

Toll Service Desk: An Improved Concept of Telephone Toll Traffic Control

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ABSTRACT: A new toll service desk (TSD) system has been developed and successfully introduced, which greatly reduces the human involvement in the processing of operator-assisted telephone toll calls. This combination of an advanced toll recording system, a modern pushbutton-operated console, and a common control crossbar switching system has automated a major portion of the traffic room functions. The design concept and features of the TSD system are discussed.

INTRODUCTION

THE TOLL service desk (TSD) system is an automatic toll recording and switching system that was developed for the purpose of reducing the requirements of manual assistance on telephone toll calls. The facilities found in regular direct distance dialing (DDD) systems have been expanded to encompass and complement virtually all toll operator activities. The TSD is a pushbutton-operated console which features visual displays, full flexibility in operating sequence, and internal checking to reduce human error. This console, coupled with an advanced automatic toll recording system, minimizes operator involvement and greatly improves manual efficiency when assistance is required for the completion of a call.

GENERAL DESCRIPTION

The TSD system is comprised of three basic parts. First, there is the switching equipment, which is responsible for receiving and analyzing the subscriber's dialed information, selecting the proper route, and controlling the outpulsing to reach the given destination. Second, there is the operator access and control equipment, which is responsible for selecting and connecting an idle operator's console to a call that requires operator assistance. It also provides the operator with the control facilities required to complete the various types of calls which require her assistance. Third, there is the data recording equipment, which is responsible for obtaining the information required for call processing and customer billing. It provides temporary storage for this information and, upon demand, provides statistical or numerical data to the switching equipment and/or the operator's console. Finally, upon call completion, the recording equipment makes a punched tape record of the call for billing.

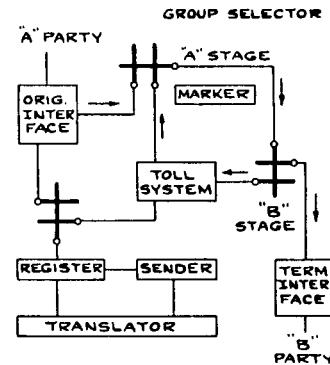


Fig. 1.

DESIGN CONCEPT

The system developed was not intended to complement the older cord-type tollboards but rather to replace them. Therefore, the TSD system was designed to handle all types of traffic inherent to most manual tollboards. This traffic includes the mobile telephone traffic, inward assistance, manual telephone subscribers, a delayed call, or a "will hold," etc. In addition, the system is able to process credit card and third number calls, provide time and charges information upon request (or automatically upon calls from hotels and motels), and record the room numbers for calls which have been dialed directly from hotels or motels.

The general systems concept is as follows. The system was designed around a universal trunk that is equipped to handle all of the different call types. The data storage facilities are located in a memory system which is common to several trunks. Each operator's desk is equipped with dedicated register facilities. The system utilizes existing North Electric crossbar registers, senders, and translators to provide the switching function.

The universal trunk approach is obviously desirable because it both provides the best traffic capability and also minimizes the problem of directing different call types to dedicated facilities. The universal toll recording trunk (TRT) is inserted in the crossbar switching matrix as a junctor or "wrap-around" trunk. Fig. 1 illustrates the relative positioning of the toll system with respect to the crossbar switching system. Note that the A and B interface blocks can either be the existing crossbar intraoffice and interoffice trunks or can be an interface between a step-by-step office and the crossbar matrix. The register, sender, and translator complex is standard North Electric crossbar equipment and can be used on a shared basis with the local switch gear.

Ferrite core memory planes were selected to provide the most economical means of data storage. The memory system was designed to provide data storage space for 30 TRTs. The 30-trunk dimension was established in order to best accommodate the various sized systems' applications.

OPERATIONAL FEATURES

The system was designed so that virtually all calls could be allowed to float. This means that an operator's desk requires connection to a call only during the time that manual functions are required. Once the operator has satisfied the immediate requirements of the call, she can release her desk from that call and can then be available to other calls which require assistance. The TRT, however, may connect an operator several times during the same call. For example, a subscriber may ask to be notified at the end of the base charge period. In this case the operator, after keying the base charge period indication, can release the call from her desk. The trunk will then time the call and will request an operator when the time period has lapsed. Note that the operator who is connected the second time may not be the same one that originally handled the call. All of the call's statistics are available to the new operator through lamp indications and numerical displays.

The desk and associated register provide facilities for operator keying of the called number (seven or ten digits), the calling number (seven digits), credit card or third numbers (ten digits), hotel or motel room numbers (four digits), the coin rate code (three digits), the initial time period indicator for "notify" calls (one digit), and a trouble code (one digit). Upon demand, the desk will display (numerically) the called number, the calling number, credit card or third numbers, and the coin station rate code. Under certain conditions the desk will automatically display either the starting time of the call or the accumulated number of overtime minutes on coin station calls. A visual display of digital information also occurs as the operator keys in a number. This feature provides immediate visual verification by the operator, thus minimizing keying errors.

The operator has the ability to change any number at any time until the call has been established and the timing has started; the keying of numbers can occur in any sequential order. This flexible sequence allows an operator to key the information in the order received from the subscriber, thus eliminating the need for scratch-pad notes. The fact that numbers can be changed allows the operator to "follow" a called person to another terminating number without forcing the originating subscriber to replace the call, even though he may have dialed the original number himself. Another feature allows the operator to resend the called number without rekeying. For example, if a call reaches a busy signal on the first attempt, then the operator can release the forward connection by pushing the release forward key and then simply reoperate the start

key. The machine will resend the called number that has been stored in the memory. This operation can be repeated as many times as required.

This flexibility of operation of the desk is complemented by a status checking feature which insures that all required billing information has been stored in the memory. If any of this required information is absent, then the equipment will not permit the operator to release from the call. There are two exceptions which override this information status check. Many types of calls processed by the system do not require billing. When the operator encounters one of these, she operates the no-charge key to mark the call. The no-charge mark overrides the status check and permits position release without complete billing information. In addition to the no-charge call, operators occasionally receive calls that cannot be completed due to the subscriber's refusal to give the required information, etc. A cancel-call key is provided to accommodate such cases. When this key is operated, the call is immediately released from the position and a busy tone is returned to the subscriber.

Fig. 2 shows the TSD control panel. The digital display at the top of the panel consists of nixie tubes behind a red filter. The fifteen numerals (from left to right) are the area code (three digits), the office code (three digits), the station number (four digits), and the time of day (five digits, for hours, minutes, and tenths of minutes). The area, office, and station numbers are displayed either upon operation of the associated display keys or as the operator keys the numbers. The time of day is displayed at all times.

Both the first row of indicators which are immediately below the display screen and also the hotel group in the second row are lamp signals, indicating the kind of call that has arrived at the desk. The rest of the second row (with the exception of the hotel group) consists of special access and control keys. These keys are not used in the normal processing of calls and are therefore located in the top section, away from the main work area. The center section of the panel is arranged to accommodate two-handed operation. Most people are right-handed; therefore, the keys that receive the most activity are located at the right side of the panel. These include the key set, the key-pulse (KP in Fig. 2), marking keys, and the class-type keys. At the lower left side of the panel are the position control keys. These are used to control displays, release the position, cancel the call, and start or stop the timing. At the upper left and center of the panel are the call control keys: the coin collect and refund, the ring forward and rear, the time and charge, and the release forward and rear keys.

In the lower center are four sets of identical keys. These represent the four loops. Normally, only one of these will be in use at one time. However, by use of the hold key a call can be placed on hold at the position, and the operator can accept or place another call on one of the other loops. The keys associated with a loop are as shown in the following list.

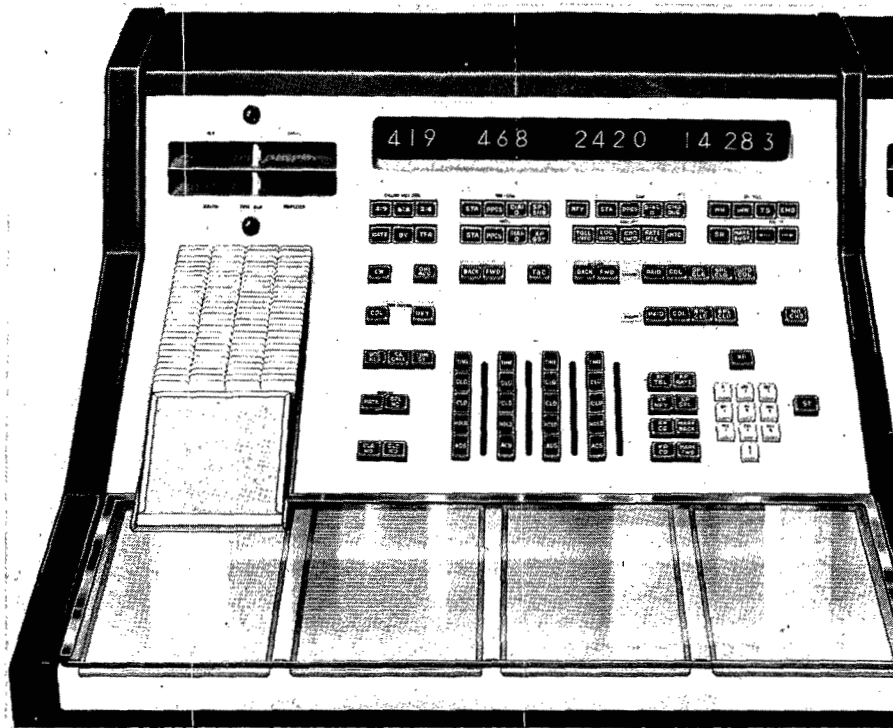


Fig. 2. TSD shelf arrangement.

1) The access key (ACS) is used to accept or place a call, and the lamp in this key flashes when a call has arrived at the desk;

2) The hold key (HOLD) is used to place a call on hold when the call cannot be completed immediately and the operator wishes to overlap with another call;

3) The called key (CLD) is used primarily as a lamp indicator to supervise the called station, and is also a locking key used to split off the calling station's transmission path;

4) The calling key (CLG) is used in the same way as the CLD, except that it supervises the calling station and splits off the called station's transmission path;

5) The time key (TIME) is used strictly as a lamp indicator to signal when the initial period has lapsed on a notify call.

The key units used on this control panel combine a push-action key and two-stage lamp indicators. Therefore, the unit can perform three separate functions. For example, on alternate operations the key marked TIME ST in Fig. 2 will start or stop call timing. When the timing is in process, the key will show a green light; when timing has not been started, the key will show a red light. At the extreme left side of the control panel is a flip card file for high-usage reference material, such as rate information, special operator routing codes, etc. The lower front section of the desk is horizontal and is used as a writing shelf. This section is glass covered with provisions to place other reference cards under the glass cover. The top of the desk is hinged and provides easy access to circuit breakers for the desk and for the replacement of

the nixie tube display units. The entire control panel is plug in and can be easily removed for maintenance or cleaning.

CIRCUITS

Memory System

The memory system uses ferrite cores for bit storage and conventional telephone-type relays for address and control logic. Three 64×64 -bit planes are provided in each memory system for a total of 12 288 cores or bits. A digit is identified by a two-out-of-five code, requiring five bits or cores per digit. Thus one horizontal line in the memory plane contains 60 bits, i.e., space for one 12-digit word. Each TRT is assigned five of these horizontal lines, a total of 300 bits. This adds up to 9000 bits that are used in the memory system, and the standard 64×64 array will leave eight horizontal lines unused for trunk storage space. Five of these lines are used for the test address, and the remaining three can be used as spares and wired to any address, in case one of the assigned horizontals becomes damaged and fails to function.

Basically, the memory operates in a linear select mode. Each TRT has its own address relay which connects five common horizontal select relays. After a horizontal is selected 60 cores are chosen in which either a read or write function may be performed. The sense amplifiers are connected to the vertical wiring in the planes, and the planes are connected in series such that each single vertical connection will pass through one row of all three

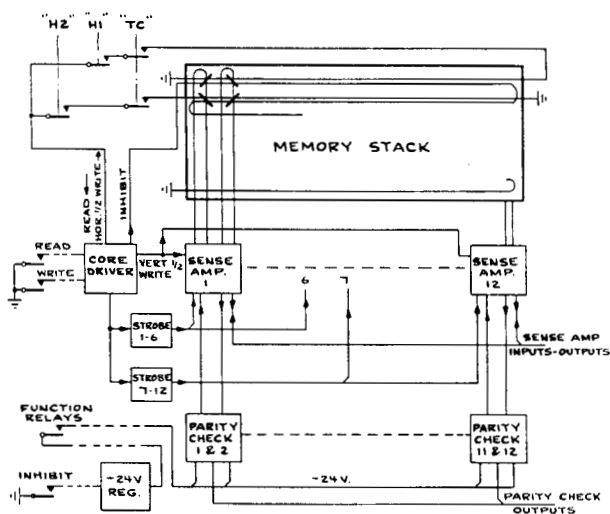


Fig. 3. Memory system.

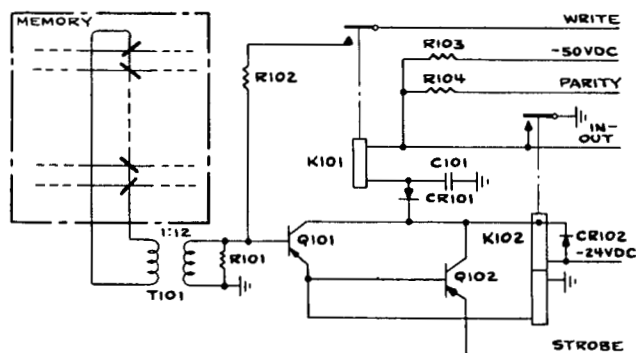


Fig. 4. Sense amplifier.

TABLE I

Function	Horizontal	Vertical	Inhibit	Total
Write	$+\frac{2}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	+1
Read	-1	0	0	-1
Write* A†	$+\frac{2}{3}$	0	$-\frac{1}{3}$	$+\frac{1}{3}$
Write* B‡	0	$+\frac{2}{3}$	$-\frac{1}{3}$	$+\frac{1}{3}$

* Write is "not write."

† A indicates that the vertical is not selected.

‡ B indicates that the horizontal is not selected.

planes and terminate at the sense amplifier. There are 60 sense amplifiers (five per printed circuit module), and each of these is connected to a vertical. The selection of a 12-digit word for a particular TRT is possible by simply operating the trunk address relay and one of five horizontal select relays.

Read and Write Operation

Fig. 3 shows the memory system; read and write current directions are indicated. Table I indicates the various functions that are applied to the cores in the memory. Plus and minus signs indicate the directions of the current applied.

Horizontal and vertical currents of $+\frac{2}{3}$ are called half-write current ($\frac{1}{2}$ write). The total current required to set the core is given by the manufacturers' specification of that core. In the column labelled "Total" in Table I are the current magnitudes generated at the core. A total of +1 current will set the core in the one state. A total of -1 current (in the opposite direction of the write current pulse) will return the core to the zero state. The write A and B conditions always exist since only one horizontal is activated at a time, and a two-out-of-five code will only activate a maximum of 24 out of 60 available verticals. A total of $\frac{1}{3}$ current will not set the core to the one state. The inhibit current provides enough margin to prevent a core from falsely switching.

Read-Write Sequence

- 1) Select desired horizontal.
- 2) Apply power (-24 volts) to the sense amplifiers which correspond to the digits that are to be retained upon reading. The power is not applied to the sense amplifiers for digits that are to be erased (where new digits are to be written in, for example). The function relays control this selective application of power.
- 3) Apply read current to the horizontal. All cores in that horizontal are now erased. Digits which were to be saved are stored on the relays in the sense amplifiers to which power had been applied; digits corresponding to unpowered sense amplifiers are lost.
- 4) Apply power to all the sense amplifiers to prepare for entering the new digits into the sense amplifiers which previously were unpowered.
- 5) Enter any new digits into the sense amplifiers by grounding the desired in-out leads.
- 6) Apply write current. The digits which were saved upon reading [steps 2) and 3)] plus the new digits that were entered [steps 4) and 5)] are now written into the cores. Parity check occurs at the same time that the digits were written.

Remove power from all sense amplifiers to release their relays before proceeding with the next read-write cycle.

The sense-amplifier module includes a storage device and a detector. Information from registers which are external to the memory can be loaded into the sense amplifier by grounding the in-out terminal (see Fig. 4). This will cause the relays in the sense amplifier to lock up. A $\frac{1}{2}$ write current is supplied through the relay contacts (K101) and is transmitted through the transformer to the vertical. During the read portion of the cycle the transistors (Q101) and (Q102) are enabled by application of the strobe (0.7 volt) at the emitter of Q102. The output from the core is stepped up via the transformer to approximately 2 volts. This will turn on the transistors which in turn pull the relay, and again the information can be stored in the sense amplifier module. Obviously the sense

amplifier is the key circuit in the read-write cycle. The core driver and strobe card has two functions: 1) to generate the read and write currents for the memory, and 2) to generate the strobe to the sense amplifiers when reading out of the memory cores.

Fig. 5 shows the read and write circuits. When the read relay ($K2$) is energized, capacitor $C1$ discharges and produces a current at the read-write output. The magnitude of the current is determined by $R5$, and $L1$ in combination with $R5$ determines the rise time of the current pulse for the optimum output from the core. Energizing the write relay produces the write current, which is opposite in direction from the read current. The Zener diode and $R18$ determine the magnitude of the current, while $L2$ and $C6$ control the rise time of the output voltage. Regulation of the output voltage is necessary in order to maintain the $\frac{1}{2}$ write output that is connected to the sense amplifiers; this results in the vertical $\frac{1}{2}$ write currents. The horizontal $\frac{1}{2}$ write current is supplied through $R18$. Resistor $R17$ determines the magnitude of the inhibit output current.

The strobe circuit (see Fig. 6) is triggered by the read pulse and enables the sense amplifiers to receive the output from the core. Resistors applying the trigger pulse turn on $Q2$ and $Q3$, which turns off $Q1$. $R3$, $R9$, and $C2$ provide a time constant of about 2.5 ms, which is required by the sense amplifiers in order to insure the operation of the reed relays. Capacitor $C7$ provides the necessary delay in the strobe output, so that the strobe will occur during the generation of the core output pulse and avoid the noise which is generated at the start of the read pulse. $R16$, $C4$, and $CR4$ generate an offset voltage which helps prevent the sense amplifiers from triggering noise.

The parity-check circuit checks for two out of five bits to be present per digit. It should be understood that the parity-check circuit cannot check for the correct numerical value of the digit but only for the fact that two bits must be present. A zero-, one-, three-, four-, or five-out-of-five code will be detected as an error by the parity circuit; the output of the parity circuit will then signal other circuits in the system. In some cases a zero out of five will indicate correct parity; this will be discussed.

Fig. 7 shows a basic parity-check circuit and resistor network located in the sense amplifiers. Applying grounds at the in-out leads of the sense amplifiers will determine voltage EX for a two-out-of-five input from the sense amplifier, transistors $Q1$ and $Q2$ will be off, and transistor $Q6$ will be on. $Q1$, $Q2$, and $Q6$ form a comparator circuit. Reference voltages VA and VB determine the limits of EX which will energize the parity-check relay. For instance, the value of EX if two contacts are closed will be between -37 and -29 volts, and the relay is deenergized. The value of EX if zero or one contact is closed would be greater than -29 volts, and $Q6$ would turn off. This in turn would remove the bias from $Q2$ and turn $Q2$ on, energizing the relay.

The parity check is controlled by transistor $Q8$. The sense amplifier receives power of -24 volts through the

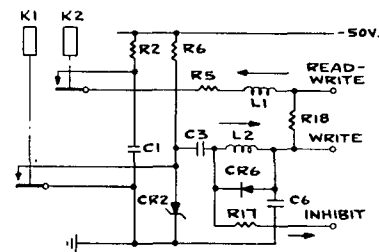


Fig. 5. Core driver.

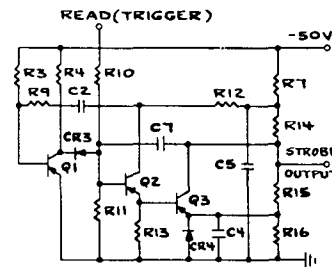


Fig. 6. Strobe circuit.

emitter base circuit of $Q8$. If any bit is present, the current drain by the sense amplifier turns on $Q8$, and the current through $R11$ powers the transistors $Q1$ and $Q2$, their emitter voltage being clamped to -37 volts by the diode. If no bit is present in the sense amplifier then $Q8$ is off and the parity circuit is unpowered. Thus the circuit says that the absence of a digit is all right, but if any bit is present there must be two and only two bits.

If a digit is intended to be present, then an external circuit grounds the digit check (DC) lead, thereby turning on $Q8$ and powering the parity circuit, regardless of whether anything is in the sense amplifier. Then if the digit is missing, or if it contains anything other than two bits, the parity circuit pulls $K1$ to indicate an error. If 50 volts are supplied on the inhibit lead, the comparator will be inhibited under all conditions. $R2$ and $R3$ supply base current to $Q6$ and $Q2$, respectively. Resistor $R14$ supplies the required value of current to energize relay $K1$, and $R11$ limits the current since $Q8$ will saturate under most conditions.

Buffer Registers

The memory system is common to 30 TRT and thus must have a relatively short holding time during each occupancy. It is therefore necessary to provide buffer registers wherever the accumulation or use of data requires any appreciable amount of time. Fig. 8 shows the buffer register arrangements employed by the system.

Each TRT has access to a pool of B address registers (the called numbers) through a crossbar link. The called number is transmitted to the B address register from the originating register-sender in code form. The accumulation of this data requires approximately one and one-half seconds. After the B address has been received and stored in the register an A address register is seized, and the

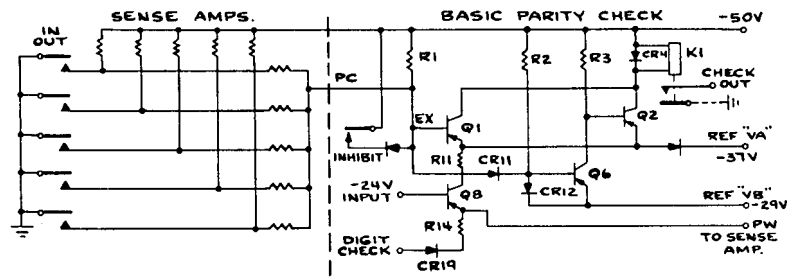


Fig. 7.

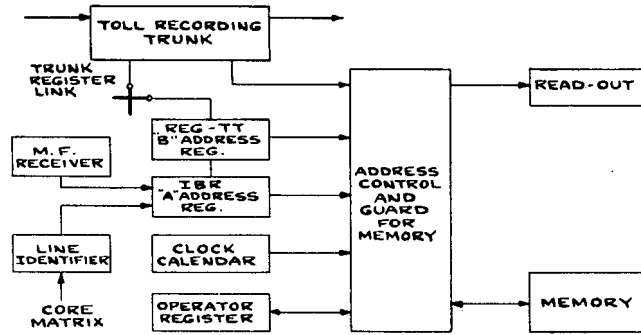


Fig. 8.

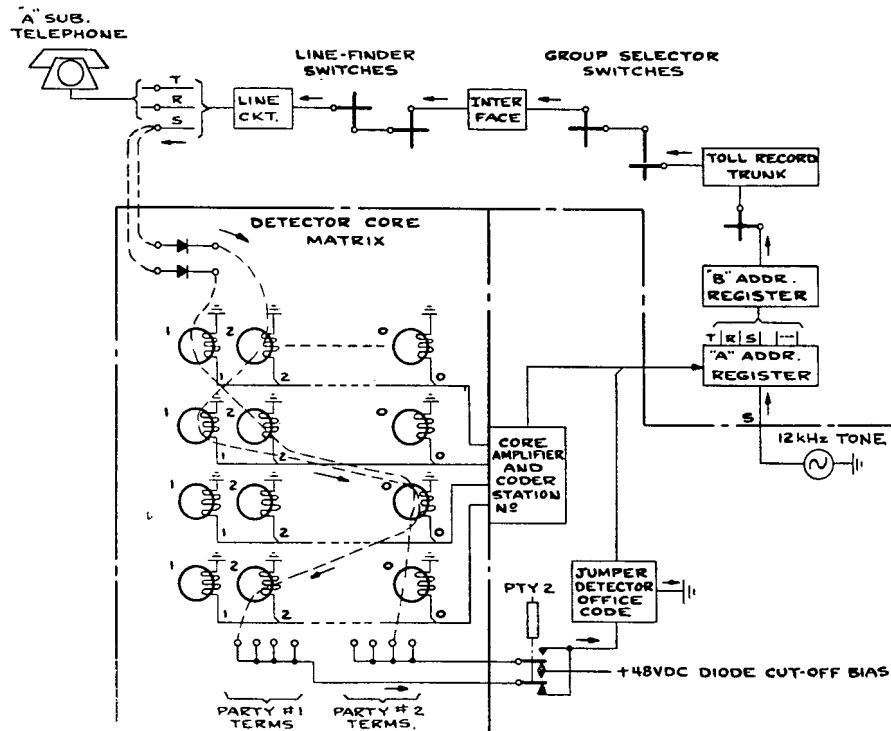


Fig. 9. Principles of line identification.

calling number is stored. When the *A* and *B* address registers have both been filled, the memory system is seized, and the information is transferred from the buffer registers to the memory. The *A* and *B* registers and the memory are then released from the TRT. The information is now stored in the memory cores, and the *A* and *B* address registers are free to serve other TRT. The *B* address is, of course, obtained from the information dialed by the subscriber while placing the call. The *A* address is obtained through the use of a line identifier. If the call originated from a line within the local office, the line identifier used is part of the recording system and will "crash" the complete *A* address into the register. If the call is originated in a remote office, the *A* address is transmitted via multifrequency (MF) signaling to the *A* address register through the MF receiver.

Line Identification

Fig. 9 illustrates the line identification method used to obtain the *A* address from a line within the recording system. When the line identifier is seized, a tone (12 kHz) is extended through the originating switch train via the sleeve or *S* wire. At the line terminal the *S* wire is connected through a diode to a jumper which is passed through a core matrix. Each core in the matrix is equipped with an amplifier and coder which detects the tone and presents a four-digit two-out-of-five code to the *A* address register. These four digits represent the station number of the originating telephone. The office code is determined by detecting the jumper terminating field in which the tone is present. The tone is superimposed on either ground or a positive voltage of about 15 volts. The jumper terminating fields are controlled by applying either the reference voltage or a +48-volt potential; thus when more than one jumper is connected to an individual line *S* wire, the diodes in series with the jumpers act as switches that are controlled by the applied voltage.

Clock Calendar

The clock-calendar circuit is not really a buffer register but a device that applies a ground potential on a group of digit buses indicating a five-digit time of day (a 24-hour clock which includes tenths of minutes). This circuit can be accessed in parallel by several memories since it will present the same digital information to all attached circuits at any given time.

Operator's Register

The operator's register is a two-way device. It can be used either as a buffer register to delivery information keyed by the operator to the memory or as a buffer register which receives information from the memory to control digital displays at the operator's desk. The operator's register is part of the toll position control circuit and each operator's position is equipped with one. The connection between the memories and the operator's register is a 20-wire crossbar link. The digital information is

serially transmitted over this link in a two-out-of-five-code form.

Readout Circuit

The readout circuit is a large register capable of storing all of the information from a TRT address plus the trunk and memory identification information. This circuit is equipped with facilities for both a plug-in (wired) program and also a control logic for operating a paper tape punch. Depending on the program, the readout circuit will present any available information to the punch in any sequential order. In addition, the readout circuit controls a time and charge printer. When a call has been marked for a time and charge quotation, the readout will drive a printer in the operator's room which repeats the call data. The requesting subscriber can then be called and informed of the call charges.

Code-Sending Converter (Memory-Register Interface)

Fig. 10 illustrates the interface between the memory and the crossbar switching equipment. This unit includes a buffer register and a sender which is capable of storing and sending a ten-digit number to the crossbar register-sender-translator complex.

When an operator wishes to extend a call forward using a number stored in the memory, the code-sending converter is seized along with a crossbar register. The appropriate information is delivered to the code-sending-converter storage from the memory. The memory is then released and the data are sent to the crossbar register. The method used to send the information to the register is a DC one- or two-out-of-four code used in the crossbar system; the information is sent sequentially at seven pulses per second. The code-sending converter releases, and the crossbar register then proceeds through its normal functions to establish the forward connection. By using the appropriate control keys on her console, the operator can release the forward connection and repeat the sending operation as often as required.

TSD Link and Marker System

The link used to connect the TRT to the position is a three-stage arrangement with 240 inlets and 200 outlets. The inlets represent TRT, and the outlets represent 50 positions, each having four loops. The marker is arranged to provide full rotation over the positions and loops, so that all operators will receive relatively the same quantity of calls and the loops will receive approximately the same amount of use. The link and marker system is a one-way system; i.e., all call signals must originate from the TRT. Therefore, to accommodate operator-originated calls, a special circuit called the originating marker and a small quantity of special TRT are provided with each system. These special TRTs have two inlets to the group selector for the origination of a two-way call, and are called toll recording trunk originating (TRTO).

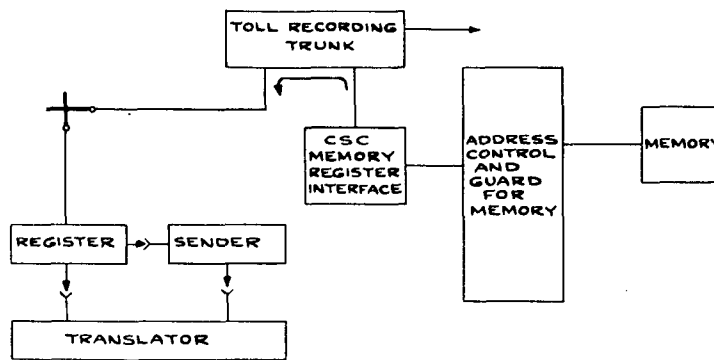


Fig. 10.

When an operator requests a TRT, the originating marker selects an idle TRTO and causes it to place a call signal to the TSD link marker. At the same time the originating marker signals the TSD link marker that no position is available except the one requesting a TRT. This causes a connection to be established between the TRTO and the requesting desk.

The marker is arranged to process calls according to call class. Five of the desks in the system have provisions for controlled class exclusion and can be used for the training of inexperienced operators. For example, a desk can be controlled by the chief operator to receive only station-to-station operator-identified DDD calls. This relatively simple type of call can be handled fairly easily by an inexperienced operator. After sufficient experience is gained by that operator another class can be opened to her desk, and she can advance to the next step. There are ten possible call classes that can be excluded from the five desks.

Queue Circuits

In order to best serve the subscribers who require the assistance of an operator a queuing arrangement is provided. Queuing comes into play when all operators are busy and not available at the time when a new call requires assistance. The queue-circuit equipment gives new calls a position in the waiting line so that they may be served in the order in which they arrive. There are two queue positions; each has a capacity of 10 calls. Theoretically then, 20 calls can be waiting in queue. The queue positions, however, cannot deliver calls out of queue while they are conditioned to receive calls. Therefore, the gate to the queue position is closed as soon as there is an absence of a call signal; calls arriving after the gate has closed are directed to the alternate queue position. The gate for the alternate queue position will remain open either until it is either filled or until the first queue position becomes empty. The queue positions continue to alternate; one is receiving calls while the other is delivering calls to operators' desks as they become available. Each call that is waiting in queue contains a class identity mark. If a restricted desk (controlled class exclusion)

becomes available, the queue control circuit may bypass the established order of priority to extract a call that is class marked in accordance with the available restricted desk.

SYNCHRONOUS PULSE SIGNALING

The TSD system employs a time division signaling scheme to transmit various information between circuits which are linked together by relatively small DC links. This signaling system, the synchronous pulse, has 24 time slots, each with a pulse width of approximately 125 μ s.

The signal pulse is a positive potential and is coupled to a common signal wire with a diode. The receiving point is equipped with a gate and amplifier circuit. Each gate is connected to a specific time slot reference signal for one of its inputs, and to the common signal wire for the other input. When the receiver gate detects a pulse on the signal wire that corresponds with its reference signal, it turns on the amplifier and operates a relay. The gate will latch and remain on until its reference signal appears during the next cycle. The first half of the reference pulse is a negative potential which will turn off the gate. If the signal pulse reappears during the second half of the reference pulse, the gate will turn back on. If it does not appear, the gate will remain off. The relay that is being controlled by the gate is slow enough that it will not be affected by the 50- μ s off periods, and since the entire cycle frame is only 3 ms, no serious problems exist in relay operate or release timing.

This signaling method provides a very convenient means of coordinating the circuits in a system that employs several links. For example, Fig. 11 illustrates the system configuration of all the major circuits and how they are linked together. The TRT is linked to a position control and the register circuit via a three-stage five-wire link. The TRT also has a connection to a given memory system, where its call data will be stored. The position control circuit must be kept informed of the memory status of the TRT to which it is attached. Each time that the memory is seized the data status for the associated TRT is checked, and the results are transmitted to the

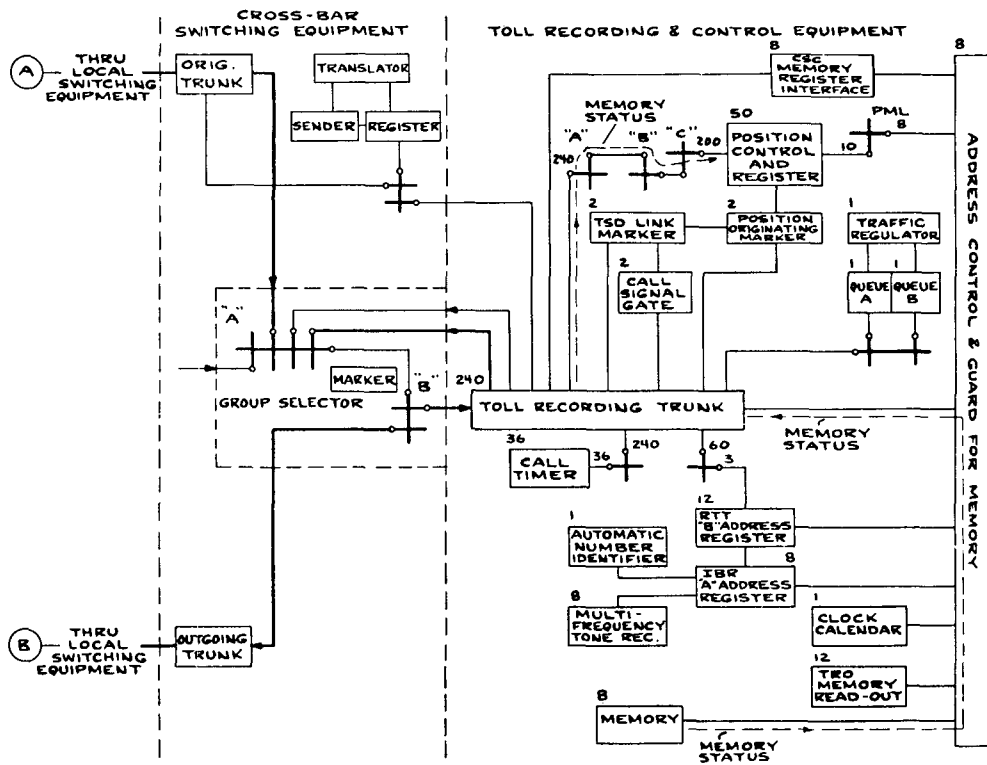


Fig. 11.

position control circuit, via the synchronous pulse signaling system over one of the wires in the link. Note that the synchronous pulse signals can be superimposed over an existing DC circuit and can be coupled from one DC path to another by means of a capacitor. Any number of signals up to the capacity of 24 can be used at relatively the same time and can be sent from either or both ends of the connection.

COIN STATION CONTROL AND TIMING

The handling of coin station calls presents one of the most difficult problems in a system such as this. To begin with, the charges for a call from a coin station must be collected while the user is still at the station. The charges for these calls vary according to both the distance called and the conversation time and must be calculated for each call. Since the conversation time cannot be determined prior to the establishment of the call, the total charges are not known until its completion.

Normally, the minimum time for a given call is three minutes; therefore, the collection for the three-minute initial period can be made as soon as the call is established. Conversation time beyond the initial period is charged on a per-minute basis and can only be collected after the fact. There are two basic methods that can be used to time calls which are charged to paystations. The first method, which is very simple from the standpoint of equipment, is to let the operator hold the call on her position for the duration of conversation and manually

record the time. This method is used presently on the older cord-type tollboards. It is not, however, consistent with the objectives established for the TSD system. The second method is to let the machine do the timing, calling in an operator only when manual functions are required.

To provide the facilities for timing and control of paystation charged traffic, a pool of call-timer circuits can be equipped. The call-timer circuit has the facilities to time the initial period, as well as overtime periods of up to ten minutes. Therefore, the operational procedure is as follows. First, the initial-period charge is deposited upon the establishment of the call; the original operator then releases the call from her position. Second, at the end of the initial period a new operator is connected, and the call timer indicates to her that the initial period has lapsed; she extends this notification verbally to the user and releases the call from her position. Third, at the end of ten minutes overtime or call disconnect (whichever is first) a new operator is connected. The call timer indicates that charges are due and, through the position display, informs the operator of the overtime minutes for which charges are to be made. If the call was not completed by this time, the operator would release from the call, and the call timer would monitor the time for another ten minutes.

It should be noted that upon determining the charge rate for the call the original operator keys a rate reference code into the memory. This three-digit code is used in conjunction with the operator's card file to obtain overtime charge information. The rate reference code is dis-

played with the overtime minutes each time an operator is connected for the purpose of collecting overtime charges.

The call-timer circuit also includes facilities for transmitting in-hand coin control signals for the collect, refund, and rering operations to prepay coin stations. The synchronous pulse signaling system, described earlier, transmits the commands from the operator's control keys to the call timer to generate the appropriate in-hand control signal. The call timers are accessed by the TRT via a full availability link, and there is a maximum of 36 circuits in the pool.

The TSD system can be equipped with a coin rate computer which eliminates the requirement of calculating charges manually. On applications where a large percentage of coin station traffic exists the rate computer would be economically feasible. However, in the average installation coin station "sent-paid" traffic amounts to less than 5 percent of the total traffic, and in many cases the cost of the added feature cannot be justified.

CONCLUSION

The TSD system has been installed in several toll centers around the country. The performance reports indicate that the system has achieved or surpassed the established objectives. The flexibility and convenience of the desk operations simplifies the training of operating

personnel, and conversion from the older cord-type toll-boards to TSD operation has been made with comparative ease. It is not intended to claim that the TSD is an ultimate system but that it is a startling improvement over past systems. Our limited experience with the system has brought to light areas where additional operational improvements can be made. This, plus the neverending increase of new customer services and advancements in the state of the art, makes continuing research and development mandatory.



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He served in the U. S. Air Force during the Korean conflict and then in 1954 joined North Electric Company, Galion, Ohio, as an Engineer, working in the design and development of DDD and automatic toll recording systems. He was Manager of the Toll Systems Design Section during the development and introduction of the TSD system and currently is Director of the Switching Systems Design Department,

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Correction to "Computer-Aided Design Optimization of FDM-FM Communication Systems"¹

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Equation (10) on page 410 should have read:

$$N_{ft} = \frac{D}{S} \frac{b_c}{BB} \frac{L_{rms} r_{et}}{I_{pf}}$$

Equation (12) on page 410 should have read:

$$T = 2.68L\theta_1\theta_2 \left[\left(\frac{\theta_1 + \phi_1}{\theta_1} \cdot \frac{\theta_2 + \phi_2}{\theta_2} \right) + 1 \right].$$

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