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Identification

Overview of Typewriter Input/Output.
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Purpose

This section provides a general description of the part of the Multics Input/Output System (IOS) which enables user programs to communicate with typewriters.

Devices and Hardware Supported

The typewriters supported by the IOS are:

1. Teletype Model 37KSR Teletypewriter.
2. IBM Model 1050 System with a single Model 1052 Printer-Keyboard.
3. IBM Model 2741 Communications Terminal.

All of the above typewriters must be equipped with certain options and special features to achieve basic compatibility with Multics; see Section BF.11.10 for complete details. The Teletype Model 37KSR will usually be referred to simply as the M37KSR or just M37; the IBM models will usually be referred to simply as the 1050 or the 2741. The M37 can operate either half-duplex (alternate receive and transmit with direct local copy while transmitting) or full-duplex (simultaneous receive and transmit with no direct local copy); the 1050 and the 2741 can operate half-duplex only. Half-duplex and full-duplex are often abbreviated HDX and FDX respectively. A simplified block diagram of these typewriters is shown in Figure 1.

It is anticipated that the Multics IOS will also support augmented typewriter systems such as the Teletype Model 37ASR, which has a paper tape attachment, and expanded IBM 1050 systems, which can have all sorts of attachments. Such augmented systems are inherently more complex than the basic typewriters, and are regarded as distinctly different devices; IOS support for such systems will be detailed later and separately. This section (BF.11) and its subsections relate only to the basic typewriter systems listed above.

All typewriter-computer connections, whether made via switched telephone facilities or private lines, use some sort of data set for a communication line interface at each end of the communication line. Most types of data sets transmit data in the form of frequency-modulated tones. The data sets supported by the IOS for use (at the computer end of the line) for typewriter I/O are the following Bell System Data Phone Data Sets:

Model 103A. A switched-line data set.

103F. A private-line data set.

103E. A newer type switched-line data set.

All of the above data sets provide full-duplex communication (simultaneous transmission in both directions). The data set options required at a Multics installation are detailed in Section BF.11.11.

The standard typewriter adapter available with GE's General Input/Output Controller (GIOC) provides half-duplex typewriter channels (alternate transmit and receive). The standard arrangement is to connect one such channel to a data set to obtain a half-duplex channel. Another useful arrangement is to connect two half-duplex channels to one data set to obtain what we will call a full-duplex channel. These arrangements are shown in Figure 2. Other arrangements are possible and useful but are not considered here. The half-duplex channel may be operated in an echoplex mode while receiving; in this mode the received data is echoed or transmitted back bit-by-bit. Thus it is possible for a Teletype Model 37 operating full-duplex and connected to a half-duplex channel to receive local copy via echoplex retransmission.

These typewriter adapter channels admit various options and contain patch panels that control character handling details; the required options and patch panel settings are detailed in BF.11.12.

Block Diagram

Figure 3 shows a block diagram of the typewriter I/O portion of the IOS connected via core storage to a block diagram of the hardware required for typewriter I/O. The I/O-Switch module is represented by a circled X. Beginning below the user, the modules encountered are:

1. Code Conversion Module (CCM).
2. User Device Terminal (UDT).
3. Device Strategy Module (DSM).
4. Device Control Module (DCM).
5. Data Set Interface Module (DSIM).
6. GIOC Interface Module (GIM).

The CCM, UDT, DSM, and DCM are "outer" IOS Modules. The CCM may in fact be implemented as a series of modules.

Beginning at the software-hardware interface, the hardware encountered is:

1. Generalized Input/Output Controller (GIOC).
2. Typewriter Adapter (plugs into the GIOC).
3. Data Set at computing center.

4. Telephone Company communication line (usually involving local and long distance channels and one or more switching centers).
5. Data Set at Typewriter.
6. User's Typewriter.

The software is shown divided into two parts - the user's working process and a device manager process (DMP) devoted entirely to the management of one typewriter. The process boundry occurs between the UDT and the DSM. Every typewriter attached to a user is managed by a separate DMP. Further, every typewriter channel not attached to any ordinary user is associated with a special user called the answering service (see Section BQ.2).

Module Descriptions

The module descriptions given immediately below are augmented by discussion later in this document and/or the referenced subsections of BF.11.

The Device Control Module (DCM)

The DCM provides the basic typewriter I/O for a specific type of typewriter; there are separate DCM's for the M37, 1050, and 2741. The DCM performs no code conversion (except that implied in the next paragraph); it reads and writes raw data. Thus a read call to the DCM obtains data in precisely the form it was originally deposited into core by the GIOC. Similarly, a write call to the DCM must offer data properly coded for the type of typewriter involved.

The DCM does examine the data flowing through it. During output, the DCM inserts appropriate time delays following control characters which cause mechanical functions which do not complete in one character time (e.g. tabs). When the character positions at which horizontal tab stops are set are known to the DCM (see Section BF.1.06), it replaces sequences of blanks by horizontal tab characters where appropriate to decrease the total time required to accomplish the output. Similarly, the DCM replaces sequences of blank lines by vertical tab and/or form-feed characters. Further, the DCM will constrain the output text to the text space specified by a format call (see Section BF.1.06). During input, the DCM will respond to certain characters or sequences in such a way as to optimize the behavior of the typewriter from a human engineering viewpoint. For example, certain characters can be typed on a 1050 keyboard which cause the keyboard to be immediately locked; the 1050 DCM responds by issuing the I/O sequence which unlocks the keyboard.

The following description of DCM synchronization behaviour describes a behaviour seen by the caller of the DCM, the DSM. The synchronization modes available to the user are described generally in Section BF.1.04 and in the description of the DSM given later in this document. The DCM implements only the

synchronous read synchronization mode (see Section BF.1.04); the DCM does not do any "read-ahead." The DCM implements only the asynchronous workspace synchronization mode (see Section BF.1.04) by returning control on a read or write call as soon as the physical read or write is initiated. Upon receip9t of a read call the DCM takes care of interpolating the I/O sequence necessary to unlock the typewriter keyboard. Before initiating physical read I/O, the DCM also arranges for the keyboard to be locked following the read. Thus a read call to the DCM results in the DCM initiating (by a call to the GIM) a complete unlock-keyboard - read - lock-keyboard sequence. A subsequent read call to the DCM results in the corresponding read sequence being interpolated before the lock sequence, if the lock sequence has not been executed.

The DCM implements only the synchronous write synchronization mode (see Section BF.1.04); the DCM does not do any "write-behind." If no reading is in progress or if the typewriter is in FDX mode and is connected through an FDX channel, the DCM can write onto the typewriter printer immediately upon receipt of a write call. The DCM interpolates any control I/O sequences necessary to implement the printing. If the typewriter is in HDX mode and reading is in progress when a write call is received, the DCM immediately terminates the read sequence and initiates the write sequence. Any data read during the partially-executed read sequence is returned to the caller's workspace. When there is no more writing to be done, the previously-terminated read sequence is not restarted. Reading is resumed only upon receipt of the next read call.

The DCM will read the typewriter identification (e.g. the contents of an M37's answerback drum) upon receipt of an order call making the proper request (see Section BF.1.07). Following this order call, the next read call will read the typewriter identification and only that.

The DCM satisfies read/write and other requests by issuing calls to the GIM (see Section BF.20). Hardware interrupts from the channel being managed by the DMP ultimately result in an upstate call to the DCM (see Sections BF.2.20 and BF.2.22). The DCM determines channel status by issuing request status calls to the GIM. If the channel status contains the "quit" condition, this is detected by the DCM. Status concerning read/write completions or errors is interpreted directly by the DCM. Status concerning the data set is passed to the DSIM for interpretation. The DCM also calls upon the DSIM for the command structure necessary for such functions as disconnecting the communication facility (hanging up the telephone line).

The Typewriter DCM's are described in detail in BF.11.06.

The Data Set Interface Module (DSIM)

The DSIM contains the software which understands a particular kind of Data Set; there are separate DSIM's for each type of Data Set. The main job the DSIM is to examine the status information relevant to the operation of data set and communication line.

A Behavior Log is maintained by the DSIM containing a history of data set and communication line behavior. The log is kept in the File System and is located in the I/O Registry File entry for the channel (see Section BF.3). The log is periodically analyzed by a communication line trouble shooting daemon. Information entered in the log includes: successful call-ins and normal disconnects; incomplete Data Set handshakes; spontaneous disconnects; carrier failure history; and any abnormal Data Set status sequences.

The DSIM supplies the command structure to the DCM for various data set control functions, such as disconnecting the line or making the line busy (103E only).

The Typewriter DSIMs are described in detail in Section BF.11.07.

The Device Strategy Module (DSM)

A single Typewriter DSM is used for all types of typewriters. A primary function of the DSM is implementation of the IOS synchronization strategy for typewriter I/O. In particular, the avoidable read-ahead and write-behind data is managed by the DSM. The DSM implements all of the synchronization calls as described in detail in BF.1.04. Calls originating in working processes and received by the DSM are satisfied normally as if no process boundary existed. No account is taken by the DSM of the process id of the calling process. The DSM is also called at its upstate entry point by the DMP's I/O Dispatcher when a DMP wake-up occurs as a result of a hardware interrupt (see Section BF.2.22).

Whenever the read synchronization mode is set to asynchronous by a readsync call, the DSM begins operating in a read-ahead mode. In the absence of a readsync call, the first read call will set the read mode to asynchronous. The DSM attempts to keep the typewriter keyboard continuously unlocked by issuing read calls to the DCM at a sufficient rate. The amount of data read-ahead is limited to the amount specified in the limit argument of the readsync call. The DSM in turn uses the asynchronous workspace synchronization mode when issuing read/write calls to the DCM. If the read synchronization mode is set to synchronous by a readsync call, the DSM reads from the DCM only upon receipt of a read call from the UDT. Unused data collected during read-ahead is not discarded following a readsync call which sets the mode to synchronous or which lowers the read-ahead limit. Such unused data is discarded only upon receipt of a resetread call.

Whenever the write synchronization mode has been set to asynchronous by a writesync call, the DSM will return control on a write call when the write is logically complete. The amount of

write-behind is limited to the amount specified in the limit argument of the writesync call. When the write synchronization mode is synchronous, the DSM will not return control to the UDT on a write call until all output is physically complete. Data still not output when the write synchronization mode is set to synchronous or when the write-behind limit is lowered is not discarded, but is written out before any data supplied by a subsequent write call. Unwritten data can be discarded by a resetwrite call. If a write call is received while operating in the read-ahead mode, no further read calls are issued to the DCM until all unwritten data is written out.

The asynchronous workspace mode is implemented as described in BF.1.04; The worksync, iowait, writewait, readwait, and abort calls are implemented.

Under certain circumstances, synchronization responsibility may be indirectly undertaken by an outer module between the user and the DSM (see Section BF.2.25).

A detailed description of the Typewriter DSM is given in BF.11.05.

The User Device Terminal (UDT)

The UDT receives the original attach call for the typewriter, and is responsible for attachment processing. For decoding of the description argument of the attach call, the UDT calls upon the comprehender, the centralized description understander (see Section BF.3.06). The latter is also passed the type argument. If the description and type are compatible and the former corresponds to an identifiable device, the UDT is returned a I/O Registry File Name (see Section BF.3). The UDT then uses this I/O Registry File Name to determine whether a DMP for the device is already associated with the user's process group. If not, the UDT calls for the creation of a new process, and initializes it by calling the Device Manager Initializer in the DMP-to-be. If a subsequent attach call requests the association of the same typewriter with another framename, a separate instance of the UDT is invoked. Calls to this second framename reach the original DMP via the second UDT.

Considerations of device access control and protection, the interaction with the Registry Files, and the interaction with the Reserver are not included; these topics are in too early a stage of evolution.

Before returning control on a successful attach call, the Typewriter UDT splices the proper Code Conversion Module (CCM) between itself and the original caller.

Subsequently, the UDT examines only attach, detach, changemode, and code calls, and passes all other outer calls directly to the DSM. Since calls to the DSM are interprocess calls, the I/O

Switch (IOSW) actually sends them to the IOS's Process Jumper (see Section BF.2.30). After sending the call to the DMP, the Process Jumper calls the working process' Wait Coordinator, to wait for the return event (see Section BD.8). Upon return from the DSM, the Process Jumper returns to the UDT. The UDT then returns to the caller.

If the UDT receives an emergency attach call (see Sections BF.1.04 and BF.3), the UDT issues a please-quit call to the DMP and spawns a fresh DMP to handle subsequent I/O. The original DMP responds to the please-quit call by quickly stopping any current I/O in such a way that it can be restarted by a subsequent wake-up due to a please-restart call, and calling the Wait Coordinator to wait.

Other aspects of typewriter attachment are discussed later in this document. The typewriter UDT is detailed in Section BF.11.03.

The Code Conversion Module (CCM)

The CCM provides input/output code conversion for a specific kind of typewriter; there are separate CCM's for the M37, 1050, and 2741. Inasmuch as certain conversion steps are device independent, these steps are implemented in subroutines callable by all CCM's.

The CCM is spliced into the I/O path by the UDT at attachment time. The typewriter CCM's provide the input and output conversion modes described in BF.1.05. The input modes are:

R Raw; no conversion.
C Canonical text, with print position erase and kill.

The output modes are:

E Edited, clean readable copy. Escape sequences for graphics are replaced by single blanks.
N Normal. Escape sequences are used for nonpresent graphics; undefined and other inappropriate characters are deleted.
S Raw output, no conversion. The bits go Straight to the DMP.

The Typewriter CCMs are described in detail in Section BF.11.04.

Typewriter Device Manager Flow-of-Control

The Typewriter DMP flow-of-control logic is completely the standard Device Manager flow-of-control logic described in BF.2.20. The synchronization management logic implemented within and between Typewriter IOS modules is that described in BF.1.04 and BF.2.25. Interpretations of the synchronization calls by the various outer modules has been briefly described earlier in this

document and is detailed in sections BF.11.03-06.

Typewriter Attachment

Many of the details of typewriter attachment were discussed above during the description of the UDT. Suitable type, description and mode arguments for the attach call are described here; general information can be found in BF.1.01 and BF.1.02.

The type argument must be "typewriter", "keyboard", or "twprinter". Because the typewriter is a sequential (Q), forward-only (F) device, the only access-mode specifiers permitted are "Q" and/or "F", or none (and "QF" is implied); further, "notD" may appear in place of "Q" and "notB" in place of "F". The "not" is used here as a representation of the PL/I "not" symbol (ASCII "overline").

Valid description arguments will be described in a subsequent version of this document.

The typewriter keyboard is readable (R) and the typewriter printer is writable (W). The use-mode specifiers permitted are: for "keyboard", "R" and/or "notR" and/or "notW", or none; for "twprinter", "W" and/or "notW" and/or "notR", or none; for "typewriter", "R" and/or "notR" and/or "W" and/or "notW", or none. In any case "ZnotZ" is equivalent to "notZ" where Z is any symbol. The absence of "R" and/or "notR" leaves the readable mode unset; likewise, the absence of "W" and/or "notW" leaves the writable mode unset. They may be set by a subsequent changemode call; the advent of a read call is an attempt to set the readable mode on; the advent of a write call is an attempt to set the writable mode on. It is only when these modes have not been set that the UDT pays attention to read and write calls. Once a use mode has been set, it can be changed by a changemode call, but it cannot be unset.

The only data mode permitted is "G" (logical), or none (in which case "G" is assumed).

Another mode which may be stipulated in the mode argument of the attach call is the duplex mode; this mode may be either half-duplex (H) or full-duplex (X). Because the 1050 and the 2741 are inherently HDX, only "H" may be stipulated when attaching them. Either "H" or "X" may be stipulated for an M37. The duplex mode refers to the actual typewriter, not to the effective channel. The latter is independently either an HDX or an FDX channel, depending on what channel the typewriter called or was called from. HDX channels may have their echoplex mode set on or off by an order call passed to and acted upon by the DCM. The default duplex mode for an M37 on an HDX channel is FDX, with the channel echoplex mode set on. The duplex mode can be changed by a changemode call.

Only typewriter channels having typewriters physically connected to them can be attached by normal users. Typewriterless channels can be associated with special users such as the Answering Service. Users that want to attach typewriters which need to be called-up to be connected to the computer system must first attach and use pseudodevice known as the Dialer (see Section BF.13). The Dialer can initiate call-outs using Bell System Automatic Calling Units which are associated with some of the typewriter channels. Once the typewriter is actually connected to the computer system, it can be attached by the user.

Quit Detection

When the typewriter operator presses the "interrupt" key on an M37, the "reset line" key on a 1050, or the "attention" key on a 2741, the typewriter sends a special signal (200 milliseconds of zeros) to the computer system (see Section BF.11.10 for the options required to implement this signal). This special signal is called a Quit signal. Provided the typewriter channel is not off, a hardware interrupt occurs and the channel is reset to idle mode (but is still on).

The hardware interrupt ultimately results in a wake-up of the DMP managing the channel. The DMP's I/O Dispatcher makes an upstate call to the DSM (see Section BF.2.22); the call is passed to the DCM, and then to the GIM in the form of an request status call. The GIM then retrieves the raw status block stored by the System Interrupt Interceptor. The GIM then returns a translated and filtered version of the status to the caller. The fact that a Quit signal occurred is detected by the DCM. The DCM informs the Overseer process of the Quit signal by signaling an event in the Overseer process.

So far the DMP does not know whether or not the Quit signal from its device is a valid Quit insofar as the user's process group is concerned. Nevertheless, the DMP assumes the Quit is valid and acts accordingly. Since the type of interrupt associated with the Quit causes the channel to terminate, some of the input/output activity previously initiated by the DCM may have been aborted; this is determinable by examination of the status returned by the GIM. The DCM updates the status bit strings for all outstanding transactions previously requested by the DSM; in particular, certain transactions may be marked aborted. The status returned for the upstate call indicates the Quit condition. The DCM then returns to the DSM which returns to the I/O Dispatcher. Neither the DCM nor DSM take advantage of this instance of having control to initiate any I/O. Because the I/O Dispatcher also received the Quit indication in its returned status, it arranges for outstanding and subsequent requests from working processes to be ignored. The DMP responds only to hardware interrupt events and the please-quit, please-restart, and please-save calls. If the Quit signal was not valid, the Overseer immediately issues a please-restart call to the DMP; the DSM takes note that certain of its requests were aborted and

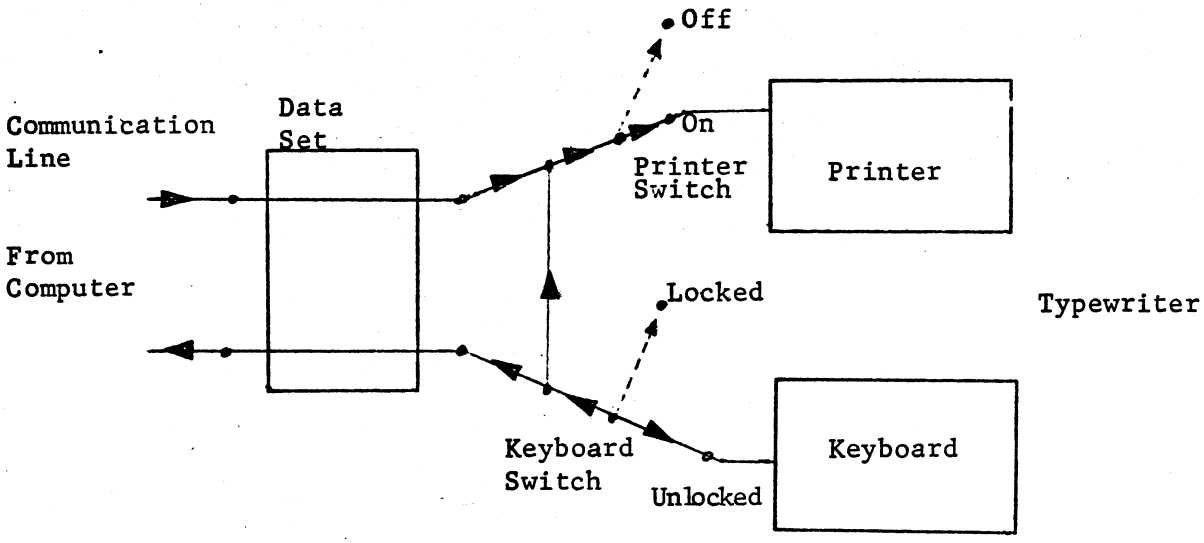
reissues them.

For a general description of "quitting" and "saving" DMP's, see Section BF.3.

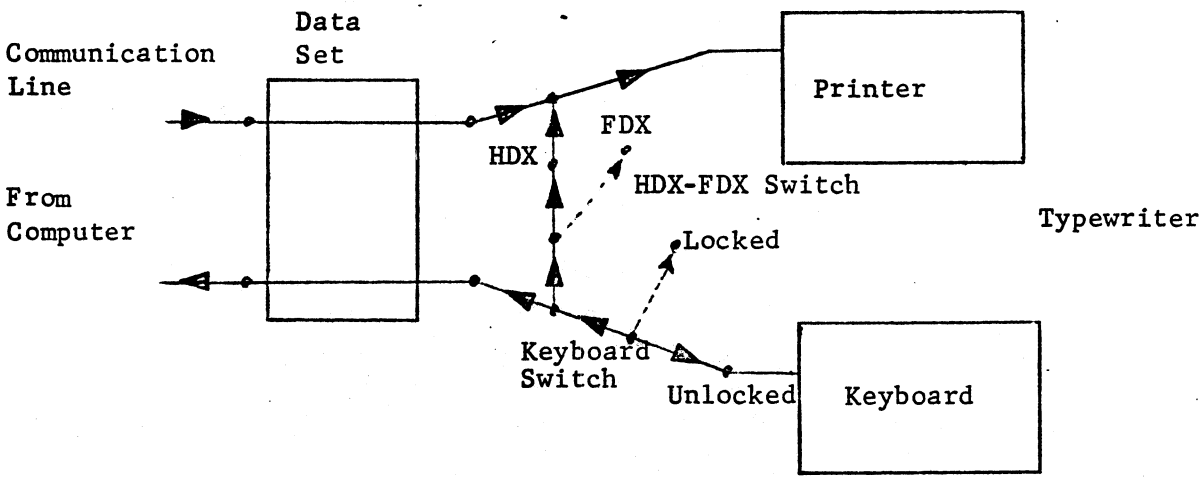
The Response of the Typewriter IOS to Outer Calls

The Typewriter I/O portion of the IOS accepts almost all IOS outer calls from the user. A detailed description of the response to these calls is given in BF.11.01.

For a description of outer call acceptance and response by the various individual outer modules within the Typewriter IOS, see Section BF.11.02. This section also summarizes the manner in which the various outer calls flow from module to module.

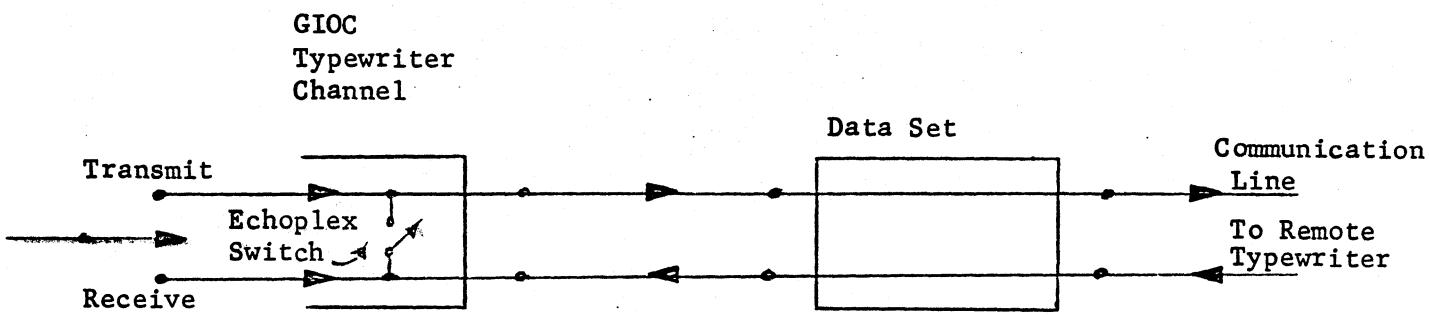


IBM 1050 or 2741 Diagram

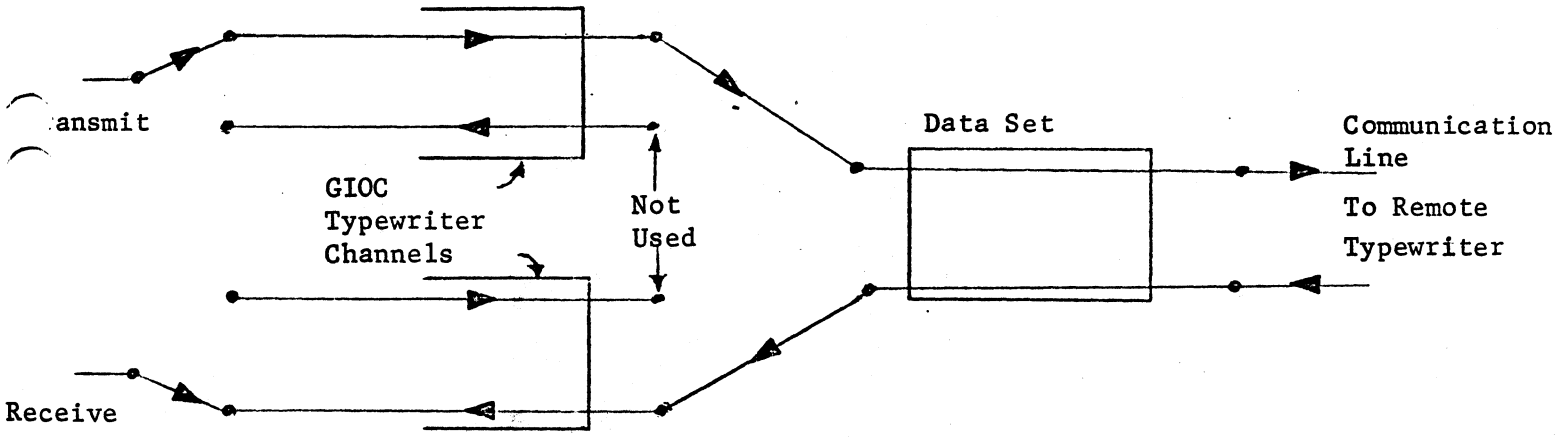


Teletype M37 Diagram

Figure 1.



"Half-Duplex Channel"



"Full-Duplex Channel"

Figure 2.

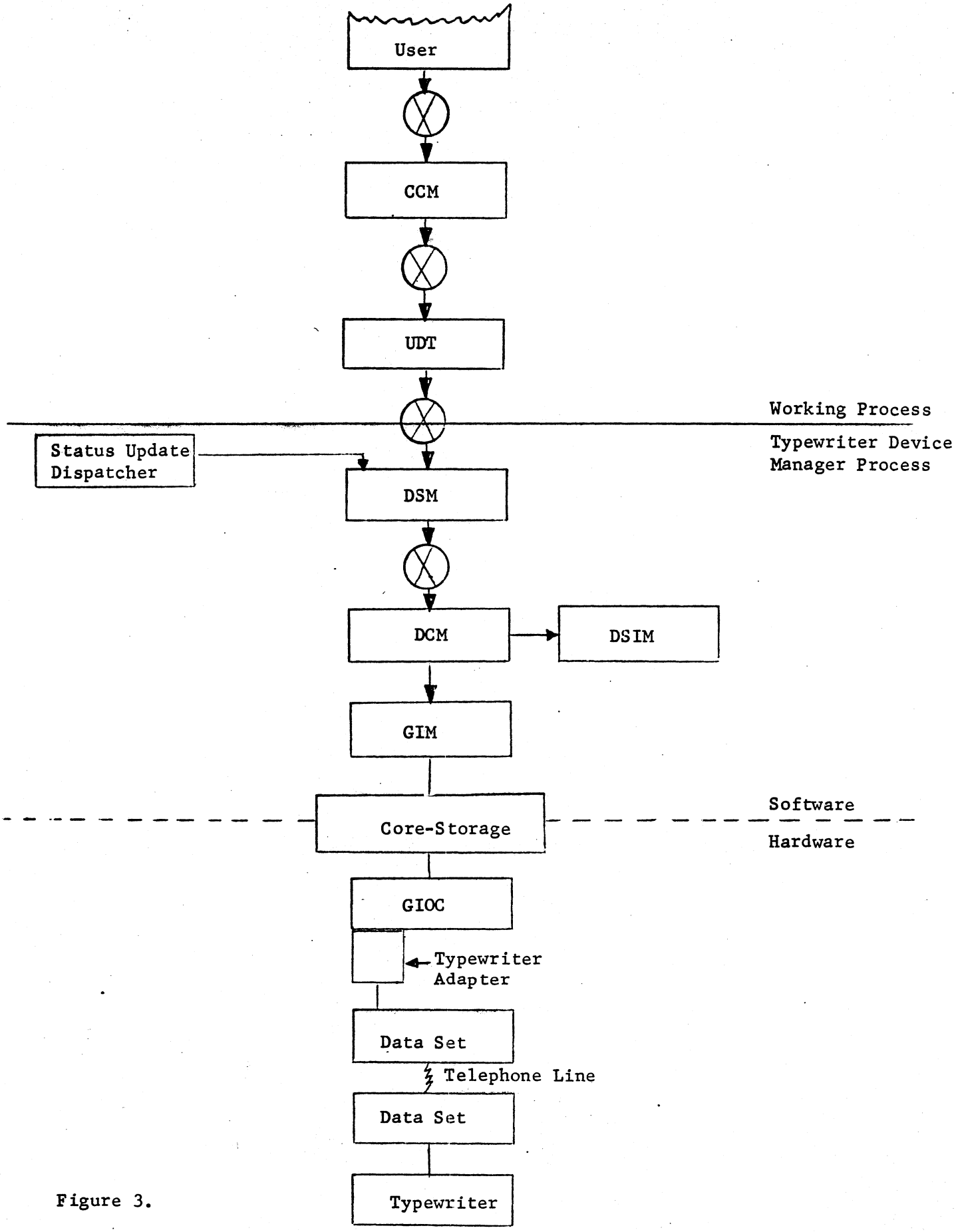

User
CCM
UDT
Working Process
Typewriter Device Manager Process
Status Update Dispatcher
DSM
DCM
DSIM
GIM
Software
Core-Storage
Hardware
GIOC
Typewriter Adapter
Data Set
Telephone Line
Data Set
Typewriter

Figure 3.