

# **FOX 1 software**

JAN 29 1973



**fastware**

**FOXBORO**

The logo features the word "fastware" in a bold, black, lowercase sans-serif font. It is centered within a graphic composed of several overlapping, curved, leaf-like shapes in shades of green and yellow, with a black quarter-circle shape in the top right and bottom right corners.

# fastware

## CONTENTS

Introduction	3
Everything you need for supervision and control	4
Powerful CRT console	6
IMPAC control package	8
FOX 1 FORTRAN and MAX	10
And more programming capability	13
Comprehensive software security	14
FORTRAN statements and assembler instructions	15
Summary of FOX 1 software characteristics	18

Companies are fast realizing that the most substantial rewards of process computer systems lie in the area of plant supervision. An on-line computer can perform a broad range of supervisory functions that maximize plant efficiency while simultaneously performing data acquisition and control. Such activities as process optimization, management reporting, adaptive control, utility efficiency, and material balancing can cut costs dramatically while boosting production and improving quality.

To date, however, computer implementation of advanced engineering concepts and other supervisory activities by process engineers has been impeded by a programming barrier. Becoming familiar with computer language is only one of the problems. Many programming languages are inadequate for the process environment and call for roundabout programming approaches. And the effort and detail involved in incorporating new programs into the system are tedious and time consuming. As a result, managements have had to either forego highly profitable supervisory benefits, or pay a fortune in programming man-hours while waiting months or years for results.

FOX 1 software was designed to bridge the gap between concept and computer, between highly creative and profitable operating plans and their effective execution by the computer. *The FOX 1 system is on line and performing while others are still being programmed.*

FOX 1 software is fast. Fast because it employs easy languages that speed process programming as never before. Fast because it's advanced, automates many functions, relieves engineers of a multitude of system details. Fast because it's more fully programmed for the process environment, freeing plant personnel from writing many programs and providing a range of programming shortcuts and alternatives.

In short, FOX 1 software is fast because it liberates process engineers from a lot of programming, and simplifies the rest. The results: far less programming man-hours, fast implementation of process supervision, and fast return of its economic rewards.

FOX 1 software. Fastware.

FOX 1 software is complete, safe, and ahead of the art. It includes every facility you'll need for all plant activities, from total plant supervision down through supervisory control, tuning, and regulatory control. It provides immediate safe response to all supervisory and control demands. And, together with the powerful array of FOX 1 equipment features, its design advances give the FOX 1 system outstanding capability for today *and* tomorrow.

### **AN ARRAY OF TIME-SAVING PROGRAMMING FACILITIES**

A strong collection of programming tools simplifies every phase of new program development, greatly accelerating implementation of new supervisory schemes, management reporting, and advanced control.

The powerful and efficient FORTRAN IV language has been greatly expanded by several convenient process extensions and such features as bit and byte handling, mixed-mode arithmetic and file management statements. In addition, a FORTRAN Optimizer improves efficiency to a level approaching assembly language programs.

Another high-level language capability is MAX, a macroprocessor that lets you define and use your own application language to speed programming and enhance communications.

The FOX 1 Assembler offers the sophistication of machine-level symbolic coding plus extensive pseudo-operations to handle extra-complex problems.

Once a new program has been written, on-line testing and debugging of the program are remarkably safe, simple, and efficient. Virtually all program implementation functions, such as linking new programs into the system, have been automated. Process engineers do less because the system does more.

In addition to all of these software features, an extremely efficient system generation package permits the user, when making plant and system changes, to restructure hardware assignments and software linkages in a fraction of the time required by other systems.

### **ADVANCED, PROCESS-READY SUPERVISION AND CONTROL**

As soon as it arrives, the FOX 1 system is ready to control your plant, thanks to IMPAC, a powerful data base generation and control package. The requirements of your process are described on simple fill-in-the-blanks forms and loaded into the computer. This can be done off line or directly at the FOX 1 CRT console with your forms displayed on the screen. Changes to the system also are made through IMPAC's easy fill-in-the-blanks forms or displays.

### **FASTER COMMUNICATION VIA CRT**

The highly advanced FOX 1 CRT-based console simplifies man-machine communication because of the speed with which information can be presented,

comprehended, and changed. Program development tools like FORTRAN, the MAX macroprocessor, the assembler and, in particular, the background debugging system can all display their outputs on the CRT.

The CRT console also gives operators and engineers fast access to all programs and plant information stored in the computer. For the first time, a CRT console is fully supported with standard keyboard input and display-generating software for total plant supervision and control.

### **HIGHLY RESPONSIVE REAL-TIME OPERATION**

The heart of the FOX 1 software is a flexible responsive operating system which manages all supervision and control functions via a priority-structured, foreground/background multi-programming scheme. Within this environment, new supervisory programs can be developed on line safely while at the same time plant control proceeds smoothly under constant surveillance. The operating system performs many system functions, including input/output handling, task scheduling, and event response.

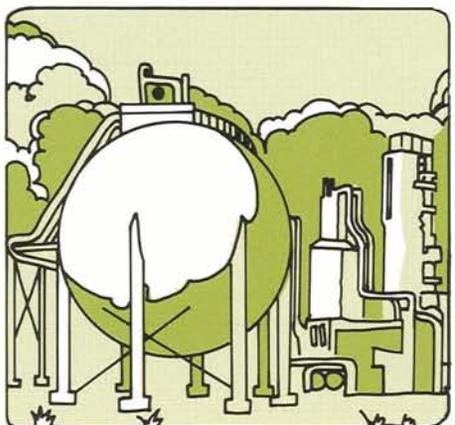
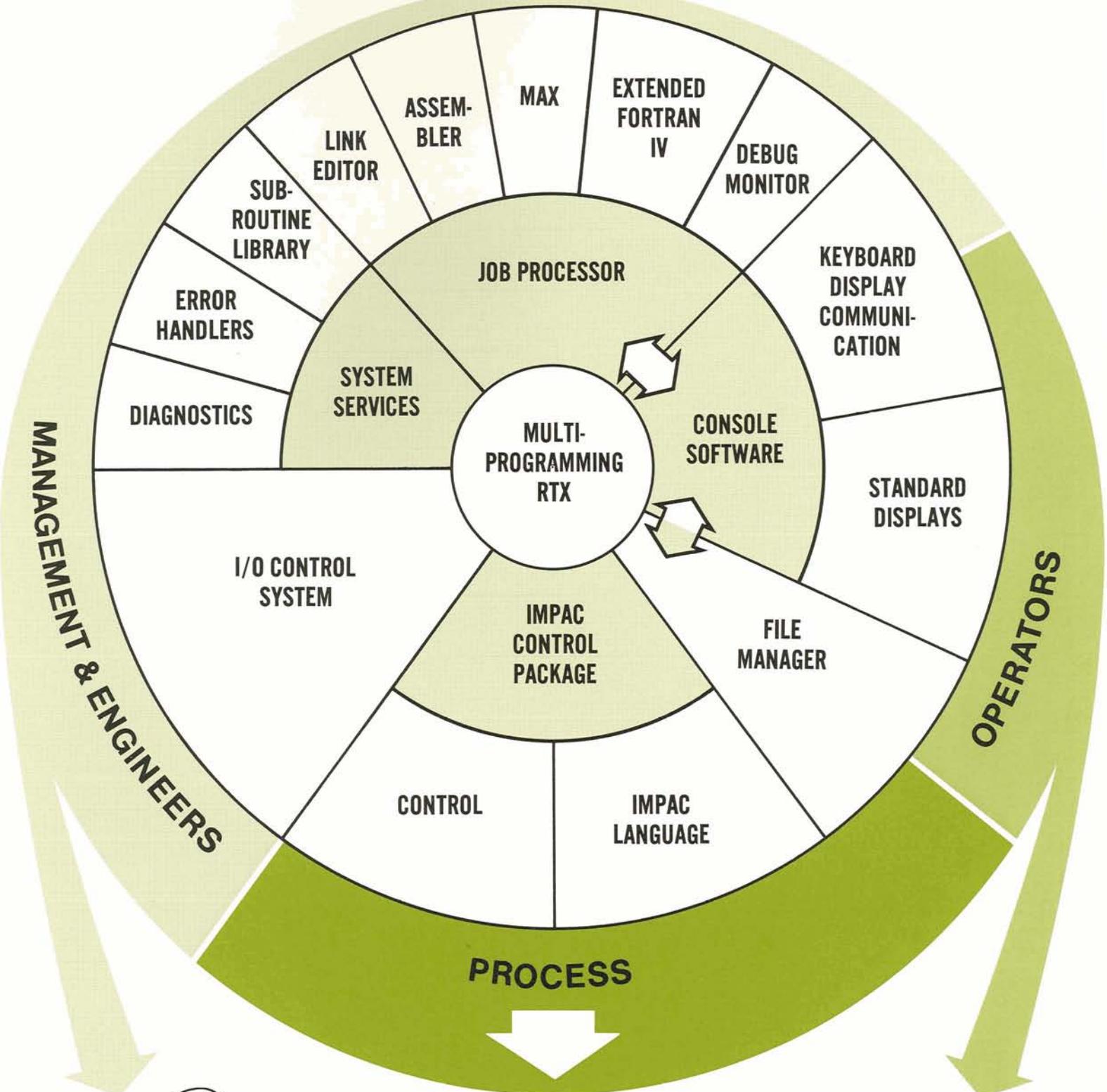
The *Real-Time Executive* is the primary element of the operating system and allocates the major system resources: computing time, core and bulk storage, and access to I/O devices. It consists of interrupt handlers, queue handlers, clock handlers, program requests, entrances and exits, and coordinates the following operating system programs in handling system activities.

The *Input/Output Control System* handles operation of all peripheral I/O devices such as the teletype, line printer, typers, and card and paper tape readers and punches. These devices all operate independently, using the internationally recognized ASCII code, and can back each other up if required.

The *Automatic File Manager* simplifies the job of data handling. It manages all storage of, and access to, plant data and programs in bulk storage. As a result, engineers need not encumber themselves with details when storing or retrieving data. The file manager creates, modifies, and repacks files, and generates all file directories.

The *Console System Software* enhances man-process communications. It controls all communication between the computer and up to six independent CRT/keyboard consoles. It services demands for use of the keyboard, trend recorder and console printer, and controls all data and command transfers involving these devices.

The *Background Job Processor* automatically sets up sequences of tests, executions and language processing required for developing and running supervisory programs, relieving the engineer of these tasks. It manages and time shares all background activity on the basis of priorities and job statements provided by the process engineer. It also includes facilities for safely testing programs under simulated conditions.



## A NEW LOOK AT YOUR PROCESS THROUGH A POWERFUL CRT CONSOLE THAT'S FULLY SOFTWARE SUPPORTED

The FOX 1 System contains a new CRT-based console that provides a window through which the engineer or operator can instantly access all plant information. In other words, supervision and control of all plant operations is centralized in a keyboard-and-display unit about the size of a television set. The console offers both alphanumeric and graphic capabilities.

### USED FOR ALL FUNCTIONS

The FOX 1 console can be used with practically all supervisory and control functions as well as for program preparation and testing. Many console functions and displays have already been provided by Foxboro; in many cases, no additional console programming will be required after the system arrives at the plant.

The Console System Software and the Automatic File Manager together form a highly effective data entry and retrieval capability for supervisory calculations, management reporting, program preparation, tuning, control initiation and control changes, process scanning and alarming.

### MANY DISPLAYS PROVIDED

FOX 1 console software provides a number of standard displays and display directories, including:

- Plant directories – names of units in the plant
- Process unit displays – all measurements for a unit
- Loop displays – identifies records linked together for supervision or control
- Measurement displays – e.g., all temperatures, all flows, etc.
- Supervisory and control data base record displays – records showing all data associated with

each process function.

- Supervisory program directory – names of background and supervisory programs.

With the aid of this versatile display capability, plant personnel can "zoom" in on a variable or see it in context of overall plant operations – in alphanumeric and graphics, judging its effect on the entire process (see illustration at right). Display formatting is easy and very flexible, allowing the user to add his own displays through the keyboard.

### EASIER PROGRAMMING

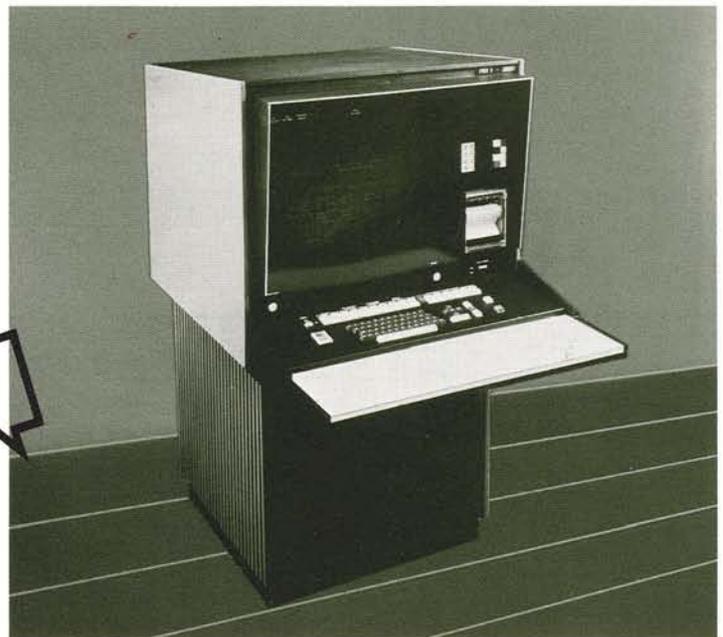
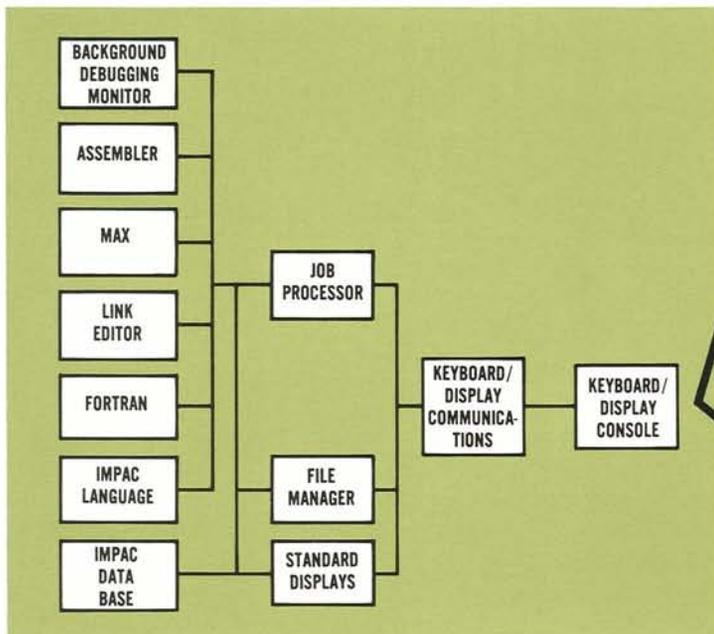
Program preparation and debugging is fast and easy when using the FOX 1 console. Its pushbutton operation and instant full-screen display permit quick retrieval and changes of single statements or entire program segments, bypassing the more complex and tedious procedures associated with conventional paper tapes or card processing.

### RAPID PINPOINT DIAGNOSIS

Investigation of plant upsets is quick and effective with the CRT console. By pressing the appropriate flashing alarm button, the operator displays complete process information for a particular plant area, giving him all relationships. The specific alarming variables blink for immediate identification of the problems.

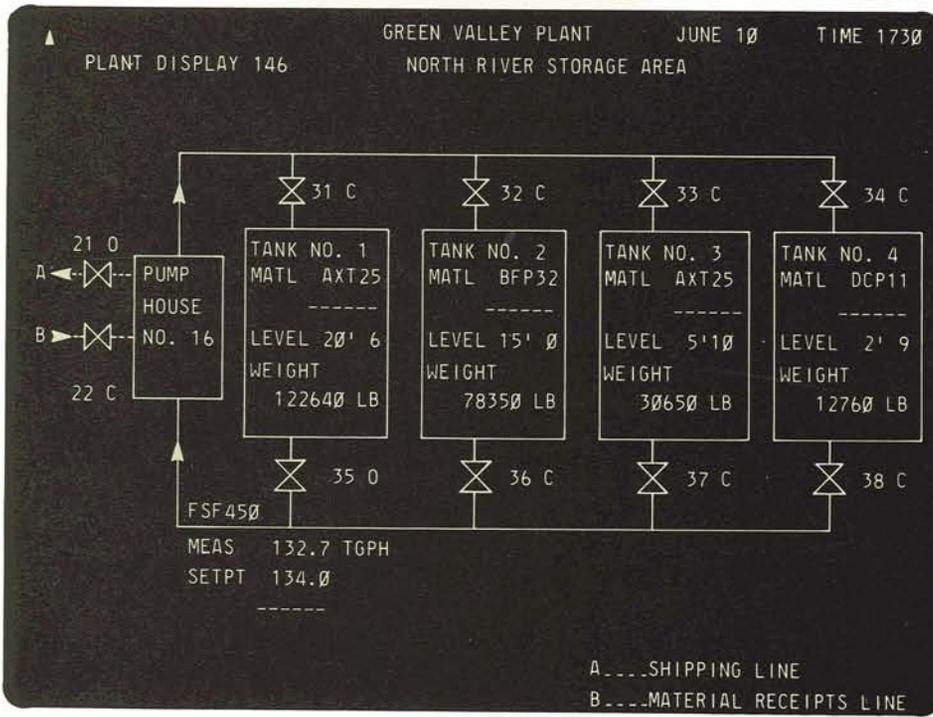
### PROCESS CHANGES

The FOX 1 console also provides a fast and simple means of implementing new approaches to supervision and control or modifying existing schemes through fill-in-the-blanks displays. It's far more convenient than existing procedures because it eliminates the need for cumbersome and time-consuming card or tape input.



These four displays, just a few of the many available with the FOX 1 CRT console, illustrate the powerful communication capability programmed into the system. Plant situations

can be viewed at any level – from the plant manager’s overview down to the process unit – zooming in to individual measurements for immediate comprehension of process situations.

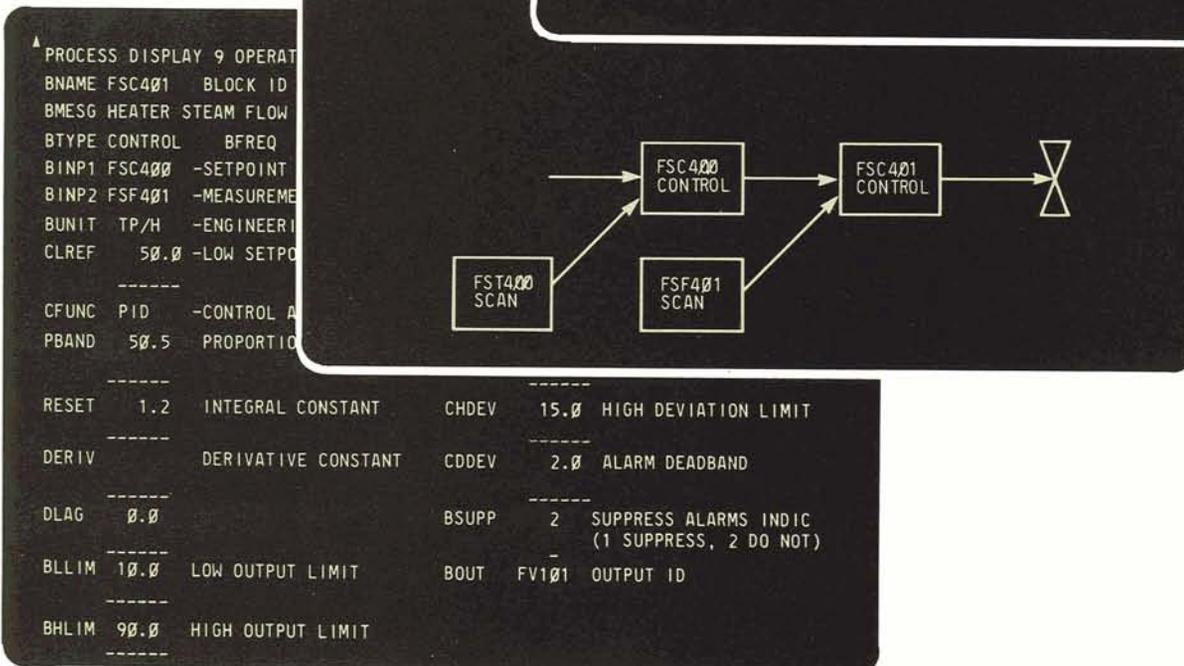


NATOR JUNE 10 TIME 1745

				ALARMS				
S	SETPT	OUTPUT	SCAN	CNT	MODE	ABS	DEV	
---	275.0	---	ON	ON	AUTO	HI	HI	
TP/H	59.5	---	ON	ON	COMP	---	---	
---	23.0	---	ON	ON	AUTO	---	---	
PFC551	PFF550	106.0 TGPH	108.0	---	ON	ON	COMP	
PFM700	PFC700	PFT700	620.0 DEGF	675.0	---	ON	ON	AUTO
PFC701	PFF701	107.0 TP/H	100.0	---	ON	ON	COMP	
PFM750	PFC750	PFF750	75.5 TGPH	78.0	---	ON	ON	COMP

PROCESS DISPLAY

BLOCK	TYPE	PID	MEASUREMENT	SETPOINT	OUTPUT	SCAN	CNT	MODE	ABS	DEV
FSC400	PID	PFC400	PFF400	106.0 TGPH	108.0	---	ON	ON	COMP	---
FSC401	PID	PFC701	PFF701	107.0 TP/H	100.0	---	ON	ON	COMP	---
FSC401	PID	PFC750	PFF750	75.5 TGPH	78.0	---	ON	ON	COMP	---



# IMPAC

## A PROCESS-READY PACKAGE PUTS FOX 1 ON STREAM FAST.

Development of a working program for supervisory and regulatory control can be a prolonged effort lasting many months and involving programming of the functions, generation of the data base, and integration of all elements into a smooth, safely operating system.

Or it can be a relatively simple, overnight task – with IMPAC.

IMPAC is a comprehensive software system for process monitoring, supervisory and regulatory control, and data base generation. Requiring only the entry of basic process information on fill-in-the-blanks forms or CRT displays, the IMPAC system does the rest:

- Data base generation.
- Scanning of analog and digital inputs over a wide range of frequencies.
- Filtering of process input data and conversion to engineering units.
- Calculation of supervisory and control outputs using either standard or user-defined algorithms.
- Real-time updating of process information on the console displays.
- Linkage of standard scan and control software to user-written programs.
- On-line modifications or additions to the control scheme.

### RAPID DATA BASE GENERATION

After receiving the user's process information, IMPAC's data base generator handles all process input and output hardware assignments and parameter specifications, creates individual records for each scan, computation, supervisory or control function, separates them by their scanning periods, and saves them in bulk storage awaiting their use by IMPAC's scan and control package.

Each record consists of a number of fields that contain information such as the alarm limits, input source, control or supervisory algorithm and all linkages. The records provide the information for all plant monitoring and control activities as well as for logging and display. Data base records will frequently be linked together in building-block fashion to form loops.

The data base generator also creates messages, cross reference tables, and the loop structure direc-

tory which links scan, computation, supervision and control records. It also produces all the necessary documentation: listings, core and drum location maps, reports and diagrams of individual loops, plus reports sorted by record or loop identification, instrument type, digital inputs, valve inputs, and so on.

### A WEALTH OF CONTROL FACILITIES

Once the system is on stream, IMPAC's scan and control package examines each record at its predefined frequency and performs the required functions. The scan and control package contains the following set of standard supervisory, calculation and control algorithms:

- Multiply/Divide
- Measurement sum
- Measurement select
- Integration
- Action
- Output summing
- Fan out
- Limit
- Three-term feedback
- Pure integral
- Pure proportional
- Error squared
- Ratio
- Bias
- Lead/lag
- Deadtime
- Parabolic
- Auto Select
- Bang-bang

### BROAD CONTROL FLEXIBILITY

IMPAC offers great versatility in supervisory and direct control strategy. Its standard algorithmic building blocks can be combined in a variety of ways, or new algorithms can be formulated using FOX 1 FORTRAN and easily incorporated into the system.

The data structure is also characterized by great flexibility. New supervisory or control schemes can be implemented *on line* in a fraction of the time possible with other systems. All file organization, linkage assignments, and cross-reference modifications are handled automatically. Just display on the console screen the existing record or a blank format and you can make any change or addition you desire. You can add a new record or whole loops; delete any specified record, its linkages, and all references to it; or change any record definition or response parameter. Or you can display any record on the console and simulate the operation of a loop without producing a process output. If you want a hard copy record of changes, a full screen of information can be reproduced on the FOX 1 console printer in less than 20 seconds.

Shown here are hard-copy and console display fill-in-the-blanks IMPAC forms for process supervision, data base generation, control, and other functions such as logging and display. Though Foxboro does provide a

standard format, the fill-in-the-blanks form is not restricted to this format. You can easily tailor the form to suit your own needs.

SCAN AND ALARM INFORMATION

IDENTIFICATION

B T Y P E = S      B N A M E = F S C 4 0 1      Block ID  
 E X I S T =      Block from existing data base (blank = No, 1 = Yes)  
 B F R E Q = 1 0      Process Interval  
 B U N I T = T P / H      Engineering Units      B F A Z E =      Phase (blanks = automatically assigned)  
 B N M O D =      Modifiable at console (blank = Yes, N = No)  
 B F O R M = 2      Index to floating point format, for display and messages  
 B M E S G = H E A T E R S T E A M F L O W C O N T R O L L E R      Point description or ID of block with duplicate description (32 characters maximum)  
 D =      Is BMESG ID of duplicate point (blank = No, 1 = Yes)  
 B C M T = S T E A M - F L O W M E A S      Comment, if desired for listings  
 M T A G = A      Input Device Tag, if desired for listings  
 M T Y P = A      Input Type (A = Analog, D = Digital, S = Stored)  
 M C A B =      Customer Cable No., if desired for listings

ANALOG INPUT INFORMATION

M I N P = 1 1 0 2 1      Multiplexer Address      M G A I N = 1      Gain Code  
 M N E S T = 1      Relay (0) or General (1) Multiplexer Nest      M U X = 1      Solid State (1) or Relay (0) Multiplexer Card  
 M R A N G = 1      Overrange Allowance Code (blank = none, 1 = +3 pct, 2 = +4.8%)  
 M O C D =      Open Circuit Detection for Relay Inputs (blank = none, Y = Yes)

GREEN VALLEY PLANT

JUNE 10

TIME 1745

▲ PROCESS DISPLAY 9 OPERATOR'S BAM DISPLAY

BNAME	FSC401	BLOCK ID	SETPT	125.0	MEAS	128.4
BMESG	HEATER STEAM FLOW CONTROLLER		-----			
BTYPE	CONTROL	BFREQ	10	PROCESSING INTERVAL IN SEC		
BINP1	FSC400	-SETPOINT SOURCE				
BINP2	FSF401	-MEASUREMENT SOURCE				
BUNIT	TP/H	-ENGINEERING UNITS				
CLREF	50.0	-LOW SETPOINT LIMIT	CHREF	150.0	-HIGH SETPOINT LIMIT	
-----						
CFUNC	PID	-CONTROL ALGORITHM	ALARM	INFORMATION		
PBAND	50.5	PROPORTIONAL BAND	CLDEV	10.0	LOW DEVIATION LIMIT	
-----						
RESET	1.2	INTEGRAL CONSTANT	CHDEV	15.0	HIGH DEVIATION LIMIT	
-----						
DERIV		DERIVATIVE CONSTANT	CDDEV	2.0	ALARM DEADBAND	
-----						
DLAG	0.0		BSUPP	2	SUPPRESS ALARMS INDIC (1 SUPPRESS, 2 DO NOT)	
-----						
BLLIM	10.0	LOW OUTPUT LIMIT	BOUT	FV101	OUTPUT ID	
-----						
BHLIM	90.0	HIGH OUTPUT LIMIT	-----			

# FOX 1 FORTRAN and MAX

**TWO MAJOR SOFTWARE ADVANCES MAKE PROGRAMMING OF SOPHISTICATED FUNCTIONS EASY.**

PROGRAM OPTIMIZER		LIBRARY NUMBER 423-1		FOX 1		PAGE 1 OF 1																																																					
PROGRAMMER WALLACE		DATE 6-24		ASSEMBLER/FORTRAN CODING FORM																																																							
COM. #	STATEMENT NUMBER	CONT.	FORTRAN STATEMENT																																																								IDENTIFICATION SEQUENCE
	72		J=IA(IP)-IP																																																								
C73			... SCALING AND CONVERSION ...																																																								
	74		F1=SIN(FS1)+COS(FS1)																																																								
C75			... ARRAY ACCESSING-2 EXAMPLES ...																																																								
	76		IA3(I,J,K)=IA3A(I,J,K)																																																								
	77		F=FPS(I)+FPS1(I)																																																								

Note the length of the optimized FORTRAN program at right, compared to the conventional FOX 1 FORTRAN program at far right.

In addition to offering fully programmed software for primary supervision and control, the FOX 1 system provides an advanced programming capability featuring two powerful programming languages – FOX 1 FORTRAN and the MAX macroprocessor. These capabilities give process engineers new levels of simplicity in programming for such high-potential profit-producing functions as management reporting, adaptive control, modelling, and optimization.

FORTRAN and MAX are supported by a host of system software, discussed in following pages, which speed the incorporation of user programs into the system with unprecedented ease.

## POWERFUL FOX 1 FORTRAN

Several features make FOX 1 FORTRAN the most powerful FORTRAN in process control. FOX 1 FORTRAN not only contains all of the elements of ANSI standard FORTRAN IV, it also includes real-time extensions for the process control environment: mixed-mode arithmetic, bit and byte manipulation, scaled-fraction data, alphanumeric statement labels, automatic data conversion, a system COMMON area, and file access statements – all enable the system to handle the many different types of data and calculations encountered in process supervision and control. It gives an engineer all the tools he needs to implement the most sophisticated calculation techniques for analysis, simulation, or on-line optimizing.

The availability of system COMMON areas (in addition to program COMMON) and file handling statements give the FOX 1 FORTRAN user direct access to all information in the data base.

In addition to the language extensions, the FOX 1 FORTRAN library contains process input/output subroutines and calls consistent with those recommended by the Purdue Workshop on Standardization of Industrial Computer Languages.

Another very valuable feature of FOX 1 FORTRAN is its object code Optimizer, used during FORTRAN compilation to improve the efficiency of the generated code. It rearranges the coding produced by the compiler for better execution and removes any redundant steps uncovered. The resulting programs approach the efficiency of assembly language programs written by experienced programmers, minimizing both core storage and execution time.

An INCLUDE feature allows information prestored in files to be automatically inserted in programs.

Included in the System Library are the standard FORTRAN mathematical subroutines such as trigonometric functions (SIN, COS, ARCTAN, SINH, COTAN, etc.), logarithmic functions, exponential routines, and mode conversions (FIX, FLOAT, INT, REAL, CMLUX, etc.).

## MAX – A PROGRAMMING MILESTONE

Programming ease was an overriding consideration in designing FOX 1 software and one outcome of this objective was an all-new programming capability, the MAX macroprocessor.

Using MAX, engineers can define and use their own plant-language statements – such as “Close Valve (V341)” or “Analyze Stream (A).” Once defined in a program, the statement can be used time and again without further definition, further reducing programming effort, and greatly improving communications between personnel.

In translating a program, the MAX macroprocessor puts the definition of the macro statement – a list of FORTRAN or assembly instructions – in a table, and then automatically inserts the instructions into the program whenever it finds the macro statement.

The original program itself may combine macro statements with either FORTRAN statements or assembly language instructions for purposes of efficiency.

```

72 J=IA(IP)-IP
00275 53504435 LDA IP,,XCREL
00276 02400322 AND (0177400)
00277 43200110 RLS 8
00300 44600007 STA R4
00301 53200000 LDA (010)
00302 12600007 SUB R4
00303 43200420 ARS 16
00304 44600007 STA R4
00305 53504435 LDA IP,,XCREL
00306 02400312 AND (0177400)
00307 43200110 RLS 8
00310 43200420 ARS 16
00311 44600010 STA R5
00312 53600007 LDA R4
00313 60600010 LXA R5
00314 10514427 ADD IA-1,AX,XCREL
00315 44324001 STA J,BX

73 C ... SCALING AND CONVERSION ...
74 F1=SIN(FS1)+COS(FS1)
00316 53504035 LDA FS1,,XCREL
00317 25000077 BSR DFFLOT,,11
00320 01300000 FML (012003600000000000)
00321 36400275 BSR COS,,11
00322 25000000 BSR COS,,11
00323 01300000 STL R4
00324 45600007 FS1,,XCREL
DFFLOT,,11

```

```

72 J=IA(IP)-IP
00154 53524427 LDA IA-1,BX,XCREL (012003600000000000)
00155 12600006 SUB R4 SIN,,11
00156 44314001 STA J,AX R4

73 C ... SCALING AND CONVERSION ...
74 F1=SIN(FS1)+COS(FS1)
00157 53504035 LDA FS1,,XCREL F1,BX
00160 25000000 BSR DFFLOT,,10 ARRAY ACCESSING = 2 EXAMPLES ...
00161 01200000 FML (012003600000000000) (I,J,K)=IA3A(I,J,K)
00162 36400237 SNR A K,BX
00163 47077775 STA R4 (5)
00164 44600006 BSR COS,,10 E
00165 25000000 J,BX
00166 01200000 (5)
00167 45600007 LDA R4 E
00170 53600006 BSR SIN,,10 I,BX
00171 25000000 R4
00172 01200000 K,BX
00173 34600007 FAL R5 (5)
00174 25000000 BSR FDFIX,,10 E
00175 01200000 STA F1,AX J,BX
00176 44314022 ... ARRAY ACCESSING = 2 EXAMPLES ... (5)
75 C IA3(I,J,K)=IA3A(I,J,K) E
76 LDA K,AX I,BX
00177 53314002 MPY (5) R5
00200 14200005 LDA E R5
00201 53077776 ADD J,AX $-1885
00202 10314001 MPY (5) E
00203 14200005 LDA E IA3A-31,BAX
00204 53077776 ADD I,AX R4
00205 10314000 STA R4 IA3-31,AX,XCREL
00206 44600006 LXB R4 PS(I)+FPS1(I)
00207 61600006 GEA $-1907
00210 01404215 LXA E
00211 60077776 LDA IA3A-31,BAX
00212 53333777 STA IA3-31,BX,XCREL
00213 44524174 F=FPS(I)+FPS1(I) (-1)

77 LDA (-1) *IMPLCT+2048
00214 53277777 GEA *IMPLCT+2048 E
00215 01400044 LXB E I,AX
00216 61077776 ADD I,BX (8)
00217 10324000 ALS 3 (010)
00220 43200503 LDE A (0130)
00221 52077775 LDA (010) (01100)
00222 53200000 DIV (0130) A
00223 15200030 ADL (01100) FPS1,BX,XCREL
00224 11200100 STL R4 E
00225 45600006 LXA R4 (017600000)
00226 60600006 LDA FPS1,AX,XCREL R4
00227 53514025 SHF R4+1 (-1)
00230 43600007 AND (017600000) I,AX
00231 02400157 STA R6 (8)
00232 44600010 LDA FPS,AX,XCREL (010)
00233 53514031 SHF R4+1 (0130)
00234 43600007 AND (017600000) (01100)
00235 02400153 ADD R6 A
00236 10600010 STA F,BX FPS,BX,XCREL
00237 44324003 E

```

## A RICH ASSORTMENT OF FEATURES MAKES FOX 1 FORTRAN EASIER, MORE EFFICIENT

EFFICI PAGE 1

```

1      MAIN EFFICIENCY
2      LOGICAL MASK (16) : (0,1,1), { TEST
3      } FRACTION { COEFF(8) : (0,6,6)
4      DIMENSION RTEMP (2,2,2,2) , ACOEFF(8)
5      EQUIVALENCE (BITS, MASK)
6      } SYSCOMMON { 3/ KAPPA(8), TEST, TOTEFF
7      DATA ACOEFF/0.03125, 5*0.0625, 2*.5125/, BITS/'FF00'B16/
8      EFF1 READ(102, EFMT) $REC=12, $ERR=&IOERR) (RTEMP(I,1,1,1), I=1,2), UNIT
9      EFMT FORMAT( 8F6.2, F2.0)
10     DO SETCO I=8
11     } SETCO { COEFF(I) = ACOEF(I)
12     TEST = .FALSE.
13     DO ELOOP I=1,2
14     DO ELOOP J=1 } 2*UNIT=1 {
15     EFFIC = } COEFF(J)* TRTEMP(I,1,1,1) + KAPPA(J) {
16     IF(TEST .AND. MASK(J)) GO TO NEXT
17     ELOOP MASK(J) = .T.
18     NEXT } SEEK { TEST, EFFIC, RTEMP, } &EFF1, { STEMP)
19     TOTEFF = EFFIC + TOTEFF + STEMP
20     IOERR STOP 16
21     END

```

1. PACKED DATA  
 2. FRACTIONAL VARIABLES  
 3. SYSTEM COMMON  
 4. NONDECIMAL NUMBERS  
 5. ERROR RETURN FOR I/O MALFUNCTION  
 6. FILE I/O  
 7. ALPHANUMERIC STATEMENT LABELS  
 8. ANY EXPRESSION FOR DO-LOOP LIMIT  
 9. MIXED MODE ARITHMETIC  
 10. "CALL" NOT NEEDED FOR SUBROUTINE REQUEST  
 11. ALTERNATE RETURNS FOR SUBROUTINES

An extension of ANSI-standard FORTRAN, FOX 1 FORTRAN offers several features which simplify programming for the process engineer. Some of these are illustrated here.

1. Packed data – Use of a single memory location for several items of data, efficiently conserving computer storage.
2. Scaled fraction data type – For dealing directly with instrument readings.
3. System COMMON area – Gives programs immediate access to system data.
4. Nondecimal numbers – For expressing logical information in efficient packed forms.
5. Input/Output error labels – Provide escape routes should a device malfunction.
6. File input/output – Allows easy access to and manipulation of plant data in bulk storage.
7. Alphanumeric labels – Provide the clarity and readability of names, rather than numbers, when identifying program statements.
8. DO-loop parameter expressions – Provide flexibility for repetitive operations.
9. Mixed-mode arithmetic – Provide flexibility for dealing with the diverse sources and types of data found in the process environment.
10. Optional deletion of CALL (before subroutine name) – To improve readability and reduce writing.
11. Alternate subroutine returns – Allow a routine to provide a variety of responses depending on its inputs.

## AND EVEN MORE PROGRAMMING CAPABILITY

Besides FOX 1 FORTRAN, IMPAC, and MAX, FOX 1 software includes a number of software packages that further simplify the program development effort.

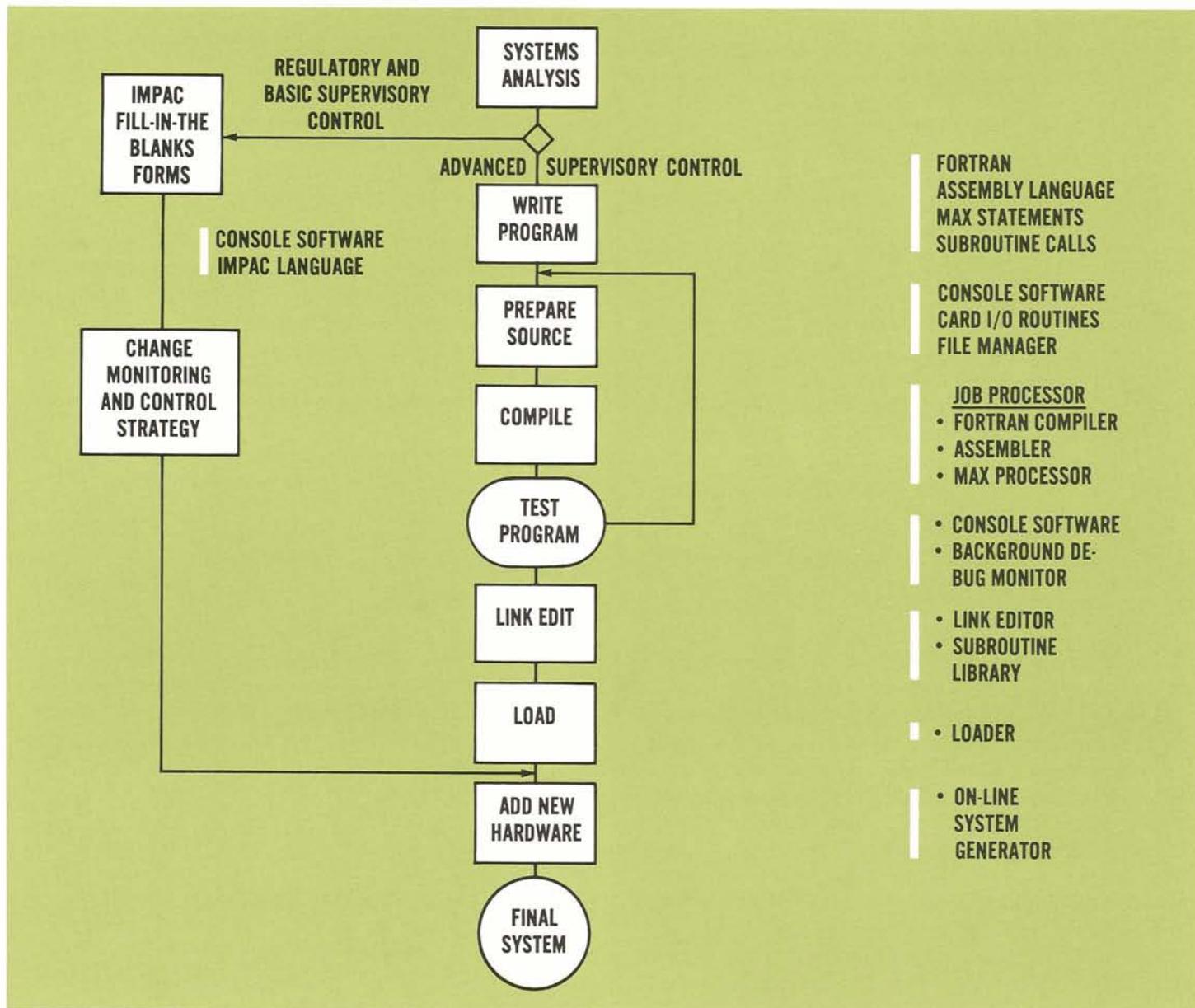
### ASSEMBLY SYSTEM

The FOX 1 Assembly System gives experienced programmers added capability through a rich instruction vocabulary. What's more, it not only checks for as many as 63 different error conditions, producing error diagnostic messages, but it also produces listings of the program for documentation and debugging. Twenty-nine directives or pseudo-operations including memory assignment, constant definitions and data packing are included in the assembler. The machine language output is relocatable, relieving the programmer of this task.

### COMPLETELY SAFE BACKGROUND DEBUGGING

Once a new program or routine has been compiled or assembled, it is tested by the Background Debugging Monitor. Testing is performed under hardware and software surveillance to ensure that an undebugged program cannot inadvertently change some parameter beyond its fenced boundaries.

The program being debugged runs in the background, time-shared with other background programs. For simulation purposes, the new program can have all of its process outputs trapped and rerouted to a peripheral device. Any attempt to violate its established area is likewise trapped and prevented, and appropriate diagnostic messages are printed.



FOX 1 software is very comprehensive and provides time-saving features for every phase in the development of a program, as shown here.

## FOX 1 PROVIDES COMPREHENSIVE SOFTWARE SECURITY

Program testing can be conducted using either the engineer's CRT console or the teletype. Hard copy output can be obtained from the line printer, the teletype, card punch, or paper tape punch. Input can be made from drum files, the CRT, the teletype keyboard, the card reader, or the paper tape reader.

Program testing usually requires displays of the memory locations occupied by the program and its associated data tables. The debugging monitor can produce these displays on line printer, teletype, card punch, paper tape punch, console printer, or the CRT. They can be expressed in ASCII, decimal integer, or single- or double-precision floating point, giving the engineer his choice of format.

The debugging monitor can stop a program as often as desired at selected locations and restart it from these or any other locations when ready. The stops can be selectively removed on line as they become unnecessary during successive executions. When problems are found, the contents of any addressable register or core location can be examined and nearly all of them can be modified.

Every instruction or just the program control instructions (branches, skips, and jumps), can be traced as they occur. The entire program or various segments of it can be traced. The trace display includes the instruction and its location, the data address and its contents before execution, and the contents of any register that changed during execution.

### LINK EDITOR

Once tested, using the on-line debugging package, programs are easily added to the system, with the required linkages supplied by the link editor. The new program can access any data base values or have its parameters displayed and modified at the console. Existing programs and library subroutines can be used as required. The new program can be executed as the result of a scheduled request, a call from another program, a call from a point or loop being processed, or as a result of a process interrupt.

### ACCELERATED SYSTEM REGENERATION

System generation is first accomplished at the time a system is installed and establishes the basic software modules. Later, however, plant expansion or major modification may dictate generation of a new software organization for greater efficiency. With most computer systems, this operation requires going off line and off control for as long as 24 to 36 hours. And with some computers, regeneration may require going to a vendor's computer center far from the control site. The FOX 1 system generator is automatic, efficient, and can perform on line in the FOX 1 system without disturbing the control of the process. Only at the moment of changeover to the new configuration must the FOX 1 be taken off line and then only for a very short time.

The Foxboro Company's long experience with process control dependability is apparent in the software security provisions that protect every aspect of FOX 1 operation. The process, the programs, and the equipment are continuously checked by software to keep the system running and operating properly.

### EXTENSIVE DATA CHECK

Data entry via the control console, for example, is thoroughly protected. Selected fields of a record being displayed can be protected from being inadvertently altered, with the operator allowed to enter data only into underlined, unprotected areas on the screen. New values appear beneath the current values on the display so that the new information can be verified before implementing the change. Moreover, new data is subject to a series of software checks before being transmitted to the computers. A loop must be made inactive before it can be modified; only after a new entry has passed all tests is the value accepted and the display updated. What's more, if the operator attempts to perform some prohibited function, the function is rejected and a message explaining the error appears on the screen.

### PROGRAM SAFEGUARDS

New program preparation is performed under closely monitored direction of the operating system and with complete safety to the system and the process. Threats to the system from programs operating in the background are automatically thwarted by both hardware and the software features of the error handler package.

The background debugging monitor system permits testing and correcting of new programs on-line in complete safety. And FOX 1 FORTRAN provides an additional measure of confidence through its self-checking features.

### SYSTEM TESTS

System operation, too, is thoroughly protected by FOX 1 software. Every I/O peripheral device is checked to see if it completed its last operation within its allotted time. The computer, also, times itself to confirm that it has finished all required tasks within a prescribed time period. The main power is constantly monitored to ensure an orderly shutdown when power is removed, and automatic startup when power is returned. An additional system feature provided by FOX 1 software is automatic peripheral backup, automatically shifting to a backup device should any peripheral device fail.

To ensure the integrity of FOX 1 software itself, it is fully checked out under a wide variety of conditions before it arrives at your site.

## FOX 1 FORTRAN STATEMENTS AND FOX 1 ASSEMBLER INSTRUCTIONS

### FOX 1 FORTRAN

#### DATA TYPES

Integer  
Real  
Double Precision  
Scaled Fraction  
Double Fraction  
Packed Data  
Complex  
Hollerith

#### SPECIFICATION STATEMENTS

Dimension  
Common  
Equivalence  
Type  
Implicit  
Data  
Syscommon  
Dsymb1  
Include

#### ARITHMETIC, LOGICAL AND CONTROL STATEMENTS

Arithmetic Assignment  
Logical Assignment  
Go To  
Computed Go To  
Assigned Go To  
Arithmetic If  
Logical If  
Continue  
Do  
Pause  
Stop  
End

#### INPUT/OUTPUT

Read, Formatted and Unformatted  
Write, Formatted and Unformatted  
Formats: F, E, G, D, S, I, O, Z, L, A, H, X  
Formats: Repetition Groups  
Rewind, Backspace, Endfile  
Decode, Encode

### FOX 1 ASSEMBLER INSTRUCTIONS

#### LOAD GROUP

LDA 53 Load A Register

LDE 52 Load E Register  
LLC 04 Load Logical Complement  
LDL 51 Load Long

#### LOGICAL GROUP

AND 02 Logical And  
IOR 03 Inclusive Or  
XOR 05 Exclusive Or

#### SHIFT GROUP

SHF 43 Shift  
NMS 41 Normalize Short  
NML 42 Normalize Long  
RLE 40 Rotate Left E Register

#### FIXED POINT GROUP

ADD 10 Add To A Register  
ADL 11 Add Long To A, E Register  
SUB 12 Subtract From A Register  
SBL 13 Subtract Long From A, E Register  
MPY 14 Multiply  
DIV 15 Divide

#### FLOATING POINT GROUP

FAS 30 Floating Add Short  
FSS 31 Floating Subtract Short  
FMS 32 Floating Multiply Short  
FDS 33 Floating Divide Short  
FAL 34 Floating Add Long  
FSL 35 Floating Subtract Long  
FML 36 Floating Multiply Long  
FDL 37 Floating Divide Long

#### STORE GROUP

STA 44 Store A Register  
STE 46 Store E Register  
STL 45 Store Long A, E Register  
SNR 47 Store Normalized And Rounded  
EAM 54 Exchange A Register With Memory  
MST 55 Masked Store  
DEM 56 Decrement Memory

#### BRANCH GROUP

BRU 22 Branch Unconditional  
BRN 23 Branch If Register A Is Negative  
BRZ 24 Branch If Register A Is Zero  
BSP 26 Branch And Save Place

## INDEX REGISTER GROUP

LXA 60	Load XA
LXB 61	Load XB
SXA 62	Store XA
SXB 63	Store XB
AXA 64	Add To XA
AXB 65	Add To XB
CXA 66	Compare XA And Skip
CXB 67	Compare XB And Skip
TIA 70	Test And Increment XA
TIB 71	Test And Increment XB
BDA 72	Branch And Decrement XA
BDB 73	Branch And Decrement XB

## TWO-WORD GROUP

MOV 50	Move Multiple
BIT 07	Bit Manipulation
CWM 20	Compare With Memory
BSR 25	Branch And Save Region

## MISCELLANEOUS GROUP

RFI 16	Return From Interrupt
GEA 01	Generate Effective Address
PIO 21	Programmed Input-Output
SPL 17	Set Priority Level
HLT 00	Halt
BYT 06	Byte Manipulation

## SHF GROUP

### ASSEMBLED AS SHF INSTRUCTIONS WITH LITERAL ADDRESSES

ALS	Arithmetic Left Short Shift
ALL	Arithmetic Left Long Shift
ARS	Arithmetic Right Short Shift
ARL	Arithmetic Right Long Shift
LLS	Logical Left Short Shift
LLL	Logical Left Long Shift
LRS	Logical Right Short Shift
LRL	Logical Right Long Shift
RLS	Rotate Left Short
RLL	Rotate Left Long
RRS	Rotate Right Short
RRL	Rotate Right Long

## BIT GROUP

### THESE MNEMONICS SPECIFY THE OP CODE AND THE SUB-OP CODE

SKS	Skip If Bit Set
SKR	Skip If Bit Reset
SKU	Skip Unconditional
BIT	Bit No-Op
SKSS	Skip If Bit Set And Set Bit
SKRS	Skip If Bit Reset And Set Bit
SKUS	Skip Unconditional And Set Bit
SBIT	Set Bit
SKSR	Skip If Bit Set And Reset Bit
SKRR	Skip If Bit Reset And Reset Bit
SKUR	Skip Unconditional And Reset Bit
RBIT	Reset Bit
SKSC	Skip If Bit Set And Complement Bit
SKRC	Skip If Bit Reset And Complement Bit
SKUC	Skip Unconditional And Complement Bit
CBIT	Complement Bit

## CWM GROUP

### THESE MNEMONICS SPECIFY THE OP CODE AND THE SUB-OP CODE

BZEQ	Branch If Zero Is Equal To Memory
BZNE	Branch If Zero Is Not Equal To Memory
BZGT	Branch If Zero Is Greater Than Memory
BZLT	Branch If Zero Is Less Than Memory
BZGE	Branch If Zero Is Greater Than Or Equal To Memory
BZLE	Branch If Zero Is Less Than Or Equal To Memory
BZSE	Branch If Zero Sign Equals Memory Sign
BAEQ	Branch If A Is Equal To Memory
BANE	Branch If A Is Not Equal To Memory
BAGT	Branch If A Is Greater Than Memory
BALT	Branch If A Is Less Than Memory
BAGE	Branch If A Is Greater Than Or Equal To Memory
BALE	Branch If A Is Less Than Or Equal To Memory
BASE	Branch If A Sign Equals Memory Sign
BEEQ	Branch If E Is Equal To Memory
BENE	Branch If E Is Not Equal To Memory
BEGT	Branch If E Is Greater Than Memory
BELT	Branch If E Is Less Than Memory
BEGE	Branch If E Is Greater Than Or Equal To Memory
BELE	Branch If E Is Less Than Or Equal To Memory

BESE Branch If E Sign Equals Memory Sign  
 BLEQ Branch If A, E Is Equal To Memory  
 BLNE Branch If A, E Is Not Equal To Memory  
 BLGT Branch If A, E Is Greater Than Memory  
 BLLT Branch If A, E Is Less Than Memory  
 BLGE Branch If A, E Is Greater Than Or Equal  
 To Memory  
 BLLE Branch If A, E Is Less Than Or Equal  
 To Memory  
 BLSE Branch If A, E Sign Equals Memory Sign  
 SZEQ Skip If Zero Is Equal To Memory  
 SZNE Skip If Zero Is Not Equal To Memory  
 SZGT Skip If Zero Is Greater Than Memory  
 SZLT Skip If Zero Is Less Than Memory  
 SZGE Skip If Zero Is Greater Than Or Equal  
 To Memory  
 SZLE Skip If Zero Is Less Than Or Equal  
 To Memory  
 SZSE Skip If Zero Sign Equals Memory Sign  
 SAEQ Skip If A Is Equal To Memory  
 SANE Skip If A Is Not Equal To Memory  
 SAGT Skip If A Is Greater Than Memory  
 SALT Skip If A Is Less Than Memory  
 SAGE Skip If A Is Greater Than Or Equal  
 To Memory  
 SALE Skip If A Is Less Than Or Equal To Memory  
 SASE Skip If A Sign Equals Memory Sign  
 SEEQ Skip If E Is Equal To Memory  
 SENE Skip If E Is Not Equal To Memory  
 SEGT Skip If E Is Greater Than Memory  
 SELT Skip If E Is Less Than Memory  
 SEGE Skip If E Is Greater Than Or Equal  
 To Memory  
 SELE Skip If E Is Less Than Or Equal To Memory  
 SESE Skip If E Sign Equals Memory Sign  
 SLEQ Skip If A, E Is Equal To Memory  
 SLNE Skip If A, E Is Not Equal To Memory  
 SLGT Skip If A, E Is Greater Than Memory  
 SLLT Skip If A, E Is Less Than Memory  
 SLGE Skip If A, E Is Greater Than Or Equal  
 To Memory  
 SLLE Skip If A, E Is Less Than Or Equal  
 To Memory  
 SLSE Skip If A, E Sign Equals Memory Sign  
 TWBZ Three Way Branch On Zero Minus Memory  
 TWBA Three Way Branch On A Minus Memory

TWBE Three Way Branch On E Minus Memory  
 TWBL Three Way Branch On A, E Minus Memory

**PROGRAMMED I/O (PIO)  
 ASSEMBLED AS PIO INSTRUCTIONS  
 WITH LITERAL ADDRESSES**

RDA Read Data  
 Literal Address =  
 Octal 03000 + Device Address  
 WDA Write Data  
 Literal Address =  
 Octal 01000 + Device Address  
 RDSK Read Data And Skip  
 Literal Address =  
 Octal 03400 + Device Address  
 WDSK Write Data And Skip  
 Literal Address =  
 Octal 01400 + Device Address  
 RST Read Status  
 Literal Address =  
 Octal 07000 + Device Address  
 RSTC Read Status And Clear  
 Literal Address =  
 Octal 13000 + Device Address  
 RSTCSK Read Status And Clear And Skip  
 Literal Address =  
 Octal 13400 + Device Address  
 WST Write Status  
 Literal Address =  
 Octal 05000 + Device Address  
 RILS Read Interrupt Level Status  
 Literal Address =  
 Octal 00000 + Device Address  
 Device Address .LT.24  
 CIO Initiate Channel I-0  
 Literal Address =  
 Octal 00000 + Device Address  
 CIOSK Initiate Channel I-0 And Skip  
 Literal Address =  
 Octal 00400 + Device Address

**MISCELLANEOUS GROUP**

NOP No-Op  
 Assembled As A BRU to PC + 1  
 RFS Return From Subroutine  
 Assembled As A BRU With A Literal  
 Address Of 0

## CHALLENGE:

COMPARE THESE FOX 1 SOFTWARE FEATURES  
WITH ANY OTHER PROCESS SOFTWARE

Package or Subsystem	Functions	Characteristics
Operating System	Scheduling. Interrupt response. I/O Control. Memory management. Error detection.	Adaptable to any process situation through flexible priority assignments. Multiprogramming for best response to process changes. Device-independent input/output for maximum backup capability. Foreground/background isolation for safe program development.
File Manager	Named-file data access by record. Creation, modification, and repacking of files.	FORTRAN I/O compatible. Fixed and variable length files. Automatic repacking for efficient storage utilization.
Job Processor	Job stacking. Operator messages. I/O assignments for background programs.	Control of background program execution without operator intervention. Interface with operator through teletype or CRT console.
Console Software	Keyboard input. Display generation. Standard displays. New display definition.	Interfaces with all other software packages to provide most effective man-machine interfacing. Plant information, control schemes, system status, language processing, debugging messages can all be displayed on the CRT.
IMPAC	Data base generation. Basic supervisory and control action including data acquisition, calculation, basic supervision, and control. In-line addition, modification or deletion of any part of the control scheme.	Employs fill-in-the-blanks forms on paper or CRT screen. Modifiable format for application tailoring. 19 calculation, supervision and control algorithms. Extensive self-checking features. Ability to add new algorithms easily. Linkage of records in building-block fashion to form loops.

Package or Subsystem	Functions	Characteristics
FOX 1 FORTRAN	All ANSI standard FORTRAN IV features. Process I/O, file I/O, packed data handling, mixed-mode arithmetic, scaled functions, system COMMON alphanumeric labels. Complete listings and cross-references.	Standardization of ANSI FORTRAN plus extensions to make it easy for the process engineer to express solutions to plant problems. Many data types to mirror the process environment and ability to mix types within calculations, avoiding lengthy conversion.
MAX	MACRO statements. Conditional translation.	Allows generation of customized language statements to express application-dependent activities naturally. MAX translates into either FORTRAN or assembly language.
Assembler	29 directives for memory assignment, data packing, constant definitions, etc. Complete listings and cross-references.	Intended for the experienced programmer who finds it desirable to deal directly with the language of the computer.
Background Debugging Monitor	Breakpoint memory dumps. Conditional traces. Memory modification.	Format selection for memory display or entry. Complete protection of foreground operation. Displays results on CRT, optional hard copy output.
Link Editor	Preparation of translated program for execution.	Links programs and subroutines. Obtains functions from subroutine library. Finds locations of common data. Checks for and flags missing information. Prepares program in proper format for entry into memory.
System Generator	For revising software structure. Inserts all initial system parameters. Establishes all linkages for start-up. Prepares initial hardware assignments.	Operates on-line. System need only be taken off line for short period for actual changeover.
Diagnostics	Peripheral device testing. Memory testing.	Available to insure proper operation of the system.

## OPERATING COMPANIES

ARGENTINA  
Foxboro Argentina S. A.  
Avda. R. S. Pena 570  
Buenos Aires

AUSTRALIA  
Foxboro Proprietary Limited  
Maroondah Highway  
Lilydale, Victoria 3140

BRAZIL  
Foxboro Brasileira Instrumentacao Ltda.  
Caixa Postal 30.770  
Sao Paulo, SP

CANADA  
The Foxboro Company, Limited  
707 Dollard Avenue  
LaSalle, Quebec 650

CARIBBEAN  
Foxboro Americana, Inc.  
G. P. O. Box 4726  
San Juan, Puerto Rico 00936

FRANCE  
Foxboro France S. A.  
B. P. 249  
62-Arras

GREAT BRITAIN  
Foxboro-Yoxall Limited  
Redhill, Surrey

ITALY  
Foxboro Italia S.p.A.  
Via G. Fara, 39  
I 20124 Milano

JAPAN  
(Licensed Associate)  
Yokogawa Electric Works, Ltd.  
2-9 Nakacho  
Musashino-shi  
180 Tokyo

MEXICO  
Foxboro, S. A.  
Apartado Postal 7-938  
Mexico City 7, D. F.

THE NETHERLANDS  
Foxboro (Nederland) N. V.  
Koningsweg 30  
Soest

UNITED STATES  
The Foxboro Company  
Neponset Avenue  
Foxboro, MA 02035

WEST GERMANY  
Foxboro Deutschland G.m.b.H.  
Ross-Strasse 112  
4000 Duesseldorf

### 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** \*