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Stored Program Controlled Network:

Calling Card Service—TSPS Hardware, Software, and Signaling Implementation

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New hardware and software were developed for the Traffic Service Position System (TSPS) No. 1 to provide Calling Card Service and related capabilities. These developments allow TSPS to provide prompting announcements to calling card customers, to receive customer-dialed billing information, to verify the received billing information utilizing the data base capabilities of the Stored Program Controlled Network, and to provide operator assistance for calling card customers when required. The implementation includes new TSPS operational and maintenance software, dual-tone multifrequency (DTMF) and multifrequency digit detection and announcement circuits, access to the Stored Program Controlled Network, and new local office interfaces.*

I. INTRODUCTION

Calling Card Service enables customers to make calls billed to their calling card number without the assistance of an operator.[1] Customers originating 0+ calls to the TSPS are prompted to dial their calling card number, or are connected to an operator based on the originating station treatment (OST) data specified at a billing validation application (BVA) data base.[2] Customers calling from stations with dual-tone multifrequency* (DTMF) signaling capability may dial their calling card number directly. The TSPS validates the billing number by initiating a

* *Touch-Tone* is the AT&T registered service mark for dual-tone multifrequency signaling.

query to the BVA, and then completes the call. Sequence calls (subsequent calls billed to the same calling card number) may be made by keying the number sign (#) character prior to dialing the new telephone number.

Operator-assisted Calling Card Service is available to customers calling from stations not equipped for DTMF signaling to the TSPS and to customers requiring operator assistance. Validation of calling card numbers is provided on an inward basis to non-TSPS operators capable of DTMF or multifrequency signaling to TSPS. Billed number screening (BNS), a related Calling Card Service capability, enables the TSPS operator to determine if bill-to-third-number or collect requests are allowed for a particular billing number.

The functions needed in TSPS for Calling Card Service and BNS are provided by new hardware and software. These new services are provided by TSPS Generic 1T10, which establishes TSPS as a node on the Stored Program Controlled (SPC) Network. New hardware is needed to provide: automated announcements and collection of customer-dialed digits; Common-Channel Interoffice Signaling/Direct Signaling (CCIS/DS)[3] to send queries to BVA data bases; and special local office interfaces which activate DTMF signaling from coin stations when calls are connected to TSPS. New software is needed to provide automated and operator-assisted Calling Card Service interfaces for customers and to maintain new TSPS hardware.

II. HARDWARE IMPLEMENTATION

Implementation of Calling Card Service required changes and/or additions to a number of TSPS peripheral circuits. Major changes were made to the Station Signaling and Announcement Subsystem (SSAS) of TSPS to provide necessary announcements and customer prompts, as well as the ability to register billing information transmitted via DTMF or multifrequency signaling. Additional equipment was introduced to interface with the CCIS network and provide the TSPS with access to the BVA. Other TSPS changes were implemented to activate the DTMF signaling capabilities of certain telephones through expanded inband signaling and to provide required maintenance functions.

2.1 Changes in the SSAS

The SSAS is a program-controlled peripheral subsystem of the TSPS which was originally developed to provide Automated Coin Toll Service (ACTS).[4] The SSAS constructs customer announcements and prompts from a prerecorded vocabulary of announcement phrases, directs them to the telephone customer, and detects customer coin deposits. The SSAS consists of duplicated controllers and announcement stores, and up to 239 traffic-engineered coin detection and announcement (CDA) circuits (see Fig. 1).

The SSAS announcement vocabulary consists of digitally encoded half-second phrases which are stored in the semiconductor announcement store. The SSAS controller retrieves announcement phrases from the announcement store and directs the appropriate phrases to each equipped CDA circuit. A digital-to-analog decoder within the CDA circuit converts the digitized announcement phrases into an analog announcement for the customer.

Customer coin deposits are identified by dual-frequency coin deposit signals, which are detected by a coin tone receiver within each CDA circuit. The received coin deposit information is monitored and acted upon by the SSAS controller. Amplifiers, four-wire terminating sets, and other transmission components within the CDA circuit protect the coin tone receiver from potential interference caused by the SSAS announcements and permit an operator to be connected to the call if necessary (see Fig. 2).

To provide Calling Card Service, two new SSAS circuits were developed: the tone detection and announcement (TDA) circuit and the multifrequency detection and announcement (MDA) circuit. The TDA

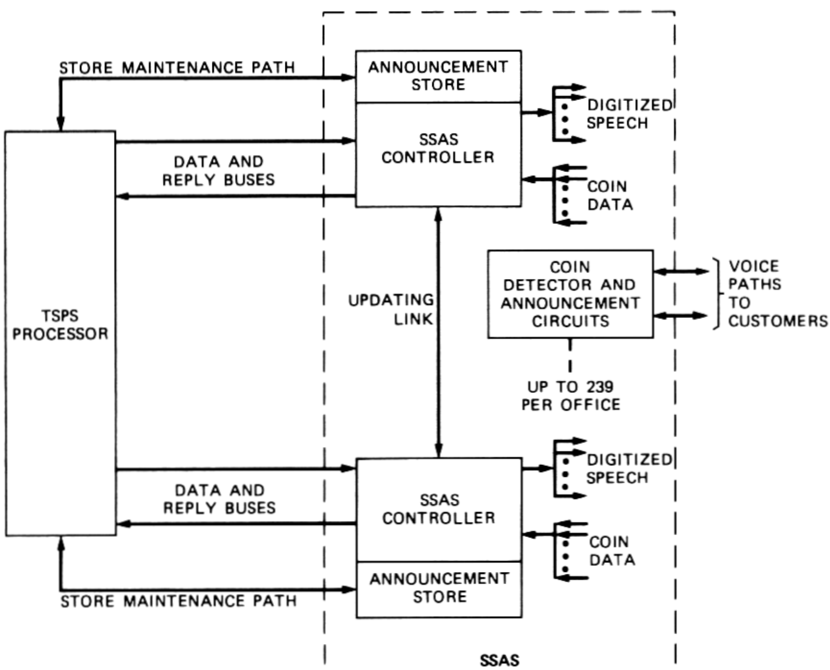

Fig. 1—Station Signaling and Announcement Subsystem block diagram.

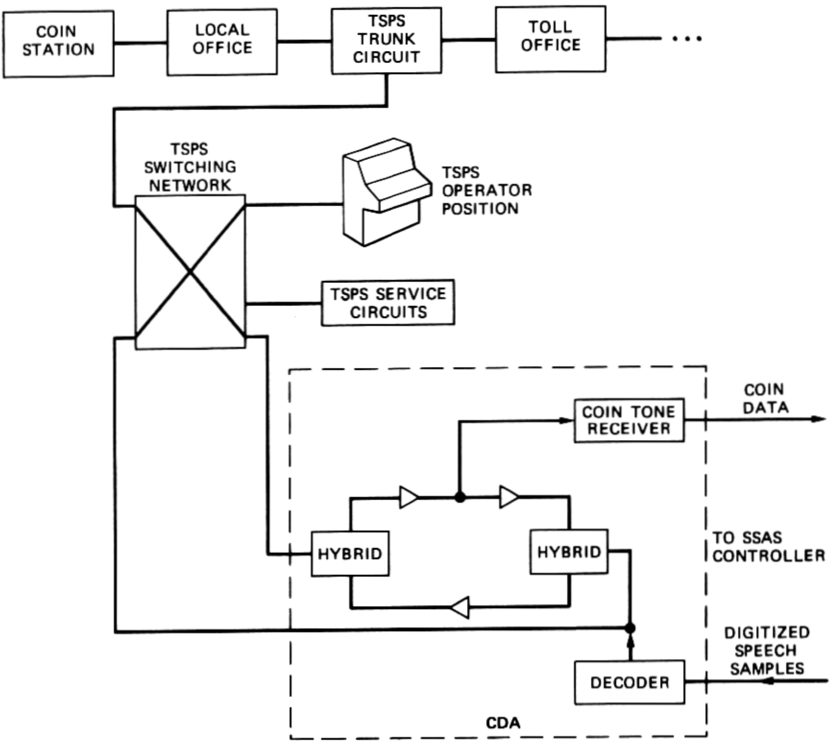

Fig. 2—Connection of SSAS CDA into TSPS.

circuit provides prompts and registers billing information transmitted via DTMF signaling on customer-dialed and certain automated inward validation calling card calls. The MDA circuit is utilized on automated inward validation calls when the billing information is transmitted using multifrequency signaling.

Implementation of the operational and maintenance functions associated with Calling Card Service required significant program additions to the SSAS controller. The capacity of the controller program store was increased to accommodate the added program. The SSAS announcement store was also equipped with additional memory to provide the new announcements and prompts required for Calling Card Service.

2.1.1 Tone detection and announcement circuit design

The design of the TDA circuit is similar to the CDA circuit used for ACTS, except that a DTMF receiver replaces the CDA coin tone receiver (see Fig. 3). The DTMF receiver provides the following functions:

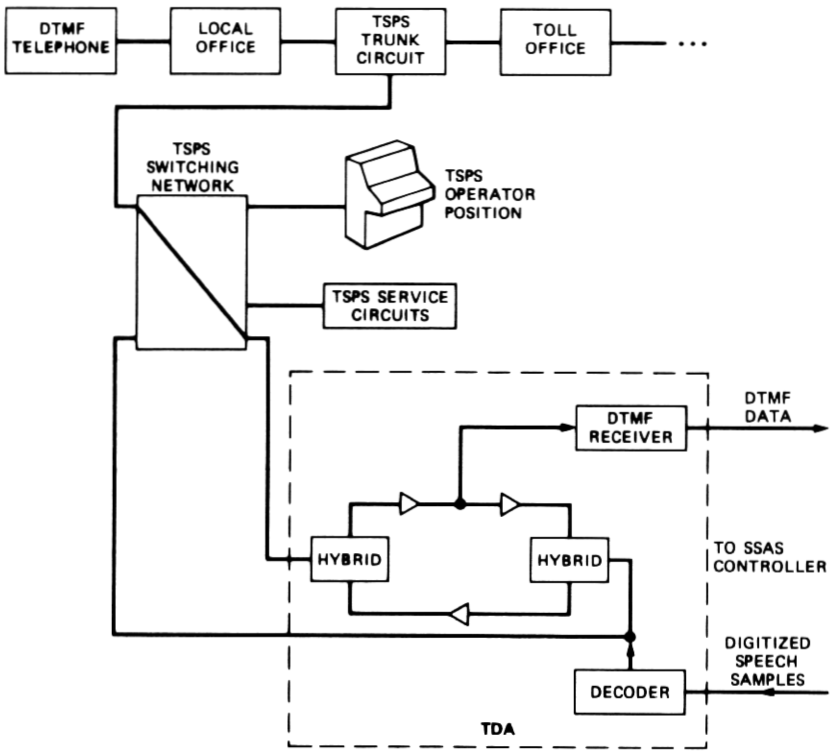

Fig. 3—Connection of SSAS TDA into TSPS.

(*i*) Detection of the standard DTMF signals used to transmit billing information during call setup (see Table I)

(*ii*) Rejection of speech simulations of DTMF digits

(*iii*) Buffering of detected digits

(*iv*) Enhanced detection of the # DTMF character while awaiting call completion.

These functions are achieved through the use of a modified local office DTMF receiver.

Table I—Dual-tone multifrequency codes

Low-Group Frequencies in Hertz	High-Group Frequencies in Hertz			
	1209	1336	1477	1633
697	1	2	3	*A**
770	4	5	6	*B**
852	7	8	9	*C**
941	*	0	#	*D**

* Currently unused.

The first two functions are shared in common with local office applications and are provided by the basic receiver. New circuitry was added to provide the other two functions which are required to implement Calling Card Service. Buffering of the detected DTMF digits permits the digits to be received at a 250-ms rate. Detection of the # character in the presence of audible ringing signals, busy signals, and network announcements, while awaiting call completion, is required to provide sequence calling.

As with the detection of coin deposit signals for ACTS, DTMF signal detection for Calling Card Service must be performed in the presence of speech and other interfering signals. Speech may contain components at the DTMF signaling frequencies that are subject to interpretation by the receiver as valid digits. To protect against errors of this type, the receiver employs a technique called "limiter guard action" (described later). However, this technique makes the receiver susceptible to the rejection of valid DTMF signals that are coincident with speech, and other techniques are required to provide protection against interference of this type. Protection against interference from coincident customer speech is provided by the design of the telephone itself, which disables the voice transmitter when a key is depressed. Protection against interference from coincident SSAS announcements is provided by isolating the DTMF receiver from these announcements through the use of four-wire terminating sets within the TDA circuit. However, since this isolation is not complete, the SSAS announcements are truncated at the earliest indication of a received DTMF signal to provide increased protection against interference from the SSAS announcements.

Figure 4 shows the SSAS DTMF receiver. The receiver incorporates an input transformer and amplifier to provide necessary impedance matching and signal gain. Input bandpass filter A shapes the incoming signal by suppressing interference at 60 Hz and its harmonics, as well as any energy above 3 kHz. When detecting the # character in the presence of audible ringing signals, busy signals, and network announcements, additional shaping is provided by input bandpass filter B which is inserted under TSPS control.

Two band-elimination filters follow the receiver input filter section. One filter rejects only frequencies in the high-group DTMF band; the other filter rejects only frequencies in the low-group DTMF band. Each band-elimination filter is then followed by a zero-crossing limiter, four channel filters, and their associated detectors. The channel filters each consist of a narrow bandpass filter centered at one of the nominal DTMF frequencies.

When a DTMF signal is introduced into the receiver, the two single-frequency components of the received signal are separated by the

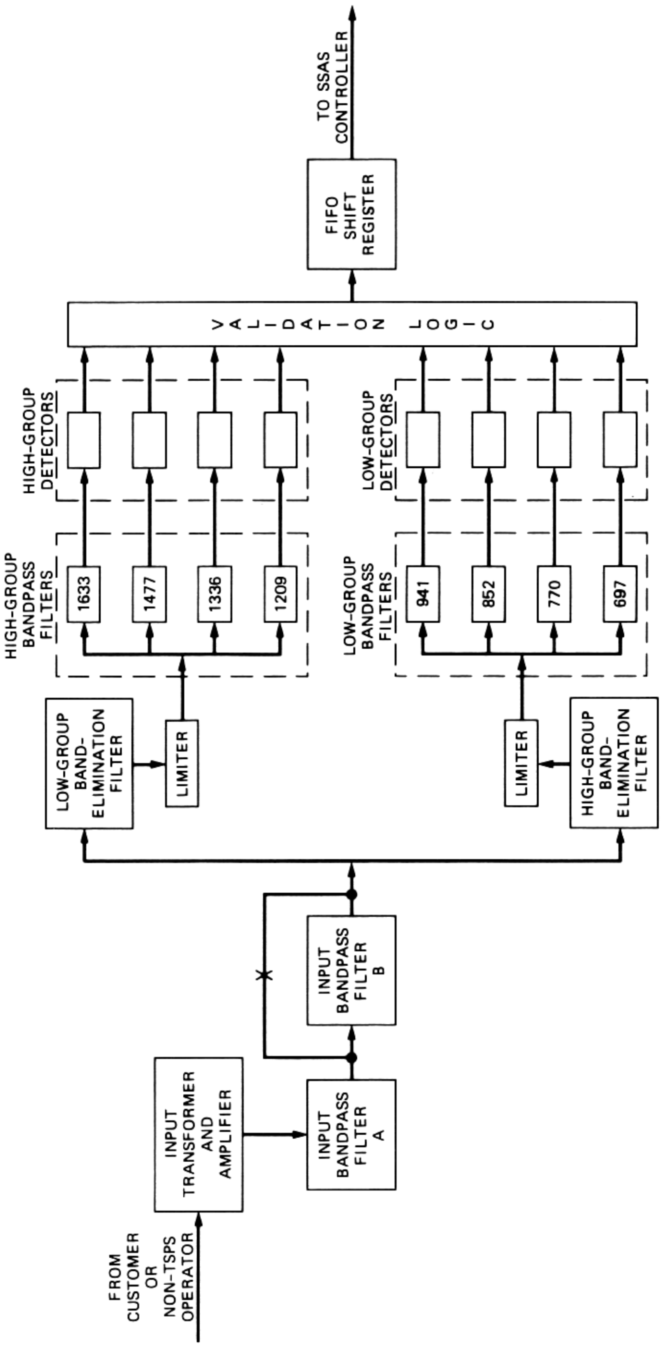

Fig. 4—Dual-tone multifrequency receiver block diagram.

band-elimination filters. If no additional interfering signals (e.g., speech) are present, each limiter will be driven by a single-frequency input signal, producing a fixed-amplitude square wave output signal of the same frequency. The fundamental frequency component of the square wave will pass through the channel filter corresponding to the specific DTMF frequency and turn on the associated detector. The detector outputs are processed by validation logic which verifies that the detected signals exceed the minimum required duration and converts the two-out-of-eight DTMF code to a binary-coded-decimal (BCD) format. The BCD information is loaded into a first-in-first-out (FIFO) shift register, which buffers the data until they are retrieved by the SSAS controller.

If the receiver is exposed to speech, the fixed-amplitude limiter output signal will be a nonperiodic waveform, rather than a periodic square wave. Any DTMF frequency components present in the limiter output signal will not contain sufficient energy to turn on the detectors and no output will be generated. This arrangement—limiter guard action—minimizes speech simulations of digits. However, as described previously, other measures are required to protect the receiver from speech energy during the reception of digits to avoid blocking valid receiver outputs.

The entire DTMF receiver is contained on four 4- by 8-inch plug-in circuit packs located in the SSAS service circuit frame.[4] Each service circuit frame can accommodate up to 16 TDA circuits, 16 MDA circuits, or any combination of the two circuit types. The SSAS service circuit frames can be arranged to provide a combined maximum of 239 CDA, TDA, and MDA circuits.

2.1.2 Multifrequency detection and announcement circuit design

The design of the MDA circuit is also similar to the CDA circuit, except for the receiver used (see Fig. 5). The MDA circuit uses a newly designed multifrequency signal receiver which performs the following functions:

(*i*) Detection of the 12 standard multifrequency signals used by non-TSPS operators to validate billing information (see Table II)

(*ii*) Protection against false operation

(*iii*) Buffering of detected multifrequency digits.

The SSAS multifrequency receiver is based on the design of existing central office multifrequency receivers, and takes advantage of modern integrated circuit and microcomputer technologies which allow it to be implemented on a single 6- by 7-inch plug-in circuit pack.

The standard arrangements used for the transmission of multifrequency signaling information minimize the potential for digit simulation and speech interference, thereby simplifying the receiver design.

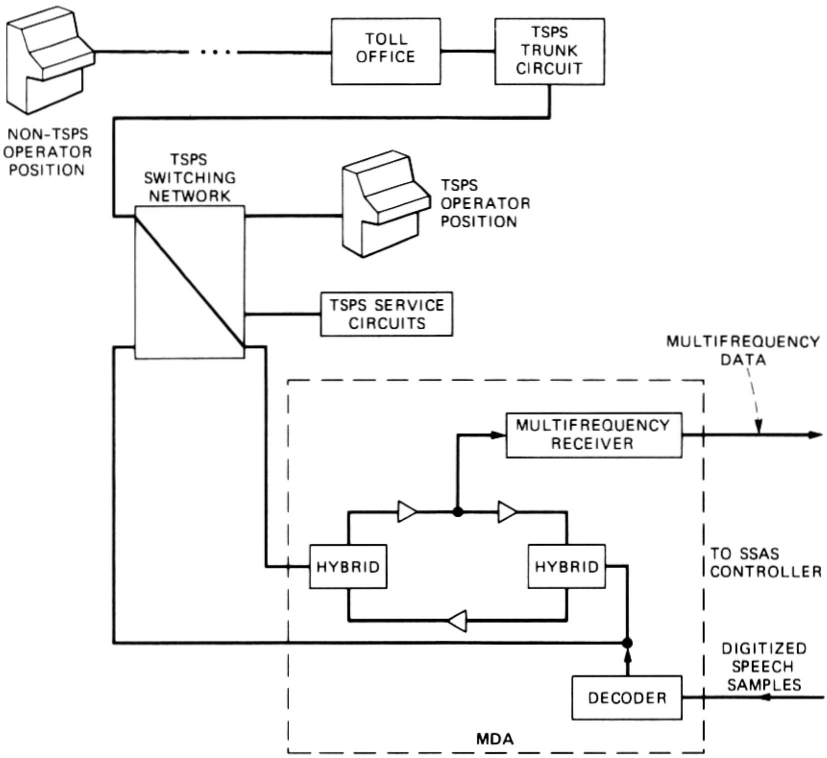

Fig. 5—Connection of SSAS MDA into TSPS.

Multifrequency signaling utilizes the KP (keypulse) and ST (start) codes to identify the beginning and end, respectively, of a multifrequency digit sequence. Depression of the KP key by a non-TSPS operator disconnects the operator's voice transmitter from the transmission

Table II—Multifrequency codes

	Frequencies in Hertz					
Code	700	900	1100	1300	1500	1700
1	×	×				
2	×		×			
3		×	×			
4	×			×		
5		×		×		
6			×	×		
7	×				×	
8		×			×	
9			×		×	
0				×	×	
KP			×			×
ST					×	×

path and provides a quiet background for the reception of multifrequency signals.

Prior to detection of the KP code, the multifrequency receiver remains in a "locked" mode in which it will only respond to the KP code; all other codes are ignored. A longer recognition time is required for the KP code than for other multifrequency codes to provide protection against false receiver operation caused by speech. Once the KP code has been detected, the receiver is switched to the "unlocked" mode in which it will respond to the remaining multifrequency codes. The detection of the ST code at the end of the digit sequence switches the receiver back to the "locked" mode.

The SSAS multifrequency receiver is depicted in Fig. 6. The input amplifier and automatic gain control (AGC) circuitry provide isolation and impedance matching for the receiver input, and provide a controlled input signal level to the channel filters. The six channel filters each consist of a narrow bandpass filter centered at one of the nominal multifrequency signaling frequencies. Each channel filter is followed by a threshold detector whose output is monitored by a microcomputer. The microcomputer provides overall control of the receiver, including timing of the received signals, code validation, mode control, and buffering of the detected multifrequency codes.

A valid multifrequency code consists of exactly two single-frequency signals. These two single-frequency components will be passed by two of the six channel filters in the receiver and trigger the associated detectors. The resulting two-out-of-six code is checked for validity by

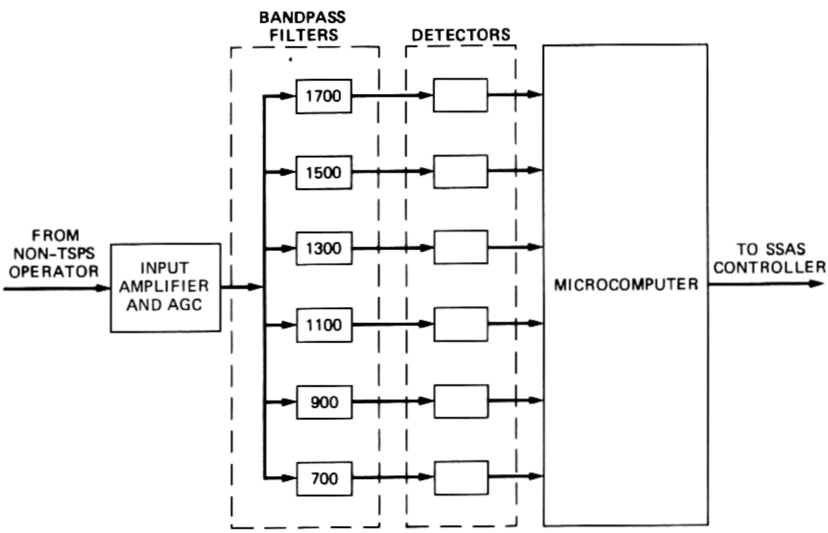

Fig. 6—Multifrequency receiver block diagram.

the microcomputer and buffered until it is retrieved by the SSAS controller.

2.1.3 Station Signaling and Announcement Subsystem program store expansion

The SSAS programmable controller, PROCON, has a basic addressing capacity of 16K program words. To accommodate the increased program requirements for Calling Card Service and subsequent features, the effective program store capacity was increased to 32K words. This was accomplished by implementing a block memory management arrangement.

Under the memory management arrangement, the 16K addressing range of PROCON is divided into a permanently active block of 12K words and a "paged" block of 4K words (see Fig. 7). Four additional 4K blocks of physical memory are provided and are paged into the 12 to 16K address range as required. Newly designed SSAS circuitry selects which one of the five 4K paged blocks is active, under control of a hardware register loaded by PROCON. This register is loaded by PROCON instructions located in the base 12K memory block. The hardware implementation ensures that one and only one 4K paged block is

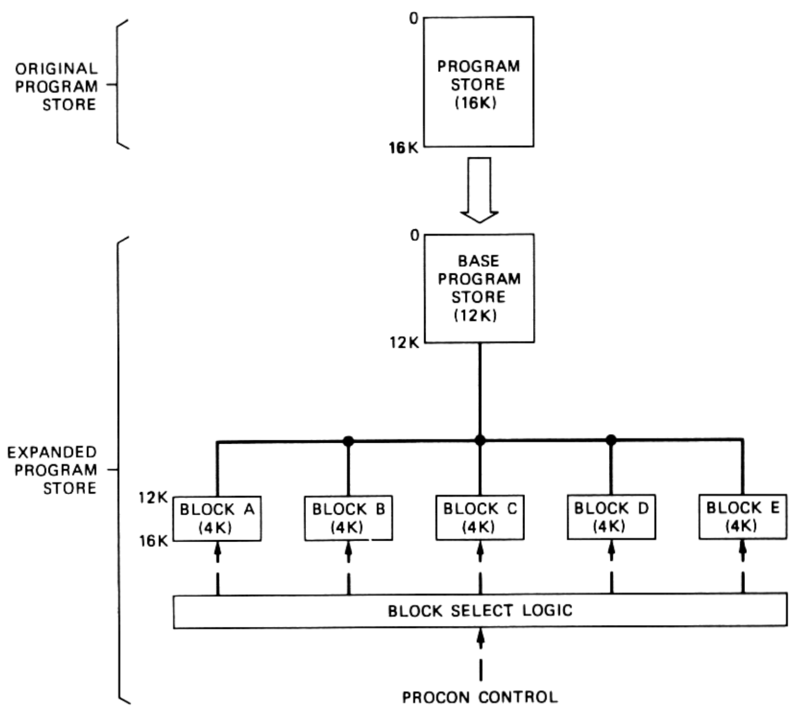

Fig. 7—Station Signaling and Announcement Subsystem program store expansion.

active at a time, and a software check is performed to verify that the correct block has been selected.

2.1.4 Station Signaling and Announcement Subsystem vocabulary expansion

The SSAS announcement store can be equipped with a maximum of six memory modules, each accommodating 80 half-second phrases, to yield a total vocabulary of 480 phrases. The implementation of ACTS required only 95 phrases, located in two memory modules. These phrases contained the speech segments used to generate announcements, as well as test tones and timing data used to perform automatic self-testing.

To provide the additional announcement vocabulary required for Calling Card Service, plus the test tones needed for the TDA and MDA circuits, the SSAS announcement store was equipped with one additional memory module. The necessary speech segments were recorded by a professional announcer, digitally encoded, and then edited to produce natural-sounding announcements. The test tones were recorded using laboratory signal generators.

2.2 Common-channel interoffice signaling hardware organization

The TSPS utilizes CCIS/DS to query BVA data bases and interconnects to the CCIS network via A-links to mate signal transfer points (STPS) in the same switching region.[5] Early in the development of CCIS/DS capabilities for the TSPS, it was recognized that CCIS equipment originally developed for the STP and No. 4A/CCIS systems could be utilized by TSPS to interconnect to the SPC network.[5,6] This is possible since both the STP and No. 4A/CCIS systems use SPC 1A processors, the same processor used by TSPS. Also, much of the maintenance software developed for those systems is adaptable to the TSPS application. The use of No. 4A/CCIS hardware and maintenance software provides an SPC network interface nearly identical to that of No. 4A/CCIS. However, even though the TSPS utilizes No. 4A/CCIS equipment, it does not perform CCIS call setup functions; instead, it utilizes only the direct-signaling capabilities of the CCIS network to communicate with BVA data bases on the SPC network. Figure 8 shows the TSPS interface to the CCIS network.

2.2.1 Signaling links

The A-link between the TSPS and the STP consists of a terminal unit at each end of a voice frequency link (VFL).[5] The VFLS are duplicated for reliability; one is normally in service, while the other VFL provides a switched backup. Because direct-signaling messages are not logically associated with individual signaling links, the TSPS distributes its

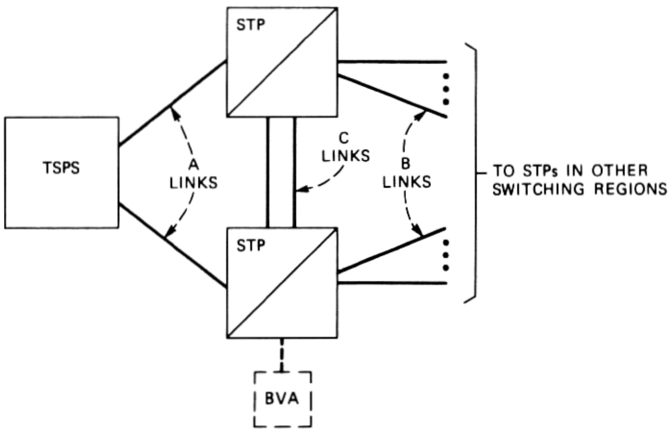

Fig. 8—Traffic Service Position System—CCIS network interface.

direct-signaling messages evenly over all in-service signaling links. When a signaling link is removed from service, because of a fault or manual action, the direct-signaling messages are distributed evenly over the remaining links. In this way, the in-service links constitute a common pool of signaling links available for direct-signaling messages. The TSPS may be equipped with a maximum of 16 A-links.

2.2.2 Common-channel interoffice signaling functional units

Figure 9 is a functional block diagram of the CCIS equipment configuration for TSPS. For simplicity, duplication of buses and controllers is not shown. For an explanation of the No. 4A/CCIS configuration see Refs. 5 and 6. The circuits added for TSPS/CCIS are the CCIS terminal group frame and the VFL access circuit. Modification of the TSPS office was required to interconnect the new circuits to the TSPS peripheral bus and to TSPS peripheral circuits.

2.2.2.1 Terminal group frame. The terminal group frame contains the signaling terminal units and data modems for up to 16 signaling links, as well as duplicated terminal access circuits (TACs) for processor communication with each terminal unit. The TSPS can be equipped with one terminal group frame.

The terminal unit is a special-purpose stored program processor which maintains data communication over the signaling link. Synchronization, error detection, and retransmission of signal units received in error are all handled by the terminal unit, independent of the TSPS processor.

The modem is the interface between the terminal and the VFL. One modem is associated with each terminal. The modem has two VFL ports which are used to switch between mate VFLs under TSPS processor

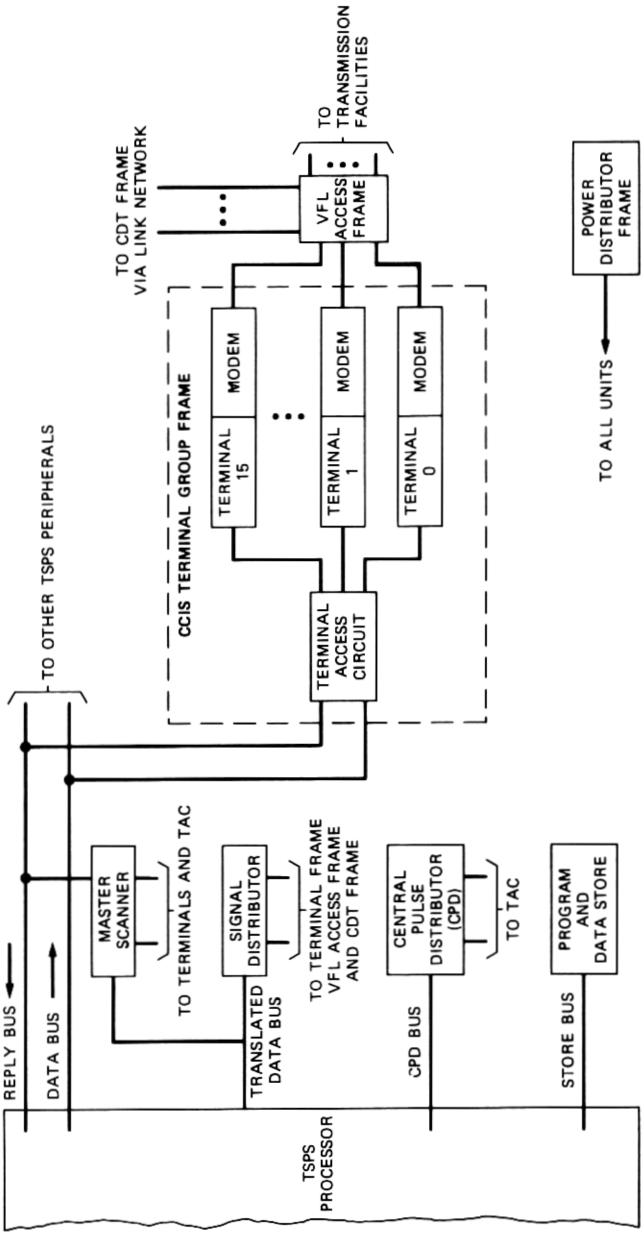

Fig. 9—Block diagram of TSPS/CCIS equipment.

control. One terminal-modem unit is associated with each signaling link. Backup capability for terminals is provided by requiring that signaling links be provided in pairs: one to the STP and one to its mate.

The fully duplicated TACs provide redundant and independent access for each terminal unit via the TSPS peripheral buses. The TAC has no autonomous functions and only one TAC is active at a given time. The TSPS processor periodically polls the TAC to determine which terminal units, if any, contain waiting signal units.

Modification of the TSPS office was required to interface the terminal group frame to the TSPS peripheral bus. Even though both No. 4A/CCIS and TSPS use SPC 1A processors, the two systems utilize different peripheral bus structures. Because of this, the TSPS peripheral buses were modified to provide the processor signals and bus lengths necessary to control the frame.

2.2.2.2 VFL access circuits. The VFL access circuits connect the terminal units to the signaling facilities to provide VFL test access. In addition, the VFL access circuits contain adjustable transmission pads which provide the proper transmission levels at the modem and test points.

2.3 Other TSPS hardware changes

Changes were made to other TSPS circuits to implement an expanded inband signaling interface with the local office and provide necessary maintenance functions.

As described in Section IV, expanded inband signaling uses six multifrequency codes to control a variety of local office functions, including activation of coin telephone DTMF dials. Expanded inband signaling is based on an earlier multifrequency signaling system which used three multifrequency codes. The multifrequency signals are applied by a TSPS service circuit called the coin control and ringback (CCR) circuit. Under control of the TSPS processor, the CCR circuit is connected to the incoming trunk from the local office via the TSPS switching network. Multifrequency tones are supplied to the CCR circuit by a common signal source. Timers and program-controlled relays within the CCR circuit then apply the appropriate controlled-duration tones toward the local office.

To provide the three additional codes and new timing parameters required for expanded inband signaling, the CCR circuits were modified by incorporating additional program-controlled relays and timing circuitry. The modified CCR circuits are bimodal and can be used to provide both expanded inband signaling and the earlier multifrequency signaling interface with the local office. The CCR circuits are automatically diagnosed using an existing multifrequency test circuit and new TSPS maintenance software. In addition, the control, display, and test

(CDT) frame and the test and display circuit (TDC), which are used to perform trunk maintenance tests, were equipped with three new keys.[7,8] The three keys control application of the additional multifrequency signals and can be used by the craftsperson during manual trunk tests.

Other modifications to the CDT frame were also required. One of these was the addition of indicator lamps to the CDT status panel. These lamps summarize the in-service/out-of-service status of the CCIS, TDA, and MDA circuits consistent with the status indications provided for other TSPS peripheral circuits.

The CDT frame and its associated TSPS processor software were also modified to permit manual transmission testing of the CCIS VFLs. Under control of the TSPS processor, each VFL can be connected to the CDT frame via the TSPS switching network. The CDT frame modifications were required to permit both transmit and receive paths of the VFL to be simultaneously connected to transmission measuring equipment located within the frame. Two-person manual transmission testing of the VFLs can then be performed as required between the CDT frame and the CCIS STP office.

III. PROGRAM IMPLEMENTATION

New software was developed to provide maintenance of SSAS enhancements and other new TSPS hardware arrangements, and to provide TSPS processing of automated and operator-assisted calling card calls and BNS calls. Additional software provides CCIS/DS capability.

3.1 Maintenance programs

3.1.1 Expanded SSAS PROCON memory

Paging a 4K memory block is done via a memory-block select register in PROCON. Since there is overhead required to select a block, paging must be kept to a minimum. To cut down overhead, a new software structure was designed to allow for efficient and simple growth of new features. The active and standby monitor programs, the scheduler, and operational programs for features developed prior to Generic 1T10, reside in the base 12K words of PROCON program store. All new 1T10 feature PROCON programs reside in memory blocks A and B. Future feature programs will be assigned to memory blocks C, D, and E as required.

Diagnostics of the block-memory select circuits are provided as a part of the SSAS controller diagnostics currently resident in the TSPS and SSAS processors. The block-memory select diagnostics generate test patterns which cause multiple memory blocks to be selected. The block-memory select circuit also has an odd parity checker which reports multiblock select errors.

Since all block-memory management circuitry is on one circuit pack, fault resolution capability is optimized. Only a few typical circuit-interface-type faults may involve two or more circuit packs in the controller.

3.1.2 Tone detection and announcement and MDA circuit diagnostics

The system configuration for testing MDA and TDA circuits is shown in Fig. 10. The CDA test circuit which was originally designed to test CDA circuits is also used to provide diagnostic test access to analog portions of the TDA and MDA circuits.[9] Transmission paths are set up by the TSPS processor, and the CDA test circuit generates and detects the required analog test signals. Additional tests are performed on the digital portions of the TDA and MDA circuits by way of their interface with the SSAS controller.

Actual tests are run by the standby SSAS. The standby SSAS receives commands from the TSPS processor, performs the tests, and returns the results to the TSPS processor.

There are 22 test phases for testing the MDA circuit and 21 test phases for the TDA circuit. Tests one through eight are the same as the

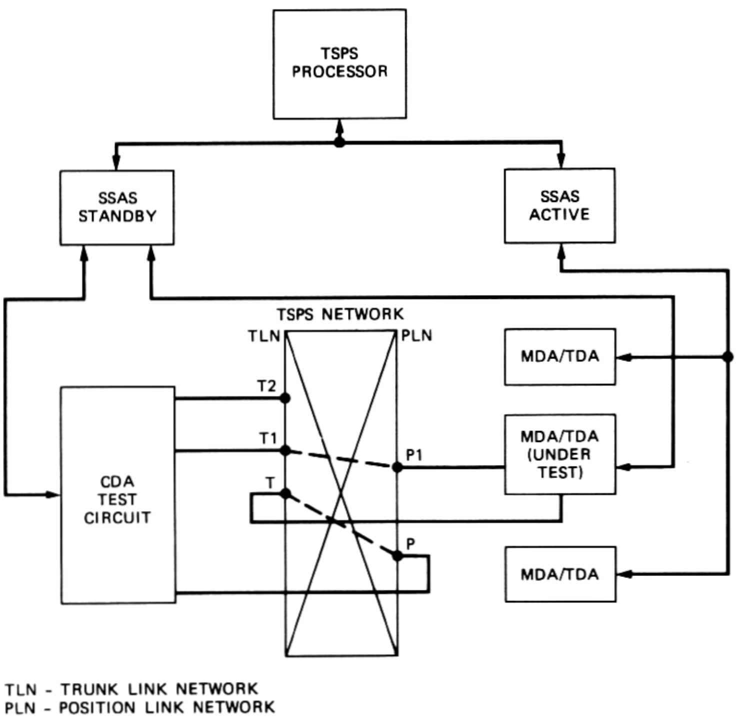

Fig. 10—Basic MDA/TDA test configuration.

original tests designed for the CDA circuit and they verify the digital and analog circuitry, as well as dc and ac transmission through the TSPS network. Phases 9 through 21 verify the proper operation of the receiver itself. These later phases check the receiver's ability to detect nominal input signals (i.e., nominal frequency, duration, and level). The phases also verify the receiver's response to various combinations of in-tolerance and out-of-tolerance signals. Phase 22 tests the MDA receiver's ability to automatically return to the "locked" mode if an ST signal is not received after a 35-second delay.

3.1.3 Common-channel interoffice signaling maintenance software

The TSPS maintenance software for CCIS is adapted from No. 4A/CCIS maintenance programs and provides the same diagnostic and fault-recognition functions. The design goal was to make the maintenance of No. 4A/CCIS and TSPS/CCIS similar to expedite craft training and to permit sharing of craft expertise between systems. Maintenance for No. 4A/CCIS is described in Refs. 5 and 6.

3.1.3.1 Terminal group frame maintenance. The CCIS TAC and terminal hardware contain extensive self-checking circuitry. The terminal is a stored program unit with a self-test exercise program which runs continuously, interleaved with signal unit processing. Routine exercises are run on the TAC and terminal automatically on a daily basis to detect nonservice-affecting faults.

Faults detected in a TAC or terminal unit will cause a processor interrupt when the unit is next accessed by the processor. This causes the terminal fault-recognition program to be entered. This program determines which unit is faulty and then reconfigures the system to isolate the faulty unit. The faulty unit is removed from service and scheduled for diagnosis. Whenever a terminal is removed from service, the signaling network must be reconfigured to use the mate signaling link.

Faults which cause an excessive signaling link error rate lasting longer than 3 minutes will cause the link security program to request diagnostics on the suspected terminal unit. If the subsequent diagnostics at the TSPS and STP find no trouble, a VFL trouble is assumed.

3.1.3.2 Diagnostic Programs. Diagnostics and Trouble Locating Manuals (TLMS) developed for No. 4A/CCIS are used by TSPS. They provide TSPS craftspeople with the location of suspected faulty circuit packs in the TAC and terminal units. The results of a diagnostic are printed on the TSPS maintenance teletypewriter in the form of a trouble number. The TLM for each unit type associates the trouble number with one or more suspected faulty circuit packs. The terminal diagnostic includes a complete test of the modem and its interface to the VFL access circuit. Diagnostics for the TAC and terminal units are invoked automatically by fault-recognition and automatic exercise programs, or manually by TSPS craftspeople via the maintenance teletypewriter.

3.1.3.3 Signaling link security. Link security programs monitor the integrity of working signaling links, invoke link recovery procedures on faulty links, and provide maintenance access for TSPS craftspeople.[5] Link security programs respond to signaling link messages received from the STP, internal fault recognition, manual inputs from the maintenance teletypewriter, and frame key actions.

Terminal units check each signal unit received and detect unacceptably high error rates. The terminal notifies the processor if the link is not suitable to carry traffic. Link security programs initiate a changeover procedure which removes all direct-signaling traffic from the link and attempts to synchronize the link on the standby VFL. When the signaling link is resynchronized, the TSPS and STP processors measure the error rate to determine if direct-signaling traffic can resume. After a sufficient prove-in period, the TSPS and STP exchange load transfer and load transfer acknowledgment signals, which causes traffic to be returned to the signaling link.

3.1.3.4 Voice frequency link testing capability. The error performance of signaling links is continuously measured by the terminal units at each end concurrent with normal service. The standby VFL may be tested with a special maintenance terminal at the STP. The test requires the TSPS to loop back the standby VFL via the VFL access circuit. When the link is active, the TSPS and STP can exchange signals to schedule a standby VFL test. The STP maintenance terminal measures the error rate on the looped-back standby VFL and signals the TSPS of the pass/fail results. This test may be requested manually from either end, and is scheduled automatically by the STP several minutes after a signaling link failure to determine if the VFL should be reported to maintenance personnel.

The TSPS provides manual test access to VFLs through the CDT. Under control of the TSPS processor, the VFL test port of the VFL access circuit is connected to the CDT through the TSPS switching network. Connection of VFLs to the CDT is requested by teletypewriter message or by key action at the CDT itself. Figure 11 shows the TSPS VFL access circuit arrangement. No. 4A/CCIS and STP use dedicated VFL test positions for manual VFL testing.

3.1.3.5 Signaling link measurement. Signaling link measurements are accumulated by the terminal program and the TSPS processor. The terminal program maintains counts on a short-term basis. Every 5 minutes a TSPS program retrieves these counts from the terminal and administers the long-term accumulation of those data. Other counts are maintained directly by the TSPS processor.

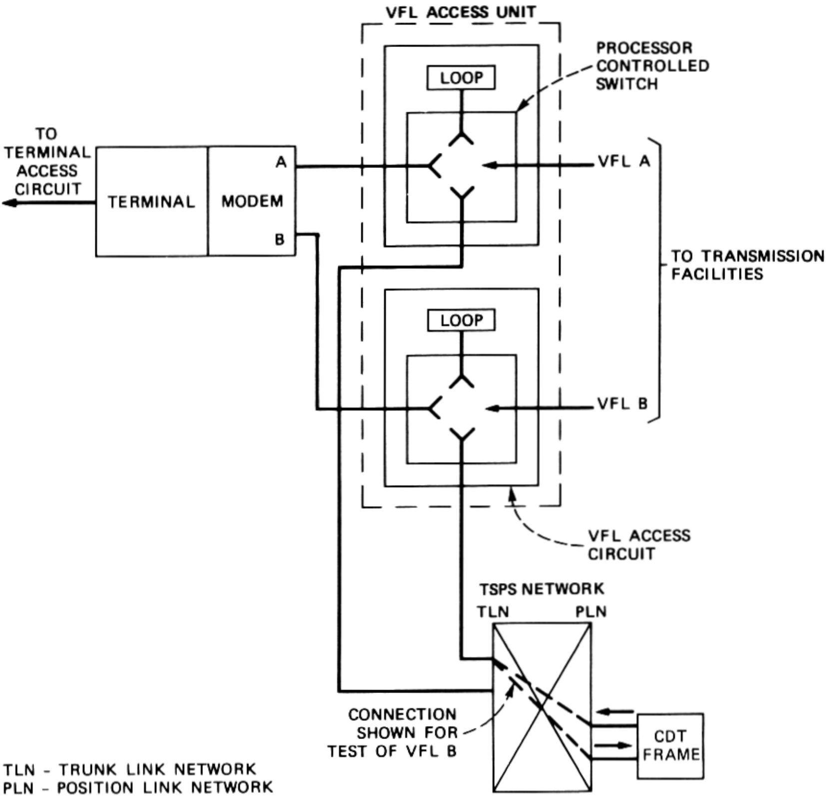

Fig. 11—Voice frequency link access circuit arrangement.

A daily summary report and a 30-minute exception report are printed on the TSPS maintenance teletypewriter for use by maintenance personnel. The daily report provides maintenance data for all signaling links on a 24-hour basis and may be printed on demand. The exception report is triggered whenever the value of a key measurement reaches a threshold value within a specific period of time. Exception reports alert maintenance personnel to possible deteriorating signaling link conditions that may warrant investigation.

3.2 Calling Card Service and BNS operational software

Calling Card Service and BNS are provided by adding new software to the TSPS processor and new firmware to the SSAS. The SSAS programmable controller, PROCON, uses read-only memory (ROM) for program and random-access memory (RAM) for transient data. Communication between the TSPS processor and for SSAS is effected over the TSPS data and reply buses (see Fig. 1).

3.2.1 Calling card number

A calling card number consists of a 10-digit billing number, plus a four-digit personal identification number (PIN). The billing number may be the directory number to which the call is billed, and is of the form:

$$NPA\text{-}NXX\text{-}XXXX.$$

Alternatively, the billing number may be a special number of the form:

$$RAO\text{-}(0/1)XX\text{-}XXXX,$$

where RAO is the Revenue Accounting Office which assigned this billing number. The fourth digit (0/1) indicates that the number is a special billing number.

The PIN is any four digits ($YYYY$) and can be designated as "restricted" or "unrestricted." Basic Calling Card Service requires an unrestricted PIN and is valid for calls to all destinations and for station or person calling. If the called number is the billing number, the calling customer need only enter the four-digit PIN. Only an unrestricted PIN may be associated with a special billing number.

A restricted PIN is used to bill station-to-station calls placed to a directory number which is the same as the billing number.

3.2.2 Customer-dialed calling card call

3.2.2.1 Service access treatment. Customers initiate calling card calls by dialing 0, plus the called number. This information, plus the calling number, is outpulsed to the TSPS by the local office. The TSPS applies OST to the call to determine the treatment the customer should receive, based on the characteristics of the originating station. Depending on OST, the customer may be routed directly to an operator, may receive an alerting tone, or may receive an alerting tone, plus an announcement, "Please dial your card number or zero for an operator now."

After the TSPS receives the called and calling number and the calling party has received OST for customer-dialed service, the TSPS processor connects a TDA circuit through the TSPS network to the local office and sends a message to the SSAS to process this call. The SSAS returns an alerting tone (or an alerting tone followed by an announcement) to the customer by utilizing an encoded tone and announcement in the announcement stores and the decoding circuits in the TDA circuit assigned to this call. The customer then has 1 second in which to begin dialing a calling card number or take action to get an operator. An operator is obtained by dialing 0, 0#, or by flashing the switchhook. Customer dialing during the announcement truncates the announcement. If no action is taken, the customer is given the announcement "Please dial your card number or zero for an operator now." The customer is given an additional 5 seconds to begin dialing or take action to get an operator. If no action takes place after 5 seconds, the call is brought to an operator.

There are four possible dialing sequences for a customer-dialed calling card call. They are:

$$NPA\ NXX\ XXXX\ YYYY,$$

$$RAO\ (0/1)XX\ XXXX\ YYYY,$$

$$YYYY,$$

$$YYYY\#,$$

where $YYYY$ is a 4-digit PIN and # is the optional end-of-dialing indicator.

If the customer wishes to dial billing information, either the 14-digit calling card number or four-digit PIN is dialed. The digits dialed by the customer are processed and checked by the SSAS.

A number of timing sequences are performed by the SSAS to interpret the dialed information. If no digits are dialed within 2.5 seconds after the initial 0, then it is assumed that no further dialing will take place and the call is connected to an operator. Two-second timing is initiated after the first four digits to check if a PIN only was dialed. If time-out occurs after four digits, validation is initiated. If a customer dials another digit (other than a #) within the next 3 seconds, the validation is terminated, and it is assumed that the customer intends to dial 14 digits. If no additional digits are received within 3 seconds and the PIN is determined to be invalid, an interdigit time-out is assumed.

After digit reception is complete, the SSAS sends the digits to the TSPS processor through the SSAS output FIFO buffer. If the customer has only dialed a four-digit PIN, TSPS forms the calling card number by prefixing the called number.

3.2.2.2 Service exit treatment. After the number has been received, TSPS performs a format check. If the customer only dialed a PIN, the called number is rejected if it is an INWATS, directory assistance, or an overseas number. After fraud checks, TSPS interrogates the BVA. If the billing information is accepted, the TSPS processor instructs the SSAS to return the "Thank You" announcement and outpulses the call.

If the billing number is rejected, a failure count is incremented. If the failure threshold is reached, SSAS gives the announcement, "Please hang up and dial zero plus the number you are calling. The card number you have dialed is not valid," and the call is ended.

If the threshold is not reached, the customer is given the announcement "Please dial your card number again now. The card number you have dialed is not valid." If no dialing has occurred within 3 seconds after the announcement, an alerting tone is returned to the customer.

The customer now has 3 more seconds to dial. If no dialing occurs after 3 seconds, the customer is given the announcement "Please dial your card number." If the customer does not dial after 5 more seconds, SSAS gives the announcement, "Please hang up and dial zero plus the number you are calling," and the call is ended.

3.2.2.3 Failures and restarts.

Hardware errors or failures—Hardware errors are detected by routine error-detection programs or fault-recognition programs. One example of such a hardware error is the inability of a TDA circuit to detect digits properly. If a hardware error occurs before a customer starts dialing, the call is routed to an operator. If the error occurs after dialing starts but before validation, the customer is given reorder. If the error occurs after validation, and the call is outpulsing, the call is treated normally, with the exception that "Thank You" may not be announced.

Customer flashes—If a customer flashes after dialing the called number, but before the alerting tone, the flash is treated as a disconnect. A flash after the alerting tone, but before dialing any calling card digits during an initial seizure, or after an initial 0 is dialed, results in the call going to an operator. Flashes are ignored from the time a customer starts dialing calling card digits to before outpulsing begins. If a flash occurs during outpulsing, the call is ended.

3.2.3 Customer-dialed calling card sequence call

3.2.3.1 Service access treatment. A calling card customer may initiate a sequence call by remaining off-hook and depressing the # key prior to called customer answer or after the called party goes on-hook. The calling customer has approximately 11 seconds after the called party disconnects to request the sequence call. After the # character is received, the forward connection is released.

When a sequence call begins, the SSAS gives the customer the announcement "You may dial another call now." The customer has 10 seconds after the announcement to start dialing. Customer dialing during the announcement truncates the announcement.

3.2.3.2 Service exit treatment. If the new called number is valid, "Thank You" is announced and the call is outpulsed. The use of the "Thank You" announcement is optional—it may either be provided or not. If the number is invalid, an error count is incremented. The number of errors allowed for dialing a new number is a changeable parameter.

If the number of attempts to redial a new number exceeds the allowable threshold, the announcement, "Please hang up and dial zero plus the number you are calling," is given and the call ended. If the threshold has not been reached, the announcement, "Please dial the number you are calling again now. The number you have dialed is not correct," is given. This allows the customer to redial the new called number. If the customer does not start dialing within 5 seconds, the announcement is repeated.

3.2.3.3 *Failures and restarts.*

Effects of customer dialing a number sign (#) character—The # character has the following implications for a sequence call:

(*i*) Receipt of a # from the calling customer after outpulsing, but before answer or after answer while the called party is on-hook, is interpreted as a sequence call request.

(*ii*) If seven or ten digits are dialed (or at least the minimum number of digits expected on an international call) followed by a #, the received digits are treated as the called number, i.e., # acts as delimiter, and are validated.

When the system is expecting seven or ten digits, the new number is validated immediately after the seventh or tenth digit is received. During outpulsing of a valid number, the number sign is ignored. After outpulsing is complete, a number sign initiates a new sequence call.

(*iii*) If a number sign is dialed after other than seven or ten digits (or before the minimum number of digits required on an international call), the number is considered invalid and the error announcement for a rejected called number is given.

(*iv*) If a customer dials multiple number signs in a row, only the first number sign is recognized.

(*v*) If the number sign is dialed during the announcements, "You may dial another number now." "Please dial the number you are calling again now. The number you have dialed is not correct," or, "Please dial the number you are calling," the announcements are aborted. The number sign is ignored if received during the announcements: "Please hang up and dial zero plus the number you are calling. The number you have dialed is not correct;" "Please hang up and dial zero plus the number you are calling;" or "Please hang up and dial direct. This number cannot be dialed as a sequence call."

Asterisk (*) or invalid DTMF signals—An asterisk (*) or an invalid DTMF signal is ignored and does not invalidate the digit sequence nor does it reset the interdigit time-out interval. If an insufficient number of digits are received, a time-out will occur.

Calling customer disconnect or flash—If a calling customer disconnects or flashes during a sequence call attempt, a billing record of the previous call is made if it has not already been done, and the call is ended. Customer-dialed calling card calls do not have flash privileges.

3.2.4 Operator-assisted calling card calls

A 0+ call is brought to an operator position when one of the following conditions occurs:

(*i*) The TSPS does not receive automatic number identification (ANI) digits from the local office. This may occur because the local office is not equipped to send the digits or because there was a failure.

(*ii*) The calling customer is dialing from a station from which calling card calls are not permitted.

(*iii*) The OST information indicates that the call should receive operator handling.

(*iv*) The caller does not want to enter a calling card number. This may occur because another form of billing is desired or because person service is required. In this case, the calling customer flashes, dials 0, or times out after hearing the tone or announcement.

3.2.4.1 Operator-assisted calls dialed 0+. When the call is brought to a position, the customer quotes billing information to the operator (calling card number or PIN only). The operator enters the number into the system as given. The operator receives validation information via lamps and displays, then relays this information to the customer (see Fig. 12). The operator may reenter the number in case of errors. When the billing information is valid, the call is automatically outpulsed and the operator may release the call.

If OST indicates that customer-dialed Calling Card Service is available on the originating line, a display, 999, is given to the operator. This display tells the operator to give dialing instructions to the customer if calling card billing is requested.

3.2.4.2 Operator key actions

Proper calling card class of charge—The proper class of charge for an operator-assisted calling card call is either STATION SPECIAL CALLING (STATION SPL CLG) or PERSON SPECIAL CALLING (PERSON SPL CLG). The latter requires an operator to handle the call to determine that the proper called party was reached. The class of charge is entered by the operator before or after the calling card number or PIN is keyed.

Keying sequence for calling card number or PIN—An operator enters a calling card number or a PIN by depressing the KP SPL key, plus the digits, and then the START (ST) key. If incorrect digits are keyed, the KP SPL key flashes.

The PIN is rejected if the called number is an overseas, INWATS, or directory-assistance number. In addition, it cannot be inward numbers which are used by operators. If the check fails, the PIN is rejected, the program displays the incorrect number, and flashes the KP SPL lamp at the position. If the format check passes, the billing number is checked against the BVA.

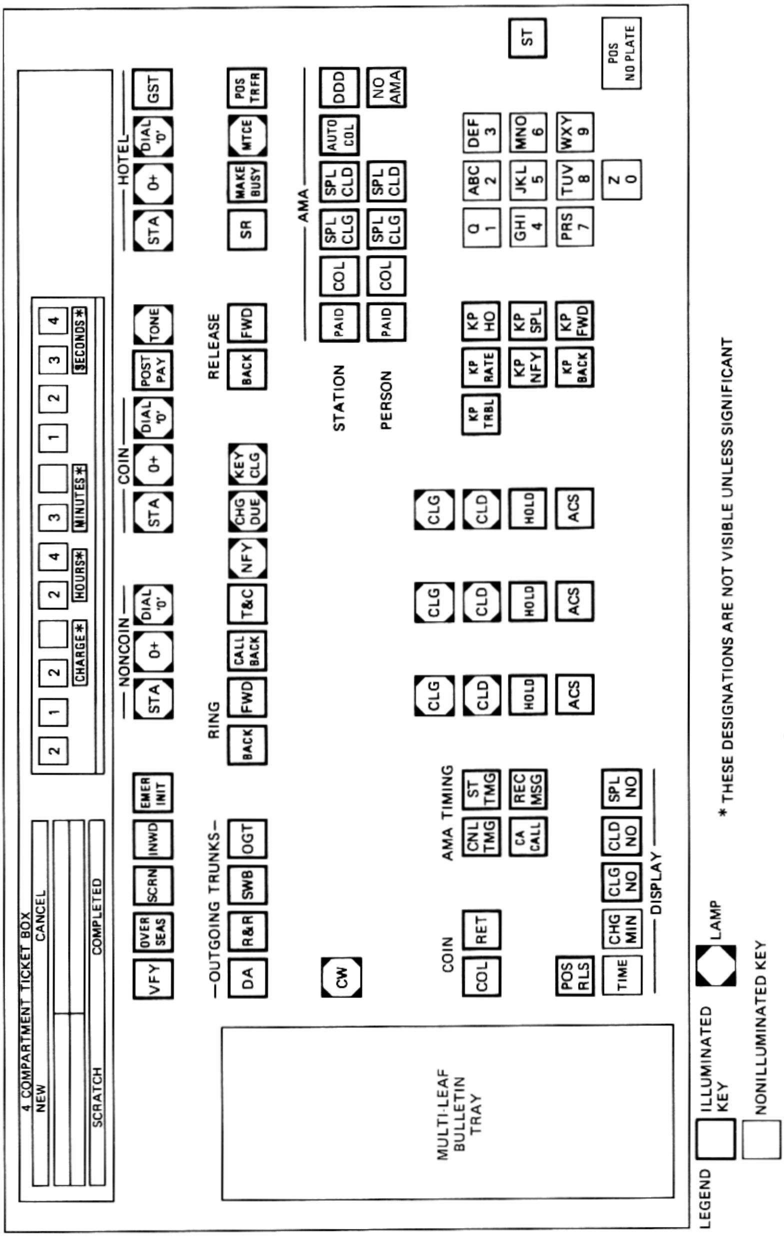

Fig. 12—Traffic Service Position System operator position.

Key actions during BVA query—Only certain key actions are allowed by an operator while a BVA validation of the PIN versus billing number is in progress. The following key actions are acceptable during a query:

(*i*) Display keys: Calling Number (CLG NO) Called Number (CLD NO), Special Number (SPL NO).

(*ii*) Appropriate class of charge keys: PERSON SPL CLG; PERSON SPL CLD, or STATION SPL CLD; DDD; NO AMA (for inward validation only); STATION or PERSON COLLECT.

(*iii*) Miscellaneous keys: Time and charge (T&C), MAKE BUSY, Cancel Call (CA CALL) (in initial period access), Position Release (POS RLS) (in interim access only). The actions CA CALL and POS RLS abort the BVA query and allow the operator to terminate the call attempt.

If the BVA query indicates that the calling card number is not accepted, the failing number is displayed and KP SPL is flashed. The operator may rekey the call. If the number is accepted, the KP SPL lamp is extinguished and outpulsing proceeds. After outpulsing is complete, the operator depresses the START TIMING and POS RLS according to local operator practices.

3.2.4.3 Display of the calling card number

Display of a rejected calling card number—When a BVA validation fails, the billing information keyed by the operator is displayed automatically. Since the 14 digits of a calling card number are more than can be displayed on the console, the display is broken into two pieces:

(*i*) 312 690 5441 (billing number)

(*ii*) 1234 (PIN).

When the number is rejected, TSPS displays the billing number immediately. The operator may then depress the DISPLAY SPECIAL NUMBER key to display the PIN. A second depression darkens the display.

If the operator entered the PIN only, a rejection results in the display of the PIN only. The operator knows that the called number is the billing number.

Display of an accepted calling card number—Once billing information is accepted the calling card number is still available for display to the operator. The first display is the same as in (*i*) above. The second portion of the display contains the RAO returned from the BVA and the PIN. Hence, if a PIN only was entered, the display is:

091	1234
(RAO)	(PIN)

3.2.4.4 Automatic number identification failures or ONI calls

Calls dialed 0+ with operator number identification (ONI) or ANI failures (ANIF) cannot be customer dialed. These calls are routed directly to an operator.

The position display is the same as a 0+ call with the addition of the KEY CALLING lamp lit steady (ONI) or flashing (ANIF). The operator actions are the same as before with the addition of keying a calling number.

3.2.4.5 Operator-assisted calling card, non-0+ type calls

Hotel, 1+ coin—A customer does not have to dial 0+ to bill a call to a calling card number. A coin customer may dial 1+, but after listening to an announcement, may decide to bill the call differently. The customer may flash or time out to access an operator. The operator may change the class of charge from STATION PAID to STATION or PERSON SPL CLG. This drops the charge and minutes display and the operator proceeds as previously described.

Incoming 1+ hotel seizures are brought to the position as STATION PAID, waiting for the hotel room number. The operator may change the call to a calling card call as described in the case of the 1+ coin call. The operator proceeds in the same way.

Non-coin, 0– coin, or hotel—A 0– customer may wish to place a calling card call. If the operator keys a 14-digit calling card number before keying the called number, validation is attempted immediately. If the number is rejected, KP SPL is flashed and the number is displayed. If the number is accepted, KP SPL is extinguished. The operator then asks the customer for the called number and keys it. Outpulsing occurs when the operator depresses the START key.

If a PIN only is keyed, BVA validation cannot start until the called number is keyed by the operator. If before this is done, the operator depresses the DISPLAY SPECIAL NUMBER key, the four-digit PIN is displayed. The call proceeds as described on 1+ coin calls.

Special called class of service—A call of any kind which starts out as a collect call, can be changed to a calling card call. This can occur at the called customer's request. The operator depresses STATION or PERSON SPL CLD as the class of charge and keys in the billing information. Acceptance or rejection of the billing information is the same as described for 0+ calls, which have a SPL CLG class of charge. Only an unrestricted PIN can be used to accept person collect calls.

3.2.5 Operator-assisted sequence calls

Conditions leading to an operator recall—A customer may recall an operator by flashing during a call which is in a talking state, provided that the call has flash privileges. Operator-assisted calling card calls are in the class of calls with flash privileges.

Service Descriptions—When a customer requests that an operator place a sequence call, the operator first terminates the current call by depressing the Record Message (REC MSG) key, which causes a billing record of the current call and allows a subsequent call to be made. The operator then keys the new called number and class of charge. On calling card calls where the class of charge is STATION or PERSON SPL billing, and the PIN is unrestricted, the operator does not have to enter the calling card number if the same type of billing is desired on the second call.

Operator key action: REC MSG *key*—Prior to Calling Card Service, depression of the REC MSG key terminated the current conversation, released the forward connection, and made an AMA record of the call. Records of the called number were erased and the class of charge lamp was extinguished. The calling party's calling card, third number, or hotel room was retained.

With the introduction of Calling Card Service, the special number information is retained if the class of charge on the first call was STATION or PERSON SPL CLG and the call was billed to a number with an unrestricted PIN, to a 10-digit special billing number, or to a third party. This frees the operator from rekeying a validated number on sequence calls.

However, if the call was placed with a restricted PIN, the class of charge and billing number are deleted, and the operator must enter a new billing number or charge the call another way. If the class of charge was STATION or PERSON SPL CLD, the class of charge is deleted and the billing number is also deleted, regardless of the type of PIN. This is because the billing number was specified by the called customer, and it is presumed that the new sequence call has a different called party.

Operator key action: Key forward new called number—Once the REC MSG key is lit, the operator must key in a new called number. The operator does this by depressing the KP FWD key, keying in the new number, and then depressing the ST key. If the billing number has not been deleted, the called number is outpulsed. After depressing STATION or PERSON SPL CLG, the operator depresses the Start Timing (ST TMG) key and the POS RLS key, according to usual practices.

Operator key action: New class of charge—If a customer does not wish to place another calling card call, but prefers to bill the call another way, the operator depresses the other class of charge key and handles the call according to usual practices. In the cases where the billing information was deleted, the operator is required to enter new class of charge information before the call can proceed.

3.2.6 Inward validation

Non-TSPS operators must dial one of three inward codes to gain access to the TSPS to perform calling card validation. The validation can occur on an automated basis if the operator has a DTMF or multifrequency dial available. Otherwise, inward validation will be done on an operator-assisted basis.

3.2.6.1 Operator-assisted inward validation. For operator-assisted validation requests, TSPS connects the call to a TSPS operator. After the non-TSPS operator informs the TSPS operator that a validation is requested, the TSPS operator depresses the KP SPL key and enters the number. In all cases, 14 digits are entered. If the customer only specified a PIN, the non-TSPS operator gives the called number to the TSPS operator for use as the billing number.

After keying in 14 digits, the TSPS operator depresses the ST key. The KP SPL key remains lit, while the BVA inquiry is in progress. If the number is good, KP SPL is extinguished, and a special display is given to the TSPS operator indicating the type of PIN. The non-TSPS operator is informed of the RAO and the type of PIN.

3.2.6.2 Automated inward validation. A non-TSPS operator may validate a number without TSPS operator assistance. The TSPS returns an alerting tone. The non-TSPS operator has 1 minute to start dialing the 14-digit calling card number to be validated.

After a format check, TSPS initiates a BVA inquiry for validation of the number. There are four possible outcomes of a validation attempt:

(*i*) Calling card number accepted; PIN unrestricted: Announce "Valid number, unrestricted PIN, RAO XXX."

(*ii*) Calling card number accepted; restricted PIN: Announce "Valid number, restricted PIN, RAO XXX."

(*iii*) Calling card number accepted; RAO unknown: Announce "Valid number, unrestricted PIN, unknown RAO."

(*iv*) Calling card number rejected: Announce "Invalid number, please dial again."

After cases (*i*), (*ii*), and (*iii*), the connection to the non-TSPS operator is dropped by TSPS. After the announcement in case (*iv*), the alerting tone is given again and the non-TSPS operator may redial.

If an operator is using DTMF signaling, the # character has the same meaning as described before. It can be used to terminate dialing and restart dialing of another number. If a * or an invalid digit is received, it is ignored. A flash ends the call.

If the operator is using MF signaling, the start (ST) signal is treated as a # and is required after the 14th digit. The KP signal must precede dialing the 14 digits. Any error in keying results in the error announcement sequence.

Any digits dialed before the initial alerting tone, after termination announcements have started, or after the 14th digit when using DTMF signaling, is ignored. If a termination signal (# or ST) follows the 14th digit and dialing follows, the BVA inquiry is aborted and the following digits are considered a new number.

The reception of digits truncates announcements in progress. The termination announcement is restarted as soon as possible, but the error announcement is not restarted. Digits dialed during an error announcement are considered a new number.

3.2.7 Operator actions—BNS

Collect calls—When an operator places a collect call on behalf of a customer, the BNS feature checks if collect billing is allowed for the called number. First, a preliminary format check is made on the forward number. The number plan area (NPA) must be a legal NPA. No BVA query is attempted if the NPA is illegal. While a query is in progress, the COLLECT (COL) key remains lit. In general, keying of a COL key darkens any lit or flashing KP key lamp, except KP FWD.

The BNS/collect reply indicates one of four collect billing states for the called number and results in the following actions:

(*i*) Collection not denied—The number is outpulsed and the collect key remains lit. When the customer answers, the operator informs the customer that the calling customer wishes to bill the call collect and attempts to procure acceptance of the call.

(*ii*) Public telephone—The called number is outpulsed, the COL key remains lit, and the called number is displayed to the operator. Collect calls to public telephones must be billed in an alternate manner by the called customer, or originated by the called customer if the called party wishes to accept the call on a sent-paid basis and pay with coins. The operator informs the called party of collect call and attempts to procure alternate billing.

(*iii*) Collect denied—No outpulsing occurs and the COL key flashes. The operator informs the customer that collect calls are not accepted by that number.

(*iv*) Indeterminate (a possible public telephone)—No outpulsing occurs and the COL key stays lit. The operator may check with a Directory Assistance (DA) or Rate and Route (R&R) operator. If it is not a public telephone, the operator depresses ST to initiate outpulsing.

Bill-to-third-number calls—After an operator places a third-number call, the BNS feature checks if the number accepts third-number billing. No class of charge is needed. Format checks and BNS inquiry are performed as described for collect calls. Replies and their actions are as follows:

(*i*) Third number not denied—The KP SPL lamp is extinguished, and the called number is outpulsed. The operator may release forward and seek acceptance by the third party, or allow the call to outpulse and seek acceptance in parallel.

(*ii*) Third number denied—The KP SPL lamp is flashed and the third number is displayed. No outpulsing occurs and the operator announces that the number is unacceptable for billing.

(*iii*) Indeterminate—The KP SPL lamp is extinguished. The operator may check with a DA or an R&R operator to check if the third number is a public telephone. If not a public telephone, the operator attempts to get third-party acceptance of the charges. Outpulsing is initiated by the operator by depressing the ST key.

3.3 Common-channel interoffice signaling/direct-signaling operational software

The CCIS/DS operational software provides the TSPS software interface to the CCIS network. This interface is provided by the CCIS/DS message handler program which formats and sends direct-signaling messages for calling card, OST, and BNS data base queries. It also receives and processes direct-signaling replies from the data base queries. Additionally, the message handler provides direct-signaling traffic volume controls when there is congestion or blockage in the CCIS network and when the BVA is overloaded. A cache memory of recently processed calling card numbers is also maintained to protect the network from focused overload of frequently used calling card numbers.

3.3.1 Call-processing interface

Call-processing programs may request that a query be sent over the CCIS network. The requesting program specifies the type of query to be sent (calling card, OST, or BNS), the location of the trunk administration register which contains various data about the call being processed, and the location to which control should be transferred when the data base reply is received. If the state of the call changes before the reply is received, the call-processing program may change the location to which control is transferred. Requests for queries during periods of CCIS network failures result in control being immediately returned to the requesting call-processing program, with an indication of the reason for failure.

Call-processing programs may also request that a CCIS query be canceled. This request would be made, for example, if the calling party hung up before the reply to a query was received. The message handler ignores the reply to a canceled query.

3.3.2 Sending direct-signaling messages

When a query is requested, the message handler obtains the necessary call data, then formats direct-signaling messages into signal units for transmission to terminal units. To associate each reply with the call requesting the query, a call identification number (call ID) is assigned to each query. The call ID is included in the CCIS query message and returned in the reply message. Timing for replies is initiated for each query sent. If no reply is received within two seconds, the reply is considered lost.

3.3.3 Message routing

The CCIS/DS messages have three address fields which are used for routing.[3] The domain field indicates the type of data in the other two fields. The TSPS uses two domain values. Domain 0 indicates that the other address fields contain a function number. A function number uniquely identifies nodes or processes on the Stored Program Controlled (SPC) Network. The BVA replies are routed to TSPS by function number.

Domain 2 is used to route calling card, BNS, and OST queries to BVA data bases. These queries contain NPA and NXX information in the two remaining address fields. The network may route the queries on the basis of NPA alone or on both NPA and NXX. Calling card queries may also be routed on the basis of RAO using domain 2. The RAO addresses are identified by setting the NPA address field equal to 1000.

3.3.4 Traffic volume controls

The TSPS automatically reduces the number of CCIS/DS messages sent when the network is congested, when messages are blocked, and when the BVA data bases are overloaded. When processor signal congestion (PSC) signals are received from an STP, the TSPS stops all outgoing messages to that STP and its mate for 10 seconds to allow the network to recover. Network problems beyond the first STP pair are detected when a query cannot reach its intended destination and is returned to the TSPS with an indication of the reason for failure. If network congestion or blockage is indicated, TSPS immediately initiates a complete cutback of all queries with the same NPA or RAO destination as the failing query.

Replies from BVA data base queries contain an overload indicator which, when set, directs the TSPS to reduce the number of queries to that data base. This indicator causes traffic reduction to be invoked for a specified interval of time. Subsequent requests for traffic reduction received during the reduction interval cause the timing interval to be restarted.

A cache of replies to recently validated calling card numbers is maintained at the TSPS to protect the network against a focused overload of BVA queries that may result from frequently used calling card numbers. Replies to calling card queries are saved in a memory scratch area which is used as a cache. A hash algorithm is used to map calling card numbers into cache locations. The hash algorithm is time-dependent and periodically changes the location used for any particular calling card number. This ensures that only recent replies to queries can be found in the cache. Before a calling card query is sent, a check is made to determine if the reply for that query is in the cache. If it is, the reply data in the cache is used to process the call and the query is not sent.

3.3.5 Traffic sampling

To monitor the use of the SPC network for division of revenue and special studies, the TSPS collects on a sampled basis the NPA and NXX of the calling and called numbers on calls using the network. These call data are transmitted to a network data collection node in the form of a supplemental query data (SQD) message. The SQD message indicates the type of query, the address used in the query message, the function number of the TSPS processing the call, the SQD sampling rate, and the NPA-NXX of the calling and called numbers.

3.3.6 Direct-signaling translation test

The direct-signaling translation test (DSTT) verifies the integrity of routing data between nodes on the SPC network.[3] This test is manually initiated and consists of a series of special data network messages which test the translation data in each signal transfer point (STP) on the path between the origin and the specified destination. The TSPS is capable of originating DSTTs and responding to translation tests originating from other nodes on the SPC network.

The TSPS originates a DSTT by sending a Data Translation Test (DTT) message over one of its A-links. The STP receiving the DTT checks its own translation data and then advances the test by transmitting a Compare Translation Test (CTT) message to its mate STP. After checking its translation data, the mate STP transmits a DTT message over the route determined by its translation. The SPC network function that ultimately receives the DTT responds with Reply to Test Messages (RTTS). If the function reached is the one specified in the DSTT, a success message is returned; if some other function is reached, RTTS indicating a routing error are returned to the originating node.

3.4 Administrative software

Changes to TSPS administrative programs were made to provide support for the new SPC network features. Recent change programs are used to administer TSPS resident data. New recent change programs were provided to activate CCIS/DS, Calling Card Service, OST, and BNS. In addition, new recent change programs administer trunk group signaling data for DTMF signaling enablement of coin stations and locally define Calling Card Service announcement protocol prior to OST data base availability. New interface programs for the No. 1A Service Evaluation System, which provides service evaluation of TSPS calls, allows Calling Card Service and BNS calls to be evaluated. Automatic Message Accounting (AMA) record changes were made to facilitate billing of Calling Card Service and BNS calls.

3.5 Measurements

Extensive new measurements include maintenance, traffic, and CCIS/DS query measurements. Maintenance measurements provide data on hardware failures, out-of-service intervals, and other indications of the service provided, and the overall system performance. Traffic measurements detail usage of Calling Card Service and other types of calls. This information is used to forecast future traffic capacity requirements and engineer equipment additions, administer the operating force, and to assess the grade of service to the customer. The number of CCIS/DS queries, replies, and failures are also measured to give an indication of CCIS/DS and BVA usage and performance.

IV. LOCAL OFFICE INTERFACES

New local office interfaces were provided at the TSPS to permit coin telephone customers to use DTMF signaling to enter billing information and place sequence calls associated with Calling Card Service. Prior to the implementation of these interfaces, the DTMF dials of both dial-tone-first and coin-first telephones were disabled by the local office upon connection of the call to the TSPS. The new interfaces extend control over activation of the DTMF dials to the TSPS.

Two signaling interfaces are provided for dial-tone-first telephones: multiwink signaling and expanded inband signaling. For coin-first telephones, a new coin-retention protocol is provided. The use of a particular interface is specified in TSPS program memory (office-dependent data) on an individual trunk-group basis. Some trunk groups may require the application of both coin-first and dial-tone-first protocols.

A new signaling arrangement was also provided to permit DTMF customers served from certain step-by-step local offices to enter billing information using the DTMF dial.

4.1 Background

4.1.1 Dial-tone-first telephones

When a customer at a 1C-type dial-tone-first telephone goes off-hook, the local office applies negative battery towards the telephone (i.e., the ring lead is negative with respect to the tip lead), dial tone is received, and the DTMF dial is activated. Upon connection of the call to the TSPS, the local office applies positive battery towards the telephone (i.e., the ring lead is positive with respect to the tip lead). This disables the dial and places the telephone in a mode in which individual coin deposits are identified by coin deposit signals.[4] The telephone must be in this mode for the customer to place a sent-paid call (i.e., one in which the customer pays for the call by depositing coins).

To activate the DTMF dial and permit the entry of the billing information required to place a calling card call, the local office must reapply negative battery towards the telephone.* However, this prevents the generation of individual coin deposit signals required for sent-paid calls. To accommodate either type of call, the TSPS must be able to control the application of positive and negative battery by the local office.

4.1.2 Coin-first telephones

The DTMF dial of a coin-first telephone is not activated until an amount equal to the initial rate has been deposited by the customer. If the initial rate is collected or returned to the customer, the dial is once again disabled.

To place a TSPS call, the customer at a coin-first telephone must first deposit the initial rate. Prior to the introduction of the coin retention protocol, the local office would return the initial rate deposit upon connection of the call to the TSPS. This was consistent with no charge being incurred to reach an operator; it also simplified the charge calculation in the event that the customer wished to place a sent-paid call. However, it disabled the dial and prevented the entry of billing information for calling card calls.

4.1.3 Step-by-step offices with DTMF service

Certain step-by-step local offices provide DTMF service through the use of DTMF-to-dial-pulse converters located within the office. These converters translate the DTMF signals received from the customer's telephone into dial-pulse signals which are used directly to establish a connection through the step-by-step switching system. These converters must be disabled, once the call reaches the TSPS, to permit DTMF billing information to be transmitted through the step-by-step office.

4.2 Multiwink signaling

Multiwink signaling consists of a series of one to five short duration on-hook "winks" sent from the TSPS to the local office. It is used by

* Alternatively, the telephone itself can be modified to permanently activate the dial.[1]

the TSPS to control the traditional functions of coin collect, coin return, and ringback (i.e., application of ringing signal), as well as the selective activation of DTMF or coin deposit signaling.

The multiwink signaling codes are shown in Table III. "Operator-attached" and "operator-released" are historical terms which identify the multiwink signals used to control the application of positive and negative battery, respectively, by the local office; their use does not necessarily coincide with the attachment or release of an operator. The last three codes are identified by the functions which they perform ("collect," "return," and "ringback").

Multiwink signaling has been available for several years between the TSPS and No. 5 Crossbar, Step-by-Step, and No. 3 Electronic Switching System (ESS) local offices. However, Calling Card Service represents its first system-wide application for providing DTMF signaling beyond the local office.

With multiwink signaling, the local office continues to apply positive battery toward the coin telephone upon connection of all calls to the TSPS. At the TSPS, incoming 0– and 1+ calls are connected to an operator or CDA circuit as appropriate. With positive battery applied, coin deposit signaling is available to handle sent-paid calls. Upon release of the call to a talking state (no operator or CDA circuit attached), the TSPS sends an operator-released signal to reverse the battery applied to the telephone. This activates the DTMF dial, thereby permitting its use by the customer for end-to-end DTMF signaling.

On sent-paid calls which require intermediate coin deposits, the TSPS sends an operator-attached signal, prior to connecting a CDA circuit, to enable coin deposit signaling. After the necessary charges have been collected and the CDA circuit is released, the TSPS sends an operator-released signal to once again permit end-to-end signaling by the customer.

On 0+ calls, the TSPS sends an immediate operator-released signal to enable the DTMF dial for the entry of billing information on calling card calls. If the customer subsequently decides to place a sent-paid call, the TSPS sends an operator-attached signal and the call proceeds in the same manner as a 1+ call. Otherwise, the DTMF dial remains

Table III—Multiwink signaling codes

Number of On-Hook Winks	Function
1	Operator released
2	Operator attached
3	Coin collect
4	Coin return
5	Ringback

activated for the duration of the call with no additional multiwink signals being sent.

4.3 Expanded inband signaling

Expanded inband signaling provides the TSPS with control over the same local office functions as multiwink signaling. Expanded inband signaling was developed to circumvent inefficiencies associated with scanning for multiwink signals in ESS local offices. It can be used between the TSPS and No. 1/1A ESS and No. 2/2B ESS local offices.

Expanded inband signaling is based on an earlier inband signaling system which utilized an alerting wink, followed by one of three multifrequency codes, to initiate the coin collect, coin return, and ringback functions. Expanded inband signaling incorporates three additional multifrequency codes to provide efficient control over the activation of DTMF and coin deposit signaling. Additional changes were made to the timing parameters of the earlier inband system (e.g., wink duration, delay, and tone interval) to enhance signaling reliability.

The multifrequency codes used for expanded inband signaling are identified in Table IV. Expanded inband signaling provides signals equivalent to the five multiwink signals. In addition, it provides a sixth signal which combines the coin collect and operator-released functions. The sixth signal is used following intermediate coin deposit requests on sent-paid calls and eliminates the need to send the coin collect and operator-released signals back-to-back.

One other difference between multiwink and expanded inband signaling is the state in which calls are connected to the TSPS. With expanded inband signaling, 0+ and 0− calls are initially connected to the TSPS with negative battery applied toward the coin telephone. Therefore, the DTMF dial is activated and remains so unless the customer subsequently decides to place a sent-paid call. In that event, the TSPS sends an operator-attached signal to enable coin deposit signaling.

As with multiwink signaling, the local office initially connects 1+ calls using expanded inband signaling to the TSPS with positive battery applied toward the coin telephone. The handling of these calls is similar to those using multiwink signaling, except that the sixth ex-

Table IV—Expanded inband signaling codes

Frequencies in Hertz	Function
900 + 1500	Operator released
1300 + 1500	Operator attached
700 + 1100	Coin collect
1100 + 1700	Coin return
700 + 1700	Ringback
1500 + 1700	Operator released/coin collect

panded inband signal is used in place of separate coin collect and operator-released signals following intermediate coin deposit requests.

4.4 Coin retention

The newly established coin retention protocol permits the entry of billing information and the origination of sequence calls from coin-first telephones. With this protocol, the return of the initial rate deposit, which was previously performed by the local office, is now initiated under control of the TSPS.

On 0− and 1+ calls, the TSPS sends a coin return signal to the local office prior to attaching an operator or CDA circuit. However, on 0+ calls the coin return signal is delayed. This leaves the DTMF dial enabled and permits the entry of billing information. If the customer successfully enters a calling card number, the return of the initial deposit will not be performed until the customer hangs up. This permits the customer to originate one or more sequence calls using DTMF signaling. If the customer flashes, keys 0 for an operator, or simply waits instead of entering a calling card number, the TSPS will send a coin return signal prior to attaching an operator.

4.5 Control of DTMF-to-dial-pulse converters

The distinctive tone used by the TSPS to prompt customers at the beginning of calling card calls also provides the TSPS with control over the DTMF-to-dial-pulse converters used in certain step-by-step local offices. The tone incorporates a # DTMF character which disables the converters when the call reaches the TSPS. Once disabled, the converters will not interfere with the transmission of DTMF billing information or the origination of sequence calls.

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