E-13 BASIC REQUIREMENT OF LIGHTING SYSTEM

1. General

The lighting system will consist of normal lighting (AC), normal emergency lighting (AC), and emergency lighting (DC) and will be used for lighting for the indoor and outdoor equipment, the offices and roads.

The normal emergency lighting will be capable of automatically providing lighting for safety on the occasion of a power source failure in the normal lighting system. The places to be installed will be the area around the main building, and the boiler, and substation.

The emergency lighting will be capable of automatically providing lighting for safety on the occasion of a power source failure in the normal lighting system. The emergency lighting shall be installed at the same places as those for the above-mentioned normal emergency lighting.

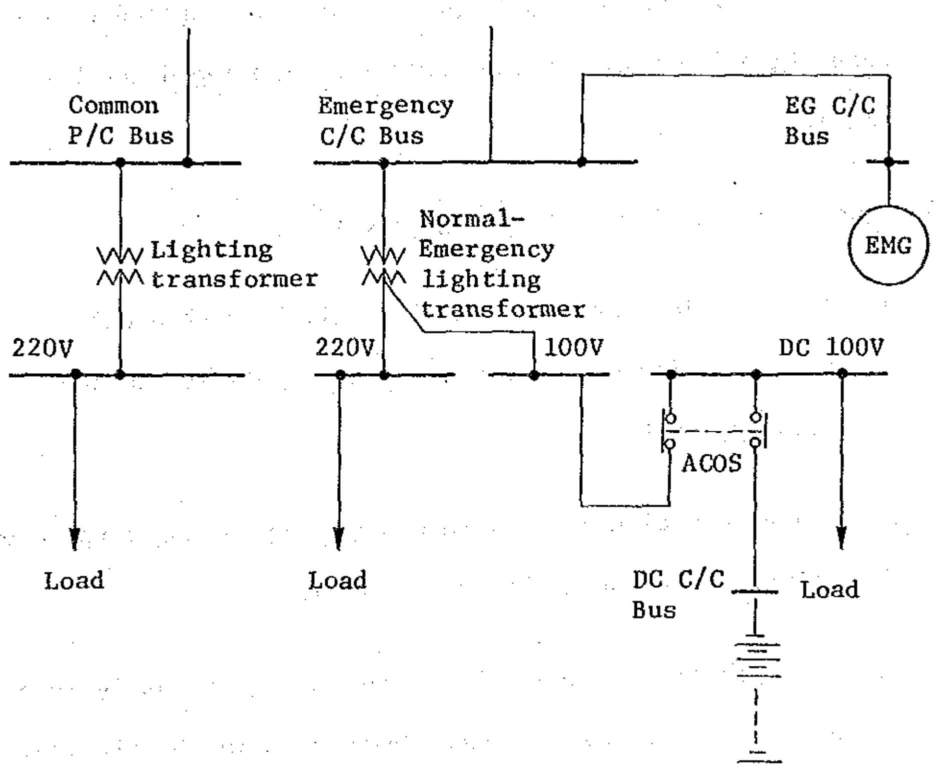
2. Illumination Level (lx)

The illumination level of the respective area with normal and emergency lighting system will be in accordance with the following.

Area	Illumination level (lx)		
	Normal lighting	Normal emergency lighting	Emergency lighting
Central control room, substation control room	500	50	5
Office	300		
Shift room, shift supervisor room	200		
Instrument and electrical repair room			
Metal clad switchgear			
Power center, control center			
Turbine-generator room	100		
Emergency diesel generator			
Control equipment room			
Plant water equipment control room			
Waste water control and chemical storage room			
Generator PT, battery room	70		
Other rooms, stairs			
Generator seal oil equipment area			
Fuel equipment, screen area, evaporator	50		
Air compressor, BFP and condenser area			
Main, auxiliary and starting transformer	20		
Main roads	5		
Switchyard			
Branch roads	2		

3. Basic Design of Lighting System

(1) Power supply system to illumination circuit



Note:

(1) EMG -- Emergency Diesel Engine Generator

(2) ACOS -- Automatic Changeover Switch

(magnetic contactor)

That is, the power source for normal lighting and normal emergency lighting during normal service is single phase AC 210 V, while that of the emergency light is DC 105 V.

The lighting power source is supplied from the common power center to individual supply points, and is supplied to the respective lighting fixtures from the lighting distribution panel.

(2) Considerations for determining circuit system

a. An economical arrangement plan will be worked out in consideration of the power source supply system and lighting system.

b. The branch circuit will be designed by taking into account voltage drop and mechanical strength.

c. The main line scheme will be worked out by taking into account the factor of load fluctuation in the fixture, and the lighting distribution panel will be conveniently located near the load to allow easy inspection and maintenance.

(3) Selection of conductor size

The conductor size will be selected so as to satisfy the following three requirements - mechanical strength, current capacity and allowable voltage drop.

a. Mechanical strength of conductor

Although the mechanical load acting on the indoor wiring is small when compared to that acting on the overhead lines, sufficient strength is required in view of safety, maintenance and wiring work. Therefore, the mechanical strength with respect to the minimum size of conductor will be as stipulated in the "Standard for Electrical Equipment". In principle, a strength corresponding to 1.6 mm annealed copper wire or larger is required. However, in the case of a power plant, 2.0 mm^2 annealed copper wire is required to be used, as the wiring is exposed to the environment.

b. Allowable current of conductor

The allowable current for each conductor is stipulated, and no current higher than the allowable current is permitted to pass through the conductor.

c. Voltage drop

The allowable voltage drop will be determined by taking into account the following requirements.

(a) To permit no deterioration in load function.

(b) To minimize the range of voltage regulation at load terminals.

(c) To allow uniform voltage at respective load terminals.

(d) To reduce the power loss in wiring.

(e) To realize optimum economy.

The conductor size of branch circuits and the main line will be determined by taking into account the above requirements.

Normally, voltage drop is divided into that of the main line and that on the secondary side of the lighting distribution panel. The voltage drop ratio is considered to be 2% on the secondary side of the lighting distribution panel and 5% to 10% in the main line (note that this may vary depending upon the distance of the conductor).

d. Calculation of voltage drop

The value of voltage drop is calculated according to the following formula on the assumption that the load is in equilibrium:

$$V = kW \times (R \cos \theta + X \sin \theta) \times IL$$

where: kW: Coefficient according to electrical system and is shown as follows:

Single phase or direct two wire system	: 2
Single phase or direct three wire system or 3-phase four wire system	: 1
3-phase three wire system	: 3

R : Resistance of conductor (m/)

X : Reactance of conductor (m/)

θ : Power factor angle (θ = 0) (in case of DC circuits)

I : Current (A)

L : Distance (m)

(4) Application for main building and boiler

a. Illumination conductor

a) Service voltage

- Normal lighting power source (200 V) — AC 3ϕ 3W 210 V
- Normal lighting power source (100 V) — AC 3ϕ 3W 105 V
- Emergency lighting power source — AC/AC 1ϕ 2W 210 V
  AC/AC 1ϕ 2W 105 V
  AC/DC 1ϕ-DC 2W 105/110 V

b) Power source voltage drop

Power source voltage drop is taken into account by dividing it into that of the main line and that on the secondary side of the lighting distribution panel. The standard values of voltage drop according to extension line rules are as described in the following table.

Distance	Voltage drop in main line	Voltage drop on the secondary side of distribution panel
60 m max.	3%	2%
120 m max.	5%	2%
200 m max.	6%	2%
Over 200 m	7%	2%

In principle, the values of voltage drop in the above table are adopted for the design of the power plant lighting system. However, should it be difficult to comply with the above values in view of the distance of the main line and the secondary side of the lighting distribution panel, the total voltage drop in the main line and that on the secondary side will be 10% or less, but this is limited to use of mercury vapor lamps only.

c) Power source system

. AC 210 V lamp circuit

. AC/AC 210 V normal emergency light circuit

. AC/AC 105 V, AC/DC 105 V emergency light circuits

b. Circuit system

The circuits for all lighting fixtures are classified into manual on/off circuits and automatic on/off circuits.

a) Flashing circuit

(a) Manual on/off circuit

. 1st floor of turbine room in main building.

. 2nd floor (mezzanine) of turbine room in main building.

. 3rd floor of turbine room in main building

. Lower floors around boiler (up to approx. FL 20,000 mm)

However, the manual on/off circuit will be provided at the portion concealed behind, ducts, etc. even if the said portions are located higher than the main building.

. Adjacent to boiler and burner

(b) Automatic lighting circuit (Timer operation)

. Higher floors around boiler

. Around transformer area

. Around outdoor facilities area

. Roads

All portions described above require illumination throughout the day and night. The manual on/off circuit will be adopted for portions concealed during daytime, and the automatic on/off circuit for other portions.

b) Emergency lighting circuit

The emergency lighting circuits will be installed for staircases and passages.

The standard for emergency lighting fixtures.

1. A special purpose battery having the capacity to provide continuous lighting for 30 minutes or longer, or a special power generator which can be started up in 10 seconds subsequent to occurrence of emergency will be installed as the emergency power source.

2. All wiring will be fireproof.

   Also required at a steam power plant are auxiliary battery equipment, emergency power generating equipment and emergency lighting fixtures for plant operation.

   Built-in type incandenscent lamps with double coils, and heat resistant thermoplastic covered wires (HIV) will be used for the wiring of AC/DC circuits and these circuits will be wired separately.

(a) AC/DC 105 V circuit

- . 1st, 2nd and 3rd floors of the main building, staircases and passages, parts of the central control room
- . Emergency lighting on the ceiling of the turbine room in the main building
  Around boiler, over staircases and passages
- . In front of burner around boiler

(b) AC/AC 210 V circuit

Around the equipment on the 1st, 2nd and 3rd floors of the main building and in the central control room.

c. Branch circuit

(a) The branch circuit will consist of MCCB 2-pole, 50 Amp. frame, 20 Amp. trip.

(b) The capacity of the branch circuit will be 80% or less of the trip value.

(c) Arrangement of circuit

- . The branch circuit will be arranged so as to provide the most economical wiring routes while taking into account the scheme of the electrical and lighting systems.
- . The branch circuit will be arranged as simply as possible to provide convenient maintenance.

d. Wire size of branch circuit

In consideration of voltage drop and mechanical strength, the wire size of the branch circuit will be as

. AC 210 V normal lighting and AC/AC 210 V emergency lighting:

. AC/DC emergency lighting

2. Selection of Lighting Fixtures

Lighting fixtures will be selected by taking into account the economics (cost of fixtures and operating costs) and the purpose of use. Generally, fluorescent lamps are used in case the lighting time is long; incandescent lamps, in case the lighting time is comparatively short.

Meanwhile, for illumination over wide areas, mercury lamps are advantageous due to their high luminance, high efficiency and long service life.

(1) Incandescent lamp

Both large and small incandescent lamps are available, offering a wide range of application. Where a large number of light sources are used or large capacity lamps are used, care will be taken to avoid excessive glare.

(2) Fluorescent lamp

Due to their high efficiency and excellent luminance, fluorescent lamps are suitable for low ceiling floors, working floors requiring high luminous intensity, and areas requiring luminous intensity over a vertical plane.

For the 1st and 2nd turbine room, high luminous intensity and pleasant illumination can be obtained by using high output fluorescent lamps, provided that the ceiling is comparatively low.

Among the various types of fluorescent lamps, the preheat start and the rapid start fluorescent lamps are frequently used. The preheat start type, which is in wide use, employs a globe tube for starting. In the case of the rapid start type, which does not employ a globe, the inside and outside of the tube wall is specially treated to facilitate starting.

(3) Mercury lamp (High pressure mercury vapor lamp and fluorescent high pressure mercury vapor lamp)

The mercury lamps are normally used in the 3rd floor turbine room due to its high ceiling. The fluorescent high pressure mercury lamp having a corrected color, is used indoors. The conventional high pressure mercury vapor lamp and the fluorescent mercury vapor lamp are used outdoors. They can also be used as floadlights.

The mercury lamp floodlight is suitable for outdoor illumination in the steam power plant area as well for the switchyard, storage yard, oil storage tank, etc. Since several minutes are required for starting and restarting mercury lamps, an incandescent lamp or fluorescent lamp is required to be used in combination in the event of lamp failure.

(4) Selecting lighting fixtures

Selecting lighting fixtures are presented below with respect to the above type lamps.

a. Two sets of 40 W fluorescent lamps and reflector pipe hangers are arranged on each of the 1st, 2nd and 3rd floors of the turbine/generator room, the roof, and the 1st and 2nd floors of the main building. Since emergency light is required on staircases, the incandescent lamp of a built-in type (AC/DC 105 V power source) is used. For normal-emergency light around equipment, two lamps (AC/AC 200 V power source), one for emergency and the other for the dual purpose of both normal and emergency service, can be used. The fluorescent mercury lamp HF400W, pipe hanger with shade and bracket can be used at places such as around the low pressure feedwater heater, at entrances which receive large equipment, for high partial ceiling areas where it is difficult to obtain the required intensity of illumination, and so on.

Since the ceiling of the turbine/generator room on the 3rd floor of the main building is high and requires a high intensity of illumination, 400 W high output fluorescent mercury lamps are used. Emergency lighting for the ceiling in the turbine/generator room on the 3rd floor is provided by 300 W incandescent lamps (AC/DC 105 V power source) to ensure the intensity of illumination in the event of emergency.

As an emergency light source, the same type of 300 W incandescent lamps (AC/DC 105 V power source) as those for the turbine/generator room ceiling are used.

Two sets of 40 W fluorescent lamps, directly coupled to the reflector (waterproof type), are used on the roof and around the deaerator, while the fluorescent mercury lamps HF400W (waterproof type) with bracket are used for illumination of the cooling water head tank and staircase.

b. Around the boiler and burner

In principle, two sets of 40 W fluorescent lamps directed coupled to reflectors will be installed. In case explosion-proof types are required, lighting fixtures applicable to the corresponding places will be adopted upon judging as to whether such represent Class 1 or Class 2 danger levels.

As appropriate attachment spots are not normally found at high places around the boiler, fluorescent mercury lamp of a bracket type using steel structures will be selected wherever practicable.

As emergency lighting fixtures for the staircase, directly coupled incandescent lamp (AC/DC 105 V power source) will be selected.

c. Around main transformer, and gas ducts

Except for a part of the illumination around the main transformer, fluorescent mercury lamps HF400W will be used. Bracket type lighting fixtures employing steel frame structures will be used wherever possible. Pole lamps will be used only in case it is impossible to use the bracket type.

d. Road inside the power plant premises

In principle, highway lamps HF400W will be adopted, and the lighting fixtures will be arranged on one side of the road. These fixtures will be installed at heights of 10 m and 8 m respectively in the case of a wide road or a narrow road.

e. Central control room

Provided that is adopted, the light source will be fluorescent lamps, and the fixtures will be of a louver type. As emergency light, the flush type incandescent lamp (AC/DC 105 V) will be adopted.

PIC-1 PLANT INTERLOCK

1. For a recent steam power plant, high level control system and operational functions have been widely required.

   In order to protect power plants from troubles and malfunction of any equipment, it is necessary to install various types of protection devices including plant interlocking devices. Therefore, the design concept of the plant interlocking system for the West Wharf Thermal Power Plant Units 1 & 2 has been established taking into account coordination with drum type boiler and steam turbine generator unit based on the following basic plans:

2. Basic Plant Interlock

2.1 Generator

   (1) In case of a sudden load rejection due to the power system trouble, etc., should there is no trouble in the generator or transformer while Unit 1 (Unit 2) is in operation, the Unit shall be protected by opening the generator breaker (52G).

   (2) Should the Master trip solenoid (MTS) relay be actuated due to turbine trouble while Unit 1 (Unit 2) is in operation, 86G shall be operated in order to prevent motoring of the generator.

   (3) In the event where 86G is operated, MTS relay shall be actuated in order to trip the turbine.

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2.2 Turbine

(1) Should any trouble arise in the turbine while Unit 1 (Unit 2) is in operation, 86G shall be operated by actuating the MTS relay in order to trip the generator.

(2) In the event where 86G is operated while Unit 1 (Unit 2) is in operation, MTS relay shall be actuated in order to trip the generator.

(3) In the event where Master Fuel Trip (MFT) relay is actuated, MTS relay shall be operated in order to trip the turbine.

2.3 Boiler

(1) Should any trouble arise while Unit 1 (Unit 2) is in operation, and then MTS shall also be actuated, the boiler shall be extinguished.

(2) Protection of reheater

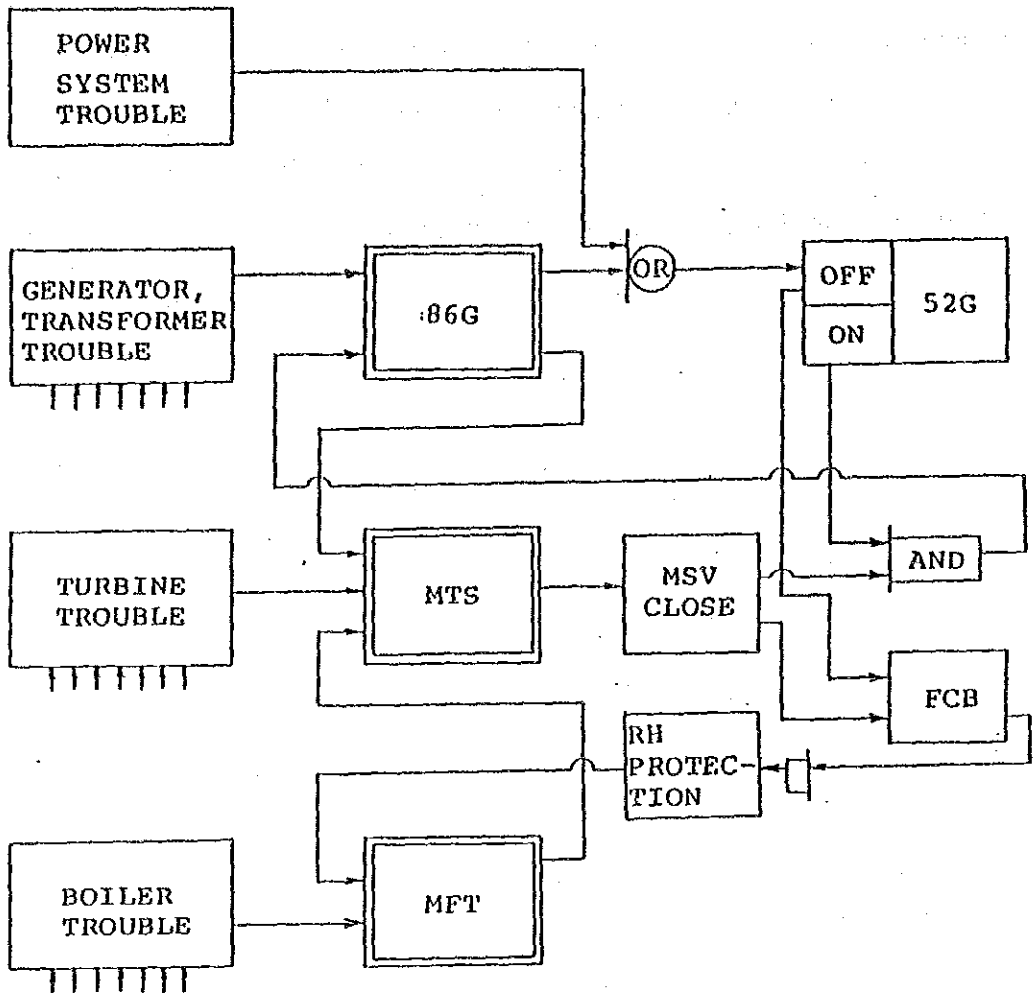
a. The Fast Cut-bak (FCB) system shall be adopted in order to protect the boiler reheater elements.

b. In case of turbine bypass valve is adopted and the turbine bypass valve is not open and the flow rate of fuel is not decreased to the minimum level when Unit 1 (Unit 2) is put to island operation, MFT shall be actuated.

In case of the West Wharf Thermal Power Plant, turbine bypass system will not be applied.

3. Conclusion

Concerning the interrelationship of the causes which result in the trip of boiler, turbine and generator as well as the causes of respective trouble, their details will be decided at the manufacturing design stage of the project.



BASIC PLANT INTERLOCK

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PIC-2 CONCEPT OF PLANT CONTROL SYSTEM

1.

The capacity of the West Wharf Thermal Power Plant Units 1 & 2 is planned to be 200 MW and will be one of the largest units in Karachi Electric Power Co. (KESC). Therefore, shutdown of this unit is expected to cause substantial effects on the entire power system in KESC. In consideration of the importance of these units, the West Wharf P.P. Units 1 & 2 shall be designed so as to meet the power system requirements in KESC as follows:

- o In order to ensure stable power supply, easy increase and decrease of plant output are necessary
- o Ensure coordination for adjustment of power system frequency
- o Proper countermeasures will be applied at the time of power system trouble.

In order to meet the above requirements, the control system for the West Wharf Thermal Power Plant Units 1 & 2 shall ensure the following requirements:

(1) Safety of the units

(2) High reliability and less troubles

(3) Easy operation of the plant

(4) Easy plant control

(5) High controllability

(6) Easy maintenance

(7) Economics

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2. Requirements for Plant Control System

From the viewpoint of the power system requirement, the plant control system for Units 1 & 2 shall be designed on the basis of the following conditions:

2.1 Safety of the Unit

The plant computer shall be introduced in order to improve the monitoring function. At the same time, the functions such as for plant interlocking, protection against turbine vibration, as well as the function for preventing water induction into the turbine shall be provided in order to ensure the safety of the unit.

In order to keep the power plant in island (boiler only) operation in case of occurrence of any trouble in the power system, Fast cut-back (FCB) function shall be provided.

2.2 High Reliability and Less Trouble

Highly reliable control equipment shall be adopted to attain a high reliability. For instance, highly reliable electronic control equipment shall be adopted for Automatic Boiler Control System (ABC), Auto-Burner System (ABS), Electro-hydraulic Turbine Governing Control System (EHC).

Any actuaters to be adopted shall be of an pneumatic type which has been adopted for many steam power plants because of its high resistance against high temperature, severe environmental condition and vibration, etc.

Local control system shall also be of an pneumatic type in view of its reliability and better resistance against high temperature, severe environmental condition, vibration, etc.

In order to improve reliability and minimize occurrence of trouble, a self-troubleshooting function shall be incorporated in the design of the plant control system.

2.3 Easy Operation of Plant

In order to ensure easy operation of the unit, ABC shall be furnished with an ALR (Automatic Load Regulation) function, and ABS shall have a burner management function. Moreover, EHC shall be furnished with functions for speed acceleration, load regulation, load limiting function, valve test and overspeed protecting function.

2.4 Easy Unit Control

The control terminal which should preferably be connected to the BTG board or the auxiliary board in view of the unit operation shall be centralized in the central control room. However, any simple loop control system shall be mounted on the local equipment. In this way, the control system shall be separated into central control and local control.

To eliminate miss operation of the unit, the BTG and auxiliary boards shall be arranged on the basis of optimum design in view of human engineering. Moreover, in order to realize easy operation and control at the time of turbine start-up, the operation guide shall be incorporation in the design of the plant control system.

2.5 Controllability

In order to meet the requirements for high controllability due to adoption of larger capacity unit, the electronics control equipment will be adopted for ABS, ABC and EHC, etc.

However, if the fluctuation or deviation from the set values will be estimated within a permissible range, it will, in principle, be not necessary to incorporate excessively complex compensating control circuits in the above control systems.

2.6 Easy Maintenance

Any electronics control systems shall, in principle, have a trouble-shooting function. Moreover, any maintenance tools shall be furnished for easy inspection and maintenance.

In addition, by adopting of high reliability equipment, the plant control system will realize a maintenance-free system.

Study for necessary spare cards in the cabinet under the power charging conditions also be made in manufacturing design stage.

2.7 Economy

The role of the control system is to keep the power plant in stable operation.

Should it be impossible to keep the power plant in a stable operation due to any troubles in the control system, such a system will be contradictory to the economy of an entire power plant no matter how the control system may be low in cost.

The proportion of the cost of control system to the total plant equipment cost is only several percent.

Consequently, the control system which is highly reliable and easy check and maintenance should be introduced rather than limiting the cost of the system.

Thereby, it will be possible to improve the availability factor of the power plant equipment and resultantly realize an economical power plant as a whole.

In other words, it will ultimately be the most economical to select a type of the control system which is high in reliability and less in trouble.

3. Concept of Basis Configuration of Plant Control System

Taking into account the above described requirements, the concept of basic configuration of the control system shall be as indicated in Fig. 1 and Table 1. Table 1 shows the classification and breakdown of the control equipment.

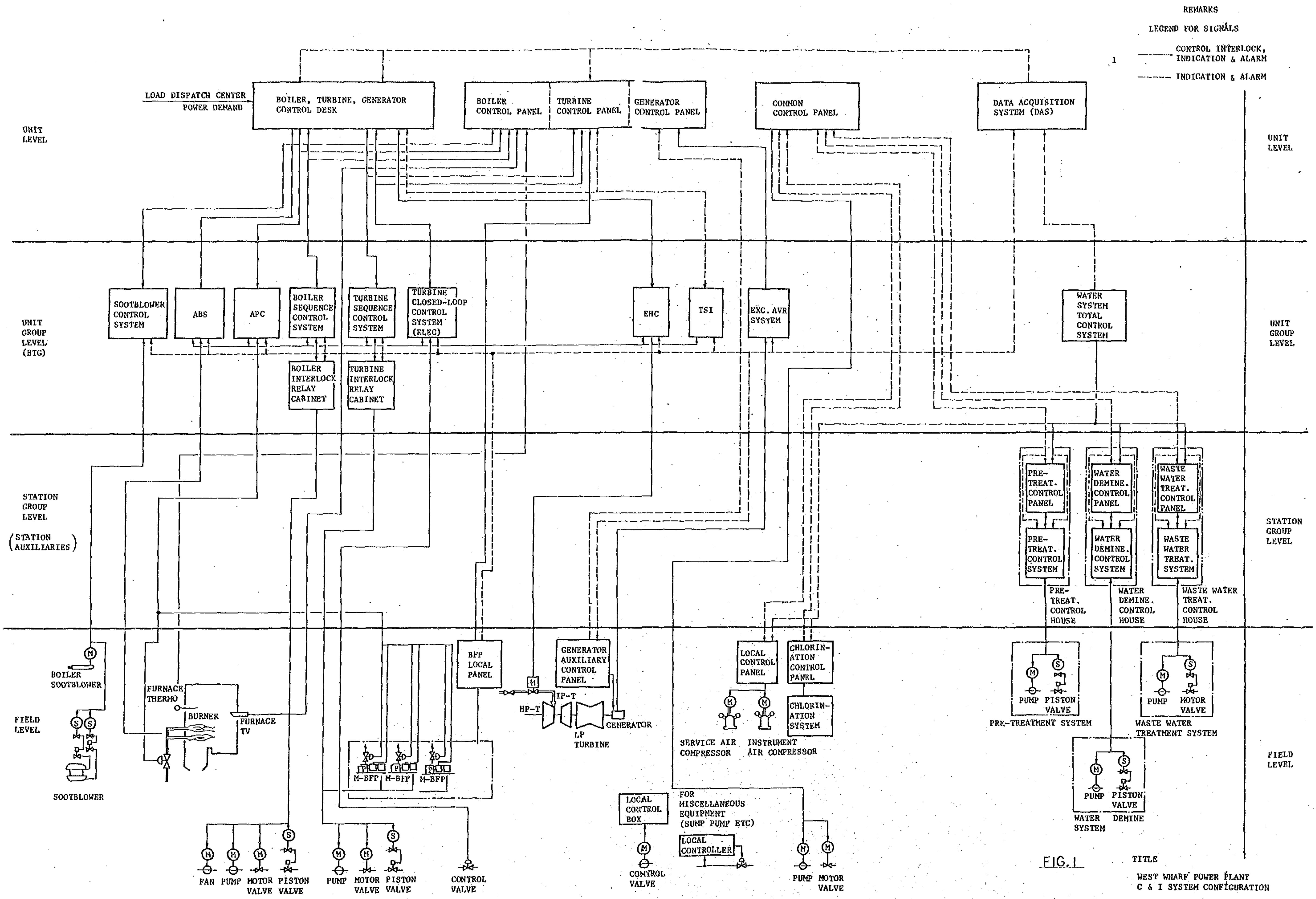

FIG. 1

TITLE

WEST WHARF POWER PLANT
C & I SYSTEM CONFIGURATION

PIC-2-6

Table 1 Classification and Breakdown of Control Equipment for Unit I

	Boiler			Turbine			Common and Aux. Equipment		
	ABS	ABS	Local	EHC	TSI	Local	Water pretreatment	Water treatment	Salt electrolyzer
Detecter/ arithmetic sections	*Electronic type	*Electronic type	Pneumatic type	*Electronic type	Electronic type	Pneumatic type	Relay logic or *electronic type	Relay logic or *electronic type	Relay logic or *electronic type
Actuator	Pneumatic type	Pneumatic type	Pneumatic type	Electrical hydraulic type	-	Pneumatic type	Pneumatic type	Pneumatic type	Pneumatic type
Location of control terminals (in central control room/ local)	Central/ Local	Central/ Local	Local	Central/ Local	Central (IND.)	Local	Local	Local	Local
Location of installation	Control equip't room	Control equip't room	Local	Control equip't room	Control equip't room	Local	Local	Local	Local
Remarks									

*The electronics type control equipment shall have a self-troubleshooting function both in arithmetic and logic circuits.

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PIC-3 TURBINE BYPASS SYSTEM

1. Review of the Necessity of Turbine Bypass System

Although it was proposed to adopt a turbine bypass system previously in Clause 4-3-5 of the Detailed Design Study (Interim Report), JICA has been considering not to adopt the turbine bypass system at this moment as a result of reviewing the role of the New West Wharf Power Plant to be incorporated into the transmission line system of KESC. This decision was based on the advantages and disadvantages of the turbine bypass system, valve trouble, cost/performance, etc.

2. Advantages and Disadvantages of the Turbine Bypass System

(1) Advantages

The following operational status can be achieved with the turbine bypass system.

(a) Boiler independent operation

The turbine bypass system enables the boiler to operate continuously after sudden load reduction from full load (100% ECR) in case of turbine trip.

(b) BTG house load operation

The turbine bypass system enables the BTG unit to operate at house load.

(Note)

During house load operation, the boiler operates at 30% load and the turbine-generator operates at about 5% load.

The remaining 25% of steam then flows through the turbine bypass system to the condenser.

(c) Shortening unit start-up time in Hot and Very Hot start-up modes.

(Note) Hot start; to start turbine within 8 hours after trip

Very Hot start; to start turbine within 2 hours after trip

(2) Disadvantages

(a) Excess equipment cost

Although the cost of the turbine bypass system varies depending on the turbine bypass capacity and initial steam conditions, the cost generally is in the range of 100 - 130 million yen (15 - 19 million Rs).

(b) Possibility of occurrence of trouble and malfunction

Because the turbine bypass system handles high pressure and high temperature steam, the following valve trouble is anticipated to occur, even though the design and the manufacturing workmanship are satisfactory.

(i) Leakage from valve sheets
(steam valves and spray water valves)

(ii) Leakage from valve glands
(steam valves and spray water valves)

(iii) Control equipment trouble

Depending upon the nature of the trouble, it may become necessary to shut down the unit for repair.

3. Comparison of Merits and Demerits

Although there are great advantages in adoption of the turbine bypass system as described above, there are limitations to these advantages.

(1) Limitation to shorten unit start-up time

The turbine bypass system can shorten the unit start-up time in the <u>Hot</u> and <u>Very Hot</u> starts-up modes.

However, the turbine bypass system is not used for cold/warm start-up modes.

The reason is that, between boiler ignition and turbine start-up, the boiler drum water temperature rise rate is limited due to thermal stress. Accordingly, use of turbine bypass system in cold warm start-up modes is not effective in reducing boiler start-up time. Furthermore, at cold and warm conditions, the main steam temperature should not be too high, as this will cause rotor thermal stress or mismatching of temperature between the first stage steam and first stage shell inner metal temperatures.

From these reasons the bypass system is not effective in cold/warm start-up modes.

(2) Limitation to house load operation (island operation) or boiler independent (boiler only) operation.

In the event of electric power system trouble, the plant can be placed in house load operation or boiler independent operation with the aid of the turbine bypass system.

In such conditions generated steam will be reduced so as to conform to the decreased rate of the power house load and/or no load operation of the boiler.

However, should any trouble arise in the house power system during boiler independent operation and/or house power load operation of the unit, the entire plant may undergo complete blackout.

(3) Time limitation to house load operation

Time limitation to house load operation depends mainly on the turbine manufacturer's design policy. However, in most cases, the allowable time duration is normally in the range of 10 to 30 minutes.

It is, therefor, recommended that the house power load operation be transferred to boiler independent operation, as the turbine exhaust hood temperature tends to rise and the last stage buckets are subjected to erosion due to the sprayed water which controls the exhaust hood temperature.

(4) House load operation

The house load operation after sudden load rejection can be achieved by applying technology so called Fast Cut Back (FCB) operation, even without the turbine bypass system, in case of oil fired power generating unit.

The FCB operation is an automatic run back of the unit load after load rejection due to power transmission line failure.

The house load operation enables the unit to pick up load quickly after the power transmission line recovery.

(5) Quick start up

One of the advantages of the turbine bypass system is a quick start up of the unit.

One comparative example of start up time for 200 MW class unit after 8-hours shut down is: approx. 110 minutes with the turbine bypass system and approx. 130 minutes without the turbine bypass system.

3. Conclusion

The advantages and disadvantages in adopting the turbine bypass system are as summarized previously.

In the event of electric power system trouble, the unit could be placed in house power load operation with or without the aid of the turbine bypass system, in case of an oil fired power plant.

A unit incorporating a turbine bypass system can be started up faster than one without a turbine bypass system. However, the difference between the two systems is not so large and the elimination of the system can be justified when considering system complexity, maintenance difficulties, cost saving, etc.

PIC-4 APPLICATION OF COMPUTER SYSTEM

1. When the capacity of a steam power plant becomes larger and the operating steam pressure and temperature conditions become higher, number of monitoring items increase simultaneously and higher level of plant operation and control system will be required.

   In order to attain safety and highly efficient operation of such a plant, a computer system is generally introduced as a monitoring system to prevent the human error and assist the operation at the time of start-up, shutdown and during normal operation of the unit.

2. As a computer system for monitoring of the West Wharf Thermal Power Plant Units 1 & 2, JICA recommends the following functions and systems concerning instrumentation and control.

2.1 Function

(1) Data collection and transaction

(2) Management of plant performance

   a. Function of calculations

   b. Preparation of daily and monthly reports

(3) Monitoring

   a. Monitoring and alarming

   b. Recording of trouble

(4) Man-machine communication

   a. Logging

   b. Printing

c. CRT display

d. Trend recording

e. Plant graphic display

f. Hard copy

(5) Operation guides

a. Plant startup schedule calculation

b. Turbine startup sequence monitor

2.2 Level of Monitoring

(1) Classification according to function

a. Monitoring function

Routine monitoring

Special monitoring

Trouble analysis

b. Operation guide

Plant start-up schedule calculation

TSM (Turbine start-up sequence monitor)

(2) Classification according to communication means

a. Logging alarm & operators typewriter

Data logging

Alarm recording

Trouble recording

Event recording

Trip sequence recording

Operation recording

b. CRT display (Colour)

Status indication

Alarm indication

TSM message

Graphic indication

c. Trend recording

d. Hard copy (Colour)

(3) Classification according to scope of monitoring

a. Equipment

Plant main equipment

Unit auxiliary equipment

b. Operation mode

Unit startup and shutdown

Unit normal operation

3. Summary Functions of Computer

3.1 Data Logging

This data logging function makes the data required for plant operation management, automatically or at operators request, by using typewriter.

(1) Group data logging

(2) Daily and monthly logging (periodic)

(3) Demand logging

3.2 Status and Alarm Printing

For this purpose alarm function is provided, and this function

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perform the alarming the error after checking the sequential detection, fluctuation of analogue input value, limitation value of process variables, etc. The alarm indication is displayed in the alarm CRT and alarm indicator window equipped on the control board and alarm typewriting sheet.

3.3 Plant Performance Calculation

This function performs the calculation, at regular intervals, of plant efficiency and major equipment performances required for plant performance management, and displays the result in log sheet or CRT.

(1) Boiler efficiency

(2) Turbine efficiency

(3) Plant efficiency at Generator end/Sending-out

(4) Condenser performance

(5) Terminal difference temperature of Feedwater Heater

(6) Auxiliary power

3.4 CRT Display

This equipment displays the various messages from computer system by using letters or graphic indication.

(1) Status and alarm indicator

(2) Graphic display

(3) Communication with operator

3.5 Trend Recording

This function displays, in accordance with the request of operator, the process analog output calculated by the computer in the continuous pen recorder.

Two sets of pen recorders can indicate the various measuring process items by requests of operator from operator's console.

3.6 Event Recall

This function continuously memories, at the interval of several seconds, the previously selected analog input items during several minutes before and after the time of accident occurs, signaling or by operator's request, printing out their data in the alarm typewriting sheets.

3.7 Trip Sequence Recording

This function finds the predetermined causes of accident by detecting the change of Contractors at the time of accident occurs, and indicates, at the interval of milli seconds, the process fluctuations and their times at or after the accident in the alarm typewriting sheets by detecting the order of actuation of the contactors caused by the accident.

In order to detect the trip sequence, the contact points actuated by MFT, MTS, or 86G relays will be printed out.

3.8 TSM (Turbine Start-up Sequence Monitor)

This function performs monitoring and instructs operation guide within a period from preparation of turbine start-up to changeover of the turbine valve.

A turbine start-up schedule is calculated based on the current plant status to derive the most suitable subsequent start-up procedures to reduce terminal stress of the turbine.

3.9 Typewriters

(1) Engineer's typewriter; which is used for the program debug, that is to correct the errors in computer programs.

(2) Logging typewriter; which is exclusively used for tabling of various data, printing out of any alarm and necessary data for operators.

3.10 Hard Copy

This function duplicates the images (letters or figures) displayed in the CRT to the printing sheets equipped to the hard copy machine by the command from operator console.

3.11 Operator Console

This equipment can request the computer function, exchange the previously memoried data and select the various functions of computer, operational points, calculation values, etc.

3.12 Floppy Disk

This device has the function which takes the place of conventional PTP (paper tape puncher) and PTR (paper tape reader), and is used for computer engineer to load, dump and compile the programs and to hold the program data.

3.13 Scope of System

(1) One (1) set of computer

a. Duplex central processing unit (CPU)

b. Duplex bulk memory unit

c. System modules

d. Peripheral devices

e. Accessories

(2) One (1) set of system peripheral devices

a. Operator's console

b. Trend recorder

c. Digital display (color CRT)

d. Printer (typewriter)

e. Printer (I/O typewriter)

f. Floppy disk

g. Hard copy

h. Operator desk & chairs

i. Printer desk

j. Engineer desk & chains

(3) One (1) set software

3.14 Sensor

To make effective use of the computer system, sufficient functions are required. Therefor, sufficient input data concerning boiler, turbine, generator and auxiliary equipment are required. For input/output data collection, following types of sensor units will be used.

Analog input unit	
Thermocouple	One (1) set
RTD (unit)	One (1) set
mA (unit)	One (1) set
Digital input unit	One (1) set
Pulse input unit	One (1) set
Analog output unit	One (1) set
Digital output unit	One (1) set

4. Specifications for Computer System

(1) Central Processing Unit (CPU)

Logic circuit element	LSI, MSI, SSI, etc.
Arithmetic operation	Binary paralle, fixed point, floating point
Register	16 general registers (Min) more over

(2) Main Memory Unit

Capacity	2 MB
Memory element	IC 32 bit
Error check	included
Cycle time	0.5 sec/2 Bytes

(3) Fixed Head Disk or IC Bulk

Capacity	40 MB

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Access time	Average 10 msec.
Memory protection	included

(4) CRT

Number of characters	4,000
Kind of character	512 kinds
Kind of colours	7
Display tube size	20 inch diagonal

(5) Floppy Disk

Storage capacity	256 KB
Number of connectable Devices	2 devices/Controller

(6) Trend Recorder

Number of pens	4 Pens
Input signal	4 - 20 mA

(7) Hard Copy

Copy size	215.9 x 279.4 mm (A4 size)
Copy speed	18 sec.

(8) Operator's Console

Type	Key Board Function Selective

(9) Logging Printer

Printing speed	240 cps
Line length	136 characters/line

(10) Engineer's Printer

Printing speed	240 cps

Line length	136 characters/line

(11) Process I/O Device

Analog input	
thermocouple	1 set
RTD	1 set
mA	1 set
Digital input	1 set
Pulse input	1 set
Analog output	1 set
Digital output	1 set

(12) Printer Desk

Size	(W) (D) (H) 800 mm x 700 mm x 700 mm With sound proof cover (tentative size)

(13) Operator Desk

Size	(W) (D) (H) 2,100 mm x 900 mm x 750 mm (tentative size)

(14) Engineer Desk

Size	(W) (D) (H) 1,250 mm x 1,000 mm x 750 mm (tentative size)

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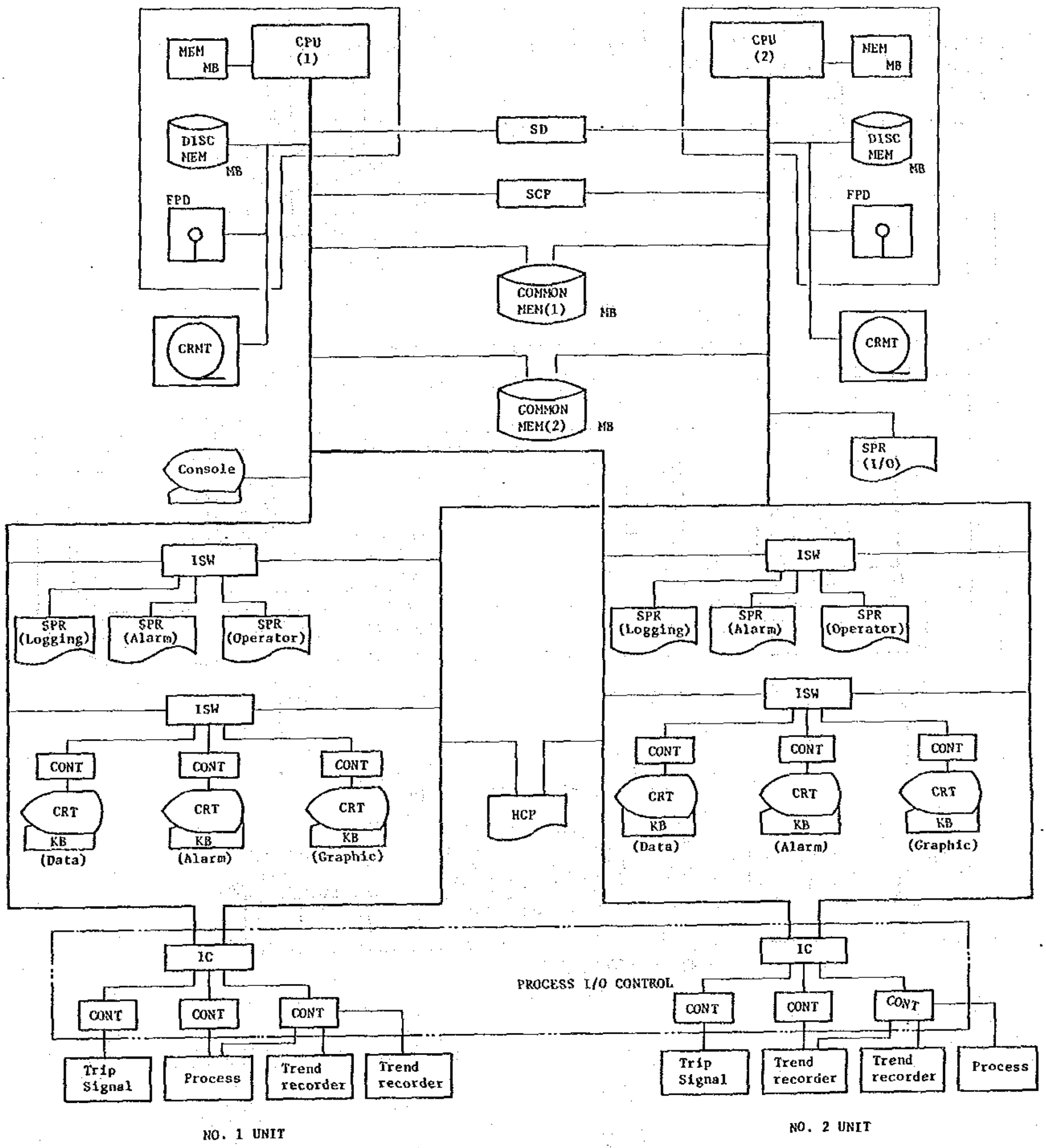
System configuration for computer system



CPU: Central Processing Unit
MEM: Memory
FPD: Floppy Diskdrive Unit
SCP: System Control Panel
SP : System Panel
CONT: Controller
CRMT: Cartridge Magnetic Tape Unit

ISW: Interface Switching Unit
SPR: Serial Printer Unit
CRT: Cathode Ray Tube Unit
KB : Key Board
IC : Interface Controller
HCP: Hard Copy Unit

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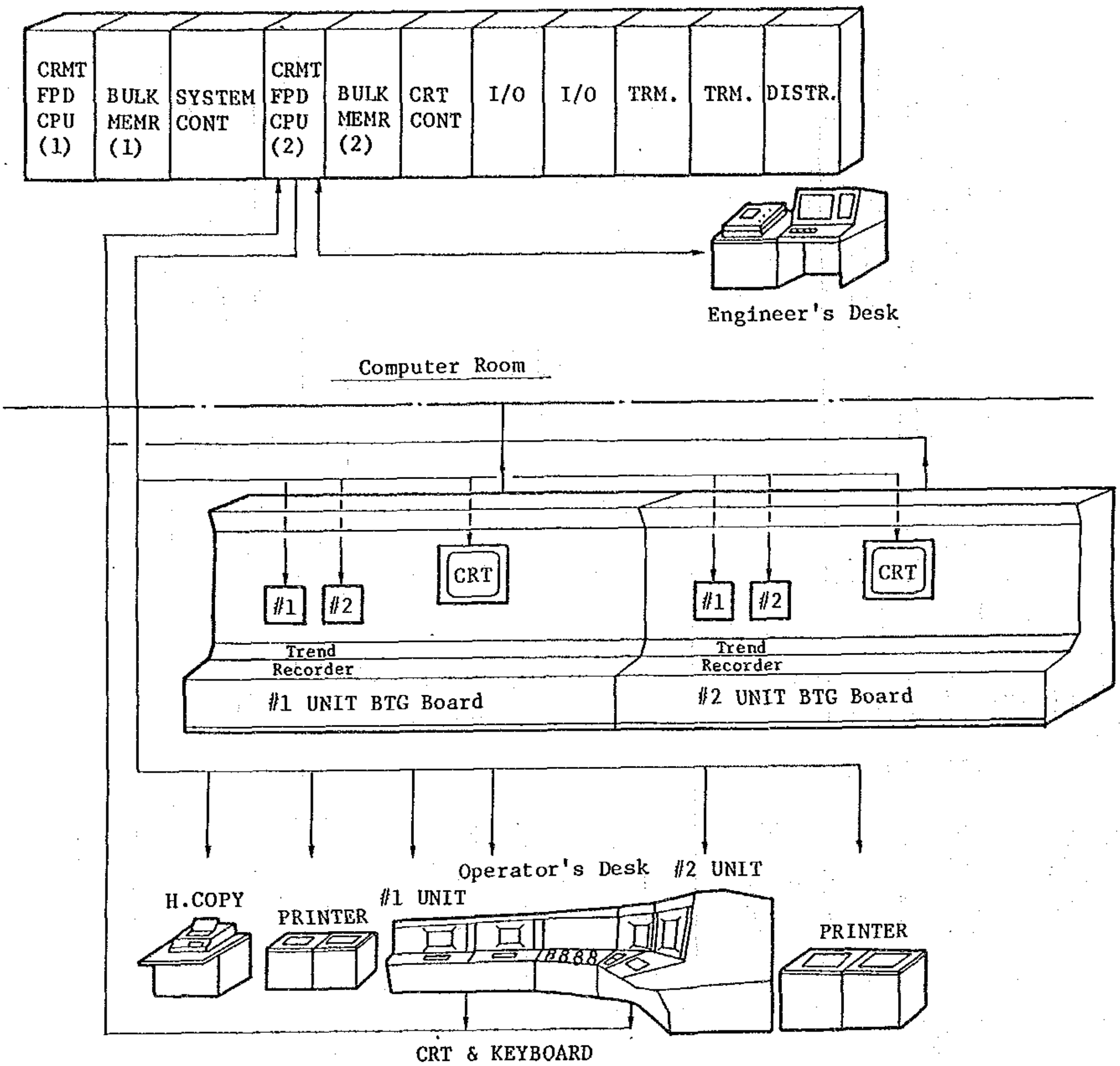
System Configuration

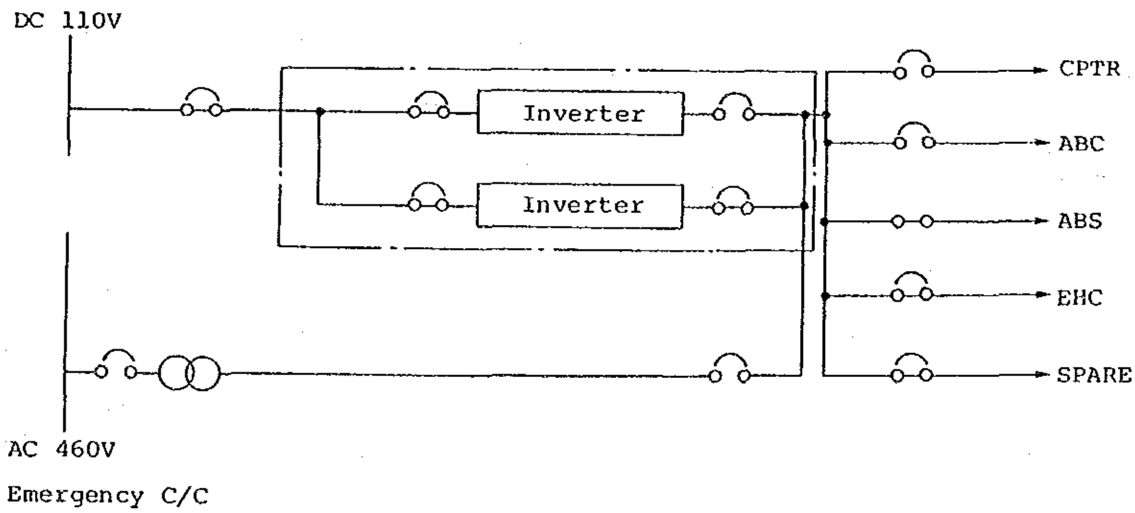


No. 1 & 2 UNIT CENTRAL CONTROL ROOM

6. Power Source Equipment

In introducing the computer system, the CVCF (Constant Voltage and Constant Frequency) equipment is required to ensure power source which is high in quality and reliability.

CVCV CONFIGURATION



7. In order to decide the computer for the West Wharf Thermal Power Plant Units 1 & 2, JICA has adopted the functions based upon the computers used in 350 MW and 600 MW units in Tokyo Electric Power Co. (TEPCO) thermal power plants which are using graphic display for the purpose of communication with operator.

PIC-5 BOILER CNTROL SYSTEM

1.

As for boiler control system, there are two (2) types, namely, one is a conventional pneumatic type and the other is an electronic type. The pneumatic type is reliable and has been adopted widely in many plants.

However, as thermal power plants become larger in size and capacity, steam conditions have increasingly become higher in temperature and pressure, thereby it has resulted in seven conditions for boiler control system.

For these reason, electronic type has been introduced and initially analog control system mainly composed of wired logic have been adopted.
Furthermore, due to automatization caused by wide adoption of micro-processors, the introduction of computer system together with the diversification of plant operation mode, the micro-processor type control system has been adopted for almost all of the recent power plants.

Because, this system has many advantages, such as easy coordination with computer and turbine control system (EHC), and having wide flexibility in design and modification of the system.

Therefore, JICA recommends to adopt the micro-processor type boiler control system for the West Wharf P.P. Units 1 & 2.

2. Function of Boiler Control System

The function of the automatic boiler control for the West Wharf P.P. Units 1 & 2 consists of the followings.

(1) Plant master control

(2) Combustion control

(3) Feed water control

(4) Steam temperature control

(5) Troubleshooting function

2.1 Plant Master Control

This function has plant coordinated control function, and sends a load demand signal to boiler control and turbine control systems.

2.2 Combustion Control

This function regulates the fuel flow and air flow by controlling signal from plant master control system.

2.3 Feed Water Control

This function regulates the drum water level by one (drum level drum feed only) or three (3) elements (drum level, feed water flow, steam flow) control methods.

2.4 Steam Temperature Control

This function regulates the main steam and reheat steam temperature by controlling water spray or other factors.

2.5 Troubleshooting Function

This function checks any points of troubles in the control system cabinet with self-diagnostic function.

PIC-6 BURNER CONTROL SYSTEM

1. Introduction

As for the possible burner control system, there are three types: a relay wired logic type, solid state type and a updated micro processor of electronic type, the solid state type is has been adopted in many cases recently.

However, TEPSCO recommends to adopt a micro processor of electronic type automatic burner control system (ABS) for the burner control system for the West Wharf P.P. thermal power plant Units 1 & 2 since it enables easy interfaces with other control systems.

In addition to the above ABS, JICA also recommends to adopt a fast cut back (FCB) system for the burner control of the West Wharf Thermal P.P. Units 1 & 2. In case the burner system is an automatic burner system, the logic system will become complex. If the conventional relay wired logic system is adopted, a great number of parts will become necessary, resulting in complex back wiring system. Solid state type control is one of the solution for the better control system, various problems mentioned above can be solved, and also the function and maintenance of the system can be improved.

Moreover, if the micro processor type is adopted for the control system, this system permits improvement and modification of the system by changing the program only without requiring any change of wiring.

When these three systems are compared in view of reliability, the system configurations of the relay wired logic and solid state type systems are more complex than micro processor type control system and their reliabilities are reduced.

In view of maintenance, the micro processor type control system has a self-diagnostic function using the indicator lamp for trouble occuring modules thereby permitting easy maintenance. In the case of the micro processor system, however, operators must be trained for proper procedures of handling instrument tools.

Speaking in an economic viewpoint, the micro processor type control system is nearly the same or less expensive in cost with the solid state type system, and the former system is going to play a major role as a power plant control system in Japan.

Moreover, the micro processor type control system is desirable for matching the technical level along with introduction of a plant computer system.

2. Function of Auto-Burner System

The function of burner control system for the West Wharf P.P Units 1 & 2 consists of the following:

(1) Boiler safety interlock

(2) Burner management function

(3) Each burner control function

(4) Troubleshooting function

2.1 Boiler Safety Interlock

o There are two kinds of interlocks, one is the Master Fuel Trip (MFT), and the other one is Furnace purge interlock. MFT must be operated when combustion status change to unstable conditions.

o Furnace purge interlock prevents a dangerous conditions at the time of the first ignition of the burner.

o The control logic unit will be adopted in accordance with NEPA, or equivalent regulation.

2.2 Burner Management Function

o There are three (3) kinds of function, the first is the Fast Cut Back (FCB), the second is the control for burner numbers, last one is the draft control between the furnace and the wind box. In a case any one unit of plant is put to sudden load rejection due to trouble in the power system, then, FCB operates, burners are forcedly cut back to regulate the flow rate of fuel into a

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minimum level by rapidly decreasing the fuel supply.

- o The burners shall be adopted with warm-up burners (firing natural gas) and main oil (furnace oil) burners.

- o The burners shall be ignited or extinguished automatically according to the load of boiler by the control for the burner numbers, but it could also be controlled manually, preferentially at anytime.

- o Draft control shall be provided to control air register damper at the time of igniting or distinguishing the burner firing.

2.3 Each Burner Control Function

- o There are two kinds of function, one is burner flame detecting, the other is burner ignition or extinguish and purge control.

- o All burners shall be operated automatically or manually through operation on the central control consol and local panel.

2.4 Flame Detecting

- o The flame detectors shall be adopted for automatic burner control system.

  Therefore, all burners shall be adopted with burner flame detector, and shall be so designed that the burner flame can be inspected.

- o All burners and ignitors shall be designed to have flame detectors of ultra-violet and accessories.

2.5 Troubleshooting Function

- This function checks the point of trouble in the control system cabinet.

- The self-trouble diagnosis unit will be designed with indicator lamps or some other appropriate means for the respective operating module during operation.

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PIC-7 TURBINE GOVERNING SYSTEM

1. Introduction

The following two (2) types of governor controls are usually adopted for the turbine control in the power plant, namely, one is a conventional mechanical-hydraulic governor control (MHC) system and the other is an electro-hydraulic governor control (EHC) system. And the latter (EHC system) is further classified into a high-pressure (HP-EHC) type and low-pressure (LP-EHC) type.

Recently, the governor control system has been in many cases required to control and operate in harmony with the operations of boiler control system with the aid of computor control system on such backgrounds as improvement of controlability, required for large capacity plant, automatization due to the introduction of computer system, diversification in plant operation mode, etc.

Therefore, EHC system which based on micro-processor has been adopted for almost all of recent power plants, because of suitability to these backgrounds.

TEPSCO recommends to adopt the EHC system, especially LP-EHC, for the turbine governing system in the West Wharf P.P. Units 1 & 2 based on the following examinations.

2. Features of EHC System

The EHC system has basically the same functions as the MHC system, such as the speed sensing unit, control valve position unit and arithmetic unit which are converted to electronic units based on the

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mechanical system practice.

2.1 LP-EHC

The LP-EHC system is applied for the automatic operation a medium capacity turbine.

In this system, the same lubricating oil and control oils as that for MHC control system can be used commonly for the control oil of the system, and the normal pressure for turbine control lubricating oil system can be used for the EHC system. Therefore, control oil system can be controlled in the same way as that for the MHC system and its maintenance is easy.

Moreover, the EHC system has roughly the same control response as that of the MHC system and excells in the range and precision of governing in comparing with MHC system.

2.2 HP-EHC

To enhance response of turbine governing, the control oil pressure for the HP EHC system is higher. This system is mainly intended to prevent overspeed of turbine and has been applied for the turbines for large scale steam power plants and nuclear power plants.

The control oil pressure is more than 100 kg/cm^2 and control oil and lubricating oil are supplied from entirely different systems. Therefore, since special oil is used for control oil, special attention must be exercised for maintenance of the control oil system.

2.3 Reason for Selecting LP-EHC

As the LP-EHC is easy in maintenance and inspection of the system, the LP-EHC is an optimum governing system for the turbine for West Wharf P.P. Units 1 & 2.

3. Function of LP EHC System

The function of the LP EHC for the West Wharf P.P. Units 1 & 2 consists of the following:

CONTROL DESCRIPTION

Refer to the EHC CONTROL BLOCK DIAGRAM attached

EHC Control Functions

Control Function	Description
Speedup control	Speedup, seeddown, and speed hold are automatically controlled over a wide range from turning speed to overspeed. Speed is raised or lowered to the target speed set at the control panel. The integrator that increases the output to the target level at the specified rate provides a speedup rate, and when the turbine speed reaches the target level as commanded by it, the valve opening is regulated.
Governor control	In load setter operation, the difference between the rated speed and actual turbine speed is added to the load set value, and governor-free operation is performed. The CVs begin to close when the speed exceeds the rated value, and close to the no-load position when the speed reaches 105% of the rated speed. The IVs being to close when the speed reaches 105% of the rated speed, and completely close when it reaches 107%. (Under 100% load)

Control Function	Description
Line speed matching control	The line frequency and generator frequency are input by PT, and the load setter is controlled upward or downward so that the generator frequency follows the line frequency 0.02 to 0.1 Hz higher than the latter.
Load setting	The load setter goes up or down according to manual increase/decrease PB operation at the control panel, and outputs a load request signal.
Governor auto following (GOV. Automatic Following Regulator, FLR)	If the load control mode is set to GOV. FLR during load control after Generator Circuit Breaker is closed, the load setter automatically follows the CV flow command at a load level 10% (preliminary) higher, and allows rapid valve closure by the governor function in case of load shut-down.
Load limit setting	Apart from load control by the load setter, turbine load limits can be set by the increase/decrease PBs on the control panel. While speed-regulated operation by the speed control system is possible during load control by the load setter, there is no speed regulation effect during load control by the load limiter.
Load limit auto following (L.L. FLR)	The set load limit automatically follows a level that has a sufficient margin from the CV opening command during load control by the load setter. This prevents a sudden change of the CV opening command in the open direction.
Load change rate limit	If the CV opening command input increases at a very fast rate of change during L.L. FLR, the rate limit circuit limits the rate of change of FLR, thus preventing turbine rotor thermal fatigue. The rate of change is not limited if the CV opening command changes in the close direction.

Control Function	Description
Load control	Flow command signals to regulate the flow rates for the steam control valve (CVs) and intercept valves (IVs) are generated from the set signal from the load setter or load limiter, the speed error signal from the speed control system, and the pressure control signal from the pressure control system. Each of these signals is output on a low value priority basis.
Initial steam	This function controls the steam control valves (CVs) in the close direction to prevent wet steam from entering the turbine when the inlet steam pressure (before MSV) falls below the set pressure. If the inlet steam pressure falls 10% of the rated pressure from the set pressure, the CVs begin to close from the 100% position. If it falls 20% of the rated pressure, the CVs close to the no-load opening.
CV-MSV transfer (FA/PA transfer)	Full arc admission (FA) is operated by controlling MSVs and fully opening CVs to minimize the turbine thermal stress at turbine start-up. As the generator load reaches an appointed value, the admission changeover control that transfers the partial arc admission (PA) from FA to get higher thermal efficiency.
CV warming	The bypass valve for the main stop valve (MSV) is fully opened from the fully close position to preheat the steam control valves (CVs) before startup, and thus prevent sudden surge of thermal stress at startup.
Power load unbalance	CVs and IVs are closed to prevent rapid acceleration and resultant overspeed of the turbine generators after load shutdown. Generator current is input as load, and reheat steam pressure is input as turbine output power. If the generator current rapidly decreases at a rate of 40% or more in less than 10 ms and if the imbalance between power and loads is 40% or more, the power load unbalance function operates.

Control Function	Description
IV flow control	A signal resulting from multiplying a load request command value by the ratio of the steam control valve regulating rate to the intercept valve regulating rate is used as an IV flow command. This IV command signal starts the intercept valves (IVs) to close when the speed rises to 105% and the steam control valves (CVs) reach the no-load position, and fully closes the IVs when the speed reaches 107%. (Under 100% load)
Turbine protection	This function detects turbine trouble, and brings the turbine to a safe stop. If a turbine or EHC fails, the master trip solenoid (MTS) for the turbine to be tripped is energized to drop the emergency oil pressure, and fully close the MSV and RSV and also CVs and IVs.
Protection tests	There are two safety tests: Oil trip test and backup overspeed test. In the oil trip test, the mechanical lockout valve is actuated to energize the oil trip solenoid, and operation of the mechanical trip valve is confirmed. In the backup overspeed test, the detector circuit is checked for normal operation by lowering the overspeed detection setting. An interlock is provided to prevent simultaneous execution of the oil trip test and backup overspeed test. These tests check the circuit functions only, and do not actually cause a trip.
Valve tests	In LP-BV, MSV, and CV tests, a valve close signal is applied to valves that are open to a certain angle, independent of the normal control signals, to check that the valves can close and open normally.
FCB control	As soon as FCB demand is input, the load set or load limit set is decreased to the house load in an instant, then the load set is controlled to keep the generator output frequency 50 Hz.

Control Function	Description
Overspeed test	This function checks emergency governor operation and operating point by raising the turbine speed setting and increasing the actual turbine speed. Turbine speed increases only as long as the overspeed test PB on the control panel is depressed. This test is can be made only before generator circuit breaker is open.
Automatic load regulating (Automatic Load Regulator, ALR)	The load set or load limit set is raised or lowered to the target load set at control panel. The integrator that increase or decrease the output to the target level at the specified rate provides a load up or a load down rate.
GOV. L.L. auto change	The load control is automatically changed from the governor to L.L. or vice versa. In this case, the FLR bias is reduced to 0, the governor and L.L. outputs are equalized, the load control is switched, and the FLR bias is set to the specified level, and thus effect a change from GOV to L.L. or vice versa.
LP turbine-bypass control	The turbine-bypass valve is regulated to control the hot reheat pressure mainly at turbine startup. The set value of the pressure is function of the first stage pressure.

Trouble Checking Function

This function checks the point of trouble in the control systems.

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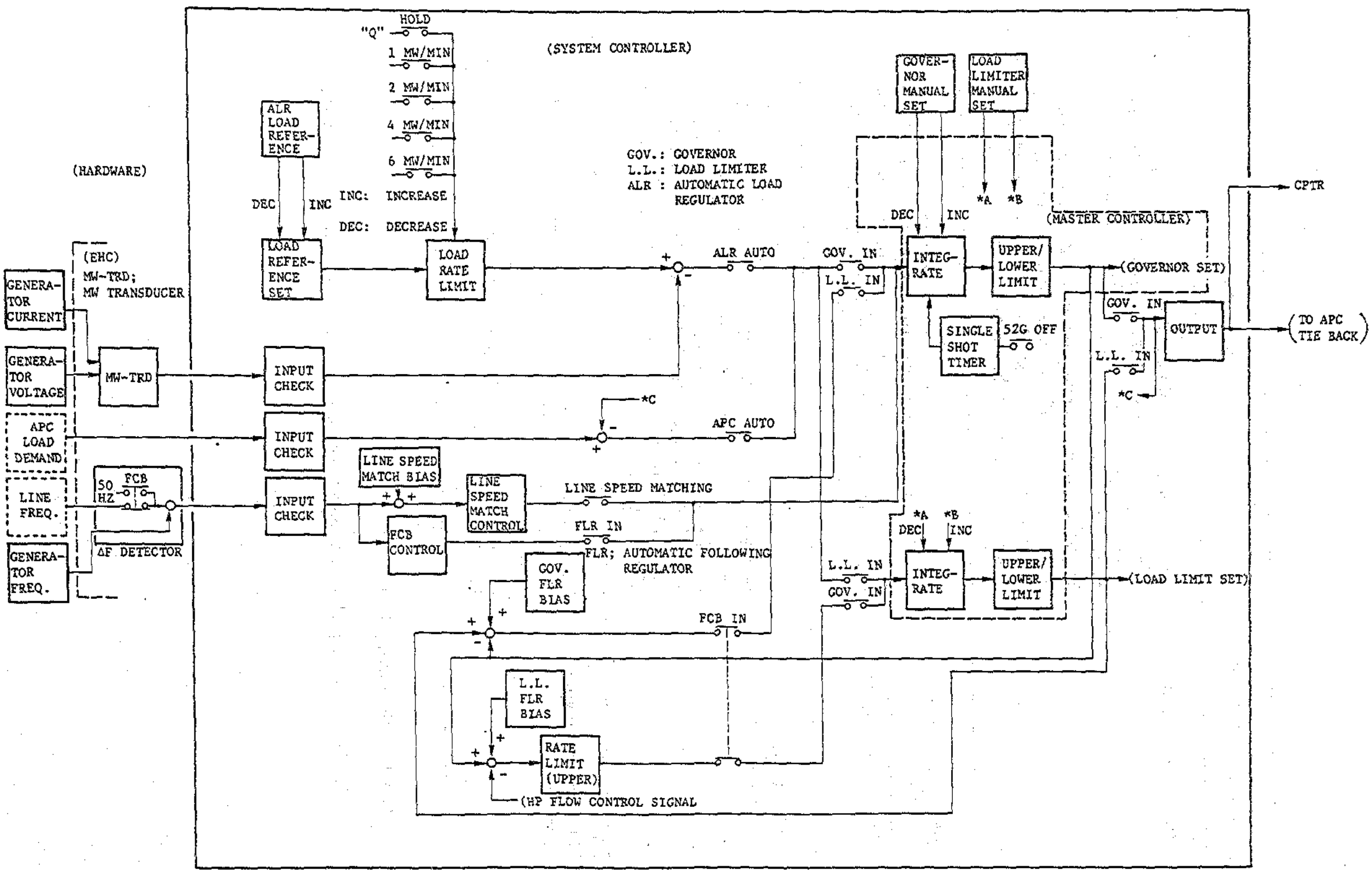
EHC CONTROL BLOCK DIAGRAM



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