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Traffic Service Position System No. 1B:

Switching Control Center System Interface

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Over the years, the centralization of the maintenance and operation of Stored Program Control Systems (SPCS) has proved to be an economically attractive and effective methodology. At the core of the centralized maintenance plan is the Switching Control Center (SCC), which has responsibility for the surveillance and control of a number of SPCS. This center is supported by the Switching Control Center System (SCCS), which is a minicomputer-based system that provides automation of, or mechanized support for, the functions of the SCC. Since SCCS support for the Traffic Service Position System No. 1 (TSPS No. 1) was already available, these capabilities needed to be carried forward to support the operation and maintenance of TSPS No. 1B. In addition, the use of the new 3B20D Processor with a new craftperson interface allowed for a number of improvements and extensions. The SCCS interface to TSPS No. 1B has made use of new technology and techniques by incorporating microprocessors, video terminal interfaces, and BX.25 protocol in the design. The result is a flexible interface with software-driven craft displays.

I. CENTRALIZED MAINTENANCE—OVERVIEW

Since the early 1970's the Bell Operating Companies (BOCs) have been taking increasing advantage of the concept of centralized maintenance of switching systems. To economically operate, administer, and maintain electronic switching systems, operations centers were formed where technical experts equipped with computer-based support systems can apply their skills to many switching systems. In the case of the Traffic Service Position System (TSPS), the daily maintenance and operations functions may be provided by the Switching Control Center (SCC).

If a TSPS is maintained and operated from an SCC, the SCC manager has overall responsibility for the quality of service provided by the TSPS and the cost of maintaining the system. To provide high-quality service at a reasonable cost, a number of functions must be performed efficiently at the SCC. Since in this environment the TSPS is unattended, except when field personnel are assigned to specific tasks in the office, the SCC personnel monitor the real-time status of the TSPS on a continuous basis. In the event of failure of equipment in the TSPS complex, the SCC exercises appropriate controls to ensure service protection. The cause of the failure is then analyzed and isolated. Finally, when the trouble is identified, field personnel are dispatched to perform any necessary on-site repair.

To accomplish these functions, a number of work positions have been established in the SCC and individual craft have been assigned particular responsibilities.

The Office Controller is responsible for real-time surveillance of several switching systems and as such has the most frequent interface to the TSPS. (Most BOCs will maintain several types of electronic switching systems from each SCC.) The controller responds to system alarms and takes necessary service-protection action. The Analyzer is responsible for those more complex problems that require sectionalization and trouble identification. The Analyzer interacts with the TSPS to collect additional data and uses previously reported data to isolate system troubles. The craftperson at the trunk-maintenance position is responsible for identifying faulty trunks and directing their repair. In addition, dispatch and administration functions exist in the SCC to identify work for field forces, facilitate proper information flow, and keep records.

II. TRADITIONAL INTERFACE

The No. 2 Switching Control Center System (No. 2 SCCS) began deployment in the mid-1970's as a computer-based support system to aid the SCC personnel in performing their jobs. It has evolved over time by providing new features and interfacing to Stored Program Controlled Systems (SPCS) such as TSPS No. 1.[1,2] With the development of TSPS No. 1B, a parallel SCCS development was done to integrate the new system into the existing operations environment while taking advantage of opportunities afforded by the new 3B20D Processor.

2.1 The TSPS No. 1—SCCS interface

The traditional interface provided by No. 2 SCCS consists of a dedicated channel from a TSPS No. 1 that parallels the Maintenance

Teletypewriter (MTTY), plus a dedicated channel that terminates on an E2A telemetry unit at the TSPS No. 1 Master Control Center (MCC). At the SCC, the TTY channel is connected to a minicomputer system, known as the Computer Subsystem (CSS) and the telemetry channel terminates on a telemetry unit that collects data from many switching offices. This basic architecture is shown in Fig. 1. The TTY channel is a 110-baud asynchronous serial communication line. The data output by the TSPS No. 1 on this channel reports detailed information in line-oriented output messages suitable for hard-copy teleprinters. In addition, line-oriented input commands may be sent to the TSPS No. 1 on this channel. The TTY channel data are collected and stored in the CSS. The data are available for real-time alerting and long-term analysis.

The telemetry system serves the purpose of reporting real-time equipment status and allows controls to be activated remotely. At the TSPS No. 1 MCC an E2A remote unit is provided to collect detailed

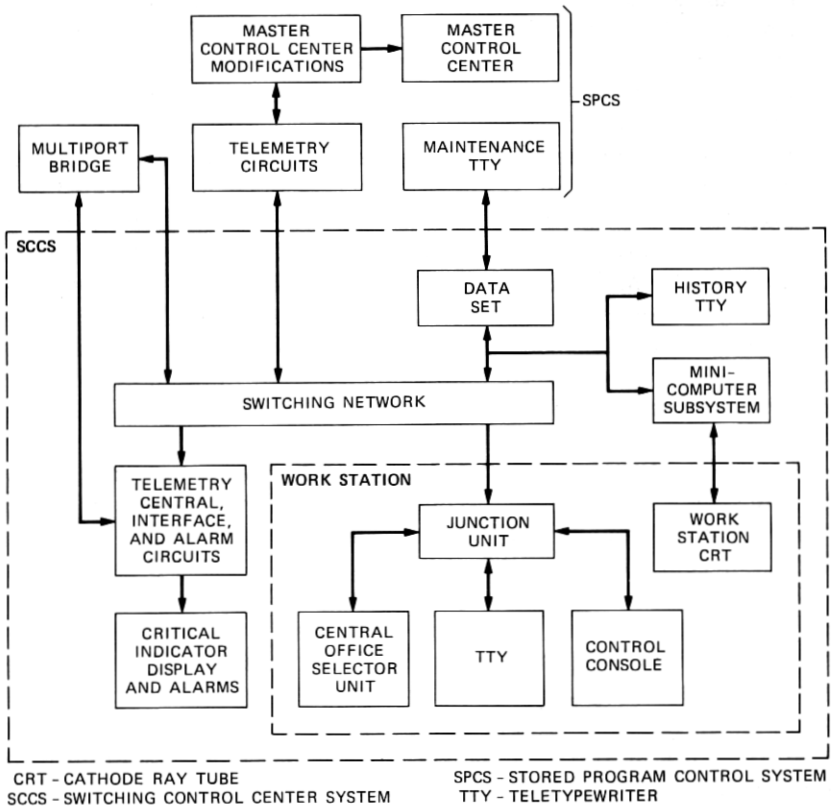

Fig. 1—TSPS No. 1-SCCS interface.

status of TSPS No. 1 hardware states. This is accomplished by connecting discrete scan points in the E2A telemetry unit to individual lamp displays on the MCC. Control capability is provided by individually connecting relay contact closures in the E2A telemetry unit in parallel with the pushbutton keys on the MCC. The interface is thus hardwired in place.

An E2A central unit in the SCCS polls up to 16 remote E2A units on a continuous basis. The polling process takes place over a data network that has a multiport bridge at its hub. The central unit transmits a request for data along with a unique address of one of the remote units. The remote units on the network respond only when their address is contained in the polling request. The message format used consists of start and stop bits, 16 data bits, and a 7-bit cyclic redundancy check sum. This data word contains a summary of the status of critical hardware units in each office. The data are displayed in real-time on a wall-mounted status panel called the Critical Indicator Panel (CIP) in the SCC.

To gain access to more detailed status-and-control capability, a control console at the SCC can be connected to the E2A remote unit at the TSPS No. 1. This is accomplished by the use of switching equipment in the SCCS to disconnect the E2A from the multiport network and connect it on a point-to-point basis with a control console at a work station in the SCC. Two types of consoles exist for interconnection with a TSPS No. 1. The original type of console provided was a wired logic console with a fixed display and keyboard. The display consisted of status lamps with labels that corresponded to labels printed on the MCC. Pushbutton keys on a keyboard were labeled with the same designations as used on the keys at the MCC.

Housed inside the console was an E2A central unit which was configured to collect all the data available from the remote unit. Its memory was hardwired to the lamps on the display panel. Such a console was then limited to functioning only with a TSPS No. 1. Any changes or additions to the MCC required corresponding changes to the consoles at the SCC. A second type of console is now provided, which consists of a CRT and microprocessor. In this type, the microprocessor communicates with the E2A remote unit to collect status information. The interface to the craft at the SCC consists of a CRT display. On this display, the lamps and keys on the MCC are represented by their labels, as shown in Fig. 2. Active status or controls are shown by displaying the label in reverse video (black characters on a white field). Keys are distinguished by preceding the label with a plus sign. Keys are activated by cursor positioning. This software-driven display allowed for the use of the same physical equipment with other types of switching systems.

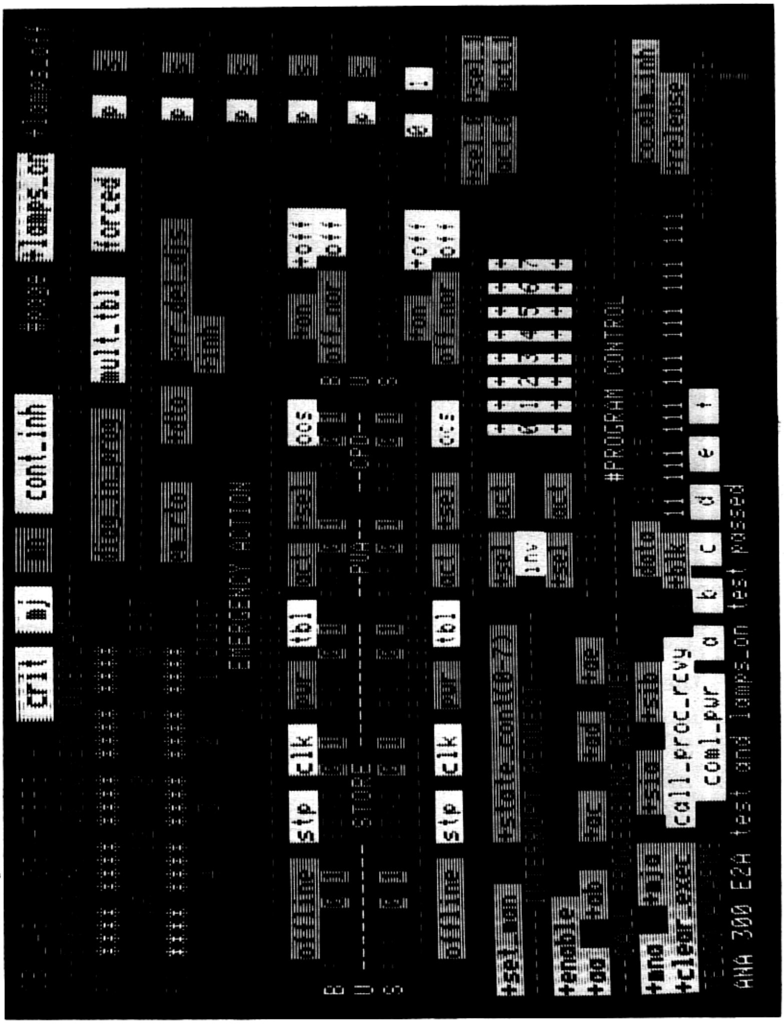

Fig. 2—TSPS No. 1 MCC display page.

2.2 Human interface

A number of human interfaces are provided to alert SCC craft to trouble conditions and to allow for further data collection, analysis, and control. As data are collected via the telemetry network in real time, alarms and status of critical equipment units are displayed on a highly visible CIP. This provides alarm visibility and long-term equipment status information to the SCC managers and craft. TTY messages are examined in real time as they are received and stored by the CSS. Messages reporting alarmed events are used to trigger a video display on an alarm monitor, which is a large CRT device. The identity of the switching system reporting the trouble and the alarm level are displayed along with a one-line summary of the condition being reported.

The office controller is responsible for responding to the real-time events reported on the CIP and the alarm monitor. The controller's work station is equipped with two CRTs that serve as additional interfaces to the system. One CRT, known as the CSS work station, is connected to the CSS. Via this device the controller can examine previously reported data that have been stored by the CSS. In addition, the CSS work station can be placed in the monitor mode where it is connected to the TSPS No. 1 via the CSS and becomes the functional equivalent of the maintenance TTY at the TSPS No. 1. That is, in this mode the work station receives each character output by the TSPS No. 1 as it reaches the CSS and any characters typed by the user are sent directly to the TSPS No. 1.

The second CRT is the microprocessor-driven console described above, which interfaces to the telemetry network. This equipment constitutes the control console and is the functional equivalent of the local MCC lamp and key panel. Thus the office controller has the same capabilities at the SCC work station that a craft at the TSPS No. 1 has via the maintenance TTY and MCC panel. The control console and CSS work station functions are provided on separate terminals and via separate processors and links in order to enhance the availability of the interface in the face of a simplex outage.

The analyzer work station is also equipped with these devices. The analyzer, however, makes more use of SCCS programs in the CSS which analyze large volumes of data and reduce them to summarized outputs and reports. For example, filtering and patterning capabilities allow for the identification of repetitive events and aid in the trouble-sectionalization process. While the office controller uses the control console for service-protection purposes, the analyzer uses it for more detailed data collection and observation of system performance under specific conditions.

It is this operations environment into which the new TSPS No. 1B was integrated. The new interface serves as the foundation for remote maintenance of TSPS No. 1B as well as other 3B20D Processor applications.

III. THE TSPS NO. 1B—SCCS INTERFACE

3.1 Elements of the new local maintenance position

With the use of the 3B20D Processor and the DMERT operating system came the opportunity for new flexibility at the local maintenance position.[3] The MCC and the MTTY of the TSPS No. 1 have been replaced by the Maintenance CRT (MCRT) and a Receive-Only Printer (ROP).[4] The ROP provides a paper history function by recording each maintenance event or alarm condition in the form of line-oriented output messages.

The MCRT has several modes of operation. The first, the Emergency Action Interface (EAI), can be thought of as the replacement of the emergency recovery functions of the MCC. Actually, the EAI provides a hardware control function that is independent of the system software. It provides recovery capabilities for the TSPS No. 1B even in the absence of software sanity. The MCRT also has a test input/output mode. This allows the user to input line-oriented commands and to receive responses to these commands as well as spontaneously generated output. This is equivalent to the old MTTY input and output mode. In addition, the MCRT has a Control and Display mode (C&D), which provides the user with page-oriented displays of system status and with a menu of commands used to affect the status or configuration of the system. The C&D mode provides a very effective human interface for the daily functions of trouble isolation and correction. Finally, the MCRT provides continuous status information on the health of the system via a critical indicator display.

These different modes of operation are provided by dividing the screen into several sections and providing keys for toggling between modes (see Figs. 3 and 4). The top of the CRT is a header line. The second and third lines of the MCRT contain critical indicator information. The fourth line is reserved for command input. Lines five through twenty-two are used alternatively to display menus and pages in the C&D mode or to display the EAI page. Finally, any lines that are unused by the page that is currently being displayed are used for text input and output. At least two lines are always available for text input and output. However, if the currently displayed page does not use the entire page region, the remaining area may also be used for output.

The MCRT and the ROP interface to the 3B20D Processor through a firmware controlled unit called the Maintenance Teletype Controller (MTTYC). This unit provides the EAI mode and interfaces between

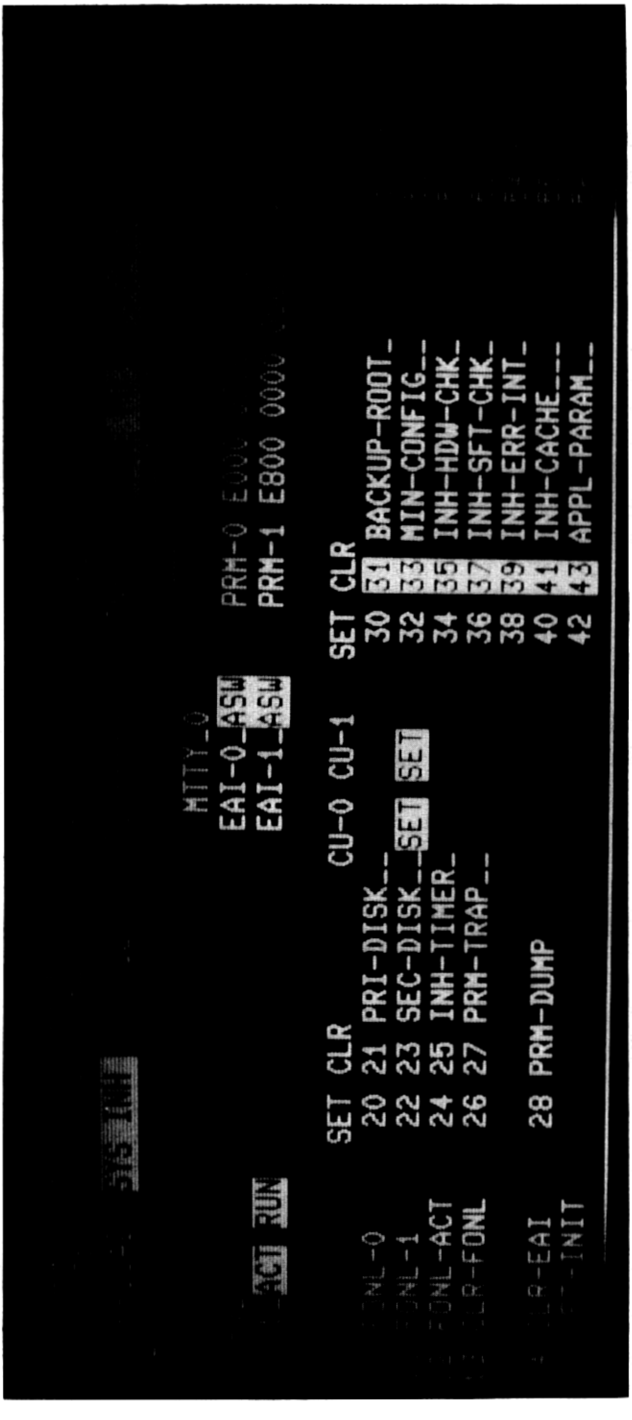

Fig. 3—TSPS No. 1B EAI page.

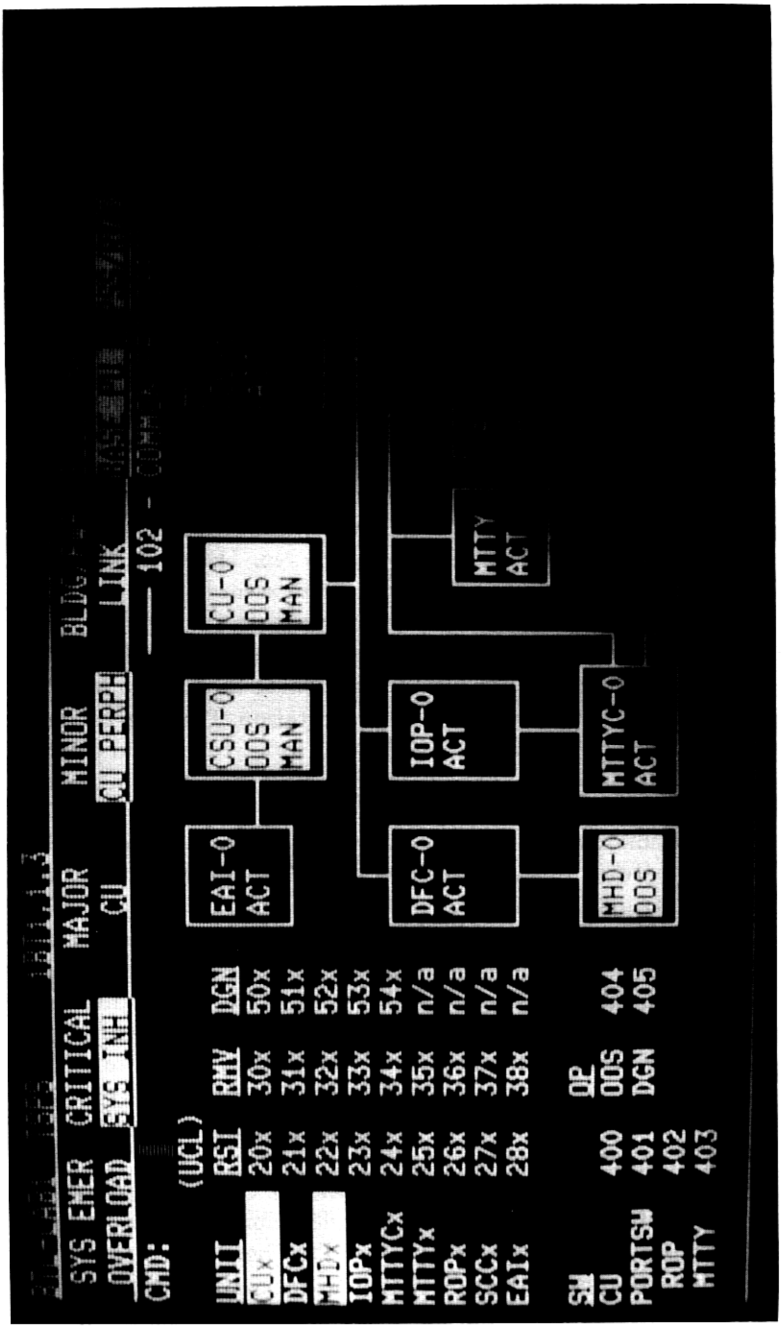

Fig. 4—TSPS No. 1B control and display page.

the terminals and the 3B20D Processor in other modes. The firmware in the MTTYC is responsible for controlling the MCRT in the EAI mode to allow access to the system in the absence of 3B20D Processor sanity. The MTTYC also controls the interface to the SCCS. All other modes of operation and information on the MCRT are controlled by software in the 3B20D Processor.

3.2 Elements of the remote maintenance interface

The allocation of information and modes of operation at the SCC is consistent with both the local interface at the TSPS No. 1B and the existing SCC functions. The critical indicator information is displayed on the CIP as was done for the TSPS No. 1. In addition, the text input/output and the data on the ROP are logged in the CSS. This provides the work station with the Monitor mode and allows the CSS to drive the alarm monitor. This will also allow the existing work station features for the controller and the analyzer to operate as before. Also, the EAI interface is available to the Control Console (CC) just as the MCC functions of the TSPS No. 1 were provided there. This allows the controller to recover the TSPS No. 1B when necessary. Providing this function on the CC gives added assurance that it will be available in the event that the CSS is unavailable.

Furthermore, to provide consistent operation with the local interface, a CRT display mode essentially identical to that at the MCRT is provided on both the CC and the CSS work station. The only exception is that the CC is not provided with the text input/output functions at the bottom of the screen. This means that both the CSS work station and the CC have access to the EAI mode and the C&D mode, and the CSS work station has full TTY input/output capabilities. Also, all the mechanized features provided by the CSS to support the controller, analyzer, and trunk-maintenance positions remain available.

To communicate between the TSPS No. 1B and SCCS in the C&D mode, a language was defined with which the TSPS No. 1B tells the SCCS what should be displayed on the screen. The SCCS then sends each user command to the TSPS No. 1B, which processes the command and sends back a description of the display, complete with all the up-to-date status information. The SCCS translates that data stream into one that is understood by the SCC terminal. The language that is used to communicate this information is known as Virtual Terminal Protocol (VTP). By this method, the SCCS is not required to have complete up-to-date information describing each of the many C&D pages provided by TSPS No. 1B. This helps keep the system relatively independent with respect to changes and enhancements.

With respect to the EAI mode and the critical indicators, however, much less information is involved and it is less subject to change. The

EAI consists of a single page, which is controlled by the firmware in the MTTYC. There are up to twelve critical indicators, the definition of which is very stable for each SPCS. Therefore, the SCCS is capable of generating a critical indicator display as well as an EAI display, and the TSPS No. 1B simply sends the data required to describe the status of each of the indicators or display components.

3.3 Basic architecture of the interface

Since the existing TTY and E2A interfaces do not have the capacity to support the amount and form of information that must be exchanged between the TSPS No. 1B and SCCS, a new interface was designed. In particular, the information necessary to drive the EAI and C&D modes requires highly reliable transmission of a significant amount of binary information. The new interface that was designed for communication between the TSPS No. 1B and the SCC, Fig. 5, consists of a pair of 2400-baud synchronous links between the MTTYC and a new device at the SCCS called the Protocol Converter (PC). One link is normally active while the other is used as a backup and is therefore normally in the standby state. The link carries seven logical streams of data under the BX.25 protocol using the virtual channel assignment capabilities of that protocol. The virtual channels (VC) are assigned as follows:

VC1—Emergency action interface
VC2—Critical indicator information

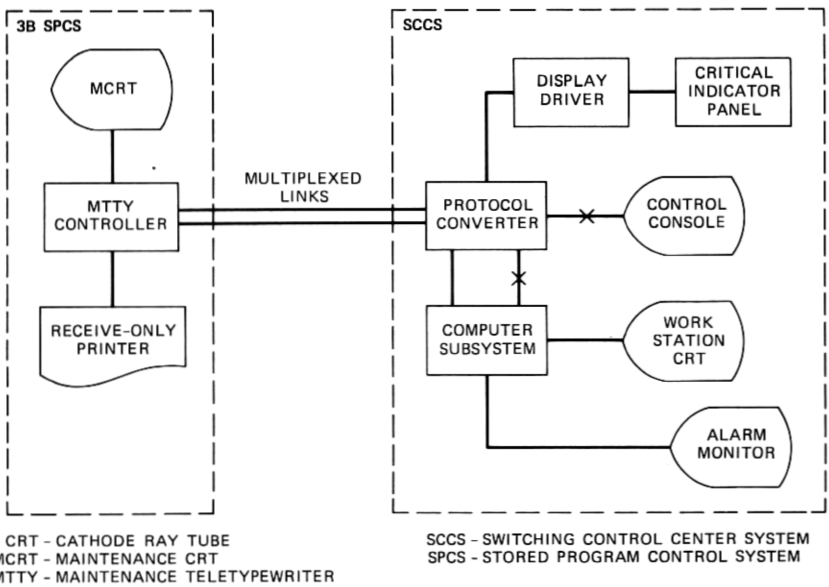

Fig. 5—TSPS No. 1B—SCCS interface.

VC3—C&D interface
VC4—TTY input and acknowledgment
VC5—TTY output
VC6—Spare
VC7—Spare

The two links provide simple backup for each other. If either end detects a link outage at level 2 of the protocol, it will switch to the other link and establish communication on that link. The function of the PC is to handle the BX.25 protocol and to divide the virtual channels into separate physical connections bound for the different subsystems of the SCCS.

The PC is a firmware-controlled microprocessor system. Each microprocessor can support up to three 3B20D-based systems. The PC is housed in a newly designed cabinet, known as the T-cabinet, which can hold up to three PCs. In addition, this cabinet contains one spare PC, which can be manually activated to replace any one of the three active PCs, should they fail.

The PC sends the critical indicator information contained on VC2 to another firmware-controlled microprocessor called the display driver, which interfaces to the CIP. The display driver is also housed in the T-cabinet and can support up to 18 systems.

The PC sends and receives the TTY information contained on VC4 and VC5 to and from the CSS. The interface is a 1200-baud asynchronous serial communication line similar to the MTTY interface in the previous architecture. Since this is a character-oriented interface and the BX.25 link to the TSPS No. 1B is a message-oriented interface, the PC provides for the translation between the two. The fact that the TSPS No. 1B emulates the TSPS No. 1 has allowed the software in the CSS—used to assist the SCC in the maintenance and operation of TSPS—to be carried forward to support TSPS No. 1B with only minor modification. That is, most information received from a TSPS No. 1B, except that which deals directly with the processor itself, is the same in form and content as in TSPS No. 1. Thus, all the mechanized tools provided by the SCCS are still applicable with very little modification. This fact significantly enhances the ease with which the TSPS No. 1B can be integrated into the SCC environment as it gradually replaces the existing TSPS No. 1's.

To provide the MCRT function, the PC multiplexes the data contained on VC1, VC2, and VC3 onto a single physical link which can be connected to either the control console or the CSS, depending on whether the control console or CSS work station is currently accessing the office. This interface is also a 1200-baud asynchronous communication line, and a simplified version of levels 2 and 3 of the BX.25 protocol has been designed for this link. This allows for the three logical data streams to coexist on this link and also allows for some error checking to increase the reliability of the interface. In addition, this link allows the user to input C&D commands or EAI commands into the TSPS No. 1B through the PC.

In summary then, the interface described in this section permits the distribution of functions among the subsystems of the SCCS, which is consistent with existing operations and allows the SCC user to access the TSPS No. 1B in the same manner as the user at the local maintenance position. The control console has access to the EAI, critical indicator, and C&D information when it is attached to the office. In addition, the CSS work station can "display" the office information and receive the same view as the MCRT at the TSPS No. 1B, including the text input/output functions at the bottom of the CRT. Finally, all the status and alarm information output at the ROP and all the input/output activity on the TTY channel—both from the SCC and the local position—are logged in the history files in the CSS. This information then becomes the basis for the alarms displayed on the alarm monitor and for the sophisticated tools provided by the SCCS to support the controller, analyzer, and trunk-maintenance positions at the SCCS.

IV. OPERATIONAL IMPACT

The TSPS No. 1B-SCCS interface introduces several new features to the SCC craft. The use of software and microprocessor technology at the SCC and the TSPS No. 1B have enabled various design objectives to be met. The available technology allows the use of the BX.25 protocol providing a multiplexing arrangement on the TSPS No. 1B-SCCS link. Intelligent control equipment administers the BX.25 protocol that provides error detection and correction on the link. Software-controlled video displays replace hardwired control panels provided on the TSPS No. 1.

The 3B20D Processor will be used in other Western Electric switching systems, which will permit the development of a common SCC interface for all such systems, These, and other new features and capabilities described below, take advantage of the available new technology. This section discusses how the features and capabilities of the architecture described in Section III affect the SCC operations.

4.1 Consistent operation with local TSPS No. 1B maintenance terminal

The CSS work station operation with the TSPS No. 1B is essentially identical with the on-site TSPS No. 1B maintenance terminal. In addition to all capabilities provided at the on-site TSPS No. 1B terminal, the CSS work station has access to the features provided by the SCCS computer subsystem. In the EAI and C&D modes, the control console also has identical operation as the on-site TSPS No. 1B maintenance terminal. Both the SCC work station and the control console have full access to the EAI page to monitor and initiate TSPS No. 1B status and recovery functions. By reducing the differences between the local and remote interfaces, training requirements are reduced and craft efficiency is enhanced.

4.2 Consistent operation with existing SCC

The design provides the TSPS No. 1B with support which is operationally similar to other SPCSs interfacing to the SCCS.

The TSPS No. 1B may be monitored and controlled from the CSS work station with the CSS providing the support functions of logging, sorting, and browsing. All the tools provided by the CSS for the support of TSPS No. 1 are extended to TSPS No. 1B. This means that operational procedures that are in place with respect to TSPS No. 1 are still applicable. The alarm monitor display of alarms is also fully functional.

In the event of a CSS failure, the control console provides craft access to the TSPS No. 1B as it does in other SPCS-SCCS interfaces. Alarms are displayed on the critical indicator panel in a standard line-up arrangement as with other systems. All CSS features operate in the same manner as with previous systems.

While enhancements have been made to the human interface, the basic SCC functions (described in Section II) have been maintained with the TSPS No. 1B.

4.3 Improvements to the human interface

Since the TSPS No. 1B introduces many new features and capabilities in the maintenance terminal, these features are also available at the CSS work station and control console as a result of the new TSPS No. 1B-SCCS interface.

For example, in addition to the text input/output message capability, used in the TSPS No. 1, the TSPS No. 1B-SCCS interface includes the C&D mode. The C&D mode provides a series of displays that give current status of various sections of the system. These displays may be requested by the craftperson using a menu selection process. The menu lists several possible display pages with a three-digit-selection menu number. In addition, the user can initiate many of the typical maintenance and recovery actions required to operate a TSPS No. 1B using menu numbers provided on these displays. This provides a significant improvement in speed and accuracy for frequently used functions over the text input and output capabilities of the TSPS No. 1 and SCCS interface.

The EAI page, Fig. 3, follows the same format as other display pages. From this page the craftperson is able to initiate various recovery functions using a two-digit menu selection. Also available on this page is progressive system status during recovery sequences. This is a significant improvement over the previous MCC interface of the TSPS No. 1 in several ways. In particular, the EAI provides more information—because of the video display—and more consistency between the emergency interface and other kinds of access to the system. Consistency between the local interface and the remote interface at the SCC is also enhanced. In the TSPS No. 1 the local interface was a hardware panel of lamps and keys and the remote interface used a video display and keyboard to emulate the local interface. In the new design the local and remote interface are identical. The system also provides four special function keys at the video terminal. These keys are designed to allow the craft fast and convenient use of the capabilities of the human interface. The keys provide one-button operation to perform the following functions:

(*i*) Request the EAI page (EA DISP)
(*ii*) Exit the EAI page (NORM DISP)
(*iii*) Change between the text input and menu input mode (CMD/MSG)
(*iv*) Retire alarms (ALM RLS).

To illustrate the advantages of the control and display operation available with the interface between the TSPS No. 1B and the SCCS, consider the example of the alerting and analysis of a major alarm associated with a moving head disk in the TSPS No. 1B. As with other systems, a TSPS No. 1B major alarm results in a visual indication at the critical indicator panel, a one-line alarm summary message is displayed at the alarm monitor, and, if activated, an audible alarm sounds. If the controller then connects the CSS work station to the office in the display mode, the display will indicate the alarm with the "Major" indication and flashing "CU PERPH" (Control Unit Peripheral problem) in reverse video in the critical indicators section of the display (second line on the screen).

The controller can retire the alarms by depressing the alarm-release special function key. This will return the major indication to normal on the screen and result in "CU PERPH" in solid reverse video. The controller can then select the CU PERPH page from the page index by entering the three-digit menu number associated with that page. The CU PERPH page will display the status of the 3B20D Processor and peripherals. On the display, the moving head disk will be indicated as out-of-service. Once called in by the controller, the analyzer may then request diagnostics be run on the disk using either a menu-selection number (from the menu of commands displayed on the left part of this display page) or, by using the special function key to change to the text input mode and typing a text diagnostic message. The result of this diagnostic should lead the analyzer to further action, (e.g. dispatch to repair or replace the faulty hardware).

Video displays and menu selection provide an effective human interface, which results in a low probability for human errors occurring and a high level of job satisfaction.

4.4 High reliability

To meet the high reliability required of the TSPS No. 1B-SCCS interface for unattended operation of TSPS, the interface is designed with a highly redundant architecture. The 2400-baud data link between the two systems is fully duplicated and the BX.25 protocol provides error detection and correction. The TSPS No. 1B components that control and administer the SCCS interface (e.g., the MTTYC) are fully duplicated and provide full access both to the local and remote users in the event of single-unit failures.

The SCCS components are also backed up. In particular, the T-cabinet provides for a sparing arrangement in the event of a PC failure, and the duplication of capabilities at both the control console and CSS work station allows these terminals to back each other up in the event of failures in either subsystem. Finally, the CIP provides alarm and status information even in the event of a CSS failure that disables the alarm monitor.

In addition, this design provides for some improvement in the capabilities provided to the SCC when single-link failures occur. In previous SPCS-SCCS interfaces, the text message data and the E2A telemetry data containing critical indicator information and emergency action information were transmitted over separate facilities. Therefore, if one facility failed, the SCC lost partial capability. The TSPS No. 1B-SCCS interfaces, using two fully duplicated links, provide the ability to transmit all the necessary data with no loss of capabilities at the SCC in the event of a single transmission-channel failure.

V. CONCLUSION

The SCCS interface to TSPS No. 1B has made use of new technology and techniques by incorporating microprocessors, video terminal interfaces, and BX.25 protocol in the design. The result is a flexible interface with software-driven craft displays. At the SCC, the craft interface devices are the same physical devices used to interface with older technology SPCSs, yet they provide new video displays and menu selection inputs. Thus, the new technology of TSPS No. 1B can be maintained from the SCC as it is introduced into the network and can also be used to enhance SCCS craft interfaces while remaining consistent with overall SCC operations.

VI. ACKNOWLEDGMENTS

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