MEMORANDUM
RM-5044-PR
SEPTEMBER 1966

JOSS: CONSOLE SERVICE ROUTINES
(THE DISTRIBUTOR)

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PREPARED FOR:
UNITED STATES AIR FORCE PROJECT RAND

The RAND Corporation
SANTA MONICA • CALIFORNIA

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This research is sponsored by the United States Air Force under Project RAND—Contract No. AF 49(638)-1700—monitored by the Directorate of Operational Requirements and Development Plans, Deputy Chief of Staff, Research and Development, Hq USAF. Views or conclusions contained in this Memorandum should not be interpreted as representing the official opinion or policy of the United States Air Force.

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Published by The RAND Corporation

PREFACE and SUMMARY

The distributor is that part of the JOSS* on-line, time-shared computing service which handles communications with the user consoles. This Memorandum describes the distributor's interface with the consoles and with other elements of the computer program. In addition, some of the design criteria which led to interface decisions are briefly described. An Appendix contains program documentation, consisting of table descriptions and flow diagrams.

This Memorandum is a part of The RAND Corporation's continuing program of research in computer sciences under U.S. Air Force Project RAND.

The JOSS system was originally implemented on the JOHNNIAC computer in 1963 by J. C. Shaw; the present expanded version is implemented on the Digital Equipment Corporation PDP-6 computer.

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*JOSS is the trademark and service mark of The RAND Corporation for its computer program and services using that program.

CONTENTS

I. INTRODUCTION

JOSS software is composed of four major components and several subcomponents (Fig. 1).

The major components are:

1) The monitor, which handles resource allocation (except for disc space), scheduling, queueing, accounting, internally generated signals, and all console and teletype input-output (I/0) buffers;

2) The distributor, which handles all I/0 to and from the JOSS consoles and teletypes (except the PDP-6 control teletype);

3) The interpreter, which does all of the processing of user programs;

4) An off-line disc maintenance program, which provides facilities for dump/restore via tape, updates, reallocation, and various other service functions.

The several subcomponents include:

1) The arithmetic processor, which contains all of the arithmetic and function evaluation routines and various other subroutines. This package is a subcomponent of the interpreter and has no interface with the monitor.

2) The on-line disc processor, which handles all I/0 to and from the disc. It is a subcomponent of the interpreter. However, communication paths are established via signals to the monitor.

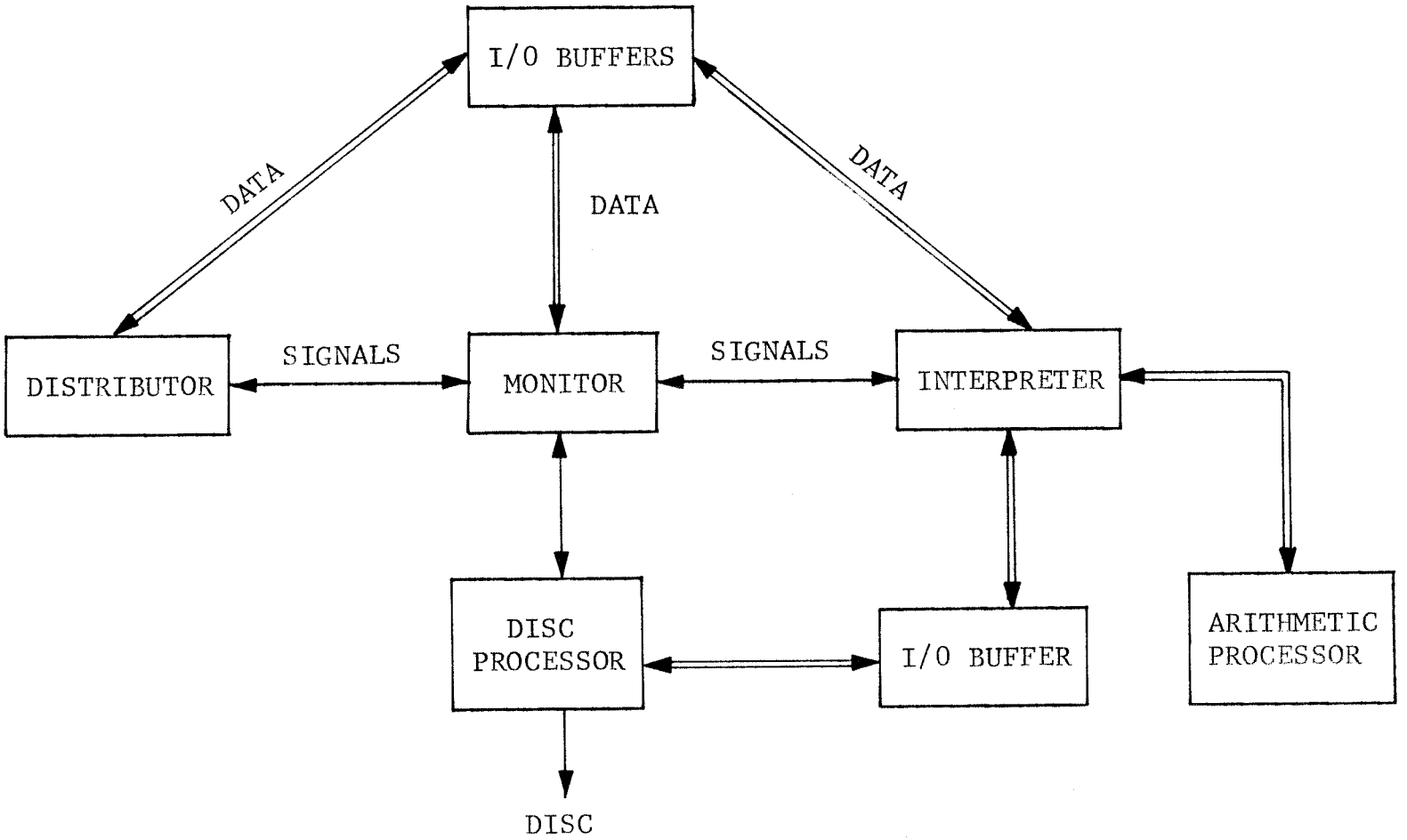

Fig. 1--Overview of JOSS Software Components

II. THE DISTRIBUTOR

INTERFACE WITH THE MONITOR

Input and output to JOSS consoles are handled on a "line" basis: an input line is terminated by a typewriter carriage return or page signal from the user; an output line is terminated by an (internal) terminal character. The main functions of the distributor are to accept input characters, convert them to internal encoding, place them in a monitor-specified internal buffer (see Appendix, Fig. 1), and signal the monitor when a line is complete. Conversely, during output, the distributor accepts characters from a monitor-specified internal buffer, converts them to external encoding, transmits them to the station, and signals the monitor when a line is complete.

To facilitate programming and to improve error detection, we distinguish between the two types of line completion by signals:

1) CR (Carriage Return or Page): input line complete.
2) TO (transmission over): output line complete.

Since the distributor operates via externally generated interrupts (input character waiting, output character transmitted), its only interface with the monitor is via signals.

All signals from the distributor to the monitor are handled via a "signal list." The distributor places the console number and signal type in a relative location (as determined by a count) in a special table, then increments the count (as well as making bounds checks). The monitor,

during selected clock interrupts, picks up the table entries and decrements the count. (During these few microseconds, character interrupts are disabled.)

In addition to the two signals generated by the distributor (CR and TO), there are three others:

1) ON: The console has been turned ON.
2) OFF: The console has been turned OFF.
3) IN: The user wishes to interrupt his processing.

All signals from the monitor to the distributor are handled via subroutine calls. Where necessary, the subroutines disable character interrupts to accomplish their purpose. Monitor-generated signals are:

1) SHUT: Turn off all consoles.
2) INIT: Initialize all consoles; turn on those waiting.
3) TL (transmit line): Initiate transmission to a console.*†
4) SU (switch to user): Give control of console to user.*†
5) BEEP: Send one beep to each console that is on.
6) ENB (enable): Enable input from a specified console.*

CONSOLE CHARACTERISTICS

When attached to the JOSS system, the consoles can be in one of two mutually exclusive states (which the computer simulates for teletype stations):

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*Console number is part of calling sequence.

†Buffer number is implicit in calling sequence.

1) GREEN: The user controls the console.

2) RED: The computer controls the console.

In the RED state, the typewriter keyboard is locked and the user is limited to three controls:

1) Power OFF, which sends a unique signal to the central processing unit (CPU).

2) Interrupt request (IN), which sends a unique signal to the CPU. This signal is interpreted as a request to interrupt processing and return the console to the GREEN state.

3) Typewriter READY/HOLD, which sends two unique signals to the CPU. The hold signal is interpreted as a request to discontinue output typing temporarily (without losing characters); the ready signal is interpreted as a request to resume output typing.

The RED state prevails whenever the carriage return or page key is struck, as well as when power is turned on. In addition, the computer can signal the console to "switch to RED." The console GREEN state can occur only as a result of a computer signal to "switch to GREEN."

Further computer control over the console includes attaching or detaching it from the system, and turning indicator lights on and off.

INTERFACE WITH THE CONSOLE

One of the design criteria for JOSS was to minimize the probability of a "stare-down problem," i.e., a situation in which the console is in one state but the computer thinks it is in another state. For example, if the console is RED but the computer thinks it is GREEN, each will be waiting for the other to take some action.

To meet this criterion, several status toggles were built into the logic of the console and made available for computer inspection:

1) ON state.
2) RED/GREEN state.
3) READY/HOLD state.
4) IN-REQUEST state (which shows the state of a computer-generated acknowledgment to user's interrupt request).

The computer can send the following signals:

1) NO-OP: no operation.
2) Set the ON state on or off.
3) Set the RED/GREEN state to RED or GREEN.
4) Set the IN-REQUEST state on or off.

At the same time, the computer may request the console to respond with the state of the status toggles.

The distributor contains a two-word station control register (SCR) for each console (see Appendix, Table 1). Among other things, the SCR reflects the computer's view of the state of the console. On any computer- or console-generated change of state or on any detected errors on incoming characters, the state toggles (except READY/HOLD) are checked against the SCR. If the check disagrees, the computer sends the appropriate signal to place the console in the same state as the SCR, then rechecks. (In addition, incoming bad characters are converted to a special code which, upon line completion, result in the interpreter's retyping the input line with overstrikes (#) replacing the bad characters. Besides informing the user of the errors, this supplies information for maintenance personnel.)

A final device for avoiding stare-down is user intervention. If the console is GREEN when it should be RED, the user can overcome the problem by hitting CR. This will place the console in RED (the distributor ignores a CR from any station whose SCR indicates RED). Conversely, if the console is RED when it should be GREEN, the user can hit INTERRUPT. An INTERRUPT from a station whose SCR indicated GREEN results in a request for the state of the status toggles, since this condition is logically impossible. (The user cannot interrupt a program in progress when he has no program in progress.)

Further interfaces with the console concern nonprinting typewriter functions which take longer than one character time to perform (i.e., TAB, Carriage Return, Page). As a result, succeeding (output) characters would type "on the fly." To avoid this problem, the console goes into a "hold" state during these functions and sends a "ready" signal upon completion. The distributor inhibits typing until the ready is received by setting the SCR to hold when it sends a nonprinting function. (The conversion table from internal to external form has a bit to indicate such a function.)

Shifting case on the typewriter during input results in changing to different look-up tables for conversion. The location of the current look-up table for a console is carried in its SCR, as is a bit to indicate "current" case. On input line completion, the distributor ensures that the typewriter is in lower case. The output conversion table carries a bit to indicate case; if this disagrees with "current" case, the latter is inverted and the appropriate shift character generated and transmitted.

The distributor also controls allowable line length, inhibiting the user from backspacing beyond the beginning of a buffer or typing over the end. In the latter case, a special character alerts the interpreter to output an error message.

On receipt of an OFF signal from a console, the distributor sets a flag in the SCR to "disable" that console, which prevents the generation of signals to the monitor until the latter has had time to "clean up," whereupon it generates the ENB (enable) signal described above (p. 4).

Finally, the BEEP signal alerts the user to an administrative message. Normally, it is sent once per second for as long as the machine operator desires.

Appendix

DISTRIBUTOR DOCUMENTATION

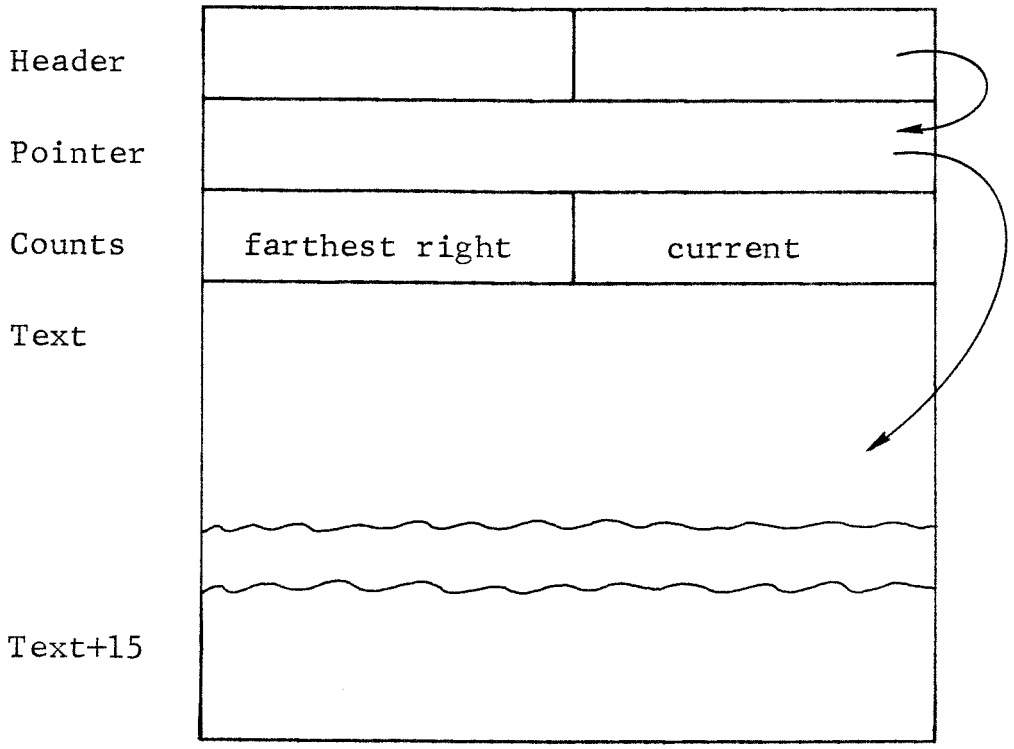

Fig. 1--Station Buffer

Table 1

THE STATION CONTROL REGISTER (SCR): A TWO-WORD-PER-STATION TABLE DESIGNATED T75 AND T76

a. Format of T75

Bit	Meaning	
0	0=enabled; 1=disabled.	
1-13	Not used.	
14	0=RED	1=GREEN
15	0=HOLD	1=READY
16	0=NO IN-REQUEST	1=IN-REQUEST
17	0=OFF	1=ON
18-35	Location of attached buffer.	

b. Format of T76

Bit	Meaning
0	1=transmitting.
1	1=awaiting done.
2	1=last character was upper case.
3-8	Not used.
9-17	One character stack bit 9=1:character to be sent bits 10-17=external form of character.
27	1=upper case table; 0=lower case table.

I. CONSOLE INPUT INTERRUPT ROUTINE

Entered via channel trap (INP)
Note INP must be less than OUP

		YES	NO
C25:	Read in station number = n		
	Pick up SCR(n)		
	Read in character & release scanner		
	Station disabled?	.90	
	TTY station?	TC25	
	SCR = ON?		.06
.03	Convert character to internal form		
Normal:	SCR = Green?		.05
	Advance current pointer via C25.63		
	Store character in buffer		
	Dismiss break and exit		
.05	Send NO-OP status request via C25.80		
	Dismiss break and exit		
.06	Is character an ON signal?	.19	
	Is character a status response?	.03	
	Dismiss break and exit		
.90	ON signal?		.90B
	Set SCR = ON + READY		
.90A	Dismiss break and exit		
.90B	OFF signal?		.90A
	Set SCR = OFF + HOLD		
	Dismiss break and exit		

HOLD Signal

.11	Set SCR = HOLD
	Dismiss break and exit

		YES	NO
READY Signal			
.13	Set SCR = READY		
	Was SCR = HOLD?	.14	
.13A	Dismiss break and exit		
.14	SCR = awaiting done?	.13A	
	SCR = character to be sent?		.17
	Reset SCR		
.18	Send via C29		
	Dismiss break and exit		
.17	SCR = transmitting?		.13A
	Set up character for output via C26.50		
	Transmission over?	.13A	.18
IN Signal			
.15	SCR = RED?		.23
	Send light IN, status via C25.80		
.16	Set SCR = IN		
	Was SCR = IN?		.16A
	Dismiss break and exit		
.16A	Place on signal list via C25.50		
	Dismiss break and exit		
.23	Send NO-OP, status via C29		
	Dismiss break and exit		
ON Signal			
.19	SCR = OFF?		.20
	SET SCR = ON + HOLD + RED		
	Send light system, status via C29		
	Place on signal list via C25.50		
	Dismiss break and exit		
.20	Send light system, status via C29		
	Dismiss break and exit		

YES NO

OFF Signal

.22 Set SCR =
All flags off
DUMBFR
Disable flag
Place on signal list via C25.50
Dismiss break and exit

IN + HOLD Signal

.24 Set SCR = HOLD
To .15 (IN Signal)

UPSHIFT Signal

.35 Set SCR = Upper Case Table
Dismiss break and exit

DOWNSHIFT Signal

.37 Set SCR = Lower Case Table
Dismiss break and exit

BACKSPACE Signal

.60 Is "current pointer" > 0? .60A
Decrement current pointer
Backspace byte pointer via C25.55
.60A Dismiss break and exit

SPACE Signal

.62 Advance current pointer via C25.63
Advance byte pointer
Dismiss break and exit

		YES	NO
PAGE Signal			
.65	Set flag = PG		
	To .67		
CR Signal			
.66	Set flag = CR		
.67	Set SCR = RED		
	Was SCR = RED?		.67A
	Dismiss break and exit		
.67A	Set SCR = lower case, hold		
	Send NO-OP, status request via C29		
	Place CR or PG adjacent to last input character		
	Set byte pointer to point to CR or PG		
	Place on signal list via C25.50		
	Dismiss break and exit		
STATUS Signal			
.70	Add to appropriate counters		
	Mask out all but GREEN/IN/ON		
	Error?	.71	
	Dismiss break and exit		
.71	Add to error counter		
	RED/GREEN error?	.76	
	ON/OFF error?	.19	
	SCR = IN?		.71A
	Send light IN, status via C25.80		
	Dismiss break and exit		
.71A	Send turn off IN, status via C25.80		
	Dismiss break and exit		
.76	SCR = RED?		.77
	Send switch RED, status via C29		
	Dismiss break and exit		
.77	Send switch to GREEN, status via C25.80		
	Dismiss break and exit		

		YES	NO
PARITY Error			
.78	Add to counter		
.78A	Set illegal character To "normal"		
Illegal Character			
.79	To .78A		
Place on Signal List			
C25.50	Signal count < signal max?		HALT
	Store (Signal, station #) in SIGTBL		
	Increment count		
	Signal count < signal limit?	Exit	
	Increment COMEBACK		
	Exit		
Backspace the Byte Pointer			
C25.55	Decrement address		
	Increment byte four times		
	Exit		
Advance Current Pointer			
C25.63	Current < 78?		.61
	Increment current		
.64	Current ≤ farthest right?		.64A
	Set farthest right = current		
.64A	Exit		
.61	Place "line too long" as first character in buffer		
	Dismiss break and exit		

		YES	NO
Send			
C25.80	SCR = character to be sent?		.83
	New character = switch to GREEN?	.82	
	Put character to be sent into new character		
.82	Clear character to be sent		
.83	SCR = READY?		.85
	SCR = Awaiting done?	.85	
	Transmit character		
	Set SCR = awaiting done		
.84	Store SCR		
	Exit		
.85	Place new character in character to be sent		
	To .84		

II. CONSOLE OUTPUT INTERRUPT ROUTINE

Entered via Channel Trap (OUP)
Note that OUP must be greater than INP

		YES	NO
C26	Disable input traps		
	Read in station # = n		
	Set SCR = not awaiting done		
	SCR = READY?		.15
	SCR = character to be sent?		.01
	Send character, release scanner		
	Set SCR = no character to be sent		
.05	Set SCR = awaiting done		
	Enable input traps		
	Dismiss break and exit		
.01	SCR = transmitting?		.20
	TTY station?	TC26	
	Set up character for output via C26.50		
	Terminal character?	.20	
.10	Send character, release scanner		
	To .05		
.15	SCR = transmitting?		.20
	Is next character terminal?		.20
	Set transmission over via C26.25		
.20	Dismiss station		
.21	Enable input traps		
	Dismiss break and exit		

Transmission over

C26.25	Set SCR = not transmitting
	Set SCR for dummy buffer
	Place on signal list via C25.50
	Exit

		YES	NO
Set up character for output			
C26.50	Pick up character according to byte pointer		
	Terminal?	.60	
	Convert by table look-up		
	Character = space?	.51	
	Case shift required?	.51	
	Set appropriate shift character		
	Exit		
.51	Advance byte pointer		
	Long function?		.59
	Set SCR = HOLD		
.59	Exit		
.60	Set SCR = lower case		
	Was SCR = lower case?	.58	
	Set downshift character		
	Exit		
.58	Set transmission over via C26.25		
	Exit		

TTY Input routine

		YES	NO
TC25	SCR = RED?		.10
	Character = ON?	ON1	
	Character = OFF?	OFF1	
	SCR = ON?		25A
	Character = IN?	IN1	
25A	Dismiss break and exit		
ON1	Set SCR = ON, READY		
	To IN1 + 1, signal = ON		
OFF1	SCR = ON?		25A
	Set SCR = RED, OFF, Disabled, Not transmitting, not awaiting done		
	To IN1 + 1, signal = OFF		
IN1	Signal = IN		
IN1+1	Place on signal list via C25.50		
	Dismiss break and exit		
.10	Execute the TTY look-up table		
.12	Bump character count		
	To CR1 on 72nd character		
	Store character in buffer		
	Send character back via C25.80		
	Dismiss break and exit		
PG1	Send CR via C25.80		
	To .20 with signal = PG		
CR1	Send CR via C25.80		
	Set signal = CR		
.20	Store signal in buffer		
	Set SCR = RED		
	Send line feed via C25.80		
	To IN1 + 1		
RUBOUT	Decrement count and go to E·BUF if < 0		
	Backspace byte pointer		
	Send backslash via C25.80		
	Dismiss break and exit		
E.BUF	Send CR, LF via C25.80		
	Dismiss break and exit		

		YES	NO
TTY Output Routine			
TC26	Get character (byte pointer)		
	Terminal		26A
	Set trans. over via C26.25		
	Dismiss station via C26.20		
26A	Convert character by table look up (XCT)		
26A5	Bump byte pointer		
.10	Send character, release scanner		
	Exit via C26.21		
.30	(PAGE) Set CR in buffer		
	Set line feed		
	TO .10		
.40	(CR) Set LF in buffer		
	Set CR		
	TO .10		

III. TURN OFF CONSOLES

Entered by JSR SHUT

SHUT: Turn off 630 traps
Delay about 30 ms
(to complete any output)
Send 271_8 to stations 0(1)N·S-1
[N·S=60_{10}; note that TTY's receive a "9"
JOSS consoles receive: "turn off
system lite"]
Delay about 30 ms
Exit

IV. INITIALIZE CONSOLES

Entered by PUSHJ PP C20

C20 Turn off PI system
Turn off system lites by JSR SHUT
Clear all receive scanner flags that are up
by DATAI (delay about 90 μs between flags)
For station 0(1) N.S-1:
Send (via C25.80) 370_8
["On, status" for consoles; "X" for TTY]
Set the SCR for:
DUMBFR, READY, RED, OFF, NØ-IN
Assign channels to 630 and release scanners
(OUP=4; INP=3)
Turn on PI system; Enable channels 2(1)7
Exit

V. TRANSMIT LINE

Entered by PUSHJ PP, C27
Station # in S(18-35)
Ptr. to buffer header in S.BUF(S)(18-35)

		YES	NO
C27	Disable 630 traps		
	Pick up SCR words		
	[S.BUF(3)]+1(= Pointer to buffer)→SCR		
	Set up pointer word in buffer		
	Set SCR = transmitting		
	SCR = awaiting done?	.20	
	TTY station? (SL CONSOL)	.10	
	SCR = READY?	.20	
	Set up character for output by C26.50		
	Terminal character?		HALT
	Send via C29		
.05	Enable 630 traps		
	Exit		
.10	(TTY station)		
	Send a null via C25.80		
	To .05		
.20	Store SCR words		
	To .05		

VI. SWITCH TO USER (GREEN)

Entered by PUSHJ PP, C28
Station # in S(18-35)
Ptr. to buffer header in S.BUF(S)(18-35)

```
                                                    YES         NO
C28     Disable 630 traps
        Set SCR for lower case look-up table
        (T78 or T90 for console or TTY)
        Set SCR, to point to buffer
        Set buffer pointer word
        Set counts = 0
        Set SCR = GREEN, NØ-IN
        TTY station?                                .10
        Send, via C25.80; switch green, status
.05     Enable 630 traps
          Exit
.10     [TTY station]
          Send, via C25.80: Ding
            To  .05
```

VII. SPECIAL SEND

Entered by JSR C29

```
C29     Send the contents of RM to station
        designated by RN
        Set SCR = awaiting done
        Store SCR words
          Exit
```

VIII. BEEP THE STATIONS

Entered by JSR C30

		YES	NO
C30	Set i = N.S-1		
.1	Disable the 630 traps		
	SCR (i) = ON?		.3
	Send, via C25.80: Beep		
.3	Enable the 630 traps		
	i≤CONSOL?		.3A
	Exit		
.3A	i = i-1		
	To .1		

IX. ENABLE STATION

Entered by JSR C31
Station # in S(18-35)

		YES	NO
C31	Disable 630 traps		
	Reset SCR disable bit		
	SCR = ON? (Set OFF)		.2
	Send, via C25.80: Lite system, status		
.2	Enable 630 traps		
	Exit		

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