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The Human Interface to the Switched Access Remote Test System

By F. J. PFEUFER

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This paper presents the features of the human-machine interface of the Switched Access Remote Test System, a remote-testing system designed to enable one person to test special-service circuits. The interface is designed to be compatible with the form and content of manual testing to help the user make the transition to an automated system. It also provides built-in aids to educate new personnel. Human-factor concepts associated with the system are also discussed.

I. INTRODUCTION

The Switched Access Remote Test System (SARTS) is a computer-based, one-person, remote access and test system for special-service circuits.[1]* The system was designed to provide the access and testing functions over a central interface located at a Special Service Center (SSC).[3] SARTS is operational and is located in major cities in the U.S. (see Fig. 1). One-person remote testing by means of automated test devices is unique to SARTS and required the development of an interactive human-machine interface for control of the testing process.

For the following brief explanation of the operation of SARTS, refer to Fig. 2. Craft personnel (hereafter called testers) are situated at the near-end 52A test positions, consisting of a *Dataspeed*® 40/4 Keyboard Display (KD), a desk and chair, and a telephone console. The KD interfaces with the minicomputer Process Controller (PC), which processes and translates into control codes the test commands the tester enters into the system via the KD. The PC sends the control codes to the Remote Test System (RTS) over a control data link. The RTS is a microprocessor-controlled test unit capable of performing tests and measurements on special-service circuits. The RTS also directly inter-

* A discussion of the evolution of SARTS is given in Ref. 2.

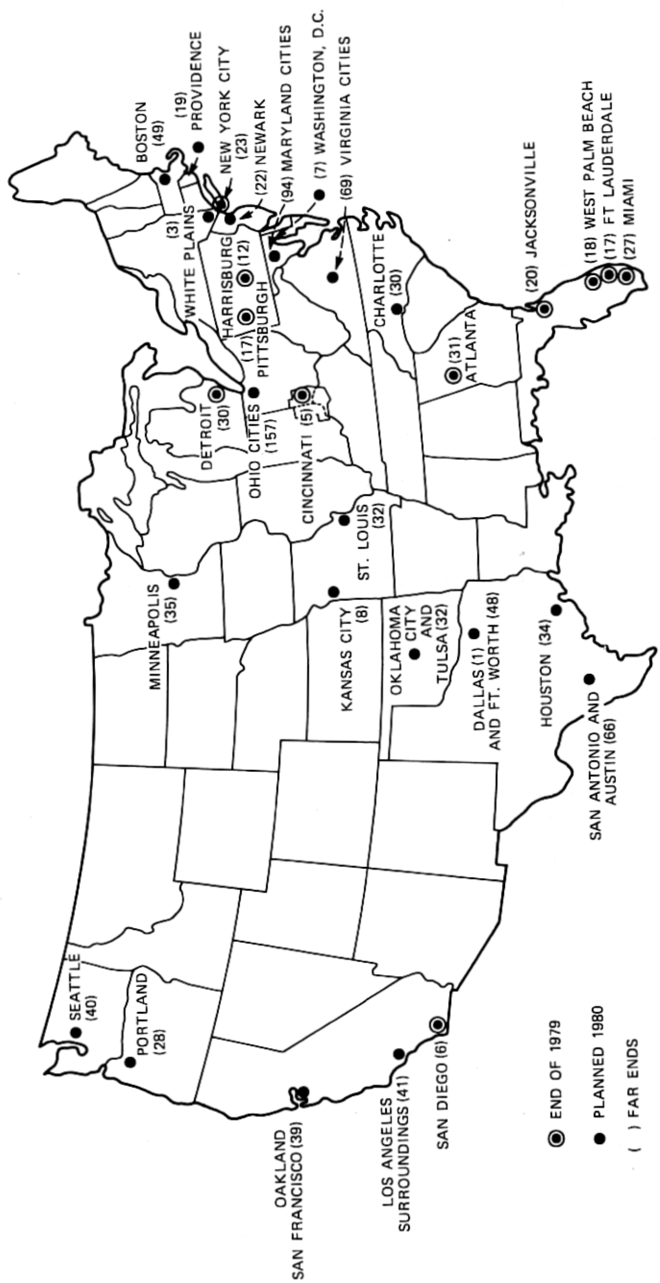

Fig. 1—Present and planned SARTS locations.

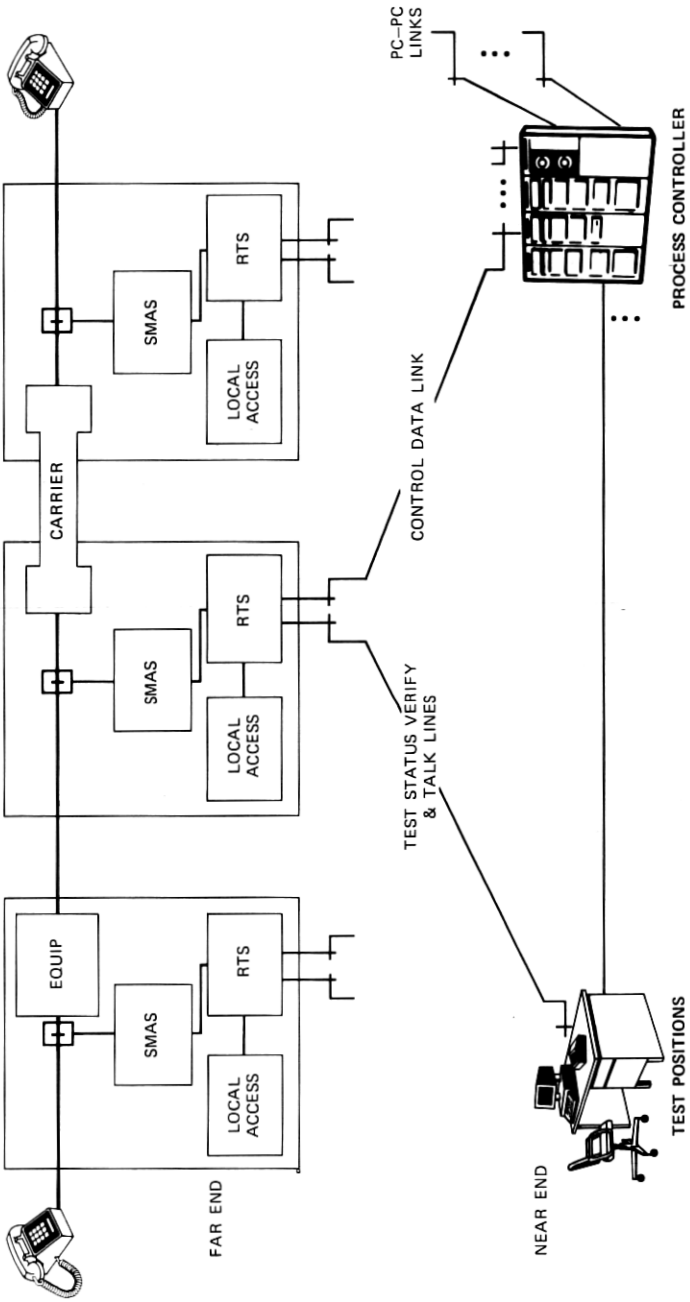

Fig. 2—SARTS operational diagram.

faces the 52A test position by establishing telephone call-backs to the console for test status verification and for talking on the circuit under test. Access to the circuits is provided by the Switched Maintenance Access System (SMAS), which provides access points in the form of wired-in switches (relays) placed at strategic points on the circuit. The RTS controls the SMAS to bring the circuit into its testing ports. SMAS points are wired into many thousands of circuits throughout the U.S., enabling many central offices to install RTSs and become part of the operational SARTS network. Local access-only capability is also furnished by the SMAS.

During testing, circuit sketches of the access point and a description of the applied test conditions are made to appear on the face of a CRT screen in the KD, thereby allowing the tester to see the testing effects as they occur.

Figure 3 shows SARTS test positions. Although the test position was also human-engineered for the physical features of the desk, chair, KD, and console, the topics of this paper are the features of the human-machine interface (HMI) provided by the SARTS PC software supporting the operation of the KD terminals.

The SARTS HMI was designed ad hoc, with practical judgments guiding most features because no precedent existed for computerized, remote, one-person testing. There was, however, considerable field experience in the general area of special-service testing. The problem of designing the SARTS HMI was to provide compatibility with the manual methods to assure a smooth transition to an automated process. Human engineering studies, other than critical evaluation by personnel experienced in making manual tests, were not practical because of urgent needs and limited time schedules. The design was guided by basic human engineering principles and by commonsense decisions, based on knowledge of the existing manual testing procedures and the projected compatibility needs of testers in a remote environment. Bell System operating company personnel, who were to be among the early users of the system, participated in the design, development, and evaluation of the HMI. SARTS illustrates the gamut of human-engineering problems and is field-proven to be a well human-engineered system.

II. INTERFACE OPERATION

The human interface to SARTS is highly interactive. Testing is controlled by test commands which are put into the PC by the tester at the KD. The PC processes the command and sends control codes to the Remote Test System. The RTS contains a microprocessor which operates the hardware to perform the action specified by the command input. Information concerning the performed function which is re-

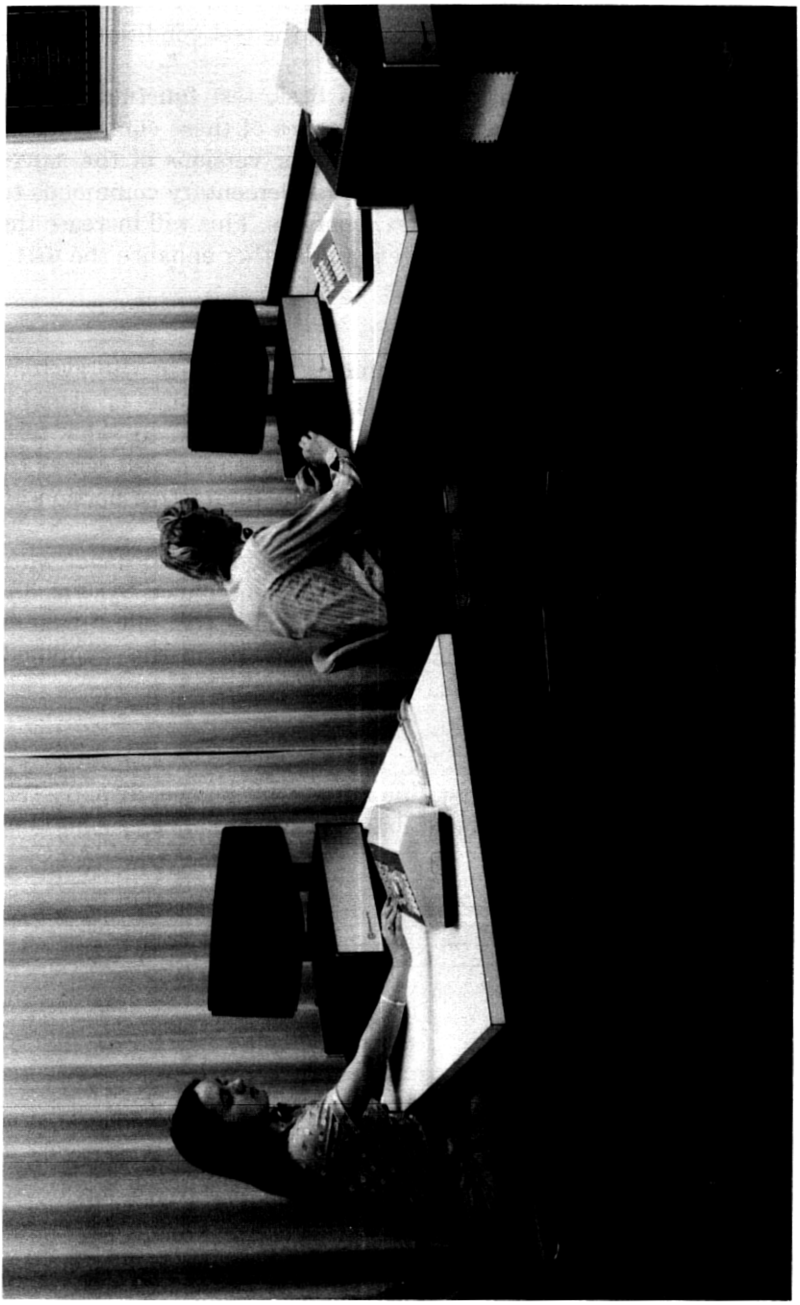

Fig. 3—Typical SARTS test positions.

turned from the RTS to the PC is also processed by the PC. This information is then returned to the KD in the form of messages and updated displays that indicate the status of the test conditions at the remote test points.

Each test command controls a single basic test function. Circuit testing is accomplished by employing a series of these commands to make needed tests and measurements. Later versions of the SARTS software will build upon this foundation of elementary commands to automatically perform more complex functions. This will increase the speed and power of the testing process and further enhance the HMI.

2.1 CRT display

A CRT was chosen as the main human interface to the system because it can be made to present a symbolic image (a sketch) representing the circuit at the remote test point and to show test conditions applied at the access point. The CRT screen also serves to display system information and to furnish the interactive portion of the HMI.

The *Dataspeed*® 40/4 KD equipment was chosen in accordance with a plan for merging SARTS with the Circuit Maintenance System 3A (CMS 3A)[4] which also uses this equipment. This will allow testers having experience in one system to feel at home in the combined system.

2.2 Screen layout

Referring to Fig. 4, the first line of the KD screen display, the command line, is where command data are entered. The second line,

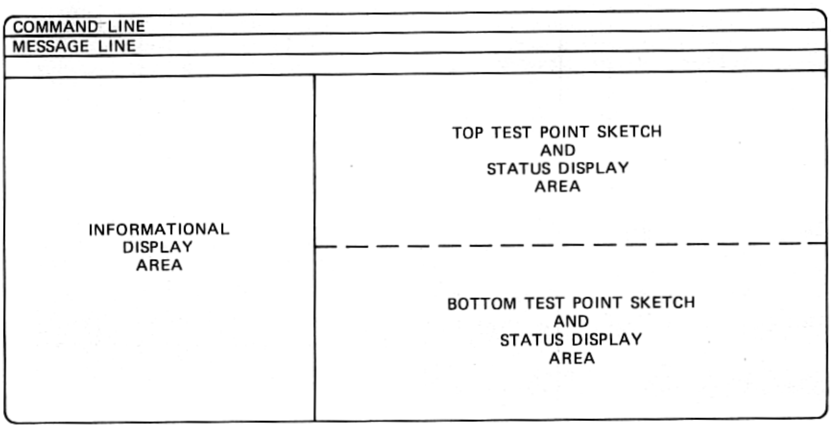

Fig. 4—SARTS CRT screen arrangement.

the message line, is used to display the last executed command, system messages, and the results of test measurements when they are made. The message line also displays command "prompters."

Prompters briefly describe command functions and show the allowable parameters which can be entered to specify the details of the command displayed in the command line. In some cases, two levels of prompters are used for commands which have a dual set of parameters: the first parameter selection determines the second set of parameter to be displayed. The prompters assist the tester in the correct use of the commands and serve to refresh the memory for infrequently used commands. The use of prompters is further described in Section III.

The left side of the screen below the message line is an information-display area used to show command lists (menus), to recall previous information entered into the system, and to display testing logs.

The right side of the screen below the message line is divided into a top and bottom half, each half displaying the status information for one test point. One or both halves may be used during testing. An indicator (the letters "TP") flashes on either the top or bottom display to identify the active test point to which the testing commands are being applied. The active test point may be changed by command as required during testing. When a command has been entered but execution is not yet completed, a pound sign (#) appears at the left side of the display area for the active test point. The sign disappears when the command execution is completed.

2.3 Test point displays

Considerable care was devoted to the design and development of the test point displays. They serve as the primary information feedback to the tester and as memory storage during the testing process. Referring to Fig. 5, both the top and bottom status display areas contain:

(*i*) Test point and circuit identity information.

(*ii*) A sketch of the transmission pairs and signaling leads of the circuit at the test point. Figures 6 through 12 show the various transmission and signaling lead configurations. In these figures, no test conditions have been applied, and the access point is in the initial monitoring condition for test status verification.

(*iii*) Special or temporary information (e.g., class marks of access points, points at which measurements are being made, etc). See Figure 13.

(*iv*) Applied test conditions. Display areas are associated with each possible point of application of test conditions to the transmission and signaling leads.

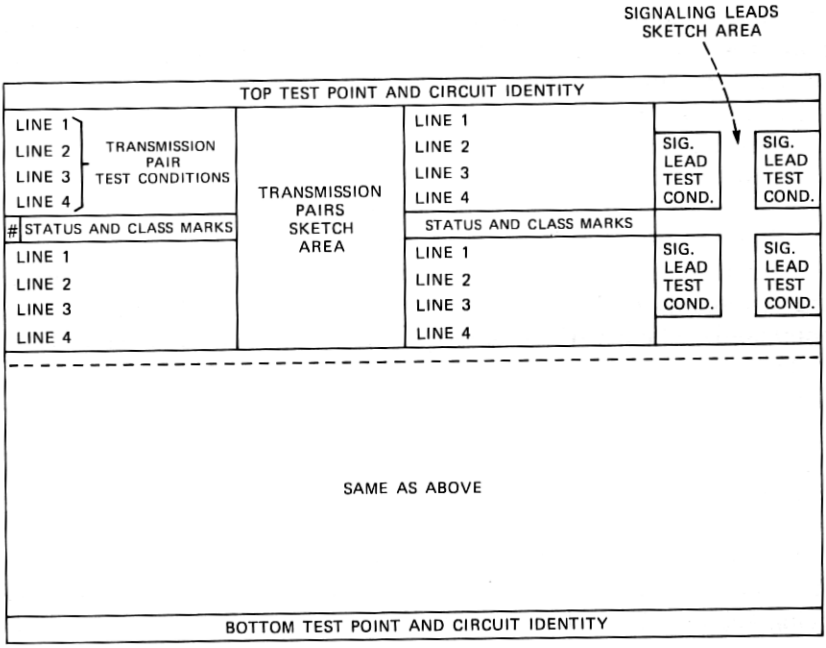

Fig. 5—Details of test point sketch and status display area.

The displays for the applied test conditions on the signaling leads use one line. Two additional lines are available for future use. Examples of signaling-lead displays with applied test conditions are shown in Figs. 14 and 15.

Each display area for the applied test conditions on the transmission pairs use four lines:

Line 1—Applied metallic conditions.
Line 2—Applied transmitting condition.
Line 3—Applied receiving condition.
Line 4—For future use.

Examples are shown in Figs. 16 through 18.

A critical design decision was to provide test point sketches in a vertical (rather than a horizontal) format. This decision was based on the need for consistency between the displays and the familiar vertically oriented Circuit Layout Record (CLR), which is used by the testers to obtain an overall description of the equipment/facility make-up of the circuit being tested. In addition, the software has been structured to insure that two test points on the same circuit are always displayed in the same vertical order in which they appear on the CLR. Preserving old images in a newly automated system is an important human engineering principle. These features have proven to be major factors in the viability and ready acceptance of the SARTS HMI.

2.4 Records interface

The CLR (shown in the two-card example of Fig. 19) was given considerable attention from the standpoint of making it a part of the SARTS human interface while also performing its function as the primary circuit record.

SARTS was designed to operate initially with the existing paper record circuit data base (CLR cards) and later to have the data base mechanized with CMS 3A, which uses a similar record called WORD (Work Order Record and Details). In either operation, sufficient information must be available on the record for getting circuit access and for obtaining testing information about the access points. To satisfy these needs, two sets of coded data were developed to be included on the CLR for each access point on the circuit. The first set of data (see Fig. 19, line M, card 02), is referred to as access point identity data. The second set (see Fig. 19, line N, card 02) is referred to as access point testing data.

The access point identity data are fed into the PC via an access command to initiate the access process (Fig. 20). It contains information necessary to establish communication with the RTS and with the SMAS access point in the circuit being tested. Parts of the data are also used by the PC to provide HMI features appropriate to the type of circuit under test.

When sent to the PC, the access point testing data (Fig. 21) serve the purpose of enabling the PC to screen and execute test commands

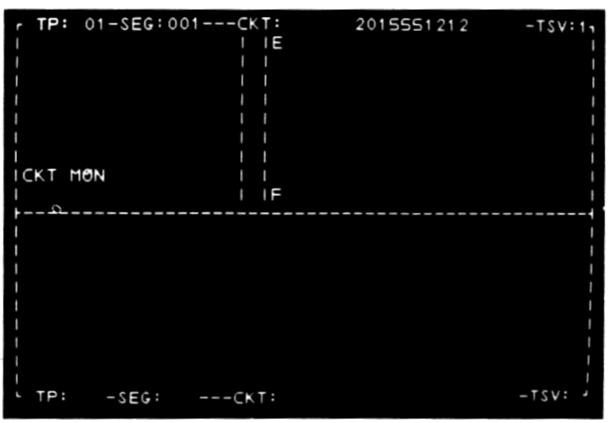

Fig. 6—2-wire circuit test point area display.

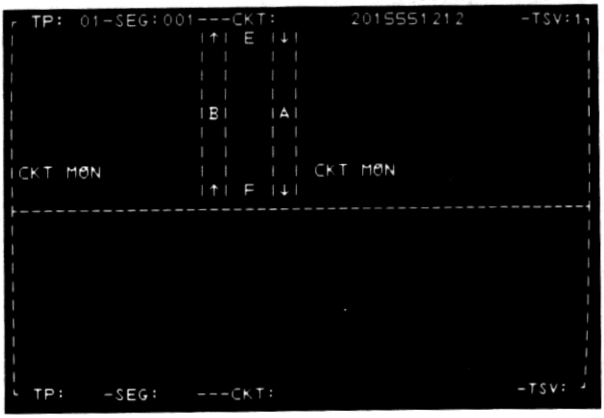

Fig. 7—4-wire circuit test point area display.

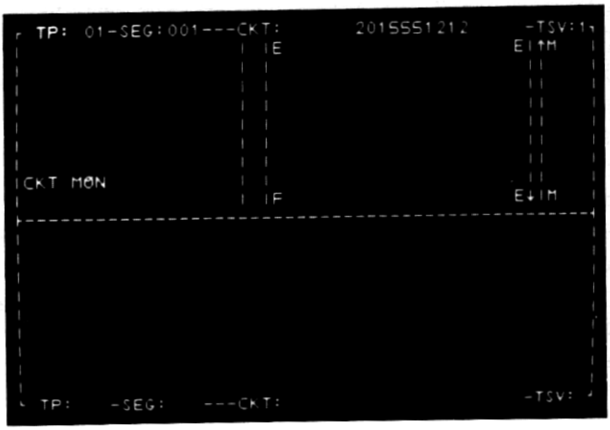

Fig. 8—2-wire E&M circuit test point area display.

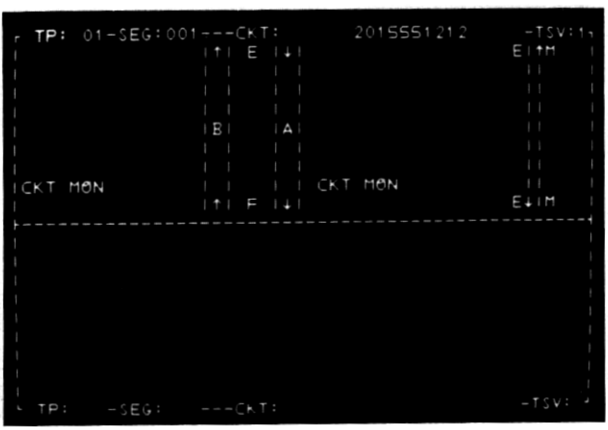

Fig. 9—4-wire E&M circuit test point area display.

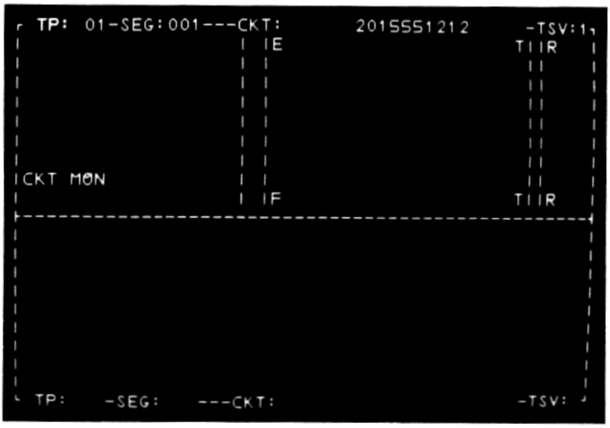

Fig. 10—2-wire circuit plus control channel display.

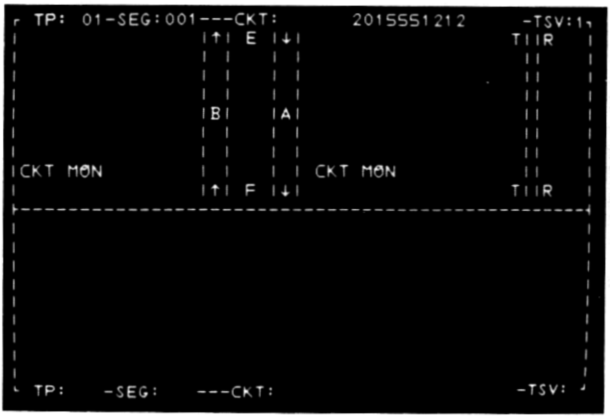

Fig. 11—4-wire circuit plus control channel display.

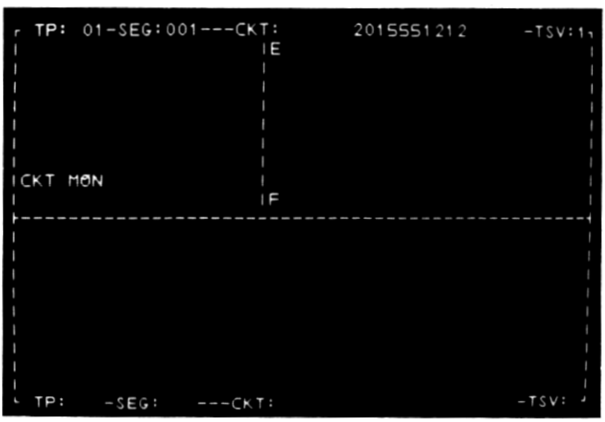

Fig. 12—Single-wire circuit access point display.

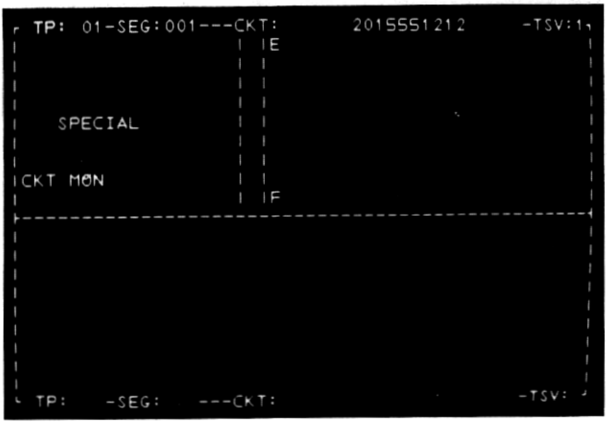

Fig. 13—Example of "special" class mark on a 2-wire circuit.

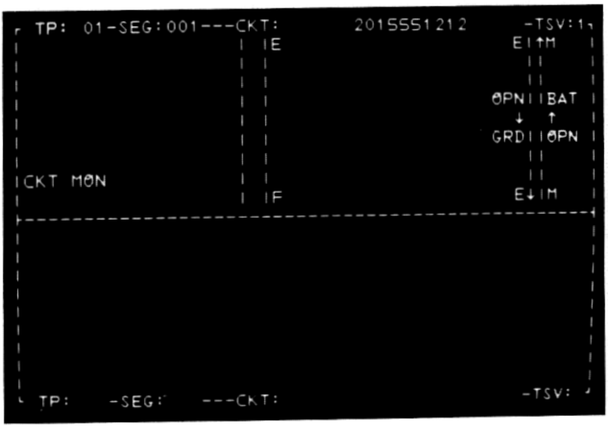

Fig. 14—2 Applied E&M conditions (battery on M lead, ground on E lead).

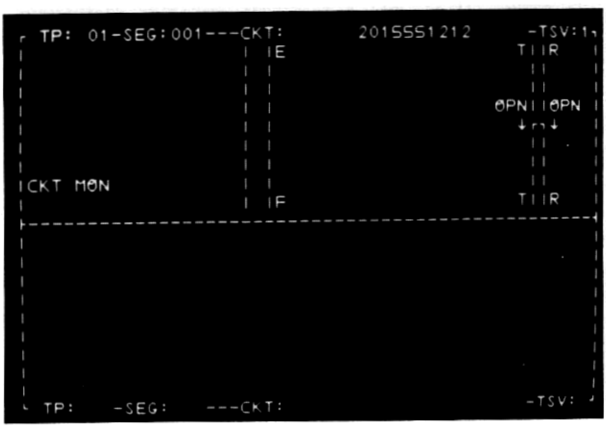

Fig. 15—Applied control channel conditions (loop closure).

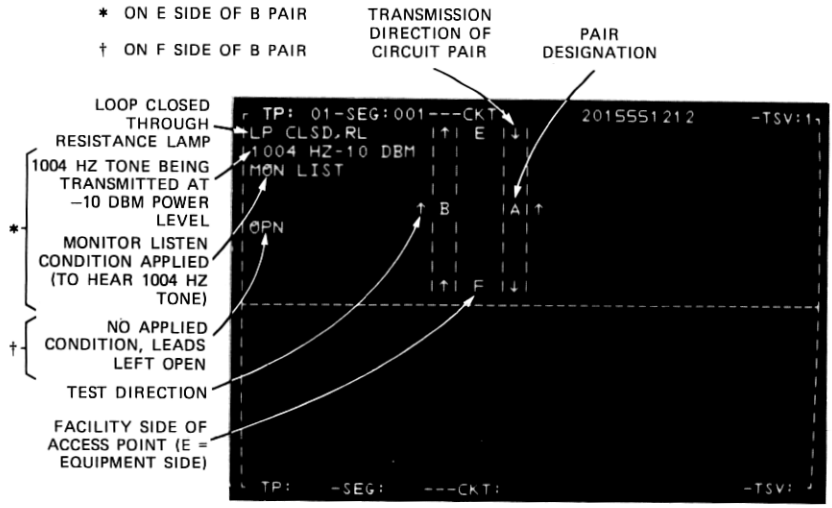

Fig. 16—Example of test conditions applied to a 4-wire circuit.

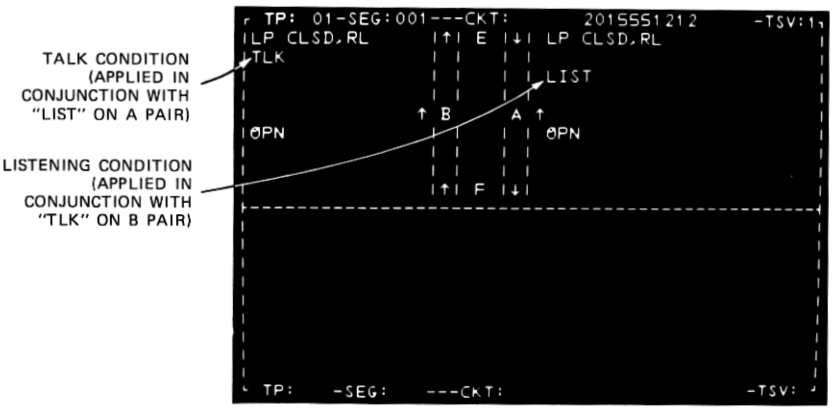

Fig. 17—Example of test conditions applied to a 4-wire circuit.

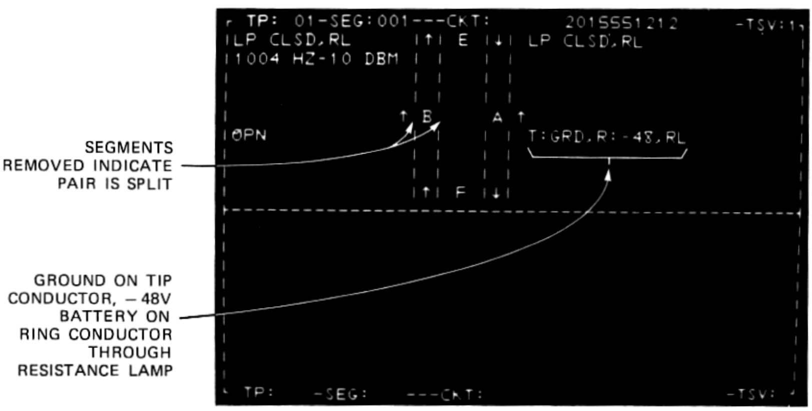

Fig. 18—Example of test conditions applied to a 4-wire circuit.

A 201 555-1212 | C HOLMNJ1180 | O WO

B SARTS DEMO | MLG

C PRI | SW SYS | SWA | BAL | NOISE | U

D TFO | A | ICL 0.0

E EML 3.0 | Z 25X

F

G

H N	OFFICE	S V	EQPT AND FACILITY	A	TLP / Z	MISC	
I A	-CSRSS	X2	HANDSET	-3.0	0.0		
J	LOCAL CHAN	X2	26NL	-3.0	0.0		
K			26-10	RES-0	DB-0		
L	HOLMNJ11	X2	SMCG410A00 10073.-00060A				
M	HOLMNJ11		41/-00060-/EF/2WA/01/				
N			L2W/LN/LN/E/33/	-3.0	0.0		
O A	HOLMNJ11W1	X2	SFMOU20D00 153.01 19		-16.0		
P	HOLMNJ11		SFXSF10				
Q	HOLMNJ11		SF6DF00				
R	HOLMNJ11	X4	SMCG410A00 10073-00070-				
S	HOLMNJ11		41/-00070-/EF/4BA/02/				
T			SFC/LN/LN/E/22/	+7.0	-16.0		
U	HOLMNJ11	X4	ONMT20 EA00 154.09 11	+7.0			
V			1 OF 2 1				
W	HOLMNJ11	X4	CHMT 200 D00 147.09 31		+7.0		
X	HOLMNJ11	X4	SMCG410A00 14032.-00180-				
Y	HOLMNJ11		41/-00180-/FE/4AB/03/				
Z			SFC/LN/LN/F/22/	-16.0	+7.0		
1	BASE SD		A SD1C240-02				

21 SEG | CARD 01-02 | ISS 02/01/76 | ISSUING COMPANY BTL | CRT LAYOUT OUTLINE 9-68

A 201 555-1212 | C HOLMNJ1180 | O WO

B SARTS DEMO | MLG

C PRI | SW SYS | SWA | BAL | NOISE | U

D TFO | A | ICL 0.0

E EML 3.0 | Z 25X

F

G

H N	OFFICE	S V	EQPT AND FACILITY	A	TLP / Z	MISC	
I A	HOLMNJ11W1	X2	SFMOU20D00 1089.07 46	-16.0	-3.0		
J	HOLMNJ11		SF6DF00				
K	HOLMNJ11		SFXTF10				
L	HOLMNJ11	X2	SMCG410A00 14032.-00190-				
M	HOLMNJ11		41/-00190-/FE/2WB/04				
N			L2W/LN/LN/F/33/	0.0	-3.0		
O	HOLMNJ11	X2	S2L	0.0	-3.0		
P							
Q							
R							
S							
T							
U							
V							
W							
X							
Y							
Z							
1							

21 SEG | CARD 02-02 | ISS 02/01/76 | ISSUING COMPANY BTL | CRT LAYOUT OUTLINE 9-68

Fig. 19—CLR (2-card example) showing access point data.

The access point testing data (Fig. 21) serve the purpose of enabling the PC to screen and execute test commands without causing circuit damage or service degradation. They also furnish testers with data that describe the circuit operation at the access point. Previously, the circuit operation information was available to the tester only by

Fig. 20—Access point identity data ready to be sent to PC.

deduction, based on knowledge of the operation of the transmission and signaling equipment used on the circuit and listed in sequence on the CLR. The circuit designer provides the SARTS testing data for the CLR on a one-time basis when the circuit or its access points are installed. It is therefore not subject to human error each time the circuit is tested because nothing need be deduced by the people who do the testing work. Future versions of SARTS will utilize the access point data to perform automatic testing functions which will further unburden the tester from important decision-making processes.

The sets of SARTS access point data, therefore, not only provide

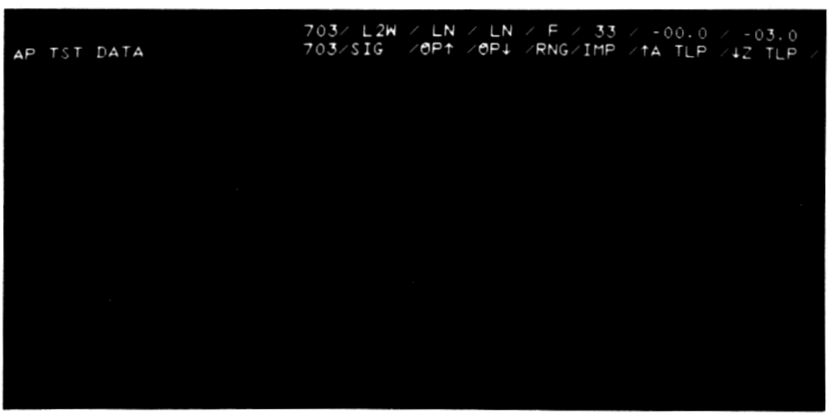

Fig. 21—Access point testing data ready to be sent to PC.

needed information for the HMI features, but also improve the overall testing process.

III. COMMAND STRUCTURE AND COMMAND INPUT METHODS

The general command structure is illustrated in the example of Fig. 22. It shows a completely specified command on the command line and the prompter for the command on the message line.

Each command is named with a mnemonic alphanumeric code (T03 in the example). This code is used for communicating with the PC. Associated with each command are parameters chosen to specify to the PC the details of the command. From this information the PC knows the action that must be performed when the command is executed by the RTS. The example contains two parameter fields, in each of which a parameter is chosen by typing in its position number in the prompter in the corresponding parameter field on the command line. When the desired command parameters are fully specified on the command line, the command is sent to the PC to be processed.

Three methods can be used to put a command into the PC. The first method uses the assistance of a command prompter. A command prompter is obtained by typing the command code name on the KD (Fig. 23) and sending this into the PC by pressing the S/R (Send/Receive) key. The PC then returns the command prompter display (Fig. 24).

The second input method bypasses the prompter display. When a command and the position numbers of the desired parameters are known, the command may be specified directly to the PC by keying in the code name followed by a slash and the parameter numbers that

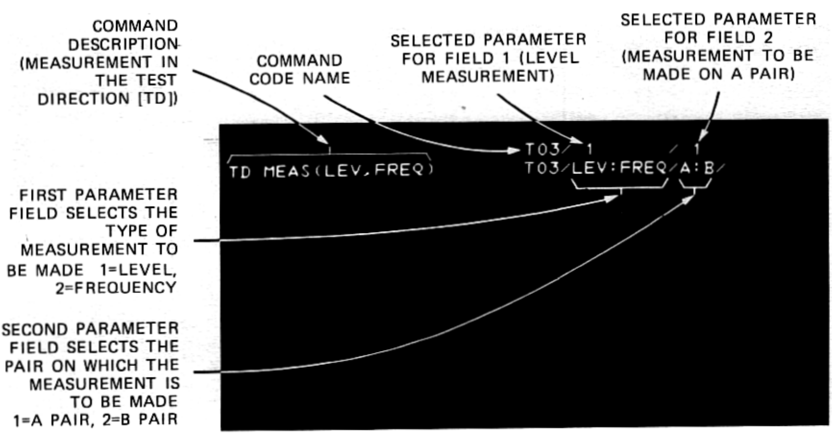

Fig. 22—General structure of SARTS commands.

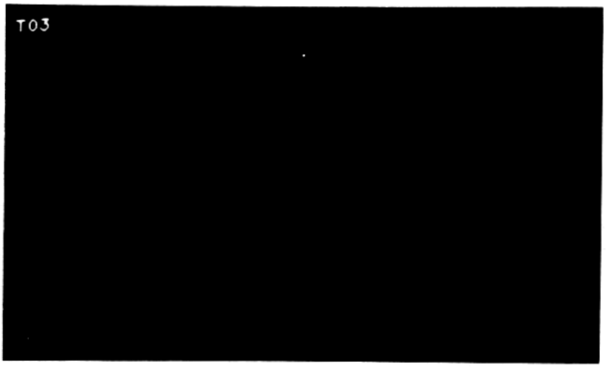

Fig. 23—Input needed to obtain T03 prompter (Fig. 24).

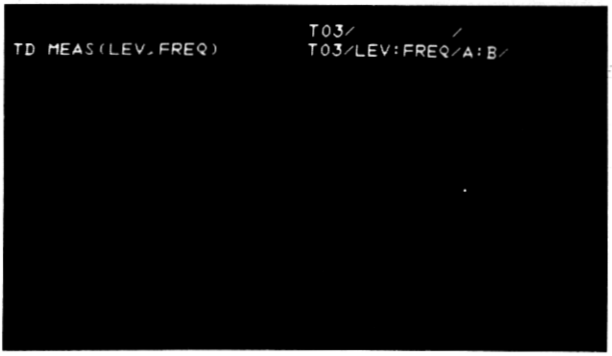

Fig. 24—T03 command prompter (PC response to input of Fig. 23).

apply. This method is illustrated in Fig. 25, which shows the direct-input equivalent of Fig. 22.

The third method is used to repeat the last executed command without having to repeat the details of the command specification. This is accomplished simply by keying in G03/. Commands which are frequently repeated with the same parameters (e.g., measurements to search for a transient condition) cause G03/ to be automatically displayed on the command line after their execution. This relieves the tester of repeatedly typing G03/.

As a further aid to the tester, any alphanumeric-coded command with zero as the second character is accepted by the PC with the zero deleted. For example, T03/ may be shortened to T3/. (This feature does not apply to commands which are numerically coded.)

When a command is correctly entered in any of these ways, the PC returns a message line display showing the command code name and

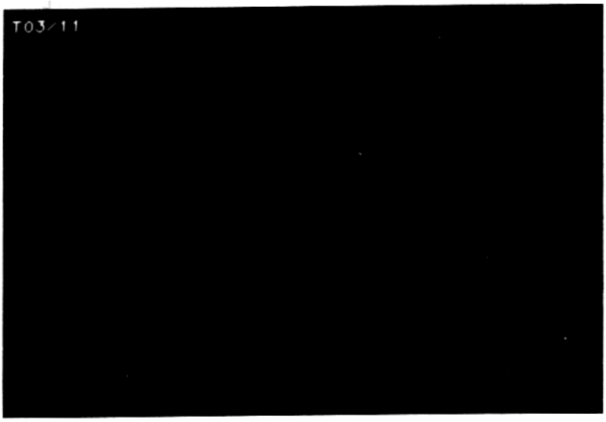

Fig. 25—Direct input equivalent of command in Fig. 22.

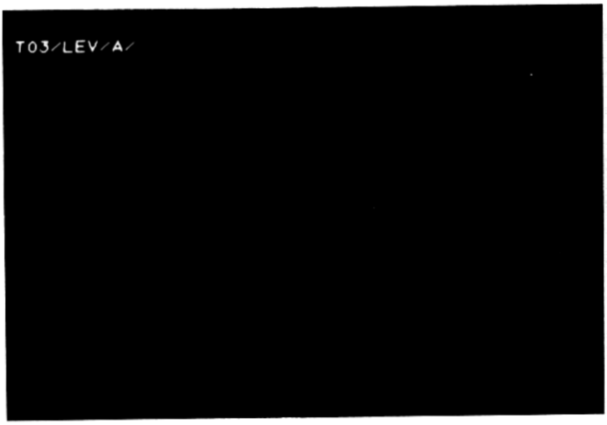

Fig. 26—Response of PC to command input of Fig. 22 or Fig. 25 (command execution not yet complete).

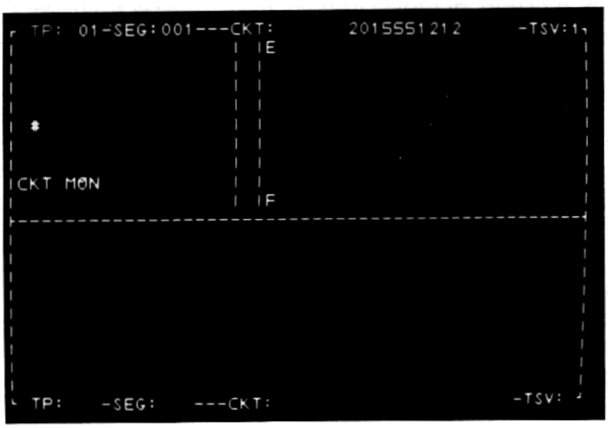

Fig. 27—Position of the # sign.

the chosen parameters. (Fig. 26). The pound sign (#) (Fig. 27) appears on the TP display until execution of the command is complete.

When a command is incorrectly entered (e.g., a nonexistent command code name, invalid or missing parameter, incorrect characters, etc.), the PC rejects the command and returns an error message indicating the reason for the rejection (e.g., "invalid command," "error in field 1," etc.). When the error message is displayed on the message line, the erroneous command continues to be displayed on the command line to allow the tester to recognize and correct the error. Figures 28a and 28b show a typical error sequence.

The command structure and input methods provide these features to the HMI:

(*i*) The user is not required to have typing skills since words are never typed (except for comments in the log—see Section 4.2).

(*ii*) Prompters aid the tester who is unfamiliar with the system or who needs memory assistance.

(*iii*) The direct-input command method allows the proficient tester to proceed at a more rapid pace.

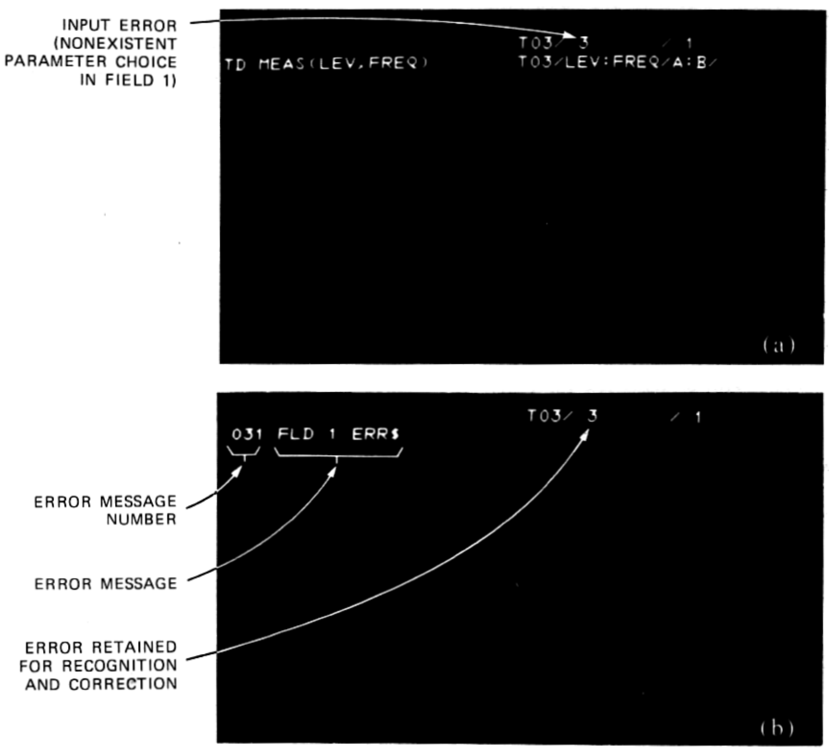

Fig. 28—(a) Erroneous command input. (b) PC error message response to input of (a).

(*iv*) Detailed error messages and retention of errors on the command line help the tester recognize errors and learn to avoid them in the future.

IV. THE COMMAND SYSTEM

The objective of the command system is to make the commands easily learned, progressively powerful, and consistently related in function. SARTS has three types of commands:

(*i*) Auxiliary commands which permit a tester to operate in the software environment and which support the operational commands [see (*ii*) below].

(*ii*) Operational (test) commands to direct the performance of remote accesses and tests.

(*iii*) Maintenance commands, which are used to maintain the system software/hardware.

4.1 Command menus

The auxiliary and operational command menu displays are obtained by using command codes ending in double zero (e.g., L00 causes the Loop Signaling command menu to be displayed). Maintenance command menus and formatted screen displays for maintenance functions are obtained using commands beginning with zero (e.g., 013 displays a formatted screen for entering information about other PCS which may be contacted for testing).

4.2 Auxiliary commands

The auxiliary commands (Fig. 29) include those commands which permit a tester to sign on and begin interaction with the system. Sign-on is obtained by entering 000/ (which can be followed by up to 23 characters for entry in a log). The PC acknowledges sign-on by returning the 100 TABLE OF CONTENTS to the screen.

Entering the 300 command causes the display of the 300 LOG menu. The log commands enable a tester to write, read, or print information in the test log, which is a 21-line by 29-character storage buffer associated with each test position. It is used to record temporarily the test commands executed by the PC. Text may also be entered into the log (using the 384 command) to record pertinent information and comments. When the log storage buffer is full, newly executed commands are recorded by deleting the record of the oldest command in a scrolling effect. An "LF" (Log Full) indication is highlighted on the far right of the message line when the log is within two lines of being full. To preserve a chronological history of test activity, the log contents can be printed before scrolling begins by using the 399

```
000/
```

```
300     LOG

384 LOG WRITE
385 LOG READ
399 LOG PRINT
```

```
600     TESTS

 611 DETAIL TESTS
```

```
100 TABLE OF CONTENTS

000      SIGN-OFF
300      LOG
    384 LOG WRITE
    385 LOG READ
    399 LOG PRINT
600      TESTS
    611 DETAIL TESTS
700      TEST POINT ACCESS
```

```
611 DETAIL TESTS

G00 GENERAL

L00 LP SIG
X00 DX SIG
S00 SF SIG
E00 E&M
C00 CONT CHANNEL
W00 SGL WIRE

T00 TRMSN
H00 LIST, TLK
M00 ELECL MEASMT

A00 DTM
D00 DDS

K00 DSK COM
```

Fig. 29—SARTS auxiliary commands.

command each time the "LF" appears. When the log is printed, the buffer is cleared so that new commands can be recorded. The log contents also may be displayed at any time in the informational area of the left side of the screen (using the 385 command). Figure 30 shows a typical log display.

Entry of the 600 command displays the 600 TEST menu. Entry of the 611 command displays 611 DETAIL TESTS, which is a master menu of all the operational command menus.

4.3 Operational commands

The operational commands are listed in Fig. 31. The first character of the name for the operational commands are coded as follows:

G — General

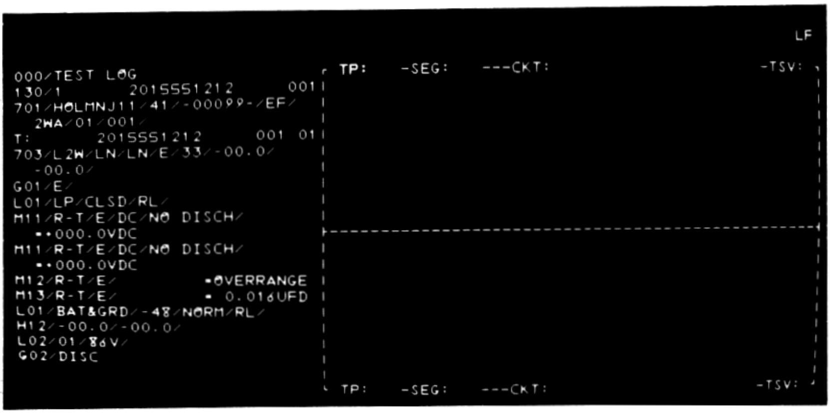

Fig. 30—Typical log display.

T — Transmission Tests
H — Talk and Listen (Hearing) Conditions
M — Electrical Measurements
L — Loop Signaling Test Functions
S — SF Signaling Test Functions
X — DX Signaling Test Functions
E — E & M Signaling Test Functions
C — Control Channel Circuit Test Functions
W — Single Wire Circuit Test Functions

The second and third characters of the code name for the *L*, *S*, *X*, *E*, *C*, and *W* commands are numerically coded according to function to make them easily learned and remembered:

Code Name *Function (in the Test Direction)*

- –01 Splits the circuit and applies supervisory conditions.
- –02 Controls the application of ringing signals.
- –03 Applies Dial Pulse address signals.
- –04 Applies *Touch-Tone*® address signals.
- –05 Applies 15 seconds of continuous dial pulsing.
- –06 Splits the circuit and applies special test conditions.
- –07 S07 controls the 2600-Hz tone level; otherwise, it is a "restore to normal" command.
- –08 Used for *E* and *C* commands to measure voltage to ground.
- –09 Used for *E* and *C* commands to measure resistance to ground.
- –10 Applies *MF* address pulsing.
- –51 Applies conditions in the non-test direction.

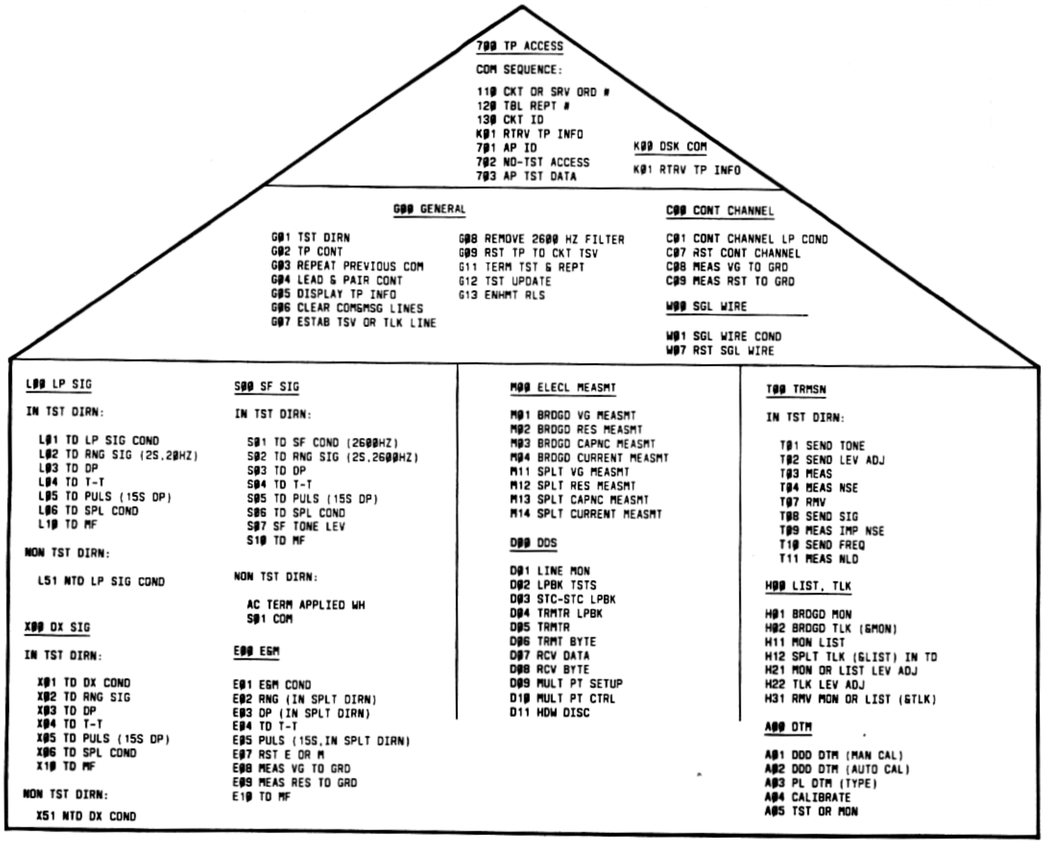

Fig. 31—SARTS operational commands.

The second and third characters of the *M* and *H* commands are also coded with a function-related scheme:

M-- (second character) Denotes mode of measurement:
- 0 = Bridged (circuit not split)
- 1 = Split (measurement mode while circuit is split)

M-- (third character) Denotes type of measurement:
- 1 = Voltage
- 2 = Resistance
- 3 = Capacitance
- 4 = Current

For example, *M*01 = Bridged voltage measurement
*M*11 = Split voltage measurement.

H-- (second character) Denotes mode of application or control:
- 0 = Bridged
- 1 = Split
- 2 = Level Adjustment
- 3 = Removal

H-- (third character) Denotes type of function:
- 1 = Monitor (Listening)
- 2 = Talking

For example, *H*12 = Applies Split Talk Condition
*H*22 = Level Adjustment of Talk Condition.

4.4 Maintenance commands

The maintenance commands are not normally used during circuit testing. They are restricted to use only by system maintenance position operators. These commands are listed in Fig. 32. They are used to verify the system status, to check the continuity of the communication system, to reconfigure the 52A test positions so that they will satisfy various application requirements, and to test the RTSS in the network. They are also used to create and maintain an optional access point data storage feature.

The code names of the maintenance commands are totally numerical to make them distinct from the auxiliary and operational commands and to insure later compatibility with the CMS 3A, which also uses numerical maintenance commands.

```
ØØ1/        CENTRAL MAINTENANCE CENTER

    ØØ2 HARDWARE ASSIGNMENTS
    Ø1Ø DIRECTORY ASSIGNMENTS
    Ø2Ø FAR-END TESTS
    Ø4Ø MISCELLANEOUS FUNCTIONS
    Ø6Ø RTS STATUS & CONTROL
    Ø7Ø ACCESS POINT DATA MANAGEMENT

ØØ2/                    HARDWARE ASSIGNMENTS

 ØØ3  INVOKE PRINTER ASSIGNMENTS FROM DISC TO CORE
 ØØ4  ASSIGN A PRINTER FOR A TP52A LOG PRINT
 ØØ8/Ø  ASSIGN LMUØ
 ØØ8/1  ASSIGN LMU1
 ØØ8/2  ASSIGN LMU2
 ØØ9  INVOKE LMU ASSIGNMENTS INTO CORE

Ø1Ø/                    DIRECTORY ASSIGNMENTS

 Ø11/X  X=1,2,3,4  ASSIGNS TLK & MON LINES FOR TEST SITES 1,2,3,4
 Ø12/1  ASSIGNS FIRST 25 LOCAL RTS
 Ø12/2  ASSIGNS SECOND 25 LOCAL RTS
 Ø13/YY  YY=ØØ-24 ASSIGNS FOREIGN PC1A & THEIR RTS
 Ø14/1  INVOKE PRIMARY DIRECTORY ASSIGNMENTS
 Ø14/2  INVOKE ALTERNATE DIRECTORY ASSIGNMENTS

Ø2Ø/                    FAR-END TESTS

 Ø21/ FAR-END TEST # NNNN
```

```
Ø4Ø/                RTS STATUS & CONTROL

Ø41  RTS ACCESS
/XA  CONN GRPS PRESENTLY ACCESSED
Ø46  FECC ROM CHECK
Ø47  FECC RAM CHECK
Ø48  TFCC ROM CHECK
Ø49  TFCC RAM CHECK
/XH  REMOTE PORT LIST

Ø6Ø/                MISCELLANEOUS FUNCTIONS
Ø61  RX11 DISK TO DISK
Ø62  SYSTEM CLOCK
Ø64  SYSTEM MODE
Ø66  /LOGICAL NAME & UNIT#  DATA LINE ABORT
Ø67  POSITION IN USE
Ø68  RTS IN USE
Ø69  ALARM CUT OFF

Ø7Ø/                ACCESS POINT MANAGEMENT
Ø71  CIRCUIT & TP COUNT ADJ
Ø72  CIRCUIT & TP COUNT READ        Ø73  CIRCUIT & TP EDITING
Ø74  DISC OPTION CONTROL
```

Fig. 32—SARTS maintenance commands.

V. HUMAN FACTORS

Two concepts are used by human factors engineers to describe the processes involved in the HMI: "quickening" and "unburdening."[5] We will add two concepts: "amplifying" and "forgiving" and indicate how SARTS demonstrates their effects.

Quickening is a tightening-up, or an acceleration, of the communication link between the human and the computer system. This is illustrated by the general operation of SARTS, and in particular by the simple command names and by the abbreviated direct command input method, which can be used after experience has been gained in command usage. Quickening will be further demonstrated when SARTS progresses toward automatic performance of more complex test functions.

Unburdening is the process of simplifying the human task by reducing the effort or choices needed to do complex tasks, thereby reducing errors and leading to eventual full automation. SARTS exemplifies this quality because it automates all special-service testing and concentrates it in the Special Service Center. It removes the need for a tester to understand the operation of complex testing and measuring equipment because all SARTS tests are performed by the RTS using sophisticated, built-in equipment, rather than by a myriad of manual test equipment generally found in central office testing environments. Also, the CLR access point testing data remove the need for deducing circuit operation from equipment information and experience.

Amplifying is defined here as an important second-order effect of altering the system after experience has been gained about its potential or shortcomings. Higher iterations are possible in SARTS without significant hardware changes because of the system's software dependency. SARTS is presently entering the first amplifying phase of development by using previous experience to provide new features and operation. Data are continuously being accumulated from the major sites of SARTS to amplify the operation in future versions.

A forgiving system is one which tolerates mistakes, indicating errors automatically, and which suggests ways around impasses. SARTS is forgiving in that it indicates and describes errors, and it immediately feeds back the results of command execution, allowing a tester to recognize errors and make corrections.

VI. AUTOMATION AND HUMAN BEINGS

There are certain disadvantages to automating people out of a system. People become increasingly isolated, and the alienation effects increase fatigue and restlessness.[6] Management of a Special Service Center requires a sensitivity to these effects on the testers. The physical setup of an office that is pleasant, well designed, and well controlled is less exciting than an office with complex equipment, interesting passageways, and a certain amount of confusion that helps break up the monotony of a monolithic 9-to-5 shift. The adventurous challenges of chasing down a failure with all its physical obstacles is eliminated in an automatic environment like the Special Service Center.[7]

It must be recognized, also, that highly automatic systems (into which SARTS is evolving) attract people more attuned to a less technically demanding job. The highly skilled testers then become available for more stringent work suitable to their training and experience.

VII. FUTURE EXPANSIONS

Computers increase the available time to do tasks. They also relieve a person from having to understand routines and operations in detail, ideally shifting the emphasis to a "higher," more holistic level.[8]

The ultimate plan with SARTS (and CMS 3A) is to fully automate the special-service circuit testing processes. When this is accomplished, for example, the diagnosis of a circuit failure may be initiated by a single action which will start an automatic testing process. This process would contact SMAS access points at strategic locations and automatically follow a series of logical testing steps to sectionalize the failure and report the results to the tester. This type of operation requires standard trouble-shooting procedures for the many types of special services, and for the many varieties of equipment used to provide these services. Operating company personnel working with Bell Laboratories people are currently developing the groundwork for these standard procedures. They will draw upon the work of other standardization processes (such as the Standard Design BSPS), and upon other automatic processes (such as the Circuit Design System of TIRKS [Trunk Integrated Record Keeping System]).

This ultimate goal will take many years to achieve, but it is an example of the benefits that can be attained through higher iterations of a mechanized testing process.

VIII. SUMMARY

SARTS is an historic initial step in the direction of creating a testing system that is entirely automatic. The SARTS concept has proven itself in the field. It reduces testing times and provides economic advantages over manual methods.

SARTS users agree that it is a tremendous improvement over the old systems of multiperson testing, because the throughput is considerably faster and the quality of testing is better because of reduced human errors and more precise tests. New personnel can also be trained more easily because the testing procedures are simplified.

Finally, SARTS is proven to be economical through organizing and centralizing the special-service testing process and removing the inefficiencies and limitations inherent in a diverse multiperson testing operation.

IX. ACKNOWLEDGMENT

In addition to his efforts in providing help during every stage of the preparation of this manuscript, Robert E. Mueller[9] contributed the research, and was responsible for the sections on human factors. He also contributed the concepts of "amplifying" and "forgiving." Bob's help and patient assistance is gratefully acknowledged.

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