

# UNINTERRUPTIBLE POWER SYSTEM MONITORS

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## 1. FOREWORD

For the modern information-oriented society, the importance of the UPS as a power supply system to improve the reliability of information and communications systems was described in a separate article of this special issue. By reliability engineering, the reliability of electronic equipment is grouped into the reliability of the electronic parts which make up the equipment, that is, parts reliability, and the reliability which displays the functions of these equipments correctly, that is, function reliability. Besides the reliability of the electronic equipment itself, erroneous operation by the people who use it is also a factor which lowers reliability. These can also be avoided by production management, but making them zero is difficult.

For a UPS, high reliability and trouble-free operation are importance, but the ability to supply power quickly and minimizing the load system shutdown time if a trouble should occur are also very important.

To cope with such conditions, manufacturers prepare various manuals and promote education and training, etc. and ask customers to take suitable correspondence for the situation, but we feel that there are many cases when sufficient results are not obtained.

To avoid such situations naturally, ordinary suitable maintenance is important and in an emergency, positive contents analysis, specifications of suitable counter-measures method, etc. are indispensable. Fuji Electric develops and puts to practical use maintenance monitors to realize this. The contents of these monitors are outlines in this article.

## 2. DEVELOPMENT AIM

In the past, companies which purchased and used heavy electric machinery employed electrical engineers and performed maintenance on the purchased electric machinery by themselves. However, the advance and diversification of the technical contents and the increase in the number of kinds of machines have made it difficult for the maintenance management engineer to contend positively to emergency situations. Especially, many UPS are used by government offices, financial institutions, service industry, etc. Compared to the manufacturing industry, etc., many are used by companies which find it difficult to procure

specialist engineers.

Therefore, at Fuji Electric, after the product is delivered, maintenance management commissions were received many customers and these commissions were carried out and efforts were made in improving actual product quality maintenance and could be appraised.

However, an increase in the number of products supplied, expansion of the product installation range, sophistication of the demand for maintenance, and other conditions are arising and improvement of the maintenance management method is becoming necessary. That is,

- (1) Demand for minimization of trouble down time
- (2) Prevention of incidental trouble by performing preventive maintenance
- (3) Demand for reduction of shutdown by maintenance or nonstop maintenance
- (4) Daily maintenance management and routine maintenance labor saving

To realize these, the number of service centers and service men was increased, the maintenance contents were reviewed by systematic analysis of maintenance data, product serviceability was improved, etc.

On the other hand, the advance the microcomputer, personal computer, communication technology, etc. is a maintenance technology management equalitative transfer seeds. Fuji Electric develops and supplies maintenance management system that use this and make efforts in UPS system quality maintenance improvement and service and has attained many results.

## 3. SYSTEM CONCEPT

UPS maintenance management contents are classified as shown in *Table 1*. Roughly, it becomes daily management and special management. Daily management is centered about data logging. Special management performs checks and analyzes which originate in quality.

The monitoring range depends on the scale of the UPS, but there is a monitor which monitors the UPS only (FAMOUS/C), monitor which monitors and manages the UPS and its peripheral devices and includes the power receiving system and other electric systems and performs everything up to management of the environment in which the UPS is installed (FAMOUS/U), in addition to this,

etc. A UPS internal diagnosis tool (FAMOUS/P) is also available to simplify and speed up inspection business and maintenance business and management business.

In this way, Fuji Electric monitors meet the needs of various applications. Each monitoring objective and their functions are given in Table 1 to Table 3.

As can be seen from these tables, monitor users are both the customer maintenance management department and Fuji Electric maintenance department. This is aimed at improvement of reliability by power system preventive maintenance and rapid recovery if a trouble should occur.

Which system should be used can be selected from the relationship of the monitoring contents with the various monitors used by the customer.

For example, when an entire computer center is managed by a building management system, UPS management by FAMOUS/C is sufficient, but when there is no

such system or when desiring total system management labor-saving, these functions can be obtained by using the FAMOUS/U, which has building management functions.

When desiring to diagnose the contents of the equipment, it can be performed with the FAMOUS/P.

These features allow automatic communication with the Fuji Electric CE (Customer Engineer) centers by using a communication line.

At the CE center, the status of the equipment is read and the optimum data can be presented and counter-measures instructions given to the customer and Fuji Electric customer engineer and service can be improved.

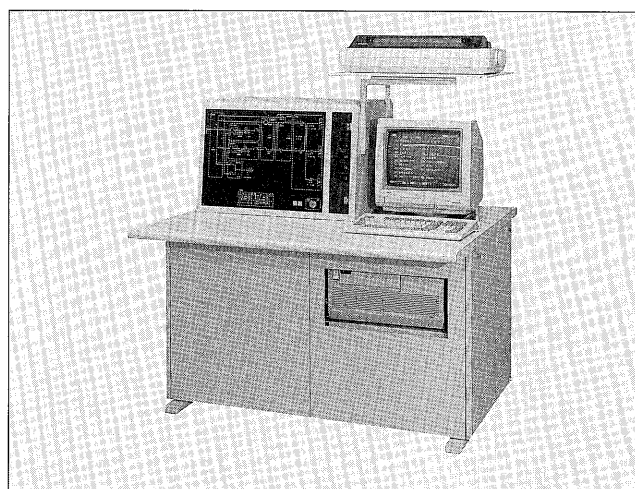
#### 4. MONITOR COMPOSITION AND FEATURES

Various UPS monitor systems are available, but the description in this section is centered about the FAMOUS/

Table 1 UPS maintenance management contents

Item	Executor	Urgency	Difficulty	Required monitor functions
Daily maintenance	Customer	Low	Low	Data logging
Routine maintenance	Manufacturer commission (customer)	Low	High	Data logging Data quality judgment Protection equipment inspection Inspection guidance Preventive maintenance guidance Remote maintenance
Trouble repair	Manufacturer, (customer)	High	High	Trouble contents display and analysis Guidance
Failure power supply restarting	Customer, (manufacturer)	Highest	Medium	Guidance Automatic transmission of trouble data

Fig. 1 Exterior view of monitor



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Table 2 Monitor management objectives and functions

Monitor model	Monitoring objective	Functions						Monitoring site			Remarks
		Status monitoring	Inspection adjustment	Logging	Data transmission	Guidance	Environment control	Site	CE center	Portable	
FAMOUS/P	UPS system	○	○	×	×	×	×	○	×	○	Two types, C1 and C2
FAMOUS/C	UPS system	○	○	○	○	×	×	○	○	×	
FAMOUS/U	Entire facility	○	○	○	○	○	○	○	○	×	

Table 3 Monitor composition and application

Monitor model	Interface with UPS			CPU		Application
	CCU	AIO	I/O Box	L25	FMR50LT	
FAMOUS/P	×	×	●	×	●	500-1XX series 600 series
FAMOUS/C1	×	×	●	×	○	500-1XX series 600 series
FAMOUS/C2	⊗	●	×	●	×	All series (with some function limitations)
FAMOUS/U	⊗	●	×	●	×	All series (with some function limitations)

< Note > ●: Standard ○: Installable

U with building management function.

#### 4.1 Monitor composition

An exterior view of the monitor is shown in *Fig. 1*. Basically, the monitor consists of only a graphic block which is connected by a direct line with operation of devices as the nucleus (left side facing *Fig. 1*) and a CRT monitor block (right side facing *Fig. 1*) with monitoring, communication, inspection, and other functions of other than device operation. (However, air conditioner scheduled starting and stopping are possible.) There may also be cases where the system consists of the CRT monitor block only.

The basic composition of the monitor and an example of connection peripheral panels are shown in *Fig. 2*.

##### (1) Monitor body

The monitor body consists of an industrial use microstation (L25). The maximum number of connectable UPS is six (for same group). The maximum number of connectable remote systems is two (connection up to 128 addresses/system is possible). For memory units, a 20MB hard disk and 1MB floppy disk drive are built in. A 14 inch CRT, keyboard, 136 digits printer, etc. are also available as additional devices.

##### (2) CCU (Communication Control Unit)

The CCU is built into the UPS body and transmits the

digital and analog data of the body control equipment to the monitor. Waveform recording is also performed at an arbitrary time on command from the monitor.

When a UPS trouble occurs, the trouble information is held and the output and control waveforms before and after the trouble are held for 200ms and transmitted to the monitor.

Optional transmission is used to block the affect from the ambient environment and for high density transmission. The monitor can also be added even for existing equipment without a CCU. There are limits on the functions, but the monitor can also be applied to old type thyristor UPS.

##### (3) AIO (Analog, digital I/O unit)

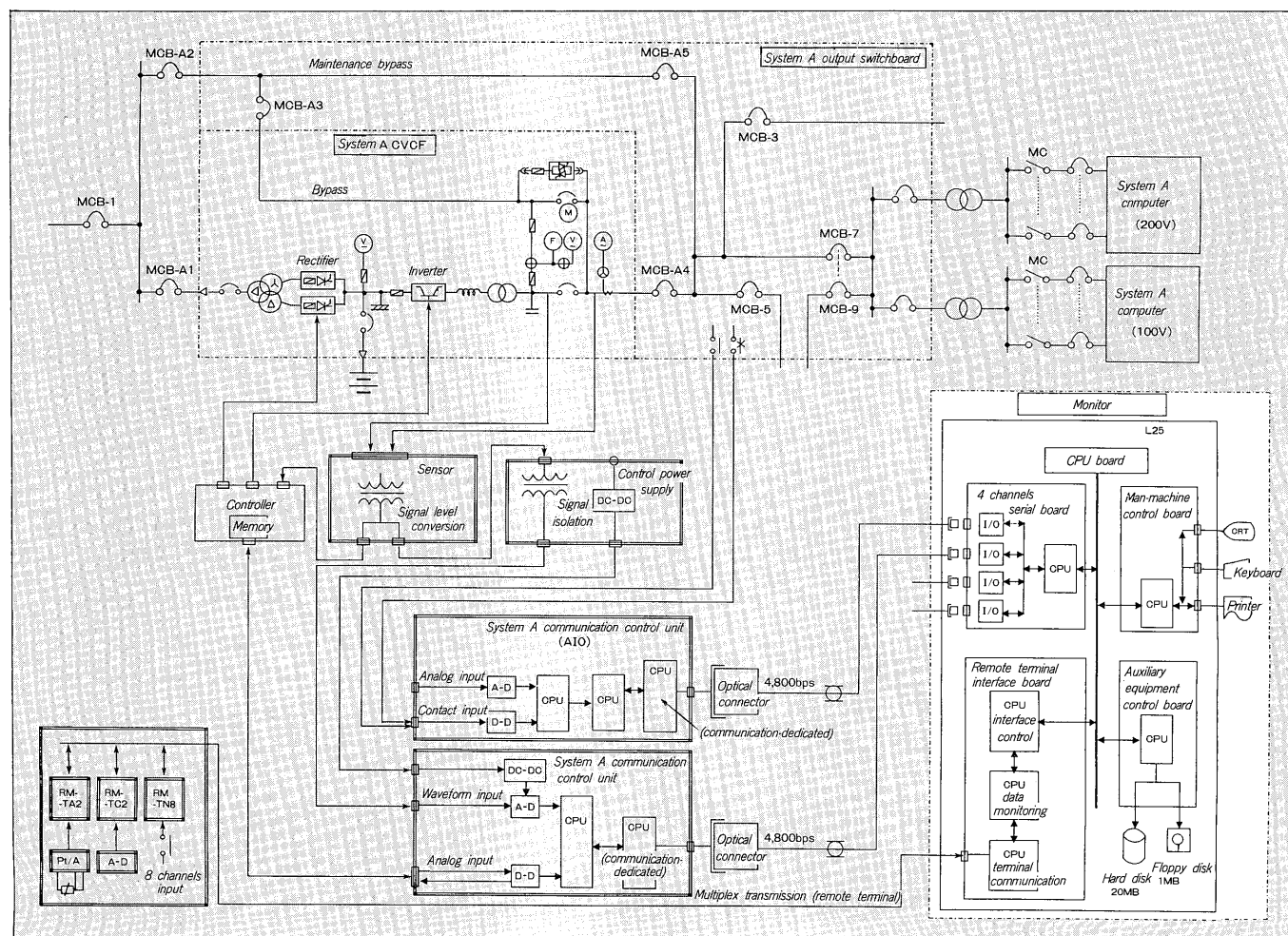
AIO is an interface unit which transmits digital and analog data which is also applicable to UPS peripheral devices to the monitor. When trouble occurs at a peripheral device, it transmits to the monitor which held the data and waveform the same as the UPS trouble described previously.

Various data can also be fetched manually at an arbitrary time.

##### (4) RM (Remote terminal unit)

When there are many peripheral devices like a power system made up of multiple UPS and the data volume becomes tremendous, it is transmitted to the monitor by using an RM. The RM is an interface which is used

*Fig. 2* Monitor basic composition and connection to peripheral panels



by ordinary building management systems, etc.

#### 4.2 Monitor functions

The functions of the monitor are outlined in *Table 2*. The functions table of the FAMOUS/U is shown in *Fig. 3*. Functionally, there is a waveform reproduction function at trouble and arbitrary times, trouble state and measured value recording, battery operation back up time display function, utility power failure emergency generator operation time display function, inspection function, forecast replacement parts display function, and group monitoring function by communication with CE center when trouble occurs, etc. Various guidance functions and trouble diagnosis and other AI functions can also be added. In addition, general building management functions are also available.

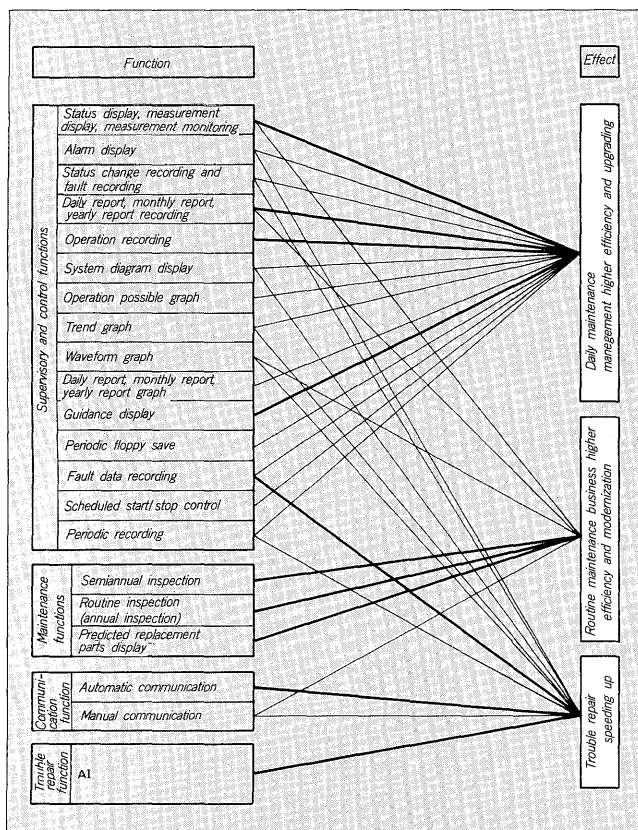
Their data is separated from UPS control etc. and the UPS is not affected even if trouble occurs in the monitor system.

The functions are outlined below.

##### (1) Normal monitoring function

Normal monitoring displays the system diagram on the CRT and displays the device status, measured value, and power supply status, etc. on the system diagram. For the measured value, upper and lower limits monitoring is performed. When the management range is exceeded, measured value color change on the CRT according to the amount the range is exceeded, printing to printer, etc. are performed automatically.

Fig. 3 FAMOUS/U functions table



The management range is set at the factory, but after at the site, it is changed automatically to match the environment and monitoring matched to the actual conditions is performed.

There are also status and measurement item dedicated screens. Especially for the measurement items, both digital value display and bar graph analog value display which simplified visual judgment are performed.

##### (2) Scheduled start/stop function

To automate operation of air conditioners, etc., the start and stop times can be specified in weekly units for each group. It is also possible to contend with the advance and extension of time for each group. Specification of special operating days is also possible.

##### (3) Trouble functions

When a device fails, alarm display and printing are performed according to the degree (heavy, medium, light) of the trouble and the alarm, status, and measurement items data of the entire system at the time of the trouble are stored on a batch file, as required. When the trouble is related to the UPS, the data is filled together with the waveforms before and after the trouble.

##### (4) Storage function

Operation recording and daily report, monthly report, and yearly report recording are saved together with recording of status changes, etc. These recordings can also be printed out, as required.

For measurement items, the measured values for 24 hours (data every 2 seconds) can be trend displayed by seconds) can be trend displayed by trend recording specification and the change of each data can be easily judged. This data can also be saved, as required. The daily report data and monthly report data can also be edited and used as weekly and monthly trend data.

##### (5) Maintenance functions

Semiannual inspection and annual inspection, and other routine maintenance items, contents, and method are systemized and fully automatic or semiautomatic inspection and recording are possible.

Of course, by using this function, the inspection time is shortened and labor is saved and personal error between inspectors is eliminated and the inspection level is improved. Semiannual inspection can be performed even while the UPS is operating. At annual inspection, the UPS is stopped and inspection is performed by monitor.

The inspection items for each inspection are shown in *Table 4*.

##### (6) Predicted replacement parts display function

By registering the delivery date, replacement period (operating time, number of operations), etc. of the component devices used by the UPS at the monitor in advance, the next predicted replacement date of the devices can be judged while normally monitoring the operating state of the devices and the replacement time can be posted beforehand. This fills out preventive maintenance and improves management efficiency. An example is shown in *Table 5*.

##### (7) Communication function

Since the operating status of the UPS can be arbitrarily

read by using a general telephone line, most maintenance work can be performed from the manufacturer's CE center.

When the UPS fails, generation of the trouble is immediately transmitted to the CE center via a telephone line and a file with the prespecified contents (trouble, status, waveform) is simultaneously transmitted automatically. Since positive data at trouble can be instantly received at the manufacturer's CE center by means of this, the trouble cause analysis and recovery processing time is shortened and is connected to quick recovery from accidents. Conversely, data other than that transmitted automatically can also be transmitted by data request from the CE center.

#### (8) Operation time display

By displaying the time battery operation and emer-

gency generator operation are possible when the utility power fails at a UPS, the current operating conditions can be grasped and the remaining operating operation time can be changed according to the load rate. By knowing this, load limiting and other suitable action can be taken.

An example of the battery operation time is shown in Fig. 4.

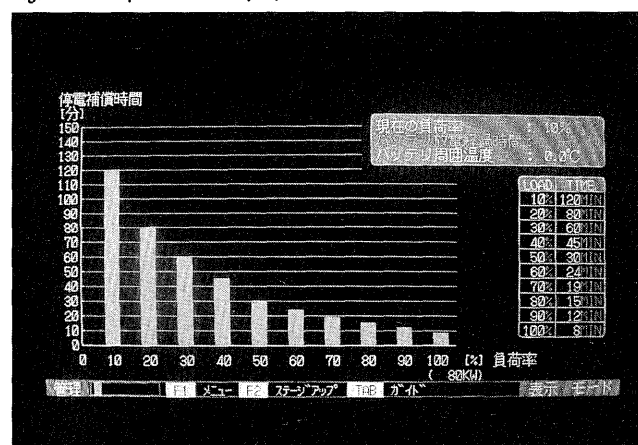
## 5. CE CENTER AND GROUP MONITORING

The group monitoring system which batch monitors

Table 4 Routine inspection items

Semiannual inspection	Annual inspection
(1) Power failure test	(1) Static characteristics
(2) Utility power transfer test	(2) Control power supply voltage measurement
(3) Parallel-single transfer test	(3) Comparator operation check
(4) Internal-external synchronous transfer test	(4) Comparator margin measurement
(5) Manual bypass supply test	(5) Trouble sequence test
(6) Battery cell voltage measurement test	(6) Pulse waveform check
	(7) Output waveform check
	(8) Set value check
	(9) UPS loader

Fig. 4 Example of battery operation time

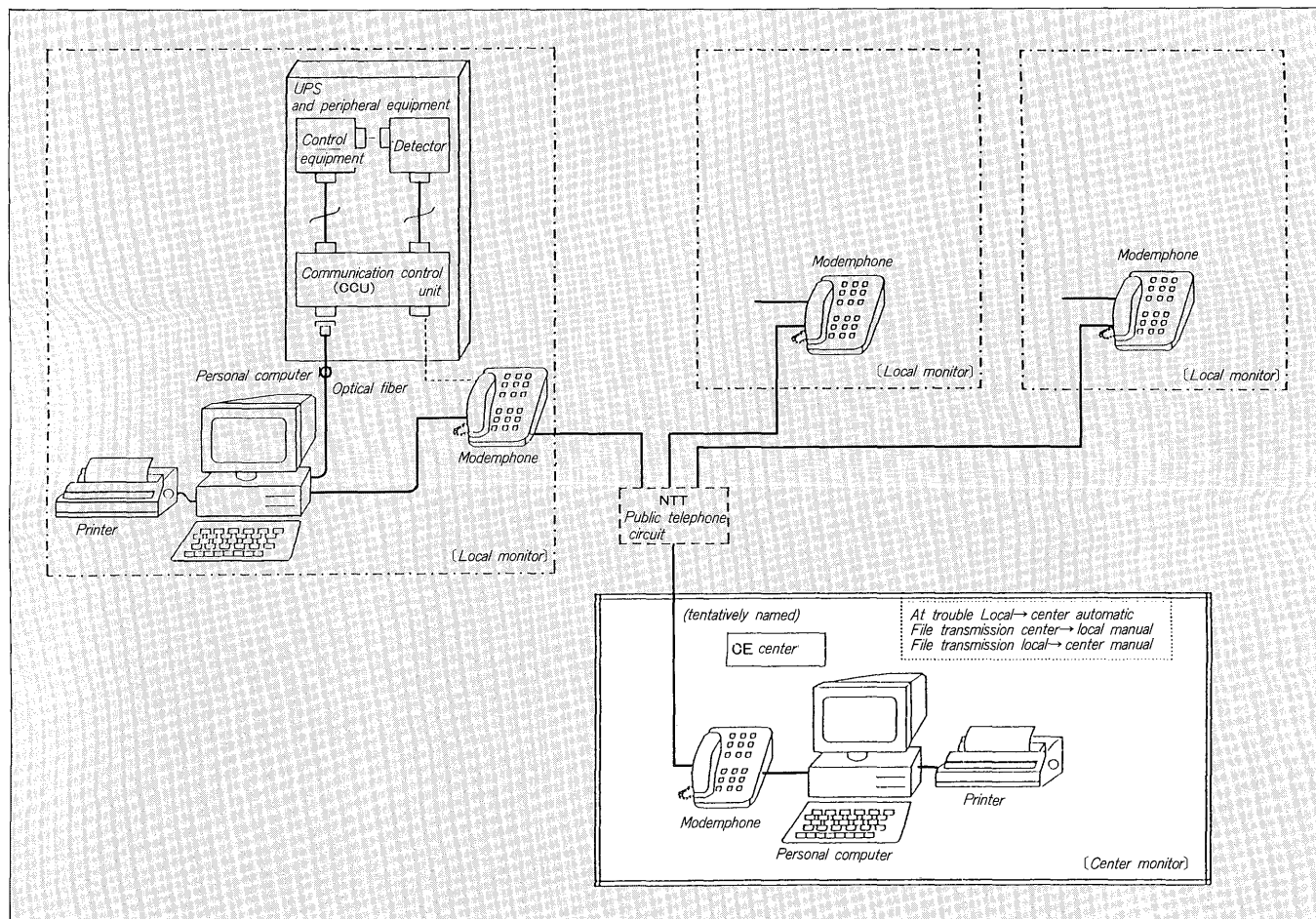


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Table 5 Parts management table

No.	Device name	Type	Quantity	Replacement date Repair date	Replace period	Elapsed time	Predicted replacement date
1	A1-MCB1	SA-403K/400XWK	1	1987.08	15.0 years	2.6 years	2002.08
2	A1-MCB2	SA403K/300XWKF-00085	1	1987.08	15.0 years	2.6 years	2002.08
3	A1-MCB3	SA403K/300MWKF-01015	1	1987.08	7.5 years 6,000 times	2.6 years 500 times	1995.02
5	A0-MCB31	SA403KS/W2	1	1987.08	15.0 years	2.6 years	2002.08
6	A0-MCB41	SA403K/400MWKF-01015	1	1987.08	7.5 years 6,000 times	2.6 years 0 times	1995.02
10	A2-MCB1	SA403K/400XWK	1	1987.08	15.0 years	2.6 years	2002.08
11	A1-MCB2	SA403K/300XWKF-00085	1	1987.08	15.0 years	2.6 years	2002.08
12	A2-MCB3	SA403K/300MWKF-01015	1	1987.08	7.5 years 6,000 times	2.6 years 500 times	1995.02
20	A1-BL1-4	FM-10A	4	1987.08	15.0 years 20,000 hr	2.6 years 2,000 hr	1995.04
30	A2-BL1-4	FM-10A	4	1987.08	15.0 years 20,000 hr	2.6 years 0 hr	1995.09
100	A1-RFU1-F1	TK772331C2	1	1987.08	7.5 years 50,000 hr	2.6 years 12,000 hr	1995.02
101	A1-RFU1AF1	TK772331C2	1	1987.08	7.5 years 50,000 hr	2.6 years 12,000 hr	1995.02
102	A1-FSU1	TK772358C2	1	1987.08	7.5 years 50,000 hr	2.6 years 12,000 hr	1995.02
103	A1-IVU1-F	TK773230C3	1	1987.08	7.5 years 50,000 hr	2.6 years 12,000 hr	1995.02
104	A1-IVU1-AF	TK773230C3	1	1987.08	7.5 years 50,000 hr	2.6 years 12,000 hr	1995.02

Fig. 5 Group monitoring system composition example



the many UPS installed at customers at a remote CE center uses a general telephone line to exchange data with the local centers as shown in Fig. 5. Therefore, the center is an important base which supports general technical assistance of each local center.

The center monitor is built by adding an external 20MB hard disk to accumulate the data of each local center as the same configuration as the local center monitor.

Completion of a group management assistance system which reads the detailed data of each local facility instantly is important and systemization by optical file, etc. is being studied.

The data which was sent from the local center is collated with the data base of each local center accumulated at the hard disk and floppy disk provided at the center monitor and the current local monitor data is reproduced and displayed at the same state and the conditions are grasped. At the same time, backed by some AI technology, the trouble cause estimation and processing methods are being studied and braffing of regeneration counter-measures is advancing.

Normally, data is periodically exchanged with the local centers by keyboard operation and the operating conditions are confirmed.

Recently, AI technology has gained attention and the introduction of AI technology centered about trouble

diagnosis is being promoted. This function is being added to the center monitor, but the intent is completion so that trouble diagnosis will be possible even at the local center in the future.

## 6. HANDY MONITOR

For customers without a monitor installed, a handy monitor is available for routine inspection. The handy monitor has the same functions as the monitor. A laptop personal computer is used at the handy monitor for convenience in carrying.

## 7. CONCLUSION

UPS monitors were introduced above. We think that the application of monitors will also expand in the continued expansion of application of the UPS. In these days in which how to raise the quality of service is a problem, we will be happy if these monitors can be even slightly connected to improvement of service. We plan further enhancement backed by advanced technology.

Finally, the authors wish to express their gratitude to users and concerned parties for their various guidance regarding this development and application.