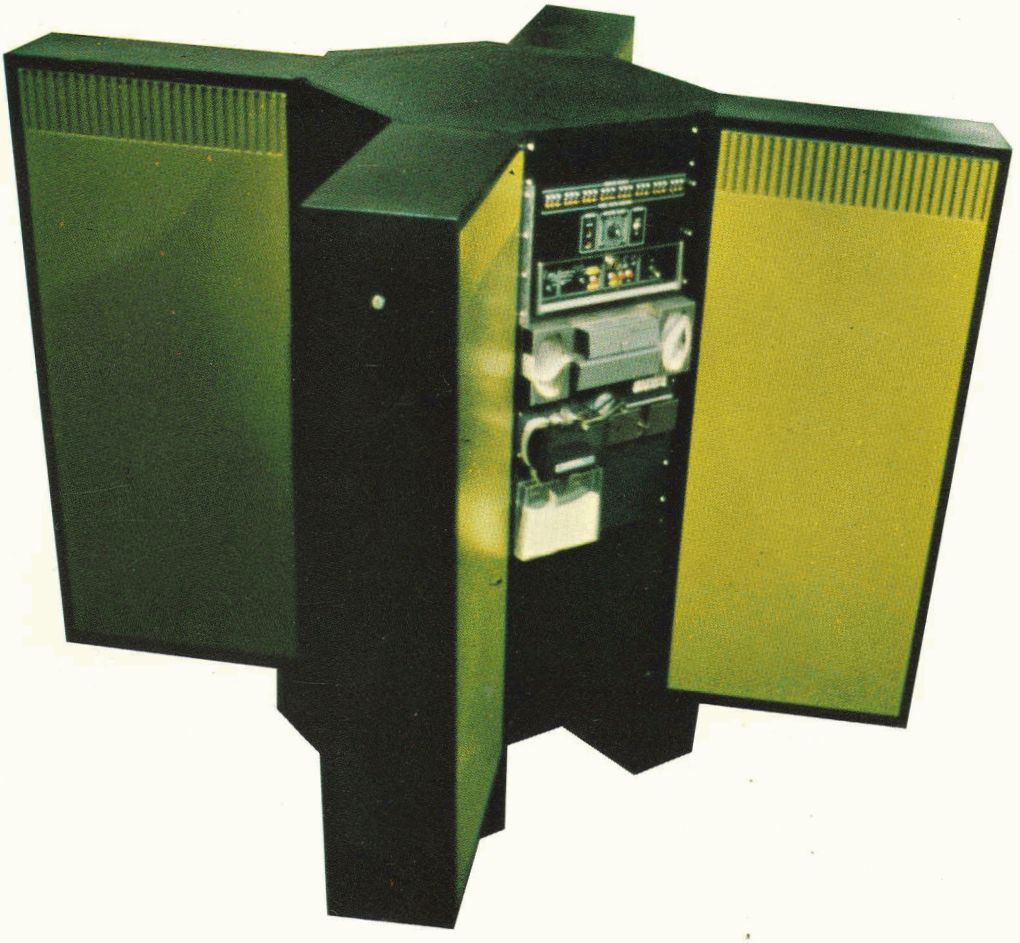
# *FOX 1*

a new and advanced

## computer system

for
plant monitoring
and
process control



System Description

## the equalizer

FOX 1 is more than just a new real-time computer system. It's a major milestone in plant monitoring and process control.

Up to now, the fast-moving, complicated effects of interacting variables have frequently kept plant personnel on the defensive, operating at less than optimal levels. Now comes a control system, FOX 1, that brings the right information to the operator at the right time. A system that gives operator and engineer advanced tools to use this information for optimum results. Now for the first time man meets process on his own terms.

Remarkably powerful pushbutton control. Faster operator response. Unprecedented familiarity with the process. Far-ahead resources for control scheme development. This is FOX 1, an all-new control system concept to help you push process operating margins to their limits.

The FOX 1 system is where process control has been heading since the time of primitive gauges. It's everything you've wanted in control. And it's everything Foxboro envisioned when we set out to design *the* computer control system for the '70's.

# FOX 1

## a powerful across-the-board capability for process control

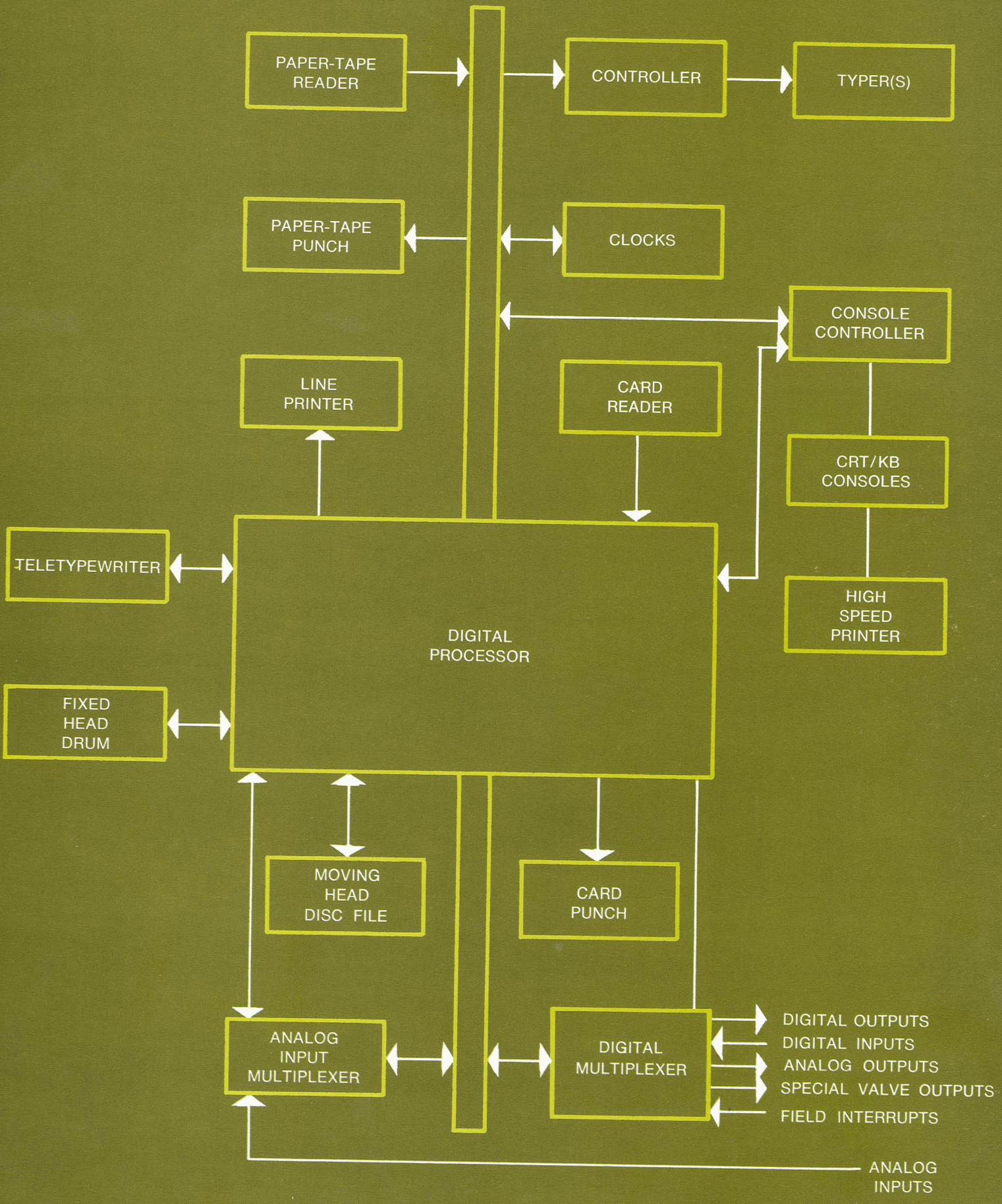
The FOX 1 system from Foxboro is a real-time computer control system designed for *all* facets of control system implementation and operation. Its capabilities include advanced control but go far beyond. It offers several work-saving software capabilities that speed system implementation and delivery. It brings to industry a new dimension in man-machine communications based on advanced CRT consoles for operator and process engineer. It includes the most comprehensive software capability in process control. It has extensive, performance-boosting power features, an essential for maximum real-time control and on-line supervisory activities. All wrapped up in the most far reaching system integrity and dependability ever designed into a process control system.

FOX 1 is an extremely versatile control system that can be applied to all process and energy producing industries: for single-unit process control or multi-unit plant level control; for continuous, semicontinuous, or batch processes; for powerful, concurrent performance of engineering functions, supervisory control, business operations, plant monitoring, *and* regulatory control — either direct digital control or set point control.

FOX 1: Control system of the '70's.

## only FOX 1 offers process control so many advanced features

- Fully programmed process control-oriented software
- FORTRAN IV augmented for process engineer use
- FORTRAN optimization package for increased program efficiency
- Advanced, fully programmed CRT control console
- Process operator's keyboard with supporting software
- General purpose keyboard and software for use by process engineers and managers
- Vector graphics capability
- Real-time software executive for total system management
- Job Processor for time-shared background programs
- Link Editor for formatting new programs for incorporation into the system
- Sophisticated File Manager package
- File Editor for assisting process engineer in data management
- Debug Monitor for testing new programs in protected environment
- Executive error handling package
- Simplified data base generation and modification
- Simplified programming via MAX, a plant language macroprocessor
- Ceramic encapsulated integrated circuitry for reliability
- State-of-the art hardware design
- Circuit packaging and interconnection designed for high industrial reliability
- Automatic fixed and variable file formatting
- Large, powerful process control instruction set
- Versatile multi-programming executive
- 24-bit word length
- 960-nanosecond core memory cycle time
- High-speed drum storage
- Programmed drum look-ahead operation
- Hardware floating point arithmetic
- 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 subroutines
- Multi-level hardware interrupt
- High-performance process input/output hardware
- Powerful system generation software
- Address Stop Module for on-line program checkout
- Hardware program protection traps and fences
- Extensive software-supported peripherals
- Power failure detection and automatic startup




FOX 1 EQUIPMENT COMPLEMENT

# advanced man-process communications console

## provides unprecedented access to system resources for data acquisition, monitoring, control, engineering, program preparation, and managerial functions — offers the opportunity for safer, closer plant control

The FOX 1 control console gives the process operator unprecedented mastery over the process, a far better command and response posture than he's ever had. Comprehensive multi-variable monitoring, alarming, and control capabilities are conveniently centralized for fingertip operation.

And it's never been easier. From the console keyboard, the operator can display a list of all process displays available, or multiple-loop data, or data for any functional block within a loop, or alarming variables, or alarm summaries, or selected groups of process variables. What's more, he can display them in virtually any format he wishes, and in *alphanumeric and graphic* form. Also, process measurements are updated on the display as they are scanned.

The operator also can use the console to initiate trending and logging. He can change batch status — open or close valves, reroute products or realign operating units and operate pumps or motors. He can open and close cascades, and modify other loop interconnections.

He can place process variables on or off scan. He can change all types of operating parameters, set-point values, data values, output values, alarm limits, and control constraints.

He can control supervisory programs: execute them, display results, activate or deactivate them, change their frequency of execution or next run time, or change program parameters.

Several levels of safeguards protect system and process from illegal data entry. To begin with, the console is human-engineered for easy comprehension. Beyond that: the console is under keylock control; fill-in-the-blanks formatting simplifies data entry; information is verified visually before entry into the computer; and even then data entry is subject to software checks to assure that it falls within acceptable limits. The display format design itself includes the capability to specify those character positions that can be changed by the operator and those that are protected.

### VAST POTENTIAL FOR PLANT CONTROL IMPROVEMENTS

The FOX 1 control console offers the process engineer an opportunity for more effective process supervision. Instant response, large data display, and pushbutton operation greatly simplify engineering activities, data file editing, and the development of new programs.

From a console keyboard, the process engineer can quickly obtain a comprehensive view of plant conditions, control status, process loop interaction, and alarm status. He can request summarized data, observe trending, or "zoom" in on any particular variable. The displayed information is continuously updated as new values occur.

A library of supervisory calculations can be stored in bulk files and activated on request or on a schedule established through the console keyboard.

Control loop tuning, also, is easier and safer with the FOX 1 control console. The process engineer can quickly display, modify, verify, and enter new data such as proportional bands, reset and derivative rates, deviations and measurement limits, deadbands, signal filtering parameters, reference values, scan intervals, and other parameters.

Data file changes are remarkably simplified: A unique File Editor program, part of the FOX 1 File Manager system, can be called through the keyboard. Information is clearly displayed and modified under minimum-risk conditions.

The FOX 1 console makes programming of new tasks less tiresome and more efficient. The whole program preparation and background processing capability of the system can be directed from the CRT console's keyboard. In particular, program preparation software facilities — such as the FORTRAN Compiler, Source Editor, Debug Monitor, and Link Editor — are ideally suited to use of the console's large alphanumeric display and character insertion capabilities.

#### Large, High-Visibility Display

A powerful control room tool, the FOX 1 control console provides virtually instantaneous full-screen response to control room requests. Process data in both alphanumeric and vector graphic forms is easily summoned and displayed from keyboard or from alarm buttons, and just as easily modified under system safeguards set by the process engineer.

Up to 2,000 characters of process information (25 lines, 80 characters per line) or 1,000 line-vectors — or a combination of both — can be displayed at any one time upon request on the 10-inch by 15-inch screen. Letters and numbers are ¼-inch high and are easily recognized because of high-resolution character generation.

#### Pinpoint Alarming

A convenient alarm button arrangement quickly spotlights alarm sources. By pressing the appropriate flashing alarm button for a particular plant area, the operator displays information on groups of variables related to that area, giving him the entire story. The specific alarming variable commands his attention by blinking. A horn alarm can also be incorporated into the console.

#### Flexible Formatting

Process information can be displayed in any format desired. Virtually unlimited formats can be stored on drum or disc and called upon request. The standard formats are easily changed using File Editor programs to tailor the console to the user's process operations.

#### Two Keyboards: Engineer's and Operator's

Use of FOX 1 control consoles is simplified by the availability of two different keyboards. One is the operator's keyboard for plant monitoring and control. The other is a general purpose keyboard for the process engineer or manager — for program preparation, monitoring, supervisory calculations, or full backup of the operator's console.

Depending upon specific requirements, FOX 1 consoles are available in one-, two-, or three-station units, each station having its individual keyboards and displays.

#### High-Speed Hard Copies

Via the console keyboard, operator or engineer can activate a high-speed jet printer to obtain a hard copy of displayed characters. The printer can reproduce a full-size 2,000-character display in just 20 seconds. The average display will take much less time.

#### Pen Recorders

Continuous pen trend recorders can be mounted on the console and scaled and assigned from the keyboard to track any particular variable.

The FOX 1 CRT control console sets new standards in human engineering, represents a giant stride in control center capability for operator, engineer, and manager.

# the most extensive, most capable software in process control

Perhaps the highlight of the FOX 1 system is its software. Underlying the design of FOX 1 software was the fundamental requirement that the process engineer have fast and easy access to all system resources with a minimum of concern for computer related detail. The result is the most comprehensive standard software offering in process control.

Truly powerful, FOX 1 software covers virtually every aspect of control system implementation and operation, freeing the process engineer from much of the programming effort, and simplifying the rest. It includes full operating system facilities for real-time monitoring and control, an advanced and flexible control package providing virtually unlimited control options, two very effective high-level language processors for simplified program preparation, and a rich assortment of utility software.

## MULTI-PROGRAMMING OPERATING SYSTEM

The FOX 1 operating system is a sophisticated package which allocates the resources of the systems to all demands. Competing demands by the process, operator, process engineer, and by the FOX 1 operating system itself are all scheduled by the multi-programming Executive on a priority basis, the most urgent tasks first.

Foreground programs have the highest priority. These include both standard and user written routines which require fast action by the system. They may reside permanently in core or they can be loaded relocatably into core from the drum, occupying any part of core memory available to them.

Background programs, comprising standard and user-written routines which are not time-critical, have the lowest priority. Typically, these are supervisory and program preparation routines. They are handled by the system immediately for all practical purposes.

### Real-Time Executive

The Real-Time Executive, highest program in the software hierarchy, directs allocation of the three major system resources: computing time, core storage, and access to bulk storage. It does this via subordinate operating system programs, including the Input/Output Control System, the File Manager, Console System Software, and background Job Processor. The Executive includes interrupt handlers, queue handlers, clock handlers, program requests, and exit routines. Operating in complete safety, all user written routines have access to system resources only by direct request to the Executive, which screens each demand protectively.

### Input/Output Control System

The Input/Output Control System schedules the operation of all peripheral devices such as teletype, card reader and punch, paper tape reader and punch, line printer, and process typers. A valuable asset is its device independence, permitting one device to handle data for another should the latter become inoperable.

### File Manager

One of the most powerful software facilities available with the FOX 1 system is its File Manager. It is used by almost every program in the system to access data stored on drum or disc. Requests need only refer to the desired data in symbolic form. The File Manager then searches its directory, finds the data, and conveys it to the program. Portions of the file directory can be core resident for fast access or the entire directory can be drum resident for more efficient utilization of core.

### Console System Software

This package controls all data transfers to and from the CRT control consoles. Data, formats, and programs stored on drum or disc are displayed virtually instantaneously in response to console keyboard action.

### Job Processor

The Job Processor controls execution of all background programs and represents one of the major interfaces between the system and the process engineer. It allocates time to all background programs on a time-shared basis so that activities such as program preparation cannot lock out more important background supervisory programs.

## IMPAC CONTROL PACKAGE

IMPAC is a comprehensive, fill-in-the-blanks software system for monitoring, control, and data base generation. Made up of semi-independent routines operating in a table-driven environment (the data base), it performs monitoring and control in the fast-response foreground. Its functions include:

- Scanning of analog and digital inputs at a wide range of frequencies.
- Filtering of process input data and performance of engineering units conversion.
- Calculation of control outputs using either standard of user defined algorithms. Control signal output can be in either analog or digital form, hence the selection of set-point control (SPC) or direct digital control (DDC) is available on any individual control loop.
- Real-time updating of process information of any kind on the console displays.
- Linkage of standard scan and control software to user written programs.

In addition, IMPAC can be used in the background mode of operation to generate and modify the system data base on-line using the CRT console or teletype.

## SYSTEM IMPLEMENTATION AND UTILITY SOFTWARE

FOX 1 provides several facilities that simplify programming, reinforce system integrity, and speed new control development.

### FORTRAN IV with Optimizer

The FOX 1 FORTRAN IV capability follows the new USASI Standard and, in addition, includes many extensions designed specifically for the real-time process control environment. Moreover, an optimizer is provided which can be used to produce executable programs close in efficiency to those produced by a good assembly-language programmer. As a result, core storage requirements and execution speeds are both optimized.

### Assembly System

This powerful language processor allows a programmer to write assembly programs for exceptional application requirements. Special features simplify assembly-level programming and handle communications with FORTRAN programs.

### Plant-Language Macroprocessor (MAX)

An extremely convenient programming tool, MAX allows a process engineer to construct his own symbolic process-oriented language for easy implementation of process control functions tailored to a particular application.

### Link Editor

The Link Editor program provides linkage and incorporation of new programs into the protected environment of the operating system.

### The Debug Monitor

When a program is first written, it is checked out by running it under the Debug Monitor which protects the rest of the system from its operation. New programs being tested can take actual data from the process or simulated data from a peripheral device. However, they can output only to a peripheral device, and are inhibited from outputting to the process. After the program has been proven to operate properly, it can be loaded into the foreground on-line where it comes under the security and operation of the FOX 1 Operating System.

### System Library

A very large set of system subroutines facilitate software development effort and reduce programming time.

### Console Support Services

This powerful software system brings the full facilities of the CRT to operating and programming activities through four major functions:

- *The File Editor* allows operator and engineer to delete, insert, and modify data contained in a drum file or to modify a particular CRT format.
- *The Job Processor* Interface allows the CRT to be used for full control of background functions.
- *The Console Key Service* programs respond to operator requests for display of foreground or background program results.
- *The Debug Monitor* Interfaces allow the CRT keyboard to be used for control of debugging operations.

### Error Handling Package

The Error Handling Package receives and analyzes both hardware and software errors, logs them in a drum file, and takes the actions specified by the user. If an error is recoverable, the system need not shut down.

### Exhaustive Diagnostics

Several diagnostic facilities for system equipment help the engineer identify functional problems where an operational error is suspected.

### Systems Generation Package

An extremely effective package for system implementation and future changes, the System Generator tailors the software system structure to the equipment configuration and requirements of the user. Subsequent changes to the system can be performed on the FOX 1 system in the plant itself. Moreover, most of the system generation steps can be performed in the background on-line so that the actual system change need only take a few minutes.

Foxboro has responded to the unusually critical reliability requirements of process control by investing every aspect of FOX 1 operation with the highest possible integrity. Hardware reliability is enhanced by the selection of the most dependable components available, combined with strict manufacturing procedures and severe testing standards. Program development is closely monitored for software errors and operating programs and data are protected by a multi-level hardware and software network that screens even suspected failures. Nothing has been taken for granted, helping to ensure that the system not only keeps operating, but operates properly.

## RUGGED INDUSTRIAL DESIGN

- **Hermetically sealed, ceramic encapsulated integrated circuits** give long-life performance under varied environmental conditions.
- **A high-reliability core memory** requires no tuning adjustments.
- **NAFI type edge connectors** provide snug, long-life, board interconnections.
- **Proven multi-layer boards** reduce noise and crosstalk.
- **Solid-state switching** is used throughout the system unless impractical.
- **Signal grounds** are completely isolated from chassis ground.
- **Differential line drivers** interconnect cabinets.
- **Double-rank flip-flop registers** prevent race conditions.
- **Highly rugged industrial design drum** provides dependable data storage.
- **A motor generator unit** is available to float through power dips and surges.
- **X-shaped computer unit** packaging eliminates swingframes and the associated flexing of chassis and cables. Additionally, the design gives free availability to both front and back of each nest while the system is operating.

## PROGRAM SECURITY

- **On-line program development** is carried out in the background environment where it is prevented from making changes to any other area of core. Program preparation processors such as the Debug Monitor and Link Editor screen programs for violations of other core areas.
- **Privileged instructions** are available only to the Real-Time Executive Software and execution of these instructions in a user program is prevented by hardware traps.
- **Hardware traps and fences** prevent action outside the immediate core area occupied by the running program unless the request for action is allowed by the Real-Time Executive Software.
- **Plant-language programming** facilities like FORTRAN IV and MAX (the FOX 1 macroprocessor) simplify programming, help reduce errors, and facilitate checking by other engineers.
- **Program debugging via control console** is easier, more flexible, further reducing the possibility of errors.

## DATA INTEGRITY

- Both **core memory parity and drum transfer parity** are provided to maintain confidence in the operation of these two hardware areas.
- The **common core memory data area** is under the protection of the system executive and cannot be violated through unauthorized access.
- Similarly, **drum and disc stored data files** are accessed by the File Manager System and can be protected from unauthorized use.
- **Operator input of data** to CRT console formats (to change set points, alarm limits, etc.,) are individually protected as specified by the process engineer.

## SYSTEM PERFORMANCE SAFEGUARDS

- **Multiple-error handling** capability permits continued operation after recoverable errors, even with several simultaneous errors, plus servicing of most critical errors on a priority basis.
- **Power-fail features** permit last-second performance of vital plant functions before system shutdown.
- **Automatic restart software** helps return the system to a specified operating status upon restoration of power.
- **A watch-dog timer device** helps check proper system operation on a second-to-second basis. If not regularly reset by the executive system, it generates an alarm.
- **Automatic peripheral backup** assures that one peripheral can handle the function of another if the latter becomes inoperable.
- **Data transfer acknowledgement** is required on every transfer to a peripheral device. Failure to acknowledge receipt of data within a specified time results in an error condition and automatic backup.
- **Exercise routines** check for proper operation of major system units. These are run at frequent intervals during the system's spare time.
- **Priority message handling** gives precedence to the most important messages on the basis of established priorities. Critical alarms get top priority, new alarms get priority over alarm summaries.
- **Automatic analog drift compensation** maintains accuracy of the analog input system by acting on reference voltage values read in.

## faster system implementation, delivery, and changes easier, safer on-line program development

Several outstanding FOX 1 system capabilities surface during implementation. All are designed to put the FOX 1 system on line sooner and at lower cost. Once on line, the system provides process engineers with a major opportunity for process analysis and the development of process improvements.

Easy-to-use FOX 1 programming capabilities such as FORTRAN IV and MAX (the plant-language macroprocessor) permit the development of management analyses, supervisory programs, tailored control algorithms, and even system subroutines in a minimum amount of time.

IMPAC is the best of all competing fill-in-the-blanks process control packages. It offers more flexibility in handling various process situations. Chances are, it will provide more control options than you'll ever need. However, additional special algorithms can be written in FORTRAN IV or assembly language and easily incorporated into the system on line.

The File Manager automatically arranges data files for the most efficient operation. It also offers a choice of fixed or variable formatting and core or drum resident directories for optimum capacity/speed flexibility.

High density terminations can take place in the multiplexers themselves on special signal conditioning cards. Or special termination racks can be installed. All field wiring can be performed in advance, in parallel with system implementation.

The system generator package organizes an operating software system in a fraction of the time required by other computer control systems. For future system expansion or configuration changes, almost all the new system generation work can take place ON-LINE. The actual changeover takes only a few minutes, not days.

A number of software facilities further simplify the program development effort. The Source Editor permits the engineer to change individual portions of source programs quickly by entering only the specific additions and deletions. Together with the File Manager which automatically reassigns the updated program to a new location on drum if more space is needed, it brings to program changes a new measure of simplicity and efficiency.

When one program references another, the Link Editor automatically performs linkages, freeing the process engineer from many tedious considerations.

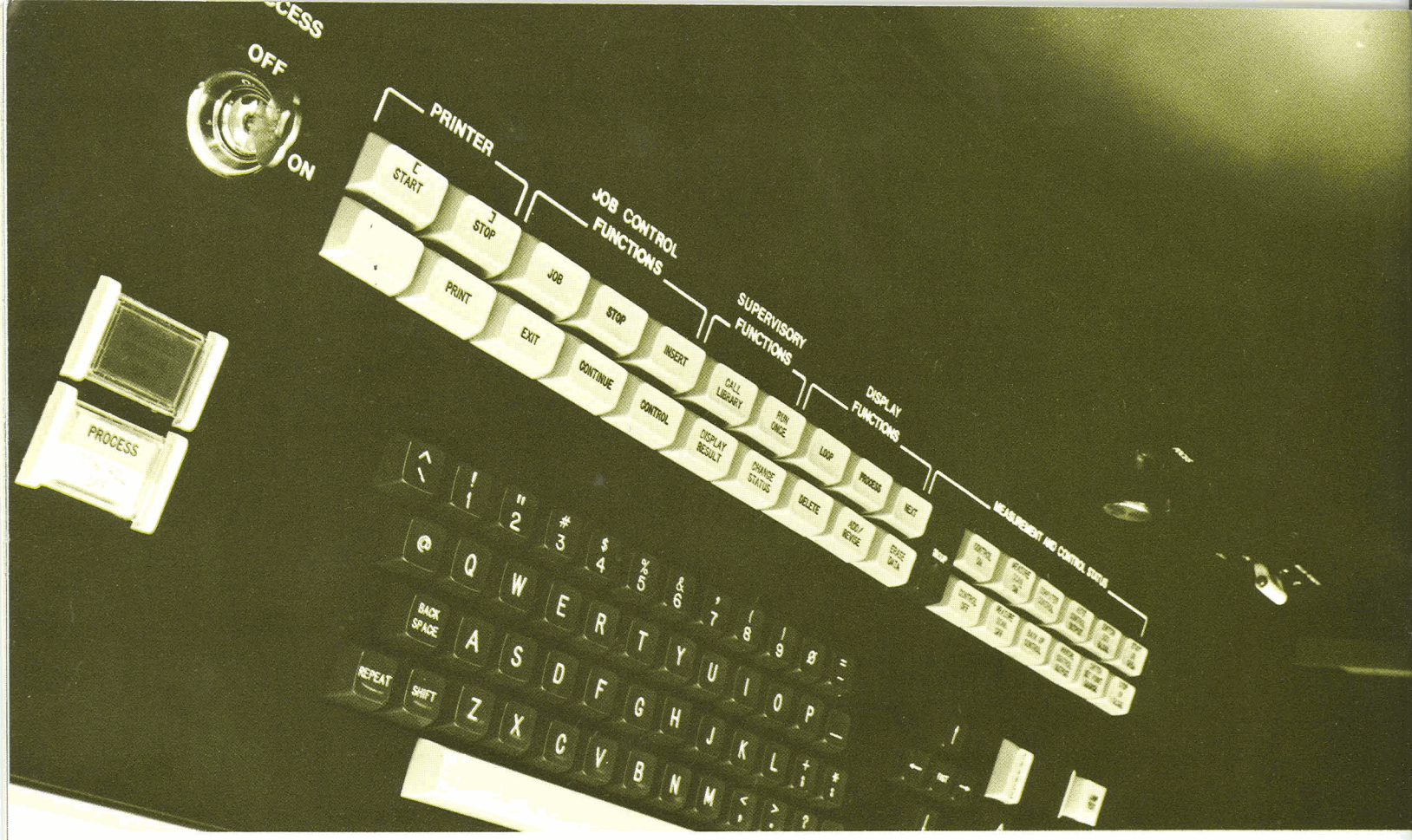
The Job Processor defers specification of input/output devices until after program assembly or compilation, eliminating recompilation or reassembly if the operating environment changes.

The availability of the powerful CRT console for programming purposes gives the engineer a unique and highly useful medium for new program development or program changes. Unlike typewriter-based devices, the CRT displays large blocks of highly visible program information virtually instantaneously, speeding programming activity by an order of magnitude.

Hardware and software are equally modular and easy to change. In fact, a basic design criterion of the FOX 1 system dictated that all hardware changes would involve no more than plugging in cards. No rewiring is required.

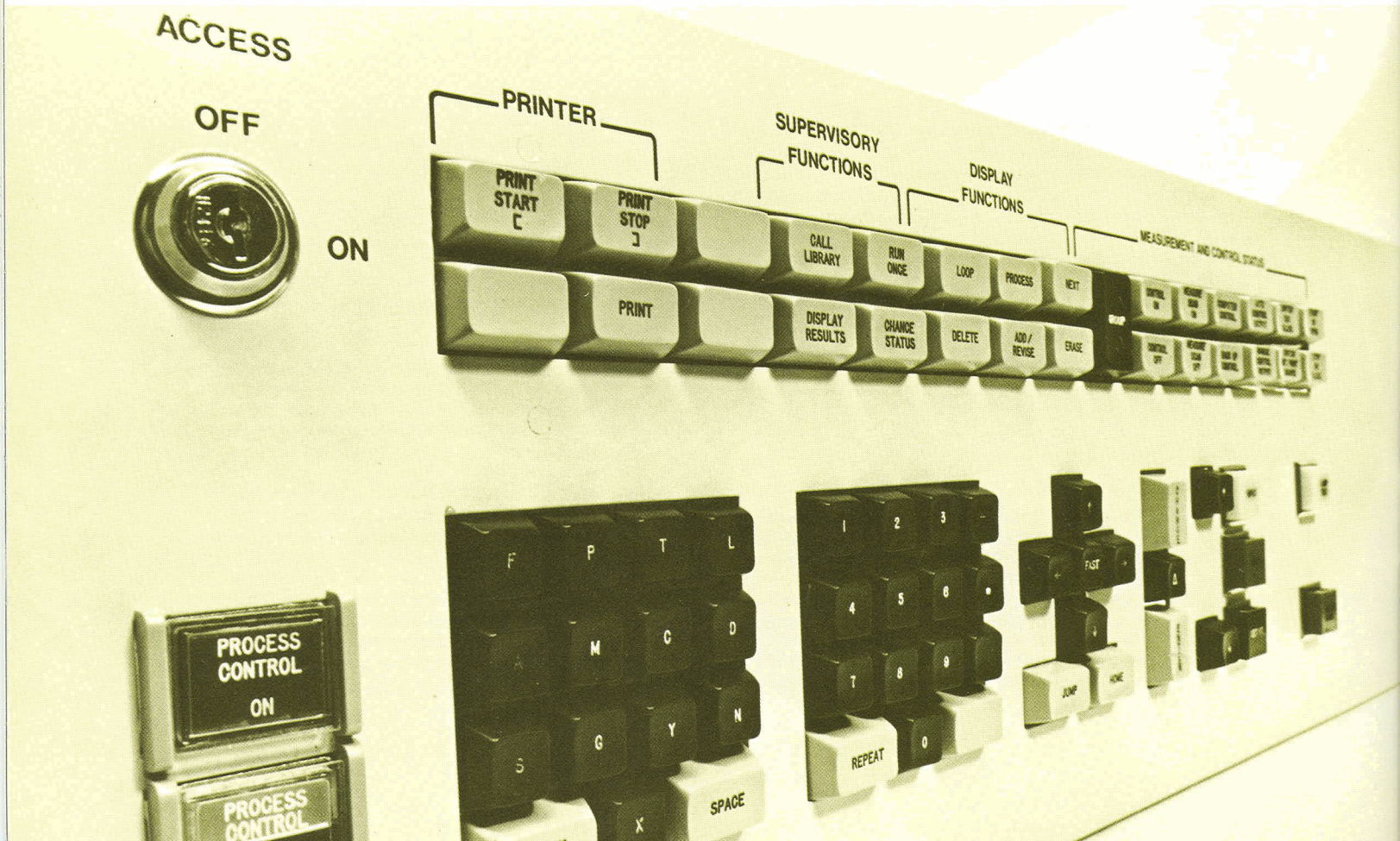
A new Foxboro Contract Automation program maximizes system manufacturing efficiency and the preparation of documentation, cutting implementation effort by weeks.

All of these FOX 1 system advances are designed to speed development, slash implementation costs, free manpower, and minimize training requirements — to help put the FOX 1 system on stream faster and at the *lowest overall cost.*




Engineer's Keyboard

Operator's Keyboard



## IMPAC gives extremely versatile loop control

A broad range of control techniques can be implemented using IMPAC for scanning, alarming, control and data base generation and modification.

This fully table-driven software subsystem simplifies specification of conventional monitoring and control strategies as well as more complex functions like digital filtering, "trigger-on-analog-value" function, switching of analog inputs between control loops, and many others.

**Control strategies** are constructed using IMPAC's standard algorithms or user algorithms for scan blocks, linearization, calculation blocks, alarms, control blocks, and outputs. The type of algorithm chosen for each block is easily specified using an appropriate data base entry.

**Output strategies** are chosen from the range of standard outputs which include pulse output driver, analog output driver, and DDC output driver, allowing any particular control loop to perform either SPC (set-point control) or DDC (direct digital control). Again, the selection is made via a simple data base entry and can be changed on line if desired. This flexibility ensures that opportunities for future improvements are not dismissed because of prohibitive changeover effort.

**Higher level supervision** of groups of SPC and DDC control loops is accomplished simply and safely. Supervisory control programs, optimization programs, and adaptive control programs are all written in FORTRAN, and therefore the results of these computations — new set points, proportional bands, reset and derivative rates, analog "trigger" levels, etc. — are symbolic FORTRAN variables. These programs can run in the foreground if they are time-critical, or in the background if a few seconds delay can be tolerated.

Control action is taken when these supervisory parameters are automatically applied to the data base files for the corresponding control loops. The powerful File Manager takes the parameters as they are, checks the protection status of the file to prevent inadvertent changes, and inserts them into the data base.

## unchallenged on-line power

The FOX 1 system parlays many advanced and unique hardware and software features to lead all other popular process control systems in terms of sheer work performance. The central processor, for example, combines a 24-bit word and 960-nanosecond core memory cycle time with single- and double-precision floating point hardware, bit and byte manipulation instructions, hardware index registers, full memory direct-addressing capability, and a fast, powerful instruction repertoire possible only with the large word size.

Overall system operation is designed around a high-speed core-drum relationship that offers a maximum cost/efficiency balance. Drum storage features a fast 8.3 millisecond average access time, plus fast data transfer speeds due in part to high-density packing. The programmed look-ahead feature further speeds overall drum access and computational operation.

Central processor and drum interplay — as well as all control system operations — are performed by the extremely effective multi-programming software system. It exploits all system resources to provide efficient foreground/background operation of real-time control and supervisory functions with plenty of time to spare.

This unprecedented computational power has direct impact not only on operational capabilities but also on the ease and cost of system implementation.

**Operationally, for example:**

- Supervisory programs, such as large linear programming optimization schemes, can run faster and leave more time for other activities.
- Supervisory action can be taken more frequently for closer control over process variables.
- The delay between process inputs to the program and optimization results using these inputs is substantially reduced, giving better control.
- Calculations can employ full-precision values, rather than settling for lesser precision because of computer time limitations.
- Executive functions take less time simply on the basis of system speed, reducing the overhead involved in housekeeping activities.

**When implementing the system:**

- Because of fast system speeds, core memory is occupied by programs for a much shorter period, therefore less core memory may be required.
- System speeds also free process engineers from concern about computer time limitations and extensive programming efforts to circumvent those limitations. As a result, system design can take the form of easily generated, easily understood process flow charts — as opposed to sophisticated programming maneuvers — speeding design and checkout, and enhancing communications between plant personnel.

**And looking to the future:**

- Greater spare capacity is available for future expansion. The FOX 1 system will still be providing extensive background computational capability when other systems are running out of background capacity because of foreground requirements.

# the culmination of your experience and ours

The FOX system comes as the result of a lengthy and exhaustive survey among major industries to determine their most important control system requirements. FOX 1 is, in effect, industry's specification for a plant monitoring and process control system — as interpreted by The Foxboro Company. And *only* Foxboro had the necessary experience required to build it.

**PROFITMAKING SYSTEMS IN EVERY INDUSTRY**

Foxboro has over sixty years of process control experience, over ten of this in computer control. Foxboro computer systems can be found in every major industry, providing increased production, tighter quality control, greater safety, and, for Foxboro, the best applications background in process control. Repeat users of Foxboro systems are several, strong evidence of a strong capability. Foxboro computer systems are in control at several of the world's leading refineries — including the largest refinery under direct digital control — controlling hydrocrackers, fractionators, reactors, ultraformers, and other plant units. Besides control, these systems are handling data collection and reporting, process optimization, and a range of supervisory activities.

The power industry is a major user of Foxboro computer systems for monitoring, logging, and automatic turbine startup.

Also benefitting from Foxboro control are several producers of such products as ethylene, butadiene, nylon, polyesters, and polyvinyl chloride. Remarkable savings are reported in materials, maintenance, and manpower utilization.

In cement, textiles, pulp and paper, and metals, too, Foxboro computer control systems are setting new standards of operating effectiveness.

**EXPERIENCE IN EVERY FACET OF IMPLEMENTATION**

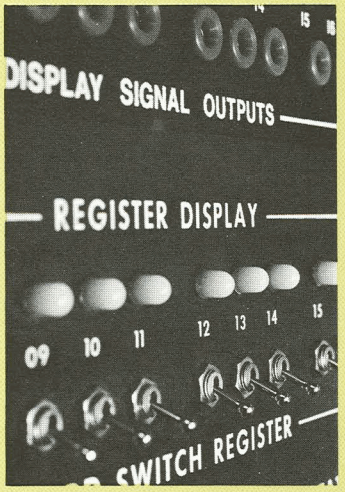
As a corollary to mounting a broad applications foundation, Foxboro over the past decade has developed an unusually strong computer organization. The company has taken most of its systems all the way from specification through startup, compiling a deep and varied expertise in all areas of implementation: project management, process analysis, programming, system design and engineering, manufacturing, checkout, training, documentation, and installation. Hence, Foxboro brought to the design of the FOX 1 system a dossier of credentials without equal in process control.

**A PACESETTER IN EQUIPMENT AND TECHNIQUES**

In the course of its broad experience, Foxboro has been called upon to provide computer solutions to control problems of all types. Many of these have been met with standard Foxboro systems such as the Systems 401 and 402, or with the PEIR-9 system designed by Foxboro specifically for power applications. Others, however, involved extremely unique, first-of-its-kind developments, many of them now standard Foxboro offerings. For example, the PCP 88 was the first dual-computer system for process control, and was designed to provide automatic computer backup for critical processes. And the BATCH software system, a batch process programming capability that brought common-language simplicity to sequential process programming for the first time. Foxboro has also pioneered in the development of man-computer interfaces, now culminating in the new and powerful FOX 1 control console.

**THE WORLD'S LEADING CONTROL RESOURCES**

Enhancing the Foxboro position as a leading single-source supplier of computer control systems are the resources of Foxboro at-large, a worldwide organization devoted solely to process control systems and instrumentation. Long the trend-setter in high-quality instrumentation, Foxboro today has manufacturing facilities in nine countries, and sales representation in over 100. Foxboro control innovations over 60 years are virtually innumerable. And intensive research along a broad front of cutting-edge technology assures its pre-eminence in control for years to come.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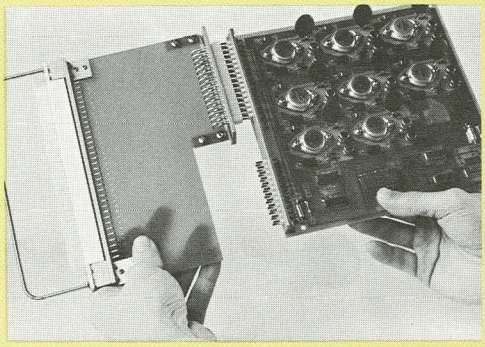
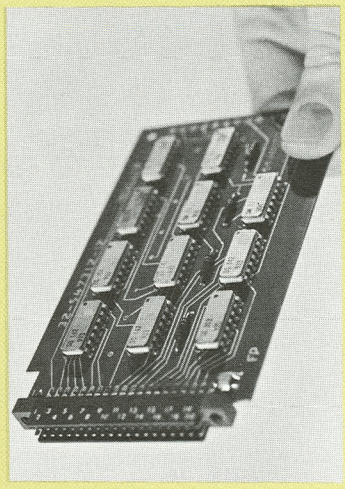
SWITCH REGISTER





## FOX 1 hardware specifications : central processor

The processing and multi-programming power of the FOX 1 system come from the advanced hardware features of both the central processor and the drum.

| | |
|---|---|
| Word Size: | 24 bits plus parity |
| Core Memory Cycle Time: | 960 nanoseconds |
| Core Memory Available: | 16K, 24K, and 32K words |
| Drum Memory Available: | 128K, 256K, and 512K words |
| Average Access Time: | 8.3 milliseconds |
| Data Transfer Rate: | 60K words per second |
| Hardware Features: | • Privileged instruction trap<br>• Program boundary fences<br>• Single- and double-precision floating point<br>• Index registers for pre- and post-indexing<br>• 24 levels of hardware interrupts<br>• 384 levels of process interrupts<br>• Automatic context switching<br>• Direct addressing of 32K core<br>• Drum "look-ahead" hardware<br>• Up to 4 internal clocks<br>• Power fail-safe and restart<br>• Automatic program tracing module<br>• Re-entrant subroutine stacks<br>• Bit, byte, word, and double-word handling instructions<br>• Boolean logic instructions |

### Peripheral Complement

A full complement of peripherals is available for use by background, supervisory, and process programs.

| | |
|---|---|
| Programmers teletype: | 10 characters/second typing speed, tape read, tape punch |
| High-speed paper tape reader: | 300 characters/second |
| High-speed paper tape punch: | 60 characters/second |
| Card reader: | 300 cards/minute |
| Card punch: | 90 cards/minute |
| Line printer: | 132 columns wide, 350 lines/minute (typical for 80 columns) |
| Process typers: | 15 characters/second, 11-inch or 15-inch carriage, 10 or 12 characters/inch |
| Moving head disc file | |
| Power distribution unit | |

### Operator's and Engineer's Consoles

Two different, interchangeable keyboards are available for operator and process engineer. A jet printer can be associated with the consoles to record, on demand, the alphanumeric information on the screen.

| | |
|---|---|
| Screen size: | 10 inches by 15 inches |
| Alphanumeric display: | 2000 characters (25 lines of 80 characters) |
| Graphic display: | 1000 vectors or a maximum of 3000 inches |
| Character size: | 0.17 inches by 0.24 inches |
| Additional hardware: | • Up to 96 backlit alarm keys<br>• Up to 2 associated pen trend recorders (3 pens each)<br>• Operator's keyboard<br>• General-purpose keyboard<br>• Jet printer, 120 characters/second, 80 characters/line |

### Process Interface Hardware

Process inputs and outputs are wired to racks containing the analog and digital multiplexing equipment. The user has his choice of termination options, using either termination racks or removable termination cards within the multiplexer itself. Both isothermal racks and reference junctions are offered for thermocouple inputs.

### Digital Multiplexer System Characteristics

Input types:
- Contact inputs
- Process interrupt inputs
- Pulse counter inputs (100 pps)
- Pulse counter inputs (15,000 pps)

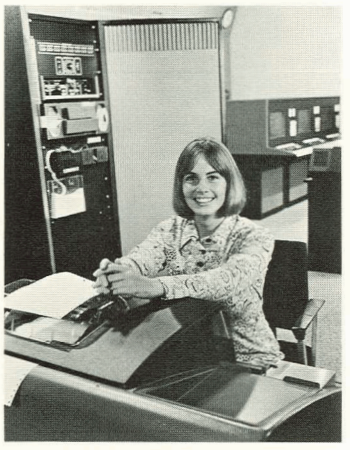
Output types:
- Solid-state latching
- Relay contact latching
- Solid-state momentary
- Relay contact momentary
- Analog current (0-50 mA)
- Analog voltage (up to +10 volt)
- Valve control outputs

Hardware features:
- Intermixing of card types in nest
- Prewired nests for full expansion
- High-voltage input protection
- Cabinet ground and signal ground can be separated
- Solid-state circuitry
- Custom implementation of interrupt levels
- Hardware self-testing on critical outputs
- Latching outputs available for power failure

### Analog Input System Characteristics

- ±0.1 percent accuracy
- 13-bit + sign resolution
- Optional protection up to 155 volts AC or DC
- Low-level solid-state multiplexer
- Relay multiplexer for high overload protection
- Differential multiplexer for both high- and low-level inputs
- 120db common mode rejection at 60 Hz (low level)
- 86db common mode rejection at 60 Hz (high level)
- Driven guarded shield multiplexing
- 5000 point/second solid-state multiplexing
- 100 point/second random relay selection
- 1000 point/second sequential relay selection
- High noise immunity inter-cabinet connections
- Signal conditioning for
  - — RTD inputs
  - — voltage dividers
  - — current inputs
  - — line filters
- Open channel detection
- Off-line maintenance test panel operates while the remainder of the system is on-line
- Signal ground is isolated from chassis ground

FOX 1: Control system of the '70's.



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## 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.

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Printed in U.S.A. Bulletin L-33-10M-1/71

PRINTED IN U.S.A.

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The Foxboro Company Foxboro, Massachusetts, U.S.A. 02035 • Telephone (617) 543-8750

November 12, 1971

Mr. J. Crapuchettes, Consultant
Frelan Associates
P. O. Box 298
Menlo Park, CA 94025

Dear Mr. Crapuchettes:

Thank you for your request for further information on the FOX 1 System.

Enclosed are two brochures, "Foxboro Answers Seven Key Management Questions about the FOX 1 System and Profits," and the "FOX 1 System Description."

I'm sure that you'll find both of these brochures to be well worth reading. "Seven Key Questions" covers the FOX 1 System from an economics standpoint for the benefit of management. The FOX 1 System -- hardware and software -- is a complete control capability designed to provide lowest overall cost performance ratio. Its potential goes far beyond on-line control performance itself, and includes several important dollar-saving features for system implementation, operation, and modifications.

The second of these brochures, the "FOX 1 System Description," covers these features, and several others, in greater detail and technical substance.

We're sure you'll find the FOX 1 System an extremely attractive and impressive capability. There is a Foxboro Digital Systems account representative in your area. If you have any further questions, we would be pleased to have you contact him. You can use the enclosed card or call our District Office at 415-785-3000.

Sincerely,

THE FOXBORO COMPANY

P. R. Wallace

P. R. Wallace
FOX 1 Marketing Director

PRW:cbh
Enclosure

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