FOX 2/30

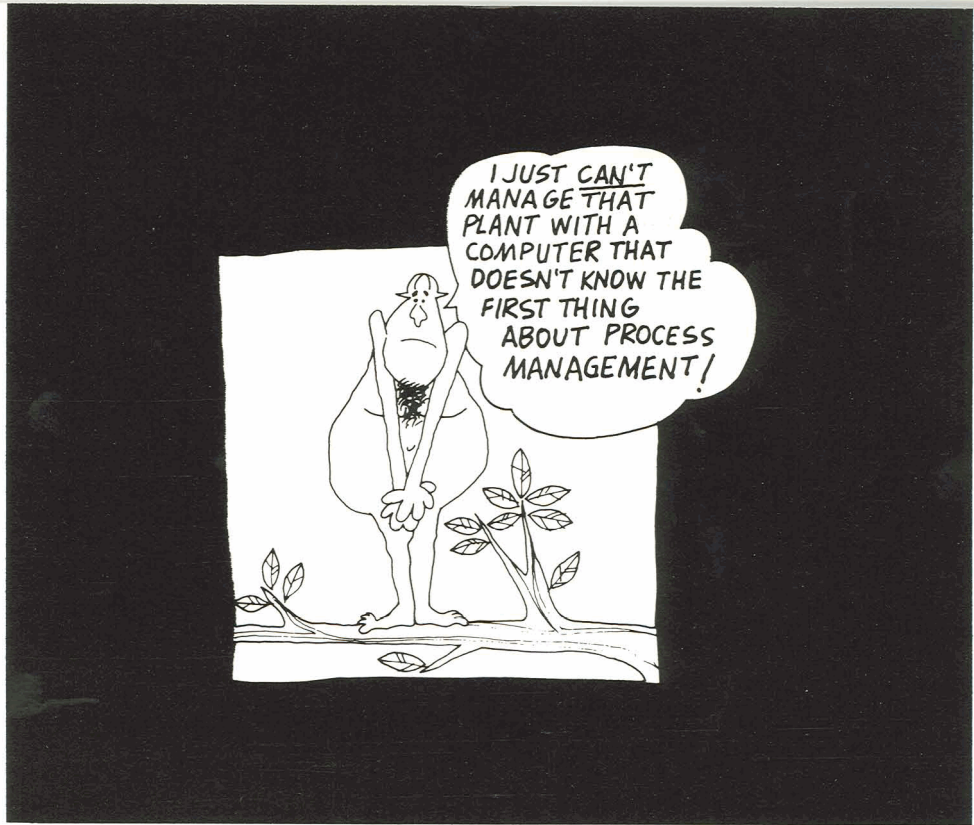## SHIRT-SLEEVE COMPUTER SYSTEMS FOR PROCESS MANAGEMENT

FOXBORO

FOXBORO SHIRT-SLEEVE COMPUTER SYSTEMS STARTED IN PROCESS CONTROL AND WORKED THEIR WAY UP TO PROCESS MANAGEMENT.

For 60 years Foxboro control systems have been making processes hum. For the past 10 of these years, more and more processes have been controlled by Foxboro computer systems.

Now, FOX 2 and FOX 1 shirt-sleeve computer systems are powerful process *management* tools. They use the same information generated for process control operations to rush you vital facts to help you make timely plant management decisions on shipments, inventory, quality, raw materials, utilities, and more.

FOX 2/30 SYSTEM —
ITS USABILITY WON'T SURPRISE A LOT OF PEOPLE

FOX 2/30 is a natural — the kind of shirt-sleeve computer system plant management people in the process industries have come to expect from Foxboro.

It's powerful — FOX 2/30 is a process computer system that can handle data acquisition, data reduction and analysis, logging, performance monitoring, software development, optimization, supervisory control, reporting, monitoring, alarming, regulatory control, and sequential control. In short — any medium-to-large plant-management and -control task imaginable.

It's easy to use — FOX 2/30 has a low-overhead foreground/background multi-programming operating system, OPSYS, that's so modular you can even pull the background out. It has two higher-level languages: Fill-in-the-blanks IMPAC for process monitoring and control; FORTRAN IV for all supervisory programming functions. It has a flexible process/operator interface — totally integrated in the software system via process oper-ator's consoles, CRT terminals, and teletypewriters. It has on-line background programming, a sophisticated file manager that lets the user easily file programs and data, and excellent system security.
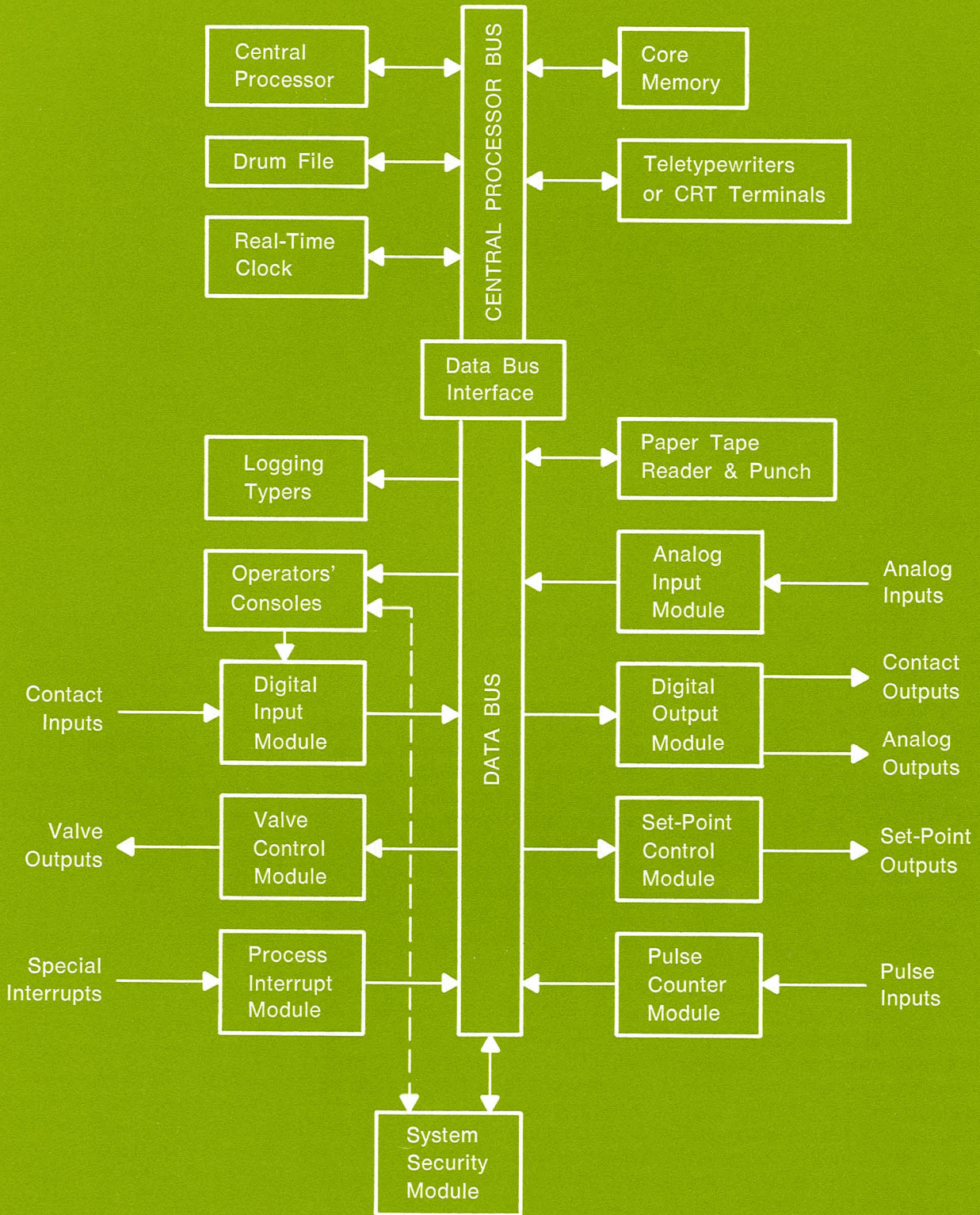
It grows on you . . . painlessly — FOX 2/30 comes in easy-to-put-together bits and pieces. Because it's so modular, both in hardware and software, you can start off at the lowest possible cost and grow as your needs grow . . . easily and economically. Consider the hardware. Systems are put together from basic building blocks — completely independent subsystems. Because of this modularity, expansion in your operation is simple. So is maintenance. Consider the software. It's modular, too, so if you don't need a particular function, you don't have to implement it.

It communicates — FOX 2/30 can easily communicate with other Foxboro computer systems and with large corporate computers in hierarchical management information systems.

FOX 2/30 PROCESS MANAGEMENT SYSTEM OFFERS YOU ALL THESE FEATURES . . . AND MORE

- FOX 2 IMPAC with fill-in-the-blanks implementation
- FORTRAN IV
- Fully programmed operator's CRT terminal
- Pushbutton operator's console
- Real-time multi-programming operating system
- Program requestor for time-shared background programs
- Object Module Linker and Librarian
- Sophisticated File Manager
- On-line Debug Monitor
- OPSYS error-handling package
- Hardware designed for reliability in industrial environment
- Large, powerful process control instruction set
- File-oriented high-speed bulk storage
- Bit- and byte-handling instructions
- Direct addressing of total core memory
- Indirect and literal addressing with pre- and post-indexing
- Hardware index registers
- Hardware stacks handle re-entrant routines
- Multi-level hardware interrupt
- High-performance process input/output hardware
- Extensive peripheral software support
- Power-failure detection and automatic restart

FOX 2/30 EQUIPMENT COMPLEMENT

CENTRAL PROCESSOR BUS

Central Processor ⟷ Central Processor Bus ⟷ Core Memory

Drum File ⟷ Central Processor Bus ⟷ Teletypewriters or CRT Terminals

Real-Time Clock ⟷ Central Processor Bus

Data Bus Interface

DATA BUS

Logging Typers ← Data Bus ⟷ Paper Tape Reader & Punch

Operators' Consoles ← Data Bus ← Analog Input Module ← Analog Inputs

Contact Inputs → Digital Input Module → Data Bus → Digital Output Module → Contact Outputs / Analog Outputs

Valve Outputs ← Valve Control Module ← Data Bus → Set-Point Control Module → Set-Point Outputs

Special Interrupts → Process Interrupt Module → Data Bus ← Pulse Counter Module ← Pulse Inputs

System Security Module

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Foxboro supplies the kind of software you need — debugged and proven. This means that with a minimum of programming involvement, you quickly get the plant sensor information you need for analysis, management, and control. Here's what we've put into the FOX 2/30 software:

- *Real-time multi-programming operating systems* — I/O control systems, file managers.
- *FOX 2 IMPAC* — a comprehensive process-oriented real-time data acquisition and control system with fill-in-the-blanks and conversational implementation.
- *System implementation and utility software* — a powerful assembler, text editor, debug monitor, console support services, error handling, on- and off-line diagnostics, and system generation.
- *And FORTRAN IV* — a powerful package for all supervisory programming functions: report generation, performance calculations, and process optimization . . . aug-

mented for use by process engineers and compatible with 1130 FORTRAN.

The Operating System

The FOX 2/30 Operating System (OPSYS) has an efficient low-overhead design that minimizes both core requirements and the complexities that add fat — but no muscle — to a system. Unlike most systems in its range, it spends a minimal percentage of its time telling itself what to do. The rest of the time it's getting things done. This cuts down the implementation costs, too, because you don't suffer the overhead of a too-complex operating system.

You can buy the smallest possible operating system for the job you have in mind. For example, the background programming feature can be eliminated for dedicated systems that do not require on-line program development. Also, the system is device-independent, so
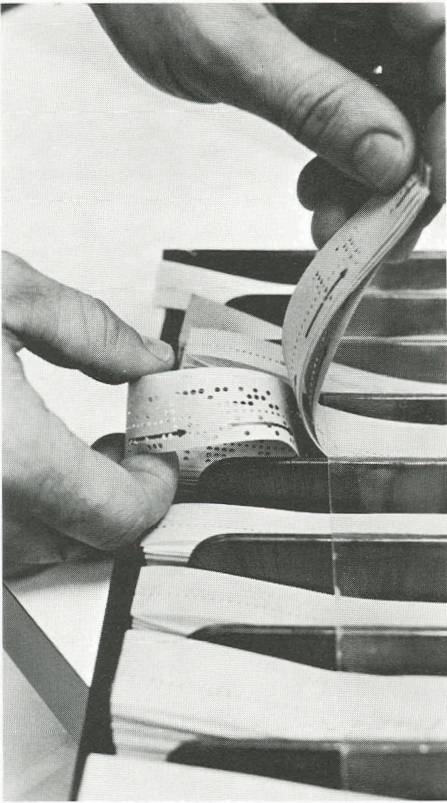
the programmer does his programming without knowing — or caring — what peripheral device (teletypewriter, printer, drum) he will ultimately use.

The file management system is large in function, but small in core requirements. You never have to know where things are; you call them by file number. This not only saves time, but simplifies programming.

An on-line program-development capability is rare in a system in FOX 2/30's price range. With this FOX 2/30 feature, a programmer can develop his programs on line and install them without interrupting other system functions.

Although OPSYS performs a wide range of functions, its primary duty is to control the operation and use of all FOX 2 resources in a way that most effectively fulfills your needs.

OPSYS can be configured to support everything from a basic con-

figuration monitoring a process and printing messages on a teletype, to a system performing on-line data-processing tasks as well as control and supervisory functions. The software can support as many as 12 peripheral input/output devices, including teletypewriters, CRT's, typers, or any serial ASCII device you may require.

Multi-programming enhances real-time response

Foreground/background with multi-programming is the technique used by FOX 2/30 to obtain the greatest amount of work from the smallest system in the shortest period of time. By maximizing the system's effective work, multi-programming significantly enhances its ability to respond in real time.

Multi-programming handles numerous routines or programs simultaneously by interleaving their execution. To the observer, the computer appears to be executing several programs simultaneously. Instead, it is performing several tasks concurrently in discrete millionths-of-a-second intervals — in much less time than it would take to perform them sequentially.

This technique permits new supervisory programs to be developed on line in the background while plant control goes on safely and smoothly in the foreground under the watchful eye of OPSYS.

First things first

Demands on the FOX 2/30 are scheduled by the multi-programming Real-Time Executive on a priority basis, with the most urgent tasks taking precedence. But rather than provide OPSYS with only program priorities to determine scheduling sequences, we've added five operating modes for greater flexibility:

1. Core resident
2. Periodic
3. Real-time (RT)
4. Internal time-shared (ITS)
5. External time-shared (ETS)

The Executive directs allocation of computing time, core and bulk storage, and access to I/O devices. It does this via subordinate OPSYS programs, including the Input/Output System, File Manager, Console System Software, and Job Program Requestor.

Input/Output System

The I/O System schedules the operation of all peripheral devices: teletypewriter, paper tape reader and punch, and process typers. Since the system is device-independent, one device can handle the work of another if it fails.

File Manager

The FOX 2/30 File Manager is

large in function, but small in core requirements. Used by almost every program in the system to access data stored in the bulk memory, the file manager keeps track of where everything is stored on drum so the user doesn't have to. He simply calls it by a file number. The File Manager does the rest: examines its directory, finds the data, and retrieves it. This not only saves the user time, but makes programming a lot simpler, too.

The File Manager protects files, making them inaccessible to certain classes of users. For example, writing cannot occur in a read-only file. OPSYS allows the operator to change his file library on line, add and delete, repack, read and punch, replace, and request a map of the contents or a printout of each file. On-line switching of devices and files is helpful in program development, since the user may develop programs without paper tape. It also lets him substitute new programs for old without destroying the old, which can be kept for backup.

Program Management
A very important function of OPSYS is to manage the program requests made by operators and other programs. Library programs can be executed in response to: (1) other programs, (2) the operator at the keyboard, (3) the timer, (4) a contact closure, or (5) an alarm condition. In short, virtually any definable real-time occurrence.

Console System Software
This package makes it easier for the operator and the process to communicate with each other. It controls all communication between the computer and up to three independent operator CRT terminals or pushbutton consoles. It services demands for use of the keyboard and console typer, and controls all data and command transfers involving these devices.

Program Requestor
The Program Requestor, which controls execution of all background programs, is one of the major interfaces between the system and the process engineer. It does these tasks so the engineer doesn't have to: automatically sets up sequences of tests, executions, and language processing required for developing and running supervisory programs. The Program Requestor manages and time-shares all background activity on the basis of priorities and job statements provided by the process engineer.
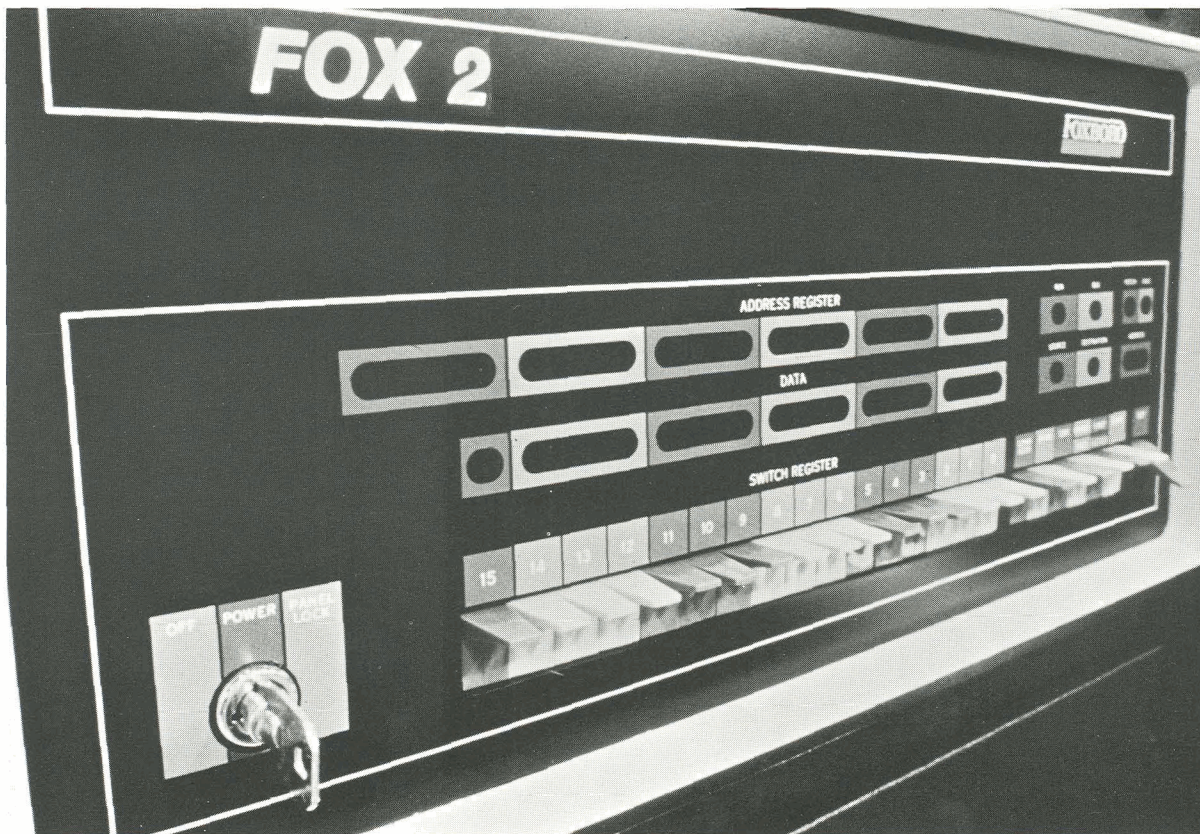
Get-Up-And-Go-FOX 2
Impac System

FOX 2 IMPAC is an advanced software system that gets a FOX 2/30 working for you quickly, and without the typical extensive programming effort. A comprehensive system for monitoring, alarming, logging, and supervisory and regulatory control, IMPAC requires the user only to enter basic process information on fill-in-the-blanks forms or conversational displays. *It* does the rest:

- Scans analog and digital inputs.
- Processes input data and converts it to engineering units.
- Allows on-line modifications or additions.
- Generates set-point or DDC outputs.

Modularity cuts costs, improves efficiency

Because IMPAC is modular, it can be configured to your specific I/O requirements. This not only minimizes hardware and software needs, but improves the system's operating efficiency. Modularity also permits variations in the numbers and types of field input devices, variations in operator input and output devices, and a broad range of system functional capabilities.

And modularity means the proper programs can be selected for efficient system sizing and operation. From the simplest to the most complex systems, IMPAC can support a variety of control modes: supervisory, set-point, direct digital, and sequential.

Fast system implementation

After absorbing the user's process information, IMPAC handles all process and output hardware assignments and parameter specifications; creates block records for each scan, computation, supervisory or control function; separates them by scanning periods; and saves them in bulk storage, awaiting their use. They provide the information for all monitoring and control activities as well as for logging and display. Scan and control blocks will frequently be linked together to form control loops.

IMPAC creates messages and cross-reference tables, and also provides all the necessary documentation: core and drum location maps, and reports sorted by record or point identification, instrument type, digital inputs, valve inputs, etc.

Many modular control elements

IMPAC's scan and control blocks may be used in plant control applications to configure feed-

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forward, feedback, computational and advanced control strategies. The FOX 2 IMPAC scan and control blocks include:

- Scan (for monitoring, alarming, and supervisory applications)
- PID
- Lead/Lag
- Ratio
- Bias
- Parabolic
- Multiply/Divide
- Add/Subtract or Weighted Average
- Auto-Select
- Set-Point Ramp

We do the dirty work — automatically

Because we know process management and control so well, it's second nature to build certain features into our systems; features that save our customers countless hours of laborious programming time and a great deal of money.

Take pre-programmed automatic point processing, for example. A lot of functions must be performed on any raw process data before it is useful — or even available — to a manager, operator, or FORTRAN program. All *you* have to do to implement these functions is to state the relevant parameters on an IMPAC fill-in-the-blanks form. We do the rest:

- Sequence the A-D converter and multiplexer, and bring raw counts into core.
- Perform amplifier drift compensation (offset and slope).
- Perform thermocouple junction temperature compensation.
- Perform other signal conditioning (e.g., square root).
- Perform digital filtering.
- Perform digital integration.
- Perform reasonableness checks.
- Perform limit checking.

- Output alarm messages.
- Trigger action programs.
- Convert data to engineering units.

Easy supervisory programming development

We know that the requirements for every process vary, and that no one single set of features will meet all needs. So we have made it easy to develop supervisory programs. Generally written in FORTRAN, they accept data from, and may pass control information to, IMPAC. Programs include flow compensation, performance calculations, calculated measurement values, sequence control, optimization calculations, and reporting and logging operations.

In FOX 2/30, FORTRAN programs can be written, compiled, and debugged on line without interfering with any other functions occurring in the system. How? Through the

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use of extensive on-line utility programs and a background mode of program execution. After debugging, the programs can be scheduled to run automatically on a periodic or demand basis.

Supervisory programs are provided with direct access to IMPAC block records and process I/O equipment. Programs may be written in either FORTRAN or Assembly language.

FOX 2 IMPAC helps man talk to system and process . . .

IMPAC provides complete facilities for the plant manager, operator, or engineer to communicate with FOX 2/30 or with the process. They include operator's consoles, pushbutton panels, trend recorders, typewriters, and CRT displays. Also, the system terminal provides manual control of the system and visual indication of computer status.

Consoles permit the operator to interrogate the process, display data, execute commands, and notify the operator of alarm conditions. The CRT displays and typers let the operator visually monitor alarms and trend data.

. . . Blankets the process with security

Process, programs, and equipment are continuously checked by IMPAC to keep the system running and operating properly. IMPAC process security consists of a network of hardware and software functions which monitor the operation of the central processor, I/O modules, AC and I/O power, etc., and cause actions to be taken which will minimize the effect of subsystem failures on FOX 2/30.

All major system functions are subject to self-checking and failure alarming. If a failure is de-

tected, the system will continue to perform any task it is able to, such as alarming, for as long as possible, and to maintain system integrity. These features increase system availability and control effectiveness.

Software For On-Line Program Development

With FOX 2/30's optional background-processing capability, you can easily develop programs on line for such plant management functions as management reporting, adaptive modeling, and optimization. Two powerful FOX 2/30 programming tools are FORTRAN IV and a powerful Assembler.

FOX 2/30 FORTRAN has process control extras

It not only has all the elements of ANSI standard FORTRAN IV*, but many real-time extensions for the

*It differs from ANSI in one way: It has a maximum of five continuation lines.

process environment, including bulk storage READ/WRITE commands and process I/O statements for controlling the process directly. In addition, we have implemented the ISA-standard process I/O subroutine calls.

FOX 2/30 FORTRAN gives you the tools you need to implement sophisticated calculation techniques for analysis, simulation, and on-line optimizing. Included in the System Library are the standard FORTRAN mathematical routines, including trigonometric functions, logarithmic functions, exponential routines, and mode conversions.

The FORTRAN compiler's language statements are designed for maximum compatibility with other large-machine FORTRAN compilers and for maximum flexibility in writing supervisory applications

programs. What about error checking? FOX 2 FORTRAN provides over 100 diagnostic checks made on the user program at compile time, plus many run-time diagnostics.

FOX 2 Assembler helps programmers do more

The FOX 2/30 Assembly language system helps experienced users write programs for exceptional application requirements. There are many directives or pseudo-operations, including memory assignments, constant definitions, and data packing. Some of the Assembler's features are:
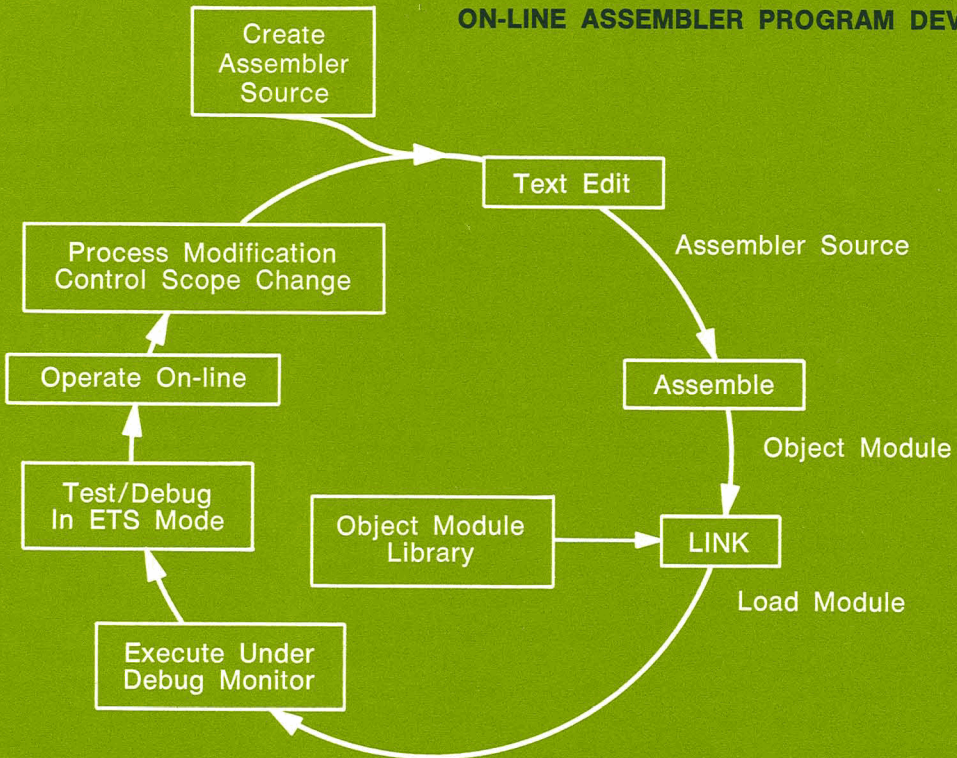
● Relocatable or absolute object code.
● You may segment your program in modular fashion. Modifications need only be made to that segment, rather than to the entire program.
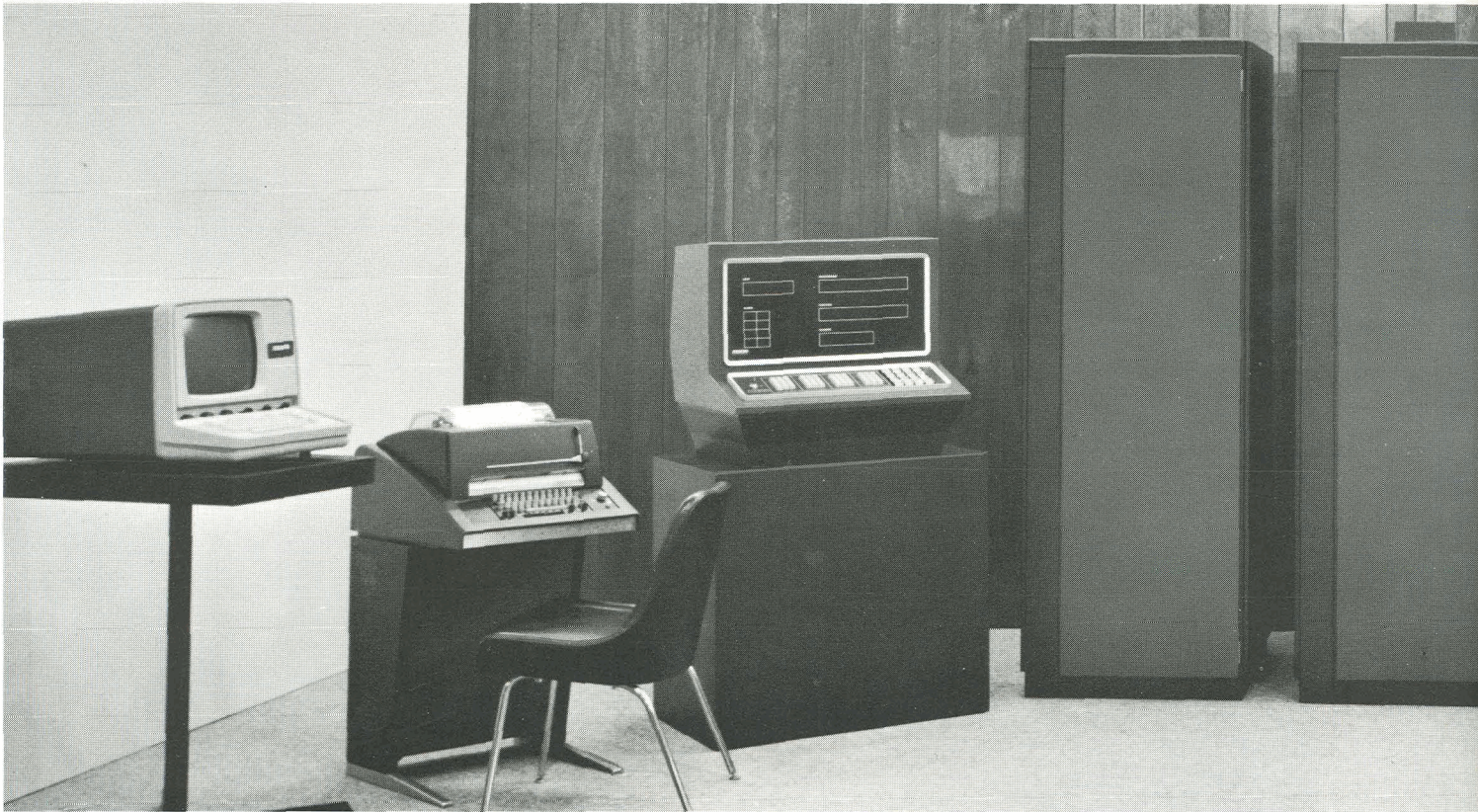
● Extra flexibility in changing several internal values upon reassembly by editing only one constant.
● Facilities for assembling a complete range of addressing modes: register, deferred register, auto-increment, deferred auto-increment, auto-decrement , deferred auto-decrement, index, deferred index, immediate, deferred immediate, relative, and deferred relative.
● Complete repertoire of commands (pseudo-operators) including Conditional Assemblies — a powerful tool for conditionally including or not including portions of the source code in the assembled object module.
● A large number of other general directives provide even more capability.

ON-LINE FORTRAN PROGRAM DEVELOPMENT

```
Create
Fortran
Source
          → Text Edit
                         Fortran Source

Process Modifications
Control Scope Change
                              Compile
                                        Assembler Source
Operate On-line

Test/Debug          Object Module          Assemble
In ETS Mode         Library                        Object Module

Load Module          LINK
```
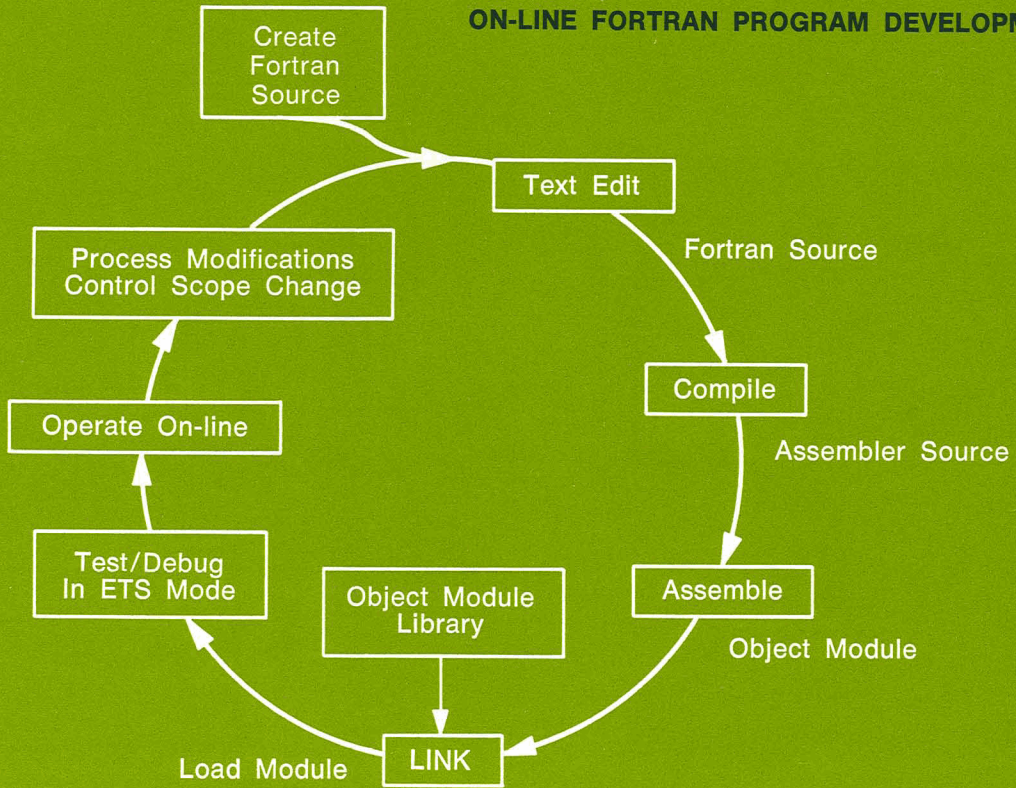
ON-LINE ASSEMBLER PROGRAM DEVELOPMENT

```
Create
Assembler
Source
          → Text Edit
                         Assembler Source

Process Modification
Control Scope Change
                              Assemble
                                        Object Module
Operate On-line

Test/Debug          Object Module          LINK
In ETS Mode         Library
                                        Load Module
Execute Under
Debug Monitor
```

Object module linker and librarian enhances program development

FOX 2/30 program development is greatly enhanced by the ability to link and relocate user programs — both Assembly language and FORTRAN. The Linker lets the user write programs and various subroutines separately, without assigning an absolute address for each module. Some of the FOX 2/30 Linker features are:

• *Program Sectioning* — named control sections allow the sharing of data and/or programs among object modules . . . if an error is discovered in a section, only that section need be reassembled. Less core is required to support background functions, since the total number of symbols in a program may exceed the allowed amount in a single assembly.

• *Address Assignments* — The Linker automatically assigns absolute core-load addresses, so the user does not have to. This not only prevents inadvertent errors or program overlays, but also allows subroutines to change size without influencing the placement of other routines.

• *Output* — A list of undefined symbols is provided for each object module, so the user can easily find linking or programming errors.

• *Object Library Searches* — This feature saves programming time, since often-used subroutines may be referenced, but need not be included, in the assembly. The user does not even have to input a file or paper tape copy of the module; it is inserted for him automatically.

Time-Saving Object Module Librarian

The Object Module Library (OML) is a file containing a group of frequently used routines or subroutines. The OML creates, modifies, deletes, or lists the contents of a library. It has these time-saving advantages:

1. Makes frequently used routines available for automatic linking, thus eliminating extra coding and extra time spent in creating input files.
2. Provides standardization and controlled updating of frequently used routines.
3. Eliminates having one file designated for each user object module, which wastes drum and core space.
4. Expedites the linking process of library searching by providing all modules within one file.
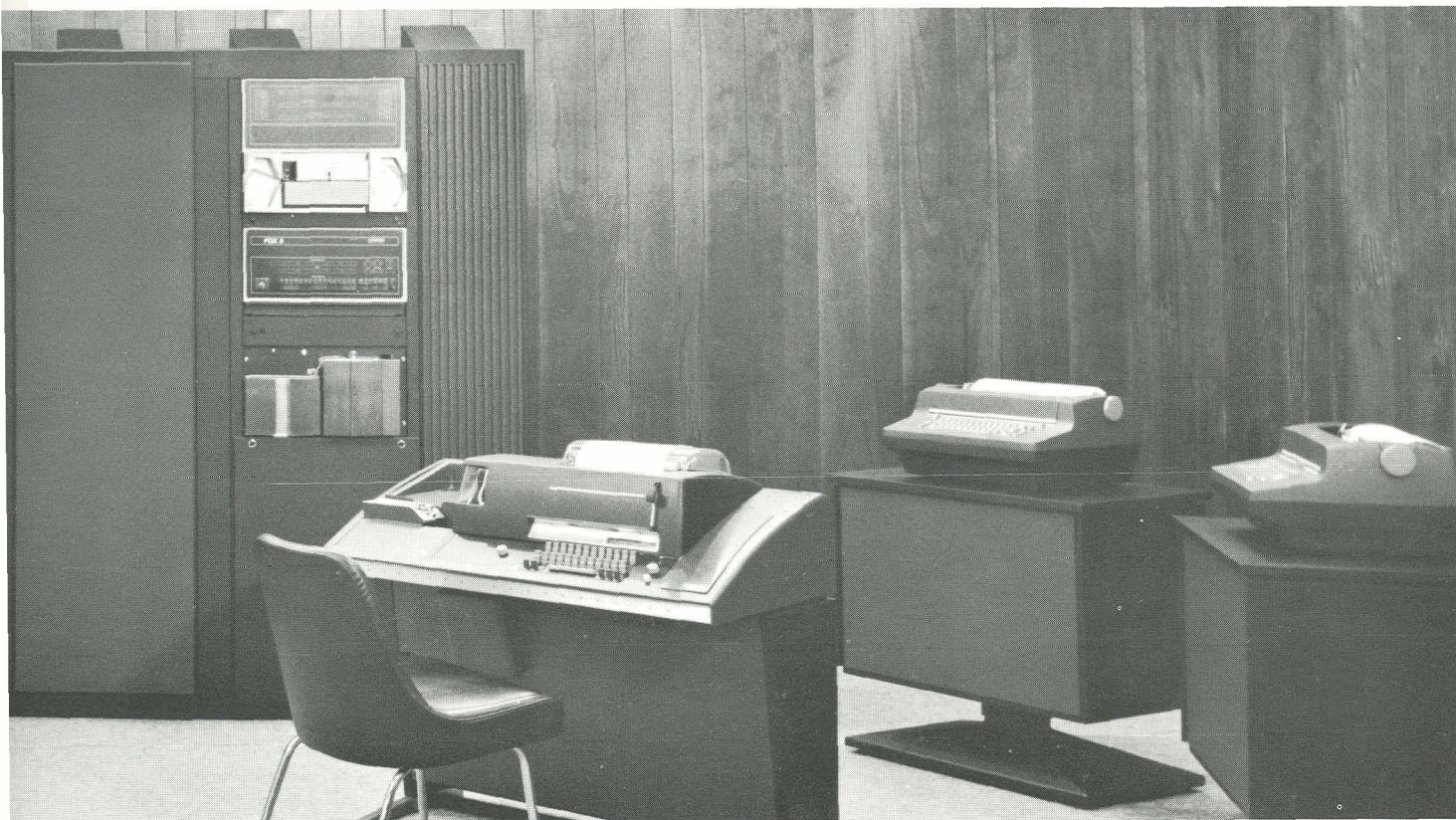
On-Line Debug Monitor provides system security

When you program in Assembly language, you have the greatest possible flexibility in utilizing such FOX 2/30 resources as core, bulk storage, and I/O devices. Although system security during online debugging of Assembler programs is normally a very difficult and complex task, it is made easy by our On-Line Debug Monitor, which prevents (1) erroneous storage of data outside the allowed transient core area, and (2) those instructions which are privileged to OPSYS from being executed.

To help the programmer find program coding errors and to protect OPSYS, the Debug Monitor allows programs to be run in Fenced Execution Mode. In this mode, the program operates within a fence which prevents it from modifying or passing control to locations outside the fence without explicit operator intervention. There are several debugging aids in the Fenced Execution Mode, too.

With FOX 2/30's Debug Monitor, you don't have any worries about interfering with normal system operation when you check out new FORTRAN and Assembly-language programs on line. This means more system up-time and more productive program-development activities.

File Librarian helps software development 14 ways

The File Librarian provides 14 important and necessary functions for software development: Load, Delete, Create, Map, Status, Exchange, I/O Status, Repack, Transfer, Kind, Join, Normal and Auto Input, Punch and Verify, and Drum Check. "Load," for example, is a command that creates a file and reads a load module onto bulk storage in that file. All the normal file may be specified, allowing the user to read the assembled object program onto bulk storage in preparation for debugging. Another command, "Exchange," is very useful when the user wants all references to one file to be switched immediately to another. This is advantageous when installing a new version of a program. Without any loss of program sequence, the control will pass to the new program, and the old one will remain inactive. If the new one is faulty, the old one may be switched in immediately and used until the new one is corrected.

We really rolled our sleeves up on this one to bring you the ultimate in hardware ruggedness, compactness, modularity, reliability, and economy. From its integrated circuits to its field interface racks, the FOX 2/30 is the kind of computer system that helps give plant managers, operators, engineers, and programmers peaceful days . . . and nights.

Powerful, fully software-supported consoles bring you latest plant data for better plant-management decision-making

At the heart of FOX 2/30 are the operator's consoles and CRT terminals — powerful tools plant managers can call upon for instantly current data, displayed the way they want it displayed to help them make the kind of decisions they're paid to make — concerning sales, costs, raw material, inventory, shipments, quality, profits, and more. They can get a total and up-to-date look at their plants any time they want to, often with no more than the touch of a button or two on a FOX 2/30 console.

These consoles can be used with practically all supervisory and control functions. The CRT terminals may also be used for program preparation and testing.

We provide a standard set of console functions and displays. No additional console programming will generally be required after the system arrives at your plant.

Together, the console software and file manager form a highly effective data-entry and -retrieval capability for supervisory calculations, management reporting, program preparation, tuning, control initiation and changes, scanning, and alarming.

FOX 2/30 CRT terminals provide a fast and simple means of implementing new approaches to management and control, or modifying existing schemes through fill-in-the-blanks or conversational displays. These procedures eliminate the need for time-consuming paper tape input.

What's good for the goose . . .
What's good for the manager is good for the operator, too. From the console keyboard, he can display process-loop data, or data for any block in a loop or alarm limits — all continuously updated. He can use the console to initiate trending and logging. He can open and close cascades; modify other block interconnections; place blocks on or off scan; change all types of operating parameters; set point, data, and output values; alarm limits; and control constraints.

He can control supervisory programs, execute them, display results, and input program parameters.

What's good for the manager and good for the operator happens to be good for the engineer as well. He has the opportunity for more effective process supervision. From the console keyboard, he can quickly obtain a comprehensive view of plant conditions, control status, process-loop interaction, and alarm status. He can request summarized data, observe trends, or get in close on any particular variable.

Control-loop tuning is safe and easy, too. The process engineer can quickly display, modify, verify, and enter new data such as proportional band, reset and derivative rates, deviation and measurement limits, deadbands, signal-filtering parameters, and reference values.

Continuous pen trend recorders can be assigned from the keyboard to track any particular variable.

Operator's consoles and CRT terminals

The CRT terminal offers the small-system user an inexpensive means of accessing his process information, while the more conventional operator's console, with the large displays, is easy to use and read, and is exceptionally reliable. The FOX 2/30 System can handle up to three operator's consoles or operator's CRT terminals — es-

pecially useful in multi-unit installations. The operator's console display panel consists of a bank of alarm/status lights and four alphanumeric display registers:

1. Point number display register
2. Measurement and units display register
3. Data display register
4. Input display register

The operator's console data entry panel has a keylock for the protection of prespecified functions, a point number keyboard, a data input keyboard, an action code keyboard, and a matrix of 16 back-lighted pushbuttons. Both the keyboard and display panel may be easily mounted in a Foxboro or user console. Both units are easily accessible for maintenance.

FOX 2/30 provides an additional pushbutton panel for those applications where more "ON/OFF" or initiating commands are required than the standard keyboard provides. This panel has 16 back-lighted pushbuttons. As many of these panels as the user requires can be installed. These panels may be used to trigger user pro-grams, initiate the printing of logs and reports, and perform any of a number of user-defined tasks.

An optional display CRT provides display-only of such process information as alarms and logs on a CRT monitor. This is useful where information is dynamic; where the CRT must be viewed from a distance, and must be self-contained for mounting.

Flexibility in terminal devices

FOX 2/30 has a selection of devices which provides convenient interaction with the system:

DEVICE	INPUT	OUTPUT
CRT Terminal	Yes	Yes
Display CRT	No	Yes
IBM Selectric	No	Yes
Teletypewriters*	Yes	Yes

System modularity eases configuring, expanding, servicing

The FOX 2/30 System has been designed with a modular approach to allow custom configuring of systems, easy expansion, and easy servicing. We can provide a wide selection of configurations, ranging from a complete system in one rack to as many as you require. We locate the electronic modules in these racks for easy access and minimal space requirements to reduce your ultimate rack-space cost.

*Paper Tape I/O is also available in ASR Versions.

Systems are composed of basic building blocks — completely independent I/O subsystems. Since there are no fixed positions for the I/O subsystem units, additional units can be mounted easily and connected to the system in the field. If replacement is required, spares can be inserted and operation resumed in a few minutes.

Central Processor has unique combination of features

The system's 16-bit central processor, heart of the CPU subsystem, has a unique combination of features:

- 16-bit word structure
- 750-ns operation increments
- 1.5-μs minimum execution time
- 2.3-μs single-precision add time
- 28,672 addressable core memory locations
- Full word operations
- Sequential addressing
- Full address indexing
- 8-bit byte addressing
- Stack addressing

- Single- and double-precision arithmetic
- 8 addressable registers
- Address stop debugging option
- Hardware multiply/divide option
- Programmed I/O bus for control and single-word data transfer
- Up to 30 channels of process I/O
- Up to 12 channels of teletypewriter interface I/O
- Direct memory access for high-speed transfers

Two buses carry the load for greater efficiency

The central processor, memory, and all peripheral devices share one common high-speed bus. This feature lets the central processor view peripheral devices as active memory locations which perform special functions. Since memory reference instructions can thus operate directly on control,

status, or data register in peripheral devices, data transfers from input to output devices can bypass the central processor completely.

All process I/O subsystems utilize their own data bus which allows totally independent and asynchronous operations. Process I/O commands and data are transmitted to the data bus interface, which then selects the appropriate I/O device, initiates action (contact output, analog input, etc.), accepts input data and/or completion indication and notifies the central processor of completion, passing any data to it.

Other CPU subsystem features

Instruction Set — Double- and triple-operand instructions allow memory-to-memory processing and eliminate the need to use registers to store intermediate results. They also significantly reduce program length by treating every memory location as an accumulator.

Addressing — Much of FOX 2/30's power comes from its wide range of addressing capabilities. Addressing modes include list sequential addressing, stack addressing, and direct addressing to 32K words (including hardware registers). Programming storage space is efficiently used, since variable-length-instruction formatting allows a minimum number of bits to be used for each address mode.

General registers — All eight are program-accessible and can be used as accumulators, pointers to memory locations, or as full-word index registers.

Priority interrupts — A four-level automatic priority-interrupt system permits the processor to respond automatically to conditions outside the system or in the central processor itself. Any number of devices can be attached to each level. Because each peripheral device's interrupt priority and ser-

vice routine priority are independent, highly efficient system operation is achieved in response to real-time conditions.

Asynchronous operation — Since the FOX 2/30 System's memory and central processor operations are asynchronous, I/O devices transferring directly to or from memory may steal memory cycles during instruction operation.

Real-Time clocks — FOX 2/30 provides two options in real-time clocks — so necessary in timing and logging operations in any real-time system:

• Line Frequency Clock — provides an interrupt every 16.6 ms (60Hz)

• Programmable Clock — provides program-adjustable timed intervals from a base rate of 10 KHz.

Extended arithmetic unit — This feature greatly reduces the amount of processing time needed to execute arithmetic. It provides signed

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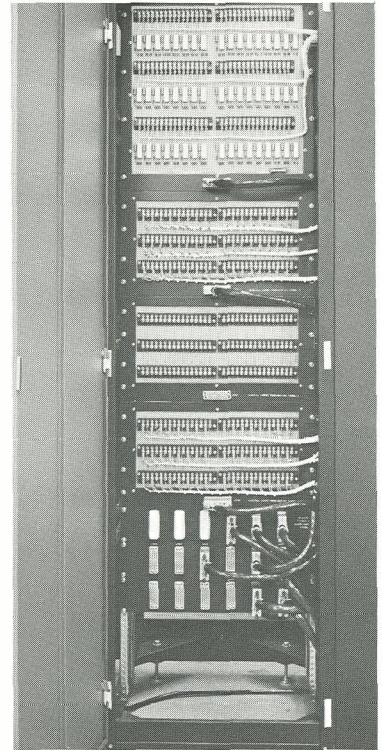
Multiply, Divide, multiple shifts, and normalizations.

Power-fail restart — This standard feature prevents power dips or outages from damaging the ability of the FOX 2/30 System to accomplish its tasks. Upon return of power, control is given immediately to the Power-Failure Interrupt trap locations, and the system software can restart the system.

Memory — The FOX 2/30 System allows both 16-bit word and 8-bit byte addressing. The address space may be filled by core memory and peripheral-device registers. The top 4,096 words generally are reserved for such registers. The remainder of address space can be used for read-write core memory.

Read-write is available in 4,096 16-bit word segments. This memory has a 1.2-μs cycle time and 500-ns access time. Optional memory is available with a 950-ns access time.

Breakpoint Module cuts debugging costs

This option will reduce program-debugging costs in those cases where users are developing their own operating-system-type software or large amounts of core-resident application programs.

High-speed bulk storage

FOX 2/30 System utilizes a high-speed bulk storage unit designed for process data acquisition and control applications. Mounted in the central processor rack, it includes:

- 1 Read/Write head per track for high-speed access
- Fixed heads for greater reliability
- Redundant timing heads and tracks
- 128 data tracks
- 2,000 word per data track
- 16 bits data and a parity bit per word

- 256,000 word capacity
- 50/60Hz power
- 8.7 millisecond average access time
- Parity generated and checked automatically on read operations
- 16-word to 16,384-word block transfers
- Optional drum status display panel
- Sealed positive-pressure helium atmosphere
- Underspeed, over-temperature, over-pressure, under-pressure, indications for software access

High-speed paper-tape reader and punch

If you don't care to use the low-speed paper-tape facilities of the Teletype units, we can supply you with an inexpensive means of program loading and data generation: high-speed paper-tape reader and punch — conveniently mounted in the central processor rack. This equipment includes:

- 300 characters/sec tape reader
- 60 characters/sec tape punch
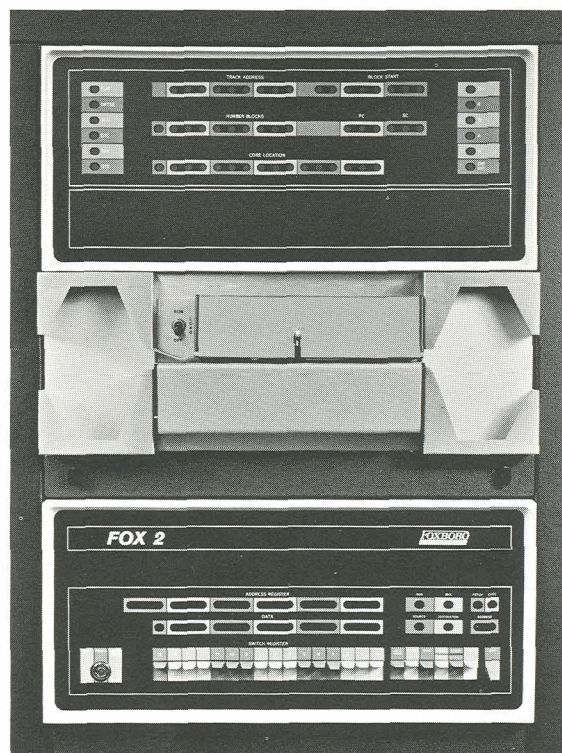
- 8 bits/character
- Fan-fold tape handling
- 200 ft read and 500 ft punch tape bin capacity
- Local power on-off switch
- Power "On" indicator light

Complete complement of process interface equipment

FOX 2/30 has a complete complement of compact and reliable process, interface building blocks — whatever you need for your application.

Analog Input Module — The eyes and ears of any data acquisition application, this option is constructed modularly to reduce initial investment and facilitate future expansion.

Pulse Counter Module — In applications where tachometers, turbine meters, or other pulsing-type sensors are used, this option will totalize the inputs and present the totals to the central processor.

Digital Input Module — This option minimizes your field cabling costs by allowing the field termination panel to be remotely located in the plant area.

Process Interrupt Module — This option is used in cases where less than a one-second response to a contact transition is required.

Digital Output Module — This option opens and closes contacts to operate valves, light alarm lights, and operate any required on/off device. The multiplexed termination panels can be remotely mounted to significantly reduce field wiring costs.

Valve Control Module — Since Direct Digital Control is common in process control, we have a module for the purpose. It provides incremental outputs to the valve controller for the best possible closed-loop control. Self-checking, it tells you when abnormalities occur.

Set-Point Control Module — Used where the power and flexibility of FOX 2/30's direct digital control capability is not required, or where the system is being installed in a plant with existing auto-manual stations containing stepping motors for driving the analog set point.

System Security Module — Maintains hardware, software, and process security in the system. Built in is our field proven FLUNK system for reverting to analog instrumentation for backup.

Field Terminations — There are 14 options for interfacing the I/O gear to the process: valve outputs, contact inputs and outputs, process interrupts, pulse inputs, set-point outputs, and analog inputs and outputs. They are connected to the process using a variety of termination facilities including local, remote, multiplexed, cabled, and direct-wired. The right facility at the right price for the job.

A

B
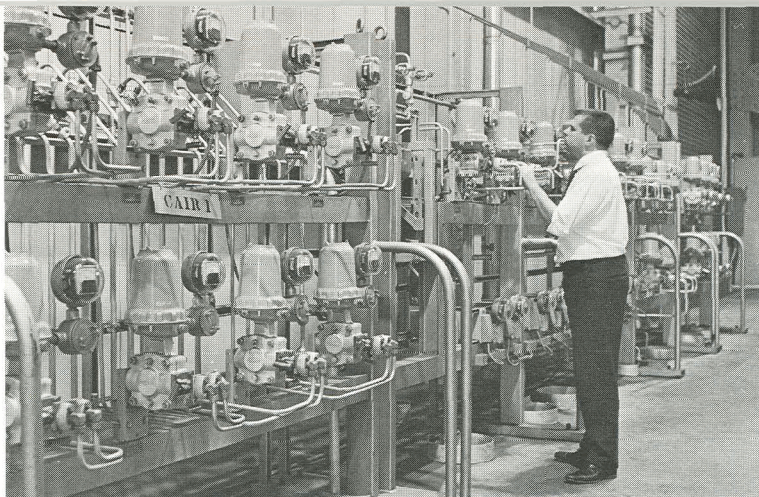
FOX 2/30 SHIRT-SLEEVE COMPUTER SYSTEMS CAN LEND A PROFITABLE HAND TO MANY INDUSTRIES IN MANY WAYS
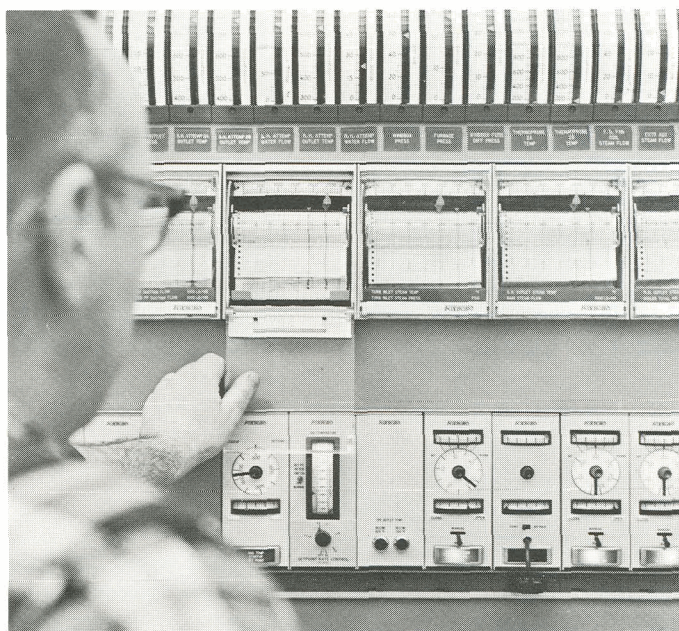
Foxboro has the best applications background in process control. Our computer systems can be found in every major process industry, helping increase production, assuring tight quality control and providing real-time data to help plant management in their decision-making. There are several repeat users of Foxboro systems — strong evidence of customer satisfaction.

Foxboro systems are being used at several of the world's leading refineries, including the world's largest under direct digital control,

controlling hydrocrackers, fractionators, reactors, ultraformers, and other plant units. These systems are also handling such process management activities as data collection, reporting, and process optimization, plus many other supervisory functions.

The power industry is a major user of Foxboro computer systems for monitoring, logging, and automatic turbine startup. Also benefiting from Foxboro systems are several producers of ethylene, butadiene, nylon, polyesters, and polyvinyl chloride. In cement, tex-

tiles, pulp and paper, and metals, too, Foxboro computer systems are being effectively used.

Foxboro has also made significant contributions in the way of analog instrumentation and control, underscoring the company's outstanding reputation as a single-source manufacturer.

You often find Foxboro instrumentation used in conjunction with Foxboro computer systems. These are Foxboro Electronic d/p Cell Transmitters **A** and Foxboro Consotrol Instrumentation — indicators, recorders, and controllers **B** used with a PEIR System.
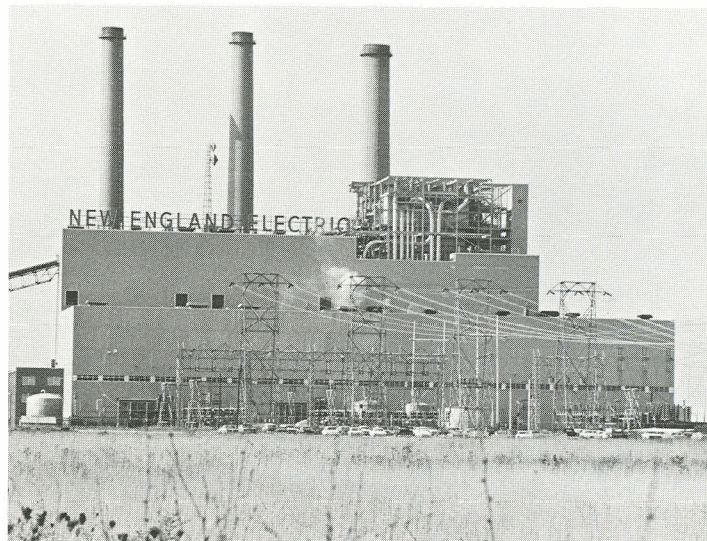
PEIR for Power

FOX 2/30 System flexibility and versatility make it ideal for special industry applications. First of these is the PEIR (*Performance Evaluation and Information Reduction*) System for the power industry. It is a data acquisition and control system designed to handle the important steam power plant operations. These include: monitoring, alarming, logging, performance calculations, control, and automatic turbine startup. The PEIR System's highly efficient power-oriented software system capitalizes on the FOX 2/30 System's high speed, I/O capability, and powerful software system.

Refining

The FOX 2/30 is ideally suited for refining applications. For example, dedicated control of a catalytic cracker can be easily implemented using the control blocks of the FOX 2 IMPAC system. Coordinated control of the reactor and regenerator using programs written on-line in FORTRAN IV will result in maximum unit throughput. The easy-to-use linkages between FORTRAN IV and IMPAC permit the optimization of the use of blower capacity.

Petrochemical

High purity distillation operations are closely controlled using IMPAC's extensive set of control blocks. Feedforward and decoupling control strategies are easily implemented by fill-in-the-blanks techniques. Supervisory linkages to provide adaptive feedback to feedforward systems are an integral part of the FOX 2/30 FORTRAN IV language.

Chemical

Yield structures, conversions, and other operating parameters are
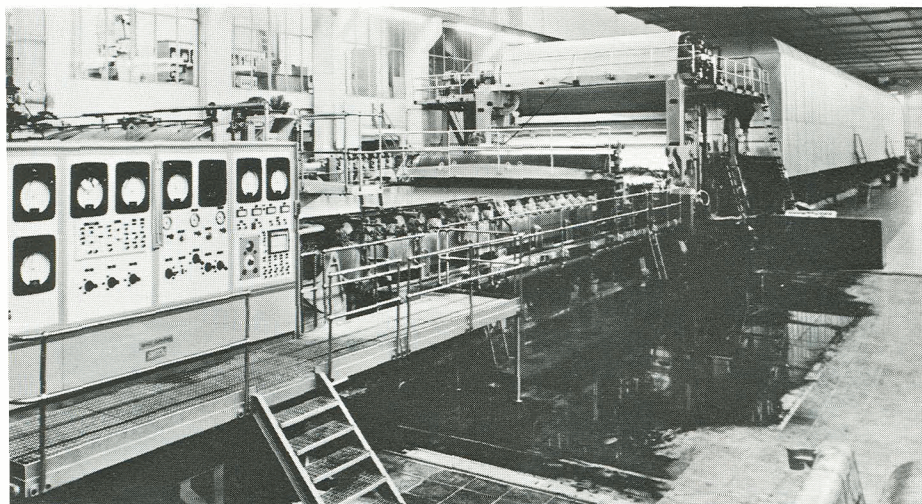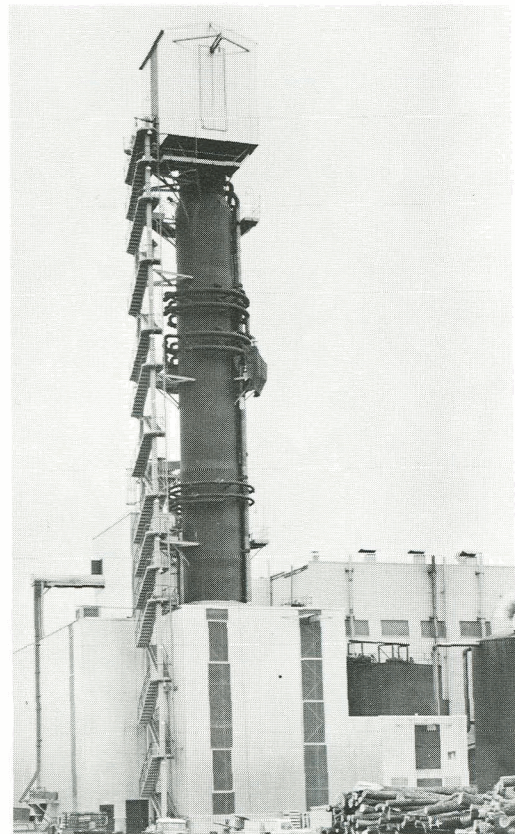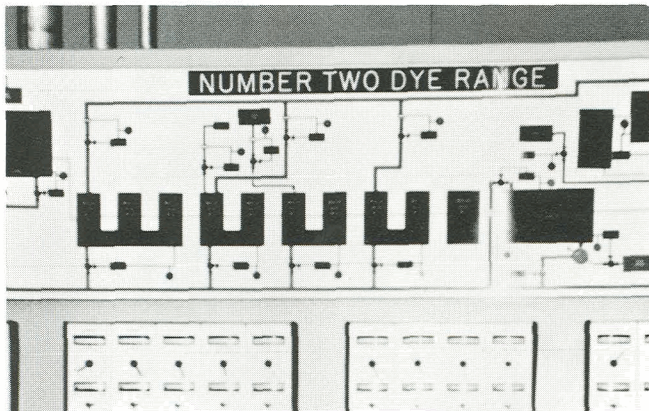
easily calculated and displayed on the flexible CRT terminal. With only minimum knowledge of FORTRAN IV, live data can be retrieved using in-line process extensions. The interactive capabilities of the fully supported CRT simplifies the development of custom formats for displaying process data and calculated values.

Pulp

The FOX 2/30's on-line FORTRAN IV compiler permits easy development of material balance programs. The FORTRAN IV/IMPAC linkages simplify the development of a control system to adjust the chemical addition rate based on active alkali and sulfidity calculations in continuous digesters. The ramp function (a standard control block in the FOX 2 IMPAC control software) is easily implemented for control of zone temperature, and chip feed rate in a coordinated control strategy.

Paper

Speed and/or grade change control systems can be easily implemented with the ramping function in IMPAC and programs written on line in FORTRAN IV.

Textiles

The bulk storage capabilities for the FOX 2/30 permits storage of numerous drug recipes. Hardware floating point enables rapid reformulation of dyes.

Cement

The FOX 2/30 is ideally suited for kiln/cooler control. The on-line FORTRAN IV system permits the easy development of programs to model and simulate the temperature profiles. Further, the computer system can be paid for quickly by optimizing raw material mix, minimizing electric power demand and usage costs.

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**FOXBORO CAN HELP . . .
WHATEVER YOUR LEVEL OF SOPHISTICATION
WITH REAL-TIME, ON-LINE
COMPUTER SYSTEMS
FOR PROCESS MANAGEMENT
AND CONTROL**
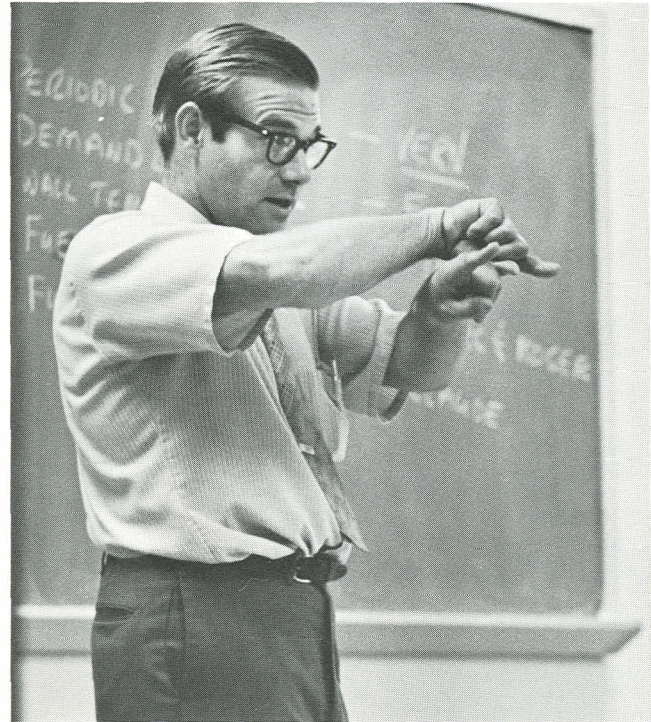
Process management and control with the help of computer systems is not that old a science — and art. We don't expect everyone who knows plenty about analog systems to have the same depth of knowledge about computer systems. That's why we are prepared to help you get started from ground zero, if that's where you stand. On the other hand, if you are one of the more knowledgeable users of computer systems in the process environment, we can get right to the bit-and-byte level, deliver just the configuration you specify, and leave you to your expertise. Here are some of the things we offer you:

TRAINING

Instruction in the operation, programming, and preventive care of Foxboro computer systems is offered both at The Foxboro Company and on your site. Courses conducted by qualified instructors — coupled with detailed instruction manuals — fully inform your personnel in the use, programming, and maintenance of our systems.

Our training program, designed to promote maximum customer self-sufficiency, draws from our wide experience in both analog and digital process control technology. At Foxboro, plant-level education encompasses the total manufacturing process, from the level of the simple control loop to a comprehensive overview of the entire plant. We expand the conventional technically-oriented training courses into higher levels of education which cover the multiple operating levels making up the total processing plant. At the heart of the program is a concept which utilizes a unique educational tool —a scale-model processing plant. This model/simulator places an entire realm of training opportunities at the student's fingertips. An
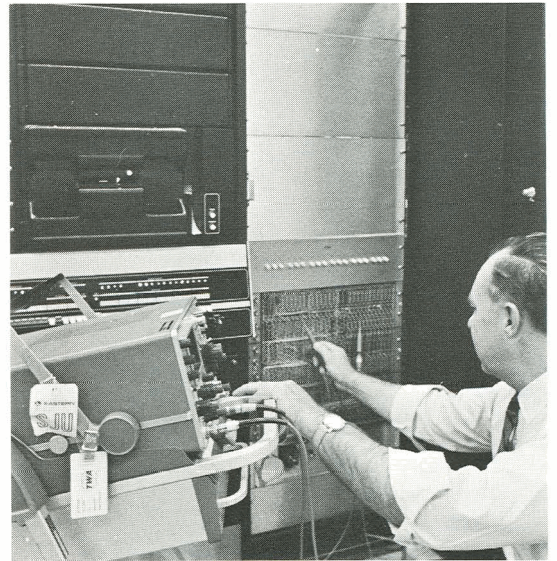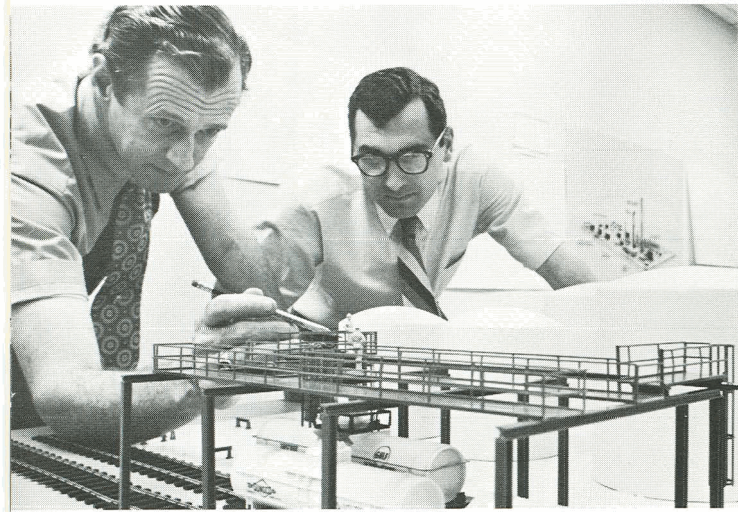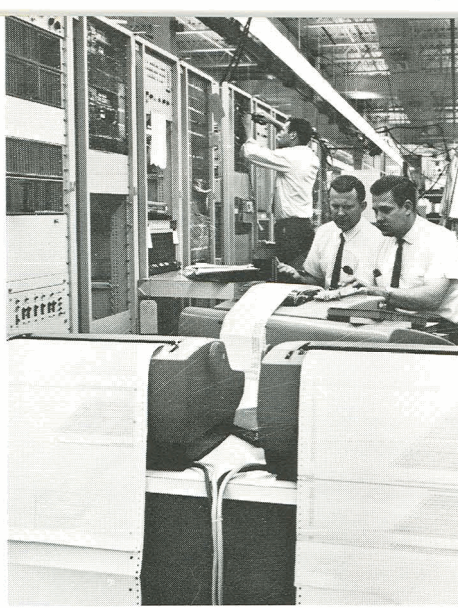
APPLICATIONS KNOW-HOW

Foxboro Application Specialists are strategically located around the country in order to assist you on your applications questions and needs. Whether your questions relate to analog or digital subjects, or to a particular control problem, these men, with their wide experience, will be able to assist you.

PROJECT MANAGEMENT

Foxboro Project Managers head up teams of technical personnel with responsibilities for systems and applications engineering, programming, system performance schedules, progress reports, performance tests, and contract administration. Sound objectives in system design, application, and performance are achieved by strong, responsible leadership guiding and coordinating many skills.

SYSTEMS ANALYSIS

Backed by resources of direct and knowledgeable association with virtually every process and energy industry, system-trained engineering teams are well qualified to specify and apply digital systems that meet the most particular demands.

ENGINEERING AND PROGRAMMING

Our staff of experienced designers, engineers, and programmers can implement your system completely, from design through checkout, from initial flow charting through debugging and final documentation.

FIELD SERVICE

A cross-country network of Foxboro Service Offices places a field specialist within call of each system location for on-demand maintenance and installation assistance.
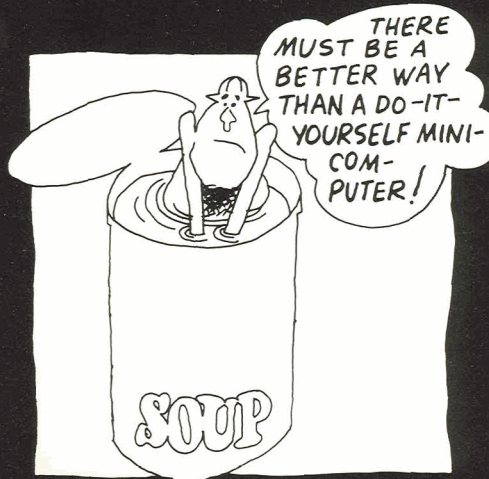
THERE IS A BETTER WAY:
WE-DO-IT-FOR-YOU
FOX 2 SHIRT-SLEEVE MINISYSTEMS

Foxboro minisystems vs minicomputers

Why go with a barebones, do-it-yourself minicomputer when there are FOX 2 minisystems around? A minicomputer might look attractive to begin with, but consider these points:

Overall cost — Consider the work you want to do later as well as now. You'll pay a lot more to expand a minicomputer than a FOX 2 minisystem. *It* starts with enough designed-in flexibility and capability to be expanded easily and economically.

Software development — Comprehensive software is complex, and expensive to develop. With a minicomputer, you can't afford to develop a package that supports applications today and allows the flexibility to expand to satisfy changing requirements. Foxboro supplies the kind of software you need — debugged and proven.

We talk your language — Foxboro provides a fully documented and operating system for process-oriented people like you to use. You don't even have to know assembly language programming, since we supply basic process programming with fill-in-the-blanks implementation features.

The one constant: change — Your plant is constantly undergoing changes, right? A temperature range is changed . . . flow meters are relocated . . . product mixes get new ingredients. Does this mean you have to rewrite your program every time one of these changes occurs? Do you have to take your computer off line to make a change? With a minicomputer you probably have to. With a FOX 2 minisystem you don't, thanks to our on-line programming capability.

Worldwide Facilities

Approximately fifty percent of all Foxboro products are sold
outside of the United States. It is significant, therefore, that the
same products, the same services, and the same facilities which
are available to customers in the U. S. are also available to
customers in other countries. Training, flow calibration,
systems engineering, instruments and supplies, panel
fabrication, installation and startup assistance, and numerous
other Foxboro benefits are available in over 100 countries.
Of the more than 125 Foxboro sales and service offices,
over 70 are located outside of the U. S.

FOXBORO *