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TSPS No. 1:

System Organization and Objectives

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This article is an introduction to a series of detailed technical articles that describe the Traffic Service Position System No. 1. The organization and objectives of the system are given and the overall operation of the system is explained.

I. INTRODUCTION

At the outset of telephony, connections between telephones were established by operators through cords, plugs, and jacks at switchboards. Within the first decade, switchboard design and operating techniques soon settled into a pattern that is still followed today. The switchboards of 80 years ago are remarkably similar to those commonly used today. (See Figs. 1 and 2.) With rapidly increasing traffic, it became apparent that to use operators to establish local calls was not the best way to continue. Dial switching was invented.

Although the shift to local dial office operation started early in this century, it was in the years following World War II that the transition was rapidly completed. (See Fig. 3.) As the efficiency of transmission

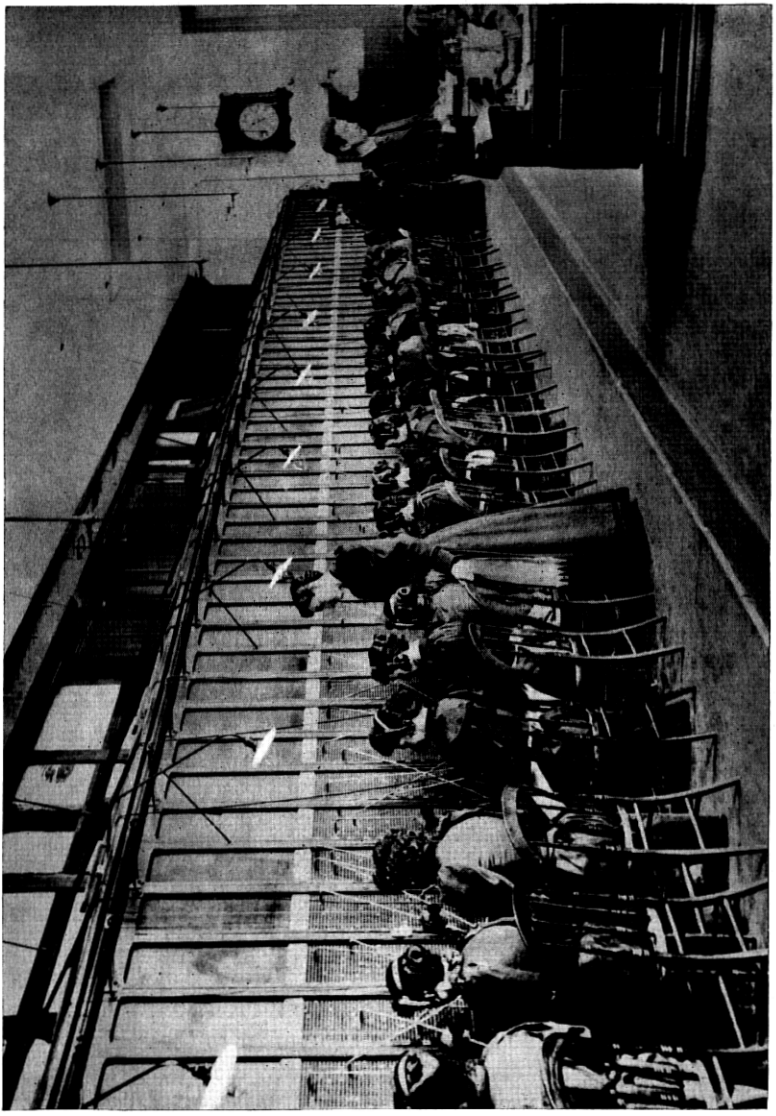

Fig. 1—Multiple switchboard in the Cortlandt exchange, New York City, installed in 1888.

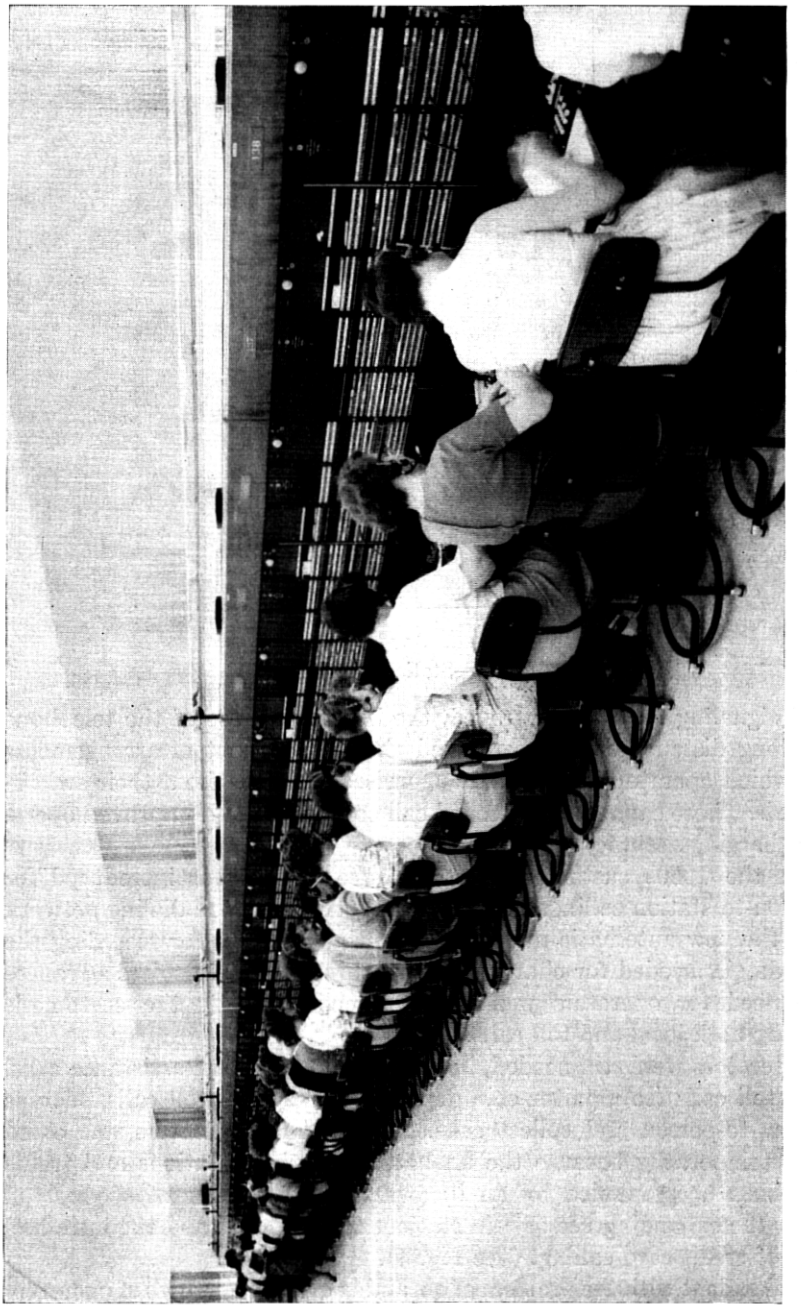

Fig. 2—Switchboards today in New Jersey.

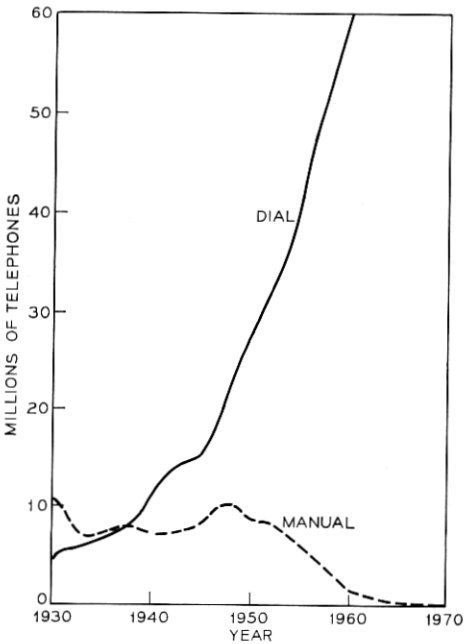

Fig. 3—Station growth.

and signaling facilities improved, the burgeoning use of the telephone for long distance calling permitted the development of arrangements by which operators dialed and supervised toll calls from their switchboards. These capabilities speeded call completion and improved operator charging accuracy.

In the 1950s customer direct distance dialing was introduced for station-to-station calling. This used the established toll dialing network and the new automatic message accounting facilities for recording the call details needed for charging. Thus, through technological advances the need for operators was greatly ameliorated by the customer's dialing both local and toll calls.

Operators were still needed, however, to handle local assistance calls, coin toll calls (to monitor coin deposits) and special toll calls, such as person-to-person and collect calls. The need for operators was eased only temporarily because the unabated growth of stations and traffic has been accompanied by an increase in the number of special toll calls, the expanding use of coin stations for toll calls, and the introduction of credit card calling. (See Fig. 4).

Coincident with the problem of obtaining greater numbers of operators was a changing labor market. It was becoming more difficult to hire

women to work in the urban switchboard locations, particularly for weekend and night duty. Competition from broadening job opportunities in business offices, sales work, and suburban factories was being felt. These factors combined to start a search to do the operator's job more efficiently and to make it more attractive.

Toward this end, the New York Telephone Company developed an operator assistance switchboard for customer dialed special toll calls to work with No. 5 crossbar system called PPCS (person-to-person, collect, and special) in 1958.[1] Based on this start, Bell Telephone Laboratories undertook the development of a standard cordless console with semiautomated call handling of customer dialed special toll calls through the crossbar tandem system in the early 1960's to provide a more comprehensive design to meet the broader needs of the Bell System. The new console was named the traffic service position (TSP) and the first standard installation went into service in 1964 in Cleveland, Ohio.[2] There are now some 21 installations in major cities. To provide TSP features with the other toll switching systems in the same manner would have required similar development for the No. 4 toll crossbar and No. 5 crossbar systems.

In order to provide a single system that could work with any toll switching system, present or future, the idea of an autonomous system to provide the automatic operator functions was conceived. That system, named the traffic service position system No. 1 (TSPS No. 1), has been developed. It is the purpose of this article and the six that follow to describe the new system.

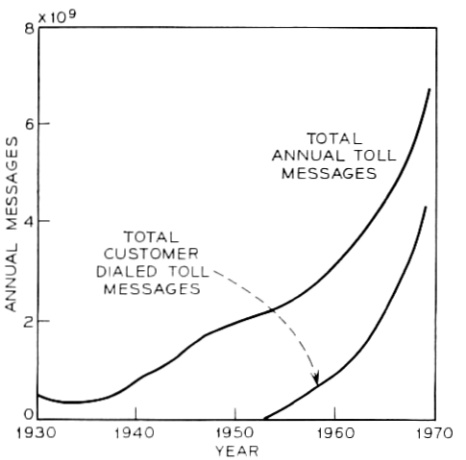

Fig. 4—How toll calls have increased.

II. OBJECTIVES

The basic objective of the system design is to relieve the operator of handling the routine switchboard operating functions so that she can concentrate on providing those functions which require judgment to be exercised and data to be put into the system. The initial design of the system provides for the types of calls and the operator functions described in Table I.

There are a significant number of call types now handled on toll switchboards that were not included in the initial design of TSPS in order to limit the size of the development and to meet the most urgent needs of the field. Typical call types not included in the initial design are conference calls, mobile and marine calls, inward to operator calls, and special handling of hotel and motel calls.

In order to handle the calls outlined in Table I and to obtain the desired service, administrative and operational improvements discussed in the introduction, these general design objectives were established:

(*i*) Autonomous system with standard trunk interfaces to other systems.
(*ii*) Modern attractive consoles.
(*iii*) Economical position remoting capability.
(*iv*) Stored program system design.
(*v*) Economical over a reasonable range of office sizes.
(*vi*) Improved administrative features.
(*vii*) Improved maintainability.
(*viii*) Flexibility in adding new features.
(*ix*) A generic processor-memory complex useable in other system applications.
(*x*) Use of "on-the-shelf" hardware.

In order to expedite development and field introduction, it was decided to adapt both the basic hardware components and the system structure of No. 1 ESS.[3] A number of fundamental modifications were made, however, and these are described later in this series of articles.

To establish bounds for the size of the design, a review of the potential market was made. Considered were trunking needs and the number and size of chief operator groups.* With the recognition that the system would receive wide application, equipment quantities were selected so that no one system component would be limiting in obtaining maximum

* A chief operator group is the location of a group of positions under a single administrator or chief operator.

TABLE I—OPERATOR FUNCTIONS

From Stations	Input Credit Card or Third Number	Called Customer Identification on Person-to-Person	Obtain Acceptance of Charges on Collect	Operator Identification of Calling Number*	Monitor Coin Deposits	Operator Assistance
Noncoin	0+	0+	0+	1+, 0+	–	0–
Coin	1+, 0+	0+	0+	1+, 0+	1+, 0+	0–

1+ Customer dialed station-to-station calls
0+ Customer dialed special calls
0– Operator assistance calls

* Needed only when calling number is not automatically identified and forwarded from the local office.

system utilization. As it now stands, the design is limited by data processing capacity. The maximum quantities of the major system elements shown below have covered the needs of all installations to date.

(*i*) 3000 trunks,
(*ii*) 310 positions, accessible as a single team,
(*iii*) 62 positions per chief operator group, and
(*iv*) 9 chief operator groups, remote, local or both.

The number of cities expected to require multiple installations of the system is small, indicating that a larger system with its higher start-up cost was not justified for the current potential market of several hundred systems.

III. SYSTEM DESCRIPTION

3.1 *100B Console*

Since the basic function of TSPS is to automate the routine aspects of the operator's work, the system description begins from the operator's viewpoint: the way calls appear on her console, her responses, and the features of the console. Against this background, descriptions of the software and hardware should be more meaningful.

Figure 5 shows a typical operating room. Each console section contains two positions in a desk-like arrangement. Figure 6 is a closer view of the console keyshelf with its lamps and keys. Except for the digital display in the uppermost portion of the section of the console, the remaining lamps are on the main panel. Some keys are equipped with lamps and are indicated in the legend.

A position becomes available to the system for service when an operator inserts her headset plug into its jack. Calls are automatically distributed to all attended positions in such a way that all operators receive an equal share of the traffic load. When a position is given a call, the operator hears a zip tone and is given a lamp display. A lamp indicates the type of the originating station, coin or noncoin, and whether the customer dialed 0 followed by 7 or 10 digits (0+), dialed 0 only (0−) or dialed a station-to-station call (1+). The use of a "1" prefix for station calls is not universal, but for purposes of description, station-to-station calls are often referred to as 1+.

With these indications the operator is able to respond appropriately. On calls received from coin stations, the deposit for the initial period and duration for the call dialed by the customer are also indicated in the numerical display when the operator takes the call. On 0+ calls she

Fig. 5—A typical operating room.

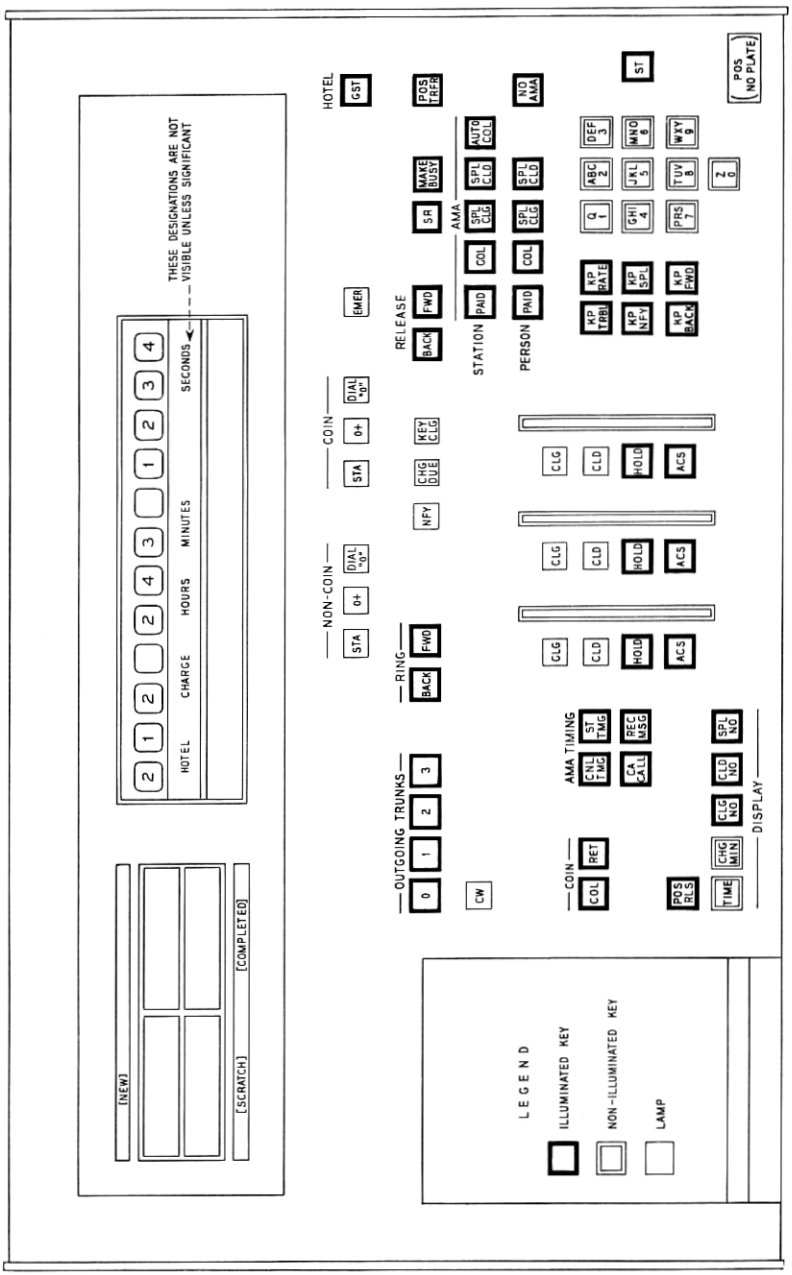

Fig. 6—100B traffic service position key shelf.

asks what type of operator assistance the caller wants. When she determines the type of call being placed, the operator depresses a class of charge key. If it is necessary for the operator to enter a credit card number, the number of a third station for billing purposes, or to provide the called number or calling number, there is a keyset in the lower right corner which is conditioned by the operation of an appropriate key pulse key to indicate the type of number being entered into the system by the operator.

In the lower center part of the key shelf are three columns of keys which are referred to as "loops". When a call is connected to the position, it is associated with one of these loops. When the operator is in voice contact with the customer, the bottom key lamp designated ACS (access) is lighted. If the operator desires to keep this call associated with her position while handling other calls, she can push the HOLD key lamp. The upper two lamps of each loop indicate the switchhook condition of the originating and terminating stations when a call is in either ACCESS or HOLD. The call is released from the position when both the ST TMG (start timing) key to the immediate left of the three loops and the POS RLS (position release) key in the lower left corner are operated.

Whenever a call is connected to a TSPS position, all call details are available from the system memory. These call details are directly equivalent to those that she would have written on a ticket if the call had been processed at a cord switchboard. She can display, under key control, the calling number, the number that is being called, a credit card number if keyed into the system, the number of a third telephone if one is being billed, and the charging rate on coin calls. Also, the operator can get the exact time of day being used by the system by depressing the TIME key. The displays associated with the two leftmost keys do not lock in and are only displayed as long as the key is operated. The time display is fixed at the instant the key is depressed.

Other operator controls include the ability to release connections forward or backward, ring the stations forward or backward, collect or return coin deposits and connect to special service operators over outgoing trunks.

Although the operator has some freedom in the way she handles calls, many of her key actions are automatically checked and flashing lamps used to indicate detectable errors. If, for instance, the operator depresses the START TIMING key before a class of charge has been recorded, the START TIMING lamp will flash. The operator must then determine what information is missing. Similarly, keying 11 digits on a 0— call will cause the KP FWD (KP forward) lamp to flash.

For all calls that are to be automatically timed by the system two key operations normally end the initial position seizure. These keys are ST TMG (start timing) and POS REL (position release). The START TIMING key is used to indicate to the system that the operator has all of the billing details on the call, and that when her position is released from the call, and the called station answers, the time of the connection is to be recorded. On 1+ coin calls the START TIMING key may be operated before the called party answers, but on person-to-person calls the START TIMING key is operated after the conversation starts. In either case, the time of connection is established when the operator is disconnected from the call. Timing for charges stops when a call is reconnected to a position for any reason.

3.2 *General*

Figure 7 is a basic block diagram for this system. All trunks have two two-wire appearances on the link network. The network connects the trunk to various service circuits—digit receivers, outpulsers, coin control circuits, tone circuits, and operator positions. Being a stored program system, the basic call logic instructions are in the memory and are executed by a processor. Changes of the supervisory state of trunk,

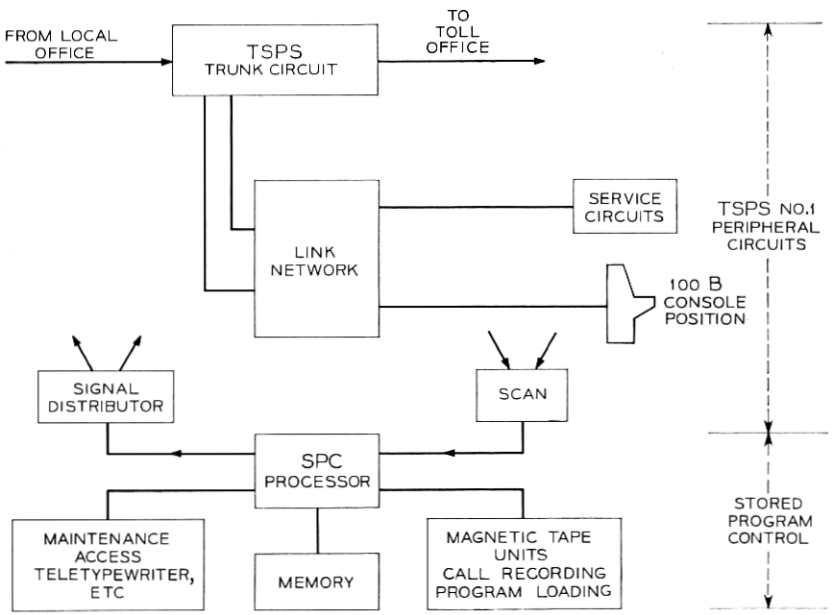

Fig. 7—TSPS elements temporarily connect operators and equipment to the trunk circuit.

service, and other peripheral circuits including the positions themselves, are detected by scanners. Output instructions via signal distributors and central pulse distributors control these circuits and the position lamps.

During the conversation period of a call, the customers are connected only to each other; there are no connections to operators or service circuits. It can be seen in Fig. 7 that the TSPS trunk circuit is a dedicated facility connecting the local office to the toll office. No switching capability nor concentration exists for this trunk circuit at TSPS. Thus, TSPS is a unique type of switching system because all the elements of a switching system are present only for the purpose of temporarily connecting equipment units and operators to the trunk circuit.

3.3 *Equipment*

The system equipment is divided into two principal parts, the processor-memory complex, and the TSPS No. 1 periphery which includes the position subsystem.

3.3.1 *Processor-Memory Complex*

One of the major points of divergence from the No. 1 ESS design is in the processor-memory complex. The processor-memory complex, including such supporting units as the control and display panel, a signal distributor, a central pulse distributor, a master scanner, the maintenance teletypewriter and the program tape unit for loading and unloading memory, constitute a subsystem called the stored program control No. 1A (SPC). The SPC equipment is covered by a separate set of engineering documents and has well defined interfaces so that it can be easily used in other applications. It is used with the electronic translator system for No. 4 toll crossbar as well as for the TSPS No. 1.[5]

The SPC No. 1A design incorporates several novel improvements. For example, the duplicated processors have fast dc matching circuits that compare the states of certain internal circuits and are able to abort orders within the failing cycle when a mismatch occurs. This provides for improved discrimination of errors and faults as well as better recovery from mismatches. Another difference is in the use of a simplified store bus arrangement to minimize the complexity and inherent hazards of having cross bus switching at every store frame.

For system simplification, a single type of store using the electrically alterable, nondestructive readout piggyback twistor was chosen to provide all of the memory required by the system applications.[4] The advantage of using this memory is discussed elsewhere in this issue.

3.3.2 *TSPS Periphery*

Many of the peripheral units of TSPS No. 1 are similar in function and appearance to those of No. 1 ESS. The plug-in circuit packs, the framework, and terminal strips are virtually identical. Details of the differences are described in Ref. 6.

The switching network used to connect the trunks to the service circuits and positions is a four-stage, two-wire space division network using ferreeds. In order to provide uniform traffic loading of the linkages for the widely differing traffic occupancies of TSPS trunks, a unique network configuration that involves build-out frames has been provided. The build-out frames are physically attached to the basic frames by cable connectors to ease the problem of network growth.

The plug-in trunk units and the universal trunk frames look like No. 1 ESS units. They are quite different in function and this is reflected in the internal design. Because TSPS works with any local office type, it must be able to receive multifrequency pulsing or dial pulsing over both loop and carrier facilities. Since the serving toll office may have a four-wire switching system, both two-wire and four-wire trunk circuits are provided. The four-wire trunk circuits are used when the toll office has four-wire switching and the incoming trunk facilities are four-wire.

3.3.3 *Position Subsystem*

While the position subsystem is really part of the TSPS periphery, it is sufficiently large and novel to warrant separate mention. Orders from the SPC to control the lamps at the consoles are decoded in a position signal distributor which operates or releases magnetically latched miniature wire spring relays. These relays are circuit pack mounted in the position buffer and, with a modest amount of wired logic, control the lamps and key lamps on the console. The console's numerical display is controlled directly from the position signal distributor.

Operators' key actions are detected by an autonomous scanner which codes and gates the keyed information along with the position number back to the peripheral master scanner.

When the positions are remotely located, the orders to control the position lamps and the data words for key operations are sent via the digital T1 carrier system which acts as an extender of the peripheral bus. The T1 carrier also provides the voice circuits for the operators. The manner in which the T1 system provides voice and data capability simultaneously is described in detail in the article on the TSPS periphery.[7]

3.4 *Software*

The program structure for TSPS closely follows that for No. 1 ESS.[3] An executive control program, interrupt levels, priority work lists, fault recognition programs and diagnostic programs are employed to provide the real-time, time-shared characteristics of the system. The individual programs are arranged to be part of either the SPC or TSPS similar to the equipment dichotomy described in section 3.3.1.

3.4.1 *SPC*

The SPC program package provides the system framework within which the TSPS programs function. It is composed of the executive control, maintenance control, interrupt and input-output programs. It also has those programs needed to maintain SPC equipment. The interfaces between the SPC and application programs have been carefully arranged to avoid significant penalties in overall program size and system real-time usage.

The SPC program package is covered by separate documentation that is coordinated with the SPC equipment. There are 35,000 words of SPC program of which 24,000 are for maintenance functions.

3.4.2 *Traffic Service Position System*

The TSPS programs operate within the SPC framework to achieve the desired total system functions. They are composed of both call processing and maintenance programs.

The call processing programs provide call handling logic and are concerned with the input-output functions of scanning and signal distribution, and the control of peripheral hardware to process calls. These programs detect changes of state, provide the data processing to interpret the changes of state, and issue orders to the periphery to change the status of the hardware to further the progress of the call. For example, call processing programs provide for the reception of digital information, establishing connections through the ferreed link network, the sending of information to control the lamp displays at operator positions, the reception of key signals from the operators, the computation of coin charges, and the placing of billing information on the magnetic tape. These programs operate under the stored program control executive control program structure which insures that all necessary work will be given an opportunity for execution within selected time periods.

For the programs that cover the operator functions, care has been

taken to insure that standard operating practices are reflected in the program design. The primary intent here is to give the operator maximum latitude in sequencing her actions while insuring that she properly completes all the necessary functions before releasing the call from her position.

There are 80,000 words of TSPS program of which approximately 37,000 are for maintenance of the peripheral equipment including the local and remote positions.

3.5 *Maintenance Features*

3.5.1 *General*

In this system as in other Bell System central office electronic switching system designs, the maintenance strategy is based on having vital hardware units in duplicate, using signals to indicate the successful execution of orders and using programs to test, detect faults, and diagnose trouble. The deductive and test strategies designed into the programs are relied on heavily to obtain fast and effective results. The use of teletypewriters and lamp displays to simplify the man-machine interface aids in an overall improvement in maintenance. The intent is to achieve greatest reliability through automation wherever possible.

3.5.2 *Equipment*

The most fundamental aspect of equipment maintenance is the extensive use of plug-in circuit packs to simplify replacement of defective units and to minimize the need to repair or adjust apparatus in the office. Duplication of important, commonly used equipment assures continuity of service while failing units are being repaired or additions are made. One method of duplication is achieved by having two separate and identical units, one active and the other a working standby operating in parallel. Only the active unit participates in system call processing. The stored program control processor and stores are examples. Another technique is to provide two halves of a unit and divide the work. When one half fails, the other half takes over the total work load; the link frame controllers are an example. There is also duplication in power and bussing of data signals.

As already mentioned, the teletypewriter is the primary means for a man to communicate with the system. Messages printed on the teletypewriter identify trouble and failing units. The messages provide

the needed detailed information for the maintenance craftsmen to take action. There are periodic teletypewriter reports given on system functioning so that a picture of the relative state of the machine can be obtained periodically. It is also possible via the teletypewriter to modify system operations. For example, the maintenance craftsman can request the system to test particular units.

In addition to the teletypewriter, there are adjacent display panels at the master control center for the SPC and TSPS equipment that give the status of the major equipment elements indicating whether they are in trouble or removed from service. These panels also have control keys which permit the maintenance craftsman to directly reconfigure the system. This permits him to manually associate certain equipment units to form a working system when automatic software defenses are inadequate or other troubles warrant.

The program tape unit for loading the electrically changeable memory via a magnetic tape is located in the master control center (see Fig. 8). This unit can also be used for recording on magnetic tape the contents of system memory to aid in the analysis of program problems. It is also used by the Western Electric Company to obtain a magnetic tape record of office data when engineering for growth.

Craftsmen gain access for testing service and trunk circuits, and to make transmission measurements over trunks through the control display and test panel. A voltmeter is available for making the normal ground and battery cross-checks on cable pairs that connect to the system.

The duplicated automatic message accounting magnetic tape units are in the master control center so that the maintenance craftsman can remove and replace the magnetic tapes on which call billing data are placed. The time of day circuit has key controls, also located at the master control center, for setting the time if commercial power interruptions cause slight time errors to occur.

Almost all frames in the office have the standard POWER OFF keys which are used to remove power from circuits when replacing faulty circuit packs. Because the position subsystem can sometimes have some of its equipment located at a remote site, special controls are provided at the remote location to aid the maintenance man in clearing troubles. Using these controls to enter requests, the system sends selected test orders to the position subsystem signal distributor and position buffer frames. These and other maintenance features unique to the position subsystem are described in Ref. 7.

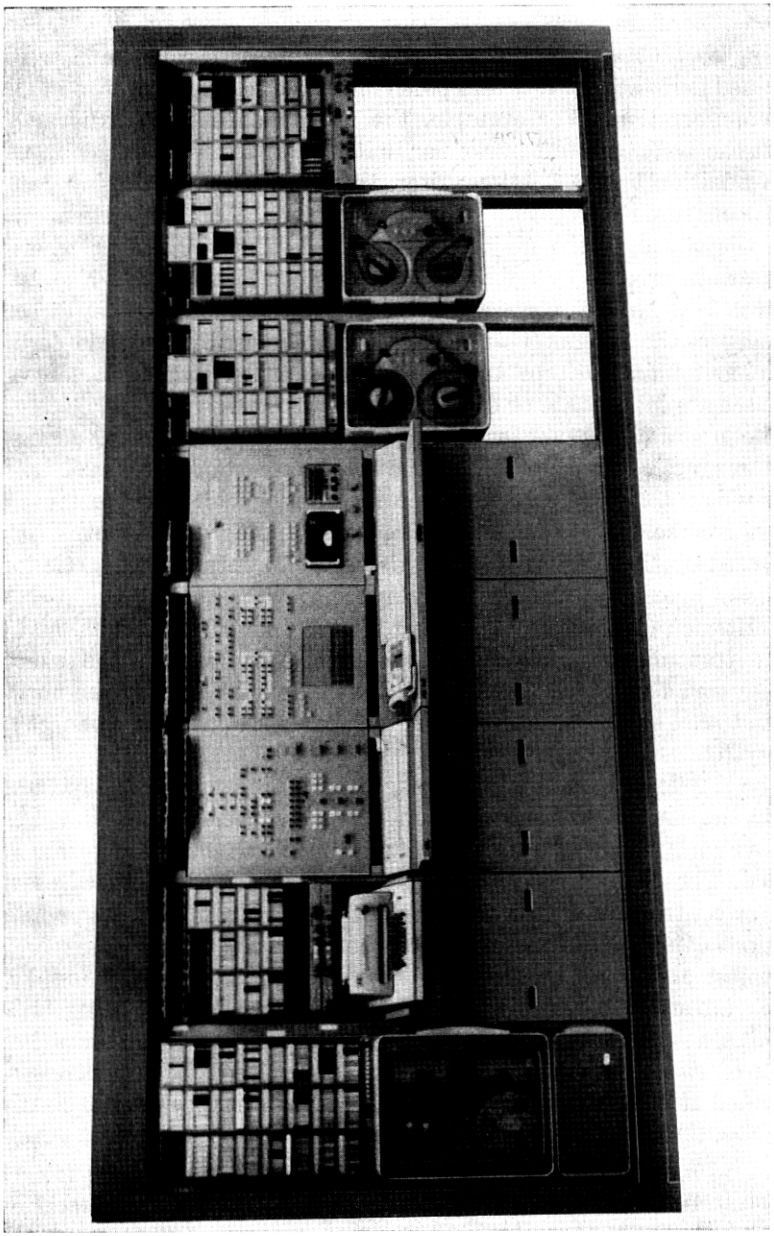

Fig. 8—TSPS master control center.

3.5.3 *Software*

Both the TSPS and the SPC provide fault recognition and diagnostic programs for all major circuit elements. The purpose of fault recognition programs is to quickly detect faulty equipment units and cause them to be removed from service. When the execution of an order fails in the processing of a call, an appropriate fault recognition program is called in to determine if the trouble is repeatable and if so, to locate the faulty unit and remove it from service. Later, on a lower level of priority, diagnostic programs are called in to test the removed unit to isolate the trouble to a small circuit area. A trouble test number is printed on the maintenance teletypewriter for each specific test that fails. The maintenance man looks this number up in a trouble locating manual which indicates the circuit pack or packs that are likely to be faulty.

IV. DESCRIPTIONS OF TYPICAL CALLS

The operation and purpose of the system is best understood by describing how it processes two of the many varieties of calls. The numbers in Fig. 9 might be helpful as a guide.

4.1 *Coin Call*

When a customer places a toll call from a coin station associated with a local office that is served by a TSPS, the instructions on the coin telephone direct that the complete called number, that is, the area code (if required) and the seven digit number for the desired party be dialed as soon as dial tone is obtained. If the customer wishes to place a station-to-station call, either a one prefix or no prefix is dialed prior to the called number depending upon local numbering plan arrangements.[8] As soon as the local office receives the digits, it determines that this call requires the services of a TSPS operator and the call is forwarded over a trunk to the TSPS. (See *1* in Fig. 8.) At the TSPS, as soon as the trunk circuit seizure is detected by scanning (*2*), a connection is established through the link network (*3*) to an appropriate service circuit.

Assuming the call is from a local office that has multifrequency outpulsing, a multifrequency receiver is attached and a supervisory signal is returned to the local office to indicate that outpulsing can begin. As each digit is received in the multifrequency receiver, it is detected by a directed scan (*4*) and placed in memory (*5*). When the complete called number has been received, a supervisory signal is returned to the local office requesting that the calling number be identi-

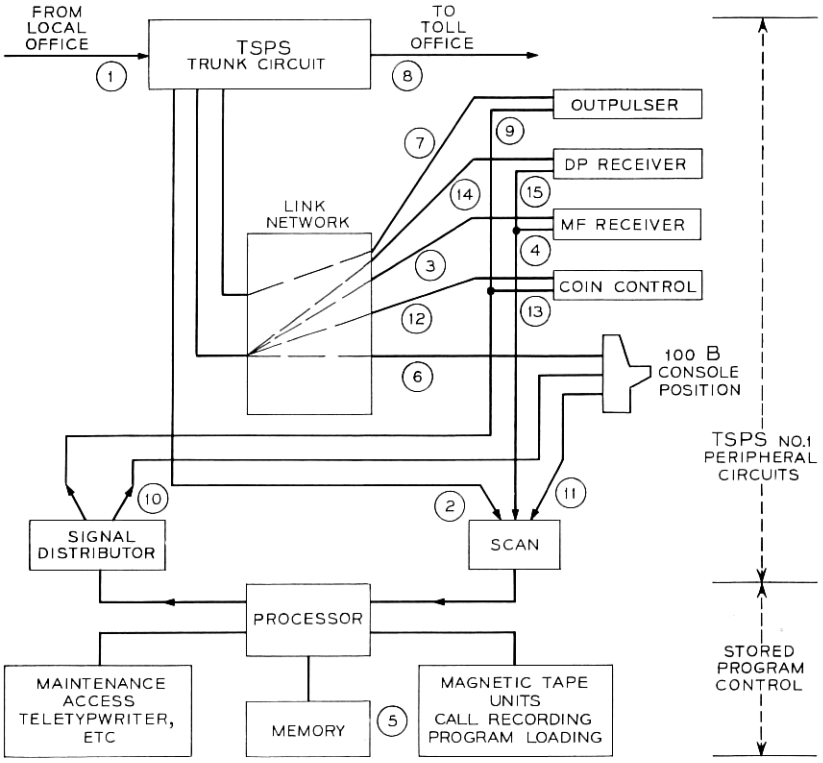

Fig. 9—To understand typical TSPS calls, study this drawing and its numbered parts in conjunction with the text.

fied and outpulsed to the TSPS office. In this case the multifrequency receiver remains attached to the trunk and receives the complete calling number and places each digit in memory.

When both the called and calling numbers are stored, the system simultaneously seeks an idle operator position (*6*) and an idle outpulser (*7*). When both are available, it establishes connections from the two appearances of the trunk circuit to these two circuits (*6*), (*7*). While the operator is responding to the call and talking to the originating party, the outpulser is connected to the toll office (*8*) and after an exchange of supervisory signals, outpulses the called number supplied to it a digit at a time by the central pulse distributor (*9*).

The operator's display, controlled by a signal distributor (*10*), indicates that this is a coin call and gives the initial charge and time period

for the call on a numerical display. She depresses the class of charge key to indicate to the system that a station-to-station type of call is being handled.

The customer, in responding to the request for money, deposits the coins. The operator monitors to see that the proper deposit has been made. In the meantime, the outpulser completes its function, is released, and the call is forwarded through the direct distance dialing network. An audible ring can be heard by both the operator and the originating party because the trunk has now connected the calling and called parties. Since this is a station-to-station call, the operator depresses the start timing key and releases her position as soon as the coins are deposited and she hears audible ringing. She is not required to participate in the call any further.

If the call is of the person-to-person type, she depresses a different call type key and remains with the call until the called station answers. After determining that the desired person is speaking, she depresses the start timing key and releases her position (*6*). All key actions are detected by a scanner and recorded in memory (*11*).

With the operator released, the call is timed by the system for the initial period. Eighteen seconds prior to the completion of the initial period, the TSPS sends a coin collect signal (*12*), (*13*) to the local office to cause the initial deposit to be collected automatically. This alerts the customer that the initial period is drawing to a close.

At the end of the initial period the system connects (*6*) an idle operator position to the trunk circuit. The position is not likely to be the same operator as for the initial seizure. This operator notifies the customer that the initial period is completed and that his call is going into the overtime period. If the call continues more than six seconds after the operator releases, the overtime period begins.

When the call is concluded, as indicated by on-hook supervision, the system seizes an available position (*6*) and indicates to its operator that this is the end of an overtime coin call. The overtime duration and charges are displayed. If the calling customer's phone is on the hook, the operator rings it by operating the appropriate key. After monitoring the deposit of the overtime charges, the operator depresses a key which signals that coins are to be collected and releases her position. Whenever charges are given to the operator for coin collection, appropriate taxes are computed and automatically added to the charge.

Studies have shown that normally it is not economical to provide memory space for coin rating tables for all calls. Most telephone companies attempt to provide automatic coin rating for about 95 percent

of their coin traffic. When calls are not automatically rated, the operator receives a display indicating that she must do the rating of the call either by using the bulletin on her position or by calling a special operator over one of the outgoing trunks. Having determined the rating information, she then keys it into the system and the system automatically computes the charge, adding appropriate taxes. Except for the manually rated cases, it is the responsibility of the system and not of the operator to use the proper rate period based on the time of day and to keep track of holidays and weekends.

4.2 *Person-to-Person Credit Card Call*

Calls made from noncoin stations are handled basically the same as they are from coin stations without the use of the coin features. To illustrate the difference in operation when dial pulsing is involved, let us follow a call from a step-by-step office.

Assuming a noncoin customer in a step-by-step office wishes to place a person-to-person call, a "0" will be prefixed before the 10-digit direct distance dialing number. The "0" indicates to the local office that the services of an operator are desired and a trunk to the TSPS is seized immediately after the initial "0" is received. Because there is no second dial tone with this type of service, the TSPS must be prepared immediately to receive dial pulse digits as soon as it detects the trunk seizure.

Because it may take 190 milliseconds to establish a connection (see *14* in Fig. 8) to an idle dial pulse receiver, the dial pulse incoming trunk circuits in the TSPS are arranged to receive and store up to two dial pulses to provide the needed time to establish the connection. When the receiver is connected to the trunk circuit through the network, a dc signal is sent from the trunk to the receiver indicating whether 0, 1, or more than 1 pulses have been received. If more than 1 pulses are indicated, the receiver signals (*15*) the processor to connect the call to reorder because it cannot assure the accuracy of the pulse counting. However, this occurs in less than five in 1,000 cases, which meets the designated service criteria. The remaining dial pulses are counted in the dial pulse receiver and at the end of each digit the processor (*15*) is given the digit for storing in memory as in the case of the multifrequency pulsing.

At the end of the called number dialing, the system releases (*14*) the dial pulse receiver and connects (*3*) a multifrequency receiver to the trunk circuit through the network. A supervisory signal is sent to the local step-by-step office to request identification of the originating

number which is sent to the TSPS and recorded in memory as in the previously described coin call. In this instance, when the position is seized, the indication to the operator is that it is from a noncoin station and that the customer dialed "0" followed by 7 or 10 digits. She asks the customer what service is required and the customer indicates that he is making a person-to-person call using a credit card. The credit card number is then given to the operator and she keys it into the system. When the called station answers, she seeks the desired party. If the party is not at the station that was called and she determines that the person is at another station, she can release the forward connection (*8*) and key a new called number into the system (*11*). An outpulser is again connected (*9*) to the trunk to send forward the new called number. When she determines that the right parties are connected to each other, she depresses the start timing key, releases her position and the call is now "floating" (not associated with a particular operator) with the system monitoring the switchhook supervision of both the called and calling parties.

If for any reason the calling customer desires the assistance of an operator, a switchhook flash is detected by the scanner (*2*) and an idle position is connected (*6*) to the call. The operator determines the problem or the reason for being brought in on the call and takes the appropriate action. If there is a noisy condition, poor transmission, or wrong number, she can disconnect the called number and try again.

All positions in a TSPS are treated as members of one large team of operators to gain efficiency in service. There are several benefits. When the team size exceeds 120 operators, it is possible to achieve the 92 percent occupancy which has been established as an objective for operator services. Also, the full access of all trunk units to all occupied operator positions is valuable during light loads because all traffic can be sent to a small group of operators. This permits all but one group to be completely shut down during the lightest loads.

V. ADMINISTRATIVE FEATURES

5.1 *Recent Changes*

As in most complex telephone systems where many of the features are dependent upon the local conditions, call routing and charging must be appropriate to that area. Therefore, it is necessary to provide information known as "office data" for a particular installation to function properly. It is often necessary to modify or change this information from time to time.

In TSPS, because it uses electrically alterable memory, it is possible to make all changes through teletypewriter messages and for these changes to become a relatively permanent part of the system memory as soon as they have been verified. In order to minimize human errors, the TSPS recent change messages use an easily understood alphanumeric format. The TSPS programs insure that the information being provided for recent changes is rational within the context of the machine. It is also necessary for a person making a recent change to specify the existing information that is being changed. This acts as a double check and minimizes the possibility of errors getting into the system. In order to provide a simple method of operation, a separate teletypewriter channel is provided for recent changes giving the telephone company the option of placing the machine in the most convenient location. Frequently it is located in traffic quarters since most recent change information originates from the traffic department. The greatest recent change activity involves the coin rating tables and the size and classes of the trunk groups.

5.2 *Traffic Facilities and Force Administration*

Of fundamental importance in the proper use of any switching system is the administration of the traffic dependent facilities of the system. Adequate quantities of hardware such as receivers, outpulsers, and coin control circuits, as well as software buffers, hoppers, and registers, must be maintained. In addition, a system like TSPS requires a sufficient number of operators to meet certain service criteria such as are set for speed of answer. To assist the traffic people of the operating companies in monitoring the adequacy of these facilities, traffic data is printed out periodically on a teletypewriter at the central administration group.

Part of this data is printed hourly to record peg counts and traffic usage measurements. Peg counts of certain service circuit seizures, usage measurements of in-service and out-of-service circuits, and usage measurements of many software facilities are provided. Additional information is also provided at 15-minute intervals on the load level of the system, the number of trunk seizures, trunk seizures requiring dial pulse receiver use, dial pulse calls encountering reorder, and the number of trunks made busy during an overload. Using this information, the facilities engineer can make adjustments in response to changes in the telephone traffic patterns and loads.

The central administration group also receives data concerning operator usage every half hour. These data include the number of position seizures, work volume, average number of positions occupied,

and actual call value or the average holding time/position/call with the figures summarized by chief operator group and for the entire complex. With this data the forcing groups determines the total size of the operator work force and works out the requirements for each chief operator group. Central force administration is particularly important in the TSPS because all operators are a part of one large team but they are divided into as many as nine groups that can be separated by many miles.

Each chief operator also receives operator usage data every half hour for her group as well as for the complex. This information allows her to assess the effectiveness of her own group in comparison with the team and modify the training and supervision of her group.

5.3 *Operator Keyed Trouble Reports*

The TSPS operator, like most operators, is in a unique position of being able to assess the general quality of operation of the telephone network. She can detect operational problems when calls fail to be completed and can judge noise and transmission quality. Moreover, she frequently can detect whether the problems are toward the called or toward the calling party.

Because TSPS is a stored program system, it has a unique opportunity to record these observations efficiently. Any time she encounters trouble, the operator can, by key operations, indicate to the system the problem with the call then connected to her position. She operates the keypulse trouble key, two digits signifying the nature of the trouble, and the start key. The system upon receipt of the two digits makes a simple translation to determine whether the trouble report should be forwarded to the master control center teletypewriter in addition to the direct distance dialing service bureau teletypewriter.

When the printout is made, the trouble code, the reporting position identity, the identity of the trunk and the calling and called numbers are given. It is possible by analyzing repeated reports to locate such units as faulty trunks or to indicate areas that should get increased maintenance scrutiny. Results to date have indicated that this is a most valuable tool and means are being sought to automatically process the trouble information supplied by the operators so that effective response to these reports can be made in minimum time.

VI. PLANNED NEW FEATURES

It is the long range intention of the Bell System to ultimately replace all cordboards with TSP operation. The tedious and repetitious functions

that can be best accomplished through mechanization will be automated. In keeping with this intention, it is expected that additional features will be placed on the TSPS No. 1 for handling those calls that still remain on cordboards. For example, mobile and marine calls, conference calls, and inward traffic to a toll center are likely candidates for addition to the TSPS.

There are plans to further automate certain calls now handled on the TSPS with manual ticketing. Included are automating time and charges record keeping on noncoin calls, semiautomated handling of hotel and motel calls, and providing operator assistance for international direct distance dialed calls.[9] It is likely that features that are not foreseen at this time will be added to the TSPS in future years. The stored program concept facilitates the addition of such features to existing offices.

VII. CONCLUSION

Nine TSPS installations are now in service in the United States. About 30 more offices have had equipment shipped which is now being installed. It is anticipated in the decades ahead that several hundred TSPS installations will be in service.

Experience in the early installations has shown that the TSPS has met its design objective. Those telephone customers who have expressed opinions about TSPS service have been most commendatory because of the speed of service and of the ability of the operator to give her undivided attention to the call. The telephone companies are pleased with this system because it provides simplified engineering, improved maintenance, adequate and timely data for traffic management and significant savings in traffic operating costs. The operators like TSPS because of the attractive decor employed in operating rooms, the modern consoles, and the fact that they can give customers their undivided attention when calls are connected to their positions.

The articles that follow describe many of the features of the system in more detail. Those items that are unique to the design of TSPS are stressed. The material covered in these articles represents the work of many people. This project was supported by many areas of Bell Telephone Laboratories and built upon the techniques of earlier developments such as No. 1 ESS and the crossbar tandem TSP. It also represents a close cooperative effort with the AT&T Company, Western Electric, and those telephone companies that received the early installations, all of whom played a most vital part in establishing requirements and implementing the design.

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