UDC 681.32:658.5.011.56:628.1/.3

INTEGRATED CONTROL SYSTEMS FOR PROCESS AUTOMATION IN WATER AND SEWAGE TREATMENT

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1. FOREWORD

To general industry, the role of information systems has changed substantially in recent years– that is, they are said to be not only a "tactical tool" for making business more efficient, but are also becoming a "strategic weapon" which has a large affect on management.

The building of a superior information system for quick and flexible reaction to the severe management environment is becoming an urgent problem. In the manufacturing industry, the total CIM concept encompassing everything from the management level to control equipment (robot machines) of the manufacturing site is being promoted forcefully. Even water and sewage enterprises are making efforts to become businesses with a strong management foundation by making management, facilities operation, maintenance management, business, and other jobs uniforms and more efficient. Information systems (total management system, water application system, etc.) are attracting strong concern as a "strategic weapon" for this purpose. Currently, most water and sewage treatment enterprise systems business department computer systems and various facilities (filtration plant, treatment plant, etc.) build for business expansion) and operation use electric and instrumentation computer systems. The latter system, the so-called process automation (PA) involves many problems from the standpoint of advancing total systemization. In particular, the worst of coordination of electric control (E), instrumentation control (1), and computer system (C) is pointed out. The Fuji Electric EIC integrated control system that solved this problem is introduced here.
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2. WHAT IS AN INTEGRATED CONTROL SYSTEM?

2.1 Water and sewage treatment system problem

The problem facing water and sewage treatment enterprises is greater equipping of the infrastructure for the 21st century. It is pointed out that the prosperous country of Japan lags behind the United State and Europe when it comes to equipping. Actually, the diffusion rate of sewage works is substantially lower than that of Europe and the United States. The diffusion rate of water works is high, but there are still many unsolved problems, such as the problems, such as the problem of water quality (trihalomethianes, etc.). That is, both departments must proceed with farther basic equipping. Electric machinery, instrumentation, and computer are expected to play an important role in promoting this equipping in both fields. The topics demanded of the system are summarized below.

(1) System matched to hierarchical equipping.

Regarding equipping of sewage works, to use the limited budget effectively, efficient investment by forecasting population growth is the basis of planning. For river side basin sewage works for a wide area, expansion can take several tens of years. Therefore, the system must be flexible enough to cover everything from the initial facilities to the final complete facility and initial investment must be held to a minimum and expansion must be possible without shutting down thw system.

(2) System matched to restructuring and integration

Renovation of facilities (filtration plant, pumping station) and restructuring of entire facilities due to population growth, underground water regulation and other raw water acquisition and aging is progressing. Consolidation of facilities and one dimensional, rational management of multiple water works are essential conditions for securing safe and fine water. Consolidation of facilities increases the number of unmanned facilities and reliability and advanced functions for unmanning are desired of a system. To realize one dimensional management of facilities and information, it is essential that the system use a computer and have an information network function which connects wide ranging facilities.

(3) System which can cope with new technology

Research and development on advanced treatment technology is advancing in all areas as an thw most important problem in water quality improvement in the water and sewage treatment fields. Development of advanced treatment by biotechnology is being promoted cooperatively by governmental, academic, and public organizations. In addition, development of artificail intelligence (AI), mapping, water quality sensors and other technologies which will be useful in the next generation is progressing.

On the other hand, fuzzy logic has also been applied to chemical injection control, and new technologies are being realized. Efforts must be made to freely incorporate these leading technologies and new ventures in systems.

(4) Operation management and maintenance management stressing humans

Water and sewage treatment facilities are steadily becoming more complex and larger and the shortage of specialists is becoming more severe. To operate facilities with limited personnel, a system that is easy to operate and simple to maintenance is a problem. Moreover, to improve the work environment, a control room that projects an office image is demanded and supervision of the operation and maintenance management data at one place must be possible.

(5) System which can display the independence of the enterprise

The size of the enterprise, water quality differences, enterprise constitution, regionality, and other nationwide water and sewage treatment enterprises are independent. Similar to the diverse needs of people, systems have also entered the age of diversity that reflects the independence of the customer. That is, for a system to incorporate the independence of each enterprise, development of easily customized equipment and freedom for the customer to recombine the system are demanded. In the past, general purpose type and standard type systems developed by the manufacturer were introduced, but in the future, the system should be built by both the customer and the manufacturer.

2.2 Why is an integrated control system necessary?

In the past, the electric control system, instrumentation, system and computer systems were planned, designed, and manufactured independently and uncoordinated points in the interallocation of functions and interfaces stood out. Therefore, degradation of system performance, high cost, and other problems were created. These problems are arranged below. The lack of standards and organization is also another cause.

(1) Nonuniformity of interfaces and complexity of system architecture

Water and sewage treatment systems are made up three elements: electric control system, instrumentation control system, and computer system. Examples of their problems will be examined from the standpoints of signal system, data management, and software.

The basic signal system concept is AC signals (PT, CT) for the electric control system, DC signals (DC4~20mA) for the instrumentation system, and digital signals for the computer system. When data is interchanged between systems, a converter is necessary between each system. The converter is not only expensive and space consuming, but also degrade performance (for example, precision). From the viewpoint of data management the distributed control system (DCS) and computer system data base have not been uniformed. Therefore, since data correction and addition are performed independently, they are troublesome and costly and errors are produced.

From the software viewpoint, when a sequence control program is written, whereas the mainstream is the ladder system for the electric control system programmable controller, that of the instrumentation system is a decision table system and the customer must learn each programming.

The system architecture involves various problems, such as the above.

(2) Private network

Recently, networking among system devices has been advancing with the advance of communication technology. However, connection only within the electrical controls instrumentation, and computer systems is possible and there are many private networks usable only within the same manufacturer.

(3) Insufficient man-machine and maintenace management functions

The advance of man-machine devices, especially VDT, is amazing and high resolution, high precision, larger size, and features which make them easier to use and view by the operator are being pursued. Conversely, the contents displayed on the VDT are delayed. The cause of this is thought to be the lack of information related to process automation (PA) maintenance management. For example, a mass of computer-related information is maximum instantly. but sensor information is only measured value. and sensor RAS information and span, zero-range, and other maintenance-related information is insufficient. This also applies to electric machinery and the balance of the overall system is worsened. Supervisory control operation in computer system has been by computer terminal, and in instrumentation, by operator control station.

(4) Insufficient engineering functions

The tendency was for the customer to specify the functions required when ordering the system and to entrust the detailed design and manufacture of the system to the manufacturer.

This was the cause in the delay of engineering tools which can be referenced in manufacture (especially software) by the customer. Further, it is point which creates a large expense at system expansion and renovation and creates problems which do not amply reflect the customer specifications in the system.

Therefore, realization of a system with the independent of water and sewage treatment enterprises was difficult.

Fuji Electric proposes the "EIC integrated control system" to solve these problems.

2.3 EIC integrated control system concept

When developing the integrated control system, the conventional electric, instrumentation, and computer systems items that could be designed independently were arranged individually and new systems and devices were developed in accordance with a new unified concept. This solves the problems previously discussed. The EIC integrated control system concept is shown in *Fig. 1*.

Fig. 1 EIC integrated control system concept

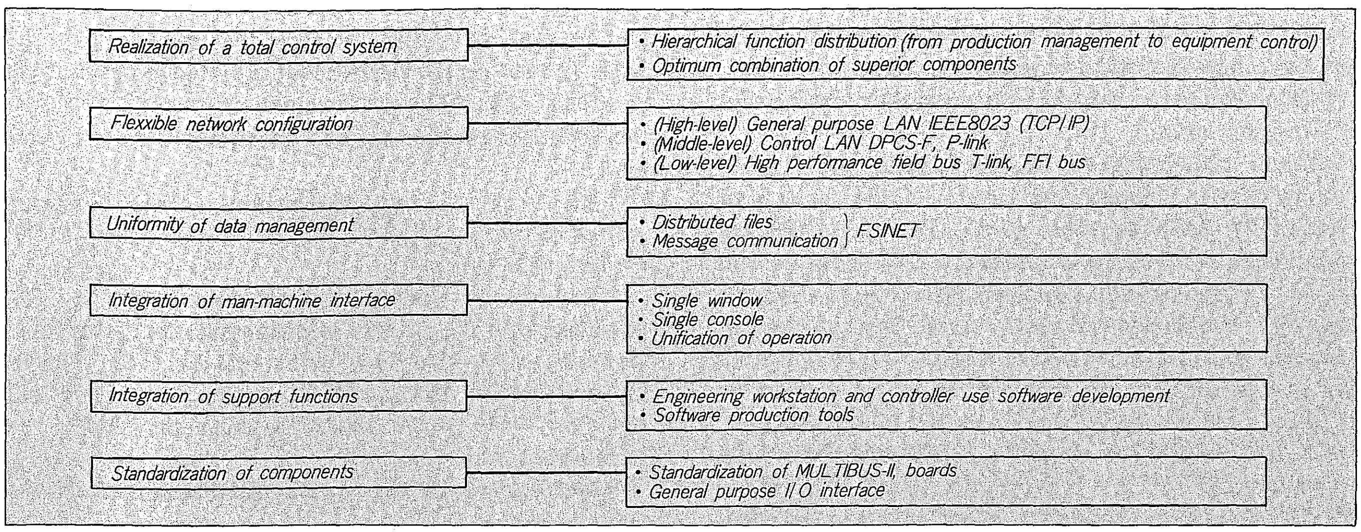
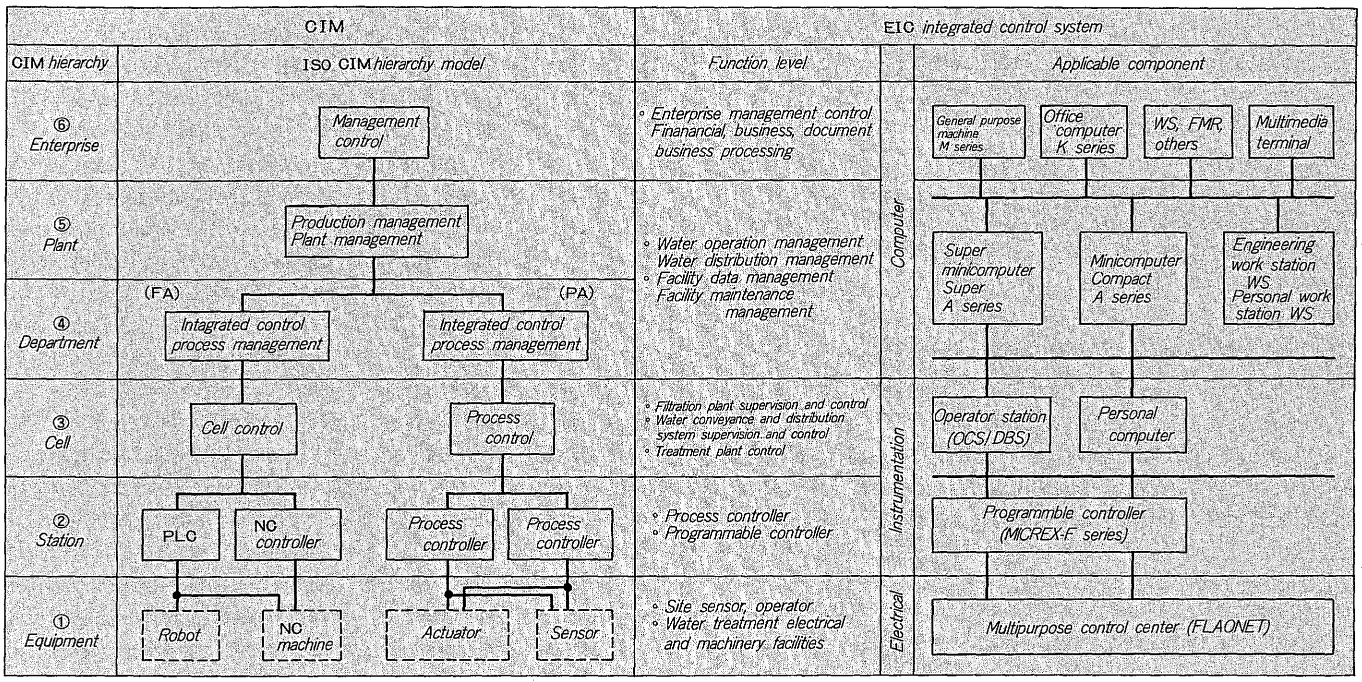


Fig. 2 CIM hierarchy model and integrated control system



3. EIC INTEGRATED CONTROL SYSTEM TECHNOLOGY

3.1 Hierarchical system configuration

With the EIC integrated control system concept, a total system is constructed by a hierarchical configuration (vertical distribution) by function level and function distribution configuration (horizontal distribution) at each level. The EIC integrated control system and an ISO CIM hierarchical model are compared in *Fig. 2*. That is, a freely combined system can be realized by networking everything from device level electric facilities and instrumentation sensors to plant and enterprise level computer.

3.2 Network technology

Network technology is one of the key components for realizing the prescribed functions and performance by each system at each level to realize a flexible and abundant system architecture, data base one dimensionalization, etc. In using the network system, from the standpoints of system expandability, maintainability, and overall technology, a network with an open architecture is necessary at middle and high-level systems. The low level system stresses performance (especially, speed) and is made Fuji Electric's unique private network with good affinity with

Table 1 Network components

Kind of LAN	Transmission medium	Speed and interface	Connected devices	Application, features, etc.
F2890 series multimedia highway	Optical fiber	• 205/410Mbps • ISO 8802/3 Digital network Private branch exchange • Image/speech	• Various computers • Exchange • Television camera/ speaker • Line terminal (data terminal) • Branch LAN	• Backbone LAN (accommodating multichannel LAN, system LAN) • Multimedia integration including moving images • Large private high-speed trucnk network • Duplexed loop • Maximum 10km between nodes
F2880 series optical data highway	Optical fiber	• ~1.5Mbs < Note > • Circuit interface • Voice interface	• Various information machines RS-232-C, V.24, V.35, G712, RS-449, etc.	• Various terminals with general purpose interface, including modem interface can be connected • Duplexed loop • Maximum 0.5km between nodes (option 3km)
CSMA/CD system LAN	Coaxial Optical fiber	• 10Mbs • CSMA/CD	• Various computers (M/K/A/U series) • Personal computer • NMC	• Construction of host ––––– and horizontal/ vertical distributed system by connection of various terminals • DSLINK network TCP/IP
FSL	Optical fiber	• 10/33Mbps • Token ring	• M/A/U series computer	• High-speed communication between processors
MAP	Coaxial	• 5/10Mps • Token bus	• A series • Controller (for FA/PA)	• International standards control system LAN • Connection of various kinds of computers and controllers
DPCS-F	Coaxial Optical fiber	• 10Mbps • Token bus	• A series • Microcontroller (MICREX-PIII)	• Control system (FTAINS) uncleus LAN
P link	Coaxial Optical fiber	• 5Mbps • Token bus	• Compact A • Microcontroller (MICREX-PIIII F100/200)	• Connect to middle- and low-level computer by data communication link between controllers

< Note > Channel speed 4Mbps, 33Mbps or F2881 connection interface speed

Fig. 3 Network configuration

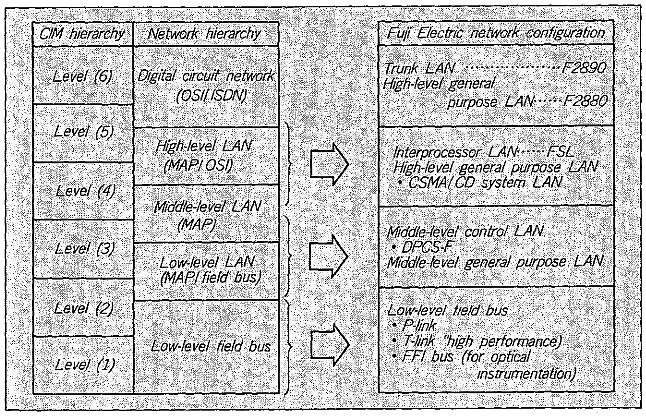


Fig. 4 Integrated data management concept

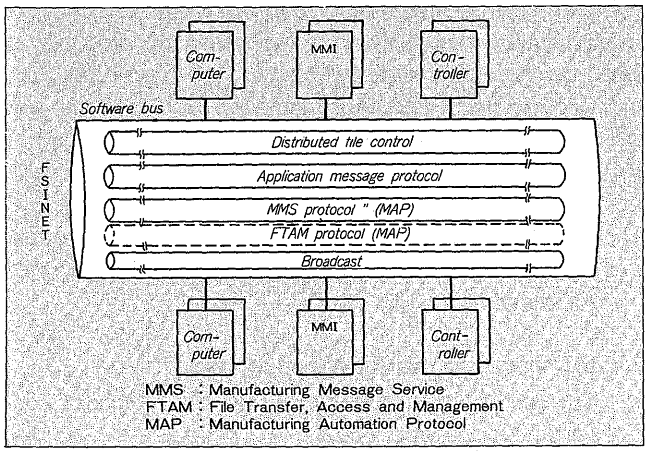
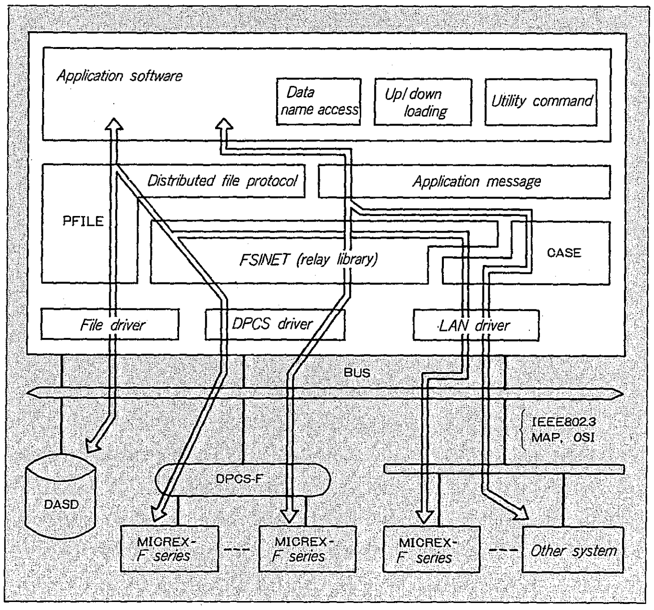


Fig. 5 Integrated data management structure



low-level devices. The network configuration is shown in *Fig. 3*. The network components are listed in *Table 1*.

3.3 Data management

Integrated data management (FSINET) that allows data access without being conscious of the configured network and components was developed for the EIC integrated control system. This concept is shown in *Fig. 4*. The

Fig. 6 Single window concept

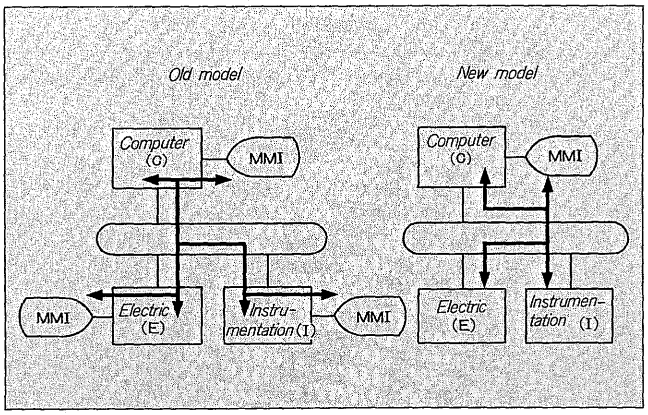
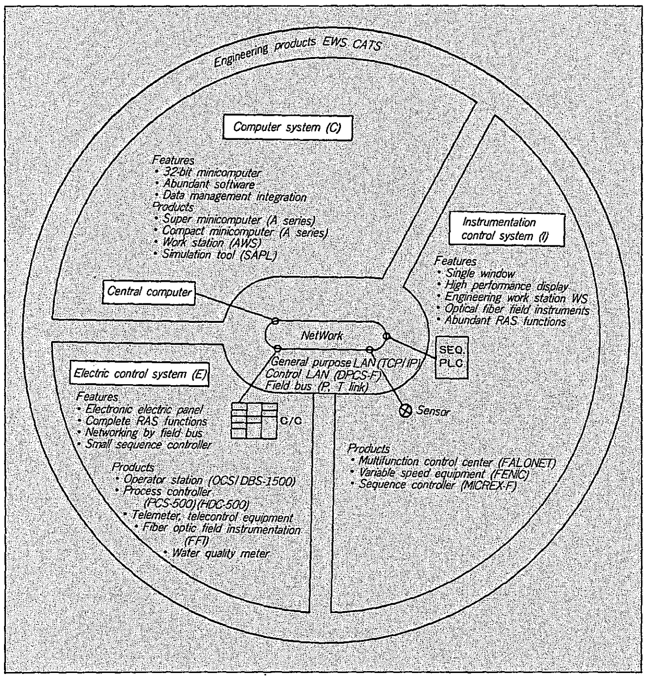


Fig. 7 EIC integrated control system product group



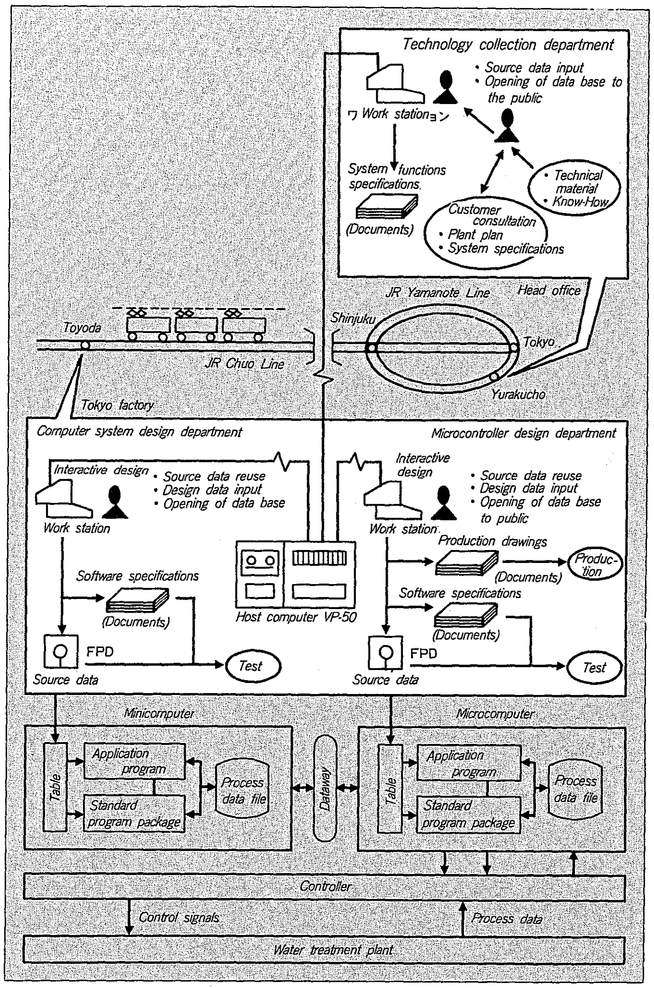
structure is shown in *Fig. 5*.

The distributed file approach extends process data file management processing developed for 32-bit minicomputer (A Series) to digital instrumentation system (MICREX-F series) files. Data can be freely accessed from application software by the same interface by means of this. That is, the data of the entire system can be modified by processing at one place for data correction and addition.

Data with the same meaning may have a different data representation format depending on the specifications of each hardware, but with FSINET, data conversion routines are provided in advance to reduce application processing.

FSINET processes data base (distributed files) between devices and uniforms the protocol between networks. Therefore, the user can handle data without a knowledge of the differences in the specifications between devices and the network specifications and the preparation of customer software is easy.

Fig. 8 CATS system concept



3.4 Man-machine interface technology

Conventional CRT displays are available in fixed display format, which stresses display and operation response, accuracy, and safety, and free display format, which provides display and operation functions with a high degree of freedom. The former was mainly used with instrumentation systems and the latter was used with computer systems.

For farther integration, the screen functions were strengthened by extensively incorporating the free format based on the instrumentation operator station. In the past, the electric, instrumentation, and computer systems was given a man-machine device and plant correspondence was performed for each department, but primary plant operation should be supervised and controlled via one window. Therefore, a single window through which all the information is seen from one CRT was realized with the integrated control system. (*Fig. 6*).

3.5 EIC integrated control system products

The product groups making up the EIC integrated control system are shown in *Fig. 7*.

3.6 Engineering technology

It is no exaggeration to say that the quality of the software determines the capability of an integrated control system. To produce good software, the participation of the customer and complete support tools for improving software quality are indispensable. An engineering work station (EWS) for electric, instrumentation, and computer system software preparation has been completed. The EWS is interactive format to allow the customer to design sequence circuits. Loading to the actual machine and testing have been made possible by using a ladder type decision table system freely. The software support tool (CATS) is a system which uniforms management of engineering data base so that the necessary data is handled for each design objective and component. The design results at each department are input to a data base and necessary data is immediately presented to the related departments. By means of this, the customer participates in system construction more than in the past from the time of system deisgn and can incorporate the special characteristics of the enterprise into the system.

The CATS system concept is shown in *Fig. 8*.

4. CONCLUSION

The integrated control system developed by Fuji Electric is expected to be used as one means of solving the problems of the water and sewage treatment world. We wish to realize system which display the independence of the enterprise through the country.