T H E U N I V E R S I T Y O F M I C H I G A N

Technical Report 28

Data Concentrator User's Guide

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ABSTRACT

This report is a user's guide for the Data Concentrator, a terminal control device designed for use with the Michigan Terminal System (MTS). This device presently supports several types of AT&T and IBM terminals together with remote computing and visual display equipment using 103A, 202C and 201A data sets. Included is a description of the extensive set of options available together with useful reference material.

This report was prepared using FORMAT, a computer program in MTS. This program is described in: Berns, G.M., Description of FORMAT, a text-processing program, Comm. ACM, 12, 3 (March 1969), pp. 141-146. The text was entered to this program partly in punched-card form and partly directly from a typewriter terminal and was printed on an IBM 1403 printer equipped with a TN print train.

KEYWORDS

Front-End Processor

Terminal Control

Typewriter Terminal

Visual Display Terminal

Remote Computer Terminal

User's Guide

Data Concentrator User's Guide

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FIGURES

1. INTRODUCTION

This user's guide describes how to use the Michigan Terminal System (MTS) through the Data Concentrator. It is assumed that the reader is familiar with MTS itself. The Data Concentrator is actually a PDP-8 computer attached, on one hand, to the two 2870 Multiplexor Channels of the IBM 360/67 and, on the other hand, to a variety of AT&T data sets. All of this equipment except the PDP-8 itself was designed and constructed by members of the Computing Center staff and the CONCOMP Project. Appendix F describes the physical construction of this equipment, while [8] and !a69] describe the architecture of its control program. The interface to MTS is common for each of the several types of data sets-- i.e., MTS is not concerned with whether a particular Data Concentrator terminal is a Teletype Model 35 or 37, an IBM Model 2741 or 1050, a CCI display terminal, or is actually a remote computer. Because the Data Concentrator is a programmable device, a great deal of flexibility is achieved in its operation. The uniform interface with MTS means that MTS does not require a separate set of device support routines for each of the various devices which the Data Concentrator supports.

The following terminals are fully supported by the Data Concentrator:

(1) Teletype Models 33, 35 and 37 terminals with optional paper-tape reading and punching equipment.

(2) IBM 2741 Communications Terminals and IBM 1050 Data Communications Systems with optional 1056 Card Reader.

(3) "Special" terminals designed to be compatible with the transmission code and operating protocol of (1) or (2) above and operating at transmission rates to 300 bits-per-second (baud). Terminals of this type include those marketed by Computek, ARDS, Datapoint, Execuport and Tektronix.

(4) IBM Binary Synchronous Communication (BSC) systems utilizing 201A data sets for remote job entry, including the IBM 1130 and System/360 Models 20 and 25 Data Processing Systems operating with the remote HASP support system. (Support for the IBM Model 2780 is contemplated but deferred at present.)

(5) Remote display and processing equipment utilizing the so-called CONCOMP transmission protocol

operating with 201A data sets and the RAMP support system.

(6) CCI (Computer Communications Incorporated) Model 300 TV display terminals utilizing 202C data sets. (Support for Computek and similar storage-tube display terminals utilizing this type of data set is contemplated but deferred at present.)

(7) Paper-tape reading and punching equipment attached directly to the Data Concentrator. This equipment is intended for low-duty-cycle operation and can read and punch fan-fold 8-channel paper tape. More rugged punching equipment is presently on order and should be installed by this summer.

Note that support provided for any of these terminals does not obligate the Computing Center to provide the terminals themselves, and the Computing Center reserves the right to discontinue service for any terminal types as actual usage indicates. Where support for new terminal types can be shown to involve minor changes in the existing system, such support can be negotiated, but only well in advance of purchase commitments.

Teletype terminals attached to the Data Concentrator may be either Models 33, 35 or 37 (ASR or KSR, i.e,. With or without paper-tape equipment) operating on the Bell System dial network through a 100-series data set and presumably, although not necessarily, capable of full-duplex operation. Special considerations are necessary in paper-tape operation with the Model 33ASR, as described in Section 4.1. IBM 2741 Communications Terminals and 1050 Data Communications Systems may also be used with the Data Concentrator. Such terminals must operate on the dial network and be equipped with the interrupt and reverse-break features. If the 1056 Card Reader is used with the 1050 it should be equipped with the extended character reading special feature. Generally, AT&T 103A data sets (or equivalent) are used to attach IBM terminals to the dial network. The 103A data set telephone number for Teletype and IBM terminals is:

(313) 763-1500

Sixteen trunk-hunting lines are available at present.

Computer Communications Incorporated (CCI) Model 300 TV display terminals may also be used with the Data Concentrator. These terminals operate on the dial network with 202C (1200 baud) data sets in the half-duplex mode. The reverse-channel feature is required with these data

sets. The 202C telephone number for CCI terminals is:

(313) 763-4208

Only one line is available at present.

Remote computers may be connected as MTS terminals or remote batch entry stations via the Data Concentrator. Communication between the remote machine and the Data Concentrator is made on the dial network using 201A data sets (2000 baud) operating in the half-duplex mode and, preferably, strapped for short-turnaround operation. Remote computers connected via these facilities must operate according to the protocols described in Section 4.5. Users contemplating such operation are advised to contact cognizant members of the Computing Center staff for additional information. The 201A telephone number is:

(313) 763-0570

Four trunk-hunting lines are available at present.

If the Data Concentrator does not answer any of these telephone numbers within a few rings or if a busy signal is present then either MTS or the Data Concentrator is not available. The Computing Center maintains a special "hot line" for a recorded message concerning current system status. The telephone number for this "hot line" is:

(313) 763-0420

2. BASIC PROCEDURES

The following sections describe the basic operational procedures in overview form. These sections are designed for quick reference by experienced users of the system. The operation of each terminal is described in more detail in Section 4.

2.1 Origination

For Teletype terminals with the half-duplex/full-duplex (HDX/FDX) switch option, the switch should be placed in the FDX position. For IBM 2741 Communications Terminals, the LOCAL/COMM switch should be set to COMM and the POWER switch should be ON. For IBM 1050 Data Communications Systems the POWER switch should be ON, the SYSTEM switch should be in the ATTEND position, the PRINTER switch in the SEND/REC position and the KEYBOARD switch in the ON position. All other switches should be in the OFF or normal position. Before dialing, press the LINE RESET key to clear the control unit. For Computer Communications Incorporated (CCI) terminals press the MASTER CLEAR button on the control unit and the RESET button on the right side of the keyboard. Then press the CTL-CLEAR key combination to clear the screen. All rocker switches on the control unit should be in the down position. For Binary Synchronous Communications (BSC) terminals using 201A data sets, the terminal should enable the Terminal Ready signal to the data set and be in a configuration to receive the first message from the Data Concentrator.

For Teletype terminals press the ORIG button, wait for a dial tone (heard on the speaker), and dial the 103A telephone number listed above. For IBM terminals using 103A data sets, press the TALK button on the data set, lift the receiver, wait for a dial-tone and dial the 103A telephone number. After the Data Concentrator answers the call a steady, high-pitched tone will be heard. Press the DATA button and replace the receiver.

For CCI terminals using 202C data sets proceed in the same manner as above for IBM terminals using 103A data sets, except dial the 202C data set number listed above. After pressing the DATA button press the ATTN button and CTL-TRANS key combination in that order.

For BSC terminals using 201A data sets proceed as above for IBM terminals using 103A data sets, except dial the 201A telephone number listed above. The procedure following this is, of course, dependent upon the particular terminal architecture.

2.1.1 Terminal Identification. The procedures used by the Data Concentrator to identify the various types of terminals using 103A data sets are described in this section. Users with special terminal equipment will need to understand how these procedures work. Users with standard Teletype and IBM terminals can skip this section. Note that the following procedures are necessarily highly volatile and are subject to revision as new terminals and different requirements arise.

When the Data Concentrator answers an incoming call a timeout is set for fifteen seconds. If the data set has not completed its handshaking procedure within this period the data set is placed in an on-hook condition and the caller is disconnected. This would occur if the caller's data set were faulty or in response to a wrong-number call.

When the data set handshaking procedure is complete the Data Concentrator sends a printer-poll sequence for an IBM Model 1050 terminal. This consists of the three-character sequence "EOT / 9" transmitted in the PTTC code at 135 baud (see Appendices). If the calling terminal is a 1050 and both the printer and the control unit are ready, the single character ACK will be returned and the identification procedure will be terminated.

If the calling terminal is an IBM 2741 the polling sequence is ignored. The terminal will automatically generate the single character STX following a 700-millisecond timeout and the identification procedure will be terminated.

If no characters are received following the 700-millisecond timeout, the Data Concentrator will switch the data set clock rate to 110 baud and transmit the Teletype terminal answerback-request character ENQ (also called WRU) in the ASCII code. Model 33 and 35 Teletypes will respond to the ENQ character with their answerback code, which is coded into a revolving drum. A five-second waiting period is allowed for the operator to hand-key at least the first character of the answerback code if his terminal is not equipped to respond automatically to the ENQ character. If any character is received during this period the identification procedure will be terminated.

If no character is received following the five-second timeout the Data Concentrator will switch the data set clock rate to 150 baud and transmit the ENQ character again. Model 37 Teletype terminals will respond with their answerback codes in the same fashion as the Model 33 and 35. If any character is received within a fifteen-second timeout interval the identification procedure will be terminated.

Otherwise the data set is placed in an on-hook condition and the caller is disconnected.

2.2 Connection

After answering the call and interrogating the terminal to determine its type, the Data Concentrator will indicate this to MTS so that the default values for device commands (see Section 3) can be set up. This process is completely automatic for all terminals except those Teletype terminals not equipped with a standard answerback code. During the identification procedure Teletype terminals may "bump" oddly. This is due to the IBM 1050 polling sequence generated as part of the terminal identification procedure and is normal. Following identification of the device type the Data Concentrator line number and answerback code are printed on the terminal and control is passed to MTS. The line number and answerback code are printed in the format:

```
%ttnn:answ
```

where "%" is the prefix character used for all messages originated by the Data Concentrator, tt is the device code as shown in Figure 1, nn is the data set number and answ is the answerback code. A user program can determine this information using the GUINFO subroutine (see Volume 3 of the MTS manual, third edition). The code ttnn is the device name used within the Data Concentrator to identify the data set or MTS interface device. This should be given to Computing Center personnel if data set malfunctions are suspected.

Device Type	Answerback Code	Terminal
DC	na	MTS interface device
IB	1050	IBM 1050
LC	2741	IBM 2741
LD	(see text)	Teletype 33, 35
LE	(see text)	Teletype 37
MA	NONE	CCI 300 (202C)
SA	NONE	BSC (201A)

Figure 1. Device and Answerback Codes

For all except Teletype terminals the answerback code is a function only of the device type. For Teletype terminals the answerback is obtained from the terminal by transmitting an ENQ character during the terminal identification procedure. Teletype terminals which are not equipped with answerback drums must nevertheless supply an answerback to MTS. This is most easily done by entering the telephone number of the terminal immediately after the "bump" during the terminal identification procedure. The answerback code should be no more than 12 alphanumeric characters in length and should be followed by a CR (RETURN) code. Users wishing to code their own answerback drums should contact the Computing Center for details.

Following the terminal identification message MTS will then transmit an announcement line to the terminal:

MTS : ANN ARBOR (DCxx-nnnn)

In the announcement message the xx in DCxx will be a number between 00 and 63, indicating the MTS device name for the particular transmission path between MTS and the Data Concentrator operable for this user. The four-digit number nnnn is the UMMPS job number for this job. The device name and job number serve as a reference in case of difficulty and should be given to Computing Center personnel if inquiries are made regarding the status of a job.

After the announcement message has been printed a "signon message" may be printed. This message contains

announcements to users regarding such items as when MTS is next scheduled to shut down. MTS will then prompt the operator with a "#" character when ready to receive the first line of input. The first input line to MTS should be a $SIGNON command. The system will indicate whether the signon is acceptable and if it is, the operator may then enter other commands. Most terminals provide a means to suppress the printing of the user password when entered from the terminal. A terminal can be disconnected at any time from MTS by simply hanging up or placing the terminal data set in an on-hook condition. However, it is usually considered more polite to enter a $SIGNOFF command, after which an itemized bill for services rendered is printed.

2.3 Operation

In most cases terminal operation procedures default to those normally expected by users experienced with timesharing terminals. See Section 4 for the details of operation peculiar to each terminal type. Changes to these procedures are indicated by commands directed to small command language interpreters resident both in the Data Concentrator and the MTS Device Support Routine (DSR) which serves the Data Concentrator. In general, Data Concentrator inbound record extents, editing procedures and code translation are under control of the Data Concentrator commands, while tabulation stops and outbound carriage control, record extents and code translation are under control of the MTS DSR commands.

2.3.1 Line Editing. Figure 2 summarizes the control keys used on the various terminals. Note that the line-delete and end-of-file characters for the IBM equipment have immediate effect, that is, they are line-ending characters. Note also that the input line preceding either an end-of-file or an attention indication is passed to MTS unless it is empty, in which case it is discarded. Furthermore, note that the literal-next character can be used preceding any character whatsoever, including device-control characters, but excluding case-shift characters. However, an alphanumeric character following the literal-next character is mapped into the corresponding control character in the first quadrant of the EBCDIC code table (see Appendix A). Since the editing characters are not considered part of the input line they cannot be "backspaced over." Line editing can be modified for convenience in paper-tape and card input modes.

Function	TTY 35/37	2741	1050	CCI
ECL	RETURN	RETURN	RETURN	CTL-TRANS
EOF	ETX (CTL-C)	¢	¢	BACKSLASH
Backspace	BS (CTL-H)	BACKSPACE	BACKSPACE	na
Line-Del.	RUBOUT	_	_	na
Attention	ENQ (CTL-E)	ATTN	LINE RESET	ATTN
Lit.-Next	DLE (CTL-P)	!	!	!

Figure 2. Preferred Editing Control Characters

In addition to the characters shown in Figure 2 several control characters are defined for use by certain terminal types. These are described separately by terminal type in Section 4.

2.3.2 Code Translation. Code translation normally defaults to the code appropriate for the terminal type: American Standard Code for Information Interchange (ASCII) for Teletype, CCI and ESC and Paper Tape Transmission Code (PTTC) for IBM terminals. ASCII is a seven-bit code with an eighth bit generated as even parity. PTTC is a six-bit code with a seventh bit generated as odd parity. Correct parity is always generated in messages sent by the Data Concentrator. Correct parity is also expected in messages sent to the Data Concentrator unless overridden by a Data Concentrator command. Both the code translation and parity operations can be modified so that the MTS program can operate with the bits exactly as received from and transmitted to the terminal.

Appendix A shows the code translation tables used by the Data Concentrator. These tables are identical in all but trivial aspects to those used within the MTS system for other devices. Appendices B and C explain the conventional interpretation given the ASCII and PTTC codes respectively.

2.3.3 Record Formation. Normally, messages are transmitted on a record-by-record basis. The extents of the terminal records are not constrained to the extents of the MTS read/write operations involved, however. MTS write operations may be of any length up to about a thousand bytes, depending upon system loading and the configuration of other terminals attached to the Data Concentrator. Users are strongly advised to use lengths less than 256 bytes

however. Any record longer than 255 bytes will be truncated at 255 bytes, unless the @BIN modifier is used. Operations using the @BIN modifier are written on the terminal without translation and are concatenated on a record-by-record basis so that the terminal receives all succeeding @BIN operations as a continuous record. Operations using either the @BIN or the @SP modifier are written without the customary prefix character(s) as generated within MTS.

The extents of MTS read operations are controlled by editing characters generated by the terminal and by a maximum character count, which may be changed by a Data Concentrator command. The behavior may be specified to:

(1) be dependent only upon the size specified by MTS (usually 128 or 256 bytes, depending upon the LEN specification) and to pack succeeding input records into these extents as necessary,

(2) be dependent on the maximum character count as specified in the Data Concentrator, and

(3) be dependent upon special line-editing characters unique to each terminal type (see Line Editing above).

Note that, in the case of MTS read operations, the specification of record extents, code translation, parity operations and control functions must be performed before the record arrives at the Data Concentrator. Thus the inclusion of the @BIN modifier in an MTS read operation does not necessarily result in the proper control of the code translation and record extents unless either the terminal itself has indicated this by a control function or a previous Data Concentrator command has been executed.

2.3.4 Error Detection and Recovery. The Data Concentrator checks at several points for transmission and equipment errors. Transmission errors are detected by means of character parity as determined by the particular terminal type. If a parity error is detected on an input record a data check condition is said to exist on that record. If an input character has not been processed by the system before another input character arrives (perhaps due to some hardware fault or to an unusual demand for service), an overrun condition is said to exist on the record containing that character. Finally, if no buffer storage space is available for an input character, then a buffer overflow condition is said to exist on the associated input record.

Depending upon the particular terminal type and the options specified, these errors may cause the associated

input record to be deleted and a diagnostic message to be transmitted to the terminal. Where the construction of a terminal permits the retransmission of a record without manual operator intervention the terminal is simply requested to retransmit and the diagnostic message is not printed. This latter behavior occurs with CCI and BSC terminals, as well as with the IBM 1056 card reader attached to the 1050 terminal.

Parity checking on input records can be disabled with the PARITY option. For BSC terminals the option applies only to checking the constraint that control characters and translated text characters have correct odd parity; the cyclic checksum transmitted following the record must still be correct. By convention, the data check condition is set only when a bad-parity data character is stored in an input buffer. A character received of bad parity is assumed to be a data character (even if it appears to be a control code) if the transmitting terminal is thought to be in a text-transmit state and is ignored entirely if the transmitting terminal is thought tc be in any other state.

An overrun condition is detected by the Data Concentrator hardware itself and may occur both on input and output operations. From the terminal operation point of view an overrun condition on an input record appears identical to a data check condition. An overrun condition on an output record will usually result in garbling of the transmitted characters. An incidence of this condition is considered a recoverable system error and is logged within the Data Concentrator as such. It indicates a possible hardware or software malfunction within the system itself and cannot normally be caused by an attached terminal.

A buffer overflow condition occurs when no storage can be found for a data character received from a terminal. Since buffer storage is assigned in small blocks (called nibbles) on demand from a large pool available to all terminals, this condition can occur only if all the available nibbles have been allocated, either because of an exceptionally heavy loading condition or because one or more terminals have made unreasonable demands for buffer storage. The behavior of the system under these conditions is that echoing usually ceases (for full-duplex Teletype terminals) or an excessive number of retransmissions is requested (for CCI and BSC terminals). When storage is once again available a diagnostic message will be transmitted to the terminal and normal operation can be resumed. Note that the buffer overflow condition is not related to the options specified by an individual terminal but only to the overall demands placed by all attached terminals upon the Data Concentrator system itself.

2. Basic Procedures

3. COMMANDS

Input/output operations in MTS are supported by a set of Device Support Routines (DSRs) for each type of hardware device which can be used. These routines interface on a uniform level with the system I/O routines (such as READ, WRITE, SCARDS, SPRINT, etc.). In this way, the user program performs I/O operations on a named device, but the system executes the I/O operation by calling the particular DSR for that device based on the device type. In the case of a terminal operator's using the Data Concentrator, information entered from the terminal passes through both the Data Concentrator control program and the MTS DSR for the Data Concentrator before being actually read by MTS or the user's program. On output, the reverse is true.

A uniform control procedure has been established for the MTS Data Concentrator DSR and the Data Concentrator itself. As a data record passes through either of these processors, the first character of the record is examined for a special selection character, which is initially set at SOH in the system (EBCDIC) code. If the selection character appears as the first character in the record, then the record is intercepted and interpreted within that processor as a command. If the record begins with two selection characters then the first character is removed, making the record one character shorter, and the remainder of the record is passed tc the next processor. A record not beginning with a selection character is passed unchanged. Given these conventions, it is clear that a terminal input line beginning with a single selection character will be interpreted as a command by the Data Concentrator control program. Likewise, an input line beginning with two selection characters will appear as a command to the MTS Data Concentrator DSR since the Data Concentrator will strip off the first, thereby making the second the first character of the record as seen by the MTS DSR. Of course, since these processors recognize commands on output too, it is possible to have an executing MTS program issue any of these commands. Both the Data Concentrator control program and the MTS DSR contain facilities to change the selection character to other than the SOH assumed initially.

3.1 Data Concentrator Commands

A Data Concentrator command may be generated either by the terminal or by an MTS program. If the command is generated by the terminal it takes the form of an SOH character followed by the command name and a list of operands. The SOH character is generated by the CTRL-A key combination on Teletype terminals and by the two-stroke sequence !A on IBM and CCI terminals. If the command is

generated by MTS program it takes the same form but preceded by two SOH characters. If a command is issued from an MTS program, prefixing must be disabled, either by the @SP modifier, the $SET PFX=OFF MTS command or the PFX OFF device command (see below). It is necessary to enter only the first and last letters of command and operand names.

Although many commands are presently implemented in the Data Concentrator system, only a few will be described in detail here. Users with unusual applications should contact the Computing Center for further information regarding these commands.

ATTENTION

This command can be used to cause an attention interrupt to MTS and is most useful if issued from the terminal. This command is useful for BSC terminals which need to cause such an interrupt and yet have the message itself acknowledged (see Section 4.5).

HELLO

This command causes the time of day and the version number of the current Data Concentrator control program to be printed on the terminal. The message is printed in the following format:

%time xxxx ttnn-ttnn PDP-8 RAMP CONTROL SYSTEM (VERSION XX)

where time is the time of day in hours:minutes:seconds format, xxxx is the location within Data Concentrator storage of certain control information and the two codes ttnn are the device names within the Data Concentrator associated with this user (see Figure 1).

OPER message

The message (which should not exceed 71 characters) will be printed on the Data Concentrator operator's console along with the time of day. Operators experiencing difficulty using the Data Concentrator may use this command. It is suggested that several BELL characters (CTRL-G) be included to alert the operator. The BELLs are not included in the 71 character limitation.

PARAMETER [PREFIX=code]

This command is used to alter certain fields of the task control block used for record transmission within the Data Concentrator system. Although several operands are available in this command, only the PREFIX operand is of

general utility. This operand causes the selection character used to identify a Data Concentrator command to be changed. If the code in this operand is a character other than a letter, digit or blank, then that character becomes the new selection character. If this code is a three-digit (octal radix) number, then the EBCDIC character code corresponding to that number becomes the new selection character. Selection can be completely disabled if the code is either a blank or the number zero.

Note that the selection character on the transmission path for this command only is changed. Therefore, if the direction of transmission is inbound to MTS, the selection code is changed for that direction only. The same is true for outbound transmission from MTS; the selection characters for the two directions are entirely separate.

READER

This command is used to start paper-tape and card equipment attached to Teletype and IBM terminals. See Sections 4.1 and 4.3 for details of operation using this command.

SENSE [devicename]

This command causes the Data Concentrator to print the private storage allocated to the device devicename. The default devicename is the terminal issuing this command. Users with special terminal equipment should obtain this information, if possible, and present it to a cognizant Computing Center staff member if a Data Concentrator malfunction is suspected.

CONTROL [MODE=mode] [ON=optlist] [OFF=optlist] [CLOCK=a]
[SIZE=n] [SYNC=n,m]

This command is used to change the operational characteristics of a terminal attached to the Data Concentrator. The operands to this command cause certain fields in the private storage attached to the terminal to be changed and in some cases cause the hardware registers to be changed. In general these operations can be performed "on-the-fly" by the terminal itself (carefully!) with due allowance made for inbound records which may be queued ahead and so forth.

The parameters that can be changed by the CONTROL command are called options and are generally represented by a set of switches which may be set ON or OFF. These switches are generally non-interacting, although exceptions to this rule are several. The options which may take on

values ON or OFF are set by the operands ON and OFF respectively in the following form:

ON=optlist OFF=optlist

where optlist is a list of options (see below) separated by commas. Options which may take on other values are set by other operands (usually the name of the option) in a form described below under the particular option.

For operator convenience a particular configuration of options has been associated with a mode. The mode of a terminal can be set by the MODE operand in the following form:

MODE=mode

where mode is a name assigned as a function of terminal type as described in Section 4. When other operands are included in the CONTROL command the MODE operand must occur first. Note that the use of a keyword as a mode name does not preclude its use as an option name; and the two uses may have different interpretations.

In some circumstances a special character or line signal generated by the terminal has the effect of an implicit MODE keyword. This happens during the terminal identification phase of connection and upon exit from the BINARY mode for instance.

Options. Several options are applicable to all terminal types, while others are specialized to certain types. The valid options for the various terminals and their defaults at connection time are summarized in Figure 3. These options provide control over error check, keyboard interlock, code translation and inbound record blocking operations. Note that the options described here apply only to inbound record transmission and terminal control. Options applying to outbound record transmission are under the control of the MTS DSR system and the applicable MTS modifiers. Unless noted below all of the following options have the value either ON or OFF as specified by the CONTROL command.

OPTION	35	37	2741	1050	CCI	BSC
BID						OFF
BINARY	OFF	OFF	OFF	OFF	OFF	OFF
CLOCK	B	D	C	C	B	
CONCOMP						ON
DUPLEX	ON	ON				OFF
DELAY	ON	ON				
ECHO	ON	ON				
EDIT	ON	ON	ON	ON		
HOLD					ON	
INTERLOCK	OFF	OFF	OFF	OFF	OFF	OFF
ODD						OFF
OVERFLOW	ON	ON	ON	ON	ON	ON
PARITY	ON	ON	ON	ON	ON	OFF
PREFIX	OFF	OFF	OFF	OFF	OFF	OFF
QUEUE			ON	ON		
READER	OFF	OFF		OFF		
REPLY						OFF
SIZE	128	128	128	256	256	256
SYNC						6,64

Figure 3. Option Combinations

BID. (BSC terminals only) If this option is ON a text message will not be transmitted by the Data Concentrator unless a positive response to a bid request has been received. Once such a response is received the Data Concentrator will continue to transmit output until its transmit queue becomes empty, after which it will transmit the single character EOT. This behavior is expected in certain IBM systems, although it is not recommended for

highly interactive systems. If this option is OFF the Data Concentrator will transmit text messages as they arrive, but with certain restrictions based on acknowledgments and timeouts (see Section 4.5). This option defaults OFF for BSC terminals at connection time and is undefined for all other terminal types.

BINARY. If this option is ON the normally effective inbound code translation from the native code of the terminal to the system (EBCDIC) code is disabled. Record extents in binary input operations are determined only by the SIZE option and blocked or not as determined by the OVERFLOW option. Inbound binary records are never processed by the Data Concentrator as commands, may contain any code combinations and may be of any length greater than zero. This option defaults OFF for all terminals at connection time.

CLOCK. (non-BSC terminals only) The data set clock rate can be set by this operand. This is useful for those terminals that can change their clock rate to values other than those assumed by the system at connection time. The format of the CLOCK operand is:

CLOCK=a

where a is a single letter which is associated with the following clock rates: (Note: These rates may change from time to time to accommodate new terminal types.)

Value	Rate (baud)	Frame	Terminal
202C data set			
A	1200	10,1	CCI 300
B	600	10,1	CCI 300
103A data set			
A	300	10,1	Computek, Tektronix, ARDS
B	110	11,2	Teletype 33, 35
C	135	9,1	IBM 1050, 2741
D	150	10,1	Teletype 37

Figure 4. Data Set Clock Rates

In the entry for frame the designation n,s corresponds to "number of bits per character,number of stop bits" as shown in Appendix D. Note that the frame is fixed at connection time and cannot thereafter be changed. Consideration will be given to providing this option in the future.

CCNCOMP. (BSC terminals only) If this option is ON then the 201A data set protocol is assumed to be compatible with one established by an earlier version of the Data Concentrator control program. If this option is OFF then the standard BSC conventions established by IBM and modified by local option (see Section 4.5) are assumed. This is not an option that can be set by the ON and OFF operands to the CONTROL command, but can be set only by an appropriate MODE operand (see Section 4.5). This option is included only for compatibility with older systems and considerably degrades the performance of the Data Concentrator. It will be removed at an early date; therefore, users are advised to convert their systems to the new standard protocol at the earliest possible date. This option presently defaults ON for BSC terminals and is undefined for all other terminal types.

DUPLEX. (Teletype, IBM and BSC terminals only) This option is interpreted differently for Teletype, IBM and BSC terminals. For BSC terminals, if this option is ON text messages and acknowledgments will be concatenated as single records whenever possible. If this option is OFF every text message and acknowledgment will be transmitted as a separate record. The latter is the behavior expected by most IBM systems, although the former provides a significant increase in throughput for highly interactive systems.

For Teletype terminals, if this option is ON then full-duplex operation is assumed; if it is OFF half-duplex operation is assumed. This option defaults ON for Teletype terminals and OFF for BSC terminals at connection time and is undefined for all other terminal types.

DELAY. (Teletype terminals only) If this option is ON an automatic 200-millisecond delay is executed at the end of each output line to allow the carriage to return to the left margin stop. This delay is overlapped with the generation of the CR and LF characters, so that the effect is equivalent to the generation of a number of NUL characters depending upon the clock rate selected by the CLOCK option: none at rates below 150 bits-per-second (baud), one at 150 baud and four at 300 baud. If this option is OFF then no delay is executed. This option defaults ON for Teletype terminals at connection time and is undefined for all other terminal types.

ECHO. (Teletype terminals only) if this option is ON then the input characters from Teletype terminals will be return-echoed in certain modes (see Section 4.1). If this option is OFF then the echo process is disabled entirely. This option is undefined for all other terminal types.

EDIT. (Teletype and IBM terminals only) If this option is ON then the normal input editing operations are in effect. If this option is OFF then certain input editing operations are suspended. This option is useful for paper-tape and card input to the system. This option defaults ON for IBM terminals at connection time. For Teletype terminals this option defaults OFF while the answerback code is being received and automatically is switched ON following reception. This option is undefined for CCI and BSC terminals.

HOLD. (CCI terminals only) If this option is ON then the CCI display will stop output when the screen is full. Only when the CTL-TRANS key combination is pressed will the screen be erased and output continued. If this option is ON then the screen will be automatically erased and output will continue. This option defaults ON at connection time for CCI terminals and is undefined for all other terminal types.

INTERLOCK. There are two terminal protocol procedures supported by the Data Concentrator in connection with the facilities for queing inbound records in advance of MTS read operations. If the INTERLOCK option is OFF with IBM terminals then the keyboard is unlocked after every MTS write operation so that the operator can enter a new input line, regardless of whether an MTS read operation is outstanding or not. If an outbound message is generated by MTS when the keyboard is unlocked and if the operator has not begun a new input line, then the keyboard is locked and the outbound message is printed. If the INTERLOCK option is ON then the keyboard is unlocked only when an MTS read operation is outstanding. In this mode it is not possible to queue records in advance of MTS processing.

In full-duplex Teletype equipment the keyboard is never locked and can be used to input records in advance of MTS processing whether the INTERLOCK option is ON or OFF. However, if the INTERLOCK option is OFF then the return-echo characters are printed at the terminal on a line-by-line basis as the input lines are entered and without regard to MTS read operations. If the INTERLOCK option is ON then return-echo lines are delayed until MTS presents a read operation for the corresponding input record. Thus the return-echo lines printed at the terminal are always in their correct position relative to the MTS input and output operations.

3. Commands

In all terminals, if the INTERLOCK option is ON when a line is entered to the Data Concentrator Command Language Interpreter the Data Concentrator prefix character (currently "%") is printed as the prefix to the next input line. See Section 4 for special considerations of operation using the INTERLOCK option with particular terminal types. See also the descriptions of the PREFIX and QUEUE options in this section. This option defaults OFF for all terminals at connection time.

Note: The interplay between the terminal, MTS and the Data Concentrator is necessarily highly intricate in the transitions between the ON=INTERLOCK and OFF=INTERLOCK states. It is recommended that entry into the ON=INTERLOCK state be made only when no output activity is in progress, no input lines are queued and MTS is waiting for an input line from the terminal. Occasionally it is possible to enter an "out of phase" state in which the 2741 keyboard may become locked or the Teletype terminal echo lines may appear out of order. This is most often due to a user program or MTS failure to respond to an attention interrupt with a read operation (eventually) and can be recovered from (for Teletype terrminals at least) by simply issuing the OFF=INTERLOCK operand, then pressing the RUBOUT key and finally issuing the ON=INTERLOCK operand.

ODD. (BSC terminals only) If this option is ON then all outbound ASCII control characters and translated text characters will be generated with odd parity. If this option is OFF then these characters will be generated with even parity. Note that if the PARITY option is ON then inbound control characters and translated text characters are checked for odd parity. This option is included primarily for compatibility with older systems and defaults OFF for BSC terminals at connection time, at least for the present. This option is undefined for all other terminal types.

OVERFLOW. If this option is ON in the event of inbound record overflow, the present record is ended and transmitted to MTS as a complete line. If this option is OFF in the event of inbound record overflow the record is concatenated with following inbound records and the blocking is a function only of the extents provided by the MTS read operations. This option defaults ON for all terminals at connection time.

PARITY. All terminals presently supported are provided with some form of transmission error detection, usually in the form of a Vertical Redundancy Check (VRC) or Longitudinal Redundancy Check (LRC) or both. The Data Concentrator always generates the correct VRC and LRC on outbound records

as required. If the PARITY option is ON then the Data Concentrator will also verify the correct VRC and LRC on inbound records as well. If a parity error occurs on an inbound record then the record is deleted and the comment "DATA CHECK" is printed on the terminal. If the PARITY option is OFF then the Data Concentrator ignores all parity check faults and the record is passed as-is to MTS. For IBM and CCI terminals this option defaults ON at connection time, while for BSC terminals this option defaults OFF. For Teletype terminals this option defaults ON only if the answerback code has correct even parity. Otherwise it defaults OFF.

PREFIX. This option provides control over the MTS prefix as it appears in response to line-delete and command operations. If this option is OFF then a line-delete or command operation is performed entirely within the Data Concentrator itself and without regeneration of the MTS prefix characters. If this option is ON then each such operation causes the MTS prefix character(s) to be printed at the terminal immediately following the operation. This option defaults OFF for all terminals at connection time.

QUEUE. (IBM terminals only) If this option is ON an operator interrupt initiated by the ATTN (2741) or LINE RESET (1050) keys while the printer is active causes the keyboard to be unlocked at the end of the current output line. If this option is OFF an operator interrupt while the printer is active causes the current output line to be immediately terminated and an attention interrupt to be generated. In either case, if the printer is not active an operator interrupt causes an attention interrupt to be generated. This option defaults ON for IBM terminals at connection time and is undefined for all other terminal types.

READER. (Teletype and IBM 1050 terminals only) This option provides control over whether the keyboard or the optional paper-tape or card reader is active at the terminal. If this option is ON in the case of paper-tape equipment attached to Teletype terminals then the Data Concentrator generates the DC1 (XON) and DC3 (XOFF) characters used to control this equipment. If this option is ON in the case of the IBM 1050 Data Communications System the Data Concentrator polls the 1056 Card Reader instead of the 1052 keyboard. This option defaults OFF for Teletype and IBM 1050 terminals at connection time and is undefined for all other terminal types.

REPLY. (BSC terminals only) If this option is ON then the Data Concentrator will expect a reply after every outbound transmission which is to be acknowledged. It will measure

the reply time autcmatically and use this measurement to ccntrol the number of SYN characters generated before the next message and thereby the turnaround time. If no reply is received after an interval computed on the basis of the present SYN count the count will be increased and an ENQ message will be initiated. If a reply is received before an interval computed on the basis of the current SYN count then the count will be decreased. This procedure is applicable only following transmission of a text message or ENQ message and is disabled by receipt of any acknowledgment, following which the ENQ timeout is in effect (see the SYNC operand description). This behavior is designed to adapt to infreguent transmission errors yet minimize the average turnaround time. If this option is OFF then the fields set by the SYNC operand are used for the SYN count and ENQ timeout and the adaptive behavior is suppressed. This option defaults OFF for ESC terminals at connection time and is undefined for all other terminal types.

SYNC. (BSC terminals only) This operand sets two parameters controlling the timing of the BSC terminal. The SYNC operand takes the following form:

SYNC=n,m

where n is the number of SYN characters to be generated preceding the message and m is the timeout (centiseconds) for ENQ generation following a no-reply condition. The value n may take on values from 1 to 63 with a minimum of 4 recommended, while the value m may take on values from 64 to 4095 (0.64 to 40.95 seconds) but will be rounded up to the nearest multiple of 64. The defaults assumed at connection time are equivalent tc SYNC=6,64.

SIZE. The maximum inbound record length is set by this operand. Records received of longer lengths are split into segments of no longer than this specification and are blocked or not under control of the OVERFLOW option. The SIZE operand takes the fcllowing form:

SIZE=n

where n takes on values from 1 to 256 bytes and defaults to 128 bytes at connection time for Teletype and IBM 2741 terminals and 256 bytes for all other terminal types. See also the MTS DSR command LEN described in Section 3.2.

3.2 MTS Device Support (DSR) Commands

Note: Commands must begin with SOH SOH (i.e., CTRL-A CTRL-A on Teletype terminals) if issued from a terminal; SOH if issued as output from MTS (with prefixing off-- see @SP

modifier description below, PFX device command description, or MTS $SET PFX=OFF ccmmand). The SOH character is the default DSR selection character (see the SEL command description below).

TAB [ON] [OFF] ["X"] [n1 n2 ...]

This command is used to control input tabbing, i.e., the processing of tabs for input being sent from a terminal to MTS itself or to an executing program running in MTS. The parameters may be entered (after the characters "TAB") in any order, may be separated by any character(s) which are not themselves legal parameters, and are processed from left to right. The parameters ON and OFF enable and disable tab processing respectively. The parameter "X" sets the tab character to any upper case character X. The decimal numbers (in the range 1 to 255) n1, n2, etc. are the tab stops to be used. An error comment is printed for numbers not within the 1 to 255 range and if more than 20 stops are given. In such cases, the remainder of the input line after the error is ignored, but the initial part takes effect. As a convenience, tabbing is enabled (as with an ON parameter) whenever a valid tab stop is set. Tab stops should be given in numerically increasing order. Whenever a TAB command contains at least one tab stop setting, all stops set by any previous TAB command are reset. The default conditions are: tabs OFF; tab stops at columns 10, 16, and 35; and the tab character is the EBCDIC HT (i.e., HT (CTRL-I) on Teletype terminals and "TAB" on IBM terminals).

Examples:

TAB ON
Enable tabbing, with stops as previously set or at 10, 16, and 35 if never set; and with tab character as previously set or EBCDIC HT if never changed.

TABS=ON;10,20,30
Enable tabbing with stops at columns 10, 20, and 30. The tab character remains the same. The ON parameter is redundant in this example since the presence of a tab stop setting turns tabs ON. The equal sign, semicolon, and commas were chosen arbitrarily in this example and are not required.

TABS 5 15 ";" 25 ,,, OFF
Set tab stops at 5, 15, and 25 and change the tab character to semicolon ";". Disable tabbing. Note that the OFF parameter must occur after (to the right of) the last tab stop setting if it is not to be overridden. The commas have no effect.

HEX [ON] [OFF] ["X"]

This command controls hexadecimal input conversion. The parameters may be entered in any order. Any upper-case character, X, may be used as the hex number delimiter. This character defaults to a prime. Hex processing transforms hexadecimal input consisting of an even number of hex characters (0...9,A...F) delimited by the current hex delimiter into half as many bytes with the delimiters removed. A delimiter may be entered by giving two consecutive delimiters. The hex processing is done before the input line is examined for an initial DSR selection character (indicating the presence of a command), before tabs (if any) are expanded, and before line number peeling (if any) is done. If an input line begins with two DSR selection characters, then the first is deleted and the line is not modified further by the DSR. Hex conversion defaults off. The CLEAR command disables hex processing and changes the delimiter to prime.

Examples:

HEX=OFF "/"
Disable hex input, but change the delimiter to a slash. The equal sign was chosen arbitrarily.

HEX ON
Enable hex input processing. The hex delimiter is not changed, it remains a prime if it has not been changed previously.

ABC'00FB' ''TEST''.
This input line, when entered with hex processing enabled and with prime as the delimiter, will result in the following line of input (shown here in hex form):

C1C2C300FB4C7DE3C5E2E37D4B

RM n
LM n

The right margin (RM) and left margin (LM) commands allow the terminal user to adjust the logical length of his terminal carriage (the carriage length is equal to the RM setting minus the LM setting). The actual RM and LM settings are irrelevant since only their difference matters. However, both numbers must lie in the range 0 to 255 and their difference must be greater than one. An error comment is given for violation of these requirements and the settings are not changed. Any MTS output line which, after truncation (see LEN command), exceeds the logical carriage length will be broken up into two or more lines each of

length equal to the carriage length (except for the last line which may be shorter). Each extra output line generated by this process will be prefixed with an asterisk "*". The default value of LM is zero. RM defaults to 72 for Teletype terminals, 126 for IBM 2741 terminals, 144 for IBM 1050 terminals and 255 for all other terminal types.

Examples:

```
RM   100

LM=6
```

LEN n

The length (LEN) command sets the output line truncation length (in the range 0 to 255). Any output line exceeding the current length setting will be truncated to that length. The default LEN settings are: 72 for Teletype terminals, 126 for IBM 2741 terminals, 144 for IBM 1050 terminals and 255 for all other terminal types. Except when the @BIN modifier is given (see Section 3.3), input lines are truncated to 128 characters if the LEN setting is no greater than 128, 255 if the LEN setting is greater than 128.

Examples:

```
LEN   100

LEN=30
```

CLEAR

This command, which requires no parameters, resets the values of all command parameters to their defaults.

UC [ON] [OFF]

The upper-case (UC) command permits all lower-case input (such as can be typed on an IBM terminal) to be converted to upper case. If disabled, conversion is controlled by the MIS @UC modifier. The default is ON for IBM and Teletype Model 37 terminals and OFF for all other terminal types.

CC [ON] [OFF]

The carriage control (CC) command permits the enabling and disabling of output carriage control processing. The command overrides the action of the @CC modifier which

normally controls the application of carriage control. Using this command to enable or disable carriage control recognition means that the MTS @CC modifier will be completely ignored. The CLEAR command must be used to return control to the @CC modifier (which is the default condition).

Examples:

```
CC   ON

CC=OFF
```

PFX [ON] [OFF]

The prefix (PFX) command operates analogously to the CC command except that it applies to prefixing (both input and output) and overrides the @SP modifier bit. The CLEAR command must be used to return control to the @SP modifier (which, again, is the default condition).

Examples:

```
PFX   OFF  PLEASE
```

SEL "X"

This command changes the current selection character for the MTS DSR to any upper-case character X. The selection character, which defaults to SOH, must be the first character of any command line. In addition, any line which begins with two selection characters will have the first one deleted and will not be treated as a command by the DSR. The CLEAR command resets the selection character to SOH.

Examples:

```
SEL "Q"

SELECTION "."
```

DON'T

The DON'T command prevents the Data Concentrator from disconnecting the telephone connection after signoff. Following the printing of the last line of the signoff message, the operator may enter an attention character which (if MTS has completed the signoff process) will cause MTS to print the announcement message again as if the operator had just dialed in. A new $SIGNON command may then be entered. This command permits the operator to signon under a

different user i.d. without placing another (perhaps long distance) phone call. If there is no response to the attention character, the operator should re-enter the character until MTS responds. Note that after signing on following a DON'T signoff, the DON'T command must be re-issued if another DON'T signoff is desired. The CLEAR command resets the DON'T switch.

JOB

The JOB command causes a line of output to be printed which gives, among other things, the MTS device name (DCXX) and UMMPS job number (nnnn) as printed in the announcement message.

3.3 MTS Modifiers

CC

The MTS logical carriage control modifiers @CC and @-CC affect the application of carriage control processing to Data Concentrator output. Current legal carriage control characters (a carriage control character is the first character of the output line, not including prefix character, if any) are:

1 Skip 6 lines
\- Skip 2 lines (triple space)
0 (zero) skip 1 line (double space)
& No carriage return at end of line
(See also CC command description.)

SP

The MTS special modifiers (@SP and @-SP) control the processing of MTS prefix characters for the Data Concentrator. The @SP modifier applied to an I/O operation prohibits the use of prefixing on that operation, i.e., no prompting character(s) are printed if the operation is input and no character(s) are prefixed to the output line for output type operations. The modifier @-SP enables prefixing for the operation.

Users should note that to have a line of output from MTS recognized as a command, it is necessary to turn prefixing off with the @SP modifier, the PFX OFF device command, or the MTS $SET PFX=OFF command because the final output line including prefix character(s), if any, is composed before command recognition is performed. Since the first prefix character is generally not an SOH (or the current DSR selection character) an output command line will not be recognized as such unless either prefixing is off or

the prefix starts with SOH. (See also MTS subroutine SETPFX description in Volume 3 of the MTS manual, third edition.)

BIN

The MTS binary modifiers @BIN and @-BIN control the application of output character translation. In addition to disabling the translation, the @BIN modifier also disables carriage control processing, prefixing, command recognition, tabbing, hexadecimal conversion, line number peeling, output or input line truncation, output margin stop processing, and any other operations which affect the input or output data.

4. TERMINAL OPERATIONS

The operation of the various terminals that can be attached to the Data Concentrator will be described in the following sections. Throughout the discussion it will be assumed that the user is familiar with the operation of MTS itself. In the sections describing the operation of particular terminal types it will be assumed that the user is familiar with the basic operation and construction of the terminal itself. Certain system operations, especially those concerned with record formation and error recovery, are common for all terminal types. These operations are summarized in Section 2.

In order to avoid confusion between several models of the same terminal, which may differ only in their keyboard and printing element configuration, the various functions performed by the Data Concentrator will be associated with the characters in the native code of the terminal which initiates them. Where meaningful, the key combinations which produce a character will be shown in parentheses following the character. See also Appendices B and C for further information regarding the conventional interpretation given the control characters of the various native codes.

4.1 Teletype Models 33, 35 and 37

All Teletype terminals operate using the ASCII code (see Appendices A and B), which contains 128 code combinations. Each character is transmitted with an even parity check bit unless specified otherwise (see the BINARY and PARITY option descriptions and the @BIN MTS modifier description). Models 33 and 35 operate at 110 bits-per-second (baud) (10 characters-per-second) with an 11-bit frame size (see Appendix D), while the Model 37 operates at 150 baud (15 characters-per-second) with a 10-bit frame size. These transmission rates can be changed with the CLOCK option.

A Teletype terminal operating in the full-duplex mode provides a facility for using MTS in an efficient manner. Because of the full-duplex operation, it is possible for a Teletype operator to input lines to MTS at any time, even when MTS is not waiting for input. The terminal operator can anticipate input requests from MTS and queue lines ahead to satisfy those requests. The Data Concentrator will buffer the lines and transmit them to MTS as they are requested. It is permissible to type while output is in progress with the result that output continues normally until the end of the current output line, at which time the input line which has been (or is being) typed is echoed.

The INTERLOCK option can be used to modify this behavior.

A Teletype terminal can also be operated in the half-duplex mode or in either of two paper-tape input modes. Special consideration is necessary in the operation of paper-tape equipment which does not respond to the standard tape-control characters DC1 (XOFF) and DC3 (XOFF) as described in Section 4.1.2. Various combinations of modes and options can be used to realize special behavior where required. Some of these will be found useful for the operation of special terminal equipment which functions in a manner similar to Teletype terminals.

4.1.1 Operations. Following is a description of the control functions performed by the Data Concentrator in connection with Teletype terminals. Each of these functions is initiated by a control character generated by the terminal, as shown in Figure 5.

The End-of-Line characters for Teletype terminals are CR (RETURN) and DC3 (CTRL-S also called XOFF). A new-line sequence (CR-LF) will be echoed to the terminal following one of these characters.

The Character-Delete (Backspace) character is BS (CTRL-H). This character may be entered repeatedly to backspace over more than one character. The underscore character "_" (which prints as left arrow on some terminals) will be echoed to the terminal unless the backspacing has reached the beginning of the input line and there remains nothing to backspace over, in which case further backspaces are ignored. The BS character is ignored if the EDIT option is OFF.

The Line-Delete character is DEL (RUBOUT). An entire line may be completely canceled by sending a DEL character at any time before an End-of-Line character is entered. A pound sign "#" will be echoed followed by a new-line sequence. The pound sign provides a visual indication that the input line was not transmitted to MTS. The editing function provided by backspace and line-delete is processed entirely by the Data Concentrator (however, see the PREFIX option description). The DEL character is ignored if the EDIT option is OFF.

Code	33/35 Keyboard	Function
NUL	CTRL-SHIFT-P	Ignored
ETX	CTRL-C	End of File
EOT	CTRL-D	End of Transmission
ENQ	CTRL-E	Attention
ACK	CTRL-F	Ignored
BS	CTRL-H	Character Delete
LF	LF	Ignored
CR	CR	End of Line
DLE	CTRL-P	Literal Next
DC1	CTRL-Q	Ignored
DC2	CTRL-R	Start Printer/Punch
DC3	CTRL-S	End of Line
DC4	CTRL-T	Stop Printer/Punch
ESC	ESC (CTRL-SHIFT-K)	Echo On/Off
DEL	RUBOUT	Line Delete
BREAK	BREAK	Attention

Figure 5. Teletypewriter Control Characters

The End-of-File characters are ETX (CTRL-C) and EOT (CTRL-D). A backslash character followed by a new-line sequence is echoed to the terminal when either of these characters are received. The EOT character has, in addition, special significance in TAPE mode. The backslash provides a visual indication that an end-of-file was entered to end the input line. It should be noted that a non-null input line ended by an end-of-file is actually transmitted as two separate records in MTS, the first being a normal data record (return code of zero from READ), and the second being a zero length record with an end-of-file indication (return code of 4 from READ).

The Attention interrupt is generated by either the BREAK signal or the ENQ (CTRL-E) character. An exclamation point "!" Followed by a new-line sequence is echoed to the terminal. The Data Concentrator will purge the output buffer whenever an attention interrupt is received from a terminal. If the attention is received while the Data Concentrator is transmitting an output line, then the portion of the output line not yet transmitted will be purged. An exclamation point "!" Followed by a new-line sequence is appended to the end of the truncated output line to indicate where in the output data stream the purge occurred. An attention received while an input line is in progress but not yet ended causes that line, along with all other lines which might be queued, to be deleted. A pound sign character followed by a new-line sequence is inserted in the echo buffer to indicate that the partial input line has been deleted.

The ENQ character is ignored if the EDIT option is OFF. The BREAK signal will not cause an attention interrupt if the EDIT option is OFF, but will result in a reset of the terminal options as described in Section 4.1.3, however.

The Literal-Next character is DLE (CTRL-P). This character causes the Data Concentrator to interpret the next character as a data character regardless of whether it may be a control character. In such a case the control character itself will be echoed and not the special echo sequence that is usually echoed. For example, the sequence "CTRL-P RETURN" will not end an input line, but will actually place a CR character in the input buffer for transmission to MTS. In this case a CR will be echoed to the terminal, but no LF will follow the CR.

The ESC character (which may also be typed as CTRL-SHIFT-K on Teletype terminals which lack an ESC key) causes the Data Concentrator to invert the echoing on/off switch. This character may be entered before and after passwords so that the password is not echoed. The ESC character itself is not transmitted to MTS. An End-of-Line, End-of-File, Line-Delete or Attention character will automatically turn echoing back on. Echoing can be disabled entirely by the ECHO option. The ESC character is ignored if the EDIT option is OFF.

It is possible for a terminal operating according to Teletype protocol to control output operations at the terminal. If a DC4 (CTRL-T) is entered from the keyboard all output operations, whether printer or paper-tape punch, will be suspended. If the DC4 character is entered during an output operation the output operation will immediately stop. Output operations will continue when a DC2 (CTRL-R)

character is received by the Data Concentrator. No output data will be lost and the DC2 and DC4 characters will not be transmitted to MTS. This feature is useful for special processing equipment and remote computers connected to the Data Concentrator via 103A data sets.

The NUL (CTRL-SHIFT-P), ACK (CTRL-F), LF and DC1 (CTRL-Q) characters are completely ignored by the Data Concentrator and are not transmitted to MTS. In addition, the BS (CTRL-H), ENQ (CTRL-E), ESC (CTRL-SHIFT-K) and DEL (RUBOUT) are ignored if the EDIT option is OFF. In any case, however, if any of these characters are preceded by the literal-next (DLE) character, then they will not be ignored and will be transmitted to MTS as data.

Figure 7 summarizes the special echo sequences transmitted in response to the various control functions. If a control character is preceded by the literal-next character the control character itself is echoed and not the special echo sequence shown. If the ECHO option is OFF, no echoing of any kind is allowed to occur.

Function	Echo
End of line	new-line
End of file	backslash/new-line
Character delete	_
Line delete	#/new-line
Attention	!/new-line
Ignored	none

Figure 8. Teletypewriter Special Echo Sequences

In addition to these special echo sequences, certain other characters transmitted to the Teletype terminal cause special behavior. If a forms-control character (CR, HT, VT and FF) is transmitted the Data Concentrator will execute a 220-millisecond delay to allow the forms movement to be completed before printing the next character. This delay is controlled by the DELAY option.

4.1.2 Options and Modes. Four modes are available for Teletype terminals. These are set using the mode operand of the CONTROL command. The applicable options include the BINARY, CLOCK, DUPLEX, ECHO, EDIT, INTERLOCK, OVERFLOW,

PARITY, PREFIX, READER, and SIZE options, which are described in detail in Section 3.1. The four modes are described below.

FDX (Full-Duplex). This is the default mode for Teletype terminals. In this mode the return echo is produced by the Data Concentrator and may include special echo sequences for editing control characters. The special echo sequences are produced by certain input characters, as shown in Figure 5 and described in the previous section. All other characters are echoed exactly as received. The return echo provides a means of visual indication of the data as received by the Data Concentrator. Transmission errors from a Teletype terminal to the Data Concentrator will show as garbles on the Teletype terminal printer. A mechanism has been provided in the Data Concentrator to defeat this echoing process (see the ECHO option and HDX mode).

The FDX mode is invoked by the MODE=FDX operand of the CONTROL command, which is equivalent to the following options:

```
CN=DUPLEX,ECHO,EDIT,OVERFLOW OFF=BINARY,READER SIZE=128
```

HDX (Half-Duplex). In this mode the terminal itself performs the return-echo process and the Data Concentrator transmits only the special echo sequences for editing control characters. The special characters for line termination and editing are the same as those defined for FDX mode. In HDX mode it is not permissible to type while output is in progress.

The HDX mode is invoked by the MODE=HDX operand of the CONTROL command, which is equivalent to the following options:

```
CN=ECHO,EDIT,OVERFLOW OFF=DUPLEX,BINARY,READER SIZE=128
```

TAPE. This mode is intended for paper-tape input in symbolic format and is useful for input of tapes punched either off-line or by a terminal connected to MTS. Tapes may be read only from Teletype terminals equipped with a paper-tape reader which responds to the control characters DC1 (CTRL-Q also called XON) and DC3 (CTRL-S also called XOFF). The terminal must also be capable of full-duplex operation. The Data Concentrator will send a DC3 to the terminal to stop the reader only in the case when a complete record has been received before the preceding record has been processed by MTS. When the preceding record has finally been processed the Data Concentrator sends a DC1 to restart the reader. In many instances the MTS input processing rate will be sufficiently high so that the reader

will run continuously.

Equipment such as the Teletype Model 33ASR, which does not respond to these control characters, can still be used with the Data Concentrator but the operator should be warned that a fair probability exists that data will be lost if the total number of input characters exceeds about 250. Is suggested that echoing be disabled using the ECHO option in such cases.

The TAPE mode is invoked by the MODE=TAPE operand of the CONTROL command, which is equivalent to the following options:

```
ON=ECHO,OVERFLOW,READER OFF=EDIT,BINARY SIZE=128
```

Note that the EDIT option defaults OFF in TAPE mode. This means that certain editing control characters are ignored and cannot be transmitted unless preceded by a literal-next (DLE) character. This behavior can be overridden of course by means of an ON=EDIT operand following the mode operand. Note also that the PARITY option is not affected by any of the mode operations; therefore, if the tape is not punched with correct even-parity characters the OFF=PARITY operand should also be used.

The ECHO option defaults ON in TAPE mode and therefore, since echo lines have priority over output lines, the order of input echo lines and MTS output lines may not be preserved as they appear on the printer. For this reason it is suggested that MTS prefixing be disabled, either by the @SP MTS modifier, PFX OFF MTS DSR command, or the $SET PFX=OFF MTS command. For example, the following MTS command might be used to copy a paper-tape to a file or device:

```
$COPY *SOURCE*@SP TO fdname
```

where FDname is the name of the file (or device) to which the tape is to be copied. This command can be given either before or after entering TAPE mode. If it is desired to keep the input echo lines and MTS output lines in sequence, the INTERLOCK option should be turned ON. The following Data Concentrator command will result in that configuration

```
CONTROL MODE=TAPE ON=INTERLOCK
```

Once TAPE mode has been entered the READER command can be used to start the reader, after which automatic operation will then continue. An EOT (CTRL-D) character should be entered when the tape reading is concluded, either from the keyboard or from the tape itself. This character will transmit an end-of-file indication to MTS, stop the tape

reader and return the terminal to either the FDX or HDX modes, whichever was in effect prior to the issuance of the MODE=TAPE operand. Pressing the BREAK button will also cause an exit from TAPE mode, but may not stop the tape reader and will not cause an end-of-file indication to be transmitted to MTS. The BREAK button will not cause an attention interrupt in this case.

BINARY. This mode is intended for arbitrarily coded paper-tape input format and is useful for the input of binary tapes punched by peripheral equipment. Since the data are assumed to be binary rather than symbolic the normal ASCII-to-EBCDIC code translation is not performed. Therefore, all code combinations are treated as data and transmitted to MTS with the high-order (parity) bit being placed in the high-order bit position in each System/360 byte. A record is formed by counting the number of input characters. When the default record size of 256 characters has been reached the record is automatically ended and transmitted to MTS. The SIZE option can be used to change the default record size.

The BINARY mode is invoked by the MODE=BINARY operand of the CONTROL command, which is equivalent to the following options:

```
ON=BINARY,READER OFF=ECHO,EDIT,OVERFLOW SIZE=256
```

Note that the @BIN modifer is required. To copy binary data to an MTS file the following form might be used:

```
$COPY *SOURCE*@BIN TO fdname
```

The @BIN modifier also turns off prefixing. It is not necessary to apply the @BIN modifier on the output file name since the file routines never do character translation and, therefore, ignore the @BIN modifier. If the copy is to a device rather than a file, it may be necessary to apply @BIN to the device (or pseudo-device) name. This will depend on whether the device involved normally does character translation (if ASCII to EBCDIC translation is desired on the tape input then TAPE mode should be used instead).

See the section on TAPE mode for a description of the terminal hardware characteristics required for BINARY tape input mode. Operation of that equipment is described in the same section.

The BREAK button is used to exit from BINARY mode and return to either FDX or HDX mode, depending on which of these modes preceded BINARY mode. The BREAK will not cause an attention interrupt in this case. An EOT (CTRL-D) character should be sent from the keyboard to end the MTS

copy operation.

4.1.3 Option Combinations. The four modes are mutually exclusive. The BINARY option precludes the EDIT and PARITY options. The remaining options can be applied or not in any combination, although some combinations may not result in useful device behavior. Figure 6 summarizes the options set by the four mode operands. Where neither ON or OFF is specified for an option, that option is not changed by the mode operand.

MODE ->	FDX	HDX	TAPE	BINARY
BINARY	OFF	OFF	OFF	ON
DUPLEX	ON	OFF	-	-
ECHO	ON	ON	ON	OFF
EDIT	ON	ON	OFF	OFF
OVERFLOW	ON	ON	ON	OFF
READER	OFF	OFF	ON	ON
SIZE	128	128	128	256

Figure 6. Teletypewriter Option Combinations

In all modes the BREAK button and the EOT (CTRL-D) character act like an implicit CONTROL command which resets the options to the following values:

```
ON=ECHO,EDIT,OVERFLOW OFF=BINARY,READER SIZE=128
```

In addition, if the EDIT option is ON, the BREAK button causes all queued input lines to be deleted and an attention interrupt to be transmitted to MTS. The EOT character initiates the end-of-file function as well if the BINARY option is OFF. The PARITY option defaults ON if the answerback code has good (even) parity at connection time. Otherwise it defaults OFF. The other options default at connection time to correspond to the following CONTROL command:

```
CONTROL MODE=FDX CLOCK=B OFF=INTERLOCK,PREFIX
```

4.1.4 Transmission Errors. The Data Concentrator monitors each input operation for a variety of error conditions,

including the data check, overrun and buffer overflow conditions described in Section 2.3.4. At the time that the Data Concentrator processes the character which caused the error condition a BREAK signal is sent to the terminal to inform the operator of the error. The BREAK signal turns on the OUT-OF-SERVICE light on the terminal and disables its keyboard. Following this action a diagnostic message will be transmitted to the terminal and operation can be resumed after pressing the BREAK RELEASE button.

Under unusual circumstances it may happen that every character entered causes the BREAK signal to be transmitted to the terminal and the OUT-OF-SERVICE lamp to be illuminated. This might be due to a terminal malfunction or to a buffer overflow condition in the Data Concentrator itself. If such a condition is suspected the operator should press the BREAK button, which causes the Data Concentrator to reset the error flags and reclaim the buffers allocated to the terminal. If the trouble persists after pressing the BREAK RELEASE button, the terminal should be disconnected and the trouble reported to the Computing Center.

4.2 IBM 2741 Communications Terminal

The IBM 2741 Communications Terminal operates using the PTTC code (see Appendices A, C and D), which contains 64 code combinations. Each character is transmitted with an odd parity check bit at a transmission rate of 134.5 bits-per-second (baud) (about 14.8 characters-per-second). The transmission rate can be changed with the CLOCK option.

The Data Concentrator operates the 2741 in a manner which permits the operator to enter input whenever output is not in progress. The Data Concentrator will keep the keyboard unlocked whenever possible. This permits the operator to queue input in a manner similar to the method available to Teletype terminal users. However, because of keyboard differences, the protocol for the 2741 differs slightly.

4.2.1 Operations.

Following is a description of the functions performed by the Data Concentrator in connection with the IBM 2741 Communications Terminal. Most of these functions apply equally to the IBM 1050 Data Communications System described in Section 4.3. Each of these functions is initiated by a control character generated by the terminal as shown in Figure 8.

Code	Keyboard	Function
NL	RETURN	End of Line
ETB	ALTN CODING-EOB	End of Line
¢	¢	End of File
BS	BACKSPACE	Character Delete
_	_	Line Delete
CAN	ALTN CODING-CAN	Data Check
BYP	ALTN CODING-BYP	Suppress Printing
RES	ALTN CODING-RES	Resume Printing
EOT	ALTN CODING-EOT	End of File
UC	SHIFT	Upper-case Shift
LC	SHIFT	Lower-case Shift
RS	-	Reader Stop
-	ATTN	Attention (2741)
-	LINE RESET	Attention (1050)

Figure 8. IBM Terminal Control Characters

Some of the characters shown in Figure 8 cannot be produced on the 2741 keyboard. All can be produced on the 1052 keyboard of the 1050 terminal. The INTERLOCK and QUEUE options have special significance for IBM 2741 and 1050 terminals and are described in Section 3.1 and in Section 4.2.2 below.

The End-of-Line characters are NL (RETURN) and ETB (ALTN CODING-EOB).

The Character-Delete (backspace) character is the BS (BACKSPACE). This character can be entered repeatedly to delete more than one character, but is ignored once the input line has been completely deleted.

The Line-Delete character is the underscore "_" character. An entire input line may be completely canceled by sending an underscore character at any time before the NL

has been entered. The line-delete operation is performed by the Data Concentrator immediately upon receiving the underscore, so it is not possible to backspace over the line-delete character itself. The Data Concentrator responds to the line-delete character (as well as the end-of-file character "¢") by locking the keyboard and sending a new-line sequence. Therefore the NL (RETURN) character should not be entered following this character. This response is deferred until the terminal shifts to lower-case. Any characters entered between the underscore and the lower-case shift are ignored.

The end-of-file character is the cent sign "¢" character. As in the case of the line-delete character, the Data Concentrator automatically responds to an end-of-file character with a new-line function. Note that a non-null input line ended by the end-of-file character is passed to MTS before the end-of-file indication itself.

The ATTN button (or the LINE RESET button on the 1050 terminal) operates in a slightly different fashion than the Teletype terminal attention characters and depends upon the INTERLOCK and QUEUE options. If the QUEUE option is ON and if the INTERLOCK option is OFF, and if the terminal is printing an output line, then pressing the ATTN/LINE RESET button indicates to the Data Concentrator that the operator desires to enter an input line. The Data Concentrator will stop printing at the end of the current output line and unlock the keyboard so that input may be typed. The operator may then enter an input line, which will be queued in advance of MTS processing. Alternatively, the operator can press the ATTN/LINE RESET button again (when the keyboard is unlocked) and this causes an attention interrupt to be transmitted to MTS just as a ENQ or BREAK would from a Teletype terminal. Thus the ATTN/LINE RESET button serves the dual function of (1) requesting use of the keyboard when it is locked and (2) sending an attention to MTS when it is unlocked.

The QUEUE and INTERLOCK options may be used to modify this behavior. If either the INTERLOCK option is ON or the QUEUE option is OFF, the ATTN/LINE RESET button will cause an attention interrupt to be transmitted to MTS, whether output is pending or not; and, therefore, it is not possible to queue input lines if printing is in progress. When the ATTN/LINE RESET button causes an attention interrupt to be transmitted to MTS the Data Concentrator responds by sending an exclamation point followed by a new-line sequence.

The Literal-Next character is the exclamation point "!". The literal-next character followed by any of the characters in Figure 7 will cause the EBCDIC code

corresponding to that character to be transmitted to MTS and the control function normally associated with that character to be suppressed. The keyboard will remain unlocked and, except in the case of RETURN, the carriage position will be unchanged. The exclamation point is also used in a manner analogous to the Teletype terminal CTRL key. if the character following the exclamation point has an EBCDIC code whose hexadecimal value lies in the range 80 - FF then its code is masked so that the resulting code lies in the range 00 - 3F. The latter code is transmitted to MTS. This feature is useful for entering the EBCDIC code for SOH in connection with command operations (see Section 3). The SOH character can be produced by the two-stroke key combination !A.

As there is no way to disable local printing of the keyboard characters, there can be no operation equivalent to that performed by the Teletype ESC character. However, if the PW= field of the $SIGNON command is omitted, MTS will blacken a space in which the password can be typed.

4.2.2 Options and Modes. There are no modes (other than the default) applicable to the 2741 terminal. The applicable options include the BINARY, CLOCK, EDIT, INTERLOCK, OVERFLOW, PARITY, PREFIX, QUEUE, and SIZE options, which are described in detail in Section 3.1. The INTERLOCK and QUEUE options have special significance for 2741 and 1050 operations and are described further below.

INTERLOCK Option. When the INTERLOCK option is turned ON for an IBM Model 2741/1050 terminal its operation is changed considerably. The general effect that the INTERLOCK option has on the behavior of a terminal is described in the section which describes the INTERLOCK option. The INTERLOCK option also changes the behavior of the ATTN (2741) and LINE RESET (1050) buttons. With the INTERLOCK option ON, the ATTN and LINE RESET buttons always cause an attention interrupt. If the terminal is printing at the time ATTN or LINE RESET is pushed, the output line is truncated and terminated with an exclamation point followed by a new-line sequence. It is suggested that the INTERLOCK option be used in conjunction with the PREFIX option. This will cause the MTS prefix characters to be repeated whenever a line delete occurs. It is important to note that if the INTERLOCK option is ON and an attention condition has been transmitted to MTS then another attention cannot be entered until MTS comes back with a read operation. This means that if a user's program or MTS ignores an attention then the operator will be hung until the user program or MTS terminates the operation the operator desires to interrupt. This problem exists only for IBM Model 2741/1050 terminals.

QUEUE Option. If this option is turned OFF then the keyboard is still unlocked whenever possible but, in addition, ATTN/LINE RESET will cause an immediate attention interrupt during output and truncate the output line (see the QUEUE option for details).

4.2.3 Transmission Errors. The Data Concentrator monitors each input operation for a variety of error conditions, including the data check, overrun and buffer overflow conditions described in Section 2.3.4. At the time the Data Concentrator processes the character which caused the error condition the 2741/1050 keyboard is locked and a diagnostic message is transmitted to the terminal.

Under unusual circumstances it may happen that every character entered from the keyboard will cause an apparent transmission error. This might be due to a terminal malfunction or a buffer overrun condition in the Data Concentrator itself. If such a condition is suspected the operator should press the ATTN/LINE RESET button, which causes the Data Concentrator to reset the error flags and reclaim the buffers allocated to the terminal. If the trouble persists after pressing the ATTN/LINE RESET button, the terminal should be disconnected and the trouble reported to the Computing Center.

4.3 IBM 1050 Data Communications System

The basic 1050 Data Communications System consists of the 1051 Control and 1052 Keyboard/Printer. A 1056 Card Reader can be attached to the basic system and is supported by the Data Concentrator programming. An auxiliary 1053 Printer can be attached to the basic system, as well as a 1054 Printing Card Punch and a 1055 Paper-Tape Reader, although no specific programming is incorporated in the Data Concentrator system to support these devices.

The IBM 1050 Data Communication System operates using the PTTC code (see Appendices A, C and D), which contains 64 code combinations. Each character is transmitted with an odd parity check bit at a transmission rate of 134.5 bits-per-second (baud) (about 14.8 characters-per-second). The bit rate and character framing constants are identical with those of the IBM 2741 Communications Terminal described in Section 4.2. The transmission rate can be changed with the CLOCK option.

The operation of the 1050 is very similar to that of the 2741 except in the choice of certain control characters. In addition, the 1050 can be equipped with a card reader, which is operated as described in Section 4.3.2.

4.3.1 Operations. The control functions applicable to the 1050 are similar to those of the 2741 Data Communications Terminal and are described in Section 4.2.1. Some minor differences do exist, however, and these are described below.

The End-of-Line characters are ETB (ALTN CODING-EOB) and NL (RETURN).

In addition to the 2741 end-of-file character "ø" the EOT (ALTN CODING-EOT) is also effective for this purpose on the 1050. The Data Concentrator responds to either of these characters with a new-line sequence.

The attention interrupt is generated by the LINE RESET button, which is equivalent in operation to the ATTN button on the 2741. However, because of the construction of the 1050 control unit, the LINE RESET button causes the terminal to immediately go into a deselected state. Therefore, if printing is in progress it will abruptly halt with the remainder of the output line being lost. The Data Concentrator will automatically terminate incomplete output lines with a new-line function. If the INTERLOCK option is ON and the LINE RESET caused an attention function then the output line will be terminated with an exclamation point followed by a new-line function.

The Literal-Next character is exclamation point "!". Its behavior parallels that on the IBM 2741 Communications Terminal. However it is worth mentioning the effect that literal-next has when applied to characters which are available only on the 1050 terminal. Literal-next followed by EOT, EOB, BYP or RES will generate the EBCDIC codes for EOT, ETB, BYP or RES respectively.

The 1052 keyboard has a pair of keys which can be used to suppress the printing of confidential information. These are the ALT CODING-BYP and ALT CODING-RES key combination, which generate the BYP and RES characters respectively. These keys affect only the 1050 control unit; the BYP and RES characters are ignored by the Data Concentrator and are not transmitted to MTS.

4.3.2 Options and Modes. All of the options described for the IBM 2741 Data Communications Terminal in Section 4.2.2 are in addition available for the 1050. In addition, two modes are available for the 1050 which provide for input either from the 1052 keyboard or the 1056 card reader.

KEYBOARD. In this mode input is expected from the 1052 keyboard. Characters can be entered at any time the green PROCEED lamp is on. This is the default mode assumed at

connection time and can be set at other times by the MODE=KEYBOARD operand to the CONTROL command, which is equivalent to the following options:

```
ON=EDIT OFF=READER
```

CARDS. The Data Concentrator provides card-reader support for IBM 1050 Data Communications Systems with an attached Model 1056 Card Reader. The card reader must be equipped with the extended character reading special feature. This feature allows the card reader to read EBCDIC cards punched on the IBM 029 Keypunch. The CARDS mode can be invoked by the MODE=CARDS operand of the CONTROL command, which is equivalent to the following options:

```
ON=READER OFF=EDIT
```

The card reader is placed in ready status by the following steps:

(1) The console switch labeled READER 1 should be in the ON position. The AUTO-EOB switch on the card reader should be in the ON position.

(2) The cards should be properly positioned in the card reader hopper.

(3) The card reader FEED button should be pressed in order to position the first card at the read station.

If the AUTO-EOB switch is ON it is not necessary to punch an ETB or NL character at the end of each card, since the card reader itself provides the NL-ETB sequence following each card read. If the AUTO-EOB switch is placed in the OFF position and an ETB is punched in the card, then an increase in net transmission rate can be achieved if the nonblank information punched in the card is short. The Data Concentrator will transmit a new-line sequence to the 1052 printer each time an ETB is received from the card reader, so that each card will be listed on the printer on a separate line.

All other switches may be left in the position indicated in Section 2.1 for normal 1050 keyboard operations. The card reader will be activated and proceed to transmit card images after the following Data Concentrator command is issued from the keyboard:

```
CONTROL MODE=CARDS ON=INTERLOCK
```

Note that the command must begin with the two-character

sequence !A (SOH) in order that the command be interpreted as a Data Concentrator command and not as an MTS input line. If the "ON=INTERLOCK" portion of the command is not used then the card reader will not start automatically. The READER command can be used to start the card reader. Pressing the LINE READER START button will also start the card reader. The PROCEED light should be ON before the button is pushed. An alternate way to place the terminal in CARDS mode would be to have the first card in the input deck contain the CARDS mode command.

The card reader will continue to operate automatically until any of the four following conditions arise:

(1) The card reader becomes empty and the last card has been read.

(2) The terminal operator presses LINE RESET.

(3) The STOP CODE switch is set to SENSE and a stop code (9-5) is read from a card.

(4) An EOT code (9-7) is read from a card.

If the card reader runs out of cards more cards may be loaded and, when the first card has been positioned using the FEED button, the card reader will automatically continue operation.

Pressing LINE RESET is equivalent to an implicit command of the form

CONTROL MODE=KEYBOARD

and returns control to the keyboard. If LINE RESET is pressed in the middle of a card reader operation the input buffer at the Data Concentrator will be purged of the partial card card image that may have been received.

If the card reader stops due to a STOP CODE the card reader will continue if the LINE READER START button is pressed.

An EOT code behaves like an implicit CONTROL MODE=KEYBOARD command and returns control to the keyboard. This character also causes an end-of-file indication to be transmitted to MTS. This code can be punched on a card which then becomes an end-of-file to the MTS program. The EOT code causes an automatic card eject, so that if another deck of cards follows, it will be in position for a subsequent MODE=CARDS command.

The LINE RESET button can always be used to escape from CARDS mode. Another way to return to KEYBOARD mode is to include a card in the input deck which changes the mode back to KEYBOARD mode. Once control returns to the keyboard, another mode command is required in order to return to CARDS mode.

All card codes including the cent sign "¢" and underscore "_" are valid and will be treated as text with the following excepticns:

BS (11-9-6) performs the backspace editing operation, and

ETB (0-9-6) terminates the card and ends the current record. The card will be ejected. In the normal case with the AUTO-EOB switch in the ON position the card reader will automatically generate the ETB character following the 80th card column.

BYP (0-9-4) and RES (11-9-4) can be used as in KEYBOARD mode to prevent printing of confidential information. These characters are not transmitted to MTS.

UC (9-6) and LC (12-9-6) are case-shift codes and are deleted by the 1050 itself.

EOT (0-7) causes an end-of-file and implicitly changes the mode to KEYBOARD (see above).

! (11-8-2) retains the literal-next behavior effective in the KEYBOARD mode.

4.3.3 Option Combinations. The KEYBOARD and CARDS modes are mutually exclusive. The remaining options can be applied or not in any combination, although some combinations may not result in useful device behavior. Figure 9 summarizes the options set by these two mode operands.

MODE ->	KBD	CARDS
EDIT	ON	OFF
READER	OFF	ON

Figure 9. IBM 1050 Option Combinations

the default options assumed for the 1050 at connection time

correspond to the following operands of the CONTROL command:

```
MODE=KEYBOARD CLOCK=C ON=OVERFLOW,PARITY,QUEUE
OFF=INTERLOCK,PREFIX
```

4.3.4 Transmission Errors. The procedures used by the Data Concentrator in the event of 1050 transmission errors are identical to those used in the event of 2741 transmission errors and are described in Section 4.2.3. The 1050 is operated with more sophisticated error recovery procedures; however, and it may happen that these procedures may detect an error which the 2741 procedures do not.

If an input line is ended with one of the end-of-line characters NL (RETURN) or ETB (ALTN CODING-EOB) and the input line contains an error, then the terminal DATA CHECK light will turn on, the RESEND light will remain on and an error diagnostic message will be transmitted to the terminal. In this case the Data Concentrator has deleted the input line and is waiting for the operator to repeat it.

If the Data Concentrator detects a transmission error in the data received from the card reader it will reply with a character that causes the card to be read once again. In addition an error diagnostic message will be transmitted to the terminal. The card reader will stop and manual intervention will be required. The card should be ejected from the reader and corrected. After re-feeding the card into the reader, the operator can start the reader with the LINE READER START key or the READER command. Cards punched with invalid EBCDIC code combinations will also cause the same behavior, that is they will be treated as transmission errors.

4.4 Computer Communications Incorporated Model 300 TV Display

The Computer Communications Incorporated (CCI) Model 300 TV Display is a video-readout terminal using an integral core-memory refresh buffer. The refresh buffer is also used to hold pre-edited input records to MTS before transmission to the Data Concentrator. The equipment operates at 1200 bits-per-second (baud) using 202C data sets operated in the half-duplex mode. Further information concerning the use of this terminal in MTS is available from the Mental Health Research Institute.

4.4.1 Operations. Since input records to MTS are held in the refresh buffer of the CCI terminal all editing operations are performed there. Editing therefore consists of manipulating the blue-topped cursor controls and retyping as required. Lines may be queued in advance of MTS

processing as with other terminals. For this reason the keyboard is unlocked whenever not actually transmitting to the Data Concentrator. Up to 256 characters may be included in any input record; longer input records will be blocked as described in Section 3.1 under the OVERFLOW and SIZE options.

When ending an input record the cursor is positioned just following the last character of the record. The CTL-TRANS key combination is then pressed to signal the Data Concentrator that a record is waiting. The Data Concentrator will then write an end-of-line code on the screen, reposition the cursor to the first character of the record and then cause the terminal to transmit all characters up to but not including the end-of-line character.

The end-of-record code is generated by the CTL-TRANS key combination and is used also following the end-of-file code and the attention interrupt. The end-of-file code is generated by the backslash key and the attention code by the ATTN button installed at the upper right corner of the keyboard. If the keyboard is unlocked when the ATTN button is pressed, the operator must also press the CTL-TRANS key combination. The literal-next character is the exclamation point "!", which can be used also in the fashion described in Section 4.2 for IBM terminals, that is, to generate certain EBCDIC code combinations in the first quadrant of the EBCDIC code table. If the caret code is included in an input record then the screen will be erased automatically before the next line is written on the screen. None of these codes are transmitted to MTS.

4.4.2 Options. The options applicable to CCI terminals include BINARY, CLOCK, HOLD, INTERLOCK, OVERFLOW, PARITY, PREFIX and SIZE options, which are described in Section 3.1 above. All of these options, with the exception of the HOLD option, have the same function as with other keyboard-oriented terminals. The HOLD option can be used to cause the output process to cease when the screen is full. If the screen becomes full and the HOLD option is ON output stops and the keyboard is unlocked. If the CTL-TRANS key combination is pressed the screen will be erased and output will begin again. If the HOLD option is OFF the screen is automatically erased when it becomes full and output is not interrupted. The default options assumed at connection time are equivalent to the following operands to the CONTROL command:

```
ON=HOLD,OVERFLOW,PARITY OFF=BINARY,INTERLOCK,PREFIX CLOCK=A
                         SIZE=256
```

4.4.3 Transmission Errors. The Data Concentrator monitors each input operation for a variety of error conditions, including the data check, overrun and buffer overflow conditions described in Section 2.3.4. Any of these conditions will cause the Data Concentrator to delete the associated input line, reposition the cursor and cause the terminal to retransmit the line. This process will be continued until the line is correctly received or until an attention interrupt is recognized. If an error occurs when the Data Concentrator attempts to read the cursor address, the attempt will be repeated until the cursor address is correctly received.

4.5 Binary Synchronous Communications (BSC) Terminals

This section describes the procedures used with the 201A data sets attached to the Data Concentrator. The terminals using these data sets are called generically Binary Synchronous Communications (BSC) terminals, although several different transmission protocols and options may be enjoyed by individual terminals of this type. It was the intent of the design of the support for these terminals to provide service for "standard" IBM Binary Synchronous Communications terminals used for remote job entry as well as for highly interactive remote computer terminals used for graphics processing. On an interim basis, support is also extended to certain terminals of an older type for the purpose of convenient transition to the newer protocols.

The 201A data sets used by the Data Concentrator are standard models operated at 2000 bits-per-second (baud), equipped with the external clock feature (the timing signals are generated by the Data Concentrator) and strapped for the short-turnaround option. This means that the data sets can be switched between the transmit and the receive modes ("turned around") in about eight milliseconds. Using the DUPLEX mode (see below), the overhead for message acknowledgment is typically less than 70 milliseconds, including the time to transmit the ending sequence, receive the acknowledgment and transmit the beginning sequence of the next record. This compares with greater than 350 milliseconds using more conventional IBM protocols.

The 201A interface adapters used by the Data Concentrator have been repackaged for use by remote PDP-7, -8 and PDP-9 computers. Several of these adapters are presently in use, although other hardware can be used for this purpose of course. Whatever hardware is used, however, it should by capable of half-duplex operation, automatic synchronization on the ASCII SYN character (octal 026) and an 8-bit frame size. Users contemplating connection via these facilities should contact the Computing Center for

further details.

4.5.1 Transmission Protocol. The transmission protocol used for 201A data set operation is modeled closely after IBM Binary Synchronous Communications (BSC) protocol. The operation of the systems likely to be connected to Data Concentrator facilities is much more interactive than the usual IBM equipment, however; and for this reason the Data Concentrator protocol is tuned for rapid turnaround and speedy recovery from potential error conditions.

At present actually three protocols are supported by the Data Concentrator:

(1) The so-called CONCOMP protocol, which has been in use since 1967 in an older version of the Data Concentrator control program. At some time, hopefully in the near future, the CONCOMP protocol can be removed and the system performance thereby improved. (This older protocol suffered greatly from various ills due to lost records, contention and so forth.)

(2) A protocol designed to be compatible with current IBM systems, that is, in a contention-with-bidding environment, where the special conversational features of the Data Concentrator protocol have been suppressed.

(3) The proposed standard "DUPLEX" protocol with all the bells and whistles useful for interactive remote computer systems.

The options applicable to BSC terminals include the BID, BINARY, DUPLEX, INTERBLOCK, ODD, OVERFLOW, PARITY, PREFIX, REPLY and SYNC options, which are discussed in Section 3.1 above. The various protocols are invoked as combinations of these options, either individually or using the MODE operand of the CONTROL command. The CONCOMP protocol is invoked by the MODE=CONCOMP operand, which is equivalent to the following options:

```
ON=CONCOMP OFF=BID,DUPLEX,ODD,PARITY,REPLY SIZE=256
```

The IBM protocol is invoked by the MODE=IBM operand, which is equivalent to the following options:

```
ON=BID,ODD,PARITY OFF=CONCOMP,DUPLEX,REPLY SIZE=256
```

The DUPLEX protocol is invoked by the MODE=DUPLEX operand, which is equivalent to the following options:

```
ON=DUPLEX,ODD,PARITY,REPLY OFF=BID,CONCOMP SIZE=256
```

Many variations in these basic protocols can be constructed using different combinations of options. The various options set by the three mode operands are summarized in Figure 10.

MODE ->	CONCOMP	IBM	DUPLEX
BID	OFF	ON	OFF
CONCOMP	ON	OFF	OFF
DUPLEX	OFF	OFF	ON
ODD	OFF	ON	ON
PARITY	OFF	ON	ON
REPLY	OFF	OFF	ON
SIZE	256	256	256

Figure 10. BSC Mode Combinations

Note: until the various users of the CONCOMP protocol have been flushed from the user population it is necessary to assume the CONCOMP mode for all BSC terminals at connection time. The default options presently assumed at connection time are equivalent to the following operands of the CONTROL command:

```
MODE=CONCOMP ON=OVERFLOW OFF=BINARY,INTERLOCK,PREFIX
                SIZE=256 SYNC=6,64
```

The following procedure can be used to change to other modes "on-the-fly" by a terminal equipped to operate only in that mode:

(1) Ignore the first message transmitted by the Data Concentrator at connection time. This will have the format:

```
SYN...SYN DLE CR % S A n n : C O N C O M P DLE CR
                          BCC1 BCC2 PAD
```

where SAnn is the device name assigned when the call is answered (see Section 2.2 and Figure 1).

(2) Transmit a Magic Message in the format given in Section 4.5.2. This message has the same control character and checksum conventions established for the "new" modes and is a standard Data Concentrator command but not preceded by a selection character (see Section 3.1). This command should be structured to set the desired options and modes. Note that the first message transmitted by the Data Concentrator has not been acknowledged at this time.

(3) When the Data Concentrator has received this message correctly it will respond with an "acknowledgment" of the form:

SYN...SYN DLE DLE ACK PAD

which is an indication that the modes and options requested in (2) have in fact been accomplished. Any other response indicates that the message was received incorrectly and should be retransmitted.

Operation in the "new" protocol can now commence; however, the first message transmitted by the Data Concentrator has not yet been acknowledged. This can be accomplished in the usual way in the new protocol and operation in that protocol can ensue.

In the following only the DUPLEX protocol will be described in detail. Fortunately, the CONCOMP protocol has not been described formally anywhere. The IBM protocol is described in [5 and 6]. The various features possible in the DUPLEX protocol are discussed in Section 3.1 under "Options" and will not be discussed further here.

The control characters used in all protocols are interpreted according to the ASCII conventions (see Appendix B) and given the code combinations shown in Appendix A. Note that if the PARITY option is ON, all inbound control characters are checked for correct odd parity. Even parity inbound control characters are ignored in some sequences and re-interpreted in others, depending on a "best guess" of the nature of the error and the most efficient recovery procedure.

Every record which is transmitted either by the Data Concentrator or the remote computer begins with a PAD character, continues with several SYN characters and ends with a single PAD character. The PAD character is coded as the character consisting only of one bits. The number of SYN characters is set by the SYNC operand of the CONTROL command and is initially set at six. A record may contain

either a text message, an acknowlegment or, if the DUPLEX option is ON, may contain both concatenated as a single record. A text message is always transmitted in transparent mode, that is all code combinations are valid. The text message terminates with a two-byte checksum calculated as described in Appendix E. The acknowledgment is a one or more character sequence designed to return to the transmitter the status of the receiver after a text message. This may take several forms, as described below.

Two special messages are defined for error recovery and attention interrupt functions. If the transmitter has lost the status of the receiver following transmission of a text message it sends the ENQ message, which is transmitted in lieu of a text message. The remote computer can cause an attention interrupt in the MTS program running on the Model 67 with the RVI message, which is transmitted in lieu of an acknowledgment. If the DUPLEX option is ON then the Data Concentrator will concatentate the acknowledgment and text messages wherever possible. If this option is OFF it will transmit each as a separate record; but, in any case, two succeeding records will be separated by an interval equal to at least that of the reply timeout (see below). (The coding of these messages has been subverted from IBM conventions which assign these messages slightly different functions.)

If the DUPLEX option is ON, a text message may be transmitted in the same record as an acknowledgment (for traffic flowing in the converse direction of course), but in this case the acknowledgment must precede the text message. If an acknowledgment is to be transmitted by itself, then the single character EOT is appended in lieu of the text message. An ENQ message can be transmitted in lieu of a text message, that is, by itself or immediately following an acknowledgment. An RVI message can be transmitted in lieu of an acknowledgment, that is, followed either by a text message, ENQ message or a single EOT character. If the DUPLEX option is ON then the the possible combinations are:

<text message>

<ENQ message>

<acknowledgment> EOT

<acknowledgment> <text message>

<acknowledgment> <ENQ message>

<RVI message> EOT

<RVI message> <text message>

<RVI message> <ENQ message>

If the DUPLEX option is OFF then all of these messages and acknowledgments are transmitted as separate records and the ECT character is not transmitted. Note that it is possible under certain conditions to transmit more than one acknowledgment in a single record. If this is the case all of the acknowledgments are concatenated together and transmitted in the position shown.

4.5.2 Message Format. The format of a text record is:

PAD SYN...SYN DLE STX (text) DLE ETB BCC1 BCC2 PAD

where BCC1 and BCC2 are the two characters of the checksum. All characters in the text are included in the checksum (except as noted below) as well as the ETB which follows. These are the only characters in the record which are included in the checksum. None of the control characters shown will be transmitted to MTS on inbound records and all will be generated by the Data Concentrator on outbound records. The code combinations used for the text characters can be any 8-bit combination with the following two exceptions:

(1) The character DLE appearing in the text is coded as the two-character sequence DLE-DLE in the message. Only the second is included in the checksum.

(2) The two-character sequence DLE-SYN is completely deleted by the receiver. Neither character is included in the checksum. (This sequence is used in some IBM equipment to reset receive timeouts.)

Following recognition of either a text message or an ENQ message the receiver transmits an acknowledgment consisting of a one or more character sequence. This sequence consists of the single character NAK if the receiver has detected a checksum discrepancy, the two-character sequence DLE-? (WABT) if the message has been received without error but the receiver is unable to accept further messages at this time, and one of the two-character sequences DLE-0 (ACK0) or DLE-1 (ACK1) if the message has been received without error and the receiver is able to accept the next message. The choice of which of the two sequences ACK0 or ACK1 is made by the following rule: The acknowledgment to the first transmission is always ACK1 and alternates thereafter between ACK0 and ACK1 following every successfully received text message. It does not alternate if the record is received in error or if an ENQ message is received. Note that transmission of an ACK0/ACK1 sequence

implies a WABT sequence; so, if the receiver transmits an ACK0/ACK1 sequence first following reception of a text message, the WABT sequence should not be transmitted. The WABT sequence is useful in connection with the REPLY option and in cases where message processing at the receiver is temporarily suspended due to a timing constraint. Following are several typical records containing acknowledgments:

```
PAD SYN...SYN DLE 0 EOT PAD

PAD SYN...SYN NAK EOT PAD

PAD SYN...SYN DLE ? DLE 0 DLE STX (text) DLE ETX BCC1 BCC2
                                                    PAD
```

Note the last record, which shows how acknowledgments and text messages can be concatenated in a single record. This example also illustrates a possible timing situation in which the WABT and ACK0 sequences are included in the same record. Terminals attached to the Data Concentrator should be able to correctly process such records, which can occur as the Data Concentrator receiver changes state during transmission of the WABT sequence itself.

Figure 11 summarizes the DLE sequences used for acknowledgments. These, together with the single characters NAK and ACK are the only valid acknowledgments. Although the only transmission code supported by the Data Concentrator at present is the ASCII code, the DLE sequences for the EBCDIC code are also shown for completeness.

Name	ASCII	EBCDIC ('HEX')
ACK0	DLE-0	DLE-'70'
ACK1	DLE-1	DLE-'61'
WABT	DLE-?	DLE-'7F'
RVI	DLE-<	DLE-'7C'

Figure 11. DLE sequences

The ENQ message is coded as the two-character sequence DLE-ENQ. Following are examples of typical records containing this message:

```
PAD SYN...SYN DLE ENQ PAD
```

PAD SYN...SYN DLE 0 DLE ENQ PAD

The RVI message is coded as the two-character sequence DLE-<. Following are examples of typical records containing this message:

PAD SYN...SYN DLE < EOT PAD

PAD SYN...SYN DLE < DLE SOH (text) DLE ETB BCC1 BCC2 PAD

There are several possible variations in the basic text message. If the BINARY option is OFF and if a received text message begins with the DLE-SOH sequence, it will be translated from the native (ASCII) code to the system (EBCDIC) code as appropriate. Furthermore, it is "vulnerable" to command language operations both in the Data Concentrator and in the MTS DSR system. If a text message begins with the DLE-STX sequence, the text will not be so translated and will be immune from command interpretation. Note that the @BIN modifier should be applied to the MTS read operation in such a case. If the BINARY option is ON then the ASCII-EBCDIC translation is disabled regardless of whether or not the DLE-SOH sequence is used. If the text message ends with the DLE-ETB sequence as shown a normal ending condition is assumed. If, on the other hand, the text message ends with the DLE-ETX sequence an end-of-file ending condition is assumed. This is the manner in which a remote computer can transmit an end-of-file indication to MTS.

An MTS write operation with the @BIN modifier will cause the Data Concentrator to begin the transmitted text message with the DLE-STX sequence. All other write operations will result in the DLE-SOH sequence. Furthermore, an MTS prefix transmission will be terminated by the ETX sequence; all other transmissions will be terminated by the ETB sequence.

As a special concession to simple terminals which can tolerate an occasional dropped or duplicated text message, the Data Concnetrator will accept the single character ACK as an acknowlegement. This character is interpreted as either ACK0 or ACK1 as appropriate. The Data Concentrator never transmits this character as an acknowledgment. Note that a simple terminal can ignore entirely a received WABT acknowledgment and can interpret both the ACK0 and ACK1 acknowledgments without respect to the count of transmitted text messages as described in Section 4.5.2. Such terminals can, in addition, elect not to transmit the WABT acknowledgment if their receiver processing is temporarily delayed; but, in this case, the REPLY option should be OFF to prevent erroneous turnaround delay calculations by the

Data Concentrator. If such a terminal is not equipped to generate odd-parity control and translated (nonbinary) text characters, the PARITY option should be OFF. Finally, a simple terminal can ignore entirely the ENQ message, although this is a drastic simplification which severely handicaps the error recovery procedures.

4.5.3 Transmission Errors. The Data Concentrator monitors each input operation for a variety of error conditions, including the data check, overrun and buffer overflow conditions described in Section 2.3.4. The data check condition can occur with BSC terminals only if the PARITY option is ON and a translated (nonbinary) text character is received with incorrect (even) parity. The overrun and buffer overflow conditions will be recorded only if the condition is detected on a text character. In any of these cases, if the checksum accompanying the text message is correct the appropriate acknowledgment will be transmitted and a diagnostic message will be transmitted to the terminal in the correct format. This message must be acknowledged by the terminal in the usual manner. If, on the other hand, the checksum accompanying the received text message is incorrect the NAK acknowledgment will be transmitted and the recovery performed in the usual fashion. These conventions are designed to support remote multi-device data concentration and batch entry equipment.

Transmission link errors show up in these systems in two ways:

(1) The receiver understands the transmitted record but has detected a checksum discrepancy;

(2) Either the receiver has not synchronized on the SYN sequence, has lost the ending sequence (and the checksum), or the transmitter has failed to understand the acknowledgment.

In the first case the receiver returns the NAK acknowledgment, which the transmitter interprets as a request to retransmit the record. In the second case the transmitter does not know the status of the receiver, so, after a discrete timeout interval (which may be set by the SYNC option), it transmits the ENQ message. If the receiver understands this sequence but has not understood the end of a previous text message it immediately deletes any text accumulated and returns the NAK acknowledgment to the transmitter.

If the receiver is temporarily busy it may return the WABT acknowledgment, which the transmitter will interpret as a successfully-received record, but will not transmit a

further record. The ENQ timeout continues to run at the transmitter in such a case. If the receiver is in an idle or non-busy state it should return its last acknowledgment, either ACK0 or ACK1 as appropriate. The transmitter will retransmit the last record if the choice of these two does not agree with its own. In other words, a "bad" ACK is treated as a NAK.

Finally, if the remote computer transmits the RVI message the Data Concentrator will interpret it as both a positive acknowledgment to the last transmitted record and as an attention interrupt to MTS. Note that this message is not itself acknowledged and can be lost in the flurry of contention. For this reason it is recommended that use of this message be avoided. As an alternative the special Data Concentrator command ATTENTION can be transmitted as a text message for the purpose of causing an attention interrupt. This message is acknowledged in the usual way, of course, and stands a high probability of being punched through under severe contention conditions. It is recommended that the remote computer use the ENQ message to recover from suspected contention hangups.

4.5.4 Timeouts. The Data Concentrator uses several timeouts to aid in error recovery and to minimize contention. These timeouts are designed to minimize the requirements of the remote computer system and, in fact, allow the remote system to operate effectively without any timeouts whatsoever except a slightly impatient operator. These timeouts are executed as follows:

(1) During transmission of a text message the two-character sequence DLE-SYN will be inserted in the text at nominal one-second intervals. The remote computer should ignore these sequences entirely; although they are necessary for certain IBM equipment.

(2) If an attempt is made to start transmission and the remote computer has not stopped transmitting (as indicated by a loss of carrier), the Data Concentrator will execute a nominal 50-millisecond timeout, after which it will once again attempt to begin transmission. Note that certain received sequences, such as an ENQ message or a checksum sequence following a text message, will cause the Data Concentrator to suspend this criterion and begin transmission regardless of the state of carrier.

(3) Following transmission of a text message or ENQ message the Data Concentrator will execute the

reply timeout as described under the REPLY and SYNC options above. If the REPLY option is ON then the timing of the reply generated by the remote computer system is used to establish the SYN count and the reply timeout interval itself. If no reply has been received before this second timeout expires an ENQ message is generated and the timeout is increased and executed again. If a reply is received before this timeout expires the reply timecut is decreased. This procedure is terminated by any received acknowledgment.

(4) Following termination of the reply timeout described above, the Data Concentrator will execute the ENQ timeout as described under the REPLY and SYNC options above. If this timeout expires before an ACK0, ACK1 or RVI acknowledgment is received an ENQ message is generated and the timeout executed again. This procedure will continue until either an ACK0, ACK1 or RVI acknowledgment is received.

Further details of transmission protocol can be obtained from cognizant members of the Computing Center staff. A special loader is available which can, in a crude fashion, load a PDP-8 program over the 201A data set link. A stripped-down version of the control program which runs in the Data Concentrator is also available. This program is intended to replace the old RAMP55 program which is in use at several installations.

4.6 Paper-Tape Bulk I/O Equipment

A high-speed paper-tape reader (300 char/sec) and punch (60 char/sec) are an integral part of the Data Concentrator equipment. These devices operate using fan-fold (only) eight-channel paper or mylar tape and are intended for light-duty operation. Since these devices require considerable manual operator intervention to load and unload tapes and to unsnarl the occasional jams, users are requested to batch their jobs whenever possible and to notify the machine operators of any unusual demands placed on the equipment. Users requiring more than about 100 feet of tape (12,000 characters) are requested to submit bulk tape for punching, although the tape submitted may not be the actual tape used for punching the user's job. The quantity and type of tape to be submitted will be arranged on an individual basis as the needs arise.

4.6.1 Paper-Tape Punch. The user's job acquires the paper-tape punch through the *MOUNT subroutine (see elsewhere MTS publications). For example, the following MTS

command will acquire the paper-tape punch:

```
$RUN *MOUNT PAR=PTPP *TAPE*
```

where *TAPE* is the pseudo-device name assigned the paper-tape punch within the user's job. The *MOUNT routine produces a special header in which the user's signon i.d., the date and time are punched in a directly readable format.it is preceded and followed by a number of DEL codes and separated from the beginning of the punched data by about a foot of blank tape. A trailer consisting of about a foot of blank tape followed by an ASCII EOT code is punched when the paper-tape punch is released, either by the *DISMOUNT subroutine or when the user signs off.

Data are transmitted to the paper-tape punch using the standard MTS commands and subroutines as with any other output I/O device. For example, the MTS command

```
$COPY fdname TO *TAPE*
```

can be used to transmit the contents of the file or device fdname to the paper-tape punch. Records transmitted should not be longer than 256 bytes and can be punched byte-by-byte exactly as received (using the @BIN modifier) or with translation to ASCII (usually using the @SP modifier).

No Data Concentrator commands are applicable to the paper-tape punch, although several MTS DSR commands and modifiers are useful (see Section 3.2). The PFX and EOF commands and @SP and @BIN modifiers have particular relevance to this device.

4.6.2 Paper-Tape Reader. The paper-tape reader attached to the Data Concentrator is intended for use only when the IBM 2871 Paper-Tape Reader attached to the Model 67 is not practical. The only application in which the Data Concentrator equipment is recommended is when large volumes of fan-fold eight-channel tape must be processed. Users with such applications are requested to contact the Computing Center, and all such requests will be processed on an individual basis.

5. APPENDIX A. CODE TRANSLATION TABLES

The tables on the following five pages show the code translation tables used by the Data Concentrator for the various terminals that may be attached to the system. The ASCII code is used by Teletype, CCI and BSC terminals, while the PTTC code is used by IBM terminals. The last table is a cross index of the names given the control characters in the various codes and the preferred (EBCDIC) names used by the system.

The code used by the terminal is called the native code, while that used by the Data Concentrator and MTS (EBCDIC) is called the system code. The translation tables from the native code to the system code are shown for ASCII (Figure 2) and PTTC (Figure 3). Native code combinations corresponding to blanks in these tables are mapped into the character consisting only of zero bits in the system code.

The translation tables from the system code to the native codes can be derived from Figure 1. Since all native code combinations are represented separately in the system code, that subset of Figure 1 corresponding to the graphic and control functions of the native code is the actual translation table used. System code combinations for which no native graphic or control function exist are mapped into the character consisting only of zero bits in the native code with the following exceptions: in the mapping to the ASCII code the NL (New Line) character is mapped into the two-character sequence CR (Carriage Return) followed by LF (Line Feed).

4567	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000	NUL	DLE	DS		SP	&	-				-	0				0
0001	SOH	DC1	SOS				/		a	j	°	1	A	J		1
0010	STX	DC2	FS	SYN					b	k	s	2	B	K	S	2
0011	ETX	(4)							c	l	t	3	C	L	T	3
0100	PF	RES	BYP	PN					d	m	u	4	D	M	U	4
0101	HT	NL	LF	RS					e	n	v	5	E	N	V	5
0110	LC	BS	ETB	UC					f	o	w	6	F	O	W	6
0111	DEL	IL	ESC	EOT					g	p	x	7	G	P	X	7
1000		CAN							h	q	y	8	H	Q	Y	8
1001		EM							i	r	z	9	I	R	Z	9
1010	SMM	CC	SM		¢	!		:		(1)	(3)	(2)				
1011	VT	CU1	CU2	CU3	.	$	,	#	{	}	˪	˩				
1100	FF	IFS		DC4	<	*	%	@	≤	¤	r	¬				
1101	CR	IGS	ENQ	NAK	(	)	_	'	‹	›	[	]				
1110	SO	IRS	ACK		+	;	>	=	+	±	≥	≠				
1111	SI	IUS	BEL	SUB			¬	?	"	÷	▪	•	–			

P	0	1	2	3	4	5	6	7

Code Structure
(P = odd parity)

Notes: 1=critic, 2=backslash, 3=caret, 4=TM/DC3 (dual assigned)

Figure 1.

Extended Binary-Coded Decimal Interchange Code (EBCDIC)

Appendix A. Code Translation Tables

4321	7 0 6 0 5 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0000	NUL	DLE	SP	0	@	P	(1)	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	(2)	l	|
1101	CR	GS	-	=	M	]	m	}
1110	SO	RS	.	>	N	(3)	n	¬
1111	SI	US	/	?	O	_	o	DEL

8	7	6	5	4	3	2	1

Code Structure
(8 = even parity)

Notes: 1=critic, 2=backslash, 3=caret

Figure 2.

American Standard Code for Information Interchange (ASCII)

Appendix A. Code Translation Tables

	UPPER CASE				LOWER CASE				CONTROL			
	1 0	0	1	1	C	0	1	1	0	0	1	1
	2 0	1	0	1	C	1	0	1	0	1	0	1
48AB												
0000	SP	2	1	3	SP	<	=	;				
0001	-	k	j	l	_	K	J	L	NAK			
0010	@	s	/	t	¢	S	?	T				
0011	&	b	a	c	+	B	A	C				
0100	8	0	9	#	*	)	(	"				STX
0101	q		r	$	Ç		R	!				
0110	y		z	,	Ÿ		Z	|				
0111	h		i	.	H		I	¬				ACK
1000	4	6	5	7	:	'	%	>				
1001	m	o	n	p	M	O	N	P				
1010	u	w	v	x	U	W	V	X				
1011	d	f	e	g	D	F	E	G				
1100	PN	UC	RS	EOT	PN	UC	RS	ECT				EOT
1101	RES	BS	NL	IL	RES	BS	NL	IL				
1110	BYP	ETB	LF	ESC	BYP	ETB	LF	ESC				
1111	PF	LC	HT	DEL	PF	LC	HT	DEL				

C	1	2	4	8	A	B		

Code Structure
(C = odd parity)

Figure 3.

Paper-Tape Transmission Code (PTTC)

CAT	EBCDIC	ASCII	TTY	PTTC	FUNCTION
	NUL	NUL	NULL		Null
CC	SOH	SOH	SOM		Start of Heading
CC	STX	STX	EOA	EOA (D)	Start of Text
CC	ETX	ETX	EOM		End of Text
DC	PF			PF	Punch Off
FE	HT	HT	H.TAB	TAB	Horizontal Tab
GR	LC			LC	Lower Case
	DEL	DEL	RUBOUT	DEL	Delete
	SMM				Start of Manual Message
FE	VT	VT	V.TAB		Vertical Tab
FE	FF	FF	FORM		Form Feed
FE	CR	CR	RETURN		Carriage Return
GR	SO	SO	SO		Shift Out
GR	SI	SI	SI		Shift In
CC	DLE	DLE	DC0		Data Link Escape
DC	DC1	DC1	X-ON		Device Control 1
DC	DC2	DC2	TAPE ON		Device Control 2
	TM	DC3	X-OFF		Tape Mark/Dev Ctrl 3
DC	RES			RES	Restore
FE	NL			NL	New Line
FE	BS	BS		BS	Backspace
	IL			IL	Idle
	CAN	CAN	FEO	CAN	Cancel
	EM	EM	S1		End of Medium
	CC				Cursor Control
CU	CU1				Customer Use 1
IS	IFS	FS	S4		Info Field Separator
IS	IGS	GS	S5		Info Group Separator
IS	IRS	RS	S6		Info Record Separator
IS	IUS	US	S7		Info Unit Separator
ED	DS				Digit Select
ED	SOS				Start of Significance
ED	FS				Field Separator
DC	BYP			BYP	Bypass
FE	LF	LF	LF	LF	Line Feed
CC	ETB	ETB	LEM	EOB (B)	End of Text Block
	ESC	ESC	S3	PRE	Escape
	SM				Set Mode
CU	CU2				Customer Use 2
CC	ENQ	ENQ	WRU		Enquiry
CC	ACK	ACK	RU	(Y)	Acknowledge
	BEL	BEL	BELL		Bell
CC	SYN	SYN	SYNC		Synchronous Idle
DC	PN			PN	Punch On
DC	RS			RS	Reader Stop
GR	UC			UC	Upper Case
CC	EOT	EOT	EOT	EOT (C)	End of Transmission
CU	CU3				Customer Use 3
DC	DC4	DC4	TAPE OFF		Device Control 4
CC	NAK	NAK	ERROR	(N)	Negative Acknowledge
	SUB	SUB	S2		Substitute

Notes: the categories of characters are defined by the following:

CC (Communication Control). A functional character intended to control or facilitate transmission of information over communication networks.

FE (Format Effector). A functional character which controls the layout or positioning of information in printing or display devices.

IS (Information Separator). A character which is used to separate and qualify information in a logical sense. There is a group of four such characters, which are to be used in a hierarchical order.

DC (Device Control). A functional character used for the control of ancillary devices associated with data processing of telecommunication systems, more especially switching devices "on" and "off."

ED (Edit and Mark). A control character used by the System/360 Edit and Mark (EDMK) instruction for the formatting of alphanumeric fields.

GR (Graphic Control). A control character indicating that the code combinations which follow are to be interpreted in a particular code table, depending upon the particular control character.

CU (Customer Use). A character excluded from future assignment by IBM. These "protected" codes are intended for use by customer systems so that their use will not conflict with a possible future IBM use.

Table 1. Control Functions

6. APPENDIX B. GLOSSARY OF ASCII CONTROL FUNCTIONS

The following glossary is compiled from [14]. It summarizes the conventional interpretations assigned the ASCII control functions as used in Teletype terminal control and Binary Synchronous Communications systems.

NUL (Null). The all-zeros character which may serve to accomplish time fill and media fill.

SOH (Start of Heading). A communication control character used at the beginning of a sequence of characters which constitute a machine-sensible address or routing information. Such a sequence is referred to as the heading. An STX character has the effect of terminating a heading.

STX (Start of Text). A communication control character which precedes a sequence of characters that is to be treated as an entity and transmitted through to the ultimate destination. Such a sequence is referred to as text. STX may be used to terminate a sequence of characters started by SOH.

ETX (End of Text). A communication control character used to terminate a sequence of characters started with STX and transmitted as an entity.

EOT (End of Transmission). A communication control character used to indicate the conclusion of a transmission, which may have contained one or more texts and any associated headings.

ENQ (Enquiry). A communication control character used in data communication systems as a request for a response from a remote station. It may be used as a "Who Are You" (WRU) to obtain identification, or may be used to obtain station status, or both.

ACK (Acknowledge). A communication control character transmitted by a receiver as an affirmative response to a sender.

BEL (Bell). A character for use when there is a need to call for human attention. It may control alarm or attention devices.

BS (Backspace). A format effector which controls the movement of the printing position one printing space backward on the same printing line (applicable also to display devices).

HT (Horizontal Tabulation). A format effector which controls the movement of the printing position to the next in a series of predetermined positions along the printing line (applicable also to display devices and the skip function on punched cards).

LF (Line Feed). A format effector which controls the movement of the printing position to the next printing line (also applicable to display devices).

VT (Vertical Tabulation). A format effector which controls the movement of the printing position to the next in a series of predetermined printing lines (also applicable to display devices).

FF (Form Feed). A format effector which controls the movement of the printing position to the first predetermined printing line on the next form or page (also applicable to display devices).

CR (Carriage Return). A format effector which controls the movement of the printing position to the first printing position on the same printing line (also applicable to display devices).

SO (Shift Out). A control character indicating that the code combinations which follow shall be interpreted as outside of the character set of the standard code table until a Shift In character is reached.

SI (Shift In). A control character indicating that the code combinations which follow shall be interpreted according to the standard code table.

DLE (Data Link Escape). A communication control character which will change the meaning of a limited number of contiguously following characters. It is used exclusively to provide supplementary controls in data communication networks.

DC1, DC2, DC3, DC4 (Device Controls). Characters for the control of ancillary devices associated with data processing or telecommunication systems, more especially switching devices "on" and "off." (If a single "stop" control is required to interrupt or turn off ancillary devices, DC4 is the preferred assignment.)

NAK (Negative Acknowledge). A communication control character transmitted by a receiver as a negative response to a sender.

SYN (Synchronous Idle). A communication control character used by a synchronous transmission system in the absence of any other character to provide a signal from which synchronism may be achieved or retained.

ETB (End of Transmission Block). A communication control character used to indicate the end of a block of data for communication purposes. ETB is used for blocking data where the block structure is not necessarily related to the processing format.

CAN (Cancel). A control character used to indicate that the data with which it is sent is in error or is to be disregarded.

EM (End of Medium). A control character associated with the sent data which may be used to identify the physical end of the medium, or the end of the used, or wanted, portion of information recorded on a medium. (The position of this character does not necessarily correspond to the physical end of the medium.)

SS (Start of Special Sequence). A control character used to indicate the start of a variable length sequence of characters which have special significance or which are to have special handling.

ESC (Escape). A control character intended to provide code extension (supplementary characters) in general information interchange. The Escape character itself is a prefix affecting the interpretation of a limited number of contiguously following characters.

FS (File Separator), GS (Group Separator), RS (Record Separator) and US (Unit Separator). These information separators may be used within data in optional fashion, except that the hierarchical relationship shall be: FS is the most inclusive, then GS, then RS, and US is least inclusive. (The content and length of a File, Group, Record or Unit are not specified.)

DEL (Delete). This character is used primarily to "erase" or "obliterate" erroneous or unwanted characters in perforated tape. (In the strict sense, DEL is not a control character.)

7. APPENDIX C. GLOSSARY OF PTTC CONTROL FUNCTIONS

The following glossary is compiled from IBM documentation. It summarizes the conventional interpretation assigned the PTTC control functions, as used by the IBM 2741 Communications Terminal and the 1050 Data Communications System.

PN (Punch On). A device control character used to start the 1055 Paper-Tape Punch when attached to the 1050 Data Communicaticns System.

RES (Restore). A device control character which causes the 1052 Printer/Keyboard and the 1053 Printer when attached to the 1050 Data Communications System to resume printing following a BYP (Bypass) character.

BYP (Bypass). A device control character which causes the 1052 Printer/Keyboard and the 1053 Printer when attached to the 1050 Data Communications System to suspend printing until an RES (Restore) character is reached.

PF (Punch Off). A device control character used to stop the 1055 Paper-Tape Punch when attached to the 1050 Data Communicaticns System.

UC (Upper Case), LC (Lower Case). Control characters used to indicate that the code combinations which follow are to be interpreted according to selected portions of the code table.

BS (Backspace). A format effector which controls the movement of the printing positions one printing space backward on the same printing line.

ETB (End of Text Block - also called EOB, circle-B). A communication ccntrol character used in the 1050 Data Communication System to end a record containing text information. This character is always followed by the LRC (Longitudinal Redundancy Check) character.

RS (Reader Stop). A device control character used to stop the 1056 Card Reader when attached to the 1050 Data Communications System.

NL (New Line). A format effector which controls the movement of the printing position to the first printing position on the next printing line. (This character causes the same action as a combination CR (Carriage Return) and LF (Line Feed) sequence.

LF (Line Feed). A format effector which controls the movement of the printing position to the next printing line.

HT (Horizontal Tabulation). A format effector which controls the movement of the printing position to the next in a series of predetermined positions along the printing line.

EOT (End of Transmission - also called circle-C). A communication control character which causes the device and its control unit to be reset and to revert to the control-receive state following a message transmission sequence. This character is used in the 1050 Data Communications System before polling and addressing operations and in the 2740/2741 Communications Terminal following the NL (New Line) character at the end of each text record.

II (Idle). A character which serves to accomplish time fill and media fill. (This character is used in the same manner as - choice of the bit combination used to represent the SP (Space) character, the all-zeros character is not available for this function.)

ESC (Escape - also called PRE). A control character used by the various components of the 1050 Data Communications System to precede device control characters interpreted specially by the device for format-effector and device control functions.

DEL (Delete). This character is used primarily to "erase" or "obliterate" erroneous or unwanted characters in perforated tape. (In the strict sense, DEL is not a control character.)

CAN (Cancel). A control character used to indicate that the data with which it is sent is in error or is to be disregarded. (This character does not exist in the standard code table and is implemented as an even parity (rather than odd parity) code which the receiver recognizes by virtue of the parity error (!).)

STX (Start of Text - also called EOA, circle-D). A communication control character used as an affirmative reply to a polling sequence. Transmission of this character indicates that the transmitter has data to follow and that this data will be terminated with either an EOT or an ETB-LRC sequence.

ACK (Acknowledge - also called circle-Y). A communication control character used in the 1050 Data Communications

System in two ways:

1) As an affirmative reply to an addressing sequence indicating that the addressed device is ready to receive data, and

2) As an affirmative reply to an ETB-LRC sequence indicating that the preceding record was received without apparent error.

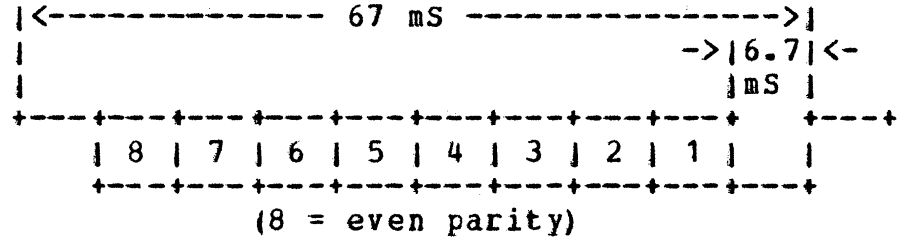
NAK (Negative Acknowledge - also called circle-N). A communication control character used in the 1050 Data Communications System in two ways:

1) As a negative reply to a polling or addressing sequence indicating the polled or addressed device is not ready to receive or transmit data, and

2) As a negative reply to an ETB-LRC sequence indicating that the preceding record was received in error.

8. APPENDIX D. START/STOP TRANSMISSION CODES

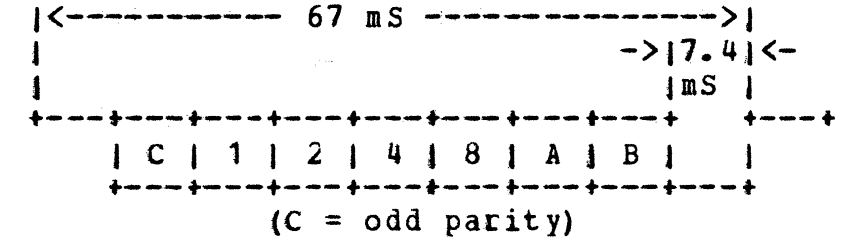
The framing of the transmission line signal assumed at connection time for Teletype, IBM and CCI terminals is shown in Figure 1. The direction of transmission is to the right.



150 WPM Teletype Model 37 (150 baud)

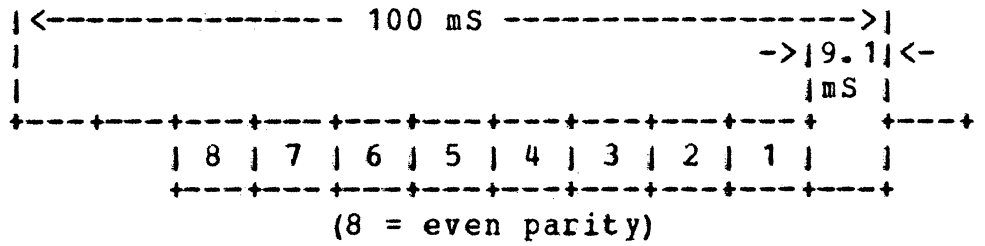
CCI Model 300 TV display (1200 baud)

American Standard Code for Information Interchange (ASCII)



IBM Models 2741 and 1050 (134.5 baud)

Paper-Tape Transmission Code (PTTC)



100 WPM Teletype Models 33/35 (110 baud)

American Standard Code for Information Interchange (ASCII)

Figure 1. Start/Stop Transmission Codes

9. APPENDIX E. CHECKSUM CALCULATION FOR BSC TERMINALS

The checksum calculation for BSC terminals can be performed either by special hardware attached to the remote computer or by a subroutine in its control program. The calculation invclves a continuous division process in which the transmitted bit sequence is formally divided by a bit sequence called the generator polynomial. The polynomials used in IBM equipment are called CRC-12 and CRC-16 and are shown in Figure 1. Although the Data Concentrator is equipped to use either of these polynomials, only the CRC-16 (8-bit bytes) is used at present.

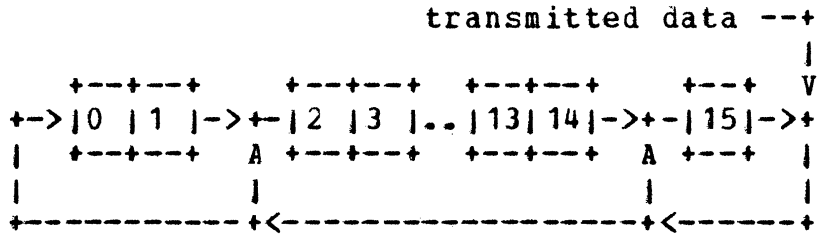
The hardware mechanization of the division circuit is very simple and can be constructed from an shift register and a collection of modulo-two adders ("exclusive-or" circuits). The connections of these components can be determined by an inspection of the gemerator polynomial as shown in Figure 1. These circuits as used in the Data Concentrator are connected so that:

1) The check digits are developed in real-time; that is in step with the message digits; and

2) The check digits are transmitted only following the message digits, so that the transmitted message consists of exactly the bits of the message as presented and followed by the check digits.

The operation of these devices is as follows: before transmission the shift register is cleared. During transmission the serial bit stream is transmitted and also fed at the point shown into the device, which is performing a continuous division process such that the remainder is in the shift register at every step. Following transmission the feedback path is brcken and the bits in the shift register are shifted onto the line as-is. Meanwhile at the receiver a corresponding process is going on in which the message is being divided by the generator polynomial. After transmission of the entire message, the remainder left in the shift register had better be zero or an error has occurred. Further information concerning the operation of these devices can be found in [11 and 12].

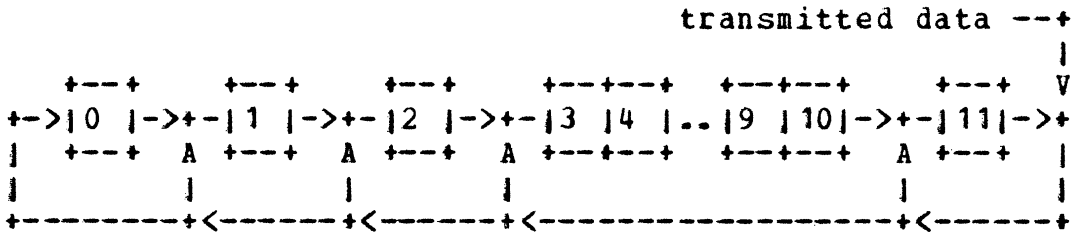
A PDP-8 subroutine to calculate the CRC-16 checksum is shown in Figure 2. Upon entry to this subroutine CYCHR, BCC1 and BCC2 contain the transmitted or received character and the two bytes of the accumulated checksum respectively (right justified). Upon exit BCC1 and BCC2 contain the updated checksum. This subroutine has an average execution time of 411 microseconds per character.



CRC-16 Checksum Computer

Polynomial: $1 + x^2 + x^{15} + x^{16}$

Prime Factors: $1 + x$, $1 + x + x^{15}$



CRC-12 Checksum Computer

Polynomial: $1 + x + x^2 + x^3 + x^{11} + x^{12}$

Prime Factors: $1 + x$, $1 + x^2 + x^{11}$

Figure 1. Mechanization of Cyclic Codes

Appendix E. Checksum Calculation for BSC Terminals

```
*
*               ROUTINE TO COMPUTE CYCLIC PARITY CHECK
*               USES POLYNOMIAL X**16 + X**15 + X**2 + 1
*               (CALLED ONLY BY SERIAL-SYNCHRONOUS REAL-TIME
*
CYCSUM 0                                AC=CHAR
       AND     K0377
       DCA     CYCHR
       TAD     K7770                    INITIALIZE SHIFT COUNT
       DCA     CYCNT
       TAD     BCC1                     SHIFT HIGH-ORDER CHECKSUM
CYC2   CLL+RAR
       DCA     BCC1
       RTR
       RTR
       TAD     BCC2                     SHIFT LOW-ORDER CHECKSUM
       CLL+RAR
       DCA     BCC2
       TAD     CYCHR                    SHIFT CHAR
       RAR
       SPA
       CML
       DCA     CYCHR
       SNL                              FEEDBACK?
       JMP     CYC3                     NO. CONTINUE
       TAD     BCC2                     YES. MOD-2 ADD LOW-ORDER F
       CLL+RAR
       CML+RAL
       DCA     BCC2
       TAD     BCC1                     MOD-2 ADD HIGH-ORDER FB TA
       AND     K0240
       CIA
       CLL+RAL
       TAD     BCC1
       TAD     K0240
       SKP
CYC3   TAD     BCC1
       ISZ     CYCNT                    HAS SHIFT COUNT REACHED 8
       JMP     CYC2                     NO. CONTINUE
       DCA     BCC1                     YES. NORMAL EXIT
       JMP*    CYCSUM
```

Figure 2. PDP-8 Subroutine to Compute CRC-16 Checksum

10. APPENDIX F. DATA CONCENTRATOR HARDWARE

The Data Concentrator is constructed of a number of special-purpose input/output interfaces, all connected to a Digital Equipment Corporation PDP-8 computer. The basic PDP-8 computer itself contains a 12-bit central processor together with a 4096-word bank of 1.5-microsecond core memory. The basic machine includes a Model 33ASR Teletype and its control unit as the basic input/output device. For the Data Concentrator application, three additional 4096-word banks of core memory have been added to the basic machine, along with a high-speed paper-tape reader (300 char/sec) and punch (60 char/sec) for convenience in program development. Hardware for high-speed multiply-divide (Extended Arithmetic Element) and automatic power restart has been field-installed on this machine. Several small modifications have been made in the processor to provide for special behavior in connection with some of the interfaces.

The special-purpose input/output interfaces attached to the Data Concentrator comprise most of the bulk hardware in the system. These interfaces connect the system on one hand to both IBM 2870 Multiplexor Channels used on the System/360 Model 67 duplex system and, on the other, to AT&T data sets of the 100, 200, 400 and 800 series, providing transmission rates on the switched telephone network to 2000 baud. The various interfaces operate both on a core memory cycle-steal basis for data transmission and on a programmed accumulator-transfer basis for control operations. Liberal use is made of the interrupt facilities in conjunction with special line-adapter scan equipment which has the capability of selectively disabling the interrupt facilities by blocks of devices. Figure 1 shows the interconnection of the various major components in the system, which are described in detail in subsequent sections. References [2, 8, 10 and 17] contain a more detailed description of this equipment than is presented here.

1. Data Multiplexor and Clock Generators

A special PDP-8 core memory data multiplexor has been constructed to satisfy the requirements of the various interfaces using cycle-steal operations. This multiplexor operates using a common-bus distribution system for memory data transfer in both input and output directions. Each device attached to these busses provides transmission gates between its registers and the busses as required, and conditions data transmission by signals distributed by the data multiplexor separately to each device.

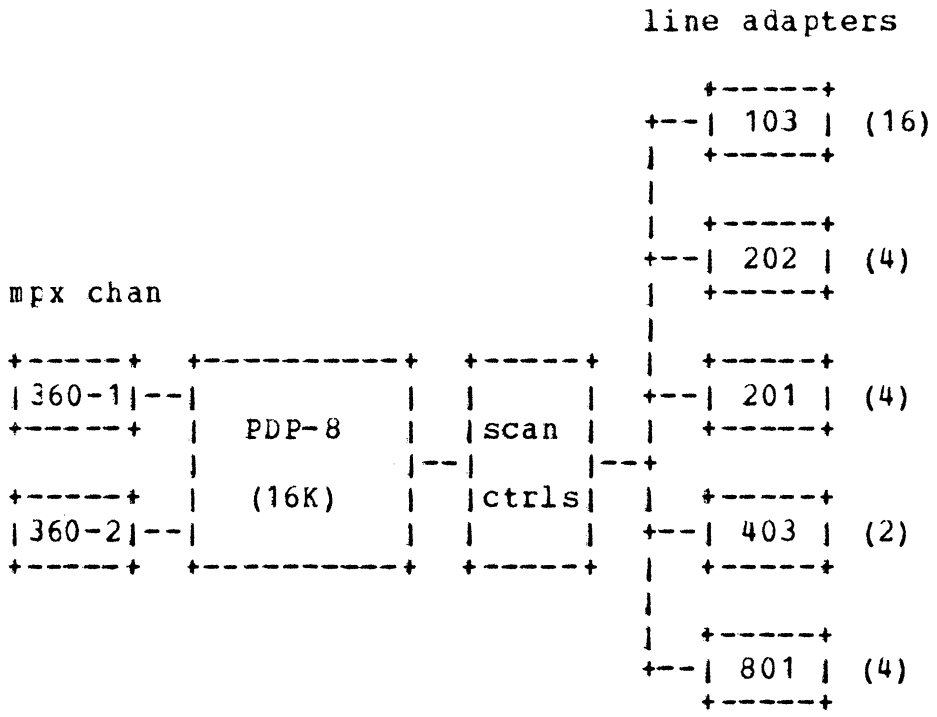


Figure 1. Data Concentrator

Included in the data multiplexor itself is a set of buffers which distribute the various PDP-8 input/output busses to the scan control and data set line adapter equipment attached to the system. Also included is a set of crystal-oscillator clocks and associated countdown circuitry which provides timing signals for the data set line adapter equipment. Signals of all popular transmission bit rates are provided from 45.45 baud (Teletype Models 28 and 32 attached to AT&T type 103E data set) to 2000 baud (AT&T type 201A data set). In addition, an interval timer using a basic clock rate of 100 Hz provides a maximum countdown interval of 40.95 sec. The timer is implemented using a memory-increment cycle-steal operation in PDP-8 memory. A timer overflow is signaled by a program interrupt.

2. System/360 Interface

The System/360 interface connects directly to the channel-control unit interface cables which interconnect the multiplexor channels and the various IBM control units to which in turn are attached such input/output devices as card readers, line printers, and communications devices. Usually, several devices of the same type share a common control unit, which serves both as a relay station between the channel and each device for command and status byte

processing and as a temporary buffer storage medium for their data streams. This channel-control unit interface normally operates in a byte-interleaved multiplex mode in which data bytes are transmitted one at a time to each control unit using separate signal sequences for each byte. Thus, several devices may transmit data records in an overlapped fashion at relatively slow transmission rates to about 110 kilobytes/sec. The transmission sequences are arranged into three classes: those intended to transmit commands from the channel to a control unit, those intended to transmit status information from a control unit to the channel, and those intended to transmit the data bytes themselves between the channel and the control unit.

Each of the two System/360 interfaces appears to its respective IBM channel-control unit interface as a standard control unit, and processes commands and supervises data transmission for a set of 64 unit addresses. Each interface, containing buffer registers, parity generators, and sequencing circuitry, provides temporary storage and isolation between the channel-control unit interface and the PDP-8. The construction is such that channel-command sequences can be processed concurrently with data transmission sequences and such that these operations do not require program intervention on the part of the PDP-8 until the entire sequence has been concluded. The various interface control operations are supervised via the PDP-8 accumulator and programmed input/output operations. Transmission of both data and status bytes is via the three-cycle data break facility using a type of cycle-steal operation in which the word count and current address registers are implemented in core memory. Transmission rates can be as high as 80 kilobytes/sec., depending upon the instantaneous loading conditions imposed by the other control units attached to the channel. The interface is non-overrunable, that is, data cannot be lost if the channel temporarily refuses data byte service due to a pending service request by a higher-priority control unit. The construction of the System/360 interface is described in detail in [10].

3. Line Adapter Scan Controls

All of the data set line adapter equipment is connected to a special interface called the scan controls. This interface connects on one hand to the PDP-8 accumulator, interrupt and cycle-steal facilities, and on the other to a set of transmission busses that is common to all line adapter equipment. The various line adapter service requests are processed for each adapter in turn by a high-speed scanner-control circuit which uses a seven-bit counter called the scan address register. The contents of the scan

address register are distributed on a common bus to each line adapter, which decodes its address consisting of the high-order six bits. Thus, each of the possible 64 line adapters decodes two addresses - one with the low-order bit equal to a zero (receiving address) and one with the low-order bit equal to a one (transmitting address).

If a line adapter requires scan service, its circuitry generates a signal to the scan controls when one of its addresses is decoded on the scan address bus. This signal causes the scanner to stop while the service requirements are met. If no further action is indicated at the conclusion of the service operation, the scanner automatically restarts. If a character-assembly complete condition is recognized, the scanner is not restarted and a program interrupt is requested. The scanner is then restarted by a program command.

Both the character assembly and line control functions of each line adapter are controlled through the same scan address. Associated with each line adapter are one or more 12-bit control registers which perform functions unique to each line adapter. The various bit positions in each of these control registers are accessed through a programmed procedure which first requests the scanner to stop scanning the line adapters, then waits for a possible pending service request from a line adapter to be cleared, and finally sets the scan address register to the required line adapter address. Following the control register operations, the scanner is restarted by a program command.

The 64 line adapters addressable through scan controls are divided into eight blocks of eight line adapters each. Each block of eight can be separately enabled or disabled for interrupt requests using an eight-bit mask register called the scan priority register. Using properly constructed programmed operations it is possible to mask off interrupts from a particular block of low-speed low-priority line adapters while one of its members is being serviced, yet while allowing interrupts to be serviced from higher-priority blocks.

Two types of line-adapter service requests can be processed by the scan controls. One type, used for serial-synchronous line adapter equipment, involves no other operation than stopping the scanner when a program interrupt condition due to a character-assembly complete signal is generated within the line adapter itself. The other type, used for start/stop line adapter equipment, involves an interesting cycle-steal-shifting operation in PDP-8 core memory. This operation is initiated whenever inbound or outbound bit service is required at the line adapter. When

this occurs a special cycle-steal operation is requested by the scan controls. This cycle, when granted, proceeds starting with a core memory read cycle, followed by a one-bit rightwise shift of the memory buffer register, and ending with a core memory write cycle. The fifteen-bit core memory address at which this operation takes place is formed by the scan address register as the low-order seven bits and by an eight-bit register called the scan page register as the high-order eight bits. Thus the serial/deserial operation of each line adapter is implemented in two words of PDP-8 core memory, one for the transmit operation and the other for the receive operation. As it happens, the PDP-8 memory buffer register is already provided with shifting circuitry in connection with an analog-digital converter option. A few logic components have been pirated from unused options for the purpose of interfacing this shifting circuitry to the scan controls.

A character-assembly-complete signal is generated by the equipment for each character when the serial/deserial process has been completed. For serial-synchronous line adapters, this signal is generated in the line adapter itself when its self-contained serial/deserial register contains a fully assembled character during a receive operation or has completely emptied during a transmit operation. This signal stops the line adapter scan process, following which the line adapter generates a standard cycle-steal operation which transmits a character between the serial/deserial register and the addressed core memory location. For start/stop line adapters, the character-assembly-complete signal is generated in this fashion: on transmission when, during the shifting of the right-hand bit of the serializer word at the addressed core memory location to the line adapter transmit bit buffer, an all-zero word is detected; on reception when, during the shifting of a bit from the line adapter receive bit buffer to the left-hand bit of the deserializer word at the addressed core memory location, a one-bit is shifted out of the right-hand end of the same word. Thus, the various frame sizes of the several start/stop transmission codes can be accommodated by loading the proper mask bits in the core memory serial/deserial words prior to the character assembly/disassembly operation.

4. Line Adapters

A line adapter is associated with each data set serviced by the scan controls. It contains the circuitry to interface the control and data transmission characteristics peculiar to each data set to the common-bus interface of the scan controls. Depending upon the characteristics of each data set, the line adapter contains none, a single bit, or a full character of buffer storage between the scan controls

and the data set transmission circuitry. Each line adapter contains either one or two twelve-bit control registers used for the various data set control functions. Several bits assigned in these words have the same interpretations among all data set types, so that common program servicing routines can be conveniently implemented. The bit/character buffers of each line adapter are accessible only through the cycle-steal operations described previously, while the control registers are accessed through the PDP-8 accumulator using programmed input/output operations. In either case, the scan address register establishes at each instant which line adapter is in fact accessible for the various operations and which core memory location is in fact available for data transfer.

There are currently five different types of line adapters connected to the scan controls. These five types correspond to the five types of data sets connected to the Data Concentrator: low-speed start/stop (AT&T 103E), medium-speed start/stop (AT&T 202C), serial-synchronous (AT&T 201A), Touch Tone digit receiver (AT&T 403E), and the automatic calling unit (AT&T 801C). The 103E data set is a full-duplex start/stop type utilizing frequency-shift modulation for simultaneous transmission rates to 300 baud in each direction. This data set is used for connection of almost all low-speed Teletype and IBM equipment, such as Teletype Models 28/32 (45.45 baud), 33/35 (110 baud), and 37/38 (150 baud), and IBM 2741 Communications Terminal and 1050 Data Communications System (both 134.5 baud). The 202C data set is a half-duplex start/stop type utilizing frequency-shift modulation for transmission rates to 1200 baud. This data set is used for connection of medium-speed data communications equipment utilizing special message conventions. Both the 103E and 202C can share the same type of line adapter in the Data Concentrator, although a special 202C line adapter has been constructed to minimize the system overhead. The 201A data set is a half-duplex serial-synchronous type using four-phase modulation at a transmission rate of 2000 baud. This data set is used for connection of IBM Binary Synchronous Communications devices and in particular for the connection of remotely located PDP-7, PDP-8, and PDP-9 computing facilities to the parent Model 67 system for purposes of remote job entry and graphics processing. The 403E data set is a receiver for Touch Tone multifrequency dialing digits transmitted by the standard telephone instrument equipped with the Touch Tone feature. Included in this data set is an audio answerback channel which enables computer-generated replies to be transmitted to the caller in response to a dialed-digit message. The 801C automatic calling unit is a transmitter for Touch Tone multifrequency dialing digits and is arranged so that outbound telephone calls can be placed in connection

with certain data set types. The automatic calling unit incorporates circuitry for the recognition of the appropriate data set type at the called terminal so that the transmission circuit can be verified before use.

4.1 Start/Stop Line Adapters. The low-speed start/stop line adapter contains two single-bit line buffers, a clock frequency selection matrix and various clock countdown and control circuitry. Four clock frequencies are distributed to all start/stop line adapters on a common bus at eight times the basic transmission rates of 45.45 baud, 110 baud, 134.5 baud, and 150 baud. The clock selection matrix circuitry within each line adapter determines which clock frequency is active at any time and allows dynamic reconfiguration during the terminal recognition phase of system operation. Both transmit and receive operations are completely independent except in choice of clock frequency, which is common to both operations. The control circuitry provides program monitoring of all data set interface lines and, in addition, program control over the lines used to enable the data set for automatic answering and to seize an automatic calling unit. Indications of data set and control circuitry faults such as character and bit service overrun are available to the program. It is possible under program control to recognize both the break signal and the space disconnect signal, each consisting of various periods of space-signal transmissions, and to generate either of these signals.

Using the standard start/stop line adapter with the 202C data set places a very severe strain on the interrupt system. The reason for this is that only about 800 microseconds is available for the program to respond to the character-assembly complete signal and to restart the line adapter scanner. In order to relax this requirement a special medium-speed start/stop line adapter has been constructed which operates in the same fashion as the 103E start/stop line adapter, except that four core memory words are assigned instead of the usual two. On receive operations a swing-buffer technique is used, so that while the program is servicing one core buffer the line adapter may be assembling the next character into the other. Such an operation requires that the scanner be left running during the interrupt-processing time but disabled for character service. In this manner character serial/deserial operations proceed normally but the character-assembly complete signal is inhibited from stopping the scanner.

4.2 Serial Synchronous Line Adapters. The serial-synchronous line adapter contains a twelve-bit serial/deserial register, a four-bit frame counter, a four-bit frame size register, a parity generator, and various

control and synchronization circuitry. The serial/deserial register is used as the primary character assembly/disassembly element and the core memory words at the receiving and transmitting scan address locations are used as backup buffer registers. Since only one serial/deserial register is implemented in this line adapter, transmit and receive operations may not occur simultaneously. The frame counter is loaded from the frame size register just before the first bit is transmitted between the serial/deserial register and the data set. Thus the frame size register, which is accessible from the program, establishes the number of bits per character (up to twelve) in the data stream. This adapter contains circuitry for the automatic synchronization of character frames using a special synchronization character which can be established, at least in some line adapters, by the program. A parity generator provides an odd vertical parity bit for each transmitted character. A corresponding detector verifies the odd parity condition on each received character. These parity features may be enabled and disabled by the program.

As in the start/stop line adapter case, the control circuitry provides program monitoring and control over all of the data set interface lines, including those to seize an automatic calling unit. Indications of data set and control circuitry faults such as character service overrun and vertical parity check are available to the program. All of the serial-synchronous line adapter equipment is connected at present to a 2000-baud clock frequency source for use with AT&T 201A data sets on the switched telephone network. However, these same line adapters can be operated at much higher clock frequencies up to the limit of the logic components themselves, about two megabaud. The construction of the serial-synchronous line adapters is described in detail in [17].

4.3 Special Line Adapters. The 403E Touch Tone digit receiver line adapter and 801C automatic calling unit line adapter are simple devices with the capability of a single-character parallel transfer between the scan control register data busses and the data set. Neither of these adapters makes use of the cycle-steal facilities in the fashion of either the start/stop or serial-synchronous line adapters. The 403E Touch Tone digit receiver adapter provides a character-assembly complete signal and a program interrupt when a dial digit has been detected; the 801C automatic calling unit adapter causes a bit to be set in its control register when the data set is ready to receive the next dialing digit. At present two automatic calling units have been installed in the system. One of these is switchable over the sixteen 103E data sets connected to the

start/stop line adapters, and the other is switchable over the four 201A data sets connected to the serial-synchronous line adapters. The association of a particular line adapter to one of these automatic calling units is by a program-selected bit in the control register for each line adapter. The automatic calling unit remains selected to the line adapter until the attached data set signals that the call is complete, after which the automatic calling unit can be selected to a different line adapter.

5. Auxiliary Equipment

A number of special-purpose input/output components have been added to the Data Concentrator for utility purposes. One of these is a programmable audible alarm, consisting of an extraordinarily obnoxious siren, which is used to attract the attention of an equipment operator for the purpose of manual intervention. A scurrilous programmed-timeout operation has been implemented within the current supervisor which sets off the siren at noon and midnight, presumably to alert the machine-room crew for a shift change.

In connection with binary synchronous communications a requirement exists to calculate a special 16-bit checksum using a procedure invclving shifting and modulo-two bitwise addition. A subroutine to implement this procedure requires a calculation time of about one-half millisecond per character. A special hardware adapter has been constructed which implements this procedure using a 24-bit shift register and a set of modulo-two adders. Using this adapter, the calculation time, including shift-register loading and storing, is about twenty microseconds per character. This device is described in detail in [2].

11. REFERENCES

1. Alexander, A.A., Gryb, R.M., and Nast, D.W., Capabilities of the telephone network for data transmission. B.S.T.J. 39, 2 (May 1960), 46 pp.

2. Burkhalter, K.E., Jr., A Cyclic Check Computer for Error Detection, Concomp Project Memorandum 19, University of Michigan, June 1968.

3. Code extensions in ASCII (an ASA tutorial). Comm. ACM 9, 10 (October 1965), pp. 758-762.

4. Control procedures for data communication - an ASA progress report. Comm. ACM 9, 2 (February 1966), pp. 100-107.

5. General Information - Binary Synchronous Communications, Form A27-3004. International Business Machines Inc., White Plains, N. Y., 1970.

6. Eisenbies, J.L., Conventions for digital data communication link design. IBM Systems J. 6, 4 (1967), pp. 267-302.

7. Michigan Terminal System (MTS), University of Michigan Computing Center, 1969. (9 volumes)

8. Mills, D.L., The Data Concentrator. Concomp Project Technical Report 8, University of Michigan, May 1968. Also in Proceedings of the ACM Symposium on Problems in the Optimization of Data Communications Systems, October 1969.

9. Mills, D.L., Multiprogramming in a small-systems environment. Concomp Project Technical Report 19, May 1969. Also in Proceedings of the ACM Second Symposium on Operating Systems Principles, October 1969.

10. Mills, D.L, System/360 Interface Engineering Report, Concomp Project Memorandum 11, University of Michigan, March 1968.

11. Peterson, W.W, Cyclic codes for error detection. Proc. I.R.E. 49, 1 (January 1961), pp. 228-235.

12. Peterson, W.W., Error-Correcting Codes. MIT Press, Cambridge, Mass., 1961, 285 pp.

13. Proposed American Standard, Character structure and character parity sense for serial-by-bit data communication in the American Standard Code for

Information Interchange. Comm. ACM 8, 9 (September 1965), pp. 553-556.

14. Proposed Revised American Standard Code for Information Interchange. Ccmm. ACM 8, 4 (April 1965), pp. 207-214.

15. Proposed USA Standard, Data communication control procedures for the USA Standard Code for Information Interchange. Comm. ACM 12, 3 (March 1969), pp. 166-178.

16. Transparent-Mode Control Procedures for Data Communication Using the American Standard Code for Information Interchange - a Tutorial. Comm. ACM 8, 4 (April 1965), pp. 203-206.

17. Wood, D.E., A 201A Data Communication Adapter for the PDP-8: Preliminary Engineering Design Report, Concomp Project Memorandum 15, February 1968.

UNIVERSITY OF MICHIGAN TERMINAL SYSTEM (MODEL PR220)

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CHARGE NBR: WDLM

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**** OFF AT 22:41.08

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**** CPU TIME USED	207.012	SEC.
**** STORAGE USED	6782.35	PAGE-SEC.
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13. ABSTRACT

This report is a user's guide for the Data Concentrator, a terminal control device designed for use with the Michigan Terminal System (MTS). This device presently supports several types of AT&T and IBM terminals together with remote computing and visual display equipment using 103A, 202C and 201A data sets. Included is a description of the extensive set of options available together with useful reference material.

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Terminal Control						
Typewriter Terminal						
Visual Diaplay Terminal						
Remote Computer Terminal						
User's Guide						