(RM-0303-90)

FINANCIAL MICRO-BASED
APPLICATION SYSTEMS

# NCR/ISO
# COMMUNICATIONS INTERFACE

# NCR/ISO GENERAL INFORMATION

## CONTENTS

INTRODUCTION . . . . . 1

CONTROL AND DATA CHARACTERS . . . . . 1
Character Format . . . . . 1
Control Characters . . . . . 2

ERROR CONTROL . . . . . 2
Block Check Character . . . . . 2
Parity Checking . . . . . 3
Message-Receive Checking . . . . . 3
Format Checking . . . . . 3
Error Recovery . . . . . 3

POLLS AND SELECTS . . . . . 3
Polls . . . . . 3
Replies To A Poll . . . . . 3
Selects . . . . . 4
Replies To A Select . . . . . 4

MODES OF OPERATION . . . . . 4
Idle Mode . . . . . 5
Control Mode . . . . . 5
Input Mode (After Poll) . . . . . 5
ACK Response . . . . . 6
NAK Response . . . . . 6
No Response . . . . . 6
NAK And No Response . . . . . 7
EOT Or Loss Of Carrier . . . . . 7
Output Mode (After Select) . . . . . 7
ACK . . . . . 9
NAK . . . . . .10
EOT Detected Before ETX . . . . . .11
ENQ Detected Before ETX . . . . . .11

RULES AND RESTRICTIONS . . . . . .13

APPENDIX A . . . . . .13

APPENDIX B . . . . . .14


Copyright © 1980 by NCR Corporation

# NCR/ISO GENERAL INFORMATION

| $B_8$ $B_7$ $B_6$ $B_5$ \ $B_4$–$B_1$ | | 0000 | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 0111 | 1000 | 1001 | 1010 | 1011 | 1100 | 1101 | 1110 | 1111 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
| 0000 | 0 | NUL | SOH | STX | ETX | EOT | ENQ | ACK | BEL | BS | HT | LF | VT | FF | CR | SO | SI |
| 0001 | 1 | DLE | DC1 | DC2 | DC3 | DC4 | NAK | SYN | ETB | CAN | EM | SUB | ESC | FS | GS | RS | US |
| 0010 | 2 | ⌀ | ! | " | # | $ | % | & | ' | ( | ) | * | + | , | - | . | / |
| 0011 | 3 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | ; | < | = | > | ? |
| 0100 | 4 | @ | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| 0101 | 5 | P | Q | R | S | T | U | V | W | X | Y | Z | [ | \ | ] | ^ | _ |
| 0110 | 6 | ` | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o |
| 0111 | 7 | p | q | r | s | t | u | v | w | x | y | z | { | ¦ | } | ~ | DEL |

Figure 1 ASCII code set

## INTRODUCTION

NCR tributary stations operating with the Financial Operating System II (FOS II) may use the NCR/ISO protocol when communicating with an NCR central computer. Only the FOS II aspects and options are described in this publication; the NCR FOS II tributary stations use a subset of the entire NCR/ISO protocol. All basic rules and restrictions on message format, error recovery, and poll and select procedures apply to NCR tributary stations without exception (refer to the "Rules And Restrictions" section).

## CONTROL AND DATA CHARACTERS

The 7-bit ASCII code is the code set used for data transmission (refer to Figure 1). The code set is in two parts: control characters and data characters. The control characters used are:

- STX
- ETX
- EOT
- ENQ
- ACK
- NAK
- US
- RS
- SO
- SI

STX, ETX, EOT, ENQ, ACK, and NAK are used for communications control and are described in "Control Characters" in this section. The data characters are all common alphabetic, numeric, and special characters that are normally used in the text of a communication message.

### CHARACTER FORMAT

Each character is made up of ten bits (Figure 2); these bits are: seven code bits, one parity bit, one start bit (value of 0) and one stop bit (value of 1). The bits are sent in the synchronous mode of communications; the characters are sent in the asynchronous mode.


Copyright © 1980 by NCR Corporation
Dayton, Ohio
All Rights Reserved. Printed in U.S.A.

| Stop Bit | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | Start Bit |
|---|---|---|---|---|---|---|---|---|---|
| 1 | $b_8$ | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | 0 |

Figure 2 Bit arrangement of an asynchronous character

The bit sequence for an ASCII character is least-significant bit to most-significant bit (b1 through b8 in ascending order), with the most significant bit (b8) assigned as the parity bit. NCR/ISO uses even parity.

## CONTROL CHARACTERS

A system operating with the NCR/ISO FOS II protocol uses the following characters for communications control between the sending and receiving stations:

STX (Start of Text)

The STX character indicates the start of the text message.

ETX (End of Text)

The ETX character terminates the text message and indicates the next character is the block check character (BCC).

ACK (Positive Acknowledgment)

Following a select, a tributary station sends an ACK response to indicate the station is ready to receive the message. An ACK response can be either ACK or TA1 TA2 ACK, depending on the application.

A receiving station sends an ACK character when a text message has been correctly received.

NAK (Negative Acknowledgment)

A receiving station sends the NAK character as a negative response to the sending station. For example, following a select, a tributary station sends a NAK character when it can not receive a text message.

ENQ (Enquiry)

The transmitting station sends an ENQ character to request a response from the other station.

EOT (End of Transmission)

An EOT is used to indicate the end of a transmission. When an EOT is sent by a tributary station following a successful poll sequence, that addressed tributary station has no data to send.

## ERROR CONTROL

Errors in a message sent by the central computer and/or the tributary station are controlled and detected by five procedures:

- Block check character
- Parity checking
- Message-receive checking
- Format checking
- Error recovery

## BLOCK CHECK CHARACTER

The block check character (BCC) is an even-parity character sent by the sending station at the end of a text sequence. It may be any character in the ASCII code set.

The sending station generates the BCC by adding every bit of each character to the corresponding bits of all the other characters in the text sequence. The addition of bits is performed without a carry and does not include the starting character (STX).

The resulting sum of this addition is the ASCII character used for the BCC. For example, if the message sent by the tributary station contains the following characters: STX 5 5 4 3 ETX, the tributary station generates the BCC shown in Figure 3.

| Bit Position | ASCII Characters | | | | | |
|---|---|---|---|---|---|---|
| | 5 | 5 | 4 | 3 | ETX | BCC |
| $b_7$ | 0 | 0 | 0 | 0 | 0 | 0 |
| $b_6$ | 1 | 1 | 1 | 1 | 0 | 0 |
| $b_5$ | 1 | 1 | 1 | 1 | 0 | 0 |
| $b_4$ | 0 | 0 | 0 | 0 | 0 | 0 |
| $b_3$ | 1 | 1 | 1 | 0 | 0 | 1 |
| $b_2$ | 0 | 0 | 0 | 1 | 1 | 0 |
| $b_1$ | 1 | 1 | 0 | 1 | 1 | 0 |

Add all 7 bits of each character including ETX

Add all 6 bits, etc

NOTE:

Addition is performed without a carry

0 + 0 = 0
1 + 0 = 1
0 + 1 = 1
1 + 1 = 0

Figure 3 BCC character

At the receiving station, the seven bit positions after the STX are added longitudinally. The received BCC (sent by the sending station) is included in this addition. The sum is zero if all the characters were received correctly.

## PARITY CHECKING

The NCR/ISO protocol uses even-parity checking. If the total number of bits that have a value of one (within a seven-bit character) is odd, then the parity bit is set to one; this gives the character even parity (refer to Figure 4).

| | ASCII Code for a 6 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| Stop Bit | $b_8$ | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | Start Bit |
| | ASCII Code for an 8 | | | | | | | | |
| 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| Stop Bit | $b_8$ | $b_7$ | $b_6$ | $b_5$ | $b_4$ | $b_3$ | $b_2$ | $b_1$ | Start Bit |

Figure 4 Even character parity

## MESSAGE-RECEIVE CHECKING

When a sending station sends a message to a receiving station, message-receive checking is performed to be sure the receiving station received the message. This check is performed by requiring the receiving station to send a reply (such as ACK or NAK) to the sending station after each message is received.

## FORMAT CHECKING

Format checking verifies that the STX and ETX control characters are properly positioned in each message; only one STX and ETX is acceptable for any one message transmission.

## ERROR RECOVERY

The sending station sends a message again as the means of error recovery. After a message is sent to the receiving station, the sending station checks for a response from the receiving station. If the sending station receives a NAK, indicating that the message contained transmission errors, the message is either sent again or the sending station branches to an error recovery routine, depending on the design of the online communications logic of the system.

## POLLS AND SELECTS

The central site sends a specific poll or select sequence to request a specific tributary station to send or receive data. Because of this, each tributary station continuously checks for a poll or select sequence containing that unique poll or select code.

The central computer sends a poll sequence to request data from the tributary station. The central computer sends a select sequence to determine if the tributary station is ready to receive data. If the station is ready to receive, it sends an ACK response (ACK or TA1 TA2 ACK). After receiving the ACK response, the central computer sends the text message.

## POLLS

A 3-character poll sequence sent by the central computer contains the address (poll code) of the tributary station. The addressed tributary station can respond by sending a single text sequence to the central computer. The format for a poll sequence is shown in Figure 5.

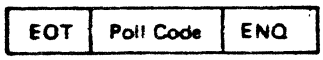



Figure 5 Format of a poll sequence

The following paragraphs describe the characters in the poll sequence.

EOT (End of Transmission)
: The EOT character is sent before all poll/select sequences. When an EOT is received by tributary stations, the stations then start checking for their unique poll or select code.

Poll Code
: Each tributary station has a unique, 1-character poll code which identifies the address of that station. Refer to Appendix A for poll code identification.

ENQ (Enquiry)
: The ENQ character indicates the end of the poll sequence and it requests a reply from the addressed tributary station.

## REPLIES TO A POLL

The positive reply to a poll sequence is a text sequence sent by the addressed tributary station. A negative reply is an EOT character.

A text sequence has the format shown in Figure 6.

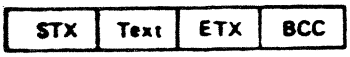



Figure 6 Format of a text sequence

STX (Start of Text)

The STX character starts the application portion of the text sequence.

Text

The actual text format is application dependent. The text portion of the message contains data such as operator-entered transaction information that needs to be sent to the central computer.

ETX (End of Text)

The ETX terminates the text portion of the message and indicates that the BCC immediately follows.

BCC (Block Check Character)

The block check character (BCC), generated by the tributary station, immediately follows the ETX character. For details on the generation and checking of the BCC, refer to the "Error Control" section in this publication.

When the central computer receives an EOT in response to a poll sequence, it polls the next tributary station in the poll cycle. The tributary station, after sending EOT, returns to an idle state where it continuously checks for a poll or select sequence which contains the unique poll or select code of that station.

## SELECTS

When the central processor has a text message to send to a tributary station, it first sends a 3- or 4-character select sequence containing the address (select code(s)) of the tributary station to be selected. A select sequence has the format shown in Figure 7. The tributary station must detect all the characters of the select sequence before responding. The following paragraphs describe the characters in a select sequence.

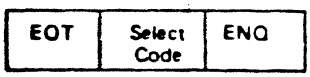



Figure 7 Format of a select sequence sent by the central computer

EOT (End of Transmission)

The EOT character is always sent before a select sequence in the NCR/ISO protocol. When an EOT is received by tributary stations, those stations start checking for their unique poll or select code.

Select Code

Each tributary station has a unique select code which identifies the address of that station. The select code may be one or two characters. Refer to Appendix A for select code identification.

ENQ (Enquiry)

The ENQ character ends the select sequence and requests a reply from the tributary station. If the tributary is ready to receive the message, the correct reply is an ACK response. If it is not ready, the tributary station sends a NAK character.

The tributary station accepts a message from central only if at least one of the following conditions are met:

- When the tributary station is not processing a transaction (idle state). This condition is referred to as an unsolicited output message.
- When the tributary station requires data from the central processor.

## REPLIES TO A SELECT

There are two possible responses to a select sequence: positive (ACK response) and negative (NAK character).

The positive response (ACK response) of a tributary station to a select sequence may be either the two identification characters and ACK character (TA1 TA2 ACK) or just an ACK character. The tributary station sends an ACK response when it is ready to receive the text message from the central computer.

Sending a negative response, a NAK character, indicates the tributary station is not ready to receive a message or the station is waiting to be polled. After sending a NAK character, the tributary station continuously checks for a poll or select sequence containing the poll/select code of that station.

## MODES OF OPERATION

A communication driver using the NCR/ISO communications protocol operates in one of four operating modes:

- Idle
- Control
- Input (after poll)
- Output (after select)

When in the idle mode, NCR tributary stations wait for poll/select sequences. Once the first character (EOT) is received, the station enters the control mode in which it checks for its unique poll/select code. From the control mode, the station

can enter the input mode (after a poll), enter the output mode (after a select) or return to the idle mode. Refer to Figure 8 for the relationship of these modes. Refer to Appendix B for flowcharts of the transferring of messages between the central and the tributary station.

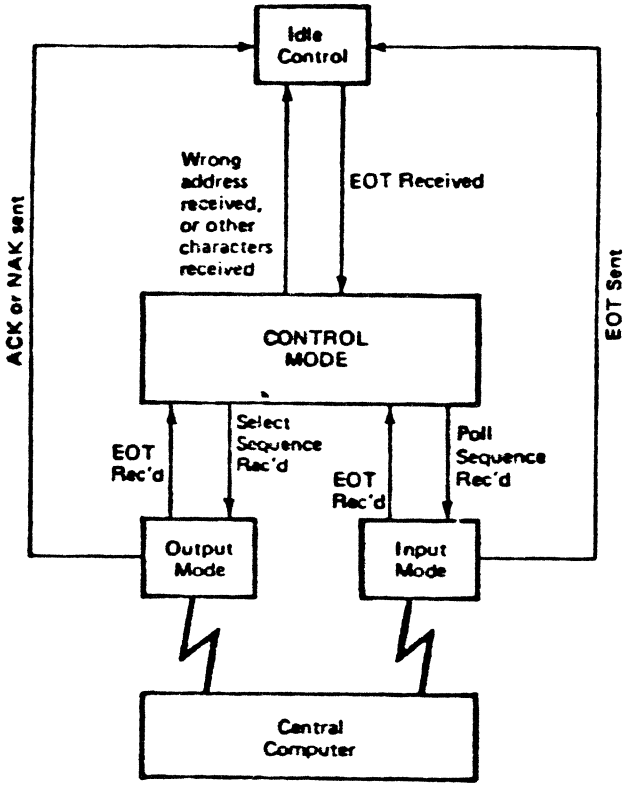



Figure 8 Modes of operation

## IDLE MODE

When a tributary station is activated, it enters the idle mode. In the idle mode, the tributary station waits for an EOT character sent by the central computer as part of a poll or select sequence; any characters sent other than EOT are ignored. When the tributary station receives an EOT character, it leaves the idle mode and enters the control mode. Refer to Table A in Appendix B for a flowchart of this mode.

## CONTROL MODE

A tributary station in the idle mode enters the control mode when it receives an EOT character. The unique poll or select code of the tributary station is the next thing that station checks for. If the code is not the poll or select code of that station, the station returns to the idle mode. If the code is the unique code of that station, the station waits for the central processor to send an ENQ character. The tributary station must detect all the characters in the poll or select sequence before responding. For example, if the station detects the EOT and its poll code but not the ENQ, the station continues to check for the ENQ, another poll sequence, or a select sequence.

Once the tributary station correctly receives the unique poll or select sequence, that station can then respond. Refer to Table A in Appendix B for a flowchart of the possible sequences.

## INPUT MODE (AFTER POLL)

After the tributary station receives its correct poll sequence, it enters the input mode. The station enters the input mode to send a text message to the central computer. When the complete text message has been sent, the tributary station waits for a response from the central processor.

There are three procedures used once the response is received: a transmission error counter, a void counter, and a timer. The transmission error counter increments by one when either the tributary station receives a negative acknowledgment (NAK) or the station does not receive a response from the central processor. A maximum (determined previously) is set so that when the maximum is reached, the tributary station branches to an error routine, indicates an error to the application, and then returns to the idle mode.

The void counter is incremented by one when the tributary station sends the text message and then receives an EOT character from the central computer. A maximum (determined previously) is set so that when the tributary station receives the maximum number of EOT characters, the station branches to a void routine.

The timer starts after the tributary station sends an ENQ or ETX; it resets when the station receives an ACK, NAK, or EOT sent from the central processor. The maximum amount of time permitted for a response from the central processor is determined by the system. If the tributary station does not receive an ACK, NAK, or EOT from the central processor within the permitted time, the transmission error counter is incremented by one and a specified action is taken by the tributary station.

The following paragraphs describe the characters which may be sent (from the central processor) in response to a text message sent by the tributary station.

## ACK Response

If the central processor sends an ACK, it is assumed the text sequence has been correctly received. The tributary station sends an EOT character and enters the idle mode. Refer to Figure 9.

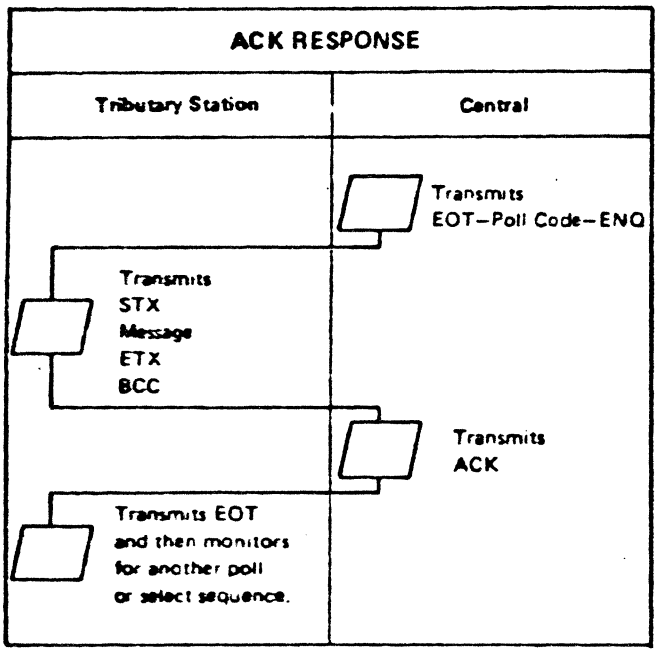



Figure 9

## NAK Response

If the central processor sends a NAK response, the text message has not been correctly received. When the tributary receives the NAK, the transmission error counter is incremented by one and tested for the maximum. If the maximum is not reached, the tributary station sends the text message again.

If the maximum is reached, the station branches to an input error routine and indicates a transmission error to the application. The station then enters the idle mode.

Refer to Figure 10 for an illustration of this sequence; in this figure, the transmission error counter had been set at 3.

## No Response

If the central processor does not send a response or the response can not be decoded, the timer in the tributary station reaches the maximum time permitted for a response from central. The transmission error counter is incremented by one and tested for the maximum. If the maximum is not reached, the tributary sends an ENQ character and waits for a reply from central.

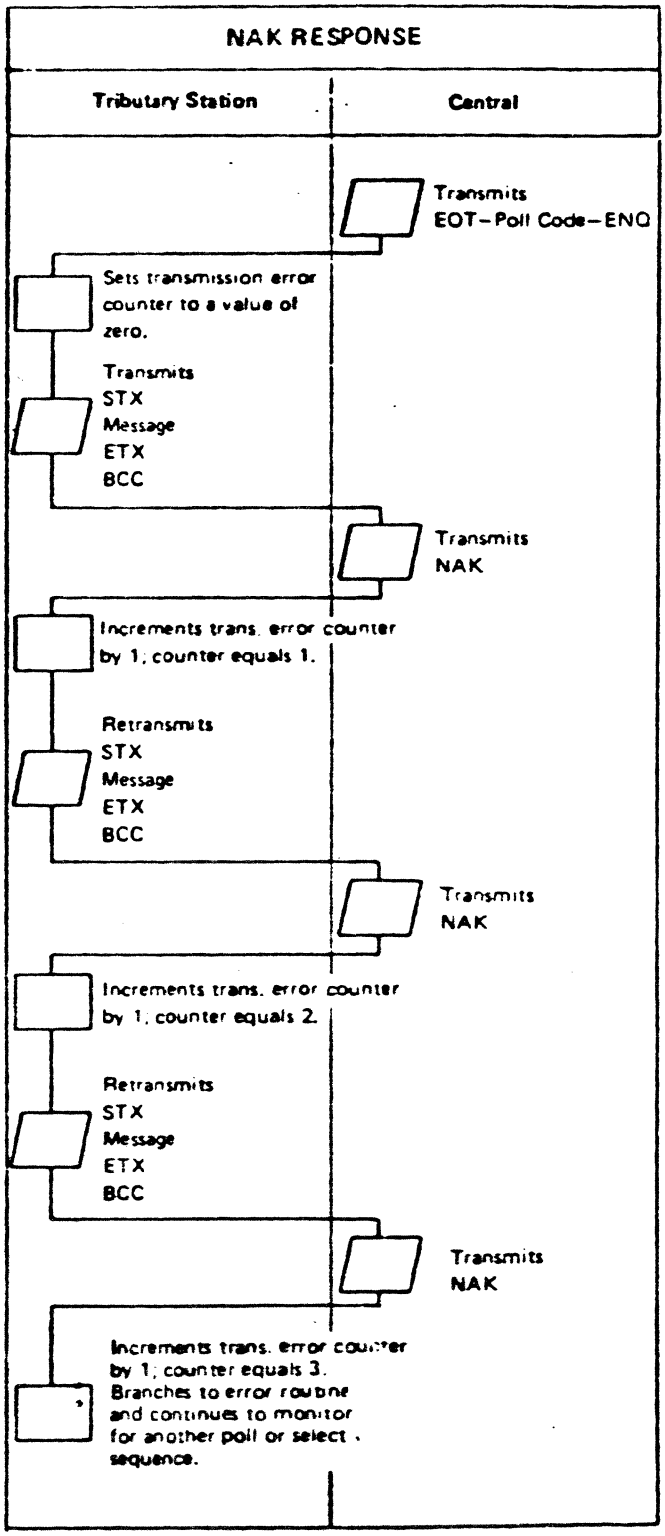



Figure 10

Note that if the central processor sends a poll or select sequence before the counter has reached the maximum, the EOT in the sequence causes the tributary station to respond to the EOT. This response is described in "EOT Or Loss Of Carrier" later in this section.

If the counter has reached the maximum, the station branches to an error routine, indicates a transmission error to the application, and then enters the idle mode.

Refer to Figure 11 for an illustration of this sequence; in this figure, the transmission error counter had been set at 3.

### NAK And No Response

Either a NAK response or reaching the maximum for the timer causes the transmission error counter to be incremented by one. Therefore, after the tributary station is polled and sends a message, any combination (of NAK characters and time maximums reached) totalling three causes the tributary station to branch to the error routine and indicate a transmission error to the application. The station then enters the idle mode.

Refer to Figure 12 for an illustration of this sequence; in this figure, the transmission error counter had been set at 3.

### EOT Or Loss Of Carrier

If the central processor sends an EOT character or the tributary station detects a loss of carrier, the response of the tributary station is the same. When the station receives an EOT or detects a loss of carrier, it increments the transmission void counter by one and tests for the maximum. If the maximum is not reached, the tributary station waits for another poll. Once the poll sequence is successfully received, the station sends the text message again.

If the counter has reached the maximum, the tributary station branches to a void routine and indicates a void to the application. The station then enters the idle mode.

Refer to Figure 13 for an illustration of this sequence; in this figure, the transmission error counter had been set to 3.

## OUTPUT MODE (AFTER SELECT)

After receiving the select sequence and sending the ACK response (either ACK or TA1 TA2 ACK), the tributary station enters the output mode. The station enters the output mode to receive a text message from the central processor.

There are two error control procedures used once the text message is received from the central

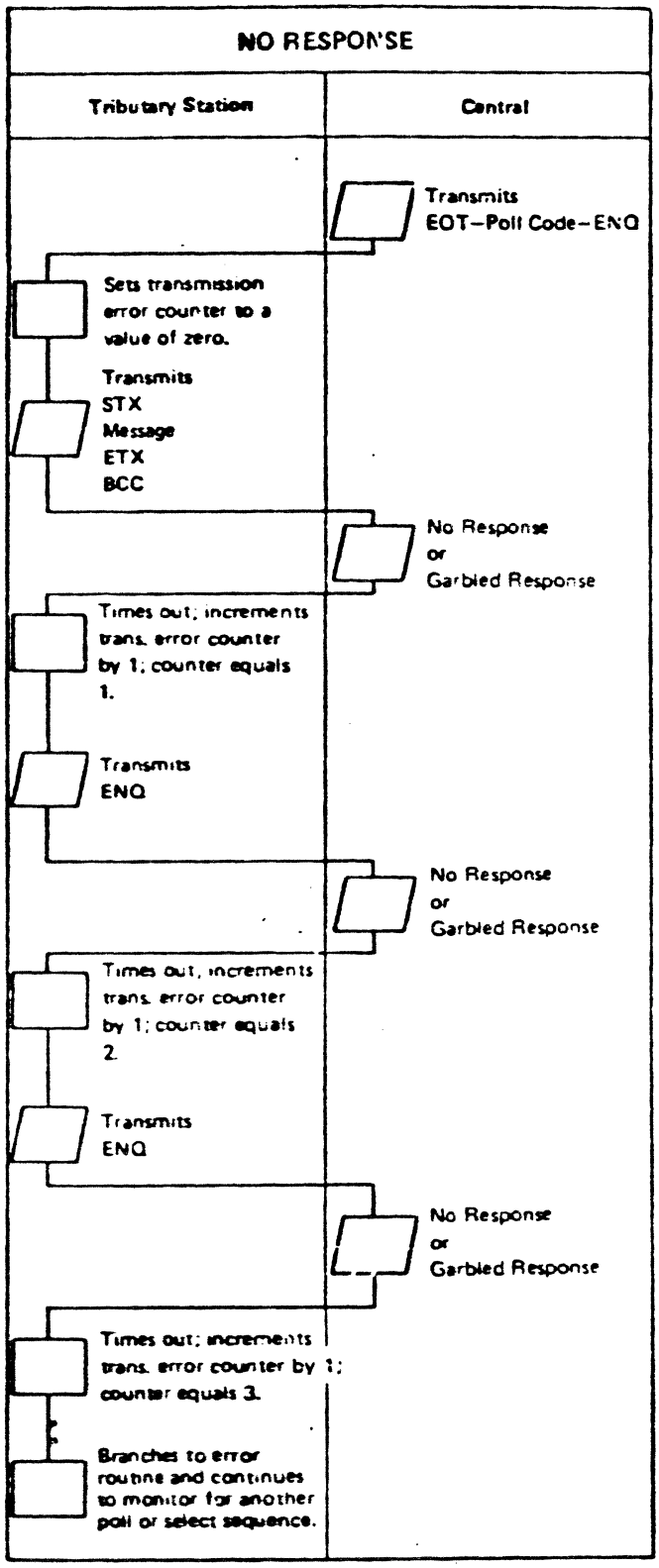



Figure 11

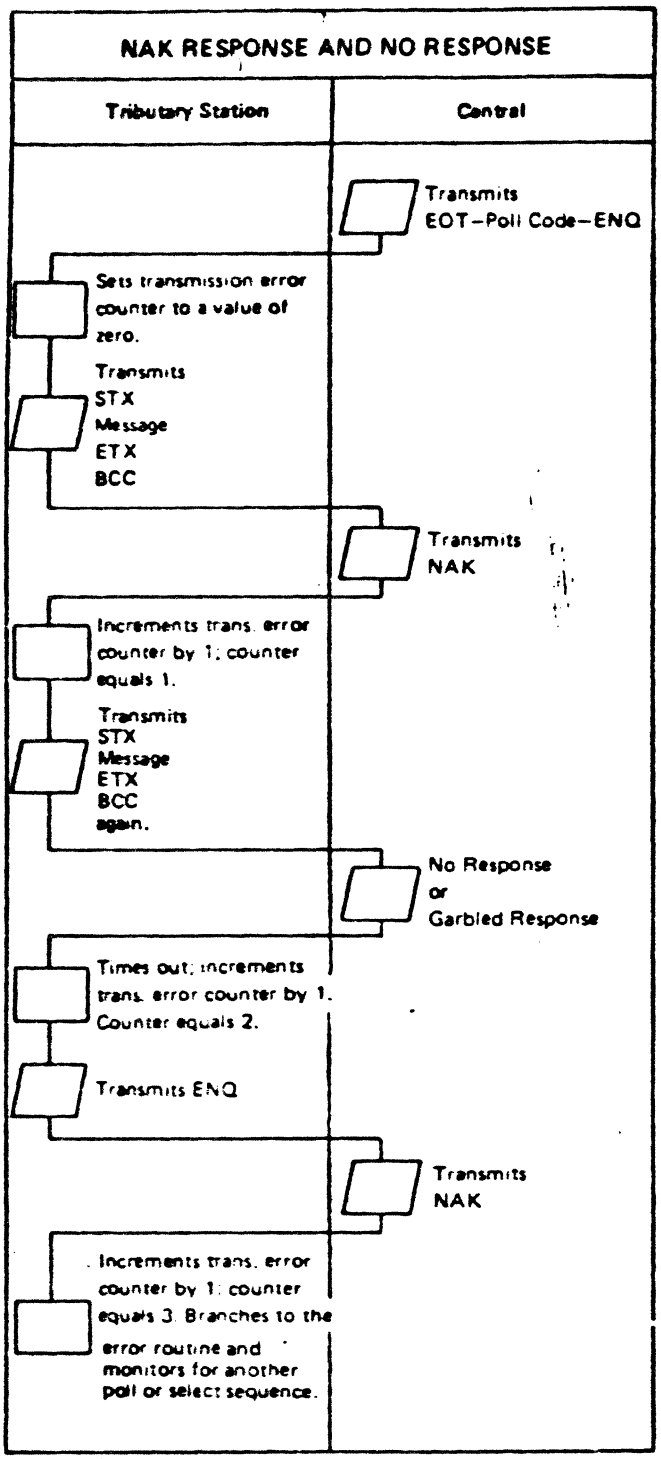



Figure 12

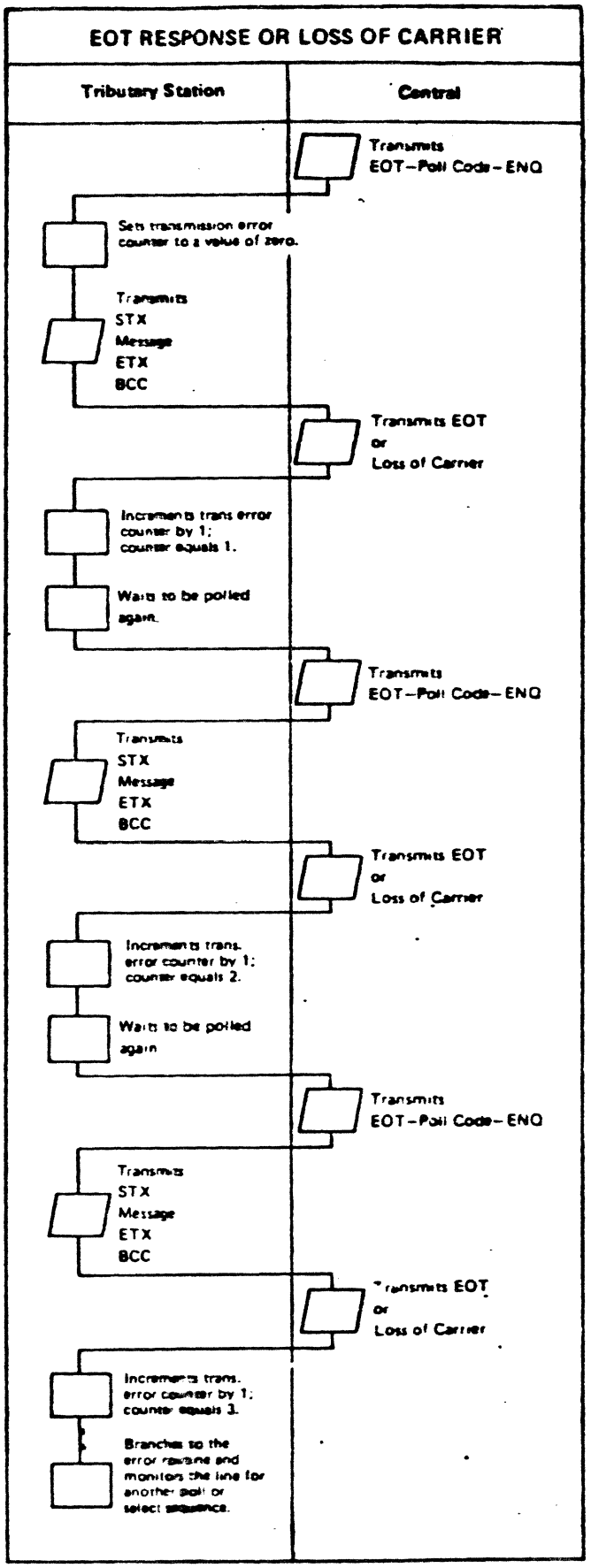



Figure 13

processor: the timer and the maximum NAK counter. The timer starts after the transmission of an ACK or NAK character to the central processor; it resets when the tributary station receives an STX, ENQ, or EOT character. The maximum amount of time permitted for a response from the central processor is determined by the system. If

the tributary station does not receive an STX, ENQ, or EOT character from the central processor within the permitted time, the tributary station takes a specified action.

The maximum NAK counter increments by one when the tributary station transmits a NAK. A maximum (determined previously) is set so that when the maximum is reached, the tributary station branches to an error routine, indicates a transmission error to the application, and then enters the idle mode.

When the tributary station receives the text message from the central processor, one of the following sequences occurs.

## ACK

The tributary station sends an ACK character when the text message is received correctly and there are no BCC or parity errors.

After the tributary station sends an ACK, the central processor can respond in one of three ways: an EOT character is sent, an ENQ character is sent, or no response is sent. If a loss of carrier is detected while waiting for a response, the tributary station branches to an error routine, indicates a transmission error to the application, and then enters the idle mode (refer to Figure 14).

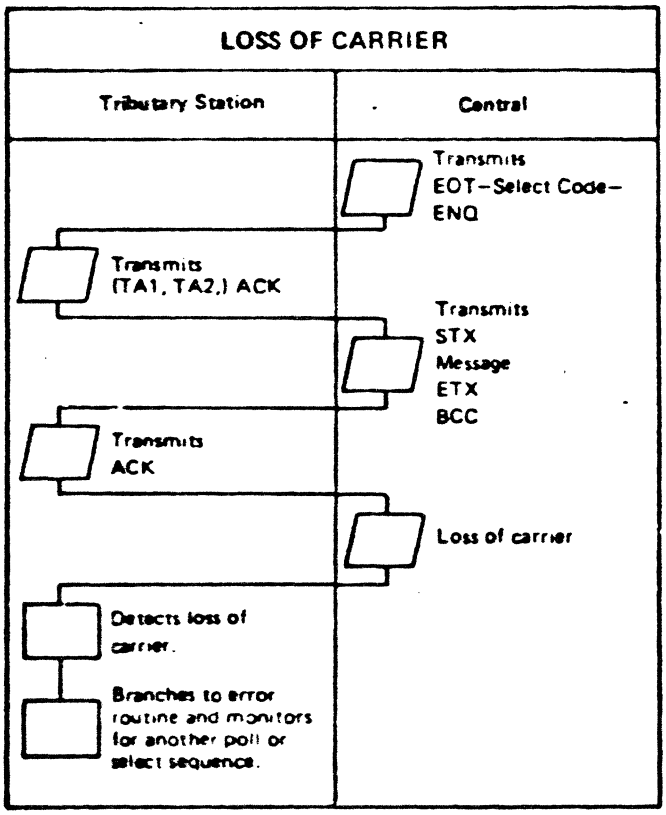



Figure 14

The three response which can be sent by central are described in the following paragraphs.

### EOT

If the tributary station receives an EOT character from the central processor, the message transfer is complete. The tributary station starts processing the message and enters the idle mode. Refer to Figure 15 for an illustration of this sequence.

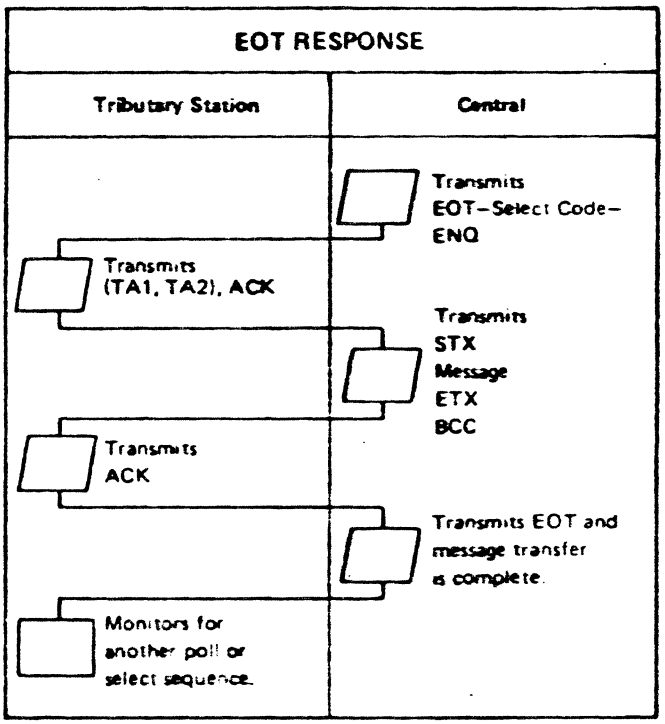



Figure 15

### ENQ

If the tributary station receives an ENQ character from the central processor, the station sends the ACK character again and then waits for a response from the central processor. Refer to the Figure 16 for an illustration of this sequence.

### No Response

If the tributary station does not receive a response from the central processor within the maximum time set for the timer, the station assumes the message transfer is complete. The station starts processing the message and enters the idle mode. Refer to Figure 17 for an illustration of this sequence.

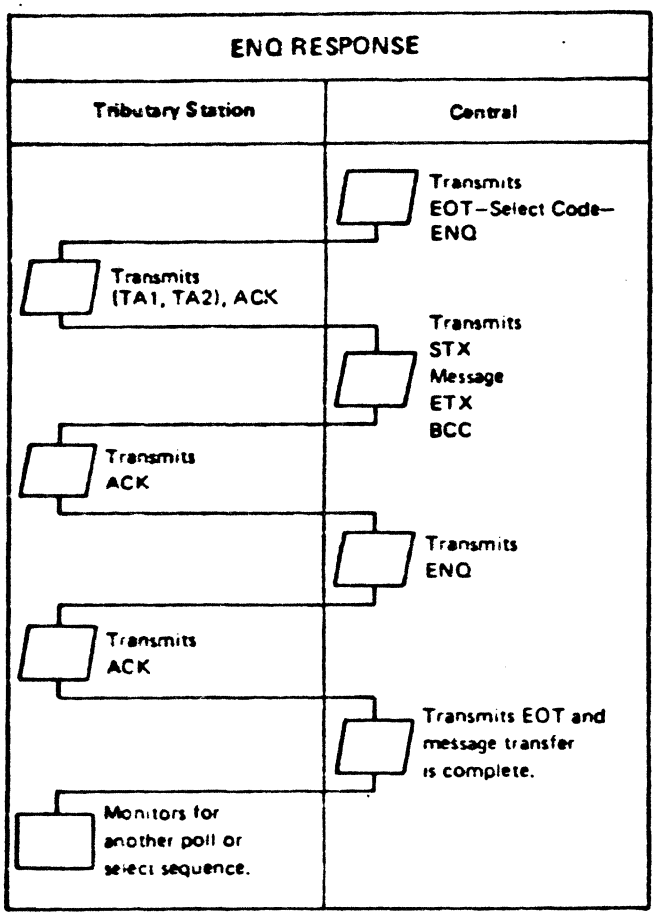



Figure 16

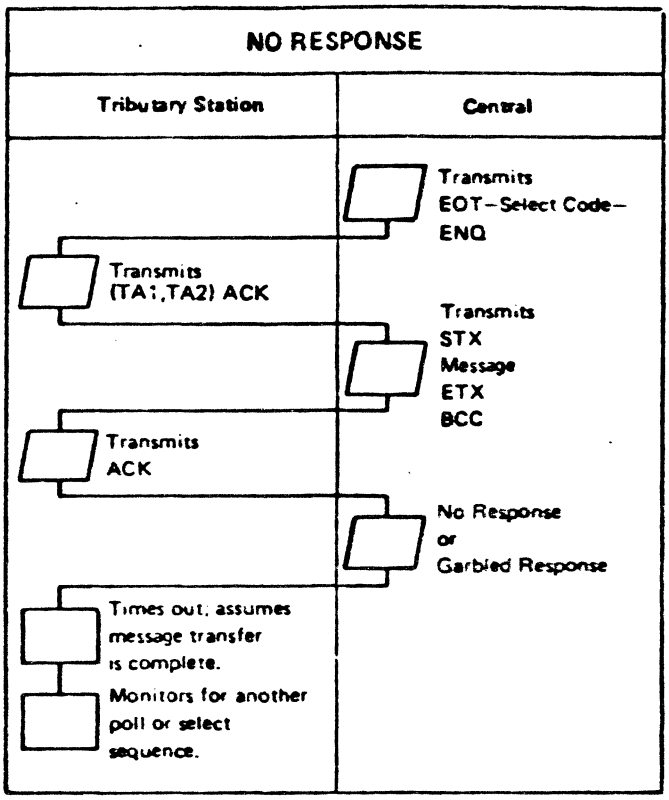



Figure 17

## NAK

When an incorrect text message is received from the central processor, the tributary station sends a NAK character. The central processor can:

- Send the message again
- Send an ENQ
- Send an EOT
- Not respond

After the central processor receives a NAK, it should not attempt to select that tributary station again until the text message is sent again.

If the tributary station detects a loss of carrier while waiting for a reply from the central processor, the tributary station branches to an error routine, indicates a transmission error to the application, and then enters the idle mode.

The following paragraphs describe the sequence used for these responses.

### Sending Message Again

When the central processor receives a NAK character and tries to send the text message again, the tributary station checks the message for BCC and parity errors. If no errors are detected, the station sends an ACK character and then waits for a reply from central. If the reply is EOT, the message transfer is complete; the station returns to the idle mode. If any other response or no response returns from the central processor, the station reaches the maximum time permitted for the timer, assumes the message transfer is complete, and returns to the idle mode.

If an error is detected in the text message, the tributary station increments the NAK counter by one and tests for the maximum set for the counter. If the maximum is not reached, the station branches to an error routine, indicates a transmission error to the application, and enters the idle mode. Refer to Figure 18 for an illustration of this sequence.

### ENQ

When the central processor receives a NAK and sends an ENQ character to the tributary station, the station increments the NAK counter

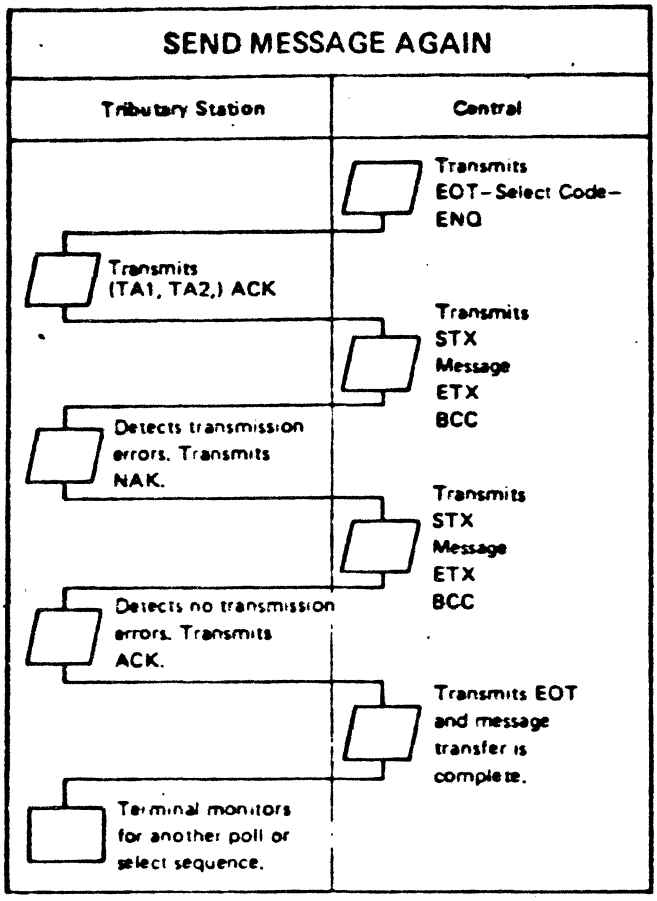



Figure 18

by one and tests for the maximum. If the maximum is not reached, the station sends a NAK again. If the maximum is reached, the station branches to an error routine, indicates a transmission error to the application, and then returns to the idle mode. Refer to Figure 19 for an illustration of this sequence.

EOT

When the central processor receives a NAK character and sends an EOT character to the tributary station, the station branches to an error routine, indicates a transmission error to the application, and enters the idle mode. Refer to Figure 20 for an illustration of this sequence.

No Response

When the central processor receives a NAK, it can either not send a response or send a response that can not be decoded by the tributary station. Both conditions cause the tributary station to reach the maximum time permitted for the timer. The tributary station then branches to an error routine, indicates a transmission error to the application, and enters the idle mode. Refer to Figure 21 for an illustration of this sequence.

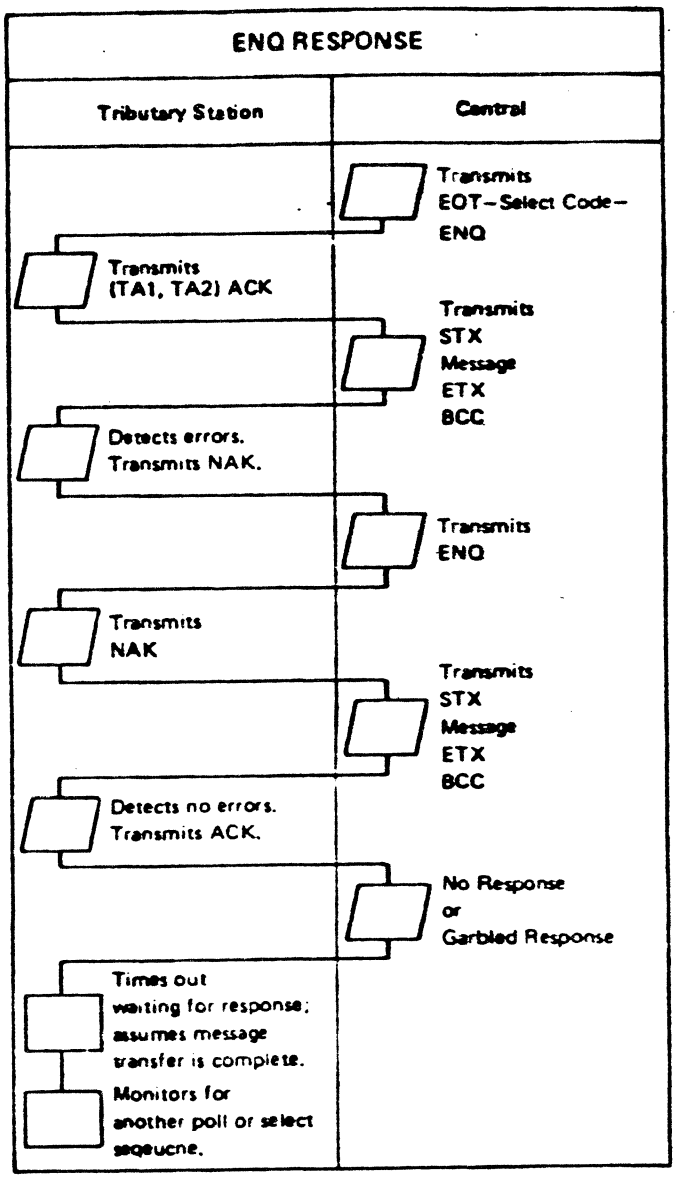



Figure 19

## EOT Detected Before ETX

If the tributary station detects an EOT character before receiving an ETX character when receiving a text message from the central processor, the station branches to an error routine, indicates a transmission error to the application, and then enters the idle mode. Refer to Figure 22 for an illustration of this sequence.

## ENQ Detected Before ETX

If the tributary station detects an ENQ character before receiving an ETX character when receiving a text message from the central processor, the station sends a NAK character to the central processor.

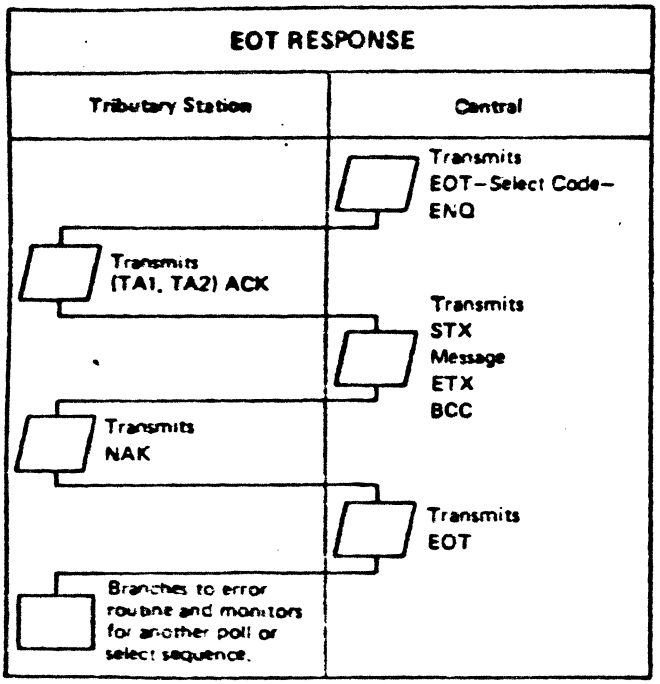



Figure 20

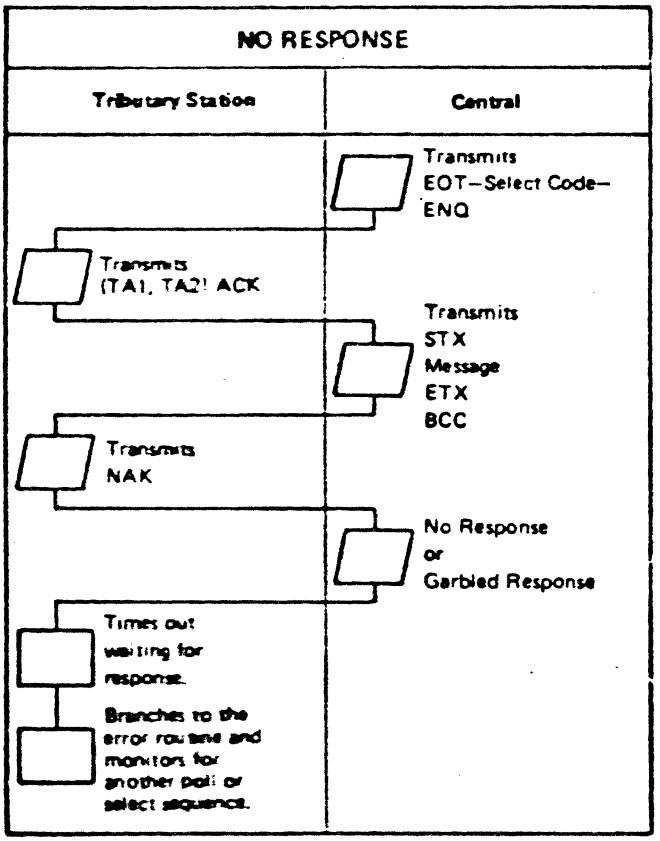



Figure 21

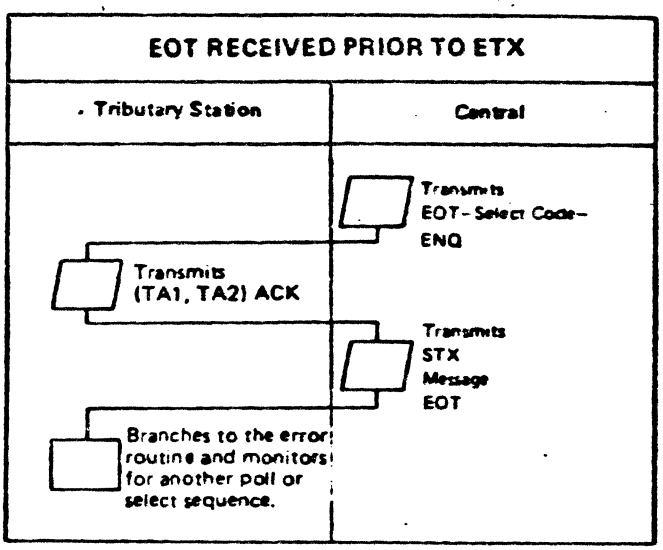



Figure 22

The station then waits for another message, an ENQ character, or an EOT character. If a response is not received from the central processor within the permitted time, the station branches to the error routine, indicates a transmission error to the application, and then enters the idle mode. Refer to Figure 23 for an illustration of this sequence.

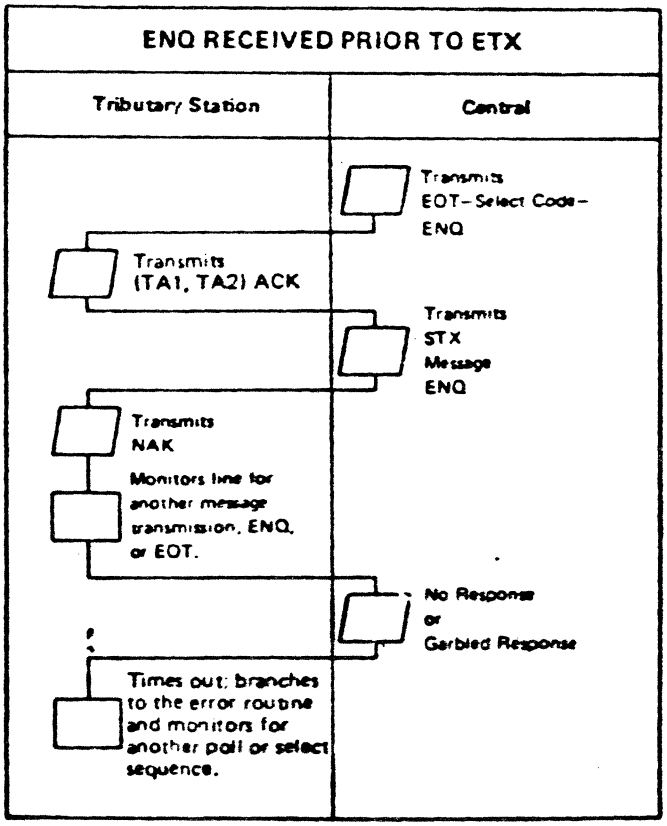



Figure 23

## RULES AND RESTRICTIONS

Tributary stations which use NCR/ISO protocol must follow specific rules and restrictions:

- Transparency, the use of code-independent text, is not supported. Additionally, tributary stations using NCR/ISO protocol can not operate on a communications line with other stations using transparency.
- Only single block transmission is supported. Multiple block transmission using ETB (End Transmission Block) is not supported.
- When a tributary station sends a text message to the central computer, the message must include delimiters (STX and ETX) and the address of that tributary station.
- NCR/ISO protocol supports only the ASCII code set (refer to Figure 1).
- NCR tributary stations support only a multipoint, dedicated, 2- or 4-wire communications link configuration.
- During an error recovery procedure, the same message is sent in response to each NAK character received from the central computer. When the retry limit is reached, the central computer responds with an EOT character (instead of a NAK character) which stops the input attempts.
- Data is sent and received in the asynchronous mode of communication.
- NCR applications support standard, specific polls and selects. The standard NCR/ISO poll and select sequences have the formats shown in Figure 5 and 7. No other poll/select sequences are supported.

## APPENDIX A

**POLL AND SELECT CODES**

| Character Combinations Hex Representation | | Bit Strings | |
|---|---|---|---|
| Poll Character | Select Character | Poll Character Bits 7654321 | Select Character Bits 7654321 |
| 20 | 30 | 0100000 | 0110000 |
| 21 | 31 | 0100001 | 0110001 |
| 22 | 32 | 0100010 | 0110010 |
| 23 | 33 | 0100011 | 0110011 |
| 24 | 34 | 0100100 | 0110100 |
| 25 | 35 | 0100101 | 0110101 |
| 26 | 36 | 0100110 | 0110110 |
| 27 | 37 | 0100111 | 0110111 |
| 28 | 38 | 0101000 | 0111000 |
| 29 | 39 | 0101001 | 0111001 |
| 2A | 3A | 0101010 | 0111010 |
| 2B | 3B | 0101011 | 0111011 |
| 2C | 3C | 0101100 | 0111100 |
| 2D | 3D | 0101101 | 0111101 |
| 2E | 3E | 0101110 | 0111110 |
| 2F | 3F | 0101111 | 0111111 |
| 40 | 50 | 1000000 | 1010000 |
| 41 | 51 | 1000001 | 1010001 |
| 42 | 52 | 1000010 | 1010010 |
| 43 | 53 | 1000011 | 1010011 |
| 44 | 54 | 1000100 | 1010100 |
| 45 | 55 | 1000101 | 1010101 |
| 46 | 56 | 1000110 | 1010110 |
| 47 | 57 | 1000111 | 1010111 |
| 48 | 58 | 1001000 | 1011000 |
| 49 | 59 | 1001001 | 1011001 |
| 4A | 5A | 1001010 | 1011010 |
| 4B | 5B | 1001011 | 1011011 |
| 4C | 5C | 1001100 | 1011100 |
| 4D | 5D | 1001101 | 1011101 |
| 4E | 5E | 1001110 | 1011110 |
| 4F | 5F | 1001111 | 1011111 |
| 60 | 70 | 1100000 | 1110000 |
| 61 | 71 | 1100001 | 1110001 |
| 62 | 72 | 1100010 | 1110010 |
| 63 | 73 | 1100011 | 1110011 |
| 64 | 74 | 1100100 | 1110100 |
| 65 | 75 | 1100101 | 1110101 |
| 66 | 76 | 1100110 | 1110110 |
| 67 | 77 | 1100111 | 1110111 |
| 68 | 78 | 1101000 | 1111000 |
| 69 | 79 | 1101001 | 1111001 |
| 6A | 7A | 1101010 | 1111010 |
| 6B | 7B | 1101011 | 1111011 |
| 6C | 7C | 1101100 | 1111100 |
| 6D | 7D | 1101101 | 1111101 |
| 6E | 7E | 1101110 | 1111110 |
| 6F | 7F | 1101111 | 1111111 |

## APPENDIX B

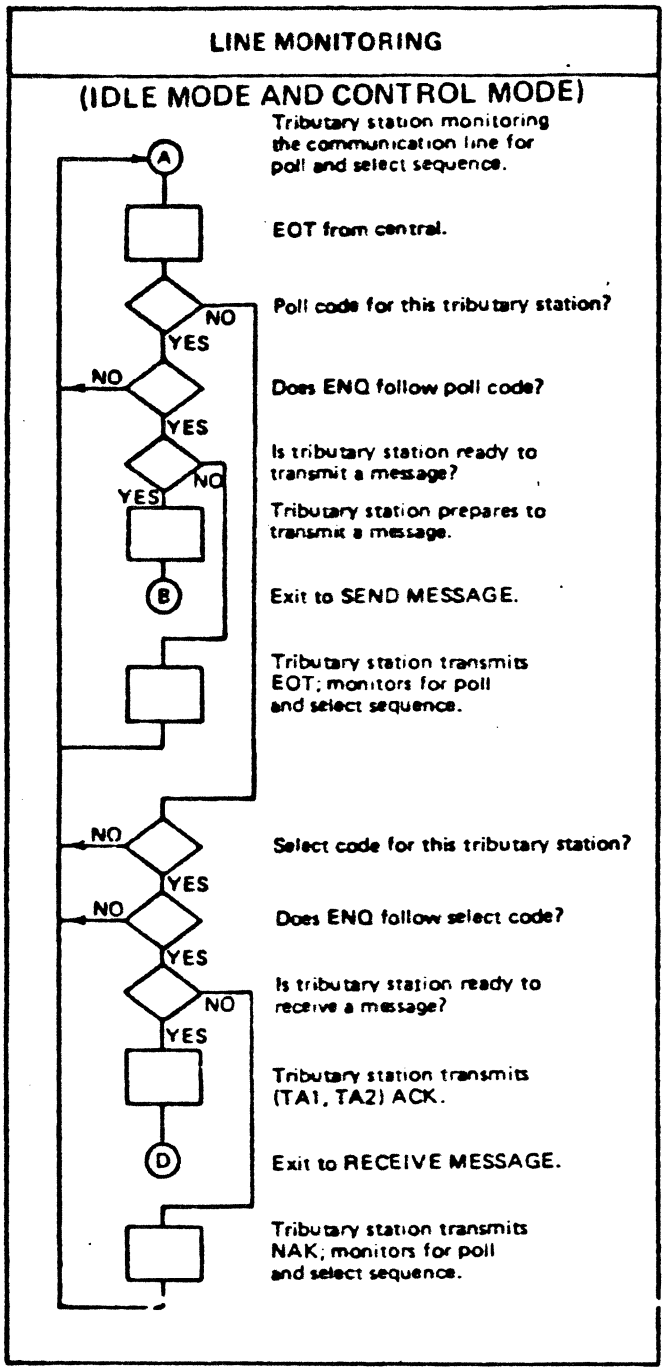
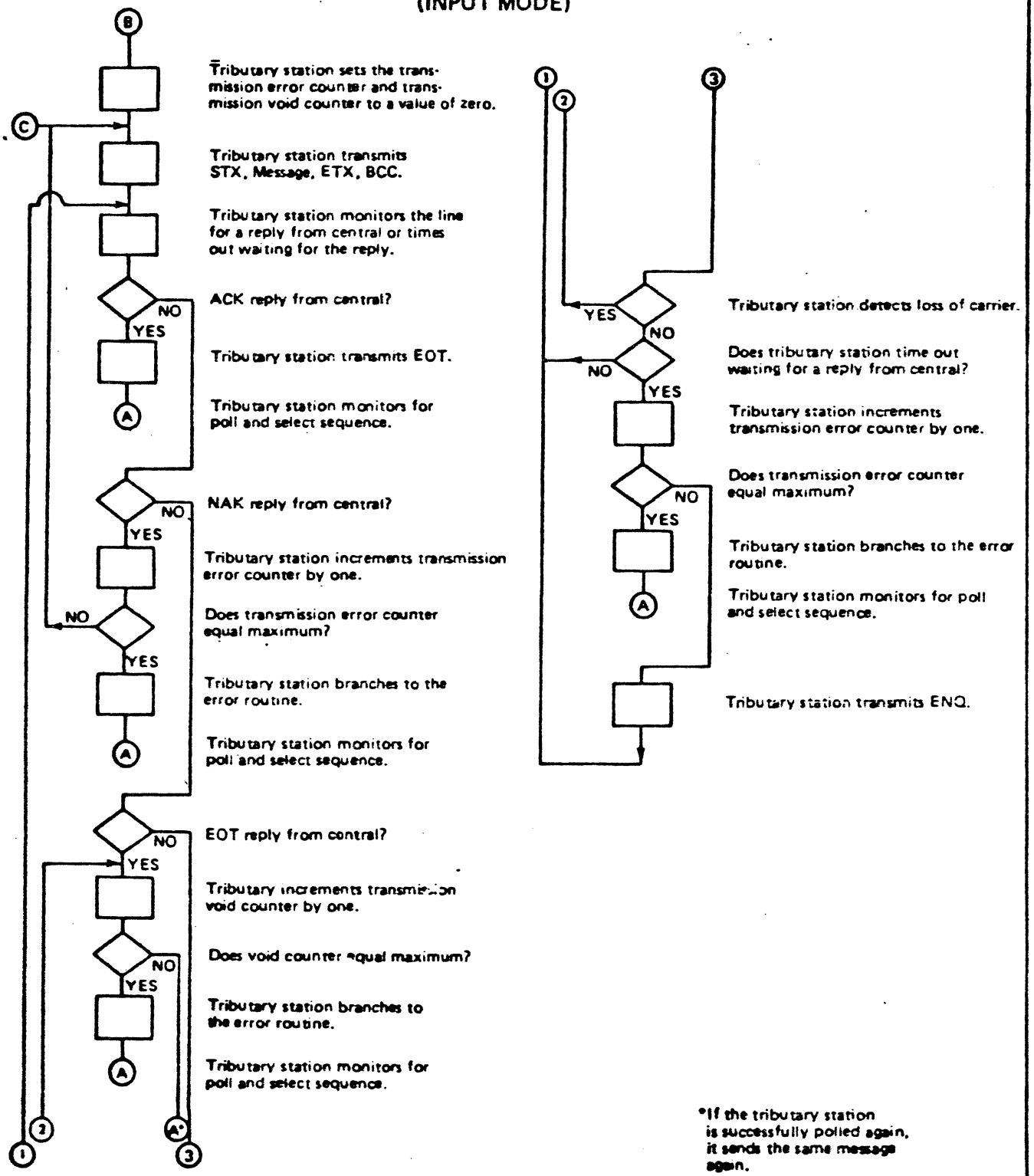



Table A

## SEND MESSAGE

### (INPUT MODE)

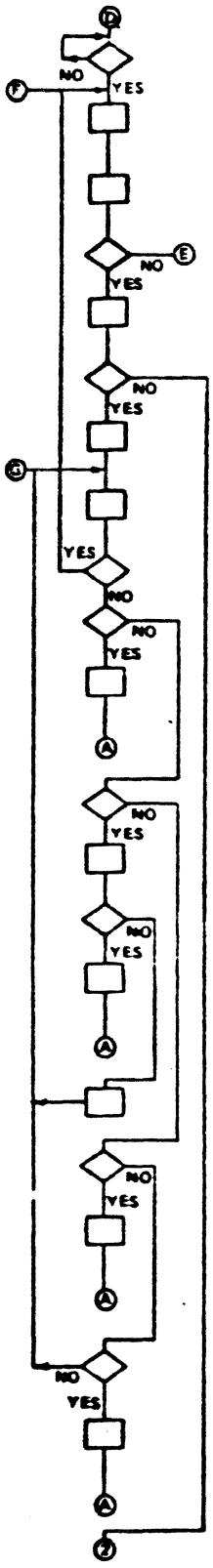



*If the tributary station is successfully polled again, it sends the same message again.

Table B

## RECEIVE MESSAGE

## (OUTPUT MODE)




STX from central?

Tributary station receives next character.

Tributary station initiates BCC calculation and adds character to BCC accumulation.

ETX from central?

Tributary station receives BCC and adds to BCC accumulation.

Did tributary station detect parity errors or BCC error?

Tributary station transmits NAK.

Tributary station monitors the line for a reply from central or times out waiting for a reply.

STX reply from central?

EOT reply from central?

Tributary station branches to the error routine.

Tributary station monitors for poll and select sequence.

ENQ reply from central?

Tributary station increments NAK counter by one.

Has NAK counter reached maximum?

Tributary station branches to error routine.

Tributary station monitors for poll and select sequence.

Tributary station transmits NAK.

Does tributary station detect loss of carrier?

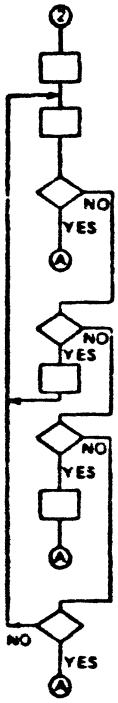
Tributary station branches to the error routine.

Tributary station monitors for poll and select sequence.

Did tributary station timeout waiting for a reply from central?

Tributary station branches to the error routine.

Tributary station monitors for poll and select sequence.




Tributary station transmits ACK.

Tributary station monitors the line for a reply from central or times out waiting for the reply.

EOT reply from central?

Message transfer complete; tributary station monitors for poll and select sequence.

ENQ reply from central?

Tributary station transmits ACK.

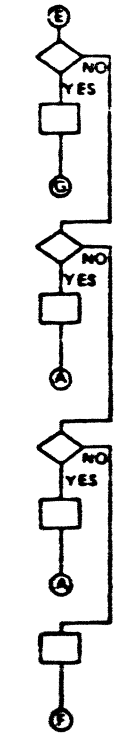
Does tributary station detect loss of carrier?

Tributary station branches to the error routine.

Tributary station monitors for poll and select sequence.

Did tributary station timeout waiting for reply from central?

Tributary station assumes message transfer is complete and monitors for poll and select sequence.




ENQ from central?

Tributary station transmits NAK to central.

Tributary station monitors the line for a reply from central.

EOT from central?

Tributary station branches to the error routine.

Tributary station monitors for poll and select sequence.

Does tributary station detect loss of carrier?

Tributary station branches to the error routine.

Tributary station monitors for poll and select sequence.

Tributary station stores data character.

Tributary station receives next character.

Table C