UDC 625.4

COMPUTER SYSTEM FOR KOBE NEW TRANSIT SYSTEM

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I. INTRODUCTION

Today's metropolitan transit systems are faced with the problems of danger, inefficiency, and poor management and great things are expected of new technologies and systems in solving these problems.

The Kobe new transit system that connects the new Kobe Port Island and downtown Kobe (Japanese National Railways Sannomiya Station) as an organization of public transport is a new transit system aimed at meeting these expections and occupies a position as a so-called transit system of middle capacity.

The most important condition demanded of a transit system is high reliability (safety). Since demand of a transit system of middle capacity is different between the morning and evening rush hours and other times of the day, exhaustive labor saving, as well as high reliability, is desired from the economical viewpoint.

For exhaustive labor saving of conventional complex transit systems operated by man, advanced computer technology must be incorporated into each subsystem comprising the system. Beside extensive labor saving, one important means of solving the problems mentioned above is by improving reliability, improving transport efficiency, increasing the operating accuracy, securing safety through quicker troubleshooting, and improving service by building a total system by organically linking these subsystems.

From this standpoint, the Kobe new transit system was made a total management system consisting of six subsystems (1) traffic regulating, (2) electric power management, (3) vehicle base control, (4) accident check, (5) station control, and (6) data control, centered about computer technology. Fuji Electric Co., Ltd. has been conducting research on a new transit system since 1971 to meet the new trends in the world. The Kobe new transit is centered about subsystems (1) - (3) above and was designed and manufactured in cooperation with Kawasaki Heavy Industries, Ltd. around a total management system developed by Kawasaki Heavy Industries, Ltd. The authors wish to take this opportunity to introduce the computer system of the traffic regulating, electric power management, and vehicle base control subsystems (called the KNT computer system hereafter).

Fig. 1 General view of vehicles KNT series 8000

II. OUTLINE OF NEW TRANSIT SYSTEM AND COMPUTER SYSTEM DESIGN CONCEPTS

1. Outline

The specifications of the Kobe new transit system are:

Length of line	: Single-track 3.5 km Double-track 2.9 km
Number of stations	: Single-track section 5, double-track section 4
Number of trains	: 6 vehicles (fixed), 11 trains
Rated passenger capacity	: 75 persons (per vehicle)
Design transportation capacity	: Approx. 10,000 persons (per hour)
Shortest headway	: Approx. 2 mins 30 secs
Type of headway	: U-shaped, closed floor, with both sides guide rails of steel structure
Minimum radius of curvature	: 30 m
Steepest grade	: Main line 50‰
Switch	: Vertical divert type
Vehicle	: Electric vehicle with rubber tires

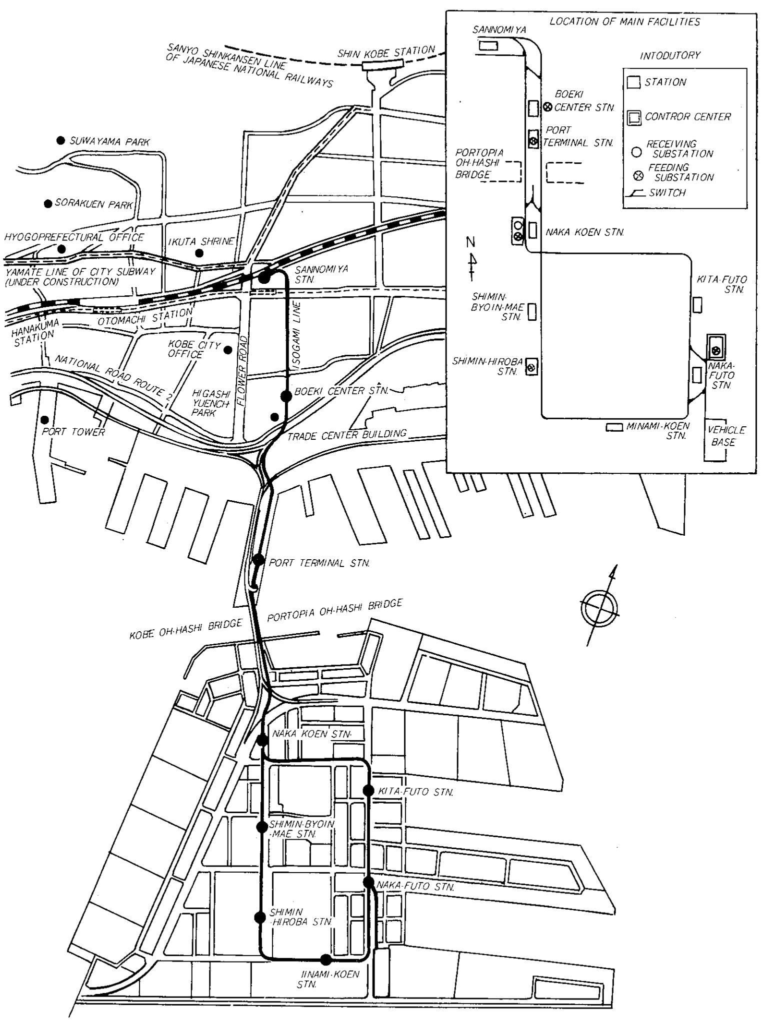

Fig. 2 2 Outline of Kobe Port Island Line

Maximum operating speed	: 60 km/h
Substation capacity	: 20 kV, 9,000 kVA x 2
Power rail	: 3ϕ AC 600 V, rigid-body, double line
Signal security equipment	: Fixed block ATC equipment and class 1 electric relay interlocking
Operation control system	: Centralized control by computer.
Automatic operation system	: ATO logic based on command from control center
Data communication system	: Polling with inductive loops
Communication equipment	: Business telephones, command telephones, train radio, wayside telephones, emergency alarm, interphone, CCTV, automatic public address device
Station equipment	: Platform door, automatic ticket vending, examination, and collection
Vehicle base	: Centralized control with computer, automatic vehicle marshalling

2. KNT Computer System Basic Design Concept

Because railways, the most classic of public transport organizations, are public and are entrusted with human life, "accident-free - high reliability" is a consistent problem. Therefore, new technology of each age is verified over a long time, then practicalized. In this sense, securing reliability was given priority and economy, another thesis of a transit system of middle capacity, was taken into account in the basic design of the KNT computer system.

That is, for example,

1) From the standpoint of reliability

(1) A computer system that performs overall management and control based on CTC (Centralized Traffic Control) with fixed block indicating our ample achievements with existing railways was employed.

(2) Furthermore, in the case of the traffic regulating system by the adoption of a computer dynamic duplex standby system (mentioned at item III-3), automatic switching within an extremely short time was realized and system reliability was increased.

(3) Moreover, the vehicle base control system was provided

with an exclusive computer system and the exchange of the necessary data with the traffic regulating system computer is performed through a communication line to improve reliability by simplifying the system.

(4) From the standpoint of software, except for the software developed especially for the new transit system, packages and subroutines with an ample usage record were used for the semi-basic common parts and the quality of the software was increased by providing abundant tools and utilities for maintenance.

(5) Even for the programs that had to be newly developed, the system was built after ample verification and testing and was organized to proceed with work under detailed development management based on SPS (Software Production Standard).

2) From the standpoint of economy

(1) The maximum cost-performance was realized on current technology having an abundant record of achievements by using the configuration of item (1) of 1) above.

(2) To secure more stable electric power and increase the labor saving at the electric power management system, the conventional remote monitoring and control device and computer were organically linked. Moreover, in this case, the CASC (Computer Aided Supervising Control) system was adopted to simplify the system. This permitted elimination of a special electric power management computer and realized sharing of the computer with the traffic regulating system mentioned above.

III. OUTLINE OF KNT COMPUTER SYSTEM

1. System Configuration and Features

The KNT computer system in linked to the data control system that performs data collection and basic operation planning by magnetic tape. Moreover, the traffic regulating system and the vehicle base control system are linked by a communication line. (See *Fig. 3*.)

These are connected as follows:

(1) Since the traffic regulating system and electric power management system share the same computer system, communication between the two systems is possible without special hardware.

(2) The data that performs automatic entrance and appearance control is transmitted between the traffic regulating system and the vehicle base control system over a communication line.

(3) On magnetic tape each system collects the daily operating results and sends it to the data control system.

(4) The traffic regulating system receives the diagram data and the vehicle base control system receives the train maintenance plan from the data control system by magnetic tape.

(5) In the case of the main line, for example, the traffic regulating, the vehicle base control computer systems and the train are linked by six ATO loops. That is, the automatic operation system performs on board processing ATO (Automatic Train Operation) by ATC

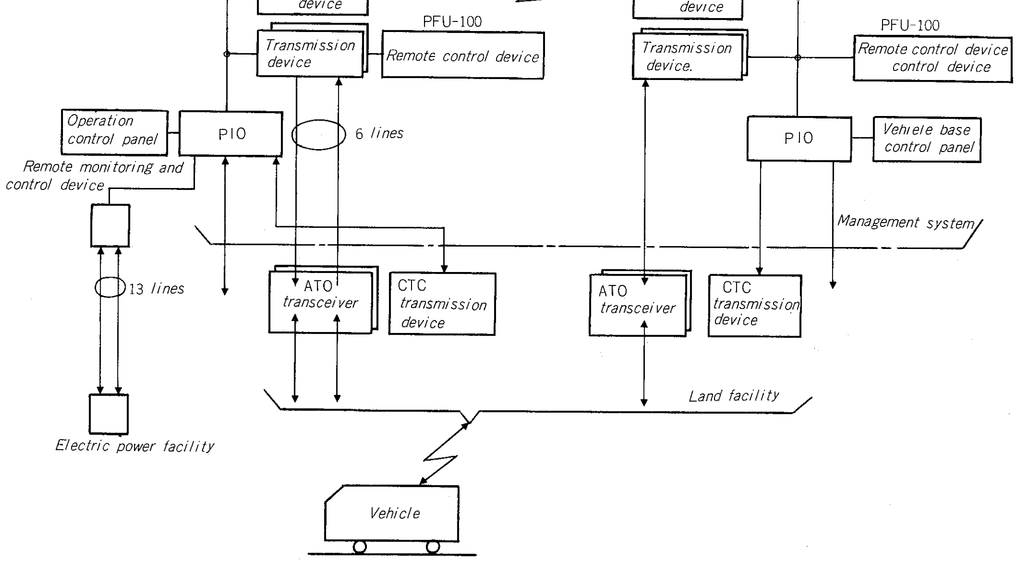

Fig. 3 General system configuration

(Automatic Train Control) backup.

(6) The roadway and guide indication, and other land facilities are connected by CTC (Centralized Traffic Control) through PIO.

(7) The electric power management system connects a total of 13 electric rooms and substations by means of remote monitoring and control devices.

The KNT computer system is extremely important for train operation, is mostly automatic and incorporates management by grouping, remote control, supervision and correcting function, etc. for rapid and accurate processing. Furthermore, unmanned operation is pointed to and a highly reliable computer system is, therefore, indispensable.

The traffic regulating system has a so-called, dynamic duplex standby construction and is configured so trouble at one computer has no affect on the system. On the other hand, high reliability has been also secured at the input/output devices by duplexing of PIO, duplexing of files, sharing of storage, typewriter and CRT display alternative measures, etc.

Even if the computer system functions stop completely, it can be backed up by the PFU-100 computer as the remote monitoring and control device. The vehicle base control system can be processed similarly.

2. Basic Software

The KNT computer system basic software is centered about the PFU-400 computer operating system UMOS-DRPS2 used by Fuji Electric Co., Ltd. from the past and used the POPS (Process Oriented Program System) having an abundant record of achievements.

The traffic regulating system has dynamic duplex standby specifications from the standpoint of transportation safety. The duplex system processing package plays an important role in guaranteeing the maintenance of high traffic regulating system reliability.

From the standpoint of application, the demand for reliability in a duplex system is a demand for continuation pertaining to operation and response and to data. Furthermore, the permissibility for continuity depends on the severeness of the status changes of the objective plants. For severe parts, a dual processing method is employed. At this time, program and data synchronization becomes a problem. In a synchronization method, there is a level viewed from density. Generally, however, if the level is high, the trend is toward a worsening of the responsiveness of processing of the application program. Deciding a suitable synchronization level is extremely important in the design stage.

Classifying the synchronization methods from the highest density:

1) Synchronization of instruction level (*Fig. 5* (a))

System A and system B both perform synchronization by instruction level. When switching, synchronization is continued positively at a step precision. However, special hardware is necessary to implement step synchronization.

2) Synchronization of transaction level (*Fig. 5* (b))

Synchronization points are provided in transaction unit in one program. At switching, processing is continued while performing partial duplication processing from the synchronization point. If the synchronization point is selected appropriately, continuous operation response is possibble.

3) Synchronization of job level (*Fig. 5* (c))

The synchronization point is taken in job units. At

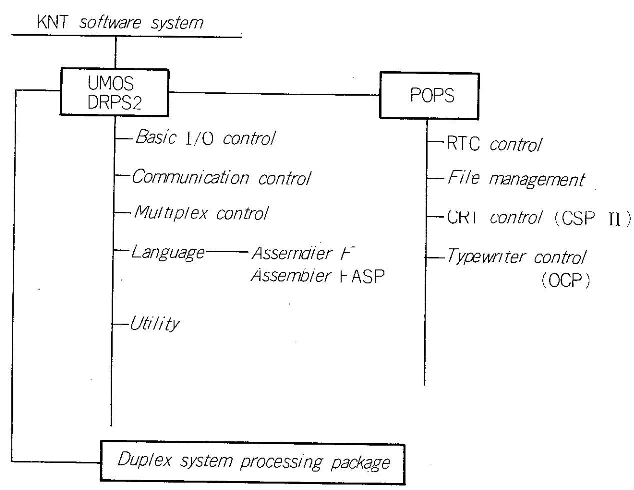

Fig. 4 Basic software configuration

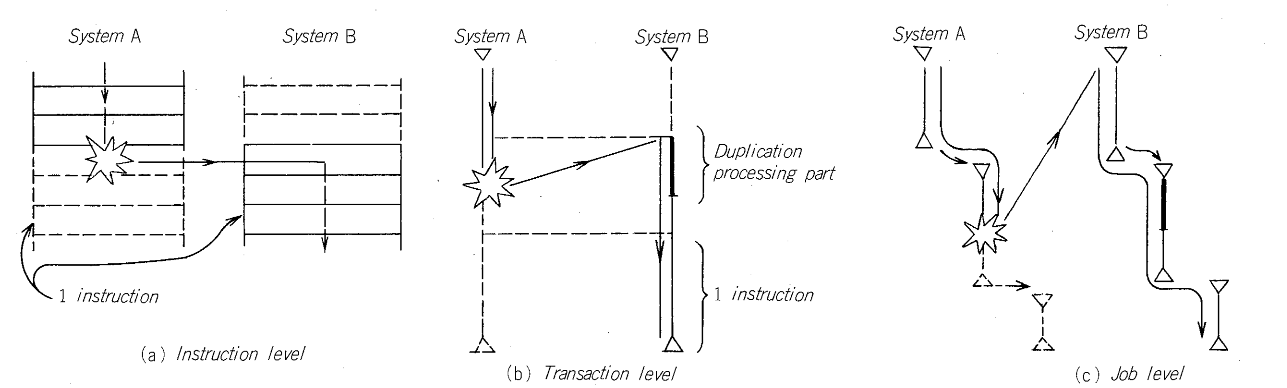

Fig. 5 Continuity of processing

switching, processing is re-executed from the beginning of the job. Operation and response continuity are lost, but processing can be continued within the range allowed by the plant.

The duplex processing package adopted in this operation control system is the synchronization of level system of item 2). However, since the actual synchronization method is a features of the application program responsiveness and processability, it is introduced below.

3. Duplex Processing

The operation control computer system has the following features from the standpoint of a multiplex system:

(1) The computer system is a medium scale system from the standpoint of economical balance as a transit system of middle capacity.

(2) As a result of (1), the system includes multiple subsystems and the load on the computer also increases.

(3) Unmanned operation is pointed to and the number of despatchers at the central command post is limited. Therefore, when a trouble occurs in the computer systems, processing continuity and functions must be maintained automatically and intervention by the dispatcher must be possibly omitted.

(4) Input from the control objective, dispatcher, etc. to the computer is random and output is also random. Realtime characteristics must be maintained so processing is not delayed when normal and when switching.

Therefore, the functions use a system that satisfies the following conditions listed below.

The system specifications are shown in *Table 1*.

(1) When trouble occurs in the computer of one part, operation switches to the other part within 1 second.

Table 1 Specifications of multiplex system

Item	Specification
Common core memory	16K bytes + 128K bytes
Common disk	10M bytes
Number of synchronous tasks	262/unit
Permitted minimum switching time	1s

(2) Processing is performed continuously even in the case of (1) above. (Example: Platform door, vehicle door opening and closing)

(3) The load on the computer system and application software is minimum.

This duplicate processing performs the following processing for the topics above:

(1) Data generation and data output are generally performed by the main part.

(2) Task start information from the process is read by both parts and the other inputs are ready by only the main part.

(3) Arbitrary synchronization points are provided at arbitrary points in a task and the processed result data are sent to the slave system at each synchronization point.

This system has the following features as compared to the conventional parallel system and standby system:

(1) Sequential processing is continued and there is no lost output even after switching.

(2) Special hardware is unnecessary and system design is simple.

(3) Processing delay, etc. at the slave part has no affect on the master part and high range task synchronization is performed.

Table 2 compares this method to the conventional method.

4. Man-machine Interface

Central operation of the KNT computer systems is performed at an operator's console centered about two CRT.

The KNT computer system operator console approach was taken to make the panel compact and the entire panel easy to see and to permit implementation of detailed communication with the controller by minimizing the number of pushbuttons and using the CRT display to the maximum limit.

On the other hand, since operations are centralized at the CRT displays, beside standby duplexing, the CRT display operation pushbuttons can be backed up by marks at the bottom righthand side of the screen of the CRT

Table 2 Comparison with usual method

Item \ Method	Conventional method		Kobe new transit system duplex precessing method
	Dual method	Duplex method	
Continuity of processing	Easy	Difficult	Easy
Continuity of all jobs	Difficult	–	Easy
Rapidity of processing	Somewhat difficult (synchronization wait, loss of sync, I/O contention)	Good	Fair (synchronization time required)
Cost	Bad (software and hardware are complex)	Good	Good
System design	Difficult	Easy	Easy
Batch processing in slave part	Difficult (unbalanced load)	Easy	Easy

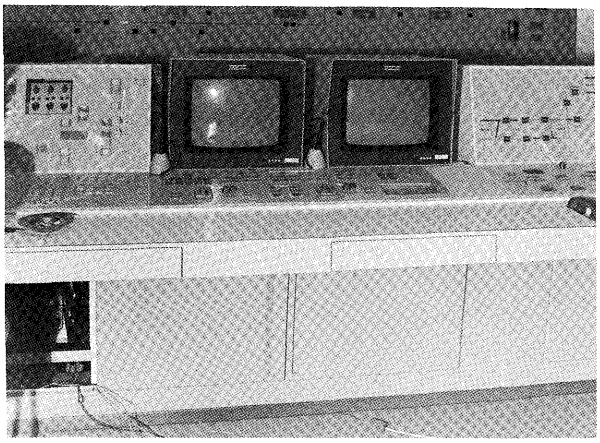

Fig. 6 Operator's console of traffic regulating system

dislplay. This has completed the back-up system.

To make operation by the controller easier and for rapid error detection and correction, the following refinements were made in operation of the CRT display:

(1) Contents confirmation at each input was stressed. Correction of data already input is possible within that range.
(2) A roll-up picture is used for easy voluminuous and variable inputs.
(3) The display can be quickly updated even when it spans several pages.
(4) Data can be input concurrently with confirmation of other data by allowing monitor display at the back-up CRT display.

IV. MAIN FUNCTIONS

1. Traffic Regulating

Unmanned operation is pointed to by sophisticated automation of train traffic. Basically, the purpose of this system is execution of business by giving commands to these automated facilities and devices. Monitoring work and failure judgement, etc. that cannot be automated are performed by the dispatcher by supplying information to the central control room. The main functions of the traffic regulating system are operation planning, operation control, operation supervision, and change of schedule. Support functions are system checks of the various facilities at the beginning and end of work and man-machine communication that simplifies dialogs with man.

1) Operation planning

The schedule system of this system is a schedule operation system. The operation schedule is decided and created after the standard schedule forecast for that day is corrected with the train running conditions and schedule change information and assignment of trains with the behicle base control system has been verified. The standard schedule can register up to 13 patterns, train running conditions, and schedule change information for up to one week in advance.

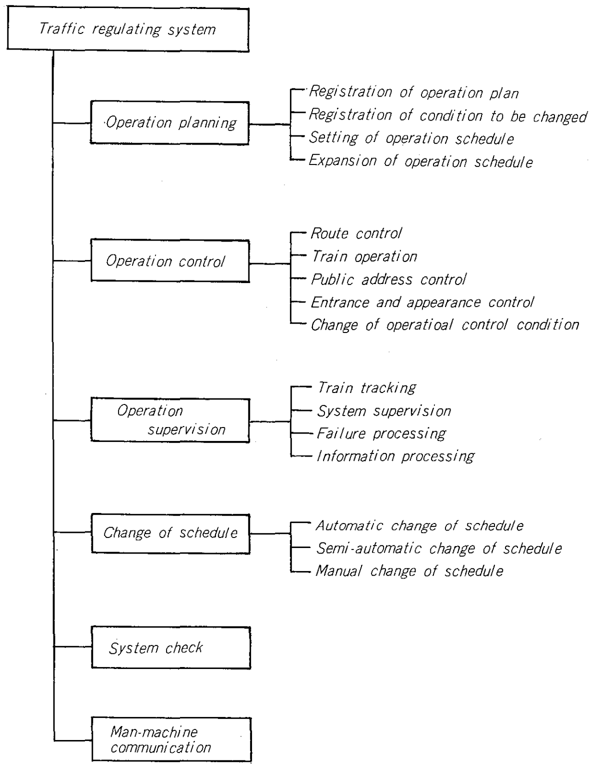

Fig. 7 Function of the traffic regulating system

2) Operation control

Operation control controls the trains and station platform facilities based on the schedule information. Its functions are operation commands for train automatic operation devices, platform door switching, etc.

3) Operation supervision

This function supervises the status of the operating trains and performs failure detection and processing and collects and records the operation results and passes information to the data control system. Failure detection covers a wide range from failures caused by equipment to failures caused by man and is a complex system having a corresponding public duty. This system is based on simplifying dispatcher judgement and operation by offering corresponding processing.

4) Change of schedule

The purpose of the change of schedule system is rapid recovery of the forecast operating schedule automatically or by issuing instructions to the dispatcher when operation scheduled by the operation schedule for that day has been disturbed by a failure. It has automatic, semi-automatic, and manual functions corresponding to the degree of intervention by the dispatcher.

2. Electric Power Management

Power facilities are distributed among one receiving substation, five feeding substations, and seven station distribution rooms. The electric power management system manages these distributed facilities centrally and maintains close contact with the traffic regulating system for more efficient operation.

This system receives 22 kV 2-wire power, steps this power down to 6.6 kV and supplies the stepped down power to the feeding substations and station distribution rooms. Three-phase 600V AC power is supplied to the trains from the feeding substations.

The substations and distribution rooms are unmanned. Control, display, and survey are controlled directly by the central remote monitoring and control device [(1 : 1) x N cyclic supervision)]. The electric power management system is positioned at higher level than the central remote monitoring and control device and implements circuit breaker and capacitor schedule control, independent control, trouble control and recovery control, etc. automatically or while communicating with the dispatcher. Its results are reported to the data control system as a daily report. (See *Fig. 8.*)

Control of the feeding system that supplies power to the trains also includes power factor improvement capacitor control and is basically schedule control.

Three receiving substation operating schedules are provided; weekday, holiday, and special. The power operation plan based on the daily train operation plan is recorded in these schedules. Sequence control is performed after approval by the dispatcher at each timing.

The receiving status is input as a pressure signal and a circuit breaker [ON] signal. The status is displayed on the CRT display and simultaneously sent to the traffic regulating system.

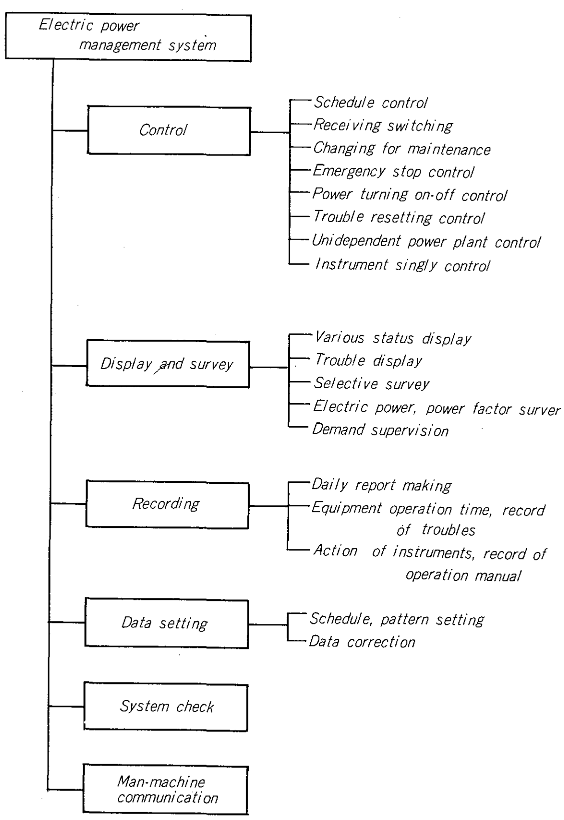

Fig. 8 Functions of the electric power management system

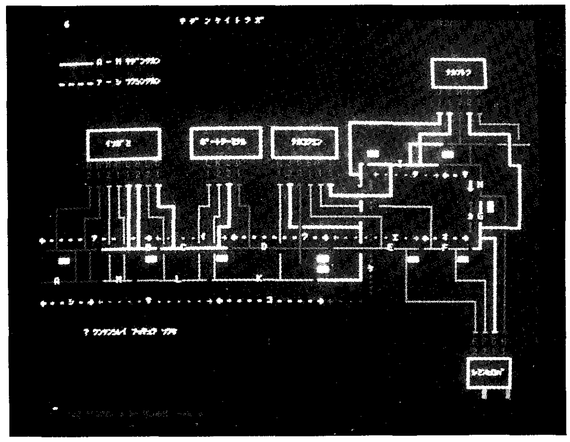

Fig. 9 Example of display for electric power management system

If an emergency situation arises on the tracks, the facilities and control system performs interlinked circuit breaking for feeding and post the state to the traffic regulating system. The electrical data from the electric power management system is used as one of the train operation conditions.

3. Vehicle Base Control

The main function of the vehicle base control system are operation of the trains within the base while communicating with the operation plan and change of schedule systems of the traffic regulating system, operation control for inspection, and operation supervision and recording that performs automatic train marshalling and working conditions supervision and recording. Similar to the traffic regulating system, the vehicle base control system has system has system check and man-machine comunications as support functions.

1) Operation management

There are two schedules at the vehicle base, one is vehicle operation schedule and inspection schedule during 1 ~ 3 month's long term, another is the entrance and appearence schedule and inspection schedule influenced by current day's main line operation. The former is made by basic operation plan making and the latter is made by schedule setting. The basic operation plan assigns the various inspections based on the train inspection results and the data on which base work is possible. Thereafter, train operation is forecast according to the preset main line standard operation schedule.

Schedule setting judges if the operation forecast from the traffic regulating system can be implemented by referring to the basic operation plan and makes the entrance and appearance schedule and inspection shedule. If the data according to the operation forecast implemented or not, the entrance and appearance data are sent to the traffic regulating system.

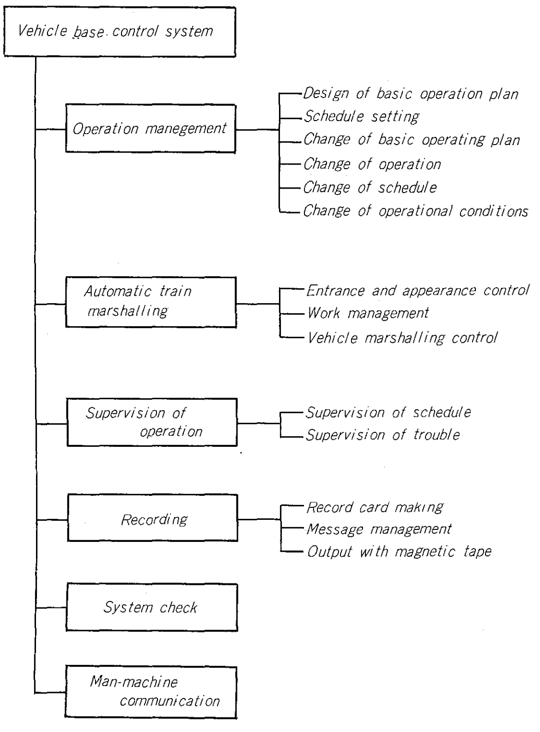

Fig. 10 Functions of the vehicle base control system

Modification functions are provided for these palns and schedule. Modification for the current day's operation is performed by change of operation instructions from the traffic regulating system.

2. Automatic Train Marshalling

Although some parts are different at the facilities for automatic train marshalling at the base and mainline, the train control method is basically the same and is performed the same as operation control of the traffic regulating system.

3. Operation Supervision and Recording

This system supervision operation of the various schedules at the base and detects and reports work delays. It also performs on-board and ground facilities supervision, and outputs sends this data to the dispatcher and also outputs it in cards. The various data are grasped as results values and are output on cards as the business results, trouble and equipement operation results and vehicle overhaul results or the data needed by the data control system are output on magnetic tape and sent to the data control system.

V. CONCLUSION

The three main subsystems, traffic regulating, electric power management, and vehicle base control, of the Kobe Port Island Portliner total management system were outlined above. Operation of the Portliner is accumulating a record of achievements as a new transit system for improved functions from the standpoints of economy, city environment, safety, and service through the adoption of new technologies. By the middle of June 1981, 10,000,000 people (daily average 75,000) had used the Portliner. There is no doubt that the Portliner will become a fixture as safe and convenient "feet" connecting the new port city and downtown Kobe after the close of the Exhibition (PORTOPIA).

Society has great expectation that the so-called "new transit system" will solve the problems of danger, inefficiency, and poor management plaguing today's metropolitan transportation. We feel that nourishing of the Portliner and more studies and research are needed to build a still better system. Especially in the field of computer control, microelectronics is expected to grow noticeably and more studies on a system configuration that can provide optimum cost-performance from the standpoints of reliability and economy and reseach on the development of higher performance and more flexible software to provide better service and safety to meet the need for increasing diversity in the future are necessary. Finally, the authors wish to thank all those who cooperated in the development of this system.