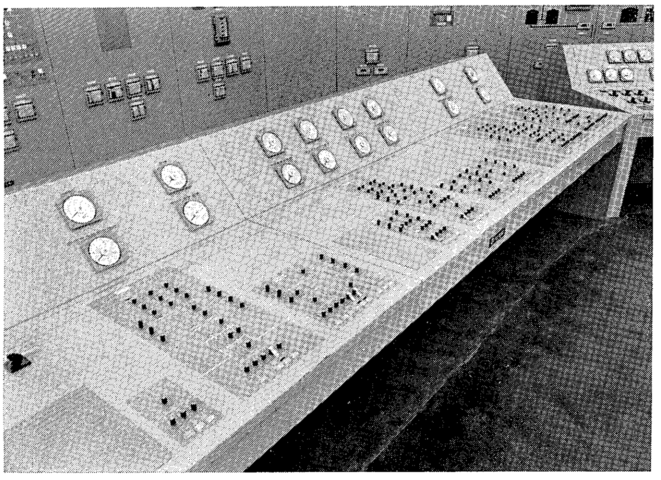

Fig. 5 Operation desk for electric power station

the remote control equipment. This system consists of three 300 mm-wide operation desks and one 800 mm-wide supervision desk.

The method of indicating each substation and transformer room, and their relationship is the same as that employed at the overall supervisory panel. One voltmeter and one ammeter is installed for each system, functioning as a selective measuring indicator. Lamps indicating the correct multiplication factor of the circuit to be measured are located under each meter.

To save space on the board, push-button switches which have lamps built into the buttons are used. There are three types of switches used : switches for selection and operation, meter selection switches, and push-button, alarm stopping switches.

3) Controlled panel

This panel consists of one 700 mm-wide panel for each substation, and one 600 mm-wide panel for each transformer room. The panels are standard JEM types. Long-distance measuring converters are located on the reverse side of these panels. They are compatible with the existing control board. This is an upright enclosed panel.

III. EQUIPMENT RELATING TO MECHANICAL POWER

This equipment pertains to mechanical energy other than electric power and water supply. The following items are placed under centralized control at the Energy Center :

(1) Gases......B gas, C gas, OG gas, M gas.

(2) Other energies......oxygen, nitrogen, heavy oil, steam.

These items are collectively measured from a distance to assist the remote control of such items as heavy oil pumps and gas holders.

1. Remote Control Measuring Equipment

Required measurements are taken at the points required and are transmitted to the center. The steel plant is divided into several blocks for the convenience of measurement. Measurements taken are collected at terminal boxes on a block-by-block basis. Terminal boxes transmit these measurements by means of multiconductor cable. The items of measurement in the mechanical power system number approximately 60. They include flow, pressure, level, temperature, and heat measurements. These items are measured by the TELEPERM oscillator, resulting in a high degree of economy.

1) Method of measuring flow

These are approximately 35 measuring points. Nine points, related to C gas and heavy oils, employ volume-type flow meters ; the rest use orifice differential-pressure type flow meters. These meters vary according to pressure used and differential pressures measured. TELEPERM flow transmitters (MMF II-0.2/144 type) are used in measuring gases because of the relatively low pressure and small differential pressure of the flow. Measurements of the converter furnace, oxygen and steam, require high-pressure and large differential pressure. Therefore TELEPERM transmitters (E-DTB type and E-IOR type) are used to transmit the output in proportion to the flow.

2) Method of measuring pressures

There are approximately 10 points of measurement. Low-pressure transmitters are used to transmit measurements of inlet and outlet pressures of B gas and C gas flow. High-pressure TELEPERM transmitters are employed to transmit measurements of O_2 and N_2 pressures at the converter furnace plant, and heavy-oil discharge pressure.

3) Method of measuring levels

There are approximately 10 points of measurement. TELEPERM transmitter (E-HLR type) is used to measure the levels of the 10 gas holders. TELEPERM float type liquid level transmitter (E-LTR type) is employed to measure the level of heavy oil in the service tank holder. It is necessary to transmit the levels and temperatures of four heavy oil tank units simultaneously with the measurements of a separate tank. Measurements of a sepecific heavy oil tank are converted into digital signals for remote transmission. The signals are represented on the figure indication tube on the overall supervisory control board at the Energy Center.

4) Method of measuring temperature

Items of temperature measurement include the blower outlet temperature of B and C gases, and the heavy oil tanks mentioned above. Since the measured temperatures are low, a platinum temperature measuring resistor is used as a detector, and the detected temperatures are converted into a 10～50 ma current for transmission.

5) Method of measuring and controlling mixed gas heat

B gas and mixed gas heat are measured. The values of these measurements are transmitted to the Energy Center. At the same time, mixed gas heat is controlled according to demand. The mixed gas comprises B, C, and OG gases. Using B gas as a base, the ratio of B gas to C gas and C gas to OG gas is controlled. Into these, heat of the mixed gas is cascaded.

2. Overall Supervisory Board

Measurements of individual energy flow are transmitted to the Center as mentioned above. A panel displaying a graphic picture of the entire plant results in instantaneous reaction based on the information displayed. It also affords a comprehensive and correct grasp of operation of all equipment. Therefore an independent, steel plate graphic panel is used as the overall supervisory board. Various factors of measurement are collected in terminal boxes, near points of measurement, for transmission.

The Energy Center distributes this information to the following panels:

Oxygen system graphic panel (1600 mm-wide)
Steam power system graphic panel (1200 mm-wide)
Heavy oil system graphic panel (2000 mm-wide)
Gas system graphic panel (3600 mm-wide)

The above panels have their own receiving meters. Each panel has an outline diagram of the main originating and consuming points and appropriate lines interconnecting these points. Various indicators (S-EIM2) and operational indication lamps are arranged on the graphic panel. Recording meters (S-ERS) and integrating meters (S-ESM or S-ESP) are installed under the panel.

1) Operational indication lamps

The controller of the Energy Center must have a complete grasp of the operational condition of all equipment. Therefore the graphic panel consists of an outline diagram of all equipment. The operational condition of individual equipment may be determined by examining the appropriate symbols on the panel. These symbols consist of indication lamps which respond to the condition of remote equipment.

2) Valve position lamp indicators

These lamps indicate opening or closing of various control valves. A red indication lamp lights when a valve is fully open, and a green indication lamp lights when a valve is fully closed. An angle indicator attached to the operation desk designates the position of a valve partially opened. When no such indicator is installed, three lamps show the position of the valve, i.e., a red lamp indicates full opening, a green lamp indicates full closing, and a white lamp indicates partial opening. These lamps are connected to limit switches attached to the valves.

3) Lamps to indicate when equipment can be operated

This will be described later.

4) Torque alarm lamp to operate valves

Each electric valve has a torque limit switch to protect the valve. This switch activates a yellow indication lamp for warning.

5) Measuring point indicator lamps

These indicator lamps, orange in color, are used to designate measuring points from which signals relative to oil level, temperature, pressure, etc., are obtained and sent to the universal indicator and recorder. With respect to water supplies, the measuring point for the universal indicator input is designated.

6) Alarm system

The alarm system consists of a buzzer and yellow indicator lamp. When activated, the buzzer sounds and the lamp flickers, indicating the position of the trouble on the graphic panel. This indicates that one of the measuring points has reached a predetermined upper or lower limit.

3. Operation Desk

To facilitate and insure positive control, an outline of the entire system is represented in graphic form at the Operation Desk. Various operating controls for valves, pumps, and substation equipment units are installed at corresponding locations on the graphic panel. Construction of control desks corresponds to the graphic panel. It consists of the heavy oil system operation desk, B gas holder operation desk, maintenance personnel desk, gas station operation desk, and the heat operation desk.

4. Remote Control Equipment

This equipment is used by the Energy Center for the remote control of heavy oil pumps, gas holders, electrically operated water valves, and gas stations. Two methods of control are utilized. When the items to be controlled are scattered over various locations, the use of the direct method is the most advantageous. Connections are made directly to the controlling points on the basis of a 1:1 correspondence. For economical reasons, however, selective type supervisory control units, utilizing a pulse code system, are used at the gas station where an extremely large number of centralized control and indication items are required.

1) Remote control of pumps and valves

The starting and stopping of pumps and the switching of various control valves is directly controlled by the Energy Center relative to power and water supply facilities.

The control cable used between the Energy Center and local equipment units is 0.65 mm local communication cable (CPEV) with PE insulation and PVC sheath. This is used for economical reasons. The measuring cable is identical to this cable. Power is supplied through appropriate auxiliary relays (Type HH22P) to excite the electromagnetic switches at the final stage.

2) Remote control of B gas holder

The inlet valve of the B gas holder, inlet valve of diffusion tower, and the water sealing valve can all be remotely controlled. In addition to the three control switches for the opening and closing of the above mentioned valves, an automatic-manual selector switch for the holder inlet valve is installed on the operation desk. For normal operation, these switches are left in the automatic position.

3) Remote control of the gas station

Four sets of blowers for B gas, C gas (including two sets for future system expansion), and the associated bearing cooling water valve, the water sealing valve at the journal of the sealing box, inlet valve, outlet valve, two sets of C gas change-over valves for B and C gas mixing, and a set of OG change-over valves are all remotely controlled. Both ganged and independent control of associated blower valves is possible.

An effort has been made to reduce the number of supervising and controlling items by combining trouble indicators.

The same selective equipment is used, however, as is used in the electric power facilities. As shown in *Table 2*, the number of items to be controlled, including those provided for future system expansion, is extremely large.

As is seen in *Fig. 7*, the control switches used for the remote control of the gas station are identical to those used for other direct controls. Since only the blower operation indicator lamps are installed on the graphic panel (*Fig. 6*), the operational state and remote controllability indicators of the various valves are classified into groups and installed on the operation desk. All trouble indicators are concentrated on the front side of the sloping panel.

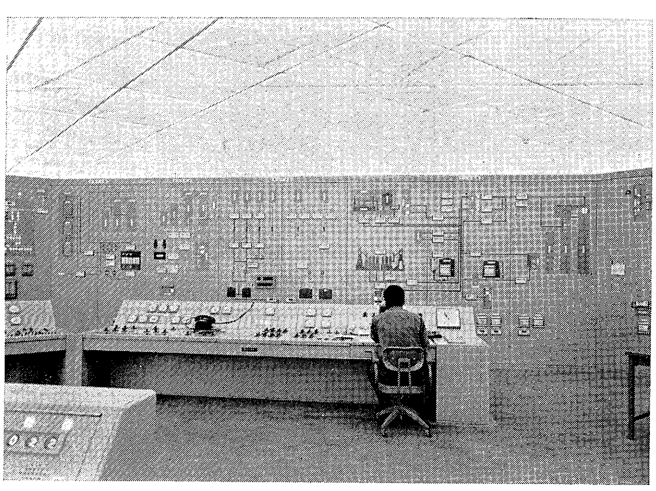

Fig. 6 Graphic panel for power supply system

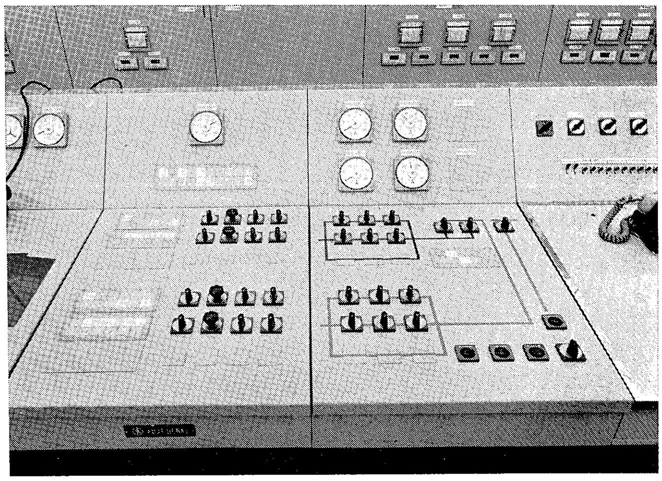

Fig. 7 Operation desk for gas station

IV. WATER SUPPLY FACILITIES

The objective of this equipment is to supervise the flow of fresh water, sea water, purified water, and filtered water, supplied and consumed within the Sakai Works, and accomplish the smooth control of water supply by the Energy Center. For this purpose, the water supply facilities monitor flow rates, pressures, and levels of various kinds of water, and control the electrically operated valves, etc., of remote equipment. Various measuring signals are routed through terminal boxes which facilitate their transmission to the Center. The same system is used with the power supply. A water supply sub-center, consisting of several blocks, allows the operation, control, and supervision of local equipment units to be accomplished at the sub-center. There are three sub-centers. The East Sub-Center comprises the water intake, the East water return, the cleaning bed, and the filter bed. The South Sub-Center comprises the North sea waterwork, the South sea waterwork, and the South water return (to be used in future). The North Sub-Center comprises the North water return, and the cold rolling water return.

1. Telemetering Equipment

Approximately 150 items are measured and monitored at the Energy Center. The measurements include flow rates, pressures, and levels.

1) Flow rate measuring system

There are approximately 65 measuring points. All indicators used are either Venturi type flow-meters, utilizing an orifice, or TELEPERM flow rate genera-

Table 2 **Supervisory and Control Signal Categories in Gas Station**

Supervised and Controlled Equipment	No. of Signals Require		Present Mountings		Future Mountings		Model of Equipment	No. of Conductors Required			
	Operation	Indication	Operation	Indication	Operation	Indication		Control operation	Measurement	Telephone	Total
Gas Station	33 (28)	58 (39)	40	80	60	20	TC-100UR	4	18	2	24

tors (MMF II-25/1600 or MMF II-25/6400 type), depending upon the pressure difference of the source to be measured.

2) Pressure measuring system

There are approximately 80 measuring points in this system. All generators are TELEPERM pressure types (E-PTH type) and measuring pressures are unified at 0 to 6 kg per sq. cm.

3) Level measuring system

Four of the five measuring points pertain to the measurement of the water level in the elevated water tank. A TELEPERM generator (E-PTB type) is installed at the bottom of the water tank and senses the level of the water.

2. Overall Supervisory Panel

The system, structure, and equipment units installed are identical to those of the power supply.

The component units are:

Sea Water System Graphic Panel (width: 4000 mm)

Fresh Water System Graphic Panel (width: 4000 mm)

Purified Water System Graphic Panel (width: 2000 mm)

All pressure and level indicators are provided with a lower limit alarm which is activated when the pressure of the system is reduced. Also, a universal indicator, recorder, and integrating indicator are installed in each of these panels. The universal indicator is used as a selective pressure indicator and there are five meters in all. Indication is available on any desired indicator by means of selector button switches located on the control panel. Two universal recorders are used to record optional measuring points so it is not necessary to have separate recorders for flow rate and pressure measurement. Also, one universal integrating indicator is provided to integrate the elements which do not have a special integrating indicator. The operating indicator lamps installed on the graphic panel and the operation desk are similar to those used in the power supply facilities. They consist of the operating indicator lamp, valve opening and closing indicator lamp, con- trollability indicator lamp, valve control torque alarm indicator lamp, measuring point indicator lamp, and the alarm indicator lamp.

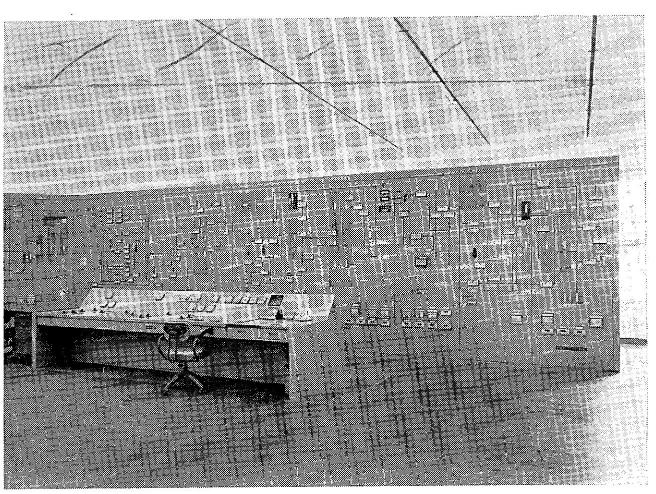

Fig. 8 Graphic panel for water supply system

3. Operation Desks

These desks are placed in front of the corresponding graphic panel as are the power supply power control facilities. The operation desks consist of the Sea Water System operation desk, Fresh Water System operation desk, Purified Water System operation desk, Selective Pressure Supervisor desk, and the maintenance personnel desk.

4. Remote Control Equipment

This equipment controls electrically operated valves in the same manner as remote control operation in the power supply system. In addition to various control valves, five emergency valves for sea water are operated by an emergency diesel generator in the event that commercial power supplies are interrupted. Because of hot rolling, heavy work, and cogging mills, water pressure variations in the water supply piping system may occur due to different plant allocations. For this reason, water is supplied by a electric/hydraulic controlling deviceand butterfly valve. The use of this control equipment assures constant pressure regulation.

V. COMPUTING EQUIPMENT FOR OPERATION CONTROL

Until now, data recorders have been used in the energy centers of iron and steel works in many cases for the purpose of daily production reports and momentary value supervision. The control computer has various additional functions besides data logging and indications of short period operation.

The additional functions of the new data recorder are as follows:

(a) Preparation of energy management record (Power and Water).

(b) Calculations for economical energy distribution.

(c) Calculation of energy distribution in abnormal conditions.

(d) Calculation of expected demand for electric power.

The component units of this computer are as follows.

(1) Computation Frame (FIDAP 400B), Input and Output Frame (420A), Additional Magnetic Drum Frame (481A)	1 each
(2) Frieden Type F10 Flexowriter	1 set
(3) Automatic Voltage Regulator	1 unit
(4) Auxiliary Air Conditioner	1 unit
(5) Console	1 set

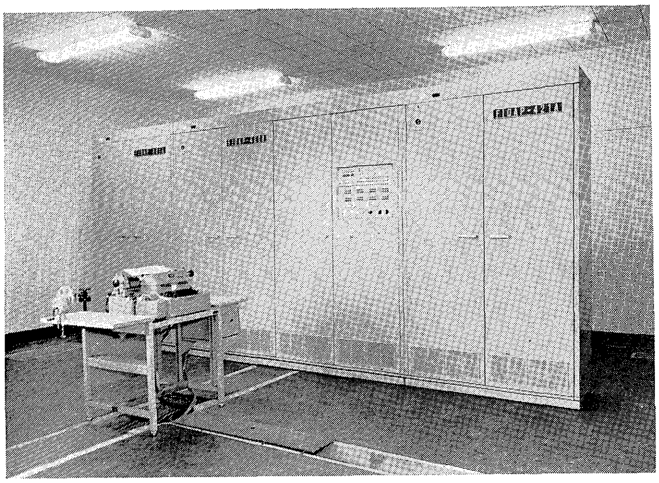

Fig. 9 Overall view of computer room

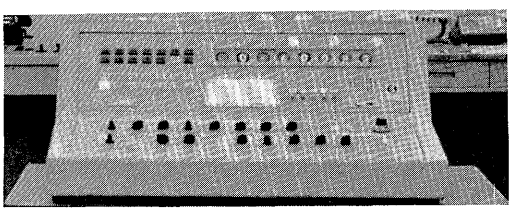

Fig. 10 Console for computer

(6) 30-inch Output Writer for Daily Report Preparation 2 units
(7) 16-inch Output Writer for printing of resultant data of calculation 1 unit

Fig. 9 shows a view of the computer room.

In ordinary use, all computer operations can be accomplished from the console.

The following control and dial switches and indicator lamps are installed on the consol. (Refer to *Fig. 10*)

(1) Value Setting Dial (Coded 7-digit Decimal)
(2) Address Setting Dial (5-digit Decimal)
(3) Program Selecting Dial
   Up to 100 different functions of the computer may be selected by use of this dial. Major functions include: the calculation of economical energy distribution, energy distribution under abnormal conditions, eight-base decimal conversion, decimal eight-base conversion, decimal indication of optional memory bank, momentary analog input value indication, pulse input digital indication, some operations before scheduled power interruption, table preparation from tapes, and various tests (indicator tubes, buzzers, alarm lamps, content indicator lamps, etc.).
(4) Selecting switch for figure indicator tube (time indication and figure indication)
(5) Push-button switches for buzzer stopping, alarm resetting, priority interrupt start, prevention of misoperation on priority interrupt.
(6) Figure Indicator Tubes (coded and 7-digit decimal)
(7) Alarm Lamp (with buzzer) 14 pcs
(8) Computation Content Indicator Lamps 14 pcs

The major contents of data handled by the control computer is as follows:

1) Preparation of Energy Management Report (Daily)

The Energy Management Report is divided into power and water supplies. The obtained data is printed at designated times (every hour on the hour) by a typewriter for each unit. Pertaining to the power supplies, 41 analog points are scanned every 5 minutes and an average value for 60 minutes of operation is calculated and printed every 5 minutes. An average value for 60 minutes of operation is calculated and printed every printing hour. During scanning, analog input current below 10 ma is excluded from the average value computation. Pertaining to electric power supplies, computation is based upon a pulse counting system utilizing an integrating watt-meter. The results of the analog and pulse integral scanning are utilized for economical energy distribution, abnormal condition distribution computation, and anticipated electric power demand computation. As is the case with power supply computations, analog signal abnormalities are detected and excluded from the final computation. Type is printed in red when either the present upper or lower limits are exceeded in power and water supplies.

2) Computation of economic energy distribution

The following matters must be taken into consideration in planning energy distribution.

(1) Allotments of energy made to each plant must be made in accordance with the amount of energy demanded by the particular plant.
(2) The mixing ratio becomes problematical when many kinds of energy sources are used in a single plant.
(3) As an example, at the gas station, not only the total energy but also heat per unit flow rate must be maintained at a constant level by controlling the gas mixing ratio.
(4) The B gas production rate is not always constant, so control must be maintained while exercising adequate care to watch the designated upper and lower limits. This is accomplished by continuous supervision of the B gas production rate and the B gas holder. This is also applicable to the OG gas.
(5) It must also be noted that the required amount of C gas may not be available, due to a possible limitation of the coke plant.
(6) When distributing B, C, OG gases and heavy oil, the fact that these energy sources have different heat and costs as well as different thermal efficiencies must be taken into consideration.

Energy distribution which minimizes the total cost required by the entire plant may be calculated using the above information. Calculation for this purpose is called Economic Energy Distributing Computation, and is conducted once every hour at

Table 3 **Specifications of FIDAP 400B Type Control Computer for Energy Center**

Value Indicating System	Fixed decimal point, binary
Successive Control System	Program memory system
Transmission System	Series synchronous transmission
Command System	1 address system (three index registers)
Kinds of Commands	approx. 70
Word Length	24 bits (including code and inspection bits)
Clock Frequency	166 kc
High Speed Memory Equipment	Magnetic core matrix, 640 words
Large Capacity Memory Equipment	Magnetic drum average access time 10 ms One unit (7552 words), installed to this equipment Additional installation, maximum 4 units actually installed, 1 unit
Computation Time	Addition 320 μs (including access time) Multiplication 2.2 ms (〃) Division 8.0 ms (〃)
Analog Input	Maximum 1024 points. Installation 114 points. Program scanning A/D Converter Converting time 1 ms Input 0 to 250 mv Minimum Unit 1/1024 Overall Accuracy 0.3 %
Pulse Input	Maximum 256 points, Installation 16 points (Counter capacity: 20 bits) Scanning and counting systems, hardware installation
Coded Input	Maximum 64 points, Installation 6 points program scanning
Priority Input	Maximum 128 points. Installation 10 points. Scanning is by hardware program level setting.
Coded or ON-OFF Output	Maximum 64 points. Installation 2 points. One coded output point is equivalent to 23 on-off output points.
Typewriter and Tape Puncher Output	Maximum 12 units. Installed 3 units. (30″×2, 16″×1)
External Dimensions	Computer Frame (2032×2232×500 mm) Input and output frame (2032×1146×500 mm) Expansion drum frame (2032×1146×500 mm)
Power Source	100/200 v (±2%), 50/60 cps 4 kva
Ambient Temperature	20 ± 10°C

a predetermined time under normal conditions. Computation utilizing the LP method has been adopted. In addition to normal computations conducted every hour, provisions for automatic computation in the event of abnormal conditions and manual computations are provided for.

3) Energy distribution computation under abnormal conditions

Computation must be conducted to meet abnormal conditions, such as a sudden change in the operating conditions, gas production, etc., since it is highly desirable to correct these conditions as soon as possible. Therefore, this computation provides criteria for emergency distribution comand. Those emergencies relative to an insufficient supply of B, C, and OG gases and heavy oil are classified into five categories. Priority orders are previously given to each energy source and take into consideration all pertinent factors.

Thus, the classification of an emergency depends upon the degree of the abnormality. Once classified, simplified computation may be conducted. Values which existed prior to the abnormality are used as a basis for computation. At the same time, values pertaining to production rate and the amount of gas retained are those present during the abnormality. Computation is started either automatically when the abnormality is automatically detected or manually.

4) Anticipated electric power demand computation

Since the contract with the electric power company is based on a 15-minute demand, the expected 15-minute demand is calculated five and seven minutes after starting the electric power integrating calculation. Scanning of electric power is conducted in one minute intervals, beginning at the same time as electric power integration computations. Time series information and straight-line calculation is conducted by the minimum squared approximation.

VI. OTHER FACILITIES IN THE ENERGY CENTER

The energy center is located at the approximate center of the Sakai Works, and occupies the third floor of a 3-story concrete building. Floor space is 16 m by 36 m, and as shown in *Fig. 11* houses the computer room, battery room, motor generator room, reference material room, and patrolling personnel room. Operation desks are located in front of overall supervisory panels so that operating personnel may conduct operations while watching the supervisory panels. Complete air conditioning equipment is installed in the energy center. The computer room, however, is located in a special room where dust control and thermostatic control may be maintained by means of secondary air conditioning equipment. The computer operation console and the input/output typewriter, which require frequent operation and checks, are installed separately behind the operation desks.

1. No-break Power Supply

Due to the nature of the energy center, the interruption of power is absolutely not permissible. For this reason a 20 kva dc driven ac generator, batteries capable of 30-minute operation, and a 20 kva three-phase transformer, are provided as an emergency power supply system.

Power can also be supplied from an emergency diesel generator, located in the south sea water lifting works, as well as from the commercial power source. Power received from this source will allow the energy center to continue operation without interruption when commercial power interruption continues

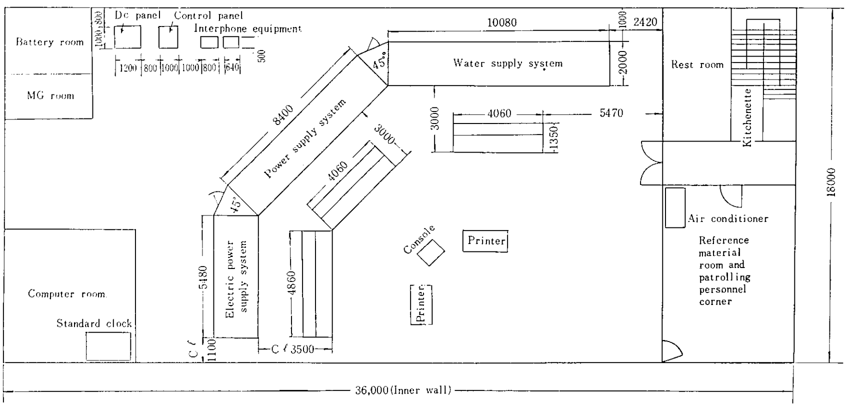

Fig. 11 **Floor plan in Energy Center**

for more than 30 minutes.

2. Message and Command Equipment

There is an interphone system which connects a number of major points with the Energy Center, and a radio telephone system that connects patrolling personnel with unattended facilities.

1) Interphone equipment

This equipment makes possible communication between the Energy Center and major points under the control of the Energy Center. This is very important in the case of an emergency. The communication system which has been adopted is a dialing method by means of relay exchange. This system allows communication between various offices; simultaneous command and group conversation are also possible.

2) VHF radio equipment

A VHF station is installed in the Energy Center and communication between the Center and personnel patrolling the various facilities is possible. Mobile patrolling stations are installed in Jeeps, and communications with the center is possible between mobile stations in the city and in the plant, and between mobile stations and handsets carried by patrolling personnel. Handsets are carried by the Jeep personnel, and conversation is possible with the base station, mobile stations, and other handsets. A crystal oscillator clock is installed in the Energy Center so that accurate time pulses are sent to the computer, clocks in the Energy Center, converter, and other required places.

VII. CONCLUSION

Various new technologies have been introduced in Energy Center equipment which Fuji Electric delivered. It is especially notable that optimum, smooth, and economical energy distribution has been accomplished by means of large scale automation utilizing the control computer and a wide adoption of remote control and supervisory equipment. Fuji Electric has a wide variation of equipment, developed through past experience, and is striving to develop and introduce the most modern engineering methods and technology.