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1:n CENTRALIZED SUPERVISORY CONTROL EQUIPMENT

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I. INTRODUCTION

Great advances have been made in automation aimmed at rationalization of operation and security control, unmanned substations and water power plants have been in operation for a number of years.

In recent years, control equipment for unattended operation has become centralized by twin by twin at a single control station and has grown into a centralized control system which efficiently controls a large number of electric stations with a minimum number of people.

However, good result cannot be expected by merely centralizing supervisory control, and emphasis must therefore be placed on centralization of precise, high-speed indication.

Moreover, centralization of transmission and recording of precise information is also required.

These requirements can be satisfied by centering the control system around an electric computer. Utilization of the information processing unit also permits a higher level of automation.

In this way, the redundancy for common parts through the combination of special purpose equipments can be reduced and an economical system can be easily realized.

In this case, the problem of reliability is encountered; however, the highly reliable centralized supervisory control-automatic operating system delivered to the Kano control station has been designed and manufactured through the combination of Fuji Electric's long record of achievements in this field with Fujitsu's electronic computer and information transmission techniques and abundant experience in the computerized control field and the long years of experience of the Chubu Electric Power Co. The contents of this system are introduced in the following.

The major features of this system are:

(1) Rationalization of status and fault condition indication methods.
(2) Small, compact control desk employing a selective method for group function switches.
(3) Efficient connection system between transmission unit and processing unit.
(4) Reduced floor space.
(5) Coordination and economical balance with existing facilities.
(6) Good balance between reliability and economy.

II. SYSTEM FUNCTIONS

The functions of this system can be roughly divided into:

(1) centralized supervisory control of distribution substations.
(2) automatic operation of the Kano substation.
(3) automatic recording.

The compoiition of the overall system is shown in *Fig. 1.*

1. Centralized Supervisory Control of Distribution Substations

The composition and information transmission route for this function are shown in *Fig. 2 (a)* and includes the related recording.

(1) Control system

The control system consists of one set of control signal transmitting units (serializer, code converter, carrier current unit) and is used by switching with respect to the separate slave station units having the same specifications as required. The selecting switches at the control desk are selected in [station name], [device name] order.

When a control switch is operated, its operation is encoded into the code required by the remote supervisory equipment by the processing unit, a parity check bit is added, and the signal is sent to the control signal transmitting unit. Error check of the code between the processing unit and control signal transmitting unit is performed by means of the parity bit and double transmission. At the same time, the transmission line is connected to the specified slave station by selecting output for the slave station.

In this case, detection of transmission line selection errors is performed by verifying the receive level at the slave station side and retransmitting indication signal to the master station side using 1 position.

(2) Indication system

A parallel receiving indication system is employed

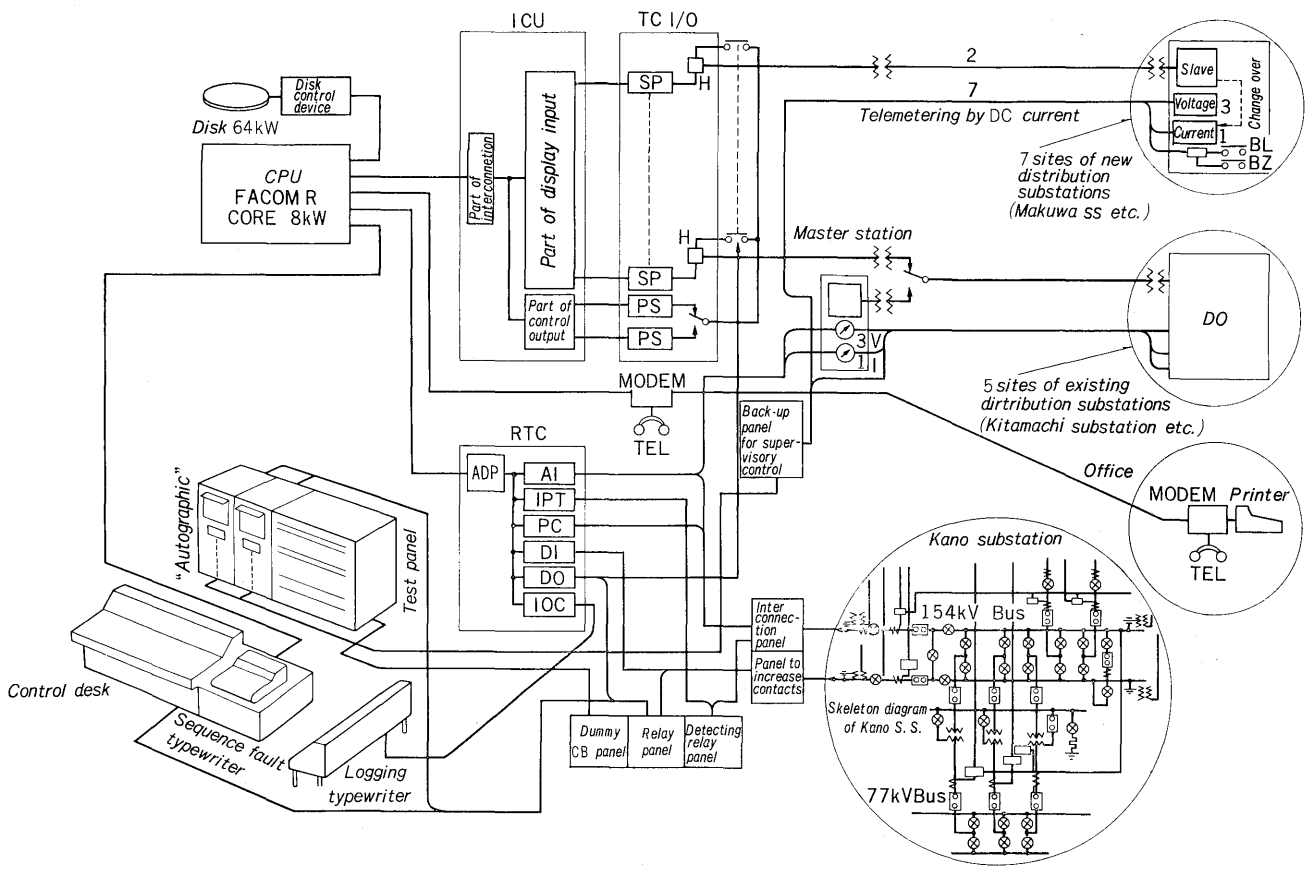

Fig. 1 Construction of centralized supervisory control and automatic operating system

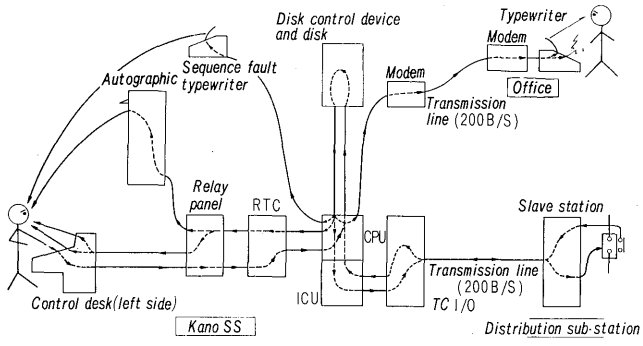

Fig. 2 (a) Centralized supervisory control function and its information route

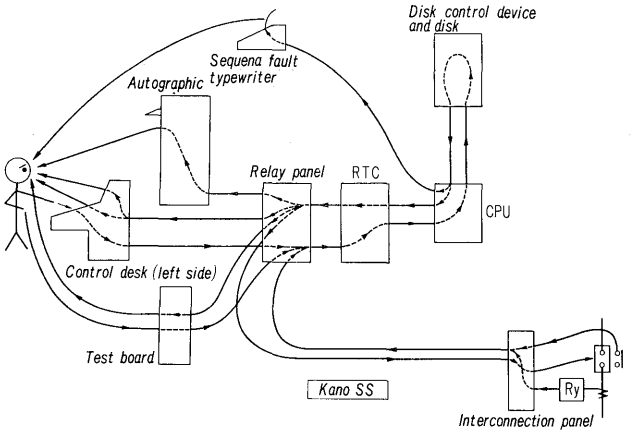

Fig. 2 (b) Automatic operating function and its information route

considering existing facilities, the characteristics of industrial power facilities, and other factors.

The indication signals from all the slave stations are normally received simultaneously and rewritten into the memory of the processing unit at a period almost the same as the sampling cycle of the remote supervisory control equipment.

External indication displays the output of only two of the controlled stations on the two sets of the "Autographics". (Refer to the description of devices for the principles of the "Autographic".)

The display unit automatically displays the skeleton of the pertinent substation at the detection of changes in status by the central processing unit, or at the manual operation of the selecting switches on the control desk and at the same time indicates the status of each device in the skeleton by blinking or flickering.

Faults are indicated by fault indicators at the control desk and its indication is cooperated with the Autographic.

2. Automatic operating Functions of the Kano Substation

The composition of the required devices and the main information path are shown in *Fig. 2 (b)*. This includes related automatic recording. Functions can be divided into the follow two classes:

(1) Normal automatic operation

Operation is started from the operating desk by

the operator and then proceeds automatically as a group of operations.

Line activation or deactivation, bus activation or deactivation, starting idle banks, and other operations are performed.

(2) Automatic operation when a fault occurs.

Timely automatic starting is performed by means of signals from fault detecting relays, etc.

Operation immediately after cut down of all receiving power, restarting of substation, interlooking operation at the faults in substation, slow speed reclosing of the line, reclosing after scheduled tripping at ground fault, etc. are performed.

The following 3 operating modes are employed:

(a) Automatic
Programmed processing progresses automatically

(b) Semi-automatic
This is an operator's guide system. The device to be operated flickers at the Autographic at each operation.

(c) Test
Both the input and output related to the dummy CB, LS at the test panel are used to test the operating sequence order (software) and devices used (hardware). When an actual fault occurs during testing, the test state is interrupted and operation is automatically switched to the semi-automatic state.

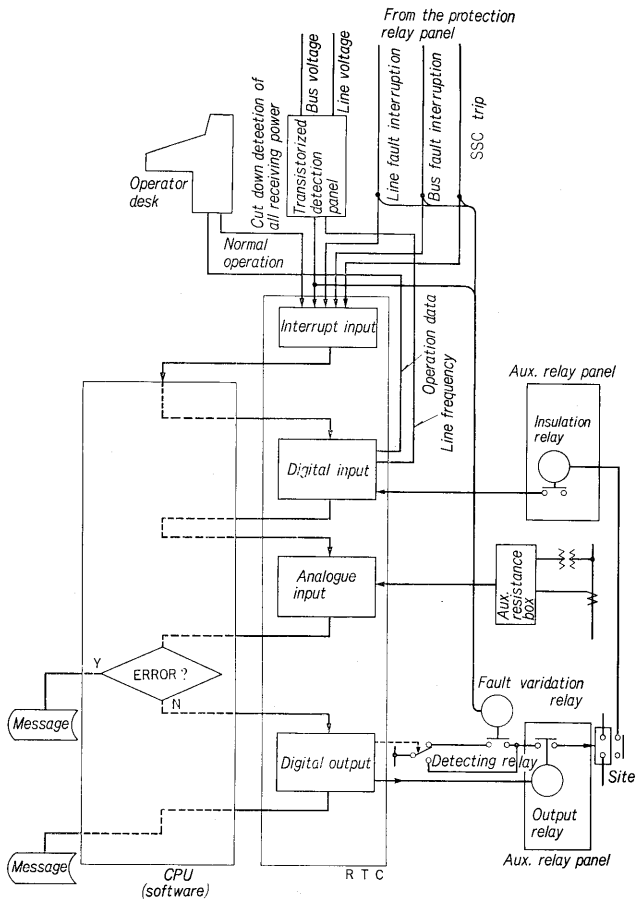

Fig. 3 Explanation diagram of automatic operating function

The concepts of starting and the conditions of the program with regard to automatic operation are shown in *Fig. 3.*

3. Automatic Recording Function

There are three automatic recording functions:

(1) Recording of operation and faults of the distribution substation and Kano substation.

The operation and fault time, location, device name, operating status, etc. are recorded in black for normal operation and in red for fault on the console typewriter at the master control station, in 1 line 1 item format.

(2) Transmission of information to the office.

The feeder fault tripping state at the distribution substation and section indicating information are sent to the line service office through a 200 B/S transmission line and are recorded.

Printing format is the same as that of item (1).

(3) Logging function

Daily report: Voltage, power etc. are printed out at each station at 3 o'clock, 11 o'clock and at lighting time (can be freely set).

Monthly report: Monthly report of supplying power, monthly report of voltage, and monthly report of phase modifier operation are prepared as specified by operator at the same typewriter of daily report.

Recording every 3rd wednesday: Active energy, active power, reactive power, voltage, current, and power factor for a total of 126 points are measured hourly at each station on 3rd wednesday and tabulated at any desired time up to the following 3rd wednesday.

III. OUTLINE SPECIFICATIONS OF UNITS COMPOSING THE SYSTEM

—Kano control station facilities.—

(1) Central processing unit (CPU) FACOM-R
1 locker (with ICU)

Core memory capacity	8 kwords
Core memory cycle time	1.5 μs
Add operation time	6 μs

The CPU is used in all information processing. A magnetic disk unit and PCPS (Process Control Program System) which controls the program group are available for operation of the system can be modified in accordance with use.

(2) Magnetic disk file control unit and magnetic disk
1 locker and 1 unit

Memory capacity	64 kwords
Average access time	20 ms
Information transmission speed	25.6 kwords/sec

These are used as an auxiliary memory. The majority of the program and the tables of input/output system for the Autographic and other lamp indicators, circuit breaker on-off control devices, etc.

and all the data necessary for the daily report, monthly report, and logging are memorized.

Since the magnetic disk unit employs fixed heads, its reliability is extremely high.

(3) Console typewriter F805A

Typing speed	20 characters/sec
Paper tape reading speed	20 characters/sec
Paper tape punching speed	20 characters/sec
Maximum typing character	120 characters/line

It reads the program into the computer, punches out contents to paper tape, and prints out messages from the computer.

It is also equipped with the functions of an operation recording.

(4) I C U 1 locker (with CPU)

ILI (interlace input) 6 : (Expandable up to 12)

DI (digital input) 3 words : (Expansion up to 12 telecontrol stations is unnecessary)

DO (digital output) 3 words : (Expansion up to 12 telecontrol stations is unnecessary)

This unit connects the telecontrol I/O and CPU. Its major function is processing of indication information which arrives from a number of telecontrol I/O asynchronously in synchronization with the CPU clock in order to feed it to the CPU.

It matches the control signals transmitted from the CPU to the telecontrol I/O and feeds the carrier current states of each telecontrol line to the CPU by means of commands read from the CPU. (bottom half of *Fig. 4*)

(5) Telecontrol I/O 1 locker

Indication receive section 6 stations (expandable up to 12 stations)

Control trantmission section 1 set (1 set can be added)

The 200 B/S carrier signals sent from the slave station are demodulated, the serial signals are converted to parallel signals, double transmission check is performed, and the signals are then sent to ILI of the ICU.

The carrier current states are sent to DI of the ICU.

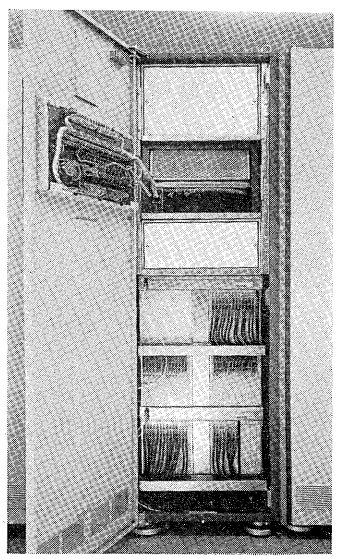

Fig. 4 Inner view of interface control unit

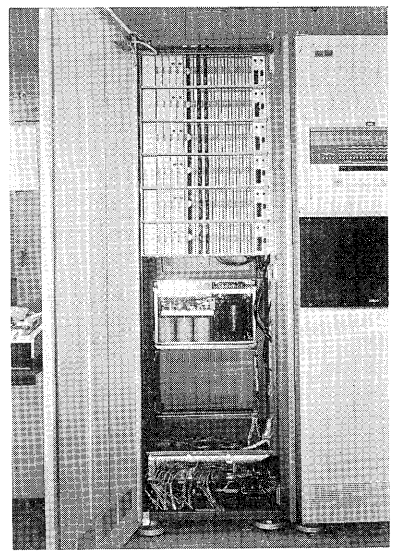

Fig. 5 Telecontrol I/O

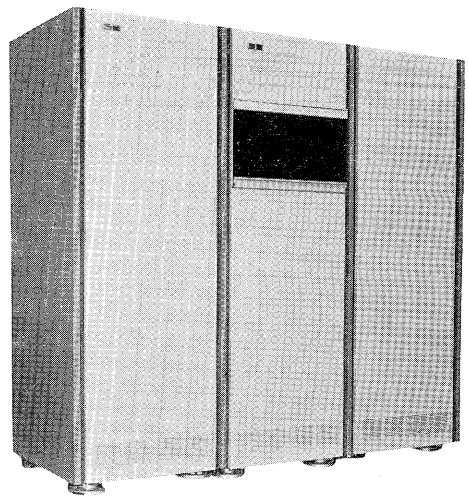

Fig. 6 Outer view of locker

The control signal from DO of ICU is corrected to a serial signal unchanged, modulated, and sent out to the slave station at 200 B/S.

In the *Fig. 5*, one shelf is for 1 station.

Fig. 6 is an external view of the telecon I/O, CPU and ICU, and magnetic disk control unit locker (from left to right).

(6) RTC (Real Time Controller) 2 lockers

IRT (interrupt input device)	20 points
AI (analog input)	80 points
DI (digital input)	5 words
PC (pulse input)	32 points
CLK (clock device)	1 set
DO/A (hold type digital output device)	8 words
DO/B (instantaneous type digital output device)	8 words
IOC (typewriter output)	1 device

IRT of RTC detects sudden changes in the substation, receives requests from the system at any time, sends these to the CPU, and starts the program which reads in data from the process. In that program, the data from analog telemeter are converted

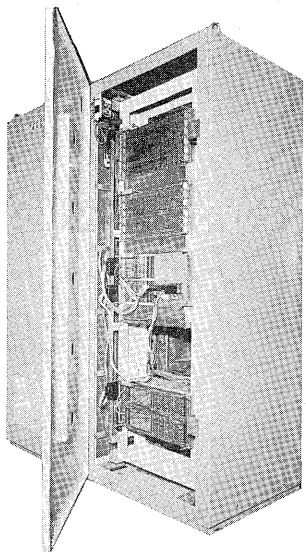

Fig. 7 RTC locker

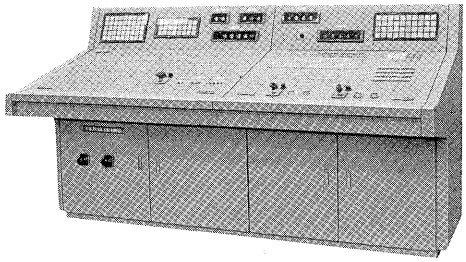

Fig. 8 Control desk

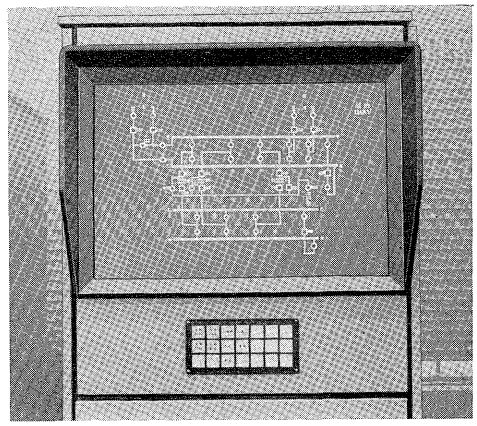

Fig. 9 " Autographic "

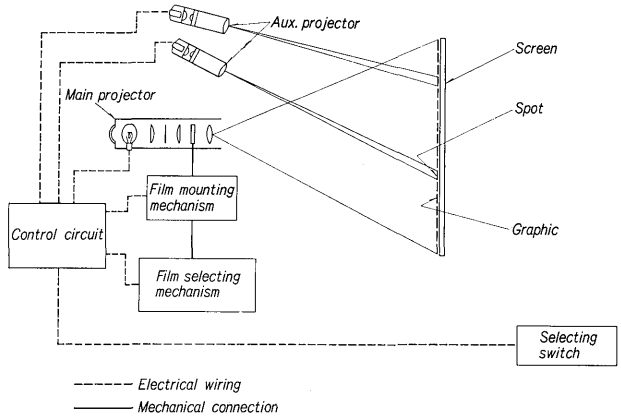

Fig. 10 Principle of Autographic

to digital values, the various AC values inside the Kano substation are measured, pulses are read in from the integrating meters, the status (on-off status) of the devices at the substation is read in, and the time is read in from the clock device.

These operations are performed through AI, DI, PC, and CLK of the RTC.

The results of processing of these data are output as lamp indication to the control desk, indication selection signal to the Autographic, on-off control signal to the various substation devices, and print signal on the typewriter. These can be performed from DO/A, DO/B, and IOC of RTC through output relays as required (*Fig. 7*).

(7) Man-machine interface

This system has the 5 following man-machine interface devices:

(a) Control desk (*Fig. 8*)

Operation for centralized control of distribution substations (right half)

Operation for automatic operation of Kano substation (right half)

Individual operation of Kano substation (refer to system back-up item) (left half).

(b) "Autographic"

The Autographic displays the skeleton of each distribution substation and the skeleton divided into voltage classes of own station upon demand. The status of the devices and changes are displayed.

The film selector is driven by switch operation at the control desk (or demand at status change from outside), the film corresponding to the operated switch is selected and extracted from the film storage of a large number of skeletons, and the film is mounted and projected onto the screen (*Fig. 9*).

The on-off status and change in status can be composed on the screen by means of an auxiliary projector (*Fig. 10*).

(c) Test panel

The test panel is used to train operator in software and hardware checkout when changing the automatic operation operating sequence. Switching and indication of dummy CB, dummy LS, setting of voltage to be detected through PT, and generation of dummy faults can be performed from the test panel (*Fig. 11*).

(d) Logging typewriter

IBM Model B 30 inch typewriter 1 device

This typewriter performs daily report, monthly report, and every 3rd wednesday recording.

Normally, the daily report paper is manually set and then the report is printed out automatically. However, changing of the monthly report and 3rd wednesday recording paper is performed by the operator and printing is started from the control desk.

(e) Sequence fault typewriter

F 805 A 1 device (Also serves as console typewriter)

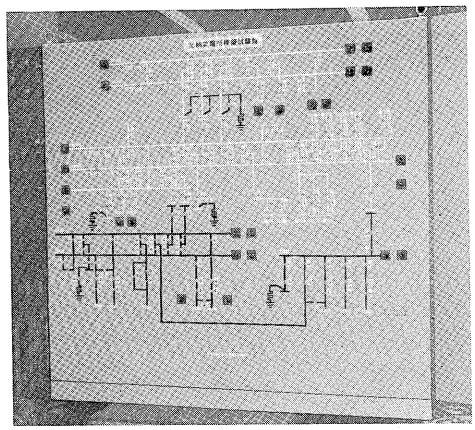

Fig. 11 Panel for test

This typewriter prints the time, station, device name, and operating sequence for operation and faults, respectively in black for normal operation and in red for faults.

(8) Relay panel and auxiliary devices

There are various relay panels to meet the problem of on site devices and their isolation and to increase relay contacts.

(a) Panel for automatic restart.....Houses dummy CB, etc. 1

(b) Panel to increase fault contacts..... Increases contacts related to Fault indicator 1

(c) Panel "I/O A"..... Houses Autographic and control desk use auxiliary relays 2

(d) Panel "I/O B"..... Houses the transitorized relay for cut down of all receiving power, etc. 1

(e) Panel for back-up of supervisory control..... Back-up line panel (described later) 1

(f) Interconnection panel.....Isolation and increaseing contacts 2

— Line service office facilities —

(9) Terminal typewriter F1520 1

The MODEM unit demodulates the information sent from the Kano substation centralized supervisory control equipment through a transmission line at 200 B/S and feeds it to typewriter for printing.

The contents of printing are fault recording of the distribution system (*Fig. 12*).

— Distribution substation facilities —

(10) Remote supervisory control equipment for slave station

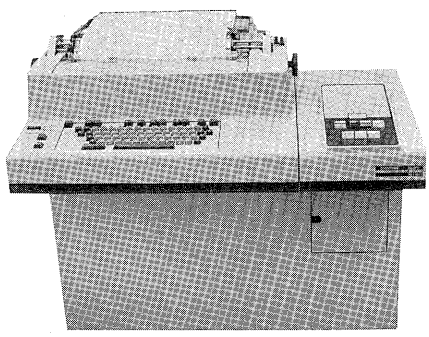

Fig. 12 Typewriter device of terminal

This part is the same as the conventional 1 : 1 equipment and is identical to the slave station component of the remote supervisory and control equipment.

IV. FEATURES OF SYSTEM CONSTRUCTION

The special features of this system construction are:

(1) System self-check function

Self-check is performed at all vital point in the system. Moreover, partial duplication is employed.

(a) CPU Self-check is performed by periodically running the check program.

(b) RTC Common parts are checked by periodically cycling the data. The analog-digital converter is also periodically examined.

(c) ICU Common parts are checked periodically and prior to operation by cycling data.

(d) The on-off control output circuit, circuit breaker, line switch, and other devices operating circuits are individually duplicated and erroneous output due to partial element faults is suppressed. In addition, the individual duplicate circuits are checked prior to operation and the detection of faults is expected.

(2) Safety plan with respect to on-off output

The on-off output circuit is operated and checked by entering external conditions to prevent on-off output by erroneous operation due to erroneous computer operation when the program is changed.

(3) System back-up function

In this type of equipment, system back-up must be naturally considered.

(a) The back-up line consists of 1 telemeter channel per destribution substation. When the system is shut down due to trouble in the CPU system, etc., heavy fault at the distribution substation is directly indicated at the Kano control station zone indicator (on the Autographic) and an alarm given.

The information path for this case is shown *Fig. 13.*

(b) Kano substation automatic operation system

Because of simplify operation, devices which are individually operated outside automatic operation are individually and directly operated at the right half of the control desk.

Operation is indicated at the Autographic during operation of the computer system. However, this is merely indication and this circuit consists of independent circuits from computer system. Consequently, this functions can be expanded up to all devices which can be operated individually and used as a back-up function when the computer system is down.

(c) Autographic system

The Autographic system consists of two Autographics and their component parts. One set is considered as a spare and at the same time is used for high-

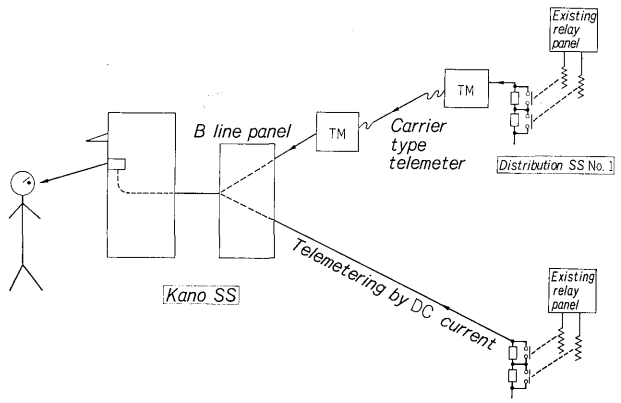

Fig. 13 Buck-up line and its information route

speed handling of queue in the case of multiple display.

In other words, display requests to the Autographic are formed into a queue in the priority decided in advance or in order of arrival in the case of the same priority level and are successively displayed one after the other by retiring opration or reset operation by the operator. In this case, if both of the sets are normal, the indication requests are handled by both of the sets.

(d) Typewriter system

When trouble occurs in the typewriter, the information for printing is output to the paper tape from the paper tape punch, and it can be reprinted on the typewriter at a later time.

(4) Development and use of a highly efficient connection system between telecontrol (digital cyclic telemeter) and computer system

Writing of the telecontrol indication input into the processing unit is normally performed by the so-called program mode in which it is read by individual programs. However, in this equipment, a so-called interlaced mode has been developed in which one group of indication input information is directly written in the core memory of the processing unit without regard to the program. This write-in uses the processing unit for less than 6 μs per group and its efficiency is several times higher than that of conventional systems. Consequently, the remaining time can be utilized for other jobs. In other words, a large amount of information can be processed by a small processing unit.

(5) Low cost, high speed AC value measurement system without an AC to DC converter

In this system, AC values are computed by computer from the instantaneous AC voltage and current values at a few number of points to be read through a high speed analog-digital converter and multiplexer without the use of equipment which converts AC value to DC value such as normally used to read-in AC value (power, reactive power phase, voltage, current, etc.) to the processing unit.

Therefore, since a high cost AC–DC converter is not used, a low cost system can be constructed.

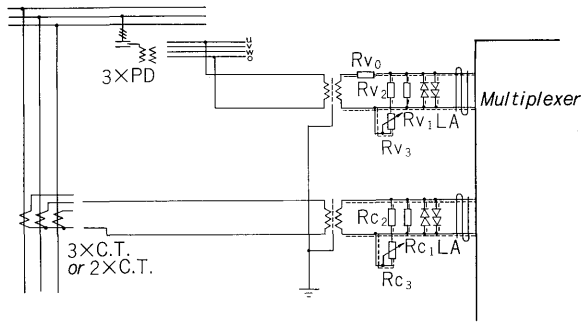

Fig. 14 Direct measuring method for AC value

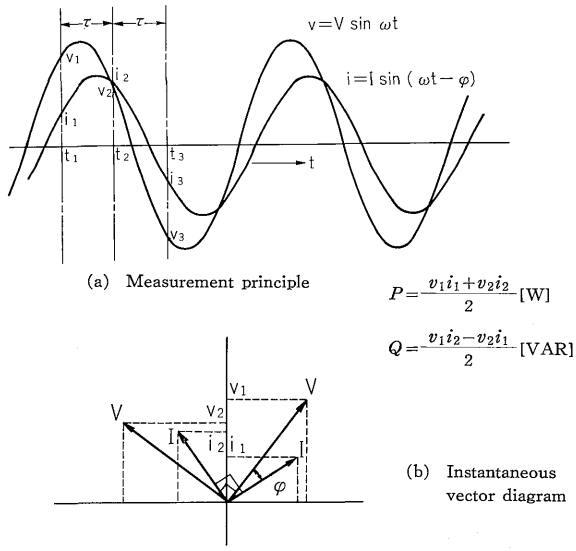

Fig. 15 Measuring method for AC multiplex value

Moreover, instantaneous value and average values can be easily prepared by program. The input circuit is shown in *Fig. 14*. Principles are shown in *Fig. 15*.

(6) Development of a language which makes modification of the automatic operating order (normal operation, operation at fault) of the substation devices easy

Since there are circumstances in which the operating order of the devices must be changed due to the state of the electric station (expansion and changes in the operating system), a language in which the order is given by a fill-in-the-blanks methods has been developed to make this operation easy.

(7) System which can be easily combined with an existing telecontrol system

(8) Data transmission to a central load dispatching center has been considered for future expansion

At the present time, data transmission to a central load dispatching center is done manually, but when this has finally been automated, a 1200 B/S line transmission path can be formed by merely adding a TM–B module to the RTC.

(9) Other expansion

Since the core memory of the CPU is in 4 kW units and the RTC, ICU input and output elements are modulized, expansion and interchanging are possible.