EXCHANGE COMMUNICATION SPECIFICATIONS

These specifications are the result of several meetings held with representatives of Product Planning, Exchange Design Engineering, Stretch Planning, and Engineering Planning, and contain the agreements reached at those meetings.

A Glossary of Terms will be shortly forthcoming as a supplement to these specifications.

These specifications will become part of a forthcoming set of complete machine specifications.

EXCHANGE COMMUNICATION SPECIFICATIONS

These specifications describe the communications between the Exchange and Computer and the Exchange and External Units. Instructions dealing with External Units are detailed and the formats received by the Exchange are described. The Exchange responses to the various instructions are included. A section of the specifications describes the External Unit Interrupt operation. All control and status wires are named and described. The specifications conclude with a description of the Controls and Lights on various External Units.

I. Computer to Exchange

A. External Unit Instruction Format

Word Address	Second Address	Index Address	Address Designators	Opcode, etc.
20	12	12	3	16

B. External Unit Instructions

1. READ; WRITE

These instructions initiate reading and writing for the specified External Unit. The Word Address specifies the location in memory of the control word to be used by the Exchange in transferring information. The Word Address may be indexed; it may be designated direct or indirect. The External Unit Number is specified by the Second Address, and may be designated direct or indirect.

2. CONTROL

This instruction causes one or more bits from the left end of the Word Address field to be sent to the External Unit as a coded control signal. The Word Address coding determines the specific meaning of the operation, which may include

Space forward

Space backward

Rewind

Double space

Skip

Turn on light

Turn off light

Etc.

The meanings may vary among different External Units, depending on their design.

The Word Address may be indexed, direct or indirect.

3. LOCATE

This instruction causes up to 20 bits of the Word Address field to be sent to the External Unit and used there as an address. The Word Address may be direct or indirect, and indexed.

Principal applications are setting up addresses on disk units, electronic printer-plotters, and automatic tape cartridge changers.

LOCATE resembles WRITE except that no control word is used.

4. DISCONNECT

This instruction forces the specified unit to be disconnected immediately from the Exchange, but any operation already initiated at the unit is completed independently of the Exchange.

The purpose of this instruction is to permit the program to free Exchange and memory facilities when the program has determined that the External Unit should not or cannot complete a transfer of information started by a READ or WRITE instruction.

One application occurs in searching on tapes or disks.

C. Exchange Instructions

1. TRANSMIT

This instruction, when an External Unit is specified in the Second Address, will cause the Exchange to transmit the corresponding control word to the main memory bus. The purpose of this instruction is to allow examination of the control word and status bits contained in the control word.

2. RELATED INSTRUCTIONS

Any arithmetic or similar instruction, whose address part (after indexing) contains an External Unit Number, causes the Exchange to transmit the corresponding control word to the computer. Thus, ordinary instructions can be used at any time to analyze the contents of any control word including the status bits. The computer must translate these instructions into the TRANSMIT format for presentation to the Exchange.

D. Format of Instructions Received by the Exchange

1. READ

Read	I/O Address	Control Word Address
1 Wire	10 Wires	20 Wires

2. WRITE

Write	I/O Address	Control Word Address
1 Wire	10 Wires	20 Wires

3. CONTROL

Control	I/O Address	Control Data
1 Wire	10 Wires	20 Wires

4. LOCATE

Locate	I/O Address	Locate Data
1 Wire	10 Wires	20 Wires

5. TRANSMIT and RELATED INSTRUCTIONS

Transmit	I/O Address	Transmit Address
1 Wire	10 Wires	20 Wires

6. DISCONNECT

Disconnect	I/O Address
1 Wire	10 Wires

E. HOLD INTERRUPT STATUS LINE

The state of the EXTERNAL UNIT INTERRUPT flip-flop will inform the Exchange to either store the interrupt request and conditions in Exchange Memory or in the I/O CONDITION and I/O ADDRESS registers (see External Unit Interrupt, II C).

II. Exchange to Computer

A. Response to External Unit and Exchange Instructions

1. READ, WRITE, LOCATE, CONTROL Instructions.

The Exchange will, depending on the status of an External Unit, send to the computer one of three signals.

    a. ACCEPTED - If the I/O Unit is Ready and not Selected.

    b. REJECT, UNIT SELECTED - If the I/O unit is Selected.

    c. REJECT, UNIT NOT READY - If the I/O unit is not Ready.

The computer will wait until one of the above three signals comes back before proceeding.

2. TRANSMIT and DISCONNECT Instructions

The Exchange will always send back the ACCEPTED signal only. The computer will wait until this signal comes back from the Exchange before proceeding. The ACCEPTED signal, in the Transmit case, will arrive when the actual transmission of the Control Word takes place.

B. Completion of Instructions given to the Exchange

    1. READ, WRITE, LOCATE, CONTROL Instructions

        a. Successful completion of these instructions will cause a
           NORMAL INTERRUPT request.

        b. Unsuccessful completion of these instructions will cause
           an OFF NORMAL INTERRUPT request.

           An example of this is when the Exchange has accepted an
           instruction, but a NOT READY condition occurs before
           a channel is assigned. In this case, a CANCEL INTERRUPT
           request is initiated by the Exchange.

    2. TRANSMIT and Related Instructions

    The control word called for by the instruction will be transmitted
    via the memory bus system to the address specified as part of the
    instruction. An Interrupt request is not made.

        a. Transmitted Control Word Format

G/D	ECC	DWA	WORD CT	CWA	STATUS
1	1	20	15	20	7

           (1) The program can determine from examination of the
               DATA WORD ADDRESS, WORD COUNT, and
               CONTROL WORD ADDRESS the present condition
               of the execution of an instruction.

           (2) The program can determine, from the Status bits
               included, the following (1 condition).

               (a) ASSIGN CHANNEL
                   This bit indicates that the Exchange needs to
                   assign a channel to the unit.

               (b) DATA ERROR
                   This bit indicates that an error exists in main
                   memory in the recently received data, or that
                   an I/O Unit has received an incorrect byte.

(c) NOT READY
This bit indicates that the unit is not in condition to be used by the program due to OUT OF MATERIAL, OFF LINE, CONTROL ERROR, MECHANICAL MALFUNCTION, STACKER FULL, or OPERATOR STOP status having occurred.

(d) SELECT FOR READ
This bit indicates that the unit has been issued a READ instruction.

(e) SELECT FOR WRITE
This bit indicates that the unit has been issued a WRITE instruction.

(f) SELECT FOR CONTROL
This bit indicates that the unit has been issued a CONTROL instruction.

(g) SELECT FOR LOCATE
This bit indicates that the unit has been issued a LOCATE instruction.

3. DISCONNECT Instruction

This instruction, when completed, will cause an OFF NORMAL INTERRUPT request, with CANCEL status.

C. External Unit Interrupt

1. Whenever an END OF MESSAGE, OPERATOR's SIGNAL or CANCEL condition occurs the Exchange will examine a HOLD INTERRUPT STATUS line.

   a. If the line is zero, the External Unit Interrupt Flip-Flop in the computer will be set (turning the above line to its one state), the I/O Unit Address will be sent to an I/O UNIT ADDRESS REGISTER in the computer and the status bits described below (II C2) will be sent to an I/O STATUS CONDITION register.

   b. If the line is one, the Exchange will store the above information in the Exchange memory. A counter, called Exchange MAC, will sequentially scan the Exchange memory control words during EXCHANGE IDLE cycles. Whenever the above conditions (II C1) occur, the Exchange MAC will stop until the HOLD INTERRUPT STATUS line is zero. (Acceptance of interrupt by the computer will set the External Unit Interrupt Flip-Flop to zero.)

2. The following Status bits are sent to the I/O CONDITION register when an Interrupt request is accepted.

    a.   NORMAL

        The computer would normally look only at this status bit. When ON, the Interrupt is considered normal and the rest of the status bits need not be considered. When OFF, the OFF NORMAL condition exists and the rest of the bits below are looked at to interpret the type of OFF NORMAL condition.

    b.   OPERATOR's SIGNAL

        This bit indicates that the operator has requested an Interrupt. This bit is turned on by the OPERATOR's SIGNAL key on the External Unit.

    c.   DATA ERROR

        This bit indicates that the message in main memory has incorrect data, or that an I/O Unit has received an incorrect byte.

    d.   END OF FILE

        This bit indicates that the unit has reached the end of a file of records.

    e.   CANCEL

        This bit indicates that the operator of an External Unit has determined that the partial message already transmitted is in error; that CONTROL ERRORS, IMPROPER INSTRUCTIONS, MECHANICAL MALFUNCTION, OFF LINE conditions have occurred during execution of an instruction; or that a DISCONNECT instruction has been given.

III. Exchange to External Units

    A.   The communications from the Exchange to the External Units shall consist of the following lines:

        1.   CONTROL

            The presence of this bit indicates that the DATA lines contain CONTROL bits obtained from the Central instruction.

2. READ

This line is activated to start the I/O unit into its read operation.

3. WRITE

This line is activated to start the I/O unit into its write operation.

4. DISCONNECT

The presence of this bit will cause cessation of information flow, but the I/O unit will continue to its normal stopping point.

5. LOCATE

This line indicates that the information lines contain address bits obtained from the LOCATE instruction.

6. OUTPUT DATA Lines (9)

These lines contain data to be written, CONTROL bits to be decoded by the I/O unit for control operations, or LOCATE bits to specify addresses. The 9th line is a Parity bit.

IV. External Units to Exchange:

A. Definition of STATUS

Status is defined as discrete events occurring and originating at an I/O unit that must be transmitted to the Exchange and/or computer for information and/or action.

B. The communications from the External Units to the Exchange shall consist of the following lines.

1. BUSY
This line indicates that the External Unit is executing an instruction. Its purpose is to allow better utilization of Exchange channels. An example of its use is in the classic Tape Search problem where only the first few words of a long record on tape have to be read to determine whether the rest of the record is useful. If the decision is negative, a DISCONNECT instruction would allow subsequent SELECTION, but the Exchange would save channel time by not assigning a channel until BUSY disappeared. (See Figure 1.)

2. **READY**

READY status can best be defined by defining conditions that would place this line into its NOT READY state.

a. **OUT OF MATERIAL**
Cards, paper, tape, (both magnetic and paper) film, documents, etc.

b. **STACKER FULL**

c. **OPERATOR STOP**
Depressing of the stop key will cause this condition. Depressing the start key will cause READY if all other READY conditions satisfied.

d. **OFF LINE**
Power off: cable disconnected, etc. An immediate CANCEL would be forced if unit in use.

e. **CONTROL ERROR**
A misinterpreted or misexecuted instruction. (This specifically excludes improper instruction). An immediate CANCEL would be forced if unit in use.

f. **MECHANICAL MALFUNCTION**
Blown fuse, card jam, broken tape, etc. An immediate CANCEL would be forced if unit in use.

3. **OPERATOR's SIGNAL**
When depressed by an operator, a computer interrupt is requested. The interpretation of this signal is left up to the programmer. In effect, this is an "operator's bit".

4. **DATA ERROR**
This bit indicates that an error exists in the transmitted byte.

5. **INPUT DATA Lines (9)**
These lines carry data into the Exchange. The 9th line is a parity bit.

6. **SERVICE REQUEST (TIMING)**
This bit indicates that significant information exists in the rest of the INFORMATION lines. It is used by the Exchange to cause handling of the byte.

7. END OF MESSAGE

This bit indicates that the Exchange is to disconnect the I/O unit from the channel and to request interrupt from the computer. It indicates completion of READ, WRITE, CONTROL, and LOCATE instructions.

8. END OF FILE

9. CANCEL

This bit indicates that the operator wants to initiate termination of an unsuccessful operation or that a CONTROL ERROR, IMPROPER INSTRUCTION, MECHANICAL MALFUNCTION or OFF LINE condition has occurred during instruction execution.

V. Controls and Lights on Input-Output Units

(The following controls and lights apply to card readers, punches, printers, and tape units, with the exception of printer carriages and automatic tape loading devices. Carriage controls are conventional. Tape loading controls have not yet been specified.)

A. CONTROLS

1. OPERATOR's SIGNAL

This key permits an operator to request computer intervention. It causes interrupt of the computer program. It has no direct functions in the input-output unit, although the I/O address is given to the computer.

2. START

This key turns on the READY status if all the necessary operating conditions are satisfied.

3. STOP

This key turns off the READY status when depressed, thus interrupting operation of the unit from the computer after any instruction in progress is executed.

4. LOAD

This key brings the medium (cards or tape) to the proper starting position, provided READY is off (run-in).

5. UNLOAD

This key brings the medium (cards or tape) to the point where it can be manually unloaded (run-out).

6. RESET
This key clears interlocks set by certain of the lights below.

B. LIGHTS

1. READY

2. BUSY

3. OUT OF MATERIAL

4. STACKER FULL

5. OPERATOR STOP

6. POWER ON

7. CONTROL ERROR

8. MECHANICAL MALFUNCTION

9. OPERATOR's SIGNAL

10. DATA ERROR

11. FILE PROTECT

12. RESERVED

This light is turned on and off by the computer program. It has no predetermined meaning, but its main purpose is to notify the operator that the unit has been reserved for use by the computer on a previously assigned program and that it should not be assigned to another program.
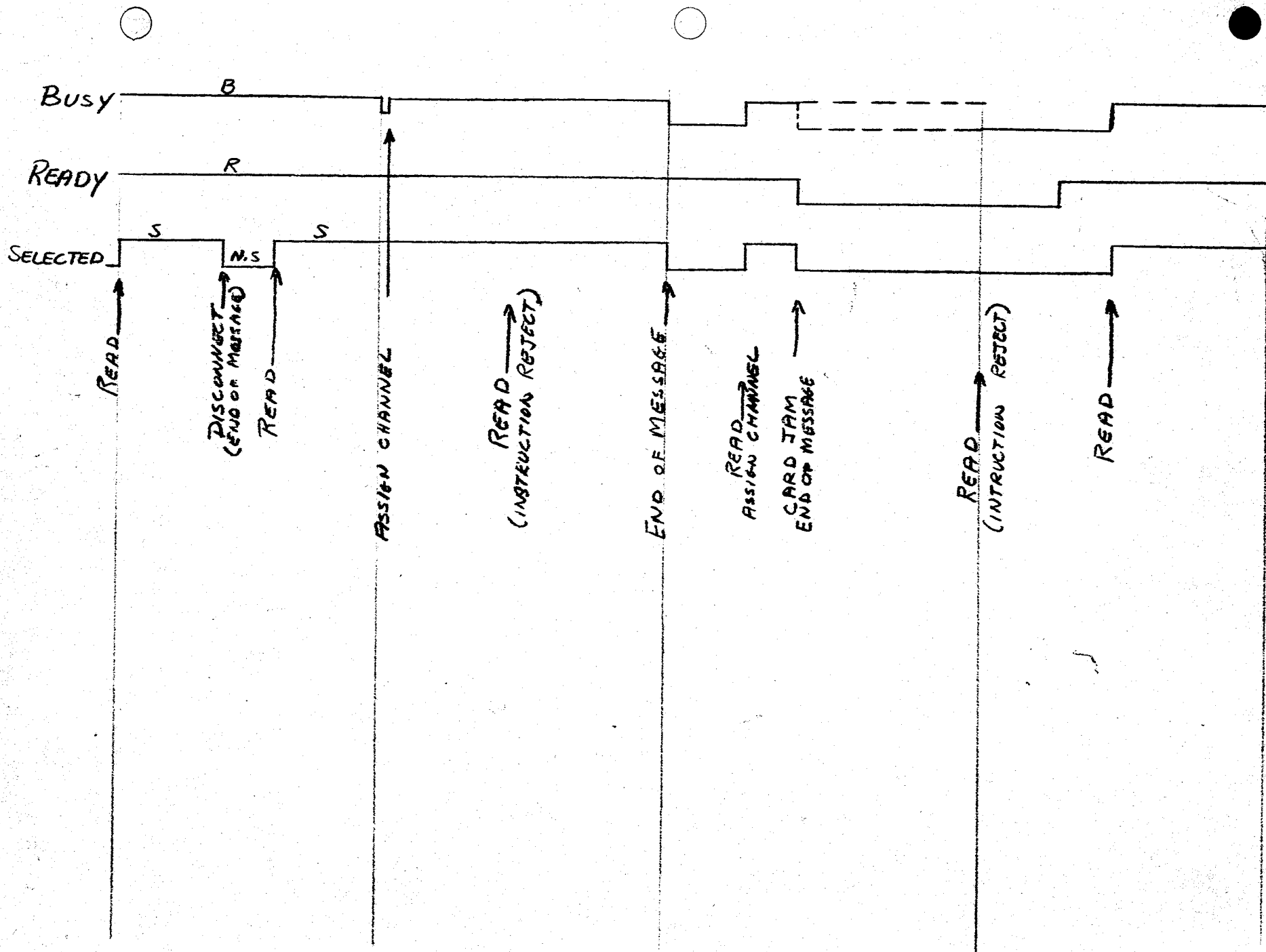
FIGURE ONE

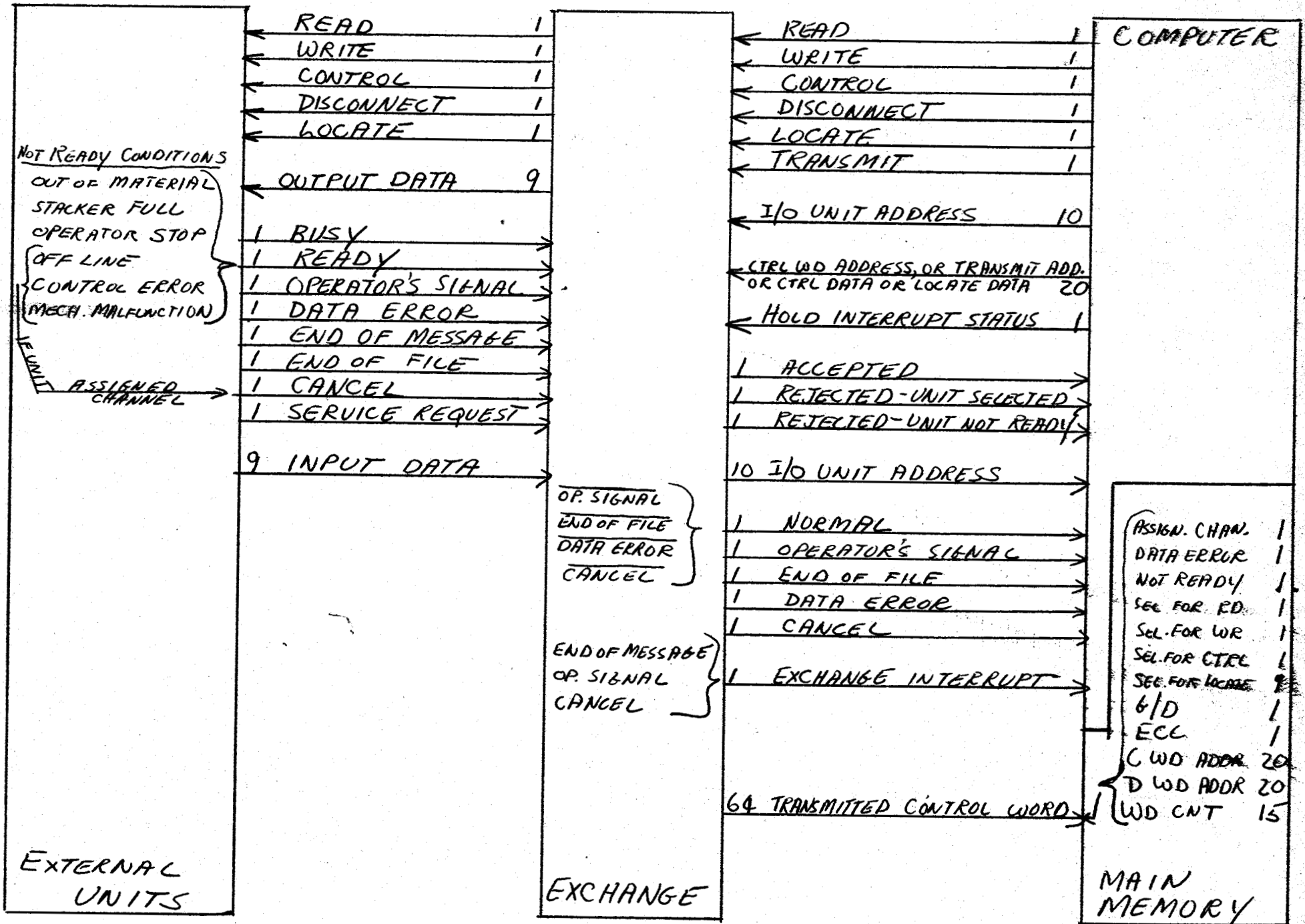POSSIBLE TIMING CONDITIONS

4/9/57

EXCHANGE COMMUNICATIONS

EXTERNAL UNITS

- READ — 1
- WRITE — 1
- CONTROL — 1
- DISCONNECT — 1
- LOCATE — 1
- OUTPUT DATA — 9

NOT READY CONDITIONS
- OUT OF MATERIAL
- STACKER FULL
- OPERATOR STOP
- OFF LINE
- CONTROL ERROR
- MECH. MALFUNCTION

- 1 BUSY
- 1 READY
- 1 OPERATOR'S SIGNAL
- 1 DATA ERROR
- 1 END OF MESSAGE
- 1 END OF FILE
- 1 CANCEL
- 1 SERVICE REQUEST

IF UNIT ASSIGNED CHANNEL

- 9 INPUT DATA

EXCHANGE

OP. SIGNAL / END OF FILE / DATA ERROR / CANCEL
- 1 NORMAL
- 1 OPERATOR'S SIGNAL
- 1 END OF FILE
- 1 DATA ERROR
- 1 CANCEL

END OF MESSAGE / OP. SIGNAL / CANCEL
- 1 EXCHANGE INTERRUPT

COMPUTER

- READ — 1
- WRITE — 1
- CONTROL — 1
- DISCONNECT — 1
- LOCATE — 1
- TRANSMIT — 1
- I/O UNIT ADDRESS — 10
- CTRL WD ADDRESS, OR TRANSMIT ADD. OR CTRL DATA OR LOCATE DATA — 20
- HOLD INTERRUPT STATUS — 1
- 1 ACCEPTED
- 1 REJECTED — UNIT SELECTED
- 1 REJECTED — UNIT NOT READY
- 10 I/O UNIT ADDRESS

- 64 TRANSMITTED CONTROL WORD

MAIN MEMORY

- ASSIGN. CHAN. — 1
- DATA ERROR — 1
- NOT READY — 1
- SEL. FOR RD — 1
- SEL. FOR WR — 1
- SEL. FOR CTRL — 1
- SEL. FOR LOCATE — 1
- G/D — 1
- ECL — 1
- C WD ADDR — 20
- D WD ADDR — 20
- WD CNT — 15

FIGURE 2

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