



1360 Photo-Digital Storage System

Principles of Operation



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Preface

This manual contains a functional description of the IBM 1360 Photo-Digital Storage Systems supplied to the Lawrence Radiation Laboratories at Berkeley and Livermore under contracts AT(04-3)-608 and -609, and to the Los Alamos Scientific Laboratory under contract LC9-83594-1. In addition, it details the methods of communication between the host computer and the storage system, gives sequences of operation and timings, and outlines operator functions.

A physical description of the photo-digital system is given in the System Summary, a companion manual released in 1968. The 1367 Data Controller described in this manual houses an interface which conforms to the rules of the CDC 3000 series I/O channel.

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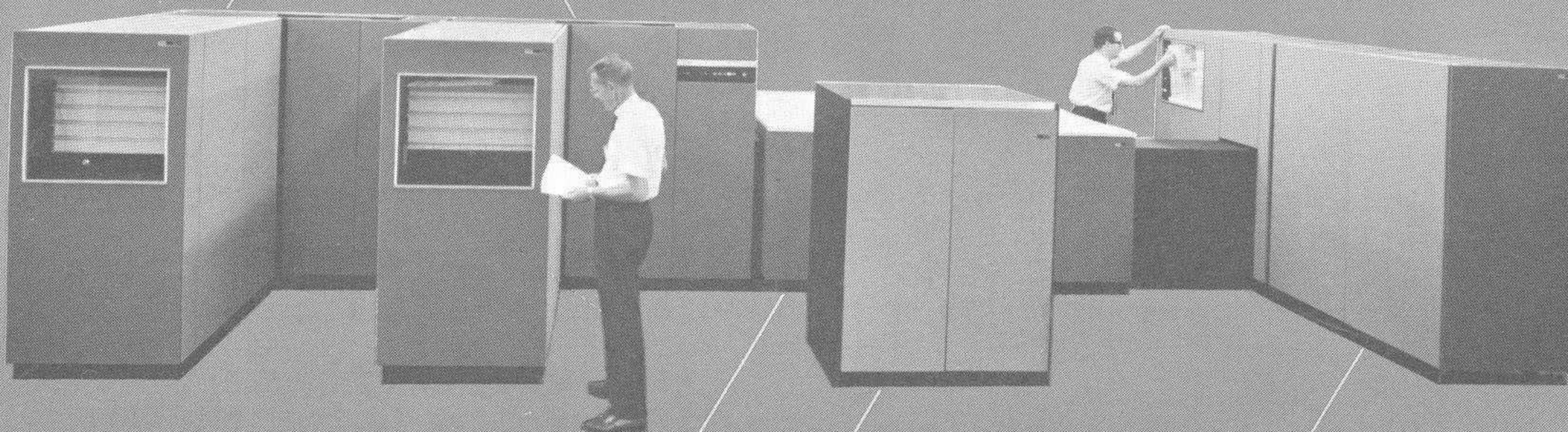
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1352 Cell File



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System Description

Introduction

The IBM 1360 Photo-Digital Storage System is a group of devices with input/output capabilities that serves as a mass storage system for a large computing system. This type of storage system is characterized by its ability to provide direct access to vast amounts of data in the range of a trillion bits or more. Its performance ranges somewhere between moderately fast-access secondary storage such as magnetic disks or drums, and the slower tertiary store, typically magnetic tape.

The photo-digital system uses photographic techniques for permanent data storage in order to achieve greater density and, hence, capacity than by magnetic means. Since this data is stored online, manual handling of cell storage sections and related library procedures are eliminated except for archival purposes.

A unique feature of the photo-digital system is the use of a stored-program

processor that accepts commands from the host computer, processes these commands, and responds upon completion of each, meanwhile keeping the host computer continuously informed of system status.

The control program also initiates diagnostics of system hardware failures and automatically recovers from a major portion of them. Another type of recovery, read recovery, occurs when data errors are detected during a read operation by the control program. Both types of recovery take place within the 1360 system without intervention from, and with only minor delay to, the host.

In addition, the system's control program dynamically interleaves host commands so as to permit numerous overlaps of hardware functions, with the result that system throughput is significantly increased. Another important factor that influences total throughput, however, is the initial organization of commands by the host.

General Purpose Design

The 1360 system was designed to fill the need for a data bank capable of storing large volumes of source information which rarely, if ever, changes. Its capacity ranges from one-third of a trillion to two trillion bits, depending on the number of file modules employed. Read, write, develop, and transport operations are automatically performed by the system under minimal host control. The net result of this system self-containment is that the host computer is released from a number of tasks normally required to service I/O devices.

The time to move cells between a file and a terminal varies from 2.5 to 4 seconds. Since this is long compared to data processing time, the 1360 is designed to handle up to 13 cells in simultaneous stages of transport, reading, writing and developing, so as to reduce access time and thus increase total throughput. Optimum mode of operation--that is, where access time may be reduced to the millisecond range--is achieved in a two-reader configuration where long reads alternate between the readers.

Functional Description

The photo-digital system operates under a set of host computer commands that causes the system to go through the mechanical actions necessary to allow data from the host to be written, or to read and send data previously written and stored to the host. The system stores information at very high densities on "chips," small pieces of high-resolution photographic film. Nearly five million bits of information can be packed on a single chip, which measures 1.3 x 2.7 inches. Data is recorded on the chips by means of a concentrated beam of electrons which emanates from tungsten filaments in the turret of an electron gun.

To record data, an individual blank chip is positioned in a vacuum chamber, and information transmitted from the computer is written by repeated sweeps of the electron beam across the chip surface. The beam, in effect, "paints" data as combinations of dark and clear spots corresponding to binary zeros and ones. Each chip is divided into 32 frames, and data is recorded a frame at a time at a rate of more than a half million bits per second.

The system has its own internal "film-processing laboratory," which develops the film chips under automatic control.

Program Control

Control and scheduling of control processor facilities, main and disk storage, the storage files, and pneumatic transport are completely preprogrammed. Programs also control the data controller which, in turn, controls the read and record functions.

In general, the 1360 control programs execute commands, organize overlapped sequences, notify the host of normal or abnormal completion, and initiate diagnostics and automatic recovery. To carry out these tasks, interplay of equipment and program is an essential consideration in the 1360 system. The control program includes a supervisory routine that coordinates and executes all I/O requests, handles exceptional conditions, and supervises scheduling and

After processing, chips are automatically packed in protective plastic cells. Transport of cells to storage files is handled by means of a pneumatic blower system designed for two-way travel at speeds reaching 25 feet per second.

In the storage file, cells are placed in individual compartments of movable trays. The host computer keeps track of all records stored in the files, and initiates requests for the retrieval of information. Individual cells can be withdrawn from any location in the file and pneumatically delivered to a reader, where the selected chip is read by a high-speed flying spot scanner. As the scanner moves back and forth across the data lines, the beam of light is transmitted through a clear spot on the chip and blocked by a dark spot. A photomultiplier behind the chip senses the transmitted light pattern, and electronic circuitry converts the signals to binary bits for delivery to the computer. The actual reading takes place at an average rate of 2,500,000 bits per second.

For a more detailed description, see the System Summary for the IBM 1360 Photo-Digital Storage System.

execution of multiple programs. The 1360 provides for efficient switching from one program to another.

The interface between the host computer and the 1360 system has a channel consisting of lines used to transfer control information and data between the host and the 1360. The function of one of these lines is to provide a signal called Master Clear that enables the host to instruct the 1360 to return to a power on state after it has experienced a possible hardware failure or following a host system failure. Master Clear, discussed later in this section, performs much the same type of "housekeeping" tasks as the Power On routine (see Recovery Procedures in Operator Functions).

Command Structure

The control programs for the photo-digital system schedule the operation of the mechanisms so that the various functions required by the host are efficiently executed.

The programming system provides a transformation between two basic levels of control. First, there is the control of the photo-digital system by the host computer. At this level the host provides commands and receives appropriate responses which indicate the commanded action has been completed (see Host Mode of Operation).

The second level of control is the actual control and scheduling of various electronic and electromechanical components of the system at what has been termed the solenoid/sensor level. At this level the program initiates an action by activating or deactivating a particular single solenoid and determines the hardware condition by sensing the state of microswitches or photosensors.

The following is a brief review of the relationship of the host command (which is one of a sequence of commands making up an I/O request) to the 1360 control program which controls system subassemblies.

Essentially, an I/O request is for a read or write of data. In either case, a series of commands must precede an actual Read or Write command in order to obtain a cell containing already-recorded information from the file or to position raw film in the recorder.

For example, an I/O read request results in the host sending address information to the 1360 as to where the data may be found, together with a sequence of five commands (Transport File, Seek Reader, Read Data, Chip Return, and Cell Return). The control program performs certain validating tests on each incoming message before establishing any possible request for action. The tests include validity of sequence, proper parameters, etc. If the control program accepts a command, it initiates a transaction. A pointer is assigned to each transaction that sequentially "points" to items in a list of actions related to the host command. A transaction is maintained in the transaction table until the cell is redeposited in its "home" compartment in the cell file.

When a host command has been executed, the control program signals a command completion response to the host and the host issues the next command in the sequence. In general, subsequent commands in any one host command sequence are invalid until the previous command has been completely executed. However, since several requests may be in various stages of completion at a time, so commands associated with different requests may be intermixed.

Likewise, though transactions are carried out in the order in which they are received, they are intermixed in an unpredictable fashion due to "pre-established priorities" maintained by the control strings that operate system hardware and pneumatics. For example, a cell designated for a reader may have to wait until another cell is returned from the reader to the file.

Overlapping

Control of the operation of the photo-digital system by a stored-program processor is similar to that exercised over industrial processes or traffic flow. The control programs manipulate the flow of read and write data and messages between the host computer and the photo-digital system as well as the physical flow of chips and cells throughout the files and terminals.

Both data and physical flows overlap functionally. Data overlap is possible since messages can be relayed over the host channel to the data controller at the same time that commands are being relayed by the control processor to system components. Hardware overlap is also possible because commands set in motion mechanical actions that take a finite time to accomplish, thus allowing the processor time to set in motion another series of subassembly actions. Pneumatic overlap allows a cell to be drawn out of its compartment to the file buffer at the same time that other cells are exchanged in the reader rotary buffer, enabling one to travel back to its cell compartment along the mainline pneumatics path while the other is readied for chip selection. Thus, the burden is upon the host programmer to sequence the commands in a manner that utilizes the full potential of the photo-digital system (see Sequence of Operations for further details).

Responses to Host

Specific responses by the 1360 system to host commands are individually cataloged in Host Mode of Operation. A response is sent at command completion and indicates whether a command was executed or was unacceptable or, in the alternative, gives condition information.

Command execution may be normal or abnormal. In the former, the command has been completed as requested; in the latter, an abnormal condition such as not finding a cell in the specified compartment (nor finding it in the buffers or at a terminal) results in a command execution response.

A command may be unacceptable for any number of reasons. It may be illegal (the command may be incorrectly formatted), hardware may be inoperative, a transaction might not be available (only four transactions are permitted at each reader, for example), etc.

Condition information is given where a command such as a transport file or transport terminal goes in a two-step progression through the rotary buffer to the cell shuttle from its point of origin. This allows the host to handle cell transport between the reader and recorder via the rotary buffer on a priority basis. A priority status is necessary when a newly developed chip has been placed in its cell and transported to a reader for a readback check. That cell must then be transported back to the recorder in time to receive the next developed chip so as not to interrupt the entire recording process.

These responses are significant to the host since they motivate proper sequencing of commands in order to take advantage of overlapped, multiple functions in the 1360.

Diagnostics and Automatic Recovery

When the 1360 system diagnoses a hardware failure, it enters Automatic Recovery mode and notifies the host with a special message. The message identifies the module number on which recovery is being attempted or may inform the host that the 1360 disk has been found unusable (the latter message is the last to be sent to or received from the host until the disk is replaced). A subsequent message

informs the host whether recovery has been successful or not. Meanwhile, the host stops any timing it might be doing between issuance of the command(s) in progress and receipt of related response(s).

Automatic recovery is defined as the various attempts made by the 1360 system to restore itself to proper operation without intervention by either the host computer or an operator. In its simplest form, automatic recovery involves retry, but extended forms may include several retries at normal or subnormal speeds which may clear up temporary conditions of substandard mechanical performance.

The variety of failure causes and recovery procedures does not permit a simple statement on recovery times. However, most recoverable malfunctions represent a delay of less than 20 seconds from suspension of processing to full restoration. The host computer is passive during the process and only experiences a time delay in completion of its commands.

The following sections discuss two types of hardware failures, recoverable and nonrecoverable, a special kind of recovery called Read Recovery, and tests for data transmission.

Total Recovery. In the case of total recovery, the failing mechanism is put back into operating condition and processing is allowed to continue. For example, total recovery from a failure to obtain a proper current level for the electron beam in the recorder may be achieved by program-controlled rotation of the filament turret to bring a new filament into operation.

Partial Recovery. Partial recovery results when a component does not recover from a hardware failure, but the remainder of the system is allowed to continue processing. The availability of a single file module, the control processor, the data controller, the pneumatics path, and a single terminal (a reader or the recorder) is sufficient to permit limited operations.

Nonrecoverable Failure. In the event of a nonrecoverable failure to the 1360 system, such as a disk failure, the host is notified that the system is down. This message is the last to be sent to or received from the host until the disk is replaced.

Read Recovery. The reading of data constitutes a special class of recovery

since it does not involve mechanical functions or diagnostic programs. If data errors are detected, rereading the bad data line is done automatically under a high priority assigned to minimize recovery time.

An independent character error detection/correction code permits a combined hardware-software procedure to correct any combination of up to five 6-bit characters in error for a given line. The time element for software participation is sufficiently small that the system is in no way suspended nor does the procedure require intervention by the host. If a line is not correctable, the host is informed by means of a bit in the 1360 operational status channel (see 1360 Control).

Data Transmission Test. A data transmission test, initiated by the host and automatically executed by the 1360, checks the data controller-host channel interface circuits to find specific areas of errors. If the host requests a data transmission test, the 1360 system forces a graceful slowdown by first entering Automatic Recovery mode and then implementing the test. The term "slowdown" is not used in the context of slower mechanical actions, but rather that actions find a logical stopping place and stop; thus, one by one, operations cease. The purpose of this test is to establish whether a problem in data transmission is with the data controller or the host.

The data transmission test may be done three ways: (1) a pre-established pattern of data sent from the 1360 to the host; (2) a pre-established pattern of data sent from the host to the 1360 (the 1360 recognizes whether or not the pattern is correct); or (3) a pattern of data (or a message) sent from the host to the 1360 and then sent from the 1360 to the host with no intervention from the 1360 processor (and, hence, the data is not scanned by the 1360).

Master Clear

Master Clear is an important tool to help implement recovery from a hardware failure or to restore the system to a known condition following a host system failure.

The host is notified in the event the following occur: (1) when the

appropriate bit(s) in the current equipment status word are set to "0" to indicate a hardware or functional malfunction (or to enable a customer engineer to do preventive maintenance), and (2) when the appropriate bit(s) in the pre-online equipment status word are set to "1" by a customer engineer to indicate the equipment is now ready to be put back online. The host may then instruct the 1360 control program to execute a Master Clear. This is a routine which resets the system to some initialization point intelligible to the host; the system may in fact already be in such a state, but the host must establish whether cells and chips are out of their proper storage places and whether mechanisms are in certain positions in order to know how to proceed.

Before calling in Master Clear, however, the 1360 control program forces a graceful slowdown (similar to "slowdown" as defined in Data Transmission Test). Upon entering Master Clear, the initial or "soft" phase may establish in milliseconds that the system is in order. If it is successful, the routine terminates. If not successful, the module in question is "cleaned out" while the remainder of the system is briefly idled.

However, even if a unit fails to recover, the entire system may not go down. If the unit is dispensable to the system, that is, reader(s), recorder, or two of the files in a three-file system, the soft phase may simply take that unit offline by changing the status bit for that module in the current equipment status word (see Type 3 Messages and Operator Communication) and relinquish control of the rest of the system to the host.

A Master Clear consists of cleaning out chips and cells from various places in the system where they are found other than in normal file storage, resetting the 1360 modules, and restoring modules to the system which have been readied for use. During cleanout, chips in the developer finish their developing cycle and are deposited in an assigned position in a cell in a special recovery section manually placed in file 1. Likewise, chips and cells found in other parts of the system out of their normal position are transported to the recovery section (see Recovery Procedure).

To sum up, the following sequence of events occurs when the 1360 experiences a possible hardware failure:

1. The system notifies the host that it is entering automatic recovery mode.
2. The system attempts to restore itself to proper operation; if successful, it notifies the host that it is leaving automatic recovery mode following recovery. If not, it notifies the host that it is leaving automatic recovery mode following non-recovery.
3. The appropriate bit(s) in the current equipment status word is set to "0."
4. The host may send messages to the system, including the down module, that tend to put things away, such as Chip Return and Cell Return.
5. The host then instructs the 1360 to execute a Master Clear.
6. The soft phase of Master Clear may quickly establish that the system is in order (the routine senses for hardware reset positions and looks at program pointers for uncompleted commands); if the soft phase is successful, the down module goes offline and messages addressed to it

will be rejected. The remainder of the system (if the offline module is dispensable) is available to the host. A complete Master Clear clears out the whole system with the exception of the down module, and, like the end result of the soft phase, the down module goes offline and the remainder of the system returns to host control.

7. The host should then call a customer engineer.
8. The customer engineer corrects the failure and/or sets the appropriate bit(s) in the pre-online equipment status word to "1."
9. The host now issues a second Master Clear; since a previous soft Master Clear may have left a cell undetected in the buffer, the second Master Clear is always a complete one.
10. At the conclusion of Master Clear, the appropriate bit(s) in the current equipment status word has been set to "1" and the entire system goes back online.

Data Flow

Data flow is controlled by the data controller as it interfaces between the host computer and the 1360 system. The host channel transmits 1200-bit bursts of data for both read and write over 12 lines. The maximum instantaneous data rate is 12 megabits per second (12 bits in parallel per microsecond). The data controller matches this high-speed channel to the slower reader and recorder. It accepts a burst of data from the host computer at its channel rate and passes the data on to the recorder in proper line format at the recorder serial-by-bit rate of 550 kHz. Once recording has started, lines of data are presented to the recorder in a continuous stream until a complete frame of 492 lines (123 bursts) has been recorded. Similarly, data is accepted from the reader in a continuous stream at its serial-by-bit rate of 2.5 MHz. The data is then passed to the host in bursts at its channel rate.

The combination of higher channel speed and data controller design enables the host computer to overlap write and read operations in the 1360 system. Write data is interleaved with read data on the channel on a burst basis, one 100-microsecond transmission being required in each 3200-microsecond period. The reader is serviced by a 100-microsecond transmission in each 680-microsecond period. Thus, read data is interleaved on the host channel with write data at about a 5 to 1 ratio because of the difference between reading and recording speeds.

A unique feature of the read operation is that the host can take read data at less than the specified rate (the only delay introduced is due to the host) without causing a rotational delay and reaccessing as in magnetic devices, since the beam of light from the flying spot scanner has a comparatively short latency time. It simply loops on a pair of lines until it receives the signal to continue reading.

Recording is done on a frame basis with no time restriction between frames. The electron beam simply idles until more data is supplied, or, if the host wishes to finish recording a chip but has no more data to supply, the command Write-Chip Fill causes zeros to be recorded on the remainder of the chip. However, the host must provide write data at a specified rate during the writing of a frame (492 lines) or create an invalid condition. A burst of 1200 bits (four lines) must be provided at average intervals of 3100 microseconds. Due to the asynchronous, overlapped nature of the transmitting, formatting, and recording sequence, however, the host can respond in intervals of from 0 to 2200 additional microseconds. Thus, the host can wait as long as 5300 microseconds without causing a write overrun. If the host should, in effect, delay sending one burst, it must eventually compensate for this by sending two bursts with a 900-microsecond interval to catch up.

If the host fails to supply enough data to fill a frame, the 1360 system causes a write overrun to occur. If this happens, the remainder of a frame is filled with zeros. Then, as stated above, the host has the option of waiting indefinitely to supply more data or the command Write-Chip Fill may be sent to fill the remainder of the chip with zeros. The ability to send the next burst is determined by a bit in the status word which is gated onto the 12 lines in the host channel that convey 1360 status to the host computer (see 1360 CONTROL).

A burst is logically considered to be composed of four 300-bit lines for error detection purposes. The data controller encodes each line with redundancy characters to permit detection of almost all lines with more than five characters (six bits each) in error and correction of any five characters in each formatted line. The redundancy bits and the procedures are invisible to the host.

Error Detection and Correction

Error detection and correction take place by means of a combined hardware-software procedure within the photo-digital system in real time. System suspension is not required because read recovery is executed during normal system operation.

The host is unaware of error correction procedures. These procedures range from simple retry and application of code correction techniques to more elaborate retry procedures with the host experiencing only minor delay.

Message Paths

The data controller not only relays read and write data, but it also acts as a message exchange between the host computer and the control processor. Since the same 12 lines are used to convey messages, the 1360 must be informed by means of a function code which type of information it will receive. The host, during a write operation, can send two types of information to the 1360. The first type, called write data, is information to be recorded on a chip. The second type, called host command (or message), conveys control and address information to the control processor. Similarly, two types of information may be transferred from the 1360 to the host during a read operation. Read data is the information read from a chip. Message response is information from the control processor.

1360 Control

In addition to the two-way, 12-line data bus discussed in the previous two sections, another one-way, 12-line channel conveys 1360 status to the host computer. If the 1360 system is connected to the channel and is also operational, the status word is gated onto the status lines. These lines may be interrogated by the host at any time independent of the operation being performed by the storage system.

It is only when efforts to read a problem line have failed that the host is notified by means of a bit change in the 1360 operational status word (see 1360 CONTROL). This serves to flag the group of four buffered lines in which the uncorrectable error was found. It then becomes the host's responsibility to decide what procedures to follow to restore the data to the file.

For a more comprehensive writeup on this subject, see the System Summary.

A host command is relayed to the control processor via the data controller. Similarly, message responses (eight 12-bit words) are transferred from the control processor to the data controller and then to the host over the data channel. These messages indicate the status of the 1360 or the action taken upon the last command issued.

The 1360 host interface program performs certain validating tests on each incoming command before it acts to satisfy it. One test is for validity of sequence. Other tests are for system conditions or for proper formatting and/or parameters of the command. (For details, see Type 0 Message Format.)

Although 12 lines are provided for the status word, only nine positions have been assigned. The first status bit is as follows:

1360 operational (00) is a control point set by the control processor. It indicates the mass store is ready to write and read. Other status bits are meaningful only when the 1360 operational point is on.

The next four bits indicate status of the four areas of the host buffer:

Write area empty (01) informs the host that it may send write data to the MSS. After a write burst is received, the empty point is turned off and it remains off until the complete burst has been transferred to the device buffer for subsequent recording.

Read area full (02) informs the host that it may take read data from the 1360. After transmission is complete, this point is turned off and it remains off until four more lines have been received from the reader (via the device buffer).

Host message area empty (03) is functionally equivalent to the write area empty point but for the host message area. The message response area full (04) provides the same function for this area as the read area full point does for its area.

The last four bits indicate error conditions and insufficient write data:

The uncorrectable error in read burst (05) informs the host that one or more of the four lines resident in the host buffer read area contains one or more uncorrectable errors. This situation arises when error correction procedures are exhausted without successfully correcting all detected errors. This point is set when the first line containing an uncorrectable error is transferred to the host buffer. It is reset when the read area full point is turned off following the next read data transmission to the host.

Write overrun point (06) informs the host that write data was exhausted during the previous frame. Consequently the frame was filled with lines containing proper frame and line number but with zeros in the 300-bit data field.

As the name implies, the parity error point (10) is set when incorrect parity (even) is detected during a function or write operation. In the Berkeley system, it remains on until reset by the subsequent rise of either a function command signal or a write command

signal. In the Livermore system, the parity error status point is reset by correct parity during a subsequent transfer cycle (usually the following one). Master clear signal resets the parity error status point in both Livermore and Berkeley systems.

The short write burst status point (11) is turned on when less than 100 words are received during a write data operation. When this occurs, the write area empty point remains on. The partial burst of data in the write area is not transferred to the recorder and thus is lost. The short write burst point is turned off by master clear or the rise of a subsequent write command. It will not be turned on if a parity error was also detected.

These status bits are updated at variable times without interrupt. They are set to a logical 1 (on) when the indicated condition exists. If bit 01 is set to a logical 1, for example, this indicates that the write area in the data controller buffer is empty and informs the host that it may send write data to the 1360. After a write burst is received, the bit changes to a logical 0 and remains there until the complete burst has been transferred to the device buffer for subsequent recording.

The host, then, is dependent on the status word in order to determine the sequence of operations in the photo-digital system. For example, when the short write burst status point (11) is turned on, it tells the host in real-time that the partial burst received by the 1360 has not been transferred to the recorder and is lost. The host must then decide in real-time whether to repeat or skip that burst of data.

In summary, the host has available a 12-bit status word that allows it to execute write and read operations in conformance with availability of the 1360 system (bits 00 through 04). In addition, bit 05 flags a read burst when one or more of the four lines contains one or more uncorrectable errors. Bit 06 flags the host when write data fails to fill a frame; bit 11 when less than 100 words are sent in a write operation and are subsequently lost. Finally, bit 10 flags the host when incorrect parity is detected during a function or write operation.

Host Mode of Operation

Basic Message Structure

Six types of messages are exchanged between the host computer and the 1360 system. The term "message" is defined as either a command, a response, or simply a request for information. A command is a request for a specific action or for information. A response is sent at command completion and indicates normal completion, unacceptable command, or status information. A host-generated command (or message) is transmitted to the 1360 in 96 bits, only 72 of which are significant; a 1360-generated response (or message) is transmitted to the host in 96 bits, only 36 to 84 of which may be significant.

MESSAGE	DEFINITION
Type 0	Normal commands and responses
Type 1	1360-generated messages to host (pertain to normal operations, but not as a response to a host-generated command)
Type 2	Host-generated messages to 1360 (for example, request for system status)
Type 3	1360-generated messages to host (for example, reporting an abnormal change in system condition)
Type 4	Host-generated messages to 1360 operator via 1816 printer-keyboard
Type 5	1360 operator-generated messages to host via 1816

Type 0 Message Format

Commands and responses are organized into words, 12 bits in length. A command has six words composed of bits 0-71. Bits 0-7 define the command function and 8-71 define its parameters. The 1360 system recognizes commands by interpreting a

formatted section of the 72-bit message which is sent from the host to the 1360. Type 0 commands and responses are described in detail later in this section.

Commands

The commands are formatted as follows:

BITS

0-7 Operation code (type 0-2; class number 3-7)

8-9 and 10-11 Terminal address
where 00 ~ Recorder
01 ~ Reader 1
10 ~ Reader 2
11 ~ Invalid

12-23 Arbitrary number (significant only to host--see note below)

24-35 Count (significant only in read commands)

where 3936 lines (one column) are maximum length of read

36-47 Continue option (significant only in read commands)

where if bits 36-47 = 0, frame and line fields will be ignored and if bits 36-47 $\neq$ 0, the chip in the picker will be positioned to the specified frame and line immediately or when the current read is completed. When positioning is complete, data transfer will start immediately with no intervening exchange of messages.

OR

24-47 Cell address

24-35 File address

where 01 ~ 1361
10 ~ 1352 (top)
11 ~ 1352 (lower)

36-42 Section location address within file (Figure 1) where sections are numbered 0-74 (decimal)

43-47 Cell location address within file section (Figure 2) where cell locations are numbered 0-29 (decimal)

48-52 Chip address (0-31 decimal)

53-71 Starting line identification

53-59 Starting line identification of frame (0-31 decimal)

60-71 Starting line identification of read (0-491 decimal)

OR

48-71 Cell address (used only if not returned to origin)

48-59 File address (see bits 24-35 for parameter boundaries)

60-66 Section location address within file (Figure 1)

67-71 Cell location address within file section (Figure 2)

Note: Bits 12-23 (word 1) are reserved for the use of the host programmer in assigning an arbitrary number which assists the host program to relate a response to its initiating command.

For internal program purposes the file is addressed by "sections" of 3 x 10 cell pockets (equivalent in size and shape to removable sections). Geometric arrangement of these sections is indicated (in decimal) in Figure 1.

The 30 cell locations within a file section (either removable or permanent) are numbered as shown (in decimal) in Figure 2.

Responses

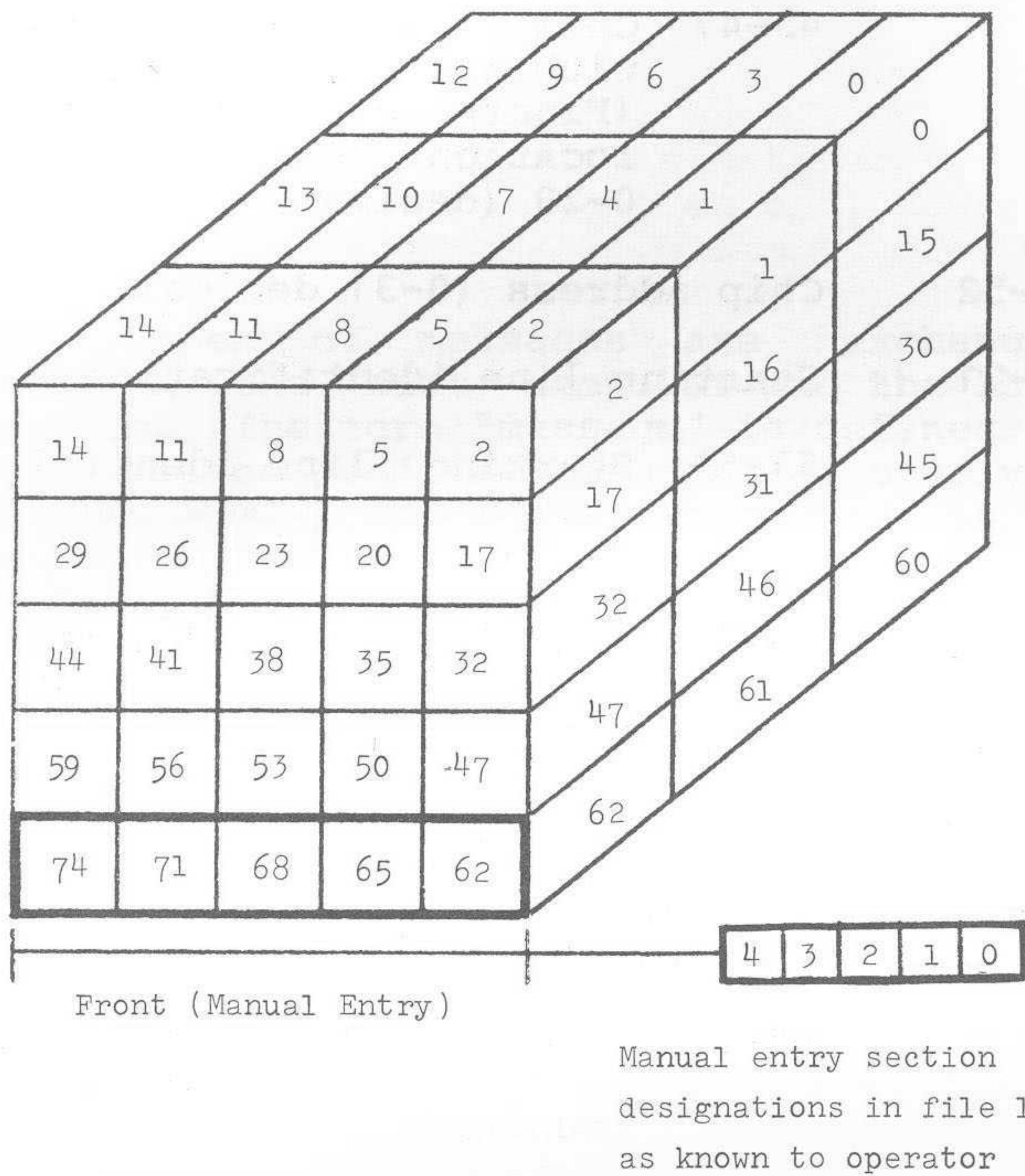


Figure 1 Section Locations Within File

Top View

20	10	0
21	11	1
22	12	2
23	13	3
24	14	4
25	15	5
26	16	6
27	17	7
28	18	8
29	19	9

Front (Handle End)

Figure 2 Cell Locations Within Section

Messages in the reverse direction use a 96-bit response. A response has from three to seven significant words depending on the type of message. A response is sent at command completion, rejection, or termination with two exceptions. A Read Terminate aborts completion of a read command, so that only one response follows. Similarly, a Write-Chip Fill intervenes between a Seek Recorder and its response if less than 32 frames of data are recorded.

Responses fall into two general categories: (1) those that indicate a command has been executed (or terminated or in the process of execution) and (2) those that indicate a command is unacceptable and, therefore, rejected.

These two categories are made up of three types of responses. Responses that indicate a command is completed and those that give information concerning the status of a command fall into the first category. Responses indicating unacceptable commands fall into the second. The three types of response messages are as follows:

Conditional
Executed Information Unacceptable

Word 0	X	X	X
Word 1	X	X	X
Word 2	X*	X*	X
Word 3	X*	X*	X
Word 4	X*	X*	X
Word 5			X
Word 6	X	X	X

Word 7 is coded 8D1 hex (4321 octal) to indicate end of message to host.

*Error statistics (read only)

Executed

Generally, only three words of the eight-word response sent upon completion of a command are significant. Words 0 and 1 duplicate the original command and word 6 indicates that it has been normally completed by using hex codes 000, 001, 002, 004 and 006 (see Figure 3 for meanings).

If, however, the command was a read and it had one or more uncorrectable lines, the response sent at read completion includes three additional words (2-4) containing error statistics. Word 2 gives the count of the lines with uncorrectable errors, word 3 gives the line number of the first line in error, and word 4 gives the line number of the last line in error (one error only results in the same number in word 3 and word 4). Words 3 and 4 have no indication of frame identity; therefore, the identification of the precise frame and line is a host function, using the response line identities.

Conditional Information

This response occurs in either of two cases: (1) when a command is accepted and action initiated but some condition occurs that prevents it from being executed completely or accurately, or (2) when the status or progress of a command up to a certain point is reported.

The response duplicates the first two words of the original command and codes the detail of the response in word 6 (Figure 3). These responses are coded to indicate to the host into which of the above cases the response falls. In the first case, codes 001, 002, 003, 004, and 005 indicate an error condition. Note that codes 001, 002, and 004 are also used to designate normal completion. However, depending on the command issued, finding no chip in a slot, no cell in file, or finding a chip already in a slot may be termed either "normal" or "error." Codes 001 and 002 indicate error conditions that may have been caused by either host or 1360. Regardless of whether the command is completed at all or whether it is completed accurately, this type of response falls into the same general category as executed commands as opposed to unacceptable commands which the 1360 makes no attempt to complete.

The second case (in which the progress of a command is reported) is dealt with by hex codes 005 and 007. Hex code 005 indicates that the timeout time has elapsed on a read, and hex code 007 indicates a cell has arrived at the rotary buffer. This is not normal completion, but only a status report. No error conditions are involved, such as the ones noted above in the first case examples.

See preceding section for information concerning error statistics after a read command has been executed.

Unacceptable

An unacceptable command is one which is rejected and no 1360 action is initiated by the command. A command is rejected because of system conditions, or if the command is not properly formatted, or if its parameters are not in range. The response uses words 0-5 to duplicate the entire original command and codes the detail of response in word 6 (Figure 3).

See hex codes 040 through 055 listed for various conditions that result in an unacceptable command response being transmitted to the host.

CODE		MEANING
Octal	Hex	
0000	000	Command complete
0001	001	No chip in slot
0002	002	No cell in file
0003	003	Cell already in file
0004	004	Chip already in slot
0005	005	Timeout on read
0006	006	Read Terminate or Write-Chip Fill completed
0007	007	Cell arrived at rotary buffer
0100	040	Illegal command
0101	041	Terminal inoperative
0102	042	File inoperative
0103	043	Line count too large
0104	044	No transaction available
0105	045	Cell already out of file
0106	046	Cell not in terminal
0107	047	Wrong chip in picker
0110	048	Picker in use
0111	049	No chip in picker
0112	04A	Previous command not complete
0113	04B	Operation in progress or previously completed
0114	04C	Manual entry operation in progress
0115	04D	Empty cell not available
0116	04E	No read in progress
0117	04F	Read Terminate in progress
0120	050	No chips formatted
0121	051	No Seek Recorder in progress
0122	052	Filament off
0123	053	Seek Recorder in progress
0124	054	No manual entry door in this file
0125	055	Other reader reading

Figure 3 Word 6 Definition

Note: In a response using hex codes 000-007 in word 6, the response repeats only the first two words of the original

command. In a response using hex codes 040-055 in word 6, the response repeats words 0-5 of the original host command.

Type 0 Messages

The following chart (Figure 4) lists the host commands with format and purpose.

Each command and response to it is then written up in detail on subsequent pages.

MESSAGES	WORD 0		WORD 1		WORD 2		WORD 3		WORD 4		WORD 5	
	Operation Code	Terminal Number	Significant Only to Host	Length of Read	Cell Address (Origin)	Cell Address (Origin)	Cell Address (not returned to origin)	Chip Starting Line Ident.	OR	OR	OR	PURPOSE
	Type No.	Term. Term.	Arbitrary No.	Count	File	Sect.&Pos.	File	Chip, Frame	Line	Sect.&Pos.		
	0-2 3-7	8-9 10-11	12-23	24-35	24-35	36-47	48-59	48-52	53-59	60-71	60-71	
Transport File	000 00000	X	X		X	X						Moves cell from file to terminal.
Transport Terminal	000 00001	X(from)X(to)	X		X	X						Moves cell from terminal to terminal.
Seek Reader	000 00010	X	X		X	X		X	X			Positions chip at desired line for reading.
Seek Recorder	000 00011	X	X									Positions a new chip for recording.
Chip Return	000 00100	X	X		X	X		X				Returns chip to cell.
Chip Select	000 00101	X	X		X	X		X				Selects desired chip slot and indicates whether or not it is empty.
Cell Return	000 00110	X	X		X	X						Returns cell to file.
Assign Cell Address	000 00111	X	X		X	X	X			X		Assigns new cell address to cell in shuttle.
Read Data	000 01000	X	X	X		*		X		X		Initiates data transfer from positioned chip.
Chip Analysis-No Data Transfer	000 01001	X	X	X		*			X			No data transferred; reader is in enhanced error detection mode.
Chip Analysis-Data Transfer	000 01010	X	X	X		*			X	X		Same as Read Data except that reader is in enhanced error detection mode.
Read Terminate	000 01011	X	X									Terminates read prior to prespecified end.
Write-Chip Fill	000 01100	X	X									Fills in remainder of chip being recorded with zeros.
Activate Empty Cell	000 01101	X	X		X	X						Assigns file address to cell newly emptied of unexposed film.
Transport File Search	000 01110	X	X		X	X						Same as Transport File except if hdwe. indicates a cell is not in that file pos., 1360 will restore file and send response.
Seek Reader Search	000 01111	X	X		X	X		X	X	X		Same as Seek Reader except if hdwe. indicates no chip in slot, 1360 will restore picker to home & send response.
Unlock Manual Entry	000 10000		X		X							Unlocks manual entry door in 1361.
Read-No Data Transfer	000 10001	X	X	X		*			X	X		Same as Read Data except no data is transferred to host.
Format Chips	000 10010	X	X	X								Formats raw film chips for recording.
Control Filament	000 10011	X	X	X								Controls status of filament.

*Continue Option for Read Commands: If bits 36-47 = 0, frame and line fields will be ignored. If bits 36-47 ≠ 0, the chip in the picker will be positioned to the specified frame and line immediately or when any current read is completed. When positioning is complete, data transfer will start immediately with no intervening exchange of messages.

Figure 4 Type 0 Messages (Normal)

Transport File

WORD 0		WORD 1		WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host		Cell Address (Origin)	
Class		Term.		Arb. No.		Sect. & Pos.	
Type	No.	8-9	10-11	12-23	File 24-35	36-47	48 ← → 71
0-2	3-7						
0	0	X	Must be 0	X	X	X	Not Used

Purpose

To move a cell from its resident location in a file to a cell shuttle position in the designated terminal.

Conditions

- (1) Must be a valid address for the system (040).
- (2) If two cells occupy the relevant cell shuttle and block entry of a third transport cell, the blocked cell will be held in the rotary buffer receive chamber until it can be entered into the cell shuttle when a position is vacated. If the cell is destined to the recorder, one cell shuttle chamber is assumed to be filled with a cell of unexposed chips, leaving only one possible chamber for the new (resident) cell. The exact sequence of operations is determined and carried out by the control processor, since actual motions depend upon many system

environment conditions which are dynamic.

- (3) No more than four cells can be in process relative to a single reader at any given time (except as described under Transport Terminal). An attempt to issue a transport command initiating a fifth cell will be rejected (044).

No more than three cells can be in process relative to a recorder (044).

- (4) With respect to a given terminal, cells will arrive in the same order in which the Transport File commands are given.
- (5) The cell will remain at the cell shuttle until removed by a subsequent command. A cell is removed from a cell shuttle by a Cell Return or Transport Terminal command.

Note: Parenthetical numbers at the end of sentences indicate the hex code contained in word 6 of response. This code identifies the reason why a command was unacceptable, executed, or conditional (see Word 6 Specifications for each command).

Transport File (continued)

Response

The host will be notified when the cell addressed by the transport command arrives at the rotary buffer and again when the cell arrives in the cell shuttle. Further commands pertaining to the cell or chips in the cell are valid only after receiving the second response indicating that the cell is in the cell shuttle.

The purpose of the first response indicating arrival at the rotary buffer is to allow for the possibility of a priority cell being at the reader but blocked from entry into the cell shuttle by two other cells. In this case, knowledge of the priority cell presence permits the host to take action resulting in more rapid service of the priority cell.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)					
Type	Class	Term.	Term.	Arb. No.	File	Sect. & Pos.			Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48←Unused→71		72-83	84-95
UNACCEPTABLE										
Duplicates original command									*	
CONDITION INFORMATION										
Duplicates original command						Unused			*	
EXECUTED										
Duplicates original command						Unused			*	

*Word 6 Specifications

Condition Information

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0102	042	File Inoperative
0104	044	No Transaction Available
0105	045	Cell Already Out of File

Octal	Hex	Meaning
0007	007	Cell Arrived at Rotary Buffer

Executed

Octal	Hex	Meaning
0000	000	Command Complete
0002	002	No Cell in File

Transport Terminal

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)			
Type	Class No.	Term.	Term.	Arb. No.	File	Sect. & Pos.		
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48	71
0	1	X(from)X(to)		X	X	X	Not Used	

Purpose

command to that terminal would be rejected.

To move a cell from the cell shuttle position in one terminal to that of another terminal.

Note: If this cell is required back at the recorder to receive the next developed chip, failure to have the cell at the recorder on time will result in an interruption to the recording process. It is the responsibility of the host to consider this factor in its regulation of processing.

Conditions

- (1) The cell governed by this command will take precedent over any Transport File or Cell Return command not already blocking the pneumatics path. In other words, this cell will be delivered between terminals as rapidly as system conditions will allow.
- (2) A Transport Terminal command uses two transactions, one at each terminal. For example, if four transactions are active at a terminal, a Transport Terminal

Note: If there is a chip in the picker from a cell leaving a terminal (via Cell Return, Assign Cell Address, or Transport Terminal), the chip's identity is destroyed. Thereafter, a Chip Select command must be issued to establish the chip's new identity before returning it to any cell.

Note: A Transport Terminal can be used to move a cell from a terminal and return it to the same terminal for the purpose of accommodating another cell with a priority read.

Transport Terminal (continued)

Response

The host will be notified when the cell moved by this transport command first arrives at the rotary buffer and then goes to the cell shuttle. The cell will remain there until removed by a subsequent command.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)					
Type	Class No.	Term.	Term.	Arb. No.	File	Sect. & Pos.	48Unused71		Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24-35	36-47			72-83	84-95
EXECUTED										
Duplicates original command						Unused			000	
UNACCEPTABLE										
Duplicates original command									*	
CONDITION INFORMATION										
Duplicates original command						Unused			*	

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0104	044	No Transaction Available
0106	046	Cell Not in Terminal
0112	04A	Previous Command Not Completed

Condition Information

Octal	Hex	Meaning
0007	007	Cell Arrived at Rotary Buffer

Seek Reader

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4		WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)		Chip	Starting Line Ident.	
Type 0-2	Class No. 3-7	Term. 8-9	Term. 10-11	Arb. No. 12-23	File 24-35	Sect.& Pos. 36-47	Chip 48-52	Frame 53-59	Line 60-71
0	2	X	Must be 0	X	X	X	X	X	X

Purpose

To pick a chip from a cell in the cell shuttle and position it to the specified frame and line.

the same address as that specified by this command (046).

- (2) The seek command is invalid if a chip is already in the picker (048).

Conditions

- (1) There must be a cell in the cell shuttle of the specified reader with

Note: A chip in the picker remains there until a Chip Return command explicitly requests that it be returned to a cell. If the cell from which the chip was picked leaves the terminal, the chip loses its identity and any attempt to return it to any cell must be preceded by a Chip Select command.

Seek Reader (continued)

Response

The host will be notified when the Seek Reader is complete.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)		Starting Line Ident.			
Type	Class	Term.	Term.	Arb. No.	File	Sect. & Pos.	Chip	Frame	Line	Detail of Response
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-52	53-59	60-71	72-83
EXECUTED										
Duplicates original command						Unused				*
UNACCEPTABLE										
Duplicates original command										*

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0106	046	Cell Not in Terminal
0110	048	Picker in Use
0112	04A	Previous Command Not Completed

Executed

Octal	Hex	Meaning
0000	000	Command Complete
0001	001	No Chip in Slot

Seek Recorder

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host				
Type	Class	Term.	Term.	Arb. No.				
0-2	No. 3-7	8-9	10-11	12-23	24	71		
0	3	0	Must be 0	X	Not Used			

Purpose

To initiate recording of a film chip. This command is given only at the start of a chip. A new command must be given for every chip. This command should be given only when data is ready to be sent for recording, as it results in the chip being moved from a wait station into the target area.

Conditions

- (1) The arbitrary number assigned by the host will be carried with the chip through the developing process. The developer index response will include this number when the corresponding chip is in the last developer station before the output station.
- (2) Raw film chips must be formatted via a Format Chips command (050).
- (3) Filament must be on (052).

Seek Recorder (continued)

Response

When the chip is properly positioned for recording to begin, the host will be notified by means of the Recorder Ready

response. The host will also be notified when the chip is completely recorded.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host						
Type	Class	Term.	Term.	Arb. No.					Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24	Unused			71	72-83
EXECUTED										
Duplicates original command									*	
UNACCEPTABLE										
Duplicates original command									*	

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0112	04A	Previous Command Not Completed
0120	050	No Chips Formatted
0122	052	Filament Off

Executed

Octal	Hex	Meaning
0000	000	Command Complete
0006	006	Recording Completed via Write-Chip Fill command

Chip Return

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4		WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)		Chip		
Type	Class No.	Term.	Term.	Arb. No.	File	Sect. & Pos.	Chip		
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-52	53-59	60-71
0	4	X	Must be 0	X	X	X	X	Must be 0	Unused

Purpose

To place a chip back into a cell slot.

Conditions

- (1) There must not be an uncompleted command pertaining to the chip (04A).
- (2) The specified cell must be in the cell shuttle and the specified chip slot must be empty (046, 004).

(3) If the return slot is not the same as the originating slot, this command must have been preceded by a Chip Select to the return slot (047).

(4) A Developer Next message must have been sent to the host before a Chip Return command to the recorder will be accepted (049).

Note: The chip's identity may be changed by a Chip Select command. (A chip is identified by a cell address and a chip number.)

Chip Return (continued)

Response

The host will be notified when the chip has been placed in its cell.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)		Chip			
Type	Class No.	Term.	Term.	Arb. No.	File	Sect. & Pos.	Chip	Unused	Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-52	53-71	72-83	84-95
EXECUTED										
Duplicates original command						Unused			*	
UNACCEPTABLE										
Duplicates original command									*	

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0106	046	Cell Not in Terminal
0107	047	Wrong Chip in Picker
0111	049	No Chip in Picker
0112	04A	Previous Command Not Completed

Executed

Octal	Hex	Meaning
0000	000	Command Complete
0004	004	Chip Already in Slot

Chip Select

WORD 0		WORD 1		WORD 2	WORD 3	WORD 4		WORD 5
Operation Code	Terminal Number	Significant Only to Host		Cell Address (Origin)		Chip		
Class					Sect. & Pos.	Chip		
Type No.	Term. Term.	Arb. No.		File		Chip		
0-2 3-7	8-9 10-11	12-23		24-35	36-47	48-52 53-59		60-71
0 5	X Must be 0	X		X	X	X Must be 0		Not Used

Purpose

To select desired chip slot and indicate whether or not it is empty. The identity of a chip in the picker is also changed.

Condition

The specified cell must be in the cell shuttle (046).

Note: The identity of the chip in the picker (if any) is changed to the identi-

ty specified in this command. A chip is identified by a cell address and a chip number.

Action

This command does not result in action with respect to any chip in the specified slot. It only establishes the presence or absence of a chip in the specified slot and is primarily intended as a security measure prior to moving a chip from one slot to another or as a method of rapidly mapping the contents of a cell.

Chip Select (continued)

Response

The host will be notified of the presence or absence of a chip.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)		Chip			
Type	Class	Term.	Term.	Arb. No.	File	Sect. & Pos.	Chip	Unused	Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-52	53-71	72-83	84-95
EXECUTED										
Duplicates original command						Unused			*	
UNACCEPTABLE										
Duplicates original command									*	

*Word 6 Specifications

Executed

Octal	Hex	Meaning
0001	001	No Chip in Slot
0004	004	Chip Already in Slot

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0106	046	Cell Not in Terminal
0112	04A	Previous Command Not Completed

Cell Return

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (origin)			
Type	Class No.	Term.	Term.	Arb. No.	File	Sect. & Pos.		
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48	71
0	6	X	Must be 0	X	X	X	Not Used	

Purpose

To return a cell to the file.

- (3) The receiving file compartment must be empty (003). If compartment is not empty, the cell will be deposited in Section 14, Position 29, in the file specified within the command.

Conditions

- (1) A cell with a cell address as specified must be in the cell shuttle (046).
- (2) There must be no uncompleted command which involves returning a chip to the specified cell (04A).

Note: If there is a chip in the picker from a cell leaving a terminal (either via Cell Return, Assign Cell Address, or Transport Terminal), the chip's identity is destroyed. Thereafter, a Chip Select command must be issued to establish the chip's new identity before returning it to any cell.

Cell Return (continued)

Response

The host will be notified when the cell arrives at its file tray and the tray has been restored to normal position.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)					
Type 0-2	Class No. 3-7	Term. 8-9	Term. 10-11	Arb. No. 12-23	File 24-35	Sect. & Pos. 36-47	48←Unused→71		Detail of Response 72-83	End Code 84-95
EXECUTED										
Duplicates original command				→	←	Unused	→		*	
UNACCEPTABLE										
Duplicates original command							→		*	

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0102	042	File Inoperative
0106	046	Cell Not in Terminal
0112	04A	Previous Command Not Completed

Executed

Octal	Hex	Meaning
0000	000	Command Complete
0003	003	Cell Already in File Position

Assign Cell Address

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)		Cell Address(not returned to origin)	
Type	Class No.	Term.	Term.	Arb. No.	File	Sect.& Pos.	File	Sect.& Pos.
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-59	60-71
0	7	X	Not Used	X	X	X	X	X

Purpose

- (2) There must not be an uncompleted command which involves returning a chip to the specified cell (04A).

To assign a new cell address to a cell in the shuttle.

- (3) A cell with the new address in the command must not be out of the file (045).

Conditions

- (1) A cell with an originating cell address as specified must be in the cell shuttle (046).

Note: If there is a chip in the picker from a cell leaving a terminal (via Cell Return, Assign Cell Address, or Transport Terminal), the chip's identity is destroyed. Thereafter, a Chip Select command must be issued to establish the chip's new identity before returning it to any cell.

Assign Cell Address (continued)

Response

The host will be notified when Assign Cell Address has been accomplished.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (origin)		Cell Address (not returned to origin)			
Type	Class	Term.	Term.	Arb. No.	File	Sect. & Pos.	File	Sect. & Pos.	Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-59	60-71	72-83	84-95
EXECUTED									000	
Duplicates original command						Unused				
UNACCEPTABLE									*	
Duplicates original command										

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0102	042	File Inoperative (pertains to new cell address)
0105	045	Cell Already Out of File (pertains to new cell address)
0106	046	Cell Not in Terminal
0112	04A	Previous Command Not Completed

Read Commands - General

There are four Read commands:

Read - Data Transfer
Read - No Data Transfer
Chip Analysis - Data Transfer
Chip Analysis - No Data Transfer

The distinctions between these commands are as follows:

(1) Data Transfer/No Transfer

Data Transfer - Results in data being transferred to the host via the data controller.

No Data Transfer - Results in data being passed through the error detection circuitry and, if necessary, through the error correction procedures, but no data is transferred to the host. The no data transfer function, however, utilizes the same facilities internal to the 1360 as the data transfer function.

(2) Read/Chip Analysis

Read - Hardware and error correction procedures are operated at the level intended for normal reading of data to be directly used in host programs.

Chip Analysis - Hardware and error correction procedures are operated in an enhanced error detection mode, that is, in a degraded state such that conditions which would be marginal in normal reading will consistently be detected as error conditions. The purpose is to significantly increase the probability of subsequently reading the acceptable data correctly. As such, the chip analysis function is primarily intended for the initial read after recording.

Certain other conditions apply generally to all of the read commands:

Responses - A response will always be sent at read completion. A read is considered complete after all the data has been taken by the host or a Read Terminate command is received.

Error Statistics - If the read has one or more uncorrectable lines, the response sent at read completion includes the following information:

Word 2

Count of lines with uncorrectable error, first line in error.

Word 3*

Line number of first line in error.

Word 4*

Line number of last line in error.

*One error only results in repetition of the same line number in Words 3 and 4.

Stacked Reads - For each reader, a single Read command may be stacked.

Read Continue - For all Read commands, the option exists for a read continue. This option in effect combines a seek and a read. With a chip in the picker, any read command with its continue option results in positioning to the specified frame and line as soon as conditions permit and the immediate start of read upon positioning with no intervening exchange of messages. One read command with or without the continue option may be stacked, that is, sent to the 1360 with another read command in the same reader not yet completed. A series of read commands, with or without the continue option, has no restriction as to the sequence or mixture of class numbers.

Note that a stacked read without the continue option must be contiguous with the read in process.

Dormancy Timeout - If a chip is positioned in the reader and one of the Read commands is not received within 45 seconds* of the initial positioning or completion of the last read, the chip will be moved to the guides. The 45 seconds* applies to any single dormant period waiting for a read, and does not place a restriction on the total time a chip may be in process.

Execution Timeout - The host is notified (word 6=5) each time the timeout time (30 seconds*) elapses. However, reading will continue until either the end of the record is reached or the host issues a Read Terminate command.

*Time specifications subject to change.

Read Data

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Length of Read	Continue Option	Starting Line Ident.	
Type	Class No.	Term.	Term.	Arb. No.	Count		Frame	Line
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-59	60-71
0	8	X	Must be 0	X	X	*	X	X

Purpose

Initiates data transfer from positioned chip.

read proceeded to a normal termination. The implied starting line of the read in this mode is the line immediately following the terminating line of the previous read, even though that line might be at the beginning of the next column.

Count

The count is the number of lines to be read. A read may not continue beyond the end of a column. Thus, the count has a limit of the number of lines between the starting line and the end of the column. This is a maximum of eight full frames (3936 lines) if the read starts at frame 0, line 0. To be a legal command, the line count must be greater than zero.

This option is not valid if the implied starting line is the beginning of a different chip. In systems having more than one reader, each reader is completely independent with respect to this option; that is, a seek between consecutive reads is not required even if a read from a different reader intervenes between the consecutive reads.

- (3) There must not be a Read Terminate command in progress (04F).
- (4) A read command can be active on only one reader at a time (055).

Conditions

- (1) A chip must be in the reader with no uncompleted commands which involve picking a chip from a cell (049).
- (2) When reading consecutive blocks of data, a Read command may immediately follow another read without an intervening seek if the preceding

*Continue Option for Read Commands: If bits 36-47 = 0, frame and line fields will be ignored. If bits 36-47 $\neq$ 0, the chip in the picker will be positioned to the specified frame and line immediately or when any current read is completed. When positioning is complete, data transfer will start immediately with no intervening exchange of messages.

Read Data (continued)

Response

A response is sent at read completion.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Length of Read	Continue Option	Starting Line Ident.			
Type 0-2	Class No. 3-7	Term. 8-9	Term. 10-11	Arb. No. 12-23	Count 24-35	36-47	Frame 48-59	Line 60-71	Detail of Response 72-83	End Code 84-95
EXECUTED										
Duplicates original command						← Error Statistics** →		Unused	*	
UNACCEPTABLE										
Duplicates original command									*	
CONDITION INFORMATION										
Duplicates original command						← Error Statistics** →		Unused	*	

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0103	043	Line Count Too Large
0111	049	No Chip in Picker
0112	04A	Previous Command Not Complete
0117	04F	Read Terminate in Progress
0125	055	Other Reader Reading

Condition Information

Octal	Hex	Meaning
0005	005	Timeout on Read

Executed

Octal	Hex	Meaning
0000	000	Command Complete
0006	006	Read Terminated

**Word 2 contains the count of lines with uncorrectable errors; word 3, the line number of the first line in error; and word 4, the line number of the last line in error.

Chip Analysis-No Data Transfer

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Length of Read	Continue Option	Starting Line Ident.	
Type	Class No.	Term.	Term.	Arb. No.	Count		Frame	Line
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-59	60-71
0	9	X	Must be 0	X	X	*	X	X

Purpose

Response

No data transferred; reader is in enhanced error detection mode. Same as Read Data.

Conditions

Same as Read Data.

*Continue Option for Read Commands:
If bits 36-47 = 0, frame and line fields will be ignored. If bits 36-47 ≠ 0, the chip in the picker will be positioned to the specified frame and line immediately or when any current read is completed. When positioning is complete, data transfer will start immediately with no intervening exchange of messages.

Chip Analysis-Data Transfer

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Length of Read	Continue Option	Starting Line Ident.	
Type	Class No.	Term.	Term.	Arb. No.	Count		Frame	Line
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-59	60-71
0	10	X	Must be 0	X	X	*	X	X

Purpose

Response

Same as Read Data except that reader is in enhanced error detection mode. Same as Read Data.

Conditions

Same as Read Data.

*Continue Option for Read Commands:
If bits 36-47 = 0, frame and line fields will be ignored. If bits 36-47 ≠ 0, the chip in the picker will be positioned to the specified frame and line immediately or when any current read is completed. When positioning is complete, data transfer will start immediately with no intervening exchange of messages.

Read Terminate

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host				
Type	Class	Term.	Term.	Arb. No.				
0-2	No. 3-7	8-9	10-11	12-23	24	71		
0	11	X	Must be 0	X	Not Used			

Purpose

To terminate a read prior to its prespecified conclusion.

- (3) A Read Terminate will force a Read Complete response to be sent with word 6 equal to 6 for each Read command pending (that is, one response will be sent if there is no read stacked and two responses if there is a read stacked).

Conditions

- (1) A chip must be in the reader (049), a Read command in process (04E), and no Read Terminate in progress on the reader address (04F).
- (2) A Read Terminate will cause the picker to be positioned as if the read (or reads) were completed normally.

Response

The host will be notified (by a response to the Read command with word 6=6) when the Read Terminate has been accomplished. A response is given because resetting operations must be artificially forced, operations that occur automatically when a read proceeds to its specified end. No response to the Read Terminate command itself is sent if acceptable.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host						
Type	Class No.	Term.	Term.	Arb. No.					Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24	Not Used			72-83	84-95
UNACCEPTABLE										
Duplicates original command									*	

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0116	04E	No Read in Progress
0117	04F	Read Terminate in Progress

Write-Chip Fill

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host				
Type	Class	Term.	Term.	Arb. No.				
0-2	No. 3-7	8-9	10-11	12-23	24 _____ 71			
0	12	0	Must be 0	X	Not Used			

Purpose

When all of the data to be recorded on a chip has been sent by the host but the chip is not full, issuance of this command results in the chip being automatically filled with zeros. This command is valid only if the recorder is paused at the start of a new frame.

Note: Every valid chip must be completely recorded. This command is,

therefore, necessary if it is desired to record data on less than 32 frames.

Response

The host is notified (by a Seek Recorder Complete message with word 6=6) when the chip has been entirely recorded. No response to the Write-Chip Fill command itself is sent if acceptable.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host						
Type	Class	Term.	Term.	Arb. No.					Detail of Response	End Code
0-2	No. 3-7	8-9	10-11	12-23	24	← Not Used →			71	72-83
UNACCEPTABLE										
Duplicates original command									*	

*Word 6 Specifications

Unacceptable

<u>Octal</u>	<u>Hex</u>	<u>Meaning</u>
0100	040	Illegal Command
0101	041	Terminal Inoperative
0112	04A	Previous Command Not Completed
0121	051	No Seek Recorder in Progress

Activate Empty Cell

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)			
Type	Class	Term.	Term.	Arb. No.	File	Sect. & Pos.		
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48	71
0	13	0	Must be 0	X	X	X	Not Used	

Purpose

To assign a file address to a cell just emptied of raw film chips. After assigning an address, this cell is treated the same as any other cell in the system. This is the only way to dispose of emptied unexposed film cells. Failure to do so will inhibit the introduction of a new cell filled with raw chips.

Conditions

- (1) This command is valid only after the host has received an Empty Cell Available response (04D).
- (2) There must not be a cell out of the file with the same cell address as in the command (045).

Response

The host will be notified when Activate Empty Cell has been accomplished.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)					
Type	Class	Term.	Term.	Arb. No.	File	Sect. & Pos.			Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48	Unused	71	72-83
EXECUTED										
Duplicates original command						Unused			000	
UNACCEPTABLE										
Duplicates original command									*	

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning			
0100	040	Illegal Command	0102	042	File Inoperative
0101	041	Terminal Inoperative	0104	044	No Transaction Available
			0105	045	Cell Already Out of File
			0115	04D	Empty Cell Not Available

Transport File Search

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)			
Type	Class No.	Term.	Term.	Arb. No.	File	Sect. & Pos.		
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48	71
0	14	X	Must be 0	X	X	X	Not Used	

Purpose

To move a cell from its resident location in a file to a cell shuttle position in the designated terminal. However, if a cell is not present in the specified file position, a response so indicates and the 1360 does not enter diagnostics to investigate a possible malfunction.

Conditions

Same as Transport File.

Response

Same as Transport File.

Seek Reader Search

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4		WORD 5
Operation Code		Terminal Number		Significant Only to Host	Cell Address (Origin)		Starting Line Chip Ident.		
Type	Class No.	Term.	Term.	Arb. No.	File	Sect. & Pos.	Chip	Frame	Line
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-52	53-59	60-71
0	15	X	Must be 0	X	X	X	X	X	X

Purpose

To pick a chip from a cell in the cell shuttle and position it to the specified frame and line. However, if a chip is not present in the specified chip position, a response so indicates and the 1360 does not enter diagnostics to investigate a possible malfunction.

Conditions

Same as Seek Reader.

Response

Same as Seek Reader.

Unlock Manual Entry

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host				
Type	Class	Term.	Term.	Arb. No.				
0-2	3-7	8-9	10-11	12-23	24			71
0	16	Must be 0	Must be 0	X	Not Used			

Purpose

Unlocks the manual entry door in the 1361 for the insertion and/or removal of the manual entry cell sections.

Condition

The host receives a status change message (type 3, class 6) when the door is opened

and when it is closed again (in addition to the normal completion response).

Response

A response is sent to the host when the manual entry door has been locked and operations are able to be resumed in File 1. However, the door will not be locked and the command therefore not considered to be complete unless a tray unlock-lock has occurred.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host						
Type	Class	Term.	Term.	Arb. No.					Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24	Unused			72-83	84-95
EXECUTED									000	
Duplicates original command										
UNACCEPTABLE									*	
Duplicates original command										

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0114	04C	Manual Entry Operation in Progress
0124	054	No Manual Entry Door in this File

Read-No Data Transfer

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	Length of Read	Continue Option	Starting Line Ident.	
Type	Class No.	Term.	Term.	Arb. No.	Count		Frame	Line
0-2	3-7	8-9	10-11	12-23	24-35	36-47	48-59	60-71
0	17	X	Must be 0	X	X	*	X	X

Purpose

To perform error detection without actually transferring data to the host. In all other respects it is identical to a Read Data, including the facilities required.

Conditions

Same as Read Data.

Response

Same as Read Data.

*Continue Option for Read Commands:
If bits 36-47 = 0, frame and line fields will be ignored. If bits 36-47 ≠ 0, the chip in the picker will be positioned to the specified frame and line immediately or when any current read is completed. When positioning is complete, data transfer will start immediately with no intervening exchange of messages.

Format Chips

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	N Chips			
Type	Class No.	Term.	Term.	Arb. No.				
0-2	3-7	8-9	10-11	12-23	24-35	36	←	→ 71
0	18	0	Must be 0	X	X	Not Used		

Purpose

After receiving this command, raw film chips will continue to be formatted until N chips have been formatted.

To format unexposed film chips in the recording station.

The host can query the system as to the number of chips formatted and the number of chips still to be formatted by requesting status (type 2, class 0).

Conditions

- (1) Recorder must be online (041).
- (2) N must be less than or equal to 1023 (040).

The 1360 will not format raw film chips until this command has been received.

N can be changed dynamically; that is, even though N has been established, it may be changed by issuing another type 0, class 18 command. In fact, N may be set to 0, thereby suppressing (until N is again set positive) replacement of raw film. It is, however, recommended that status be queried and N changed during recording of frames 8-31 for otherwise N is likely to change between the status request and the command to change it.

Format Chips (continued)

Response

The host will be notified when N has been established. In addition, a status change message (type 3, class 14) is sent whenever N goes to 0.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	N Chips					
Type 0-2	Class No. 3-7	Term. 8-9	Term. 10-11	Arb. No. 12-23	24-35	36	Unused	71	Detail of Response 72-83	End Code 84-95
EXECUTED										
Duplicates original command							Unused		000	
UNACCEPTABLE										
Duplicates original command									*	

*Word 6 Specifications

Unacceptable

<u>Octal</u>	<u>Hex</u>	<u>Meaning</u>
0100	040	Illegal Command
0101	041	Terminal Inoperative

Control Filament

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5
Operation Code		Terminal Number		Significant Only to Host	On/off Request			
Type	Class No.	Term.	Term.	Arb. No.				
0-2	3-7	8-9	10-11	12-23	24-35	36	←	→ 71
0	19	0	Must be 0	X	X	Not Used		

Purpose

To control the status of the filament so that it can be turned off when no recording is being done.

Note: It takes from 3-7 minutes to turn the filament on.

If word 2 of this command is a 0, the filament will be turned on; if it is nonzero, the filament will be turned off. If the command requests "on" when it is on, or "off" when it is off, the command will be rejected (04B).

Response

Conditions

- (1) Recorder must be online (041).
- (2) No Seek Recorder in progress (053).

The host will be informed when the 1360 control program has been notified of the request. In addition, a status change response (type 3, class 16) is sent when the filament operation is complete.

WORD 0				WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7
Operation Code		Terminal Number		Significant Only to Host	On/off Request					
Type	Class No.	Term.	Term.	Arb. No.					Detail of Response	End Code
0-2	3-7	8-9	10-11	12-23	24-35	36	←	Unused	→ 71	72-83
EXECUTED										
Duplicates original command								Unused		000
UNACCEPTABLE										
Duplicates original command										*

*Word 6 Specifications

Unacceptable

Octal	Hex	Meaning
0100	040	Illegal Command
0101	041	Terminal Inoperative
0123	053	Seek Recorder in Operation

Type 1 Message Format

Type 1 messages are transmitted to the host from the 1360. They pertain to normal operations, but are not a response to a host-generated command. Type 1 messages are organized into words, 12 bits in length. A message uses eight words, of which four, composed of bits 0-47, are significant. Bits 0-7 define the function and 8-47 define its parameters. In addition, word 7 (bits 84-95) is coded 8D1 (hex), 4321 (octal), to indicate end of message to host.

The messages are formatted as follows (Figure 5):

BITS	
0-7	Operation code (type 0-2; class number 3-7)
8-11	Unused
12-23	Arbitrary number (an identification number assigned by the host, at host's option, to the original Seek Recorder command issued for the chip in question)
24-35	Line number of failure (significant only in Write Overrun messages)
36-47	Frame number (significant only in Bad Frame, Recorder Ready and Write Overrun messages)

MESSAGES	WORD 0			WORD 1	WORD 2	WORD 3	WORDS 4-6	WORD 7
	Operation Code			Significant Only to Host				
	Class				Line No. of Failure	Frame No. of Failure	Unused	End Code
	Type 0-2	No. 3-7	Unused 8-11	Arb. No. 12-23	24-35	36-47	48-83	84-95
Empty Cell Available	001	00000						X
Developer Index Next Chip	001	00001		X				X
Developer Index Next Next Chip	001	00010		X				X
Recorder Ready	001	00011		X		X		X
Write Overrun	001	00100		X	X	X		X
Bad Frame	001	00101		X		X		X
Chip Bad (but developed and delivered)	001	00110		X				X

Figure 5 Type 1 Messages

Type 1 Messages

- 0 (00000) Empty Cell Available. Tells the host an empty cell is available that the host must "activate" (i.e., give it an address). The cell is then available for whatever purpose the host wishes.
- 1 (00001) Developer Index Next Chip. Identifies the chip next to come out of the 8-station developer.
- 2 (00010) Developer Index Next Next Chip. Identifies the chip following the one next to come out of the developer.
- 3 (00011) Recorder Ready. Tells the host the identity of a chip positioned to record at the first frame; 31 subsequent Recorder Ready messages follow for each chip.
- 4 (00100) Write Overrun. In the event data is not supplied fast enough by the host, the recorder finishes recording a frame with zeros and transmits this message identifying the line number of the failure to the host. Then it is up to the host to supply more data or a Write-Chip Fill command in order to fill the remainder of the chip.
- 5 (00101) Bad Frame. In the event something occurs to cause a bad frame to be recorded, the host is informed of the identity of the chip together with the bad frame number.
- 6 (00110) Chip Bad (but developed and delivered). In the event the pumps fail or recorder doors are opened, the host is sent this message, the developing process finishes, and the chip is delivered to the proper cell.

Type 2 Message Format

Type 2 messages are transmitted to the 1360 from the host. Type 2 messages are organized into words, 12 bits in length. A message uses eight words, of which only one, composed of bits 0-11, is significant. Bits 0-7 define the function and 8-11 are unused.

The messages are formatted as follows:

BITS

0-7	Operation code (type 0-2; class number 3-7)
8-95	Unused

Only one class is sent: class 0 (Request for System Status).

Response

For 1360 response to type 2, class 0 messages, see type 3, class 9 status information.

Type 3 Format

Type 3 status information is transmitted from the 1360 system to the host. This information falls into 17 classes. Class 0 does not, strictly speaking, transmit status information; rather it transmits location information concerning cells and chips found out of their normal file compartments and cells, respectively, after the cleanout routine has been completed. Classes 1 through 16 (Figure 6) do transmit status information as follows:

CLASS	TYPE OF STATUS INFORMATION
1, 2, 4-7, 10, 11, 14, and 16	Changes in system conditions
3	Changes in current, previous, and pre-online equipment status
8	Statement of current equipment status (sent by power on routine or master clear)
9	Statement of current equipment Status (response to a type 2, class 0, host-generated message)
12	Entering automatic recovery mode
13	Leaving automatic recovery mode following recovery
15	Leaving automatic recovery mode following non-recovery

Eight 12-bit words are transmitted, of which seven (0-6) are significant (bits 0-83). In addition, word 7 (bits 84-95) is coded to indicate end of message to host. Word 0 indicates type and class number. Meanings of the remaining words are dependent upon the class number in word 0. Class 0 location information is transmitted to the host. The remaining classes not only transmit status information to the host but, with the exception of word 0, the words are carried in permanent places in core storage and are updated on the disk at the same time the message is sent (except class 12).

Class 0

Word 0 - Bits 0-2 of the operation code indicate type number 3 (011) and bits 3-7, the class number (00000). Bits 8-11 are unused (and hence 0).

Word 1 - Bits 12-23 indicate in binary code the total number of cells found after the power on routine or master clear has been completed.

Word 2 - Bits 24-35 correspond to cell locations 0-11 in the recovery section (Figure 7). A "0" in any bit indicates no cell has been placed in the corresponding location in the recovery section and a "1" indicates one has been placed there by either the power on routine or master clear.

Word 3 - Bits 36-47 correspond to cell locations 12-23 in the recovery section. See word 2 above for meanings of "0" or "1".

Word 4 - Bits 48-59 indicate in binary code the total number of chips found after the power on routine or master clear has been completed.

Word 5 - Bits 60-71 correspond to chip slot locations 0-11 in the recovery cell. A "0" in any bit indicates no chip has been placed in the corresponding location in the recovery cell, and a "1" indicates one has been placed there by either the power on routine or master clear.

Word 6 - Bits 72-75 correspond to chip slot locations 12-15 in the recovery cell. See word 5 above for meanings of "0" or "1". Bits 76-81 correspond to cell locations 24-29 in the recovery section. See Word 2 above for meanings of "0" or "1". Bits 82-83 are unused.

Word 7 - Bits 84-95 are coded 8D1 (hex), 4321 (octal), to indicate end of message.

	WORD 0		WORD 4				WORD 5				WORD 6				WORD 7
	Operation Code		Current Equipment Status				Previous Equipment Status				Pre-online Equipment Status				
	Type	Class No.													End Code
	0-2	3-7	8-11	48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59	60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71	72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83									84-95
Data Controller Read	011	00011		X			X				X				
Data Controller Write	011	00011		X			X				X				
Reader 1 Data	011	00011		X			X				X				
Reader 1 Mech	011	00011		X			X				X				
Reader 2 Data	011	00011		X			X				X				
Reader 2 Mech	011	00011		X			X				X				
Recorder Data	011	00011		X			X				X				
Recorder Mech	011	00011		X			X				X				
File 1	011	00011		X			X				X				
File 2	011	00011		X			X				X				
File 3	011	00011		X			X				X				

1 = online
0 = offline

Figure 6 (continued) Type 3, Class 3 Status Information

Note: Words 4 and 5 reflect changes that may take place in system conditions. Word 6, however, will not reflect a change until a customer engineer individually sets the bits affected to "1" after he has corrected a malfunction. This notifies the host that the equipment is ready to be put back online.

Each time a change occurs, a type 3 message is transmitted. All eight words are sent, Word 7 always coded 8D1 (hex), 4321 (octal), to indicate end of message to the host. See the preceding page for the first four words.

Each message includes only one change from the previous message. The changes occur only in Words 1 through 4, and in 6 after a maintenance call (5 simply shows equipment status immediately preceding that shown in word 4). Changes that occur in Words 1, 2, and 3 are not reflected in Word 4; for example, if the recorder doors are opened and raw film replacement is suspended, the current status word will not indicate that the recorder (data) is offline.

Classes 8 and 9 do not reflect changes to system conditions and so are not listed here.

RECOVERY SECTION (Manual Entry Position 3 or Section 71)	
Chip Recovery Cell Slot Assignments	
Slot	Chip From
0	
1	Reader 1 Picker
2	Reader 2 Picker
3	
4	Recorder Picker
5	Developer Station 7 (Dry)
6	Developer Station 6 (Dry)
7	Developer Station 5 (Dry)
8	Developer Station 4 (Wash)
9	Developer Station 3 (Wash)
10	Developer Station 2 (Fix/Rinse)
11	Developer Station 1 (Dev./Stop)
12	Developer Station 8 (Load/Unload)
13	Format Station 2
14	Format Station 1
15	Format Station 0

NOTE: Chip slot 0 is last slot uncovered as cell lid is opened.

NOTE: Format and developer station numbers indicate position of chip in its process, not unique "buckets" in the mechanism.

NOTE: Chips go through a complete develop cycle.

*An empty cell must be in position 00 or recovery will not function.

20	10	00
	Cell from Pneumatics	Chip Recovery Cell*
	RECORDER Lower Position Cell Shuttle	RECORDER Upper Pos. Cell Shuttle
	RECORDER Eject Chamber Rotary Buffer	RECORDER Rec. Chamber Rot. Buffer
	READER 2 Lower Position Cell Shuttle	READER 2 Upper Pos. Cell Shuttle
	READER 2 Eject Chamber Rotary Buffer	READER 2 Rec. Chamber Rot. Buffer
	READER 1 Lower Position Cell Shuttle	READER 1 Upper Pos. Cell Shuttle
	READER 1 Eject Chamber Rotary Buffer	READER 1 Rec. Chamber Rot. Buffer
Top cell retrieved by cell-on-cell diagnostics from File 3	FILE 3	FILE 3
Top cell retrieved by cell-on-cell diagnostics from File 2	FILE 2	FILE 2
Top cell retrieved by cell-on-cell diagnostics from File 1	FILE 1	FILE 1
HANDLE		

Figure 7 Recovery Section and Cell Slot Assignments

Word 0 - Bits 0-2 of the operation code indicate type number 3 (011) and 3-7, the class number. Bits 8-11 are unused.

The class numbers indicate the following changes in system condition:

- 1 (00001) Change in the status of raw film supply
- 2 (00010) Change in the status of developer fluids
- 3 (00011) Change in the equipment status words (current and previous) reflecting operative or non-operative conditions
- 4 (00100) Change in the status of treated water availability
- 5 (00101) Change in the status of wetting agent availability
- 6 (00110) Change in the status of manual entry station
- 7 (00111) Change in the status of recorder doors, i.e., closed or open
- 10 (01010) Change in unexposed film status in format station
- 11 (01011) Change in developer drain tank status
- 14 (01110) Change in formatted chip status
- 16 (10000) Change in filament status

Word 1 - Formatted Chip Status. Bits 12-21 indicate in binary code the total number of chips yet to be formatted as a result of the last Format Chips (type 0, class 18) command. Bits 22-23 indicate in binary code the number of chips actually formatted.

Bits 12-21 are decremented and bits 22-23 incremented by 1 whenever a new raw film chip is picked from the raw film cell. Bits 22-23 are decremented whenever a chip is fully recorded and moved into the developer. A status change message (type 3, class 14) is sent whenever bits 12-21 go to zero.

Word 2 - Recorder Doors and Unexposed Film Status. Bit 24 is set to 0 if all chips in the format station are proceeding normally through the four stages of load, outgas, record, and unload with recorder doors closed. It is set to 1 if chips were possibly damaged by light exposure as a result of recorder doors being opened. The chips possibly damaged are those residing in the three positions of the format station and in the opened cell in the cell shuttle. The host is notified by two type 3 messages from the 1360 that the doors have been opened and that chips are possibly damaged by light exposure. In addition, the host receives two type 1 messages giving it the arbitrary numbers of the two recorded (or partially recorded) and possibly damaged chips that were in the record and unload positions of the format station at the time the doors opened. Exposed unrecorded chips will be assigned arbitrary numbers by the host when they reach the record position (column 0, frame 0) that will "flag" them for later checking. It is then the host's responsibility to exercise its option of recording these possibly damaged chips (in the outgas position of the format station and the opened cell at the time of possible light exposure) with data or zeros before they are developed and readback checked.

To recapitulate, when the recorder doors are opened, two chips already recorded (or partially recorded) and other unrecorded chips may be damaged by light exposure. The host receives two types of messages from the 1360 informing it of the opened recorder doors and possibly bad chips. The host must keep track of these chips to check for possible damage.

Bit 24 will not reset to 0 until the recorder doors are closed and raw film from a new cell is supplied to the record position of the format station. A 0 in bit 24, however, does not establish the condition of the chip at format unload since this was the last chip to sustain possible damage when the recorder doors were opened.

Bit 25 is set to 0 if the recorder doors are closed; to 1 if they are opened.

Bit 26 sets to 1 to indicate that the last unexposed film cell is in the lower shuttle. Bit 27 sets to 1 to indicate that the last unexposed film cell is in the upper shuttle. They reset to 0 when the last raw film chip has been removed.

Bit 28 sets to 1 to indicate that the filament is off; it resets to 0 when the filament is on.

Bits 29-32 are unused.

Bits 33-35 reveal the supply of raw film to the host. Five possible conditions exist. A normal supply of raw film is indicated by 000 set in the bits. Two conditions, raw film low in hopper (001) and raw film empty in hopper (010), are sensed by two cell level sensors in the raw film hopper. One sensor indicates that raw film is low in the hopper when the hopper load changes from 5 to 4 cells (at which time 10 more cells may be added), and the other sensor indicates when the last cell exits to the recorder. Reloading of raw film becomes mandatory at the expiration of the 32 chips housed in this cell; recording at optimum rate would exhaust the chips in nine minutes. When this happens, the system is out of film (raw film empty in system, 011) and the raw film status word is changed to reflect this condition but the current equipment status word (bit 54) concerning the ability of the recorder to write data is not changed. When the host interrogates the current equipment status word as well as ascertains the status of the raw film, it may then notify the host operator by some means. The last condition (100) tells the host when reload has been accomplished; the bits change to 000 as soon as the next cell goes into the shuttle.

Word 3 - Wetting Agent, Treated Water, Developer Fluid and Manual Entry Status. Bit 36 is set to 0 when a wetting agent is available; to 1 when a wetting agent is not available.

Bit 37 is set to 0 when treated water is available; to 1 when treated water is not available.

Bit 38 is set to 0 when developer drain tank is not full; to 1 when drain tank is full.

Bit 39 is set to 0 whenever the manual entry door is closed; to 1 when the door is opened.

Bits 40-44 are unused.

Bits 45-47 reveal the supply of developer fluids in banks A and B to the host. The banks can be either empty, full, or in use. Eight valid combinations exist:

A in use, B full	000
A empty, B in use	001
A full, B in use	010
A in use, B empty	011
A empty, B empty	100
A empty, B empty	
(operation suspended)	101
A selected, B unknown	110
A unknown, B selected	111

Continuation of the "A empty, B empty" condition (101) suspends the process of bringing in more raw film to the cell shuttle and then to the format station for recording since fluids are not available for developing the chips. Chips already in the cell shuttle and format station, however, will continue their normal progression through the record/develop cycle.

Word 4 - Current Equipment Status. Each of the bits in word 4 (with the exception of the unused low order bit) is assigned to a specific module and function of module. A "1" in the specified bit indicates the module and function is currently operative. A "0" in the specified bit indicates the module and function is not currently operative. These bits are individually set to "0" by the diagnostic master and/or diagnostic routines when they analyze a malfunction as nonrecoverable. The bits may be interrogated by the host to establish the extent to which the system may continue to operate. A message identifying the down component is typed out on the 1816 printer-keyboard to request a customer engineer. After the customer engineer has corrected the malfunction, however, the bits affected will not reflect online status until a Master Clear is initiated by the host (see Word 6).

In addition, a customer engineer may take a module offline to work on it while not affecting operation of the remainder of the system by setting the appropriate bits to "0."

The following table identifies the bit number with the module, its function, and a brief description of what a "1" set in that bit means:

BIT	EQUIPMENT		MEANING OF "1"
0	Data Controller	Read	Data controller is online to accept read data from reader for transmission to host.
1	Data Controller	Write	Data controller is online to accept write data from host for transmission to recorder.
2	Reader 1	Data	Reader is online to read chips.
3	Reader 1	Mech	Reader is online to move cells and chips.
4	Reader 2	Data	See bit 2 above.
5	Reader 2	Mech	See bit 3 above.
6	Recorder	Data	Recorder is online to record chips.
7	Recorder	Mech	Recorder is online to move cells and chips.
8	File 1		File 1 is online.
9	File 2		File 2 is online.
10	File 3		File 3 is online.
11	Not used		

Note that for a reader or the recorder, a distinction is made between a data failure and a mechanical failure. In either event, the host may send messages to the 1360 system, including the down module, that tend to put chips and cells away, after which he issues a Master Clear (see Master Clear).

Online status of the data controller and file 1 is essential to the system. If the system has two readers, one can be bypassed. If a single reader or the recorder is offline, however, the function performed by that unit is bypassed completely, i.e., if recorder is offline, the system can still read data and if the reader is offline, the system can still record.

Word 5 - Previous Equipment Status.
Each of the bits in word 5 (with the exception of the unused low order bit) is assigned to a specific module and function of that module exactly as in word 4. When a change in system condition is reflected in word 4, the condition immediately preceding is shifted in core to word 5. Therefore, a "1" in the

specified bit of word 5 indicates the previously operative condition of the module and its function, and a "0" that an inoperative condition existed. The bits may be interrogated by the host to establish a history of the condition of equipment immediately preceding the one set in the current status word.

Word 6 - Pre-online Equipment Status.
Each of the bits in word 6 (with the exception of the unused low order bit) is assigned to a specific module and function of that module exactly as in word 4. Unlike words 4 and 5, however, a change in system conditions is not reflected in word 6 until a customer engineer individually sets the bits affected

to "1" after he has corrected the malfunction. This notifies the host that the equipment is ready to be put back online. The host then calls for a Master Clear which changes word 4 to reflect the new current status, word 5 to reflect

the previous status, and resets word 6 to 0.

Word 7 - Bits 84-95 are coded 8D1 hex (4321 octal) to indicate end of message to host.

Classes 8 and 9

The difference between the status information transmitted to the host by classes 8-9 and most of the other classes is that the latter reflect changes to system condition. Classes 8-9 simply provide a statement of current equipment status without any connotation of a change having taken place. This statement of system status may or may not contain information different from that last transmitted

by a class 1 through 7, 10, 11, 14 or 16 message.

Class 8 is automatically transmitted to the host by the power on routine or master clear.

Class 9 is a response to a type 2, class 0, host-generated message to the 1360 system requesting system status.

Classes 12, 13 and 15

A class 12 message is sent whenever the 1360 enters Automatic Recovery mode. When the 1360 leaves Automatic Recovery mode, a class 13 message is sent if the failure was recoverable and a class 15 message if the failure was not recoverable, except for a disk failure (see below). A class 15 message also implies a change in equipment status.

Class 12 messages have the following format:

Word 0 - Bits 0-2 of the operation code indicate type number (011) and bits 3-7, class number (1100). Bits 8-11 indicate in binary code the number of the module on which recovery is being attempted. However, if bits 8-11 are all zero, this informs the host that the 1360 disk has been found unusable and that a customer engineer should be called. This message is the last to be sent to or received from the host until the disk is replaced. In case

of a disk failure, words 1-7 should be ignored.

The possible module numbers are:

Binary	Dec.	Module
0000	0	Disk
0001	1	File 1
0010	2	File 2 or File 3
1011	11	Reader 1
1100	12	Reader 2
1101	13	Recorder
1111	15	Data Controller

Words 1-7 - Contain the same information as the other classes (with the exception of class 0) of type 3 messages.

Classes 13 and 15 messages have the following format:

Word 0 - Bits 0-2 of the operation code indicate type number (011) and bits 3-7, class number (1101 or 1111). Bits 8-11 are unused.

Words 1-7 - See class 12.

Type 4 Message Format

Type 4 messages are transmitted from the host to the 1360 operator via the 1816 printer-keyboard. These messages are originated by the host operator and may be a response to type 5, class 0 messages from the 1360 operator.

Type 4 messages are organized into words, 12 bits in length. A message uses eight words, composed of bits 0-95, all of which are significant. Bits 0-7 define the function and 8-95 define its parameters.

Type 4, class 0 messages are converted from 1360 internal code to tilt/rotate code (Figure 8), then print out as a 14-character message on the 1816.

Type 4 messages receive a response when the message is typed on the 1816.

The messages are formatted as follows:

BITS

0-7	Operation code (type 0-2; class number 3-7)
8-11	Unused
12-23	Contains two characters in 1360 internal code
24-35	Contains two characters in 1360 internal code
36-47	Contains two characters in 1360 internal code
48-59	Contains two characters in 1360 internal code
60-71	Contains two characters in 1360 internal code
72-83	Contains two characters in 1360 internal code
84-95	Contains two characters in 1360 internal code

Type 5 Message Format

Type 5 messages are 1360 operator-generated messages to the host via the 1816 printer-keyboard. These messages are originated by the 1360 operator and may be a response to type 4, class 0 messages from the host operator.

Type 5 messages are organized into words, 12 bits in length. A message uses eight words, composed of bits 0-95, all of which are significant. Bits 0-7 define the function, and 8-95 define its

parameters. The messages are formatted exactly like type 4 above.

Type 5, class 0 messages are converted from the keyboard character code entered on the 1816 printer-keyboard (14 characters per message) to 1360 internal code (Figure 8). The data is packed in two 6-bit characters per word (see RMG routine in Operator Functions for procedure).

GRAPHIC	1360 INTERNAL CODE	GRAPHIC	1360 INTERNAL CODE
Space	00	K	22
1	01	L	23
2	02	M	24
3	03	N	25
4	04	O	26
5	05	P	27
6	06	Q	28
7	07	R	29
8	08	!	exclamation 2A
9	09	\$	dollars 2B
:	colon 0A	*	asterisk 2C
#	number 0B	)	right paren. 2D
@	at 0C	;	semicolon 2E
'	apostrophe 0D	—	overline 2F
=	equal 0E	&	amper. 30
"	quotes 0F	A	31
0	zero 10	B	32
/	slash 11	C	33
S	12	D	34
T	13	F	36
U	14	G	37
V	15	H	38
W	16	I	39
X	17	¢	cents 3A
Y	18	.	period 3B
Z	19	<	less than 3C
(no graphic)	1A	(	left paren. 3D
,	comma 1B	+	plus 3E
%	per cent 1C		vertical 3F*
—	underline 1D		
>	more than 1E	EOF	end of field FF
?	question 1F	ER CHR	erase character Deletes last character
-	minus 20	ER FLD	erase field Deletes message
J	21		

*This character is used as an EOM (end of message) character for 1816 communication with the host.

Figure 8 Character Codes

Sequence of Operations and Timings

Sequence of Operations

From the host system point of view, 1360 activities can be classified into three basic tasks: reading, writing, and file maintenance. This section lists typical sequences of commands for some of these tasks, along with variations which may be appropriate. In this discussion, the

interface hardware, commands, signals, logical flags and data are assumed to be understood and to occur at the appropriate times. Timings between a command and its response, as seen from the host, are given in a subsequent section.

Reading

Although reading can be considered only as the actual function of scanning a film chip, the whole procedure of moving a cell from a file to a reader and its return must be described to form a valid sequence of operations.

Since it is the host responsibility to index the data stored in the 1360 system, it is assumed that the host has performed the necessary conversion from a file identification to a geometric file address. Further, the host must have considered to the fullest extent possible such factors as distributing requests among the files which may improve throughput, using alternate readers to balance throughput or establish priority, and organizing data by cell or chip for optimum read throughput.

Generally speaking, the longer the read, the greater the throughput, as more data is obtained with fewer mechanical delays.

A typical read sequence follows:

A. Purpose: To read data from a chip.

Transport File. Moves a cell from its file to the shuttle of a designated terminal.

Seek Reader. Picks a chip from the cell in the cell shuttle and positions it to the specified line.

Read Data. Initiates data transfer from the positioned chip -- see note #5 below.

Chip Return. Places the chip back in the original cell slot.

Cell Return. Returns the cell to the original file location.

Note #1: A Transport File Search may be used as an alternative to a Transport File; the difference is that if a cell is not detected in the specified file location, diagnostic routines are not called.

Note #2: A Seek Reader Search may be used as an alternative to a Seek Reader; the difference is that if a chip is not detected in the specified cell slot, diagnostic routines are not called.

Note #3: A single Read command may be stacked for each reader (see Read Commands - General). A stacked Read must be on the same chip, but need not be contiguous to the preceding read.

Note #4: A read continue option exists for all read commands which, in effect, combines a seek and a read of data on the same chip but not necessarily contiguous to the preceding read (see Read Commands - General).

Note #5: For any given sequence, there may be one or more Seek Reader and Read Data commands. A second Seek Reader command is employed only if a subsequent read is on a chip other than the one being read. A single read command can read no further than the last line of the column.

Thus, maximum read length is 3936 if begun at the first line of a column. To read an entire chip then, four read commands must be given with only one Seek Reader, as the four column reads are sequential and no positioning of the chip is necessary (the implied starting line of a read is the line immediately following the terminating line of the previous read, even though that line might be at the beginning of the next column). See note #4 concerning the read continue option if a read is non-sequential, for example, a read of frames 1 and 3.

Note #6: A Read Terminate command can terminate any read command. Another Read Data may follow a Read Terminate provided the read is on the same chip.

Writing

The actual function of writing a chip is embedded in a sequence of commands that takes a raw film chip from the format station into the target area for recording, through the developing cycle, and finally stores it in the proper cell and file. At no added cost of time because of functional overlap, the newly recorded chip may be readback checked to verify its readability before the original data is released from host storage.

Like the host commands Seek Reader and Read Data which are concerned solely with the function of reading, the host command Seek Recorder is concerned solely with the function of recording. At the conclusion of recording, the 1360 responds with a Command Complete and the process of developing the chip proceeds automatically.

Basically, timing of the writing function is limited by three factors: (1) the optimum record rate of 550,000 bits/sec; (2) the basic record-develop cycle which limits chip output to one every 18.5 seconds; and (3) the ability of the host to supply data in 4-line bursts for up to 492 lines (one frame). (See Data Flow for information on timing requirements between bursts of output data.) The host can wait an unrestricted time between recording frames. Once writing has started, however, the host must provide data at a specified rate until the frame is filled or a write overrun occurs. If this happens, the remainder of the frame is recorded with zeros. The electron beam is then blanked until more data is supplied or, in the alternative, a Write-Chip Fill command from the host serves to fill the remainder of the chip with zeros.

A typical write sequence follows:

- B. Purpose: To record and readback check data on a chip.

Format Chips. Formats raw film chips for recording (and informs the 1360 as to how many raw film chips are needed).

Seek Recorder. Moves chip from format station into the target area and records frame by frame as data becomes available (developing is done automatically when the chip is completely recorded).

Transport File. Moves a cell from the file to the cell shuttle of the recorder to receive recorded and developed chip(s).

Chip Return. See A.

Transport Terminal. Moves a cell from the recorder to the reader.

Seek Reader. See A and note #2.

Chip Analysis. (two options are available: Data Transfer or No Data Transfer). Checks for errors in enhanced error detection mode. See note #10.

Chip Return. See A.

Cell Return. See A.

Note #7: The host sends data on a frame basis with no intervening commands until all 32 frames of a chip are recorded.

Note #8: The host receives a message concerning the chip(s) coming out of the developer and then transmits the Chip Return command.

Note #9: The command Write-Chip Fill causes zeros to be recorded on the remainder of a chip if the host has insufficient data to fill it.

Note #10: "Enhanced error detection mode" is actually a degradation of reader capability so as to eliminate marginally-recorded chips.

Note #11: Tradeoffs between use of the pneumatics, the number of commands the host must issue, and the time and capacity necessary to store source data in host buffers are all involved in determining whether readback checking should be done on a chip-by-chip basis or by groups.

Another consideration is the fact that a chip undergoing chip analysis is being read while hardware and error correction procedures are in an enhanced error detection mode. Because of this, conditions that would be marginal in normal reading will consistently be detected as error conditions. Once a chip passes chip analysis and subsequently returns to the reader for reading under normal conditions, a read takes only about two seconds. Thus, on the table below, no attempt is made to estimate the amount of time it might take to read a chip or group of chips. This fact might rule out the possibility of trying to readback check on a chip-by-chip basis using only one cell to shuttle back and forth between the developer and reader. But it does not rule out the possibility of readback checking on a chip-by-chip basis using a chip's destination cell as its vehicle. Transport time implications and pneumatics path impingement suggest that it would be more efficient to readback check groups of chips. However, this must be weighed against the need for the host buffer to retain the original data until write verification is completed.

Note on the table also that to readback check one chip at a time involves eight commands (Seek Reader, four Chip Analysis, Chip Return, and two Transport Terminal).

The host (at its option) must store 5 million data bits until the successful conclusion of readback checking one chip. To readback check two chips at a time involves only six additional commands and cuts transport time in half, but doubles the storage load on the host buffer. In fact, if the recorder is being used to capacity (that is, chips fill the 8-station developer and the record and outgas stations of the format station), the host is required to store over 50 million data bits.

One feature of the 1360 that might be helpful in calculating the most efficient method of readback checking is the fact that if a cell has not returned from the reader in time to receive the next chip which has completed developing, the chip will simply be held in the chip picker for the

18.5 seconds that remains before another chip is ready. Then when the cell returns, the chip picker deposits the chip and immediately picks and deposits the next chip from the developer. (Bear in mind, however, that because the picker is tied up during this cycle, it is unable to deposit a new raw film chip in the format station at this time.)

An alternate method to shuttling one cell between the recorder and reader would be to employ two cells with a third cell at the reader to receive verified chips. Provision must also be made for bad chips. There are also other possibilities which the host programmer may wish to examine.

The following table sets out some of the considerations for readback checking:

No. of Chips	No. of Commands	Transport Time	Amount of Data	Store Time During Record-Develop Cycle
1	8	10 sec.	5M bits	3.0 min.
2	14	10 sec.	10M bits	3.3 min.
4	26	10 sec.	20M bits	3.9 min.
8	50	10 sec.	5M bytes	5.2 min.
16	98	10 sec.	10M bytes	7.6 min.
32	194	10 sec.	20M bytes	12.5 min.

Thus, as use of 1360 pneumatic facilities lessens, so use of host storage facilities increases.

File Maintenance

File maintenance is a broad term employed to include all functions of the host other than reading or writing. Such sequences of commands can assign a new cell address to a cell in the shuttle, return a chip to a slot other than the originating slot, assign a file address to a cell in the cell shuttle just emptied of raw film chips, and unlock the 1361 file door so that removable sections containing cells can be exchanged at the manual entry station.

Some typical file maintenance sequences follow:

- C. Purpose: To move a cell from one location in file to another.

Transport File. See A and note #1.

Seek Reader. See A and note #2.

Read Data. See A. The Seek Reader, Read Data, and Chip Return commands are all optional in this sequence. Only the Transport File, Assign Cell Address, and Cell Return are mandatory.

Chip Return. See A.

Assign Cell Address. Assigns new cell address to cell in shuttle.

Cell Return. See A.

- D. Purpose: To move a chip from its original slot to another slot.

Transport File. See A and note #1.

Seek Reader. See A and note #2.

Read Data. See A (a read command in this sequence is optional).

Chip Select. Establishes the presence or absence of a chip in a specified slot and readdressed the chip in the picker.

Chip Return. Returns the chip to a slot other than the originating slot

when preceded by a Chip Select.

Cell Return. See A.

- E. Purpose: To assign a file address to a cell just emptied of raw film chips.

Format Chips. See B.

Seek Recorder. A series of Seek Recorder and Format Chips commands combine to empty a cell of raw film chips on which to record. An "Empty Cell Available" response is sent to host when last raw film is removed from raw film cell.

Activate Empty Cell. Assigns a file address to cell in shuttle just emptied of raw film chips (a cell without a file address cannot be moved). The empty cell is subsequently sent to a file or it may be used to accept a chip from the developer in order to transport it to the reader for a readback check.

- F. Purpose: To unlock the manual entry door in the 1361 file for the insertion and/or removal of all or any of the five removable sections from the bottom tray.

Unlock Manual Entry. See above.

Note #12: The operator must unlock and lock the tray door and close the file door for the manual entry condition to be cleared.

Note #13: This command will not be accepted until the system finishes processing other commands involving the cell file. Once accepted, other commands involving the cell file containing the affected manual entry door will be rejected until the manual entry operation is complete.

To the host computer, the 1360 system is a device which accepts commands, acts upon them, and returns a response indicating that the command is complete or if not, why not. Within the 1360, each command results in a series of operations which are performed sequentially or concurrently, asynchronously or synchronously with each other and with operations generated by other active commands. Timings for a single command at a time can be predicted, but become only rough indicators when a variety of commands are overlapped.

Basically, execution of commands (write, read, move cell) consists of four steps: logic, activate, time, and sense. Once the control program has determined that proper hardware and system conditions exist, the operation is initiated. An action is started, such as engaging a clutch, lifting a detent, or opening a valve. Most conditions are determined by program polling, rather than by an interrupt at action completion. There are usually two times associated with an action. The first is normal time, or the interval after which the result of the action can be expected. This time is used to avoid taking processor time to look immediately for the end of an action that normally takes a finite time for completion. The second time, called tolerance, specifies the limit for normal completion. The sense is, of course, the determination that the appropriate sensors reflect a successful completion of the action. Both times are measured via system clocks.

To illustrate this level of control and sense, the buffer has two positions, 180 degrees apart, for sending and receiving cells to and from the main pneumatics path. A command to move the buffer to the send position is given; after an interval a sense confirms the command has been completed or a malfunction has occurred. Normally, the buffer is given 150 ms to rotate, with a tolerance time of +50 ms, -25 ms. In effect, then, the rotation may be successfully accomplished at any time between a minimum of 125 ms and a maximum of 200 ms before diagnostics and automatic recovery programs attempt to rectify the malfunction.

The times mentioned in this section are nominal values. The programming method used allows a variation in mechanical times. Program tolerances sometimes allow as much as three times the nominal, though actual deviation is seldom that large.

Times are listed for actions that are complete or partial results of a host command. To determine the duration between a command and its response, often the times of two or more actions have to be added.

All actions listed involve the reading process or positioning cells and/or chips for reading. The following section discusses some of these actions in detail.

Terminal Action Detail

To understand the actions at a terminal (reader or recorder), it is necessary to go into the mechanical motion in some detail. Each terminal contains two pairs of chambers, the rotary buffer and the cell shuttle (Figure 9) that combine to make the chips stored in a cell accessible and then provide for return of the cell to its file.

The rotary buffer has a receive chamber and a send chamber. The buffer rotates around a horizontal axis passing between the chambers. At each of its two detent positions, one chamber is directly above the other. The lower chamber interfaces with the pneumatics tube from the files.

When the receive chamber is in the lower position (Figure 10a), it accepts incoming cells. When the send chamber is in the lower position, it holds cells prior to their transport (Figure 10b).

The upper chamber of the buffer interfaces with the other pair of chambers, the cell shuttle. The cell shuttle chambers are positioned one over the other. The shuttle has two movements, one vertical and one horizontal. "Shuttling" is done in the vertical direction so that either chamber of the shuttle can be aligned with the top buffer chamber (Figure 11). The second movement, horizontally at right angles to the chamber axes, is called "chip select" (Figure 12). A position designated "home uncaged" is at one end of the chip select movement (Figure 12a).

Chip select movement of the shuttle away from home uncaged removes the lid of the cell and positions the cell body to any of the 32 chip positions. Position 31 (i.e., chip 31) is closest to home uncaged and position 0, the furthest. Once the chip select movement has ceased at a certain slot, the related chip may be withdrawn. At this point, it does not matter from which cell shuttle chamber the chip select is being made, nor does it matter which rotary buffer chamber is uppermost.

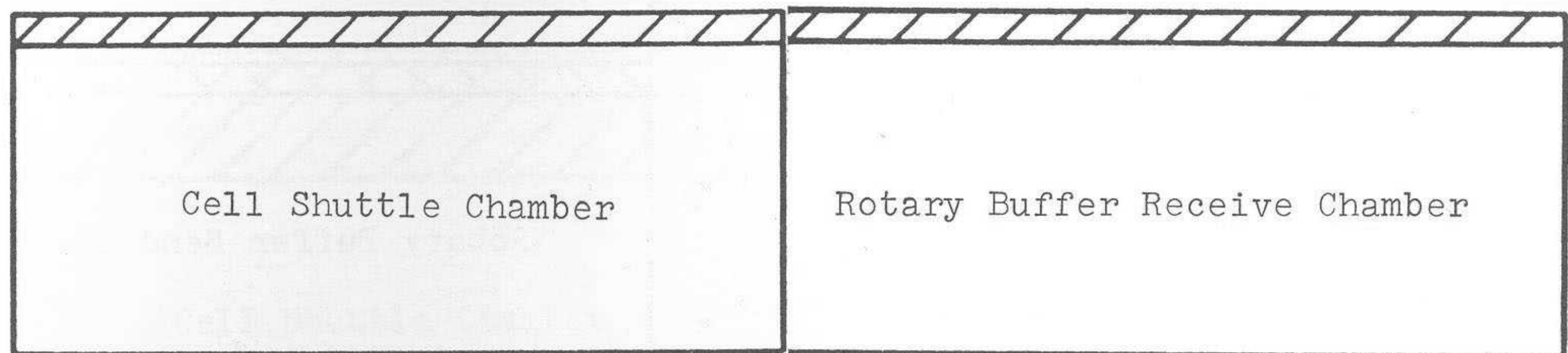
At home uncaged with the shuttle in the upper position, a cell may be moved between the lower chamber of the shuttle and the upper chamber of the buffer. Shuttle down allows movement between the upper shuttle and upper buffer chamber. Cells are loaded from the receive chamber or unloaded into the send chamber (Figure 10).

Figure 13 lists the actions that occur before, during, and after a chip read together with nominal time values. As stated previously, program tolerances allow up to three times the nominal values given for action completion, so values in the table are not to be construed as constants.

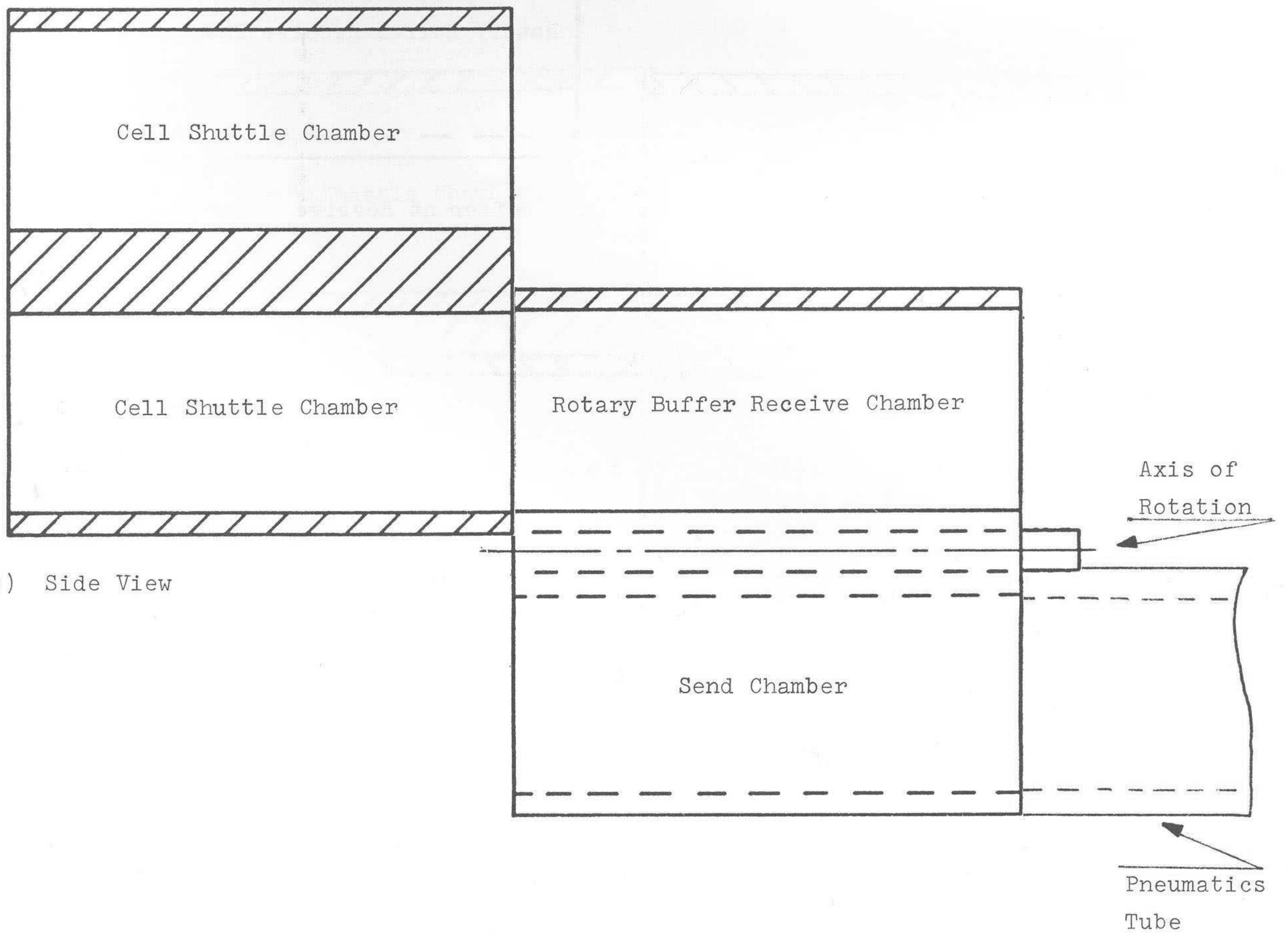
Referring to Figure 13, the cell is transported to the receive chamber of the reader buffer. The buffer is then rotated so that the receive chamber is in the upper position. The shuttle is moved to home uncaged and shuttled, if necessary, so that an empty chamber is aligned with the receive chamber. The cell is loaded. Then a chip select motion is made to the chip desired and it is picked.

If a second cell is received while a chip from the first cell is being read, it is also placed in the shuttle. To do this, the buffer rotates to accept the new cell in the receive chamber. The buffer rotates. The shuttle is shuttled and moved to home uncaged. The new cell is loaded. The shuttle then moves back to the position of the chip being read and shuttles so the original cell is ready for replacement of the chip.

After the last chip to be read is replaced in its cell slot, the cell is returned by chip select to home uncaged. There the cell is unloaded into the send chamber, rotated to the send (or lower) position and transported through the pneumatics back to the file.



(a) Top View



(b) Side View

Figure 9 Terminal Rotary Buffer and Shuttle

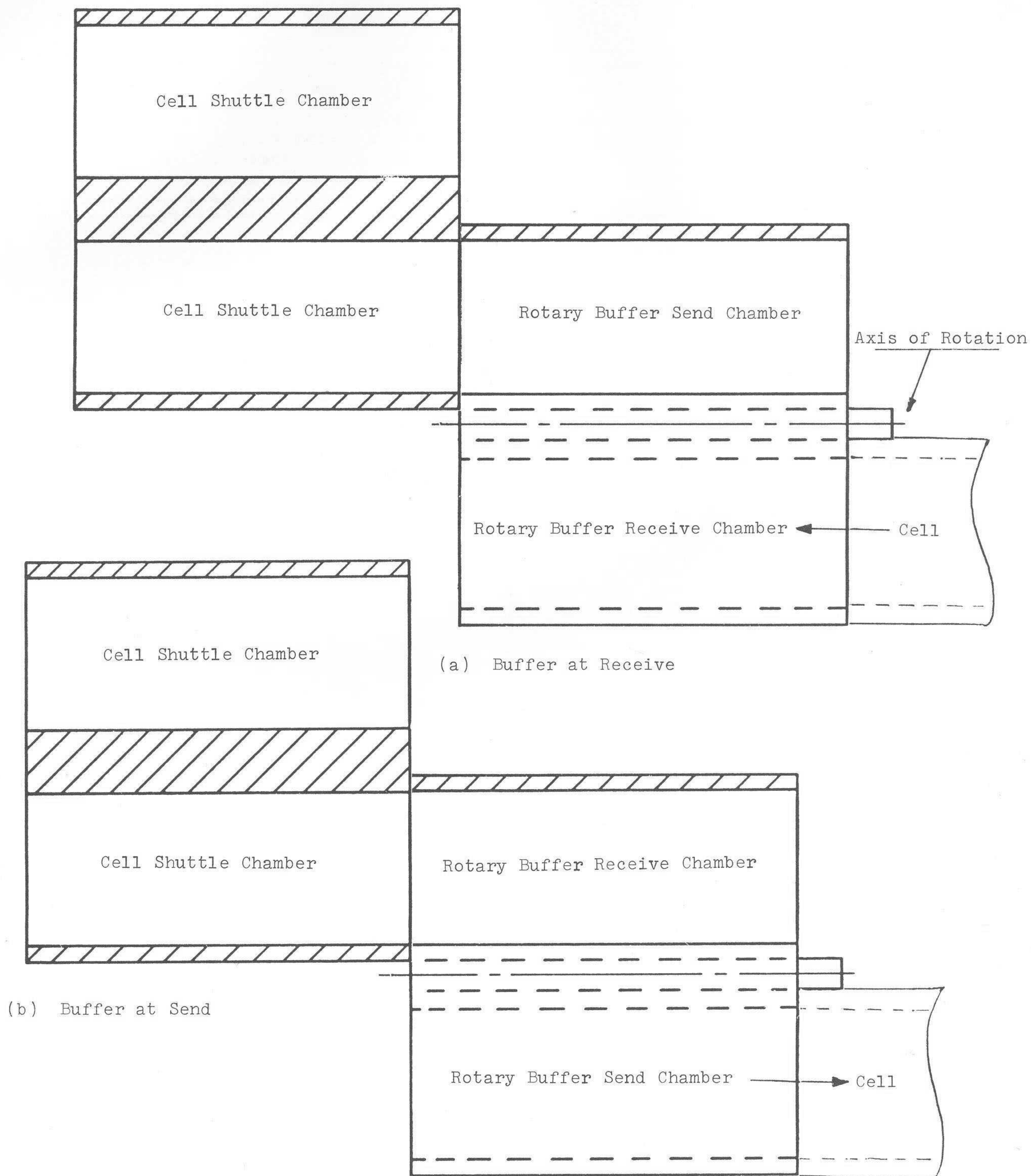
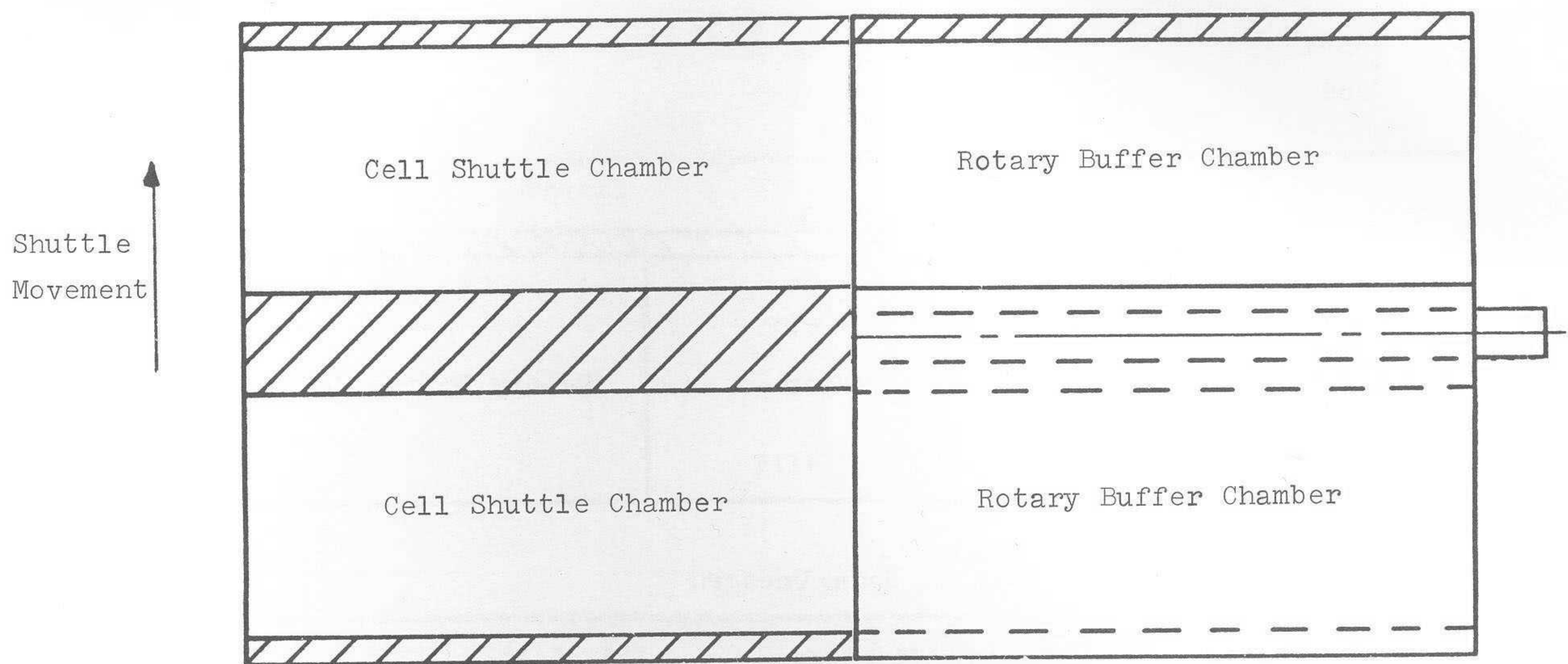
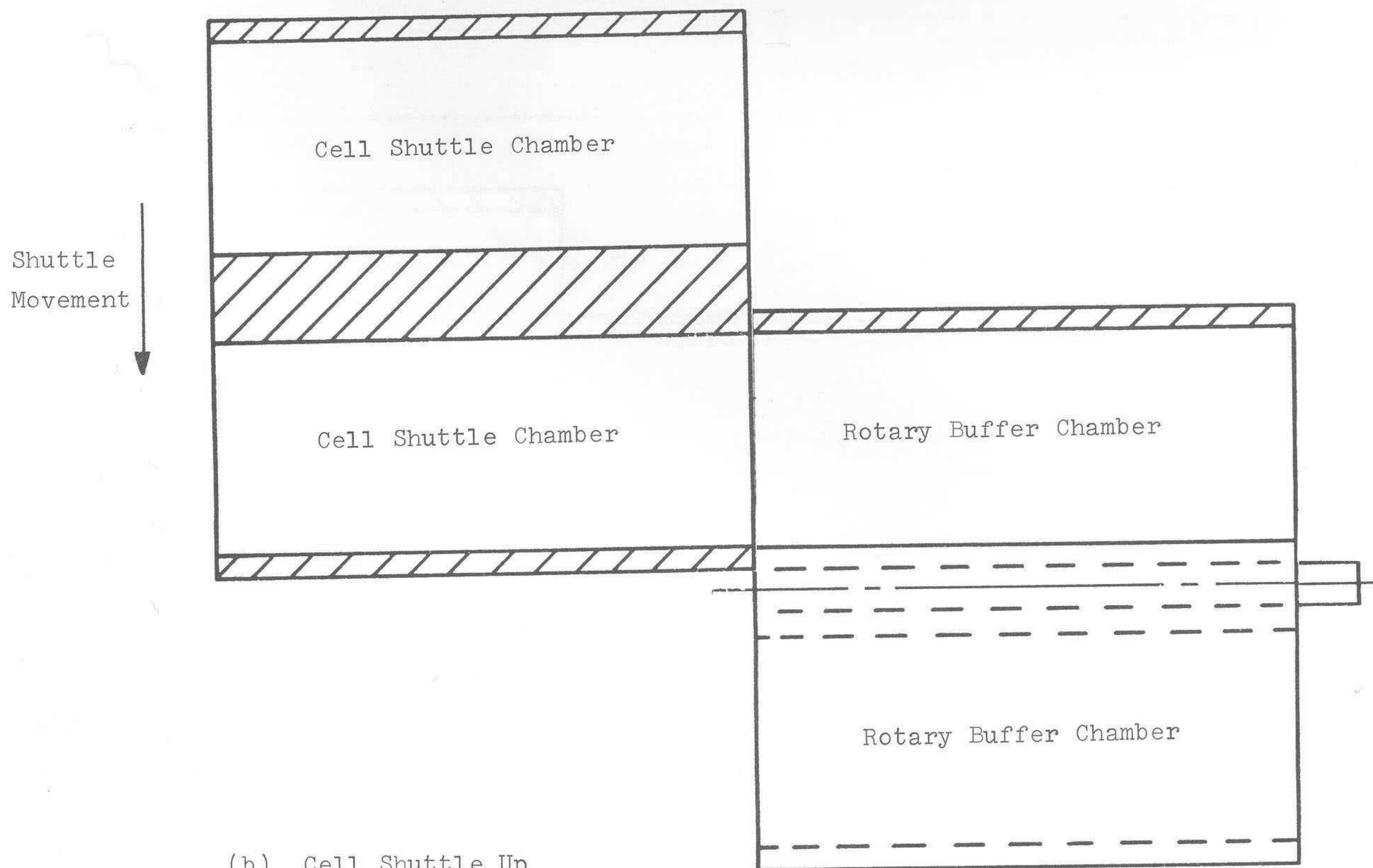


Figure 10 Positions of Terminal Rotary Buffer (side views)

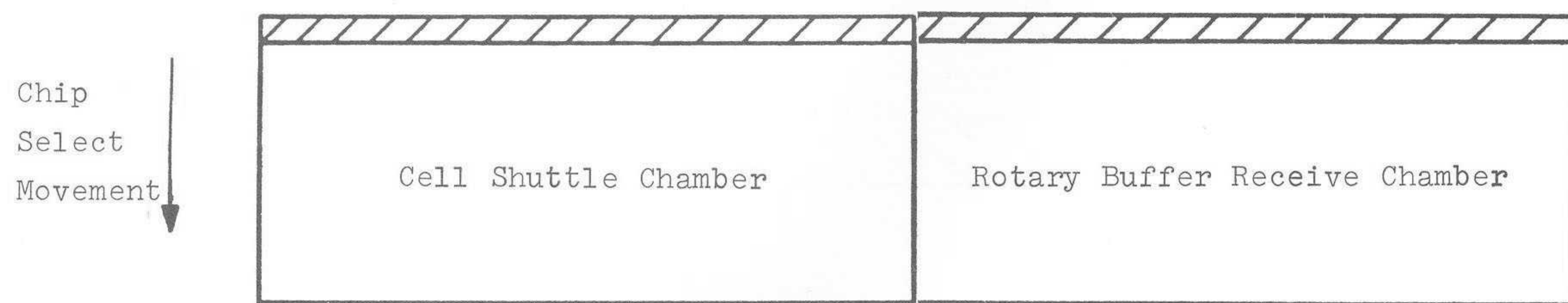


(a) Cell Shuttle Down

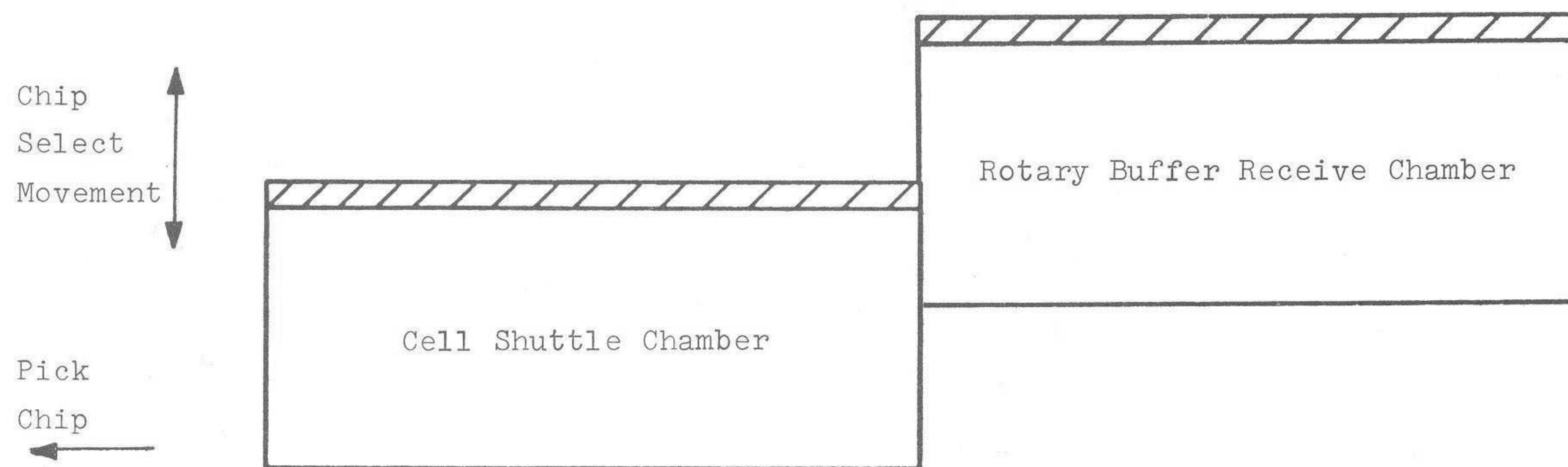


(b) Cell Shuttle Up

Figure 11 Cell Shuttle in Down and Up Positions (side views)



(a) Cell Shuttle at Home Uncaged



(b) Cell Shuttle at Chip Position

Figure 12 Cell Shuttle Chip Select Movement (top view)

<u>ACTION</u>	<u>CONDITIONS</u>	<u>NOMINAL TIME (ms)</u>
File to File Buffer	Longest route	1460
	Shortest route	660
File Buffer to Terminal Receive (includes File Buffer rotation)	File 1 - Reader 1	760
	- Reader 2	1350
	- Recorder	1760
	File 2 - Reader 1	985
	- Reader 2	1635
	- Recorder	2100
	File 3 - Reader 1	1290
	- Reader 2	1890
	- Recorder	2360
Reader Receive to Shuttle	Shuttle at home uncaged	750
	Shuttle transfer - from chip 12-31	1190
	No shuttle transfer - from chip 31	990
	- from chip 0	1300
Chip Select	31 chips difference	560*
	1 chip difference - no shuttle transfer	250*#
*From home uncaged, add 240 each # For shuttle transfer, add 195		
Chip Pick	Frame 24	511
	Frame 0	460
Read (not Chip Analysis) - good* chips	One frame	85
	Full column	680
	Move to next column	90
	Full chip (four Reads)	3000
*previously readable with Chip Analysis		
Chip Return - with shuttle positioned	From column 0	620
	From column 3	540

Figure 13 1360 Timings

Commands and Actions

This section lists commands and the actions they initiate involving the reading process or positioning cells and/or chips for reading.

Transport File consists of (1) movement of cell from the tray to the file buffer, (2) rotation of the buffer and transport of the cell to the terminal receive chamber, and (3) movement of cell from receive chamber into the shuttle.

Chip Select consists of positioning the cell in the shuttle so that the desired chip is ready to pick. Moving to the other pocket of the shuttle (shuttling) may or may not be necessary. This action is performed in response to a specific command or as a portion of the Seek Reader command.

Seek Reader positions a chip to be read. It consists of (1) a chip select and (2) a chip pick.

Read (all types) occurs after a Seek Reader has positioned the chip. Each read command allows reading only as far as the bottom of the column in which the read originated but subsequent reads may be given for the same chip without intervening commands.

Chip Return replaces the chip in the cell.

After a Chip Return, a Seek Reader can be issued for any chip in the shuttle. An example is when a read on each of three chips in three different cells is underway. After the first chip has been returned and the second chip positioned, the second read is begun. If the third cell has arrived at the reader receive chamber, the first cell is moved to the send chamber and the third cell to the shuttle during the read of the second chip. If this read takes longer than 1.7 seconds, no time is lost by the cell exchange sequence.

After chips are recorded, they are usually transported to a reader for a chip analysis read. It requires approximately 5.2 seconds to transport the cell, pick the chip, and begin the read. If the chip is read completely, a command complete response is sent. This response contains the number of lines in error. If the read is not complete by a prespecified timeout time, a response is sent so indicating. This response also indicates the number of lines in error to that point. This response is sent again each time the timeout time elapses until either the read is complete or a Read Terminate command is received from the host.

Operator Functions

Introduction

The photo-digital system requires the intervention of an operator from time to time to supply raw film, chemicals, etc. The operator can also exercise a limited amount of control over the system by means of the 1816 printer-keyboard and the operator's panel on the control processor. In addition, the system keeps the 1360 operator informed of system conditions by means of printer-keyboard messages. The information in these messages may or may not require that the operator take action. A list of these

messages is printed in OPERATOR COMMUNICATION.

In its narrowest definition, the term "1360 operator" is defined as the person assigned by the user to control (within the limits set out below) and supply raw materials to the 1360 system. In its broadest definition, the term can be expanded to include anyone who operates the system, including customer engineers and programmers. This section addresses the user-assigned 1360 operator for the most part.

Operator Control

Limited control can be exercised by the 1360 operator over the system by means of two keys, Power On and Power Off, on the operator's panel of the control processor. However, where depressing the Power On key initiates subsequent interaction between the system and the 1360 operator, the Power Off key is activated only after interaction between the system and the 1360 operator has taken place. The function of each control and indicator on the operator's

panel is discussed in the following sections.

In addition to the controls on the operator's panel, the operator has available to him three types of operator-generated messages: (1) to extract information about the system (RES), (2) to communicate with the host operator (RMG), and (3) to power the system down (RPD). These messages are entered by the system operator on the printer-keyboard (see OPERATOR COMMUNICATION).

Operator's Panel

The following table lists the controls and indicators on the operator's panel (Figure 14) of the control processor by name and implementation:

NAME	IMPLEMENTATION
Power On	Key
Power On	Indicator
Power Off	Key
Attention	Indicator
Emergency Pull	Switch

Power On

The 1360 operator depresses the Power On key to cause power on. A program load routine initiates system readiness. From this point on, the operation follows the Recovery Procedure (see Servicing Manual Entry Station). This routine takes approximately 30 to 40 minutes to complete.

The Power On indicator light goes on when the Power On key is depressed.

Power Off

WARNING: The 1360 operator is not to power down the photo-digital system under any circumstances without first communicating with the host operator (see RMG).

Host read and write requests must be terminated in an orderly fashion so as to restore cells and chips to their proper storage places. In addition, a Master Clear signal from the host must precede a power down. In its "soft" phase (see Master Clear in System Description), this routine takes only milliseconds to determine if all chips and cells are properly stored, what units are online, and, if a failure has occurred, to change the status bit for that unit to reflect this condition.

Once these two conditions are fulfilled, the 1360 operator may proceed to enter the RPD message on the 1816 printer-keyboard (Figure 15):

1. Press KBD REQ (keyboard request) key;
2. Wait for Proceed light to go on;
3. Press Alpha key;
4. Press R, P, D keys;
5. Press EOF (end of file) key.

Note: If the Master Clear program finds cells and chips out of position during its "soft" phase, it then goes through the complete cleanout phase detailed in Power On, omitting the purge cycle that is included in Power On.

Note: If, in fact, host read and write requests have not been terminated and these functions are going on in the 1360 system at the time of Power Down, the message, SYSTEM NOT IDLE-REQUEST REJECTED, is sent. Read and write functions must then be terminated by the host and the procedure repeated.

When the request is accepted, an automatic routine powers down the system, with the exception of the control processor and the roughing pumps in the recorder, a process which takes about 13 minutes. Then, and only then, is the Power Off key enabled and a message, POWER OFF SWITCH ACTIVATE, typed out. The operator then depresses the Power Off key which shuts down the control processor. (The roughing pumps are turned off only for servicing and need not concern the operator.)

Attention

This indicator flashes whenever a message for the 1360 operator concerning the file door or a CE service call is typed out on the printer-keyboard. See RES for procedure to stop the CE buzzer and Attention light, if this is desired.

Emergency Pull

WARNING: The 1360 operator must exercise the greatest discretion in using this switch. Only a few conditions warrant such a sudden stop to the system. One would be smoke or fire; another, physical danger to a person due to electricity or mechanisms.

Pulling this switch turns off all power to the system. The switch latches in the out position and can be restored to its in position only by a customer engineer. When the emergency pull switch is in the out position, the Power On key is ineffective.



Figure 14 Operator's Panel

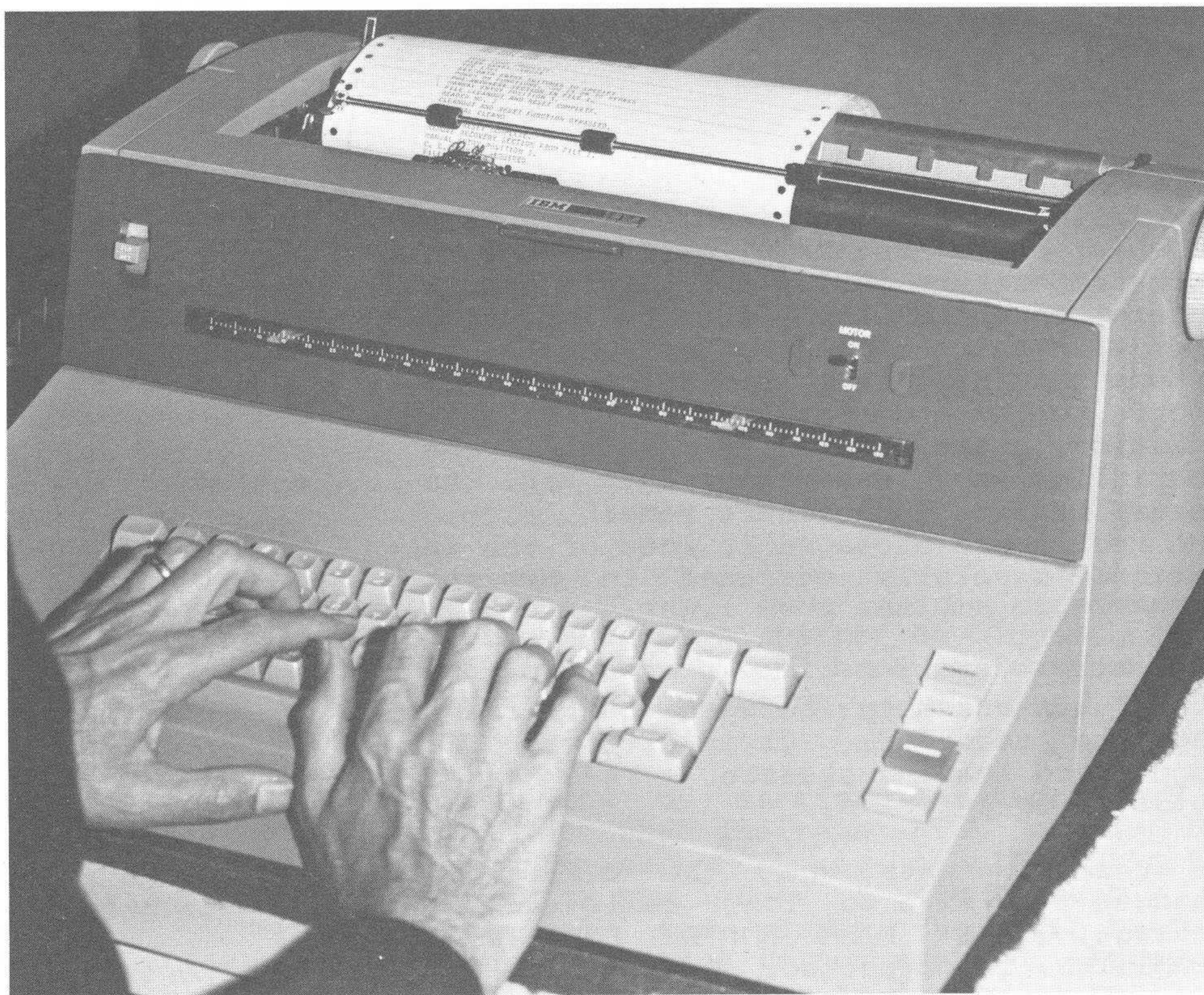


Figure 15 1816 Printer-Keyboard

Operator Intervention

During normal operation, intermittent operator intervention is required to supply raw film and chemicals to the system, as well as to service the manual entry station. The amount of servicing required is directly proportional to the amount of recording the system is doing, i.e., the more recording, the more servicing. Working at optimum speed, the system requires raw film loading approximately every two hours, chemical loading every three to six hours.

Messages are outputted on the printer-keyboard that direct the 1360 operator to take certain actions. In addition, other messages direct him to call the customer engineer or to stand by while the system

automatically recovers from an intermittent failure. These messages are not actively transmitted to the host operator but, rather, the conditions are sensed and appropriate bits are changed in the equipment status word (see RES). See OPERATOR COMMUNICATION for a list of messages.

Other messages relayed to the 1360 operator and not supplied to the host are also listed in OPERATOR COMMUNICATION. Some may identify a condition that requires the services of a customer engineer. Others may require action on the part of the 1360 operator, such as loading more paper in the 1816, then typing in REP (replaced paper).

Servicing Raw Film Entry Station

Raw film chips contained in standard plastic cells must be allowed to come to room temperature for at least six hours before entering them into the system. (Raw film chips should be refrigerated at a temperature of less than 50 deg. F in order to extend their shelf life. In addition, the humidity should be controlled to less than 50% R.H. to insure that the containers remain firm.) The cells are packaged in lots of ten in cartons specially designed to prevent exposure to ambient room light.

The entry station is located in the spacer box assembly between the reader and the recorder. It is composed of a hopper and loading shuttle. The hopper holds up to 14 cells.

A sensor detects when the cell load changes from five to four cells and a message, RAW FILM HOPPER LOW-RELOAD PERMITTED, is outputted.

Note: Load cells only when this message is transmitted as the hopper cannot hold more than 14 cells.

CAUTION: If a cell containing raw film is dropped, discard that cell because of the possibility that film chips may have been dislodged from their individual slots.

The proper procedure to insert a carton of cells into the raw film entry station follows:

1. Cut the seal on the outer plastic wrapper and remove the carton from the wrapper.
2. Match the arrow on the carton label with the arrow on the manual entry port and insert the carton lid over the metal guide visible within the receptacle. (Also visible are the white plastic slide adjacent to the guide and the metal entry door which is normally closed.)
3. Lower the carton, causing the guide to force the cantilever-type bottom open. The carton bottom will not open if the wrong side is oriented over the guide.

For correct hand position, see Figure 16. Note that the flat of the hand is placed on top of the carton and pressed. Grabbing in the center might cause a constriction in the carton that would prevent cells from falling freely into the hopper.

Pressure applied on top of the carton forces the plastic slide down and automatically opens the metal entry door. Cells fall slowly, so allow enough time (about 10 seconds) for all of them to drop.

When the empty carton is raised, the release of pressure allows the plastic slide to rise and the metal entry door to close. A follow-up message, RAW FILM HOPPER FULL-RELOAD NOT VALID, is now outputted on the 1816.

If film is not loaded when the first message appears, the message is repeated every time the system gets a new raw film cell until the hopper goes empty.

If the operator fails to reload until the last cell is removed from the hopper, the message, RAW FILM HOPPER EMPTY-RELOAD REQUIRED, is sent. If no reload is made at this point, another message, NO RAW FILM IN RECDR--RELOAD REQUIRED, makes it mandatory that raw film be loaded within nine minutes if recording is to continue. After raw film is loaded, the message, RAW FILM RELOADED-RECORDER READY, is sent. Meanwhile, the host is kept apprised of this condition by means of the equipment status word.

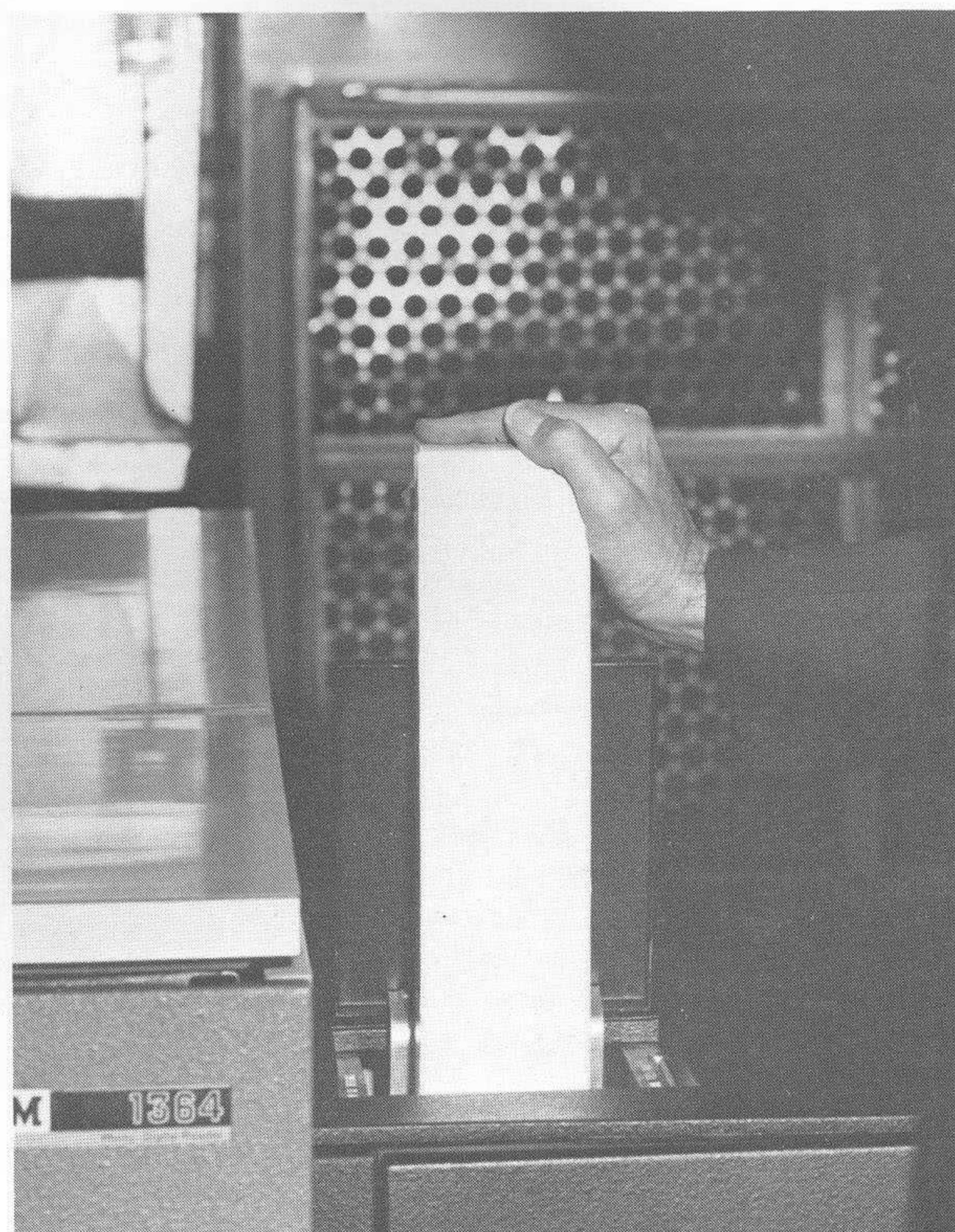


Figure 16 Raw Film Loading Station

Servicing Chemical Supplies

Developer, stop and fix chemicals are contained in two banks of three carriers each, inserted drawer-fashion, one row directly above the other (Figure 17). Below each carrier is a button on the developer panel which, when depressed, releases the carrier from the latch that locks it in place. This action also closes a quick disconnect fitting.

The two banks hold duplicate supplies of chemicals and the carriers in each bank hold three different types of processing fluids. That is, each carrier holds a removable cardboard carton containing a flexible polyethylene bag with a one-

gallon supply of either developer, stop, or fix, enough for three to four hours of continuous operation.

Each row of carriers has two lights to the left that indicate FULL or IN USE conditions. FULL is lighted when the operator has loaded a fresh supply of chemicals and pushed the FULL button. The FULL button is not enabled, however, unless the carrier is locked in position so as to activate the enabling switch in the rear. Once the FULL light goes on, a carrier can be removed and the light remains on.

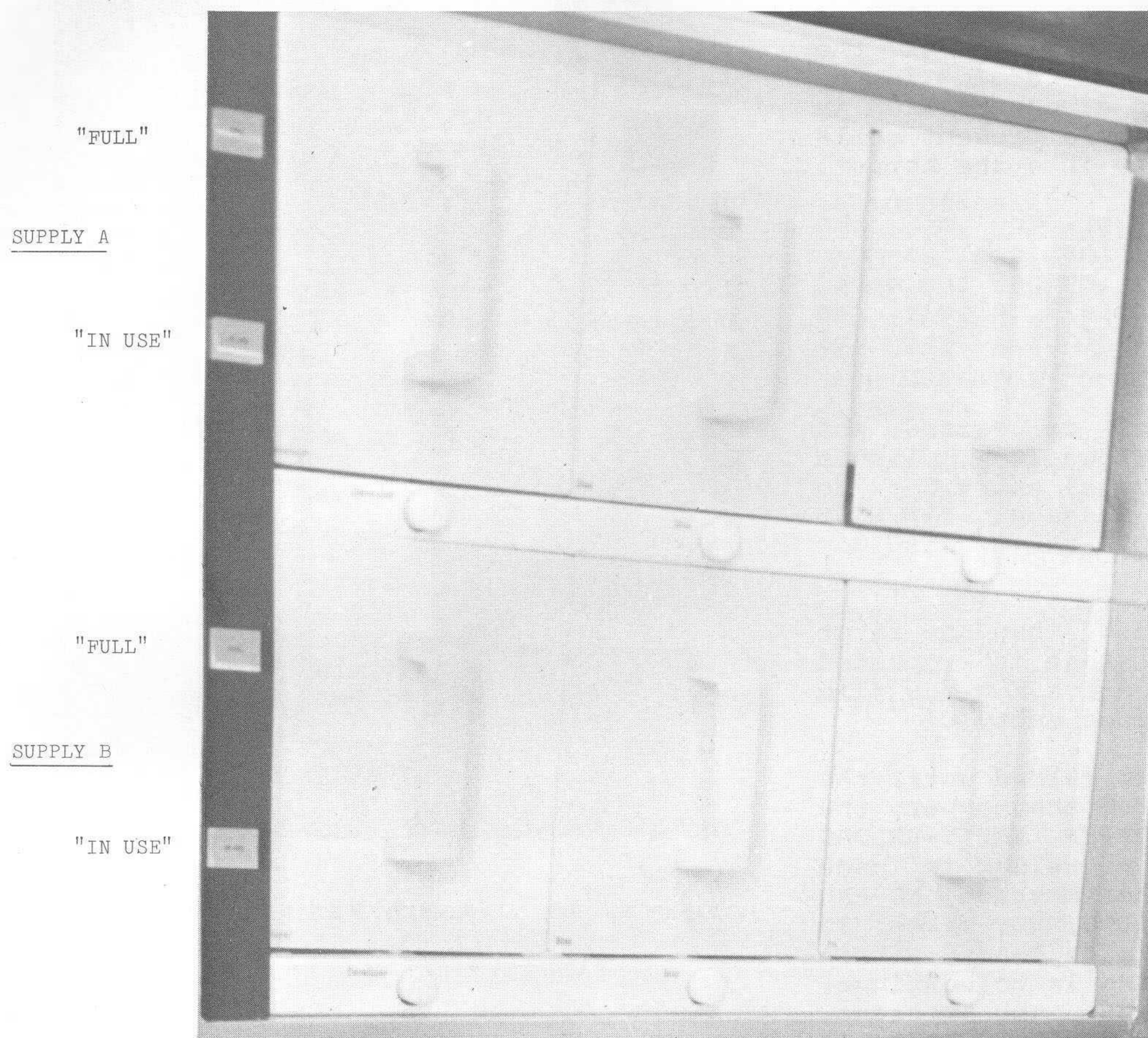


Figure 17 Chemical Banks

The system program selects the bank which will supply chemicals to the developer, whereupon the FULL light for that bank goes out and the IN USE light goes on. The FULL light for the other bank remains on until it is selected. When the bank is no longer FULL or IN USE, the system operator and the host are notified (see list of messages in OPERATOR COMMUNICATION).

Note: In the event of a normal shutdown, the status of chemical supplies must be manually reestablished. The operator may remove the carriers to verify their contents. The system program then selects the bank last designated as IN USE. If the shutdown was not normal, a customer engineer should be called.

If the chemicals become fully depleted, all lights go off, the host is notified,

a message is sent to the system operator, and recording subsequently stops.

If the operator fails to push a FULL button after loading a fresh supply of chemicals, the system will not switch to that bank as it last sensed a "no fluids available" condition which was not subsequently changed.

On the other hand, if the operator accidentally pushes the FULL button for a bank with depleted chemicals, the system switches to it automatically upon depleting the other bank's chemical supply only to sense the empty condition. This results in the lights on the developer panel going off, a change in the equipment status word to notify the host, and a message printed at the 1816, DEVELOPER FLUIDS--A EMPTY--B EMPTY. Chemicals must then be supplied in less than one minute or recording terminates.

Loading Chemicals into Developer

The following steps are taken to load cartons containing chemicals into the carriers and the carriers into the developer:

Note: Shelf life of chemicals can be extended by maintaining supplies at a temperature of less than 75 deg. F. In addition, the humidity should be controlled to less than 50% R.H. to insure that the containers remain firm.

1. Place the carrier on the floor right side up in order to gain the leverage necessary to thrust the carton into the carrier.
2. Lift the proper fluid carton by inserting the fingers into the slot in the top of the box.

CAUTION: Care should be taken to double check that the proper fluid is being loaded into the carrier; that is, fix into the fix carrier, etc. However, the cartons have key flaps that will physically prevent the insertion of the wrong carton into a carrier.

3. With knuckles extending into the carton slot and against the polyethylene fluid container (Figure 18), insert the carton into the carrier approximately halfway to insure proper guiding action of carrier sides.

Note: The cardboard carton has a small (1" diameter) hole in the bottom. Orient the carton so that this hole is over the stainless steel carrier probe.

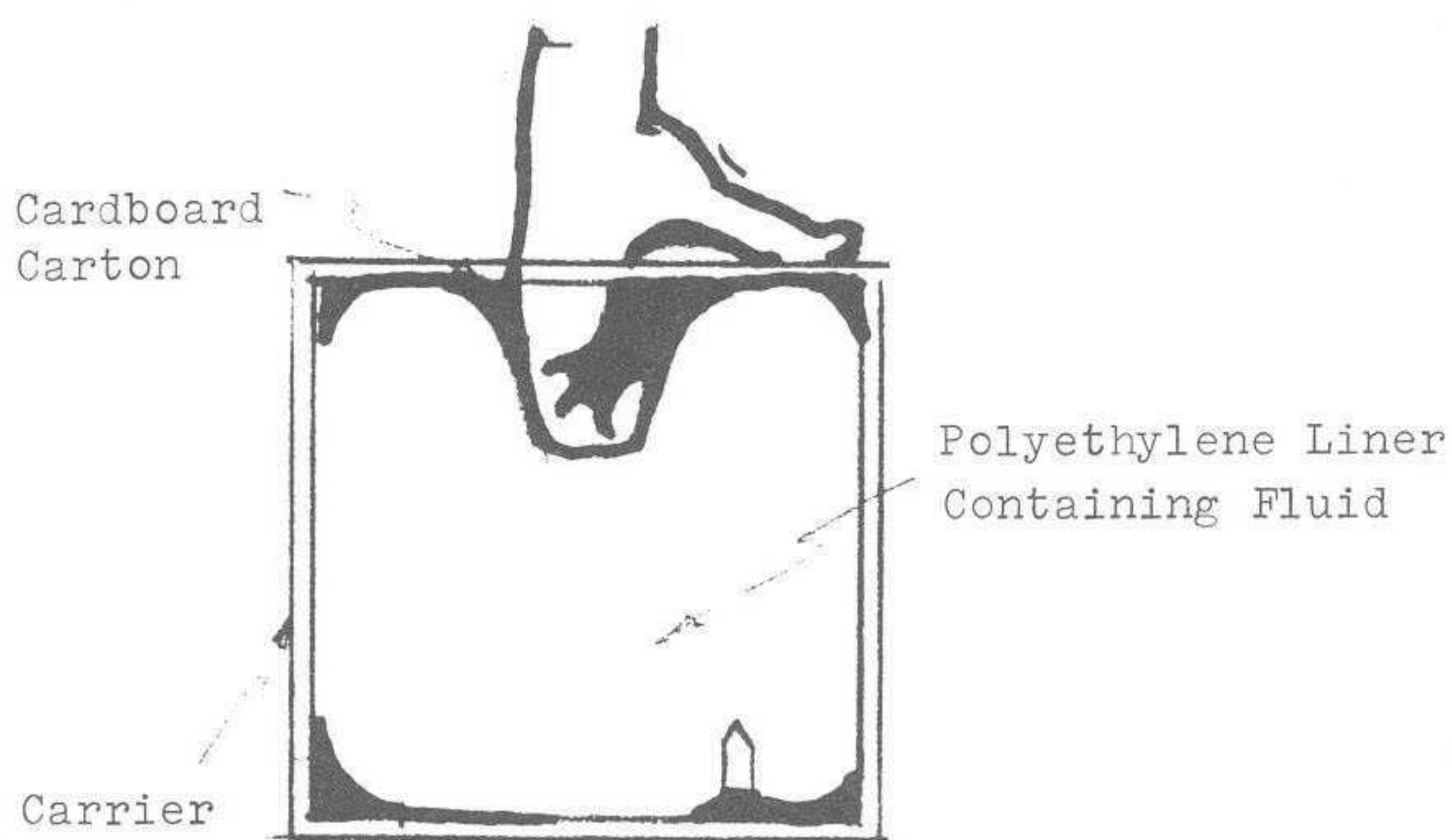


Figure 18 Inserting Carton into Carrier

4. With one firm continuous thrust, complete insertion of the carton into the carrier, maintaining the knuckle contact shown in Figure 18. This is most important since it insures that the probe properly penetrates the inner plastic bag.
5. Set the loaded carrier aside for about 10 minutes to see if a leak develops. (If a leak does occur, a new carton should be loaded.)
6. Load the carrier into the machine with an easy push motion (Figure 19). Latching in place should be automatic and can be verified with a slight pull on the handle.

Note: If the FULL light does not go on when depressed, pull out the carrier and push it back again. A switch at the rear of the carrier must be activated when the carrier is entered to enable the FULL light.

Removing Used Carton

1. Push the release button and remove the carrier from the developer frame.
2. Carry the unit to the sink, place on the edge with handle up, and pull the carton out.
3. Set the used carton in the sink with probed hole up to prevent chemicals from soaking into the carton. Remove the plastic bag and empty any residue of chemicals into the sink before disposing of the bag and the empty carton.
4. Clean the carrier with water and dry.

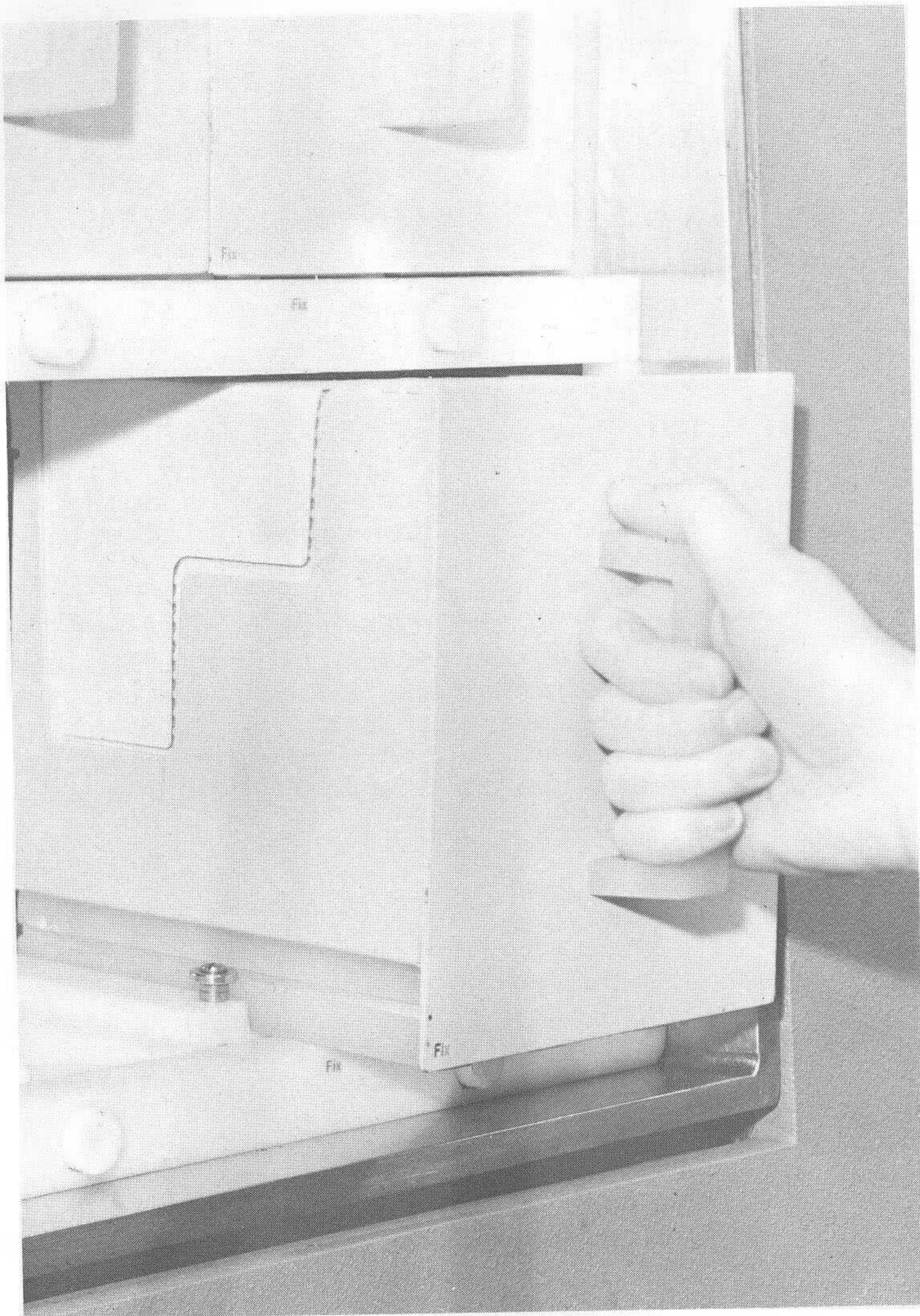


Figure 19 Loading Carrier into Developer

Servicing Manual Entry Station

The manual entry station (Figure 20) consists of the five removable sections in the bottom tray of the 1361 cell file. Each section has compartments for 30 cells, making it possible to exchange a total of 150 cells at a time. All five sections are interchangeable. Control of the section contents is the responsibility of the 1360 operator and the host computer.

When access to the manual entry station is required, the system program automatically unlocks the front door of the file. An interlock is provided to disable the tray drive whenever the front door is unlocked. Once the file door is opened, it cannot be closed unless a manual unlatch/latch of the tray door is done. Both doors must be locked or the system cannot use the file. During a Power Off, both doors remain locked.

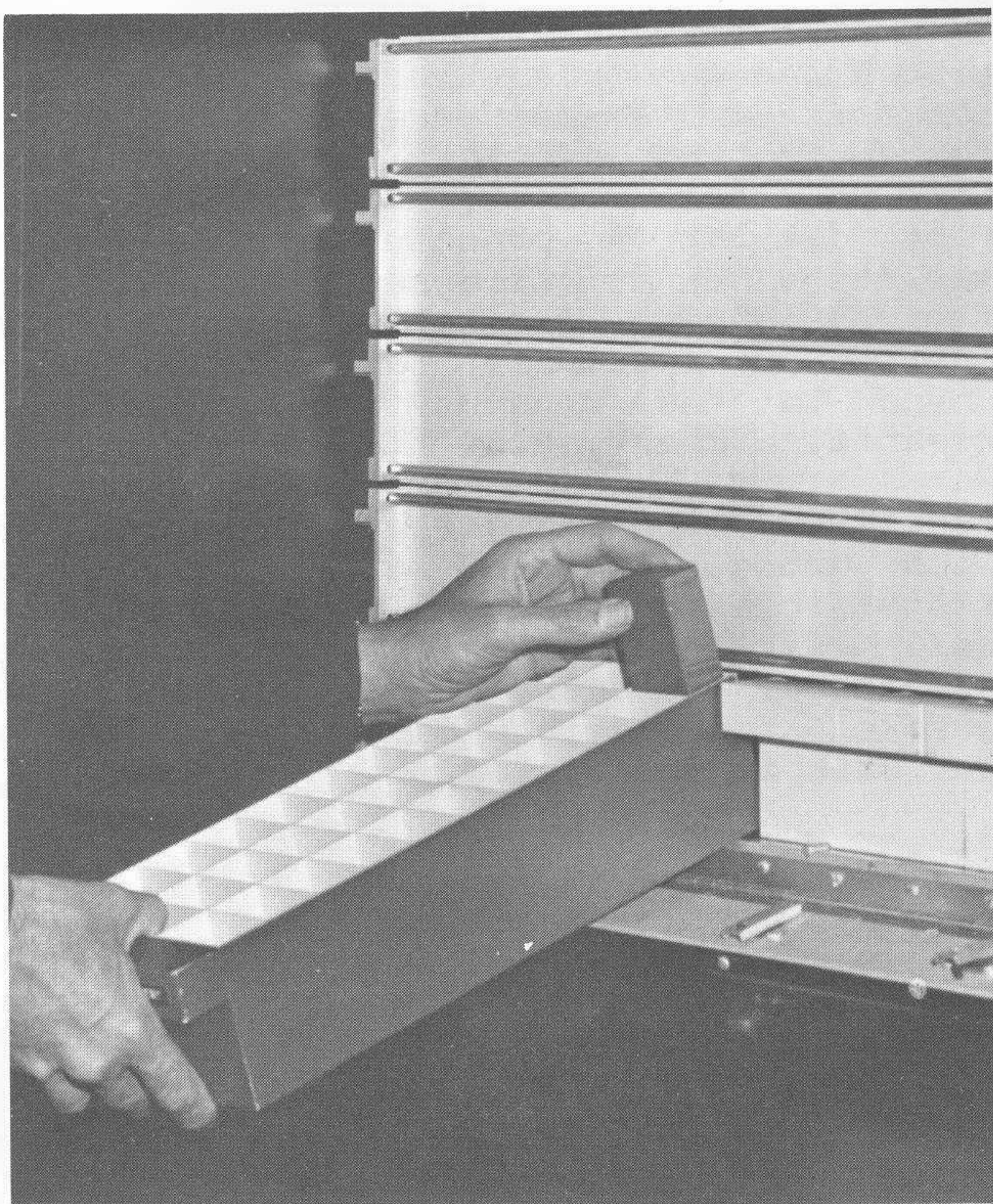


Figure 20 Manual Entry Station

Generally, a manual entry operation is undertaken by the 1360 operator as the result of one of the following three conditions:

1. When the 1360 operator initiates the Power On routine, he must enter and subsequently remove a recovery section containing one empty cell used in the retrieval of cells and chips left out of their normal locations in the event of a failure (see Recovery Procedure).
2. When the host operator initiates the Master Clear routine to cause the 1360 to be set to a normal power-up state, the 1360 operator must enter and subsequently remove a recovery section exactly as specified by the Power On routine (see Recovery Procedure).
3. When the host operator wishes the 1360 operator to manually enter groups of cells into the system or to remove them for archival purposes, he sends an Unlock Manual

Entry command (see Type 0 Messages in Host Mode of Operation) that causes the door to the 1361 file to be unlocked (see Archival Procedure).

The following recovery procedure is always initiated when the Power On key is depressed by the 1360 operator and may be initiated when the host operator starts a Master Clear. However, the Master Clear has an initial or "soft" phase which may determine in milliseconds that the system is in order and thereby bypass the full-fledged recovery procedure set out below. Additionally, Master Clear is module dependent. That is, if only one module (e.g., Reader 1) needs to be cleaned out and the other modules (in this case, the Recorder and Reader 2) are initialized and idle, only the module in question will be cleaned out.

Recovery Procedure

This procedure involves 1360 operator response to messages typed out on the 1816 as follows:

PUT RECOVERY SECTION IN FILE 1
MANUAL ENTRY POSITION 3
(relayed only to 1360 operator)

Operator removes section 71 in position 3 of the bottom tray (Figure 1) and inserts another section known as the recovery section, empty except for an empty cell (known as the recovery cell) in position 0 (Figure 2).

Note: The five sections accessible from the manual entry station are numbered 4-0 from left to right; therefore, position 3 is second from left.

The program searches the system for cells out of file and places any it finds into unique compartments in the recovery section related to the place in which they were found (Figure 7). When all cells have been located and removed to the recovery section, the recovery cell is brought to the reader and if a chip is still in the picker, it is put into the cell. This process is repeated until all chips found in the system are located in unique slots in the recovery cell (Figure 7).

As cleanout of chips and cells is completed in various units, these messages are printed out: TERMINAL CLEANOUT AND RESET COMPLETE and FILE CLEANOUT AND RESET COMPLETE. Concurrently with the cleanout phase of a power up, the system is put into readiness for operation.

When the cleanout phase is concluded, the program checks and selects a developer bank to supply chemicals to the system. This is not done by sensing the chemical supplies themselves, but by sensing which bank was in use when power down occurred and switching to that bank. For further details, see Servicing Chemical Supplies.

A unit (or units) will be bypassed during power on and cleanout (1) if its power was off when the cleanout phase began, (2) if it is offline (meaning either that it is not connected to the system or that the equipment status word so indicates), or (3) if it is already in an initialized condition at the beginning of Master Clear.

This bypass condition is indicated to the operator by the message, POWER OFF, OFFLINE, OR BYPASSED BY MC, followed by a terminal designation and the additional message, CLEANOUT AND RESET FUNCTION BYPASSED. However, the system may still be able to operate in a limited condition until maintenance personnel put that terminal back into operation. For example, if one reader is offline, the other reader can continue read operations; if there is only one reader and it is offline, recording may take place; or, if the recorder is offline, the reader(s) may continue to function.

If an operator puts a chip into the recovery cell and a chip sense is subsequently made by the program in an attempt to put a chip in that particular slot, he will receive the message, CHIP SLOT IN RECOVERY CELL NOT EMPTY. Also, if he fails to put an empty cell into the recovery section, he will receive the message, NO CELL FOR CHIPS IN RECOVERY SECTION.

When the entire system has been cleared and reset, the following message appears:

SYSTEM READY
System is online to accept commands from the host.

For other messages that might appear during this recovery procedure which require the services of a customer engineer, see OPERATOR COMMUNICATION.

An important part of the recovery procedure is knowledge of what to do with the chips in the recovery cell and cells found in the recovery section. Since this is a host responsibility, the user must develop a procedure for restoring the chips found in the recovery cell to their rightful cells. Likewise, there must be a procedure to restore cells found in the recovery section to their rightful compartments.

CAUTION: Chips and cells must be handled with great care and only by those responsible for relocation. If a chip or cell is dropped, it should not be discarded. However, the film must be checked for possible damage before it is put back in the system.

Archival Procedure

The Unlock Manual Entry command will not be accepted until the system finishes processing other commands involving the cell file, but once accepted, other commands involving the cell file will be rejected until the manual entry operation is complete. This procedure involves 1360 operator response to messages typed out on the 1816 as follows:

BEGIN MANUAL ENTRY OPERATION
Program opens the file door.
Attention indicator flashes to alert operator to message.

OPEN TRAY TO CONTINUE*
Operator unlatches tray door.

CLOSE TRAY TO CONTINUE*
Operator latches the tray door.

CLOSE DOOR TO CONTINUE*
Operator closes file door.

MANUAL ENTRY OPERATION COMPLETE
Notifies both host and 1360 operator that the manual entry operation is satisfactorily completed. If, however, the tray door was not unlatched and latched, the file door will not close and the message, MANUAL ENTRY OPERATION NOT COMPLETE, is sent.

*These three messages will be bypassed if the operator correctly follows the procedures listed in the righthand column.

A command complete response is then sent to the host by the system program (in addition, a status change message is sent the host when the door is opened and again when it is closed).

The host and 1360 operators will probably find it advisable to communicate via

type-in and type-out messages (see RMG) or by other means before the host issues an Unlock Manual Entry command. Since it is a host responsibility to maintain an index of file contents, it may be necessary for the 1360 operator to physically map or label the contents of a section for identification purposes.

Operator Communication

There are four types of communication between the 1360 operator and the host operator and/or photo-digital system.

1. 1360 operator-generated messages via the 1816 to extract information about the system (RES - Request Equipment Status), to communicate with the host operator (RMG - Request Message), and to power the system down (RPD - Request Power Down). These messages allow the 1360 operator a limited amount of control over the system.
2. Host operator-generated messages via the 1816 (see Type 4 messages, Host Mode of Operation) to communicate with the 1360 operator.

3. System-generated messages to the 1360 operator via the 1816 giving information about the system that is also available to the host by means of the equipment status word.
4. System-generated messages to the 1360 operator via the 1816 independent of the host.

These messages either (1) request some action on the part of the 1360 operator, such as supplying raw film or chemicals; (2) request him to call a customer engineer; or (3) direct him to stand by while the system automatically recovers from an intermittent failure.

RES

Even though this is fundamentally a routine designed for the customer engineer, it may be used by the 1360 operator as a convenience to diagnose a system failure so he can pass along the information to the customer engineer.

This routine also stops the CE buzzer and the Attention light, if this is desired.

The operator proceeds as follows to enter the RES message on the 1816 printer-keyboard:

1. Press KBD REQ (keyboard request) key;
2. Wait for Proceed light to go on;
3. Press Alpha key;
4. Press R, E, S keys;
5. Press EOF (end of file) key.

The routine prints out the contents of the Current Equipment Status Word (CESW), the Film Status Word, the Fluid Status Word, the Purge Flag, and the Pre-online Equipment Status Word (Figure 21) on the 1816 printer-keyboard.

	WORD 0															WORD 1																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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1 = online
0 = offline

Figure 21 RES Format (continued on next page)

Current Equipment Status Word

The CESW is a method of indicating to the programs the availability of the various modules that make up the system. A unit or function within that unit is said to be online when its associated bit in the CESW is a 1, and offline when it is a 0. The online/offline status, as defined by the equipment status word, is a programming feature and may not reflect the actual physical condition of the

hardware. Thus, this word provides the customer engineer with the means to determine what units are online to the programs.

Word 0 of the RES message shown in Figure 21 identifies the bit number with the module, its function, and a brief description of what a "1" set in that bit means. Compare this word with the following table to establish the relationship between the CESW and the information coded into it.

BIT	EQUIPMENT		MEANING OF "1" IN WORD 0
0	Data Controller	Read	Data controller is online to accept read data from reader for transmission to host.
1	Data Controller	Write	Data controller is online to accept write data from host for transmission to recorder.
2	Reader 1	Data	Reader is online to read chips.
3	Reader 1	Mech	Reader is online to move cells and chips.
4	Reader 2	Data	See bit 2 above.
5	Reader 2	Mech	See bit 3 above.
6	Recorder	Data	Recorder is online to record chips.
7	Recorder	Mech	Recorder is online to move cells and chips.
8	File 1		File 1 is online.
9	File 2		File 2 is online.
10	File 3		File 3 is online.
11	File 4		File 4 is online.
12	File 5		File 5 is online.
13	File 6		File 6 is online.
14	File 7		File 7 is online.
15			Control bit

The ESW shown in the following table has 16 bits (one word) divided into four groups of four bits each. Within each group, in order from left to right, the bit positions have a place value of 8, 4, 2, 1. Since each bit position can be assigned only a binary 0 or 1 (to indicate either offline or online, as the case may be), a 1 in a bit position is assigned the decimal number equal to its place value. Thus, bit position 0 in this table, set to 1, is worth a decimal count of 8 and reflects the online status of the read function of the data controller. If the read function of the data controller were not online, then bit position 0 would be set to 0 (binary) and be worth 0 (decimal). Therefore, if both units and their functions (represented by bit positions 0, 1, 2, and 3) were online, their place values would total 15 (decimal). This number is expressed in hexadecimal code in the CESW by an F (decimal numbers 10 through 15 are represented in hexadecimal code by the letters A through F).

Likewise, the normal CESW for a three-file, two-reader system configuration would contain a hex FFE1. In this event, note in the first table that only the bits representing files 4-7 are not included in the total place values.

Film Status

Word 1, which holds film status, corresponds to word 2 in a type 3 message (see Host Mode of Operation).

Fluid Status Word

Word 2, the fluid status word, corresponds to word 3 in a type 3 message (see Host Mode of Operation).

EQUIPMENT STATUS WORD (ESW) -- 16 BITS																
	1st Group				2nd Group				3rd Group				4th Group			
Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	1st HEX CHARACTER				2nd HEX CHARACTER				3rd HEX CHARACTER				4th HEX CHARACTER			
Place Value (Decimal)	8	4	2	1	8	4	2	1	8	4	2	1	8	4	2	1

The normal CESW for a one-file, one-reader system configuration would contain hex F381 (check the first table for bits 0 - 15 assignment). This would indicate to the 1360 operator (and/or customer engineer) that both units and their functions are online in the first group; that only the recorder and its functions are online in the second group (place value of 3); that only file 1 is online in the third group (place value of 8); and that the control bit is set to 1 in the last group (place value of 1).

Say, for example, that the CESW for the above configuration was F181. This deviates from normal only in the second group (or second hex character). Since there is a difference of 2, it means that the bit with a place value of 2 (bit position 6) is offline. Thus, the host is informed that the recorder is offline to record chips.

Purge Flag

If word 3 holds zeros, this indicates that chemicals are loaded in the developer; if non-zeros, that water is in the developer. The Power On and Master Clear routines use this flag to decide whether to purge water from the developer and refill with chemicals, i.e., when the purge flag is 0, the developer already contains chemicals and this phase of the cleanout routine may be bypassed.

Pre-online Equipment Status Word

Each of bits 64-74 in word 4 is assigned to a specific module and function of that

module exactly as in word 0, the current equipment status word. Unlike word 0, however, a change in system conditions is not reflected in word 4 until a customer engineer individually sets the bits affected to "1" after he has corrected

the malfunction. This notifies the host that the equipment is ready to be put back online. The host then calls for a Master Clear which changes word 0 to reflect the new current status and resets word 4 to 0.

RMG

The RMG routine enables the 1360 operator to send messages to the host operator via the 1816 printer-keyboard (in turn, the host operator has available a routine to send messages to the 1360 operator).

These messages are organized into eight words, seven of which may be used for a message composed by the operator. Each of the seven words may contain two typewriter characters (example: BRING RAW FILM).

The operator proceeds as follows to enter the RMG message on the 1816 printer-keyboard:

1. Press KBD REQ (keyboard request) key;
2. Wait for Proceed light to go on;
3. Press Alpha key;
4. Press R, M, G keys, space;
5. Press up to 14 characters on the keyboard;
6. Press EOF (end of file) key.

RPD

The power down request provides the 1360 operator with a means of powering down the system. Refer to the Power Off

write-up for precautions to take before calling in this routine and for operating instructions.

Typewriter Output Messages

The following messages are printed out on the 1816 printer-keyboard under the indicated conditions. These conditions

also cause a change in the equipment status word, thereby notifying the host.

MESSAGE	CONDITION	OPR. ACTION
<u>Cell</u>		
MSS HAS DETECTED CELL ON CELL PROBLEM	Self-explanatory	Stand by
REQUIRED CELL NOT ON LINE	If no cell found in proper place, command terminated	Stand by
<u>Chip</u>		
ALL RECORDER CHIPS RETURNED TO CELL	All formatted chips recorded, developed and returned	Stand by
CELL SLOT NOT EMPTY	Chip return terminated because chip slot is full	Stand by
REQUIRED CHIP NOT ON LINE	If no chip found in proper cell, command terminated	Stand by
<u>Data</u>		
RECORDER READY-NO DATA RECEIVED	Self-explanatory	Stand by
WRITE OVERRUN PROGRAM LOOPING	Self-explanatory	Stand by
<u>Developer</u>		
DEVELOPER FLUIDS-A EMPTY-B EMPTY	Sent if chemicals in one bank go low and other is empty	Load chemicals in both banks or recording stops
DEVELOPER FLUIDS-A EMPTY-B IN USE	Sent if chemicals in one bank go low and other bank put in use	Load chemicals in empty bank, if desired
DEVELOPER FLUIDS-A IN USE-B FULL	Sent if empty bank is loaded and button depressed	Stand by
DEVELOPER FLUIDS-B EMPTY-A IN USE	Sent if chemicals in one bank go low and other bank put in use	Load chemicals in empty bank, if desired
DEVELOPER FLUIDS-B IN USE-A FULL	Sent if empty bank is loaded and FULL button depressed	Stand by
DEVELOPER FLUIDS CONTINUED LOW	Sent if chemicals continue to be low (first message of two)	Load chemicals
RAW FILM REPLACEMENT SUSPENDED	Sent if chemicals continue low (second message of two)	Load chemicals
<u>Drain Tank</u>		
DEVELOPER DRAIN TANK FULL	Sent if drain tank is full (first message of two)	Stand by

RAW FILM REPLACEMENT SUSPENDED	Sent if drain tank is full (second message of two)	Stand by
DEVELOPER DRAIN TANK NO LONGER FULL	Sent if drain tank is no longer full (first message of two)	Stand by
RAW FILM RELOADING- RECORDING RESTARTED	Sent if drain tank no longer full (second message of two)	Stand by
<u>Manual Entry</u>		
BEGIN MANUAL ENTRY OPERATION	Sent when system opens file door	Stand by
OPEN TRAY TO CONTINUE*	Continuation of previous message	Unlatch tray door
CLOSE TRAY TO CONTINUE*	Sent after operator unlatches tray door (see next group of messages for intervening actions)	Latch tray door
CLOSE DOOR TO CONTINUE*	Sent after operator unlatches and latches tray door	Close file door
MANUAL ENTRY OPERATION COMPLETE	Sent at end of operation	Stand by
MANUAL ENTRY OPERATION NOT COMPLETE	Sent if operator fails to unlatch and latch tray door subsequent to opening file door	Unlatch and latch tray door; close file door

*These three messages are sent only if the operator fails to do the indicated actions after receiving the message BEGIN MANUAL ENTRY OPERATION.

Raw Film

RAW FILM HOPPER EMPTY -RELOAD REQUIRED	Sent if hopper empty as last cell is removed	Load raw film
NO RAW FILM IN RECDR- RELOAD REQUIRED	Sent if hopper empty and raw film is needed to continue recording	Load raw film within 9 min. or recording stops
RAW FILM RELOADED- RECORDER READY.	Sent when raw film reloaded after previous message sent	Stand by
RAW FILM HOPPER FULL- RELOAD NOT VALID	Sent when raw film hopper will not accept an addi- tional 10 cells	Stand by
RAW FILM HOPPER LOW- RELOAD PERMITTED	Sent when raw film hopper goes low and will accept 10 cells	Load raw film

Recorder Doors

RECORDER COVERS OPEN	Sent if recorder covers are opened (first message of three)	Close doors
RECORDING STOPPED- DEVELOPING CONTINUING	Sent if recorder covers are opened (second message of three)	Close doors
RAW FILM REPLACEMENT SUSPENDED	Sent if recorder covers are opened (third message of three)	Close doors
RECORDER COVERS CLOSED-RAW FILM STARTED	Sent when recorder covers are reclosed	Stand by
RAW FILM THIS CELL POSSIBLY EXPOSED	Sent if recorder covers are opened and raw film is in system	Stand by
NEW RAW FILM CELL- UNEXPOSED CHIPS	Sent when new raw film is reloaded after doors have been opened	Stand by

Treated Water

NO TREATED WATER- DEVELOPING STOPPED	Sent if treated water is not available; developing will stop	Call C. E.
TREATED WATER AVAIL.- DEVELOP STARTED	Sent if treated water again available; developing will restart	Stand by

Wetting Agent

NO WETTING AGENT- RAW FILM STOPPED	Sent if wetting agent not available; raw film is stopped; recording and developing continue	Call C. E.
WETTING AGENT PRESENT- RAW FILM STARTED	Sent if wetting agent again available; raw film will be restarted	Stand by

The following messages are printed out on
the 1816 printer-keyboard under the
indicated conditions. The host is not
notified of these conditions.

MESSAGE	CONDITION	OPR. ACTION
<u>Power On</u>		
PUT RECOVERY SECTION IN FILE 1 MANUAL ENTRY POSITION 3	Sent during manual entry operation after operator has unlatched tray door	Put recovery section in file
REMOVE RECOVERY SEC- TION FROM FILE 1 MANUAL ENTRY POSI- TION 3	Sent during manual entry operation at conclusion of cleanout phase of Power On	Remove re- covery sec- tion from file
TERMINAL CLEANOUT AND RESET COMPLETE	Cleanout has been com- pleted in all online terminals	Stand by

FILE CLEANOUT AND RESET COMPLETE	Cleanout has been com- pleted in all online files	Stand by
POWER NOT UP ON FILE 1	File is offline; must be online for system operation	Call C. E.
FILE 1 OFFLINE	Cleanout and reset is by- passed if file 1 is offline	Call C. E.
TERMINAL POWER OFF OR UNIT OFFLINE	Reader or recorder did not power up properly; terminal can be bypassed for operation of other units (specific terminal name follows this message)	Call C. E.
CLEANOUT AND RESET FUNCTION BYPASSED	Preceded by terminal designation; may also indicate reason why by- passed such as having no power, etc.	Call C. E.
CHIP SLOT IN RECOVERY CELL NOT EMPTY	Chip slot in recovery cell not empty; operation aborted	Repeat manual entry oper- ation and place <u>empty</u> cell in position 00.
NO CELL FOR CHIPS IN RECOVERY SECTION	Self-explanatory	See above
UNABLE TO CONTINUE CHIP DEVELOP CYCLES	System is out of chemi- cals, pumps are non- functional, etc.; chip clearing aborted	Call C. E.
CONDITIONS NOT MET FOR FORMAT MOVE	A hardware malfunction detected with diag- nostic sensing; chip clearing aborted	Call C. E.
FORMAT STATION NOT AT COLUMN ZERO	Format station has made incorrect move; chip clearing aborted	Call C. E.
RECORDER CHIP CLEARING ABORTED	Preceded by message giving reason (see two messages above)	Call C. E.
VACUUM NOT OK FOR DIFFUSION PUMPS	Roughing pump operation is necessary to move format station; chip clearing and format initialization bypassed	Call C. E.
RECORDER FORMAT INITIALIZATION BYPASSED		Call C. E.
RECORDER CHIP CLEAR- ING BYPASSED	Recorder may be in C. E. mode and must still be cleared out	Call C. E.

Messages Transmitted Other Than During Power On

PRESENCE OF CE REQUESTED	A condition that may result in only one module being offline and the rest remaining functional (specific module is identified)	Call C. E.
FILE NUMBER 1 FILE NUMBER 2 FILE NUMBER 3 RECORDER READER NO. 1 READER NO. 2	One of these messages will follow above message	
DISK CALL C.E.	An error (data, seek or parity) in disk operation renders system inoperative	Call C. E.
KEYBOARD PARITY	Characters being transferred internally are not correctly coded	Retype message
	After retyping message, if keyboard parity message again results, system remains operative but must be serviced	Call C.E.
ILLEGAL CHARACTER FROM 1816 KEYBOARD	An illegal character passed parity check but message is now rejected because of illegal character having been typed in	Retype message
SYSTEM READY	System is online	Stand by
ILLEGAL OPERATOR REQUEST	Operator made an error while typing in operator request	Retype message
CE PRESENT SWITCH NOT ON	CE Present switch not set to 1 before C. E. typed in request	Non-operator routine called
ILLEGAL ENTRY	Operator used illegal code to preface message typed in	Retype message using correct code
EQUIPMENT NOT ON LINE	Preceded by name of specific unit, this message indicates that unit is either in CE mode or is physically disconnected	Stand by
TYPEWRITER OUT OF PAPER	1816 has detected that paper is almost depleted	Load more paper and type in REP (replaced paper) on keyboard
FILAMENT 15 EXPENDED CHANGING TO 0 REQUEST NEW FILAMENT TURRET	Electron beam column running out of filaments	Stand by; call C.E. when convenient



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