PUB 41703

Bell System

TECHNICAL REFERENCE

86A1 AND 86A2 DATA SELECTIVE CALLING SERVICE STATIONS

JUNE 1969

326-541

Bell System Data Communications

TECHNICAL REFERENCE MANUAL

86A1 and 86A2 Data Selective Calling Service Stations

June 1969

ENGINEERING DIRECTOR - DATA COMMUNICATIONS

NOTICE

This Technical Reference is specifically intended for the developers and designers of business machine data terminal equipments and devices which interface with Bell System data communications equipment and for technical consultants for use in designing data communications systems and arrangements employing Bell System data communications services and equipments. The right to revise this Technical Reference for any reason, such as conformity with USASI, EIA, CCITT or other standards, to utilize new advances in the state of the technical arts, or to reflect changes in the design of the equipment and/or service described herein is expressly reserved.

If further information is required, please contact:

Engineering Director – Data Communications
American Telephone and Telegraph Company
195 Broadway
New York, New York 10007

TABLE OF CONTENTS

List of Figures

86A1 AND 86A2 HDX DATA SELECTIVE CALLING SERVICE STATIONS

1. INTRODUCTION

New, 4-row private line half-duplex data selective calling service station arrangements have been developed by the Bell System for data services. The 86A1 stations provide for 100-word-per-minute operation using 33- and 35-type teletypewriter equipment. The 86A2 stations provide for 150-word-per-minute operation using 37-type teletypewriter equipment. Both types of stations employ the same on-line operating procedure and control dialogue using the USA Standard Code for Information Interchange (USASCII), USAS X3.4 – 1967.

As illustrated in Figure 1, these stations may be employed in multipoint systems that are controlled by a customer-provided computer. The line control station (computer switcher) governs the selection of stations for sending and receiving. Compared to existing Bell System half-duplex selective calling service stations, such as the 83B types, the 86A half-duplex stations offer an improved system operation and a widely expanded list of station and system features.

In the past, the design of half-duplex selective calling service stations has been dependent on the inherent capabilities of the terminal device employed. This has generally resulted in narrowly defined operating systems that are not readily adaptable to modern computer-oriented systems. In the case of the 86A half-duplex stations, however, the design has employed solid state electronic technology to provide station arrangements that are more flexible in their operational capabilities because they perform the required, on-line administrative functions independent of the terminal equipment. The 86A station control logic offers a variety of features to maintain the flexibility required to adapt to computer-controlled systems that may employ somewhat different operational procedures.

The normal operation of 86A-type stations permits the line control station (computer switcher) to (1) pick up messages from a selected sending station, or (2) deliver messages to one or more selected receiving stations, or (3) cause the transmission of a selected sending station to be received directly by one or more selected receiving stations on the line as the message is being transmitted by the originator. In brief, the line control station "polls" the individual outlying stations in turn asking each station whether or not it has traffic to send. The outlying stations respond, when polled, with discrete indications of their traffic-to-send status. When a station is selected to send, it transmits a start of heading indicator and stops. The line control station may then send any information that is to be printed at the selected sending station (e.g., a time and date or message number record) before reinitiating the transmission from the selected sender. The selected sending station then sends the entire heading of the message to the line control station and stops.

The heading contains the address information of those stations that have been designated by the originator as recipients for this message. The line control station translates the address information into the appropriate station call-in codes, in the process of which it can verify the validity of the heading information. If the message is intended for other stations on the same line, the line control station normally selects the required receiving stations by initiating the call-in process before having the selected sending station transmit the text of the message, to enable delivery of the message directly from the originator to the available, intended receivers. This method of operation, when applicable, makes most efficient utilization of the line, because the line is used only once to accomplish both the pickup and the delivery of the message. If the message is not intended for delivery to stations on this line at this time, or if it is desired (option) to treat all message handling transactions in the same way, the call-in process is by-passed and the originator's transmission to the line control station is caused to resume.

The "call-in" process used for message delivery consists of the line control station asking each of the addressed receiving stations on the line individually in turn whether or not it is ready to receive the message. The outlying stations respond, when called, with discrete indications of their ready-to-receive status. Stations that respond ready-to-receive to call-in, automatically become selected receivers. In the case of stations that respond not-ready-to-receive to repeated call-in attempts, the line control station invokes the message intercept routine being employed in the system. When all of the available addressed stations on the line have been called in, the line control station unblinds all selected receivers, and either instructs a selected sending station to resume transmission, as previously

mentioned, or initiates delivery of a message of its own.

In the case of a selected sending station, the originating station then sends the text of the message directly to all selected receivers, and stops upon detection of the end-of-message indicator. The line control station may then perform a "roll-call" function to determine the satisfactoriness of the delivery before releasing the selected receivers and instructing the originating station to resume transmission. The originating station will then send either the start-of-heading indicator of another message or the end-of-transmission indicator and stop. In the case of a multiple message pickup (selected sending station sends start-of-heading indicator and stops), the line control station must then take the appropriate action, as indicated earlier, to deliver a possible time and date or message number record to the originator and to reinitiate the transmission from the selected sending station in order to get the heading information of the next message. In the case of a termination of transmission (selected sending station sends end-of-transmission indicator and stops), the selected sending station will automatically assume the idle, unselected condition. The line control station may then proceed to poll the next station in the polling round, looking for another station with traffic to send, or it may proceed with a delivery of its own by initiating the call-in process.

It will be possible to associate customer-provided equipment with 86A stations in two ways. First, a customer-provided computer switcher (CPT) may be employed as the line control station for 86A stations.* The operational flexibility of the Bell System outlying stations is such that, in general, the final definition of available system features can be those attributable to the line control station itself. This adaptability allows a certain amount of tailoring of the station operation to fit the particular system needs.

* A standard 150 Baud Private Line Channel interface arrangement will be used. Reference should be made to:

Bell System Data Communications Technical Reference 150 Baud Private Line Channels Interface Specification February 1968

which is available from:

Engineering Director – Data Communications
American Telephone and Telegraph Company
195 Broadway
New York, New York 10007

Second, a customer-provided terminal (CPT) may be employed in place of the Bell System teletypewriter equipment as the terminal device at an outlying station. This arrangement will be offered for service at such time as the 86A station control logic is available with an appropriate EIA-RS232B interface. The 86A station logic is designed to accommodate this permissive change in terminal device equipments. This arrangement would retain the 86A station control logic to handle the polling and call-in functions of the system.

In its final form, this technical reference will include all of the detailed information that is required to enable customer-provided equipment to be associated with 86A stations in either of the arrangements listed above. This preliminary issue of the technical reference, however, supplies only that information required for programming a computer switcher as the line control station. The type of information it contains includes a brief description of the salient features of the Bell System teletypewriter outlying station and how the station control logic operates, a review of the on-line signal characteristics of the 86A stations, and a detailed examination of the operational aspects of 86A stations.

2. GENERAL CHARACTERISTICS OF 86A STATIONS

The 86A stations incorporate many features that are not now available with existing Bell System teletypewriter selective calling service stations. Some of these features that directly or indirectly affect on-line operation are described briefly in this section to aid in understanding the capabilities that are available and the limitations that apply when 86A stations are employed in half-duplex selective calling systems controlled by customer-provided computer switchers.

Figure 2 illustrates the general organization of the 86A station. The teletypewriter terminal device serves as the source and sink for administrative signals. The teletypewriter terminal device is not actively involved in the logic organization of the station, but provides the stimuli required by the station control unit regarding traffic-to-send and ready-to-receive conditions. The station control unit includes all of the character detection and character generation capability required, along with the necessary logic, to accommodate the on-line administrative procedures of the system. This separation of machine and control results in a versatile station arrangement and accounts for many of the new features available with the 86A stations.

An 86A1 station may employ either 33- or 35-type teletypewriter equipment as the terminal device. An 86A2 station employs 37-type teletypewriter equipment as the terminal device. Both the 86A1 and 86A2 stations will be available in station arrangements that employ (1) an automatic send-receive (ASR) terminal, (2) a receiving-only page printer (RO) terminal, or (3) a receiving-only tape punch (ROTR) terminal. In the case of arrangements (1) and (2), it will also be possible to employ an auxiliary receiving device (RO or ROTR) as a slave to the primary terminal. This auxiliary receiver may be cut on and off during any message delivery under on-line signal control. Under certain conditions it will also be possible to use the tape punch of the ASR as an auxiliary receiving device.

When an auxiliary receiving terminal device is employed, its cut on and cut off is normally accomplished within the text of a message as a part of the message delivery process and, hence, requires no special administrative action on the part of the line control station. The control character DC2 (Device Control 2) in text will cut on the auxiliary receiving device. The control character DC4 (Device Control 4) in text or the control character ETX (End of Text) at the end of the text will cut off the auxiliary receiving device. However, when it becomes necessary to abort a message delivery, the computer switcher will have to act to insure that an auxiliary receiving device that is in the cut-on state at the time of the delivery abort is cut off so that a subsequent message delivery to that station will not automatically commence with the auxiliary receiving device in the cut-on state. A DC4 or ETX included as a part of a delivery abort service message will bring about the required auxiliary receiving device cut-off function.

The typical message sent by an 86A station has the following format:

S		S		E
O	Heading	T	Message Text	T
H		X		X

There is a heading section that contains the addresses of those stations that are to receive the message text, and there is a section that contains the message text itself. The control characters SOH (Start of Heading), STX (Start of Text), and ETX (End of Text) are message format delineators that are used to define the beginning and the end of the different elements of the message. The 86A stations are arranged to stop transmission upon detection of these control characters to permit the line control station to perform possible operating functions that may be desired for the particular system application (e.g., delivery of time and date or message number records, call-in of intended receivers on the same line, or roll-call of selected receivers in order to verify adequacy of message delivery). A number of messages may be grouped together to form a single "transmission" that will be picked up as a result of a single poll. The end of a transmission is delimited by the control character EOT (End of Transmission) following the ETX of the last message.

The 86A stations offer "continuous tape" operation such that it is not necessary that the station operator tear the tape and handle pieces of tape in the normal operation of the station. The station control logic automatically insures that a transmission is available before giving a traffic-to-send response to polling. Whenever the 86A station is in the IDLE condition and the proper conditions exist at the station (including an operator-initiated bid-for-service), the station control logic causes the tape reader at the station to advance through any DELETE characters used to physically separate transmissions in tape until the SOH character that delineates the start of the heading of the first message in the transmission is detected. Only then will the station control logic respond affirmatively to polling. The subsequent transmission by the station on line will then be an SOH character followed by the heading as prepared by the originator. This feature offers two obvious advantages. First, since the DELETE characters used to separate transmissions in the tape, or to provide a tape leader, are discarded off line, the line control station need not be arranged to take any special action on leading DELETES as a result of a poll. Second, by discarding such intertransmission "fill characters as an overlap operation off line, better

utilization is made of the available line capacity for actual message traffic.

The operator-initiated bid-for-service function (mentioned above) can result from either the deliberate operation of an attendant control at the station by the station operator, or as a natural by-product of the normal tape preparation process. The attendant control would be employed whenever the tape to be transmitted either was prepared when the station was in an "off-line" mode of operation (in order to have local copy at the time of preparation), or had been prepared on some other machine or at some other time, and hence, is being processed as a foreign torn tape. The station control logic would then depend on the detection of a tape-out condition indicating the end of a foreign torn tape, or a taut-tape condition, indicating that there is no more prepared tape to transmit, to reset the manually initiated bid-for-service condition. The bid-for-service function obtained as a natural by-product of the normal tape preparation process requires that the operator prepare tape blind (without local copy) concurrent with the transmission or reception of other traffic. A differential EOT counter in the station control logic increments an EOT count each time an EOT is generated from the keyboard (during blind tape preparation) and decrements the EOT count when an EOT is transmitted. As long as the EOT count is not zero, the station control logic will exercise the search-for-SOH function (mentioned above) whenever the station is in the IDLE condition. When the SOH character is detected, the response to polling will be a traffic-to-send response. When the EOT count falls to zero, the station control logic will stop the search-for-SOH function and will give a no-traffic-to-send response to polling independent of whether there is tape in the tape reader or not.

The 86A stations are capable of giving either of two types of affirmative responses to a poll – "regular traffic available" or "priority traffic available." This capability permits system organization such that selected traffic can be qualified by the station attendant as being more important from a precedence of pickup standpoint than other traffic in the system. An attendant control is provided at 86A stations that, when operated, conditions the station control logic to respond to polling with the "priority traffic available" response in place of the "regular-traffic available" response. There is no automatic insertion of a priority indication in the message itself as a result of this action, although one could be put in by the attendant to govern the treatment to be accorded it if the desired system operation required it. The use made of this feature is up to the program organization since the difference between the two responses can obviously be ignored within the program structure.

The 86A station response to polling is designed also to include information pertaining to the readiness of the receiving terminal device at the station to receive. Such information obtained as a response to polling can be useful in determining whether or not a delivery to the station responding should be attempted at this time or not. Again, this type of information can be ignored by the system program if it is of insufficient value to the particular system implementation planned. However, the computer switcher must be prepared to accept such information from the station as a part of a polling response, whether use is made of it or not.

With 86A station operation, a selected sending station sends the entire heading section of the message to the line control station (computer switcher) and stops. The computer switcher is then responsible for translating the addresses in the heading into the necessary individual station call-in codes (unless the call-in codes themselves are used as addresses) and performing the call-in of receiving stations for delivery of the message. There is no direct call-in of receiving stations by an originating outlying station. The 86A station control logic is transparent to what is in the heading portion of a message. Therefore, the addressing capability that can be employed in any system is governed only by the capabilities of the computer switcher. Consequently, in most applications, multi-character mnemonic addresses can be employed to advantage to increase the meaningfulness and capacity of station addressing, and user-assigned message numbering and delivery precedence indicators, for example, can be employed to expand the feature capability of system operation.

The call-in (selection) of receiving stations, on the other hand, involves the use of single character station call-in codes only. The call-in operation involves asking each intended receiver individually whether it is ready to receive and receiving a discrete response concerning its readiness to receive. Group or broadcast call-in codes are not available with the 86A stations. Stations will be arranged to respond to one and only one station call-in code. Group and broadcast address codes may be employed by the user in the message heading, if desired, but they must be translated into individual call-in codes by the computer switcher before the process of selecting receivers begins. The call-in operation is so arranged that as each selected receiving station responds to

call-in that it is ready to receive, it alone is unblinded. Hence, it is possible to deliver separate information to each addressed station during a multiple station call-in process without other selected receiving stations receiving it. A system unblind code function is provided so that when the call-in process has been completed all selected receiving stations will receive the message text delivery at the same time.

Because of the separation of machine functions and control functions in the station organization, it is possible to exercise motor control and turn off the teletypewriter motors whenever the associated station equipment is not directly involved with message preparation, pickup or delivery. This may be a very desirable feature at locations that principally receive traffic, thereby resulting in a considerably quieter environment. However, having such a feature means that sufficient time must be allowed during the call-in process to permit the motors of the receiving terminal devices to attain proper operating speed before data signals are sent on the line. The 86A station control logic does not provide explicitly for such a timing function in connection with its response to a call-in. Consequently, the computer switcher must be programmed to provide the required timing when motor control at 86A stations is employed. Detailed information concerning the timing required for teletypewriter motors to get to proper operating speed is given in Section 3.7 – Timing Considerations.

A new and potentially useful feature of the 86A station is its ability to indicate at the end of a message delivery whether or not the message was received properly. This feature is called roll-call. The indication is in the form of a unique, discrete response given to a call-in type operation performed at the end of the message delivery. The 86A station control logic bases its decision on whether a message delivery is good or not on such things as message format checks, machine operation checks, and service continuity checks.

Another important feature of the 86A stations that may be quite useful in connection with providing secure service with computer switcher operation is the use of the Station Identity Check as a part of the call-in and roll-call processes to increase the probability of message delivery to the proper station. Each receiving station can be assigned a discrete Station Identity Code that is different than its call-in code. Since Station Identity Codes are integral parts of the responses to call-in and roll-call functions, the computer switcher can check that the proper stations have been selected to receive before proceeding with the message delivery, and that the proper station is responding with respect to the satisfactoriness of the message delivery.

3. ON-LINE SIGNAL CHARACTERISTICS

A computer switcher employed as a line control station should have the following on-line signal characteristics in order to be compatible with 86A1 and 86A2 outlying stations.

3.1 CODE

The transmission code employed on-line should be USAS X3.4-1967, the USA Standard Code for Information Interchange (USASCII). This code is illustrated in Figure 3.

3.2 TRANSMISSION SPEED

Acceptable transmission speeds are 100 wpm (10 characters per second) when 33- or 35-type teletypewriter terminals, or combinations thereof, are employed in 86A1 stations, or 150 wpm (15 characters per second) when 37-type teletypewriter terminals are employed in 86A2 stations.

3.3 CHARACTER STRUCTURE

At the operating speed of 100 wpm (10 char/sec.) the on-line character structure should be 11.0 units – a 1.0 unit start pulse, seven 1.0 unit information bits, a 1.0 unit parity bit, and a 2.0 unit stop pulse. Even parity should be employed for all characters transmitted on-line.

At the operating speed of 150 wpm (15 char/sec.), the on-line character structure should be 10.0 units – a 1.0 unit start pulse, seven 1.0 unit information bits, a 1.0 unit parity bit, and a 1.0 unit stop pulse. Even parity should be employed for all characters transmitted on-line.

3.4 BIT ORDER

Transmission of information bits within a character should be low order bit first. The parity bit is considered to be the eighth bit following the start pulse.

3.5 DISTORTION REQUIREMENTS

The computer switcher should transmit data with less than 5 percent telegraph distortion. Likewise the computer switcher should be capable of

accepting incoming signals with up to 40 percent telegraph distortion. In cases where the computer switcher is unable to meet the above requirements, special engineering will be required.

The above values represent long-term objectives for acceptable sending and receiving telegraph distortion tolerances on 150 baud private-line transmission channels. As the state of the art improves, it is anticipated that these sending and receiving distortion requirements will become 3 percent and 45 percent, respectively.

Detailed information concerning these distortion requirements is covered in the document referred to earlier.

Bell System Data Communications
Technical Reference

150 Baud Private Line Channels
Interface Specification
February, 1968

3.6 BREAK SIGNAL

A BREAK signal is available to the computer switcher for interrupting transmission from a sending station. This signal is not included in the USASCII character code set. To generate a BREAK signal, the computer switcher should send a minimum of 400 milliseconds and a maximum of 750 milliseconds of continuous spacing signal. An outlying station that is sending will stop transmission upon detection of a BREAK signal.

3.7 TIMING CONSIDERATIONS

This section provides information concerning the various timing considerations that a computer switcher should observe when operating as the line control station.

3.7.1 Station Motor Turn On

The use of automatic motor control at an 86A receiving station requires that the computer switcher provide sufficient time after a call-in function to allow the teletypewriter motors to attain proper operating speed before data signals are delivered to the station. Otherwise, erroneous characters are likely to be detected and acted upon by the receiving teletypewriter. As mentioned in Section 2.0, the outlying station control logic does not provide for a delay in the response to a call-in function when the receiving teletypewriter motor is off.

Under worst case conditions, it takes 750 milliseconds for a teletypewriter motor to attain proper operating speed. Taking into account the two-character response to the call-in, but ignoring any propagation delay, the computer switcher, should wait, after receipt of the two-character response, for a minimum of 650 milliseconds for 150 wpm operation and a minimum of 550 milliseconds for 100 wpm operation, maintaining a steady marking condition on the line, before sending any information intended for the called-in receiver. This will allow sufficient time for the motor in any of the various types of receiving teletypewriter terminals that may be employed to attain the proper operating speed.

If several stations are being called in and there is a need to deliver separate information to each station during the call-in process (e.g., terminating message numbering), the computer switcher should introduce this delay, after the call-in of each station. However, if there is no need for separate information to be delivered to each station during the call-in process, then this delay need be employed only once, after the call-in of the last station.

3.7.2 Transmission Turn Around

During the normal system operation, there will be various times when the computer switcher will receive data signals from the outlying station indicating that the computer switcher should assume the role of sender. These data signals are broadly referred to in this document as "transmission turn around" signals.

Typical examples of such signals are responses to polling or call-in functions, and the EOT character denoting the end of a transmission. At such times that a "transmission turn around" signal is received, the computer switcher must exercise care that its transmission does not begin before the line is idle and the outlying stations are in a condition to receive data signals.

The operation of the teletypewriter terminal at the outlying station demands that each transmitted character be sent in its entirety, including the full specified stop interval, before the teletypewriter can act on the next character to be sent or received correctly. Consequently, even though the computer switcher may detect a "transmission turn around" character during the receipt of the parity bit and be ready to transmit before that character interval has been completed, it must wait for at least the entire prescribed character interval to be expended, including the total stop pulse interval,

before initiating any outward transmission. If transmission was forthcoming from the computer switcher before the teletypewriter at the outlying station had acted on the entire stop pulse, the teletypewriter station would be likely to lose synchronism. It is suggested that, as a positive safeguard to insure that the line is truly idle, the computer switcher allow for receipt of at least 30 milliseconds of continuous marking after receipt of the parity bit of the supposedly last character of the "transmission turn around" signal before sending to the line.

3.7.3 One-Character Buffer Delay

In order to provide screening of received characters so only pertinent information is delivered to the terminal device, the outlying station control unit incorporates a one-character buffer store. Each character received is "pushed through" to the terminal device by the next character received. Consequently, whenever transmission of message text from the computer switcher to an outlying station is to be halted for some period of time either to allow for a mechanical operation by the terminal device (e.g., tabulation or form feed) or because a natural end of the information stream has been reached, the computer switcher should send at least one character to act as a "pushing character" to insure that the last information text character reaches the terminal device. This type of "pushing character" is required after each of the following control codes:

HT – Horizontal Tabulation
VT – Vertical Tabulation
FF – Form Feed

A "pushing character" is also required after any message number, time and date record, or equivalent sent to the outlying station during the call-in or roll-call operations.

In the cases cited above, a suitable and suggested "pushing character" is the DELETE character.. This is the character that is normally used as a timing character when the aforementioned control codes are generated by an outlying station. However, for computer-switcher generated messages, the next regular printing character can be employed as the "pushing character" after HT, VT, and FF control codes since it will stay in the buffer storage at the outlying station until it is pushed through by the resumption of transmission. In certain cases, a control code may even be employed to serve the pushing function and at the same time pass along desired control information. An example of this might be the use of the End of Text character (ETX following a FF character at the conclusion of a message delivery.

3.7.4 Outlying Station Mechanical Functions

Timing is required after various machine control functions to allow time for the teletypewriter terminal device to complete the necessary mechanical operation. Perhaps the most often used function of this type is the carriage return – line feed function. When performing this function at an operating speed of 150 wpm, two fill characters, or their equivalent, are required following the carriage return (CR) character to allow sufficient time for the maximum physical return of the typing mechanism. The line feed (LF) character provides one of these timing character intervals. The other may be a timed interval of continuous marking or a DELETE character. It is suggested that the computer switcher adopt the policy of always sending the sequence CR LF DEL when executing this function to allow sufficient time for the carriage return function to be completed independent of the type of teletypewriter terminal or the transmission speed employed.

In the case of those systems that employ teletypewriter terminals equipped with the "New Line" feature where both the carriage return function and the line feed function are executed upon receipt of a single control character (LF), two DELETE characters, or an equivalent interval of continuous marking signal, are required at an operating speed of 150 wpm to allow sufficient time for the maximum physical return and proper positioning of the typing mechanism. Therefore, when the "New Line" feature is employed, it is suggested that the computer switcher adopt the policy of always sending the sequence LF DEL DEL when executing this function independent of the type of teletypewriter terminal or the transmission speed employed.

The timing required for the tabulation and form feed functions varies according to the tab settings and length of form employed. Therefore, it is not possible to specify here the exact timing intervals required for these functions. However, it is possible to indicate the operating speeds for the tabulation and form feed functions for the various teletypewriter equipments that may be employed in 86A stations. This information is given in terms of the number of spaces or lines moved per character interval during the execution of the indicated function. The following chart indicates these values:

Terminal Device	Tabulation		Form Feeding
	Horizontal	Vertical	
33	–	–	6:1*
35	3:1	6:1*	6:1*
37	3:1	3:1	3:1

These figures mean, for instance, that the 37-type teletypewriter printing mechanism moves three spaces during a character interval in the process of horizontal tabulation. Thus, knowing the settings for tabulation and form feed functions employed in the system, the computer switcher can be programmed to provide the timing required for each function. This timing can either be quite exact based on the amount of mechanical movement required to complete the operation from the point of execution, or it can be gross based on the maximum mechanical movement possible for the particular function.

3.7.5 Response and Intercharacter Time-Outs

Timing is required in the computer switcher in the form of gross time-out functions to signify when certain time intervals have been expended waiting for particular events to occur. Two such timing intervals are inquiry response time-outs and intercharacter time-outs.

With the electronic station control unit used with teletypewriter terminals at outlying stations, the responses to inquiries, such as polling, call-in and roll-call, can be expected within the limits of the transmission delay time for the system layout. Under almost all circumstances, a time-out interval for this function having a minimum of 600 milliseconds should be quite satisfactory.

It is suggested that an intercharacter time-out interval be employed by the computer switcher on text received from an 86A station, long enough to allow the operator at the outlying station time to clear a taut tape or twisted tape condition without losing control of the line. A recommended timing interval for this function is approximately 30 seconds. An intercharacter time-out of this magnitude is required if the HOLD feature available with 86A stations is to be employed in the system (see Section 4.8 – HOLD Feature).

* The 33- and 35-type teletypewriters can be modified to have vertical tabulation and form feed ratios of 3:1 instead of 6:1, as applicable. Thus, the feeding ratios for any system application should be verified before programming time intervals to permit such mechanical functions.

4. DETAILED SYSTEM OPERATIONAL PROCEDURES

This section covers the allowable operational aspects of an 86A station and describes the features, capabilities, and limitations that exist. This material is organized such that it generally follows the logical sequence of events illustrated in Sequence Chart SC1. This sequence chart should be referenced to aid in the understanding of the station operation being described.

The 86A stations may employ an intraline mode of operation such that a message is delivered to addressed receivers on the same line at the time it is transmitted by the originating station. Alternatively, or in addition, traffic may be handled in an interline mode of operation such that messages are picked up by the control station as one operation and then delivered by the line control station later as a separate operation. In this document, these three operations will be referred to as intraline operation, message pickup operation, and interline delivery operation, respectively. This distinction is made to aid in the understanding of the various operational procedures suggested for each of these situations.

The following sections provide an orderly presentation of both the required and the optional operating features available with the 86A outlying station. Principal emphasis is placed on the type of information required to program the operational aspects of the system.

4.1 SYSTEM INITIALIZATION – IDLE STATE

When the power is turned ON at an 86A station, the station control logic will automatically become activated and assume the "idle" state. In this condition the station control logic will be sensitive to line signals and will become selected to send or selected to receive if the proper signals are detected. Because it is possible for noise on the line to generate such signals, it is recommended that at the time of initial system turn-on, or at any other time after the line has been left in the idle state for an extended period, the computer switcher checks to see that the line is idle incoming to it before proceeding with the system operation.

If the incoming line is not idle, the computer switcher should initiate an emergency stop action (see Section 4.12 – Emergency Stop) to silence the incoming line and to get all elements of the system in step with one another. The computer switcher should then send the control character EOT

(End of Transmission) to insure that any receiving elements in the system not in the "idle" state (e.g., selected to receive) return to the "idle" state and that all station elements are initialized to perform their operations in step with the computer switcher.

With the system in the "idle" state the computer switcher can –

(1) Proceed with the polling operation looking for stations with traffic to pick up (see Section 4.2 – Polling Operation and Responses),

(2) Proceed with the call-in operation to initiate a message delivery (see Section 4.6 – Call-In Operation and Responses), or

(3) Although less desirable, do nothing and leave the line in the "idle" condition.

4.2 POLLING OPERATION AND RESPONSES

The computer switcher initiates the polling operation by sending the control character DLE (Data Link Escape). This character will define the beginning of polling and will activate the appropriate logic in the 86A stations. The computer switcher should then send the station polling code (SPC) of the station to be polled and wait for a response from the station. The SPC for each station should be a single character chosen from the set of printing graphics* in ASCII. The only characters not available for use as SPCs are R, P and +. These three characters are required to provide specific station functions that are described elsewhere in this document.

The response received as a result of this polling operation may be any of the following five types:

(1) A single-character, no-traffic-to-send response,

(2) A two-character, regular-traffic-to-send response,

(3) A two-character, priority-traffic-to-send response,

(4) An invalid response, or

(5) No response at all.

The reaction of the computer switcher should be somewhat different for each of these possible responses.

1. No-Traffic-To-Send Response

   There are two, single-character, no-traffic-to-send responses, depending upon the ready-to-receive status of the receiving element at the station. The control character CAN (Cancel) indicates that the station has no traffic to send, but that its receiving element is ready to receive. The control character NAK (Negative Acknowledge) indicates that the station has no traffic to send, and that its receiving element is not ready to receive. An 86A station will respond to polling with one of these two no-traffic-to-send responses whenever there are no completed transmissions ready to send.

   It is suggested that, when either of these two responses is received, the computer switcher send the SPC of the next station to be polled. There is no need to resend the DLE character to redefine a polling operation, although repeating the DLE character will not adversely affect 86A station operation.

2. Regular-Traffic-To-Send Response

   There are two, two-character, regular-traffic-to-send responses, depending upon the ready-to-receive status of the receiving element at the station. The two-character sequence R ACK (ACK = Control Character Acknowledge) indicates that the station has regular traffic available, and that its receiving element is ready to receive. The two-character sequence R NAK indicates that the station has regular traffic available, but that its receiving element is not ready to receive. An 86A station will respond to polling with one of these two regular-traffic-to-send responses whenever it has traffic to send and the PRIORITY key on the station attendant unit has not been operated.

   An 86A station responds to polling without becoming selected as a sender. A separate sending-station-selection function is

* To facilitate testing of a station, preference should be given to assigning the larger of the printing graphics first (e.g., alpha-numerics, $, &, etc., over punctuation marks such as the period, comma, etc.)

required in order to assign selected status to the station. This type of operation then allows the computer switcher to poll to determine which and how many stations have traffic ready to send before selecting a sender (status polling). Also, it allows the pickup of all traffic from stations indicating "priority traffic available" before accepting any traffic from stations indicating "regular traffic available."

If the computer switcher does not make a distinction between regular and priority traffic available conditions, then the computer switcher, upon receiving a "regular traffic available" response, should proceed to the sending-station-selection function (see Section 4.3 – Definition of End of Polling). If the computer switcher does distinguish between regular and priority traffic available conditions, then it is suggested that the computer switcher, upon receiving a "regular traffic available" response, send the SPC of the next station to be polled, as in the case of a no-traffic-to-send response, looking for a station with priority traffic available before deciding to select a station with regular traffic available.

3. Priority-Traffic-To-Send Response

There are two, two-character, priority-traffic-to-send responses, depending upon the ready-to-receive status of the receiving element at the station. The two-character sequence P ACK indicates that the station has priority traffic available, and that its receiving element is ready to receive. The two-character sequence P NAK indicates that the station has priority traffic available, but that its receiving element is not ready to receive. An 86A station will respond to polling with one of these two priority-traffic-to-send responses whenever it has traffic to send and the PRIORITY key on the station attendant unit has been operated.

Since an 86A station responds to polling without becoming selected as a sender, a separate sending-station-selection function is required in order to assign selected status to a station. Under most circumstances the receipt of a "priority traffic available" response will mean that the computer switcher should proceed to the sending-station-selection function (see Section 4.3 – Definition of End of Polling). If for some reason a station giving a "priority traffic available" response is not to be selected to send, the computer switcher can proceed with the polling function by sending the SPC of the next station to be polled, as in the case of a no-traffic-to-send response.

4. Invalid Response

An invalid response is any response that is not one of the six previously defined responses – CAN, NAK, R ACK, R NAK, P ACK, or P NAK. If the invalid response takes the form of a single– or two–character response, it is suggested that the computer switcher repoll the station in question by sending DLE, to redefine the polling operation, followed by the SPC of that particular station. The assumption is that the first response was legitimate but had been affected by noise on the line in such a manner that the computer switcher could not recognize it as a valid response.

If the invalid response takes the form of continuous transmission from an outlying station, it is suggested that the computer switcher initiate an emergency stop action (see Section 4.12 – Emergency Stop); send an appropriate service message to the station to explain the reason for this action, follow any system defined trouble reporting routine, and start the polling process over again with the last station polled.

If repeated invalid responses are received from a particular station, it is suggested that the computer switcher initiate the emergency stop action, send an appropriate service message to the station to explain the reason for this action, follow any system defined trouble reporting routine, and start the polling process over again with the next station in the polling round.

5. No Response

The computer switcher should employ a response time-out function that will provide it an indication when expected responses are not received within some specified time interval. Responses from

86A stations can be expected within 600 milliseconds under most circumstances.

It is suggested that in the case of a no-response time-out the computer switcher repoll the station in question by sending DLE followed by the SPC of that particular station. Since there was no response of any kind, it is probably not necessary to initiate an emergency stop action as in the case of an invalid response. It is assumed that what most likely happened is that when the DLE or the SPC was sent the first time it was affected by noise on the line in such a manner that none of the stations recognized it as a station polling code.

The 86A stations are designed always to include the status of the receiving element at a station as part of the normal polling responses. This information is provided as an aid to the computer switcher in determining whether or not it is worthwhile attempting a delivery to the receiving element at a station. Since stations are probably more often polled than called in for delivery, inclusion of such information in the polling response provides the computer switcher with a more up-to-date picture of the status of receiving elements in the system. This information need not be employed in its intended fashion, but the computer switcher should be arranged to accept the information and determine the proper traffic-to-send status of a polled station from the contents of the polling responses.

4.3 DEFINITION OF END OF POLLING

As stated earlier the control character DLE defines the beginning of the polling operation. There are two ways to define the end of the polling operation. First, if it is desired merely to terminate the polling operation and return all sending stations to the "idle" state, the computer switcher should send the control character EOT (End of Transmission). Upon detection of this code all stations will assume the "idle" state. Second, when a response to polling indicates that an 86A station has traffic to send, and its traffic is to be picked up at this time, the computer switcher defines the end of the polling function by initiating a sending-station-selection function. For this, the computer switcher should send the control character ENQ (Enquiry) followed immediately by the Call Enquiry Code (CEC) of the sending station to be selected. The receipt of the two-character sequence by the sending station designated by the CEC will cause that station to assume the selected sending state (see Section 4.4 – Stop on SOH for Delivery to Sending Machine Printer). Subsequent transmission of a DC1 code (Device Control 1) as a part of the normal operation will then define the end of polling for all other stations on the line.

With the use of the status poll concept described above, it is possible that the computer switcher knows that a sending station has traffic to send and, therefore, may wish to initiate a sending-station-selection function without actually polling and receiving responses from the station. To initiate a direct sending-station-selection function without going through the poll-response routine, the computer switcher must first initiate the polling operation in the standard way by sending the DLE code. Then the computer switcher can send the ENQ CEC sequence to select the desired sending station. The subsequent transmission of the DC1 code, as required in the normal operation, will then define the end of polling for all other stations on the line.

4.4 STOP ON SOH FOR DELIVERY TO SENDING MACHINE PRINTER

As described above, the computer switcher selects a sending station by sending the two-character sequence ENQ CEC while in the polling state. If, having sent the ENQ CEC sequence, the computer switcher receives either an invalid response or no response from the outlying station within the system response time-out (recommended, 600 milliseconds), it is suggested that the computer switcher send DLE ENQ CEC to redefine polling and reselect the sending station designated by the CEC. If repeated attempts to start the transmitter or obtain a valid response are unsuccessful, it is recommended that the computer switcher initiate an emergency stop action (see Section 4.12 – Emergency Stop), send an appropriate service message to the station to explain the reason for this action, follow any system defined trouble reporting routine, and reactivate the polling function with either the next station to be polled or the next station to be selected as a sending station.

Independent of the station's original response to polling, it now may or may not have traffic to send. If it has no traffic to send at the time it is selected (because, for example, tape has been removed from the reader or the station has been taken out of service), the station control logic will send the control character NAK. The computer switcher can then proceed with another polling function, or send EOT and leave the stations in the "idle" state.

If the selected sending station has traffic to send at the time it is selected, it will send the control character SOH and stop. There will be no DELETE (fill) characters preceding SOH.

The stop on SOH is provided for two reasons. First, it allows the computer switcher to acquire the storage necessary to handle the traffic pickup at the last possible moment so that blocks of storage are not held available, but unused, during the entire polling operation. Second, stopping on SOH provides a convenient place during the traffic pickup operation to implement the optional delivery of a time, date, or message number record, or the like, to the selected sending machine printer so that it will appear first on the local copy at the sending station.

The computer switcher should send the control character DC1 (Device Control 1) after having received the SOH from the selected sending station. The DC1 code terminates the polling function (as mentioned earlier) and also causes the selected sending station to unblind its printer so that any information that follows will be printed thereon. The computer switcher may then send information (e.g., an originating message number) to the selected sending machine printer.

If there is no need to deliver information to the selected sending machine printer, the computer switcher should proceed with the pickup of the heading from the station after the DC1 code is sent.

4.5 PICKUP OF HEADING

To initiate transmission of the heading by the selected sending station, the computer switcher should send the control character STX (Start of Text).

If, having sent the STX code, there is no response from the outlying station within the system response time-out period (recommended, 600 milliseconds), it is suggested that the computer switcher send the STX code again. If repeated attempts to start the transmitter are unsuccessful, it is recommended that the computer switcher initiate an emergency stop action (see Section 4.12 – Emergency Stop,) send an appropriate service message, to the station to explain the reason for the action, follow any system defined trouble reporting routine, and reactivate the polling function with either the next station to be polled or the next station to be selected as a sending station.

Normal 86A station operation will be to begin transmission of the heading portion of the message when the STX code is detected. The station control unit will subsequently stop the station transmitter automatically when it detects that the STX code in the tape (defining the end of the heading portion of the message) has been sent to the computer switcher.

The station's stopping on STX allows the computer switcher to validate the contents of the heading and to call in any receiving stations on that line that might have been designated as addressees in the heading. Thus, stopping on STX allows intraline operation when the text of the message is to be received by selected receiving stations while it is being sent by the originator.

If there are no receiving stations on this line designated as addressees for this message, or if intraline operation is not being employed, the computer switcher should initiate the resumption of transmission by the selected sending station by sending the STX code (see Section 4.7 – Pickup and/or Delivery of Text). If there are receiving stations on this line designated as addressees for this message and intraline operation is being employed, the computer switcher can initiate the call-in process (see Section 4.6 – Call-In Operation and Responses) to select the addressed receivers.

4.6 CALL-IN OPERATION AND RESPONSES

The Call-In Operation may be initiated by the computer switcher as a result of a heading received in an intraline operation, or it may be initiated from the "idle" state for an interline delivery operation where the computer switcher is going to originate an outgoing message. In either case it is recommended that the computer switcher preface the call-in process by sending the control character EOT (End of Transmission) to insure that all receiving stations are in the "idle" state. Call-in involves calling each intended receiving station individually and receiving a response indicating its ready-to-receive status.

To initiate the call-in function, the computer switcher should send the control character ENQ (Enquiry). This character defines the beginning of a call-in function, blinds any previously selected receiving stations, and activates the appropriate logic in each outlying station to look for the Call Enquiry

Code (CEC). The computer switcher should then send the CEC of an intended receiving station, and wait for a response from the called station. The CEC for each station should be a single character chosen from the set of printing graphics* in ASCII, with the exception of R, P and +. Since an 86A station requires detection of the sequence ENQ CEC in order to become selected, the computer switcher must send the ENQ with each CEC generated.

The response received as a result of a call-in operation may be any of the following four types:

(1) A two-character, ready-to-receive response,

(2) A two-character, not-ready-to-receive response,

(3) An invalid response, or

(4) No response at all.

The action of the computer switcher should be somewhat different for each of these possible responses.

(1) Ready-To-Receive Response

The ready-to-receive response is the two-character sequence SIC ACK, consisting of a Station Identity Code (SIC) followed by the control character Acknowledge (ACK). The receipt of a ready-to-receive response means that the called-in station has assumed the selected-to-receive state, is unblinded, and will copy any information sent to it. Since, as was mentioned earlier, the ENQ code used as a part of the call-in sequence blinds all other selected stations, it is possible to deliver separate information to each selected receiving station when it is called in without other selected stations recording it. A terminating message number is an example of such per station information.

A Station Identity Code can be any character chosen from the set of printing graphics* in ASCII, with the recommended exception of R and P (to avoid possible confusion with their use in polling responses). By choosing a different CEC and a different SIC for each station in a given system, the computer switcher can undertake an additional verification, if desired, to further insure that the proper stations are selected for each message delivery. This verification can be performed by matching the received SIC with the one that the computer switcher has stored as being paired with the CEC that was sent. With over 90 different graphics available for both CECs and SICs, over 8100 stations can be handled by a given computer switcher before it becomes necessary to repeat any CEC-SIC combination.

(2) Not-Ready-To-Receive Response

The not-ready-to-receive response is the two-character sequence SIC NAK. This response can result from the receiving station being out of paper, out of service, etc. The decision as to what is done with messages that cannot be delivered at the time of initial call-in is dependent entirely on the computer switcher and how it is programmed.

As in the case of the ready-to-receive response, the inclusion of SIC as part of the not-ready-to-receive response allows the computer switcher to verify that the not-ready-to-receive response actually came from the station that was called.

(3) Invalid Response

An invalid response to call-in is any response that does not fulfill the requirement of the correct SIC in combination with ACK or NAK. The recommended courses of action that may be taken by the computer switcher upon receipt of an invalid response depend on the nature of the invalid response, whether an intraline operation or an interline delivery operation is being employed, and whether or not other receivers have already been selected.

In the case of an invalid response received to the call-in of the first (or only) addressee, it is suggested that the computer switcher simply send the EOT code to terminate the call-in process, regardless of the nature of the invalid response, and then repeat the call-in operation to insure selection of the correct station. The EOT

* To facilitate testing of a station, preference should be given to assigning the larger of the printing graphics first (e.g., alpha-numerics, $, &, etc., over punctuation marks such as the period, comma, etc.).

code will de-select any possibly selected receiving station(s) and set the stage for a new call-in attempt. This procedure is the most straightforward and is equally applicable to both an intraline operation and an interline delivery operation.

Because it is not possible to selectively de-select one selected receiving station without de-selecting all selected receiving stations, the following procedures may be employed when an invalid response is received to the call-in of a station after one or more stations have already been selected, in order to avoid having to repeat the entire call-in process in all cases. If the invalid response is a SIC NAK response with the wrong or unintelligible SIC, it means that the wrong station responded to the call-in. However, since it was a NAK response, the station that responded is not selected. Therefore, it is suggested that the computer switcher ignore such a SIC NAK response and repeat the attempt to call-in the intended receiver. If the invalid response is a SIC XXX response with the correct SIC but an unintelligible ACK or NAK, it is suggested that the computer switcher repeat the call-in of the intended receiver to determine whether or not it is ready to receive. Stations that have already been selected will not be affected by such repeated call-in attempts.

If the invalid response is a SIC ACK response with the wrong SIC (or a XXX ACK response with an unintelligible SIC), it means that an incorrect receiving station has been (or may be) selected and will receive the message if it is transmitted. The action to be taken by the computer switcher depends on whether or not it is deemed acceptable to deliver this message to a wrong (or potentially wrong) station in addition to the intended stations. If it is deemed that the message can be delivered to this station in addition to the intended receiver, the computer switcher may send a "Disregard This Message – Selection Error" record at this time to the incorrectly (or potentially incorrectly) selected station to label the delivery at that station alone without having this record appear on the copy at any other selected station, and then proceed with the rest of the call-in operation. If, on the other hand, it is deemed that the message cannot be delivered to an incorrect station, the computer switcher can de-select this plus any previously selected receiving stations, without alarming the selected receiving stations, by sending the EOT code and then repeating the entire call-in operation. If per station information had already been sent to the previously selected receiving stations, it would not be necessary to include this information again as a part of a repeated call-in of those stations de-selected by the EOT code. If an explanation for this selection and almost immediate de-selection is required, the computer switcher can send the sequence ENQ DC2, to unblind all of the selected receiving stations, and deliver such a message before the EOT code to de-select all of the selected receiving stations and return them to the idle state. The call-in operation can then be repeated in preparation for the intended message delivery. In the case of an interline delivery operation where the delivery is to be made by the line control station, the computer switcher can, alternatively, activate a local alarm at the incorrectly selected receiving station, as well as at any correctly selected receiving stations, by initiating an emergency stop action (see Section 4.12 – Emergency Stop) with an appropriate service message, to perform the de-select function. In the case of an intraline operation (delivery to be made by a selected sending station), however, the use of the emergency stop action is not recommended because it would also de-select and alarm the selected sending station and require operator intervention before that sending station could again be selected to transmit.

If an invalid response should take the form of continuous transmission, it means that a selected sending station has been falsely started. To stop this erroneous transmission and then proceed with the business at hand, the computer switcher should initiate an emergency stop action (see Section 4.12 – Emergency Stop), send an appropriate service message to the stations involved to explain the reason for this action, follow any system defined trouble reporting routine, and then proceed as follows. In the

case of an interline delivery operation (delivery to be made by the line control station) the computer switcher should reinitiate the call-in process to select the intended receiving stations once again for the message delivery to be made. In the case of an intraline operation (delivery to be made by a selected sending station) the computer switcher should return to the polling function with either the next station to be polled or the next station to be selected as a sending station, since the emergency stop action de-selected any selected sending station.

(4) No Response

The computer switcher should employ a response time-out function that will provide it an indication when expected responses are not received within some specified time interval. Responses from 86A stations can be expected within 600 milliseconds under most circumstances.

It is suggested that in the case of a no response time-out the computer switcher repeat the call-in by sending the sequence ENQ CEC for that particular station again. Since there was no response of any kind, it probably is not necessary to de-select selected receiving stations as in the case of an invalid response. However, if desired, the de-selecting procedure can be employed in the case of no response to call-in. It is assumed that what most likely happened in the case of no response is that when the sequence ENQ CEC was sent it was affected by noise on the line in such a manner that none of the stations recognized it as its call-in code sequence.

After all of the available addressees have been called in and after any separate information for each selected receiving station has been delivered during the call-in process, the computer switcher should send the sequence ENQ DC2 to unblind all selected receiving stations. The computer switcher may then send any information that is to be common to all selected receiving stations. The date and time record is a possible example of such common information. The computer switcher should then initiate the delivery of the message text to the selected receivers (see Section 4.7 – Pickup and/or Delivery of Message Text).

4.7 PICKUP AND/OR DELIVERY OF MESSAGE TEXT

There are three situations that can require initiation of the pickup and/or delivery of message text function by the line control station. The first is the case of a message being picked up by the line control station from a selected sending station with no intraline delivery at the time of transmission (message pickup operation). The second is the case when a selected sending station is to deliver a message directly to selected receivers on this line at the time of the message pickup by the line control station (intraline operation). The third is the case of a message delivery by the line control station to receivers on this line that have been selected by the call-in process (interline delivery operation).

For each of the above situations the computer switcher initiates the pickup and/or delivery of the message text by sending the STX code. If what is involved is an interline delivery operation, then the computer switcher itself should follow the STX code with the message text. If it is either a simple message pickup operation or an intraline operation, involving a selected sending station, then the STX code will cause the selected sending station to resume transmission, sending the message text. In the case of an interline delivery operation or an intraline operation, all of the selected receivers will copy the message text as it is being transmitted.

If, in the case of a simple message pickup operation or an intraline operation, after the computer switcher has sent the STX code, there is no response from the outlying station within the system response time-out (recommended, 600 milliseconds), it is suggested that the computer switcher send the STX code again. If repeated attempts to start the transmitter are unsuccessful, it is recommended that the computer switcher initiate an emergency stop action (see Section 4.12 – Emergency Stop), send an appropriate service message to the station to explain the reason for this action, follow any system defined trouble reporting routine, and reactivate the polling function with either the next station to be polled or the next station to be selected as a sending station.

In the case of an interline delivery operation, transmission of the message should proceed through the ETX (End of Text) code and stop. In the case of a transmission from a selected sending station (message pickup or intraline operations), the selected sending station control unit

will stop the station transmitter when the ETX code has been transmitted. This stopping on ETX will then allow the line control station to:

(1) Perform a Roll-Call function of selected receivers to validate the adequacy of a delivery in an intraline operation or an interline delivery operation (see Section 4.9 – Roll-Call Operation & Responses), or

(2) Interject the delivery of any line control station originated information to the selected receiving stations in an intraline operation or an interline delivery operation (see Section 4.9 – Roll-Call Operation & Responses), or

(3) Regulate the transmission of multiple messages from a selected sending station as the result of a single poll in a message pickup operation or an intraline operation (see Section 4.11 – Single and Multiple Message Transmissions).

Because of the HOLD feature and because it is possible for tape in a transmitter to become taut or twisted accidentally during its transmission, thereby causing the transmitter to stop, it is recommended that a minimum intercharacter time-out interval of 30 seconds be employed to measure periods of unauthorized interruption in traffic pickup before corrective action is taken by the computer switcher. When corrective action is required, it is recommended that the computer switcher initiate an emergency stop action (see Section 4.12 – Emergency Stop), send an appropriate service message, follow any system defined trouble reporting routine, and reactivate the polling function with either the next station to be polled or the next station to be selected as a sending station.

During the pickup of traffic from a selected sending station, it is recommended further that the computer switcher monitor for receipt of repeated characters from a station. Such a check will then uncover an unlikely, but possible, stuck tape condition at the selected sending station. Under such circumstances the computer switcher should employ the emergency stop action and follow the same procedures cited above.

If, in the process of a message pickup operation or an intraline operation, the computer switcher receives an EOT code from a selected sending station without an intervening ETX code, the incoming message format has been violated, and the validity of the traffic transmitted is in question. However, because of the EOT, the selected sending station, and any selected receiving stations are no longer selected, so the computer switcher cannot initiate an emergency stop action to deliver a service message to the affected stations. In order to inform the stations about the detected error in message format, the computer switcher will have to generate a message of explanation for delivery to the involved stations.

4.8 HOLD FEATURE

The 86A stations are arranged with a HOLD feature such that when a HOLD key control on the attendant unit is operated, the transmitting station, having stopped when the ETX code is transmitted, will activate a local alarm and will not resume transmission, upon command, until the operator releases the HOLD condition. The purpose of this feature is to allow the station operator to interject a tape of greater urgency than that being transmitted without relinquishing control of the line. Once the tape has been changed, the operator releases the HOLD key to cause resumption of transmission if (or when) the "go-ahead" command is received. The transmitter will then send until the SOH of the inserted message is transmitted, and will again stop in the normal fashion. By operating the HOLD key again the station attendant can cause the station to again activate the local alarm and refuse to resume transmission, upon command, until the operator releases the HOLD condition. The original tape can then be reinserted into the transmitter and the transmission operation returned to normal by releasing the HOLD key.

From the computer switcher viewpoint the only variance in this operation from what can normally be expected is that a station employing the HOLD feature may not respond immediately to a "go-ahead" command after ETX. There will be no response from the station during the period that the station is stopped and is in the HOLD condition. For system operations that utilize the HOLD feature, the computer switcher should be arranged to accept a possible response delay after ETX. The 30-second intercharacter time-out interval described earlier should provide ample time for the station attendant to perform the necessary exchanging of tapes. Therefore, to permit the use of this feature, it is recommended that the computer switcher invoke the 30-second intercharacter time-out function after sending the "go-ahead" command before treating this situation as a true no response condition and taking corrective action.

4.9 ROLL-CALL OPERATION AND RESPONSES

Roll-call is the performance of a call-in

operation of already selected receiving stations after the delivery of the ETX code at the conclusion of the message. Its primary function is to verify whether or not the selected receiving stations received the information sent to them. The 86A stations incorporate the roll-call capability, but it is not mandatory that the computer switcher implement it.

Roll-call involves calling each selected receiving station individually and getting a response indicating whether or not the message was properly received. When the ETX code defining the end of a message delivery has been sent, the computer switcher initiates a roll-call operation in the same way it initiates a call-in operation, by sending the control character ENQ. The ENQ code defines the beginning of a roll-call function, blinds all selected receiving stations, and activates the appropriate logic in each outlying receiving station to look for the Call Enquiry Code (CEC). The computer switcher should then send the CEC of a selected receiving station and wait for a response from that station. The CEC for each station that is used for roll-call should be the same as that used for call-in. Since the 86A stations require detection of the sequence ENQ CEC in order to respond, the computer switcher should send the ENQ with each CEC generated.

The response received as a result of a roll-call operation may be any of the following four types:

(1) A two-character, message-correctly-received response,

(2) A two-character, message-improperly-received response,

(3) An invalid response, or

(4) No response at all.

The reaction of the computer switcher should be somewhat different for each of these possible responses.

(1) Message-Correctly-Received Response

The message-correctly-received response is the two-character sequence SIC CAN, consisting of a Station Identity Code (SIC) followed by the control character CAN (Cancel). The receipt of a message-correctly-received response means that during the delivery of the message the various checks made by the receiving 86A station were satisfied (see Section 4.10 – Causes for Message-Improperly-Received Response).

Station Identity Codes can be any character chosen from the set of printed graphic characters* in ASCII, with the exception of R and P (to avoid possible confusion with their use in polling responses). As explained in the case of the call-in function, by choosing a different CEC and a different SIC for each station in a given system, the computer switcher can verify that the proper stations are responding for each message delivery. This verification can be performed by matching the received SIC with the one that the computer switcher has stored as being paired with the CEC that was sent.

Because the roll-call and call-in functions employ the same ENQ CEC sequence to request responses, the affirmative station responses have been designed to be different – SIC ACK for call-in and SIC CAN for roll-call. This then provides protection against a condition in which a selected receiving station fails to see the ETX code ending the message delivery and, hence, interprets the roll-call operation as another call-in. It also protects against conditions in which a temporary loss of carrier or commercial power failure causes the station to reinitialize in the "idle" state so that a roll-call function would appear to the station as a call-in. Under such circumstances, the computer switcher should treat a SIC ACK response as an invalid response to roll-call (see Section 4.9 (3)–Invalid Response).

(2) Message-Improperly-Received Response

The message-improperly-received response is the two-character sequence SIC NAK. This response means that during the delivery of a message one or more of the various checks made by the receiving 86A station were not satisfied (see Section 4.10 – Causes for Message-Improperly-Received Response). The computer switcher can record the receipt of this response and deal with the redelivery of the message to this station in the fashion prescribed for the particular system application.

* To facilitate testing of a station, preference should be given to assigning the larger of the printing graphics first (e.g., alpha-numerics, $, &, etc., over punctuation marks such as the period, comma, etc.).

The inclusion of SIC as a part of the message-improperly-received response allows the computer switcher to verify that the response received actually came from the station roll-called.

Even though the SIC NAK response means not-ready-to-receive to call-in and message-improperly-received to roll-call, there is no ambiguity concerning interpretation of a SIC NAK response to roll-call. If some anomaly has caused the station to interpret the roll-call as a call-in, then any condition that would cause a not-ready-to-receive response to a call-in function should be interpreted as a condition that would mean that the message was not received properly.

(3) Invalid Response

An invalid response to roll-call is any response that does not fulfill the requirement of a correct SIC in combination with CAN or NAK. Since the roll-call is intended to provide a receiving station interrogation function, it is suggested that the following procedures be followed when an invalid response is received.

If the invalid response takes the form of an undetectable one- or two-character sequence, it is suggested that the computer switcher roll-call the intended selected receiving station again by sending the sequence ENQ CEC for that particular station. The assumption is that the first response was legitimate but had been affected by noise on the line in such a manner that the computer switcher could not recognize it as a valid response.

If the invalid response is a SIC CAN, SIC ACK, or SIC NAK response with the wrong SIC, it is suggested that the computer switcher ignore the response and send the sequence ENQ CEC for the intended selected receiving station again.

If the invalid response is a SIC ACK response with the proper SIC, it means the station has interpreted the roll-call function as a call-in function and has become a selected receiving station. As mentioned earlier, this can happen if the selected receiving station is in the "idle" state when the roll-call operation takes place. The computer switcher should treat such a SIC ACK response as a SIC NAK response (message-improperly-received) and deal with the redelivery of the message to this station in the fashion prescribed for the particular system application. Since only this station is unblinded at this time, the computer switcher could send a statement indicating the condition that has occurred and advising the station that the message in question will be redelivered at some future time.

If the invalid response should take the form of continuous transmission, it means that a selected sending station has been falsely started. To stop this erroneous transmission the computer switcher should send the BREAK signal and then proceed with the roll-call function to acquire the desired validation-of-delivery responses. Upon completion of the roll-call function the computer switcher should then send the EOT code to de-select the selected receiving stations and then initiate an emergency stop action (see Section 4.12 – Emergency Stop) with an appropriate service message to explain to the selected sending station(s) the situation that was encountered.

(4) No Response

The computer switcher should employ a response time-out function that will provide an indication when expected responses are not received within some specified time interval. Responses from teletypewriter outlying stations can be expected within 600 milliseconds under most circumstances. It is suggested that in the case of a no-response time-out the computer switcher roll-call the station again by sending the sequence ENQ CEC for that particular station. It is assumed that what most likely happened is that when the sequence ENQ CEC was sent the first time, it was affected by noise on the line in such a manner that none of the stations recognized it as its roll-call code sequence.

After all of the selected receiving stations have been roll-called, the computer switcher can send the sequence ENQ DC2 to unblind all selected stations for the receipt of any information from the computer switcher that is to be common to all selected stations. A date and time record is a possible example of such common information.

The delivery of common information from

the line control station to all selected stations after the delivery of a message in an intraline operation or an interline delivery operation may be performed by the computer switcher either before or after any roll-call operation. When performed before a roll-call operation, it will not be necessary to send the ENQ DC2 sequence. This capability then permits the line control station to attach a system acknowledged "end of delivery" record to the message to serve as a means of validating that delivery. This record would appear on the copy at all selected stations. When a roll-call function is employed, the use of such an "end of delivery" acknowledgement would most logically follow the roll-call operation as described above.

To terminate the message delivery operation, whether interline or intraline, the computer switcher should send the EOT code after the roll-call process is completed, if employed, or should send the sequence ENQ EOT, if the roll-call process is not employed*, to cause all selected receiving stations to revert to the "idle" state. Then, in the case of an interline delivery operation, the line control station should initiate either the polling function or the call-in function, as appropriate, to handle the next order of business on the line. In the case of a message pickup operation or an intraline operation, the computer switcher should then send the STX code to restart the selected sending station transmitter (see Section 4.11 – Single & Multiple Message Transmissions).

4.10 CAUSES FOR MESSAGE-IMPROPERLY-RECEIVED RESPONSE

The 86A station will respond to the roll-call function with the message-improperly-received response SIC NAK if any of the following conditions have occurred since the station was selected.

A. A paper-out condition was detected on a sprocket-feed machine that resulted in part of the delivery being lost, or

B. The terminal device failed to respond to the received signals during delivery.

The computer switcher should be programmed to cope with a condition in which a selected receiving station repeatedly responds "ready-to-receive" to call-in but then responds "message-improperly-received" to roll-call. This can be the result of a station malfunction in which one of the checks performed during message delivery (e.g., check to see that terminal device responds to received signals) is not satisfied. Such a malfunction would not cause the station to assume a not-ready-to-receive status when idle, but would affect the validity status of messages received.

* The ENQ of the ENQ EOT sequence is necessary in a system that employs ROTR receiving stations, to initiate tape feedout.

4.11 SINGLE AND MULTIPLE MESSAGE TRANSMISSIONS

Transmissions from stations may consist of single messages or multiple messages. Multiple message transmission capability from a selected sending station is provided with 86A stations through the use of the stop-on-ETX feature described in Section 4.7 and the use of discrete and different codes to cause selected receiving stations to become unselected (EOT) and a selected sending station to resume transmission (STX).

Multiple message transmission capability allows the station attendant to decide how many messages the station should be allowed to send when it is polled. Administrative rules can be set up regarding the upper limit on the number of messages a station attendant may put in a transmission and this flow of traffic can be regulated by appropriate programming of the computer switcher. Hence, it would be possible to effectually provide a day-to-day, or even hour-to-hour, varying traffic pickup pattern to optimize the overall traffic pickup operation of the system.

Multiple message transmission capability also provides a more efficient means for picking up multiple messages from a given station than having to expend the line time required to repoll the station after each message pickup to determine the traffic-to-send status.

As stated earlier, to restart a selected transmitter at the end of a message transmission, the computer switcher should send the STX code. In the case of message pickup operation, the STX code should be sent following the receipt of the ETX code from the selected sending station. In the case of an intraline operation the STX code should be sent following the EOT code used to terminate the previous intraline delivery. The STX code will cause the selected sending station to resume transmission.

If, having sent the STX code, the computer switcher receives no response from the selected sending station within the system response time-out (recommended; 600 milliseconds if the HOLD feature is not used in the system, 30 seconds if the HOLD feature is permitted), it is suggested that the computer switcher send the STX code again. If repeated attempts to start the transmitter are

unsuccessful, it is recommended that the computer switcher initiate an emergency stop action (see Section 4.12 – Emergency Stop) with an appropriate service message, follow any system defined trouble reporting routine, and reactivate the polling function with either the next station to be polled or the next station to be selected as a sending station.

If there are more messages in the transmission, the selected sending station will likely send a number of DELETEs (possibly none) plus the SOH of the next message and stop. As in the case of the stop on the first SOH in the transmission, the computer switcher can now acquire the storage necessary to handle the additional message and can deliver information to the selected sending machine printer (see Section 4.4 – Stop on SOH for Delivery to Sending Machine Printer). The operation should then proceed with the pickup of the heading information as in the case of the previous message transmission.

If there are no more messages in this transmission, the selected sending station will send the EOT code, stop transmitting, and automatically assume the "idle" state. Upon detection of the EOT code the computer switcher should proceed with the polling function or the call-in function, as appropriate, to handle the next order of business on the line.

4.12 EMERGENCY STOP

An emergency stop function is available with 86A stations so the computer switcher can stop the traffic pickup in progress from a selected sending station in case an error condition or system irregularity is detected during the normal system operation and alarm all stations involved with the transmission. The 86A stations themselves are not capable of initiating emergency stop actions toward the computer switcher.

The complete message format for the emergency stop function is:

		D	D		E
BREAK	Pause	L	C	Service Message	O
		E	1		T

If necessary, the computer switcher interrupts any incoming transmission in progress by sending a BREAK signal (a minimum of 400 milliseconds and a maximum of 750 milliseconds of spacing signal) to the line followed by a PAUSE that consists of either at least one DELETE character or at least one character interval of continuous marking. The PAUSE is required in order to insure that the stations have regained synchronism before sending specific coded information on line. (It is the BREAK signal that actually stops a transmitting station and blinds all stations.) The computer switcher then sends the sequence DLE DC1 to alarm the selected stations and to unblind them for receipt of a possible service message. The DLE code defines the beginning of a polling function and activates the local alarms at the affected stations. The DC1 codes define the end of the polling function as far as all stations on the line are concerned so that the information in a service message will not be mistaken for SPCs.

In general, service messages can be quite helpful to the station attendant in clarifying the reason for the interruption, what action is being taken, and what to expect next. The computer switcher then sends the service message, explaining the reason for the interruption of traffic pickup, ending with the character EOT. The EOT code causes the selected stations to return to the unselected state. The selected sending station is locked in a no-traffic-to-send state until the EMERGENCY STOP lamp at the station is manually extinguished, indicating that the interrupted tape has been repositioned and is again ready for transmission.

4.13 LOOP-BACK

Loop-Back is an operating test mode wherein a selected 86A station will respond to control sequences (polling, call-in, etc.) in the normal fashion for that station, but will send back to the line all message text characters received. This function is provided to facilitate remote testing of outlying stations by Bell System maintenance personnel. It is not intended for use by customers. However, since it is possible for stations to get into this mode inadvertently by detection of a particular two-character sequence, it is mentioned here for the purpose of listing its symptoms and indicating how to return the system to normal.

The receipt of the character + anytime while in the polling state (after DLE but before an EOT or DC1) will cause an 86A station to assume the loop-back mode. The computer switcher can verify if one or more stations are accidentally in the loop-back mode by sending characters and checking to see if garbled information is being received with one character delay concurrent with the transmission. To terminate a possible loop-back condition, the computer switcher should send repeated EOT characters until there is no more garbled information being received on the incoming line. The computer switcher should then reinitialize the system and start over.

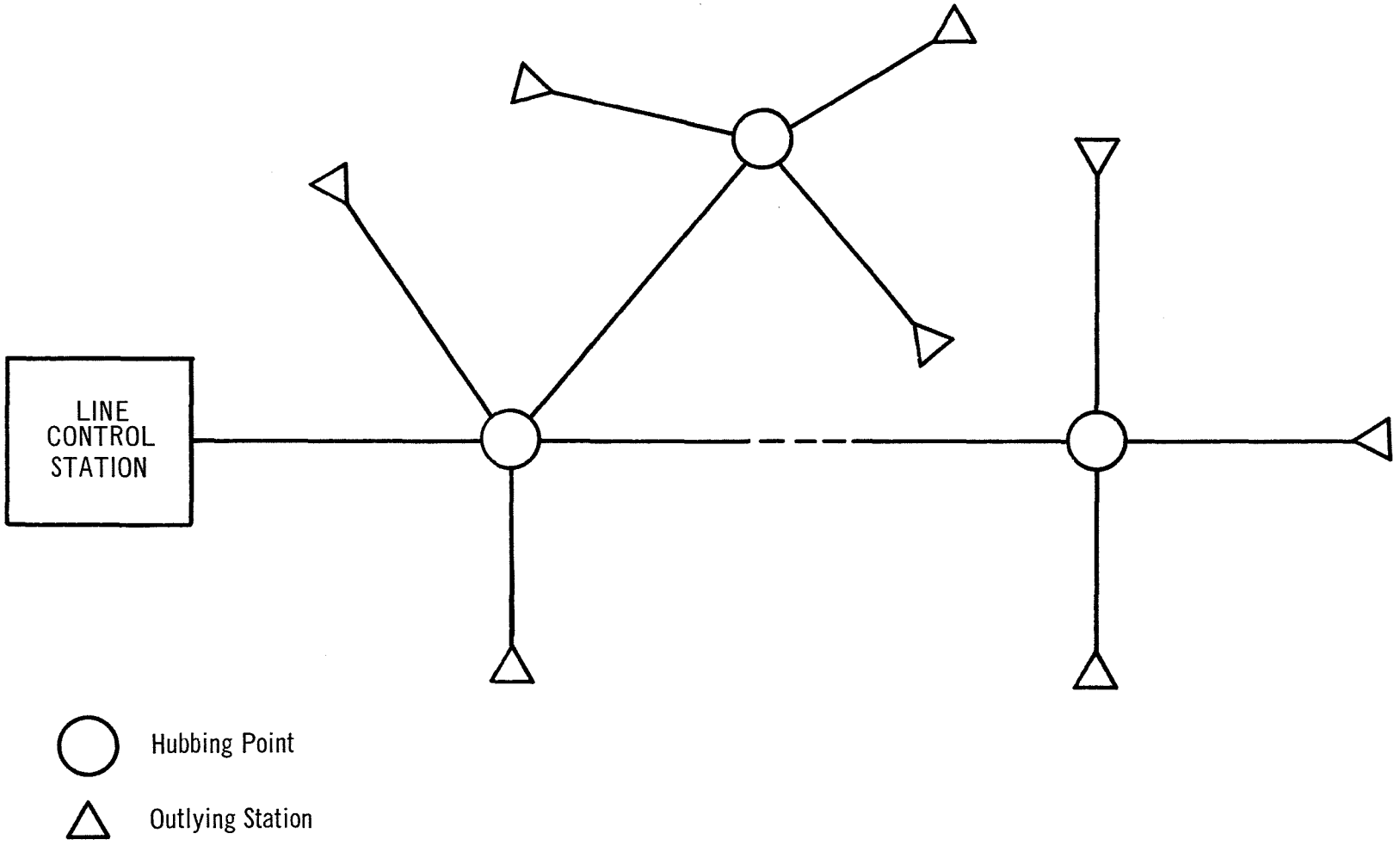


FIGURE 1 – BLOCK DIAGRAM REPRESENTATION OF TYPICAL 86A SYSTEM LINE

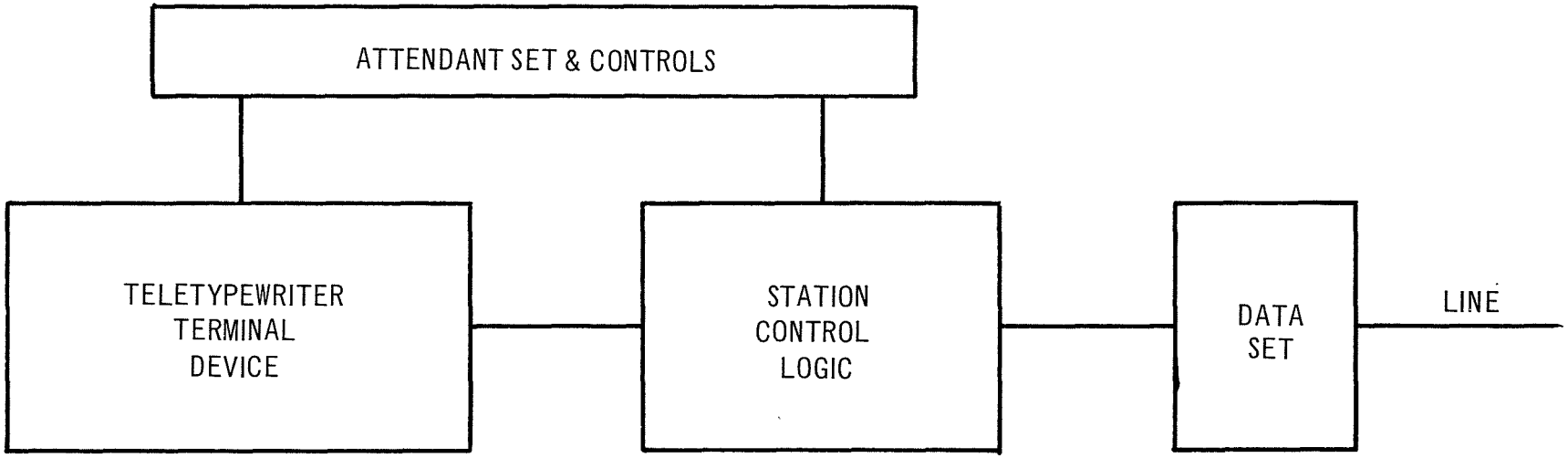


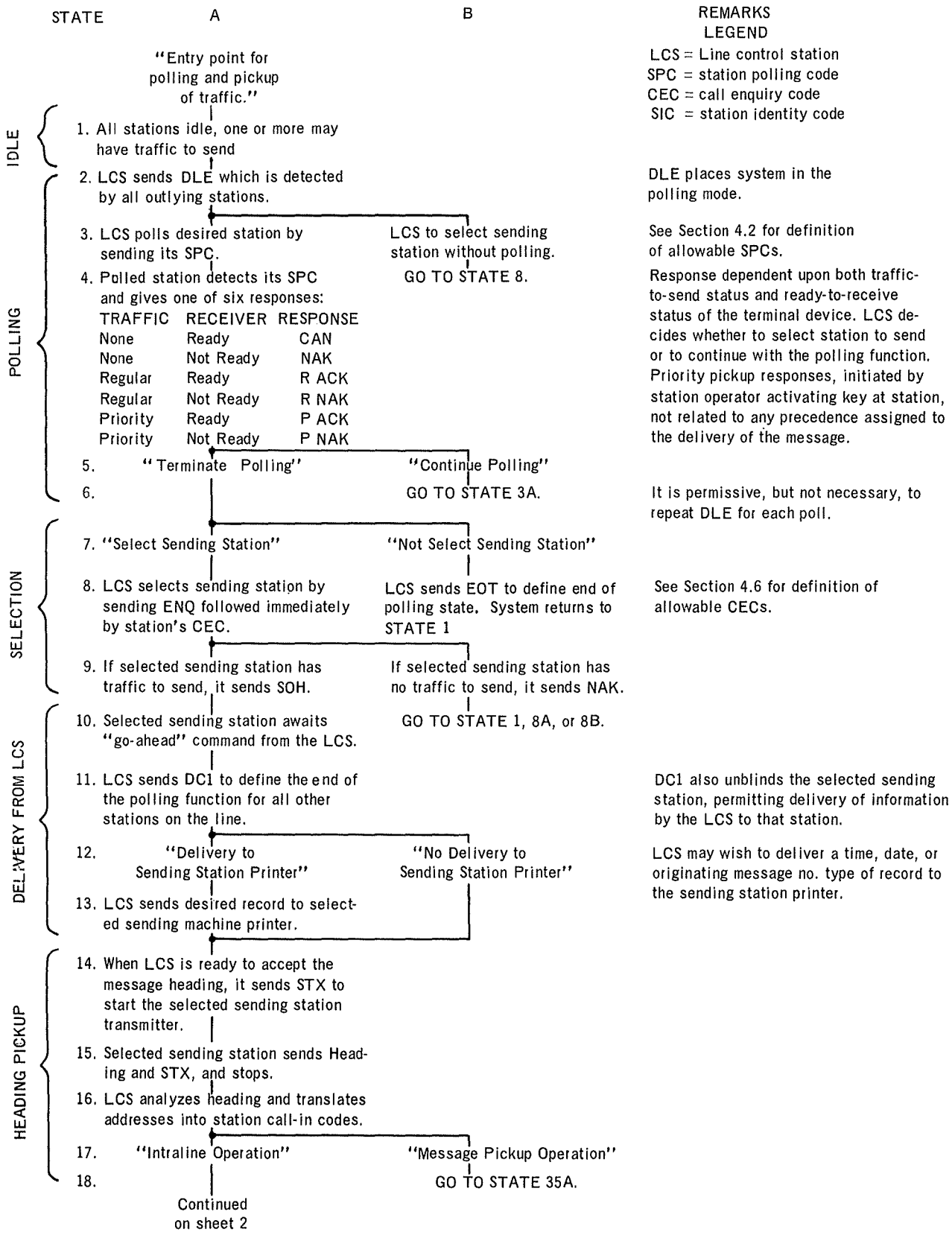
FIGURE 2 – BLOCK DIAGRAM REPRESENTION OF TYPICAL 86A STATION

USA STANDARD CODE FOR
INFORMATION INTERCHANGE
USAS X3.4 – 1967

b7 b6 b5 → / Bits b4 b3 b2 b1 ↓ / Row ↓ Column →	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
	0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SUB	*	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	K	{
1 1 0 0	12	FF	FS	,	<	L	\	l	|
1 1 0 1	13	CR	GS	-	=	M	]	m	}
1 1 1 0	14	SO	RS	.	>	N	^	n	~
1 1 1 1	15	SI	US	/	?	O	-	o	DEL

*Only columns 2 to 7 are normally printed with the exception of SP (space) and DEL (delete).

FIGURE 3

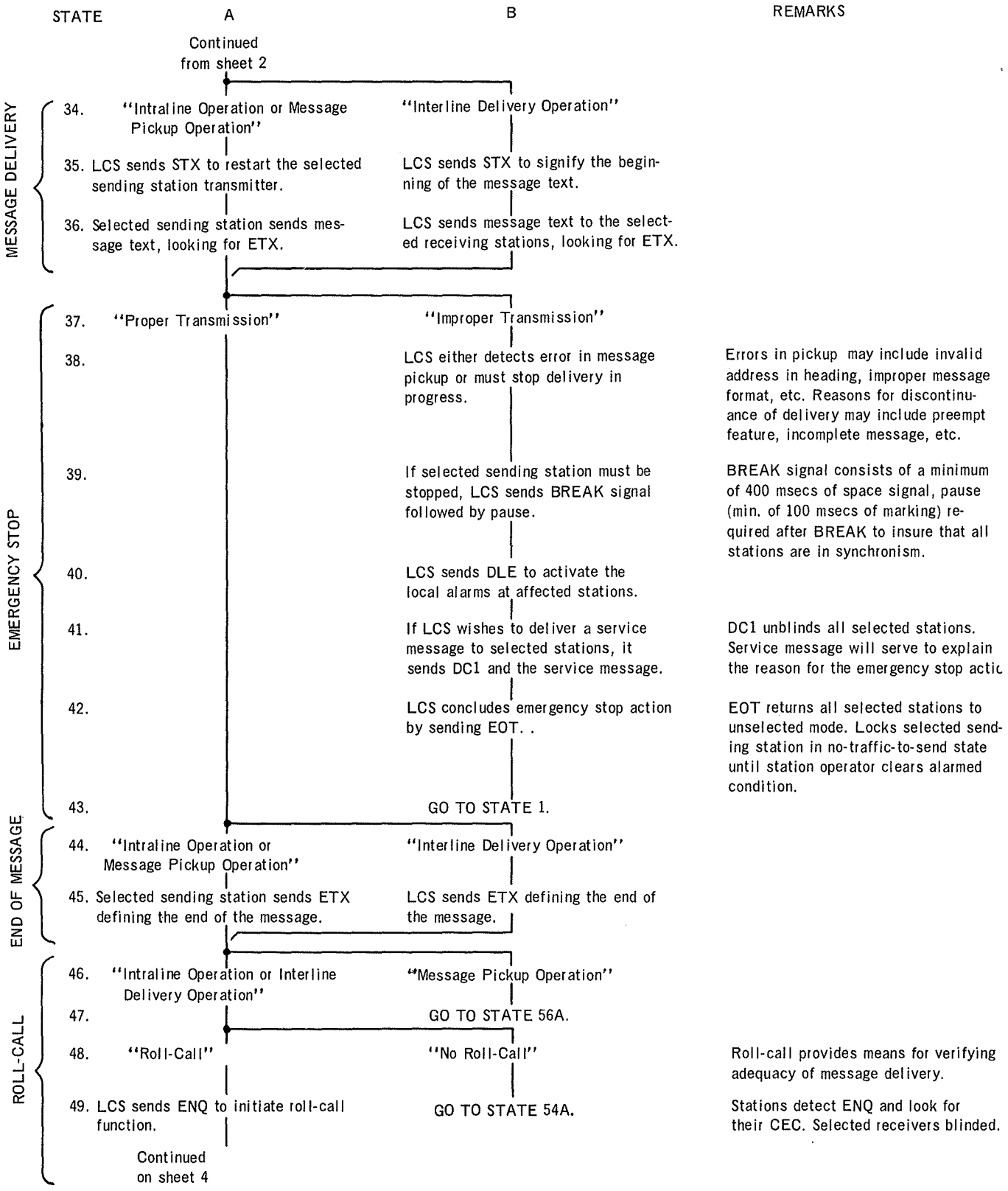


SC1 – SEQUENCE OF OPERATION FOR HDX 86A STATION WITH COMPUTER SWITCHER EMPLOYED AS LINE CONTROL STATION.

Sheet 1 of 4

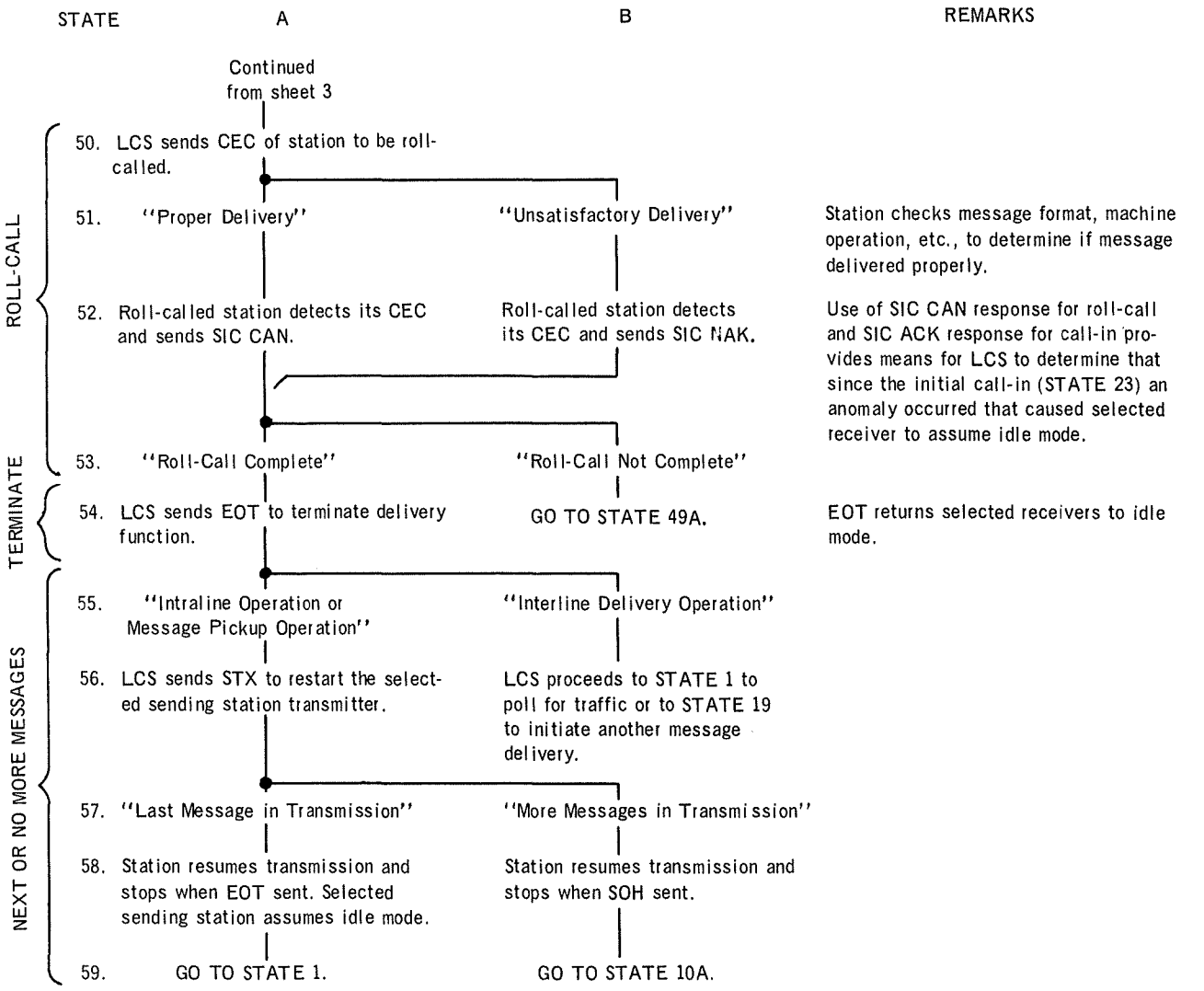
STATE		A	B	REMARKS
		Continued from sheet 1		
		"Entry point for Interline Delivery Operation"		
IDLE	19.	LCS sends EOT to insure that all receiving stations are in the idle mode.		
RECEIVER CALL-IN	20.	LCS sends ENQ to initiate the call-in function.		Stations detect ENQ and look for their CEC.
	21.	LCS sends CEC of station to be selected as receiver.		See Section 4.6 for definition of allowable CECs.
	22.	"Station Ready to Receive"	"Station Not Ready to receive"	
	23.	Called station detects its CEC, starts teletypewriter (TTY) motor, and sends SIC ACK.	Called station detects its CEC, and sends SIC NAK.	See Section 4.6 for definition of allowable SICs. LCS checks validity of received SIC.
	24.		GO TO STATE 27.	
SEPARATE INFORMATION	25.	"Separate Information Sent to this this Selected Receiver"	"No Separate Information Sent to this Selected Receiver"	ENQ of call-in function blinds any previously selected receivers so that only the station now selected is unblinded.
	26.	LCS waits for TTY motor to attain operating speed, then sends information for this selected receiver.		For 100 wpm operation, minimum of 600 msecs is required. For 150 wpm operation, minimum of 650 msecs is required.
MORE CALL-INS	27.	LCS determines if more receivers are to be called in.		
	28.	"No More Receivers to be Called In"	"More Receivers to be Called In"	
	29.		GO TO STATE 20.	
RECEIVER UNBLIND	30.	"At Least One Receiver Selected"	"No Receivers Selected"	
	31.	LCS sends ENQ DC2 to unblind all selected receivers.	LCS action depends on whether this is an intraline operation or an interline delivery operation a. Intraline – LCS picks up message for future delivery. GO TO STATE 31A if there is information to be sent to selected sending station. GO TO STATE 35A if sending station is to resume its transmission. b. Interline Delivery – LCS holds message for later delivery. GO TO STATE 1 to poll for traffic. GO TO STATE 19 to call-in for another message delivery.	
COMMON INFORMATION	32.	If no separate information delivered to last receiver called in, LCS waits for TTY motor to attain operating speed.		For 100 wpm operation, minimum of 400 msecs is required. For 150 wpm operation, minimum of 500 msecs is required.
	33.	LCS may send any information that is common to all selected receiving stations.		A date and time record is an example of such common information.
		Continued on sheet 3		

SC1 – SEQUENCE OF OPERATION FOR HDX 86A STATION WITH COMPUTER SWITCHER EMPLOYED AS LINE CONTROL STATION. Sheet 2 of 4



SC1 – SEQUENCE OF OPERATION FOR HDX 86A STATION WITH COMPUTER SWITCHER EMPLOYED AS LINE CONTROL STATION

Sheet 3 of 4



SC1 – SEQUENCE OF OPERATION FOR HDX 86A STATION WITH COMPUTER SWITCHER EMPLOYED AS LINE CONTROL STATION. Sheet 4 of 4