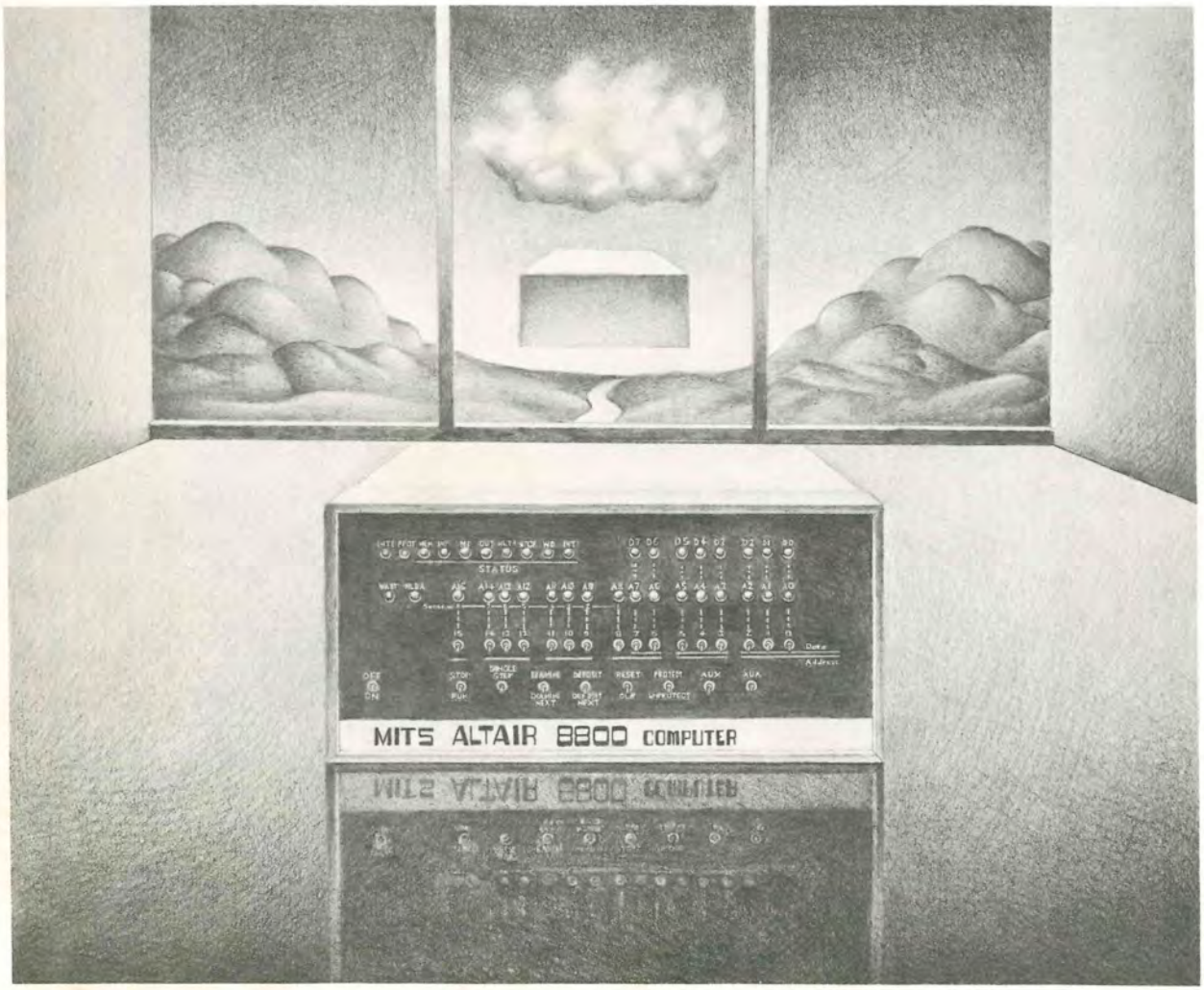
MITS · MOBILE Computer Caravan

WELCOME TO THE

ALTAIR Short Course



YOUR INSTRUCTOR TONIGHT WILL BE:
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INTRODUCTION TO COMPUTER TECHNOLOGY

- 1 COMPUTER ORGANIZATION
- 2 NUMBER SYSTEMS
- 3 BASIC LOGIC CIRCUITRY
- 4 PROGRAMMING CONCEPTS

HARDWARE

- 1 ALTAIR ORGANIZATION
- 2 I/O STRUCTURE
- 3 INTERFACING TECHNIQUES

SOFTWARE (VARIABLE HARDWARE)

- 1 PROGRAMMING TECHNIQUES
- 2 ASSEMBLY LANGUAGE
- 3 "BASIC" LANGUAGE

1 COMPUTER FUNDAMENTALS

2 HARDWARE

3 SOFTWARE

ALTAIR SHORT COURSE HOUR ONE

COMPUTER STRUCTURE

MEMORY

I/O

SOFTWARE

MEMORY (65K WORDS IN ALTAIR)

1 STORES INSTRUCTIONS

2 STORES DATA

INPUT/OUTPUT (I/O)

256 I/O POSSIBLE IN ALTAIR

CENTRAL PROCESSING UNIT (CPU)

1 PERFORMS LOGICAL OPERATIONS

2 SUPPLIES ADDRESSES

3 PERFORMS ARITHMETIC OPERATIONS

4 MANY OTHER THINGS

BUZZ WORDS

BIT	WORD
BYTE	CPU
ADDRESS	I/O
MEMORY	BUS
REGISTER	DATA

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BINARY NUMBERS

2 DIGITS IN BINARY

"1" AND "0"

WITH ELECTRONIC CIRCUTS, IT IS EASY TO ACHIEVE ON OR OFF, IE

1 OR 0

"0" = 0 VOLTS (FALSE)

"1" = 3 VOLTS (TRUE)

BINARY TO DECIMAL CONVERSION

100 10 1

7 5 2

700 + 50 + 2

32 16 8 4 2 1

1 0 0 1 0 1 =37

1 1 0 1 1 0 =54

1 0 0 1 =9

1 1 0 =6

BINARY ADDITION

$$\begin{array}{r} 0 \\ +0 \\ \hline 0 \end{array} \qquad \begin{array}{r} 0 \\ +1 \\ \hline 1 \end{array}$$

$$\begin{array}{r} 1 \\ +0 \\ \hline 1 \end{array} \qquad \begin{array}{r} 1 \\ +1 \\ \hline 10 \end{array}$$

$$\begin{array}{r} 1\ 1\ 1 \\ +1\ 1\ 0 \\ \hline 1\ 1\ 1\ 1 \end{array} \qquad \begin{array}{r} 1\ 1\ 1 \\ +1\ 0\ 1 \\ \hline 1\ 1\ 0\ 0 \end{array}$$

$$\begin{array}{r} 1\ 1\ 0\ 1\ 1\ 0\ 1\ 0 \\ +1\ 0\ 0\ 1\ 0\ 0\ 1\ 1 \\ \hline 1\ 0\ 1\ 1\ 0\ 1\ 1\ 0\ 1 \end{array}$$

BINARY TO OCTAL CONVERSION

```
   11  101  110                    10  011  100
    3    5    6                     2    3    4

   01  111  001                    11  010  110
    1    7    1                     3    2    6
```

BINARY CODED DECIMAL

BCD

BCD CONVERSIONS ARE USEFUL WHEN
MAKING NUMERICAL DISPLAYS

```
0000 =0                    0101 =5

0001 =1                    0110 =6

0010 =2                    0111 =7

0011 =3                    1000 =8

0100 =4                    0110 =9
```

DAA COMMAND IN ALTAIR CONVERTS
BINARY TO BCD

LOGIC CIRCUITS

LOGIC CIRCUITS CAN:

ADD

SUBTRACT

MAKE DECISIONS

AND MANY OTHER THINGS

GATING CIRCUITS

FLIP-FLOPS

BISTABLE

MONOSTABLE

DECODING CIRCUITS

THE NUMBER OF POSSIBILITIES

2 (RAISED TO THE NUMBER OF BITS)

EXAMPLES

8 BITS =256

16 BITS =65,536

COMPUTER PROGRAMMING

1 DEFINE PROBLEM (90%)

2 ORGANIZE LOGICALLY (7%)

3 CODING (3%)

PAYROLL CONSIDERATIONS

HOURS WORKED

OVERTIME

GROSS PAY

STATE TAX

NET PAY

INSURANCE

U.S. BONDS

WORKMANS COMP

FEDERAL TAX

ALTAIR SHORT COURSE HOUR TWO

FRONT PANEL

BUS

I/O

MEMORY

CPU

MASS MEMORY

INTERFACING THE ALTAIR

CPU

CLOCK (2MEG. HERTZ)

2 PHASE

INTERRUPT

READY

STATUS LATCH

MI — $\overline{WO}$

IN — OUT

MEMR

FRONT PANEL

DATA INDICATORS

ADDRESS INDICATORS

RUN

STOP

SINGLE STEP

EXA

EXAMINE

EXAMINE NEXT

DEPOSIT

DEPOSIT NEXT

PROTECT

UNPROTECT

EXT, CLEAR

AUX

SENSE SWITCHES

INP 255

MEMORY

1 1K BYTES

2 2K BYTES

3 4K BYTES

TYPES

1 STATIC MEMORY

2 DYNAMIC MEMORY

3 ROM

4 PROM

USING SLOW MEMORY

NEW PRODUCTS

INPUT/OUTPUT

SERIAL I/O

UART

PARALLEL I/O (LATCH)

NEW PRODUCTS

1 4 CHANNELS PARALLEL

2 2 SERIAL CHANNELS

3 BAUDOT TTY INTERFACE

MASS MEMORY

AUDIO TAPE INTERFACE

1 INEXPENSIVE

2 50K BYTES STORAGE

3 LIMITED SEARCH CAPABILITY

4 SLOW

FLOPPY DISC — NOT IBM COMPATIBLE

1 STORES 315K BYTES

2 LOW COST

3 RELATIVELY FAST

NEW PRODUCTS

HIGH SPEED TAPE (3M TYPE)

CARTRIDGE DISK

9 TRACK TAPE — IBM COMPATIBLE

INTERFACING

ADDRESS SELECTION

IN-OUT SELECTION

LATCHING

GENERAL I/O SELECTION

AND ADDRESSING

ADDRESSING

I/O SELECTION

LATCHING DATA

PRECAUTIONS

1 POWER SUPPLY LOADING — 600 MA / CARD

2 STATIC ELECTRICITY

3 BUS LOADING — 1 LOW POWER TTL / CARD

4 USE OF READY

POWER OFF BEFORE PULLING ANY CARDS

ALTAIR SHORT COURSE HOUR THREE

SOFTWARE

GENERAL PRINCIPLES

MACHINE LANGUAGE

ASSEMBLY LANGUAGE

BASIC LANGUAGE

BASIC LANGUAGE

CALAULATOR MODE

```
? 2+2
4

?(1+3)*(4-3)
4

? 2/4
.5

? ((2+3) * (1-7)) / (2+3)
-6
```

SIN (X)

COS (X)

RND (X)

TAN (X)

SQR (X)

LOG (X)

EXP (X)

X ↑ Y

ATN (X)

INT (X)

VARIABLES

A-Z

A0, A9 - Z0, Z9

AA, AZ - ZA, ZZ

ASSEMBLY LANGUAGE

LABELS

MNEMONIC CODES

OPERAND

COMMENTS

```
LOOP LDAX   D                       LOAD A WITH (DE)
```

MACHINE LANGUAGE

ADD (208)

SUB (229)

MOV (105)

JMP (303)

LDA (072)

STA (062)

CALL (315)

RAR (037)

RST (3A7)

```
RT= (R1 * R2) / (R1 + R2)
10 INPUT R1, R2
20 RT= (R1 * R2) / (R1 + R2)
30 PRINT RT

RUN
?1
?2
.666667
10 INPUT R1, R2
20 RT= (R1 * R2) / (R1 + R2)
30 PRINT RT
40 GO TO 10

RUN
?1
?2
.666667
?2
?3
1.2

10 FOR I=1 TO 5
20 PRINT 2↑ I
30 NEXT

RUN
```

```
     2
     4
     8
    16
    32
GO SUB
RETURN

IF STATEMENTS
10 IF A> B THEN GO TO 450
10 X=INP  (I)
20 OUT I,J

LOGICAL STATEMENTS
AND, OR, NOT

STRING VARIABLES
10 N$= "NAME"
20 PRINT N$
RUN
NAME

MULTIPLE STATEMENTS PER LINE
     10 FOR I=1 TO 10; PRINT I; NEXT I
N DIMENSION ARRAYS
     BOTH NUMERIC AND STRING

     PEEK, POKE
```

COMPARED TO

HP

DG

DEC

DECISION

THANK YOU

CRITIQUE

OCTAL PROGRAM SET 8800

RETURNS		STACK		INPUT		MACHINE		ADD PAIRS	
RET	311	POP B	301	IN	333	HLT	166	DAD B	011
RNZ	300	POP D	321	B_2		NOP	000	DAD D	031
RZ	310	POP H	341	OUTPUT		DI	363	DAD H	051
RNC	320	POP SW	361	OUT	323	EI	373	DAD SP	071
RC	330	PUSH B	305	B_2		SHIFTS		SET PAIRS	
RPO	340	PUSH D	325	XCHG	353	RLC	007	STAX B	002
RPE	350	PUSH H	345	XTHL	343	RRC	017	STAX D	022
RP	360	PUSH SW	365	SPHL	371	RAL	027	LDAX B	012
RM	370			PCHL	351	RAR	037	LDAX D	032

JUMPS		CALLS		REGISTERS		ACCUMULATOR		LOAD IMMED PAIR	
JMP	303	CALL	315	ADDR r	20S	ADI	306	LXI B	001
B_2	< >	B_2	< >	ADC r	21S	B_2	< >	B_2	< >
B_3	< >	B_3	< >	SUB r	22S	ACI	316	B_3	< >
JNZ	302	CNZ	304	SBB r	23S	B_2	< >	LXI D	021
B_2	< >	B_2	< >	ANA r	24S	SUI	326	B_2	< >
B_3	< >	B_3	< >	XRA r	25S	B_2	< >	B_3	< >
JZ	312	CZ	314	ORA r	26S	SBI	336	LXI H	041
B_2	< >	B_2	< >	CMP r	27S	B_2	< >	B_2	< >
B_3	< >	B_3	< >	INCREMENT ±		ANI	346	B_3	< >
JNC	322	CNC	324	INR r	0S4	B_2	< >	LXI SP	061
B_2	< >	B_2	< >	DECREMENT		XRI	356	B_2	< >
B_3	< >	B_3	< >	DCR r	0S5	B_2	< >	B_3	< >
JC	332	CC	334	MOVES ↔		ORI	366	INCR PAIR	
B_2	< >	B_2	< >	MOV r_1r_2	1DS	B_2	< >	INX B	003
B_3	< >	B_3	< >	MVI r	0D6	CPI	376	INX D	023
JPO	342	CPO	344	B_2		B_2	< >	INX H	043
B_2	< >	B_2	< >	VALUES FOR		DIRECT		INX SP	063
B_3	< >	B_3	< >	S & D		STA	062	DECR PAIR	
JPE	352	CPE	354	B = 0		B_2	< >	DCX B	013
B_2	< >	B_2	< >	C = 1		B_3	< >	DCX D	033
B_3	< >	B_3	< >	D = 2		LDA	072	DCX H	053
JP	362	CP	364	E = 3		B_2	< >	DCX SP	073
B_2	< >	B_2	< >	H = 4		B_3	< >	SHLD	042
B_3	< >	B_3	< >	L = 5		DAA	047	B_2	< >
JM	372	CM	374	M = 6		CMA	057	B_3	< >
B_2	< >	B_2	< >	A = 7		STC	067	LHLD	052
B_3	< >	B_3	< >			CMC	077	B_2	< >
						RST	3A7	B_3	< >

B_2 = byte two B_3 = byte three

S = source D = destination

SOFTWARE INFORMATION PACKAGE

The MITS system software consists of three packages, an assembly language development system (called Package I), a machine language debugging package (DBG-8800) and ALTAIR BASIC.

These three packages operate in a stand-alone environment i.e. without disk or other high speed random access storage device. I/O devices supported are asynchronous serial ASCII terminals, parallel ASCII terminals (such as TVT's) and the ACR (cassette) interface board.

Two disk based systems are now under development and should be ready by mid-December. These are Extended BASIC and the DOS. Extended BASIC and the DOS both use the same file structure I/O code; Extended BASIC is an advanced BASIC interpreter while the DOS package is a disk based assembly language development system.

Here is an overview of the features of the packages currently available:

Package I
(System Monitor, Editor & Assembler)

System Monitor - 2K Bytes

Contains I/O drivers for system console, ACR board (supports multiple files on one cassette). Loads programs from paper tape or cassette.

Text Editor - 2K bytes

Facilitates editing of source programs. The editor is line oriented, that is, commands always reference a line or group of lines.

Commands:

- P - Print Lines
- I - Insert Lines
- D - Delete Lines
- R - Replace Lines
- E - Exit to Monitor
- A - Alter a line. Enables user to change, delete or insert minor changes in an already existing line.

F String - Searches from the current line forward for an occurance of the character string given as its argument.

Relative addressing is allowed. P.+6 would print the sixth line after the current one.

Line Feed - Prints and moves the current line pointer to the next line.

Escape - Prints and moves current line pointer to line before current one.

S - Saves File.
L - Loads a File.

Assembler - 3K Bytes

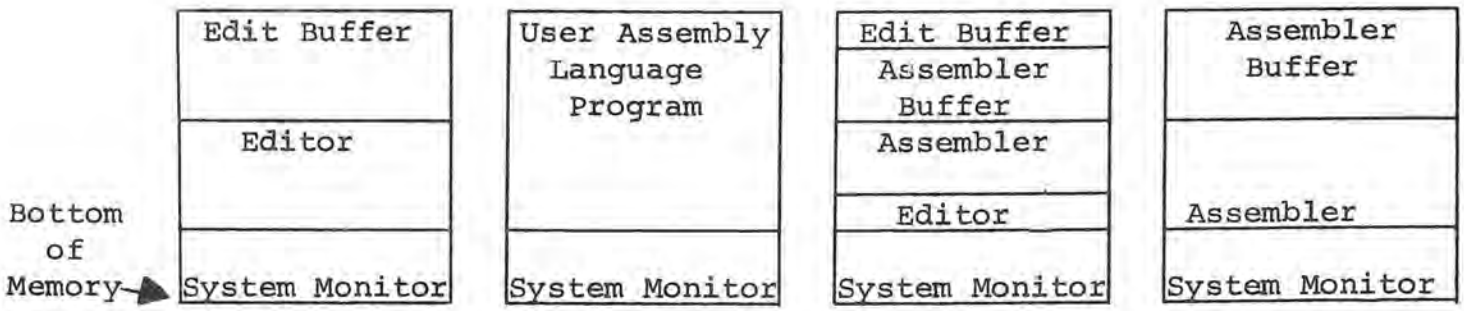
The ALTAIR loading assembler assembles a source program in one pass from paper tape, cassette or from the current Editor buffer. Object code is stored directly into memory as assembly progresses.

Since the assembler is one pass, it is possible to avoid the time consuming process of re-reading source tapes more than once, which is the case with multi-pass assemblers. Also, if the program being assembled resides in the edit buffer, assembly is almost instantaneous and the user may immediately correct and re-assemble his program.

Features not provided by the ALTAIR assembler:

- Conditional Assembly
- Macros
- Cross Reference Listing

ALTERNATIVE MEMORY MAPS FOR PACKAGE I



NOTE: Package I can use all available memory. A minimum of 8K is necessary, but any extra memory may be allocated for Package I buffer or program storage.

DEBUG CAPABILITIES OF DBG-8800
2K Bytes

Examine/Modify Commands

A location to be examined can be specified by an octal address, a register name (A,B,C,D,E,H,L, or S for status word), or a period to indicate the address in the current address pointer. In addition a location can be specified with any of the above forms but with a + or - octal offset (e.g. .+7).

The specified location can be examined by typing a / after it. A / causes the following:

- Type the specified (and possibly following locations) in accordance with the current I/O mode.
- Open location(s) for modification.
- A carriage return will close the location.
- A line feed will print the address and contents of the next memory location(s) (depending on I/O mode).
- ↑ acts as a line feed but goes to previous instead of next location(s).
- ; causes contents to typed in octal regardless of I/O mode.
- A tab (control I) will open for examination the address associated with a previously displayed symbolic 3-byte instruction.
- Otherwise input information will be accepted to modify the contents of the current location. Input data must conform to the specified I/O mode.
- A rubout typed at any time will cause input to the current line to be aborted, and a new line will be started.

I/O modes can be respecified at any time by typing an escape followed by one of the following characters:

O	(octal)
A	(ASCII)
S	(symbolic) (instruction format)
W	(two-byte words)
D	(decimal)

Execution Commands

An address (as specified above) if followed by a G will cause execution of the user program to begin at the specified address.

A P will cause execution of the user program to proceed from the most recently encountered break point. An octal number can precede a P to indicate the number of breakpoints that the user wishes to pass over before finally returning control to DEBUG.

Breakpoint Commands

There are 8 possible breakpoints (numbered 0 thru 7). To set a breakpoint an address is followed by an X. The first free breakpoint will be set.

A Y is typed to remove all breakpoints.

A Q will cause a table of all set breakpoints to be displayed.

Memory Block Commands

The contents of a block of memory can be displayed by typing a command of the form:

(ADDRESS A),(ADDRESS B)T

This command will cause memory contents beginning with (ADDRESS A) and ending with (ADDRESS B) to be displayed in the current I/O mode.

8K BASIC

ALTAIR BASIC (Version 3.1) requires a minimum of 6K bytes of memory.

Features not normally found in BASIC include Boolean operators (AND, OR, NOT) which can be used in IF statements or for bit manipulation, INP and OUT which can read or write a byte from any I/O port, and PEEK and POKE to read or write a byte from any memory location. Variable length strings (up to 255 characters) are provided, as well as the LEFT$, RIGHT$ and MID$ functions to take substrings of strings, a concatenation operator and VAL and STR$ to convert between strings and numbers. Number representation is 32 bit floating point. Both string and numeric arrays of up to 30 dimensions may be used, and can be allocated dynamically during program execution. Nesting of loops and subroutine calls is limited only by available memory. Intrinsic functions are SIN, COS, TAN, LOG, EXP, SQR, SGN, ABS, INT, FRE, RND and POS, in addition to TAB and SPC in PRINT statements.

Other important features are direct execution of statements, multiple statements per line, and the abiltiy to interrupt program execution and then continue after the examination of variable values.

For the MITS' line of ALTAIR microcomputers, 8K BASIC costs $75 with the pruchase of 8K memory and an I/O interface board.

4K BASIC

The 4K version of BASIC, with less features than 8K BASIC, costs $60 for ALTAIR owners with 4K memory and an I/O board.

The features of 4K BASIC are a subset of those of 8K BASIC. Main restrictions are:

- No strings.
- Matrices of only one dimension.
- Math functions are ABS, INT, SQR, RND, SIN, SGN
- No AND, OR, NOT
- No PEEK, POKE, INP, OUT
- No interrupt response subroutines.
- No ON...GOTO, ON...GOSUB
- No CONTinue command.

NOTE: it is often advantageous to run 4K BASIC in an 8K ALTAIR if you have a long program or a program that uses large single dimensioned arrays.

BASIC LANGUAGE

REFERENCE

MATERIAL

MITS
"Creative Electronics"

COMMANDS

A command is usually given after BASIC has typed OK. This is called the "Command Level". Commands may be used as program statements. Certain commands, such as LIST, NEW and CLOAD will terminate program execution when they finish.

NAME	EXAMPLE	PURPOSE/USE
CLEAR	*(SEE PAGE 42 FOR EXAMPLES AND EXPLANATION)	
LIST	LIST LIST 100	Lists current program optionally starting at specified line. List can be control-C'd (BASIC will finish listing the current line)
NULL	NULL 3	(Null command only in 8K version, but paragraph applicable to 4K version also) Sets the number of null (ASCII 0) characters printed after a carriage return/line feed. The number of nulls printed may be set from 0 to 71. This is a must for hardcopy terminals that require a delay after a CRLF*. It is necessary to set the number of nulls typed on CRLF to 0 before a paper tape of a program is read in from a Teletype *(TELETYPE is a registered trademark of the TELETYPE CORPORATION)*. In the 8K version, use the null command to set the number of nulls to zero. In the 4K version, this is accomplished by patching location 46 octal to contain the number of nulls to be typed plus 1. (Depositing a 1 in location 46 would set the number of nulls typed to zero.) When you punch a paper tape of a program using the list command, null should be set >=3 for 10 CPS terminals, >=6 for 30 CPS terminals. When not making a tape, we recommend that you use a null setting of 0 or 1 for Teletypes, and 2 or 3 for hard copy 30 CPS terminals. A setting of 0 will work with Teletype compatible CRT's.
RUN	RUN	Starts execution of the program currently in memory at the lowest numbered statement. Run deletes all variables (does a CLEAR) and restores DATA. If you have stopped your program and wish to continue execution at some point in the program, use a direct GOTO statement to start execution of your program at the desired line.

*CRLF=carriage return/line feed

	RUN 200	(8K version only) optionally starting at the specified line number
NEW	NEW	Deletes current program and all variables

THE FOLLOWING COMMANDS ARE IN THE 8K VERSION ONLY

CONT	CONT	Continues program execution after a control/C is typed or a STOP statement is executed. You cannot continue after any error, after modifying your program, or before your program has been run. One of the main purposes of CONT is debugging. Suppose at some point after running your program, nothing is printed. This may be because your program is performing some time consuming calculation, but it may be because you have fallen into an "infinite loop". An infinite loop is a series of BASIC statements from which there is no escape. The ALTAIR will keep executing the series of statements over and over, until you intervene or until power to the ALTAIR is cut off. If you suspect your program is in an infinite loop, type in a control/C. In the 8K version, the line number of the statement BASIC was executing will be typed out. After BASIC has typed out OK, you can use PRINT to type out some of the values of your variables. After examining these values you may become satisfied that your program is functioning correctly. You should then type in CONT to continue executing your program where it left off, or type a direct GOTO statement to resume execution of the program at a different line. You could also use assignment (LET) statements to set some of your variables to different values. Remember, if you control/C a program and expect to continue it later, you must not get any errors or type in any new program lines. If you do, you won't be able to continue and will get a "CN" (continue not) error. It is impossible to continue a direct command. CONT always resumes execution at the next statement to be executed in your program when control/C was typed.

THE FOLLOWING TWO COMMANDS ARE AVAILABLE IN THE 8K CASSETTE VERSION ONLY

CLOAD	CLOAD P	Loads the program named P from the cassette tape. A NEW command is automatically done before the CLOAD command is executed. When done, the CLOAD will type out OK as usual. The one-character program designator may be any printing character. CSAVE and CLOAD use I/O ports 6 & 7. See Appendix I for more information.
CSAVE	CSAVE P	Saves on cassette tape the current program in the ALTAIR's memory. The program in memory is left unchanged. More than one program may be stored on cassette using this command. CSAVE and CLOAD use I/O ports 6 & 7. See Appendix I for more information

OPERATORS

SYMBOL	SAMPLE STATEMENT	PURPOSE/USE
=	A=100 LET Z=2.5	Assigns a value to a variable The LET is optional
-	B=-A	Negation. Note that 0-A is subtraction, while -A is negation.
↑ *(usually a shift/N)*	130 PRINT X↑3	Exponentiation (8K version) (equal to X*X*X in the sample statement) 0↑0=1 0 to any other power = 0 A↑B, with A negative and B not an integer gives an FC error.
*	140 X=R*(B*D)	Multiplication
/	150 PRINT X/1.3	Division
+	160 Z=R+T+Q	Addition
-	170 J=100-I	Subtraction

RULES FOR EVALUATING EXPRESSIONS:

1) Operations of higher precedence are performed before operations of lower precedence. This means the multiplication and divisions are performed before additions and subtractions. As an example, 2+10/5 equals 4, not 2.4. When operations of equal precedence are found in a formula, the left hand one is executed first: 6-3+5=8, not -2.

2) The order in which operations are performed can always be specified explicitly through the use of parentheses. For instance, to add 5 to 3 and then divide that by 4, we would use (5+3)/4, which equals 2. If instead we had used 5+3/4, we would get 5.75 as a result (5 plus 3/4).

The precedence of operators used in evaluating expressions is as follows, in order beginning with the highest precedence:
(Note: Operators listed on the same line have the same precedence.)

1) FORMULAS ENCLOSED IN PARENTHESIS ARE ALWAYS EVALUATED FIRST

2) ↑ EXPONENTIATION *(8K VERSION ONLY)*

3) NEGATION -X WHERE X MAY BE A FORMULA

4) * / MULTIPLICATION AND DIVISION

5) + - ADDITION AND SUBTRACTION

6) RELATIONAL OPERATORS: *(equal precedence for all six)*

=	EQUAL
<>	NOT EQUAL
<	LESS THAN
>	GREATER THAN
<=	LESS THAN OR EQUAL
>=	GREATER THAN OR EQUAL

(8K VERSION ONLY) *(These 3 below are Logical Operators)*

7) NOT LOGICAL AND BITWISE "NOT"
LIKE NEGATION, NOT TAKES ONLY THE FORMULA TO ITS RIGHT AS AN ARGUMENT

8) AND LOGICAL AND BITWISE "AND"

9) OR LOGICAL AND BITWISE "OR"

In the 4K version of BASIC, relational operators can only be used once in an IF statement. However, in the 8K version a relational expression can be used as part of any expression.

Relational Operator expressions will always have a value of True (-1) or a value of False (0). Therefore, (5=4)=0, (5=5)=-1, (4>5)=0, (4<5)=-1, etc.

The THEN clause of an IF statement is executed whenever the formula after the IF is <u>not</u> equal to 0. That is to say, IF X THEN... is equivalent to IF X<>0 THEN... .

SYMBOL	SAMPLE STATEMENT	PURPOSE/USE
=	10 IF A=15 THEN 40	Expression Equals Expression
<>	70 IF A<>0 THEN 5	Expression Does Not Equal Expression
>	30 IF B>100 THEN 8	Expression Greater Than Expression
<	160 IF B<2 THEN 10	Expression Less Than Expression
<=,=<	180 IF 100<=B+C THEN 10	Expression Less Than Or Equal To Expression
>=,=>	190 IF Q=>R THEN 50	Expression Greater Than Or Equal To Expression
AND	2 IF A<5 AND B<2 THEN 7	*(8K Version only)* If expression 1 (A<5) AND expression 2 (B<2) are both true, then branch to line 7
OR	IF A<1 OR B<2 THEN 2	*(8K Version only)* If either expression 1 (A<1) OR expression 2 (B<2) is true, then branch to line 2
NOT	IF NOT Q3 THEN 4	*(8K Version only)* If expression "NOT Q3" is true (because Q3 is false), then branch to line 4 *Note: NOT -1=0 (NOT true=false)*

AND, OR and NOT can be used for bit manipulation, and for performing boolean operations.

These three operators convert their arguments to sixteen bit, signed two's, complement integers in the range -32768 to +32767. They then perform the specified logical operation on them and return a result within the same range. If the arguments are not in this range, an "FC" error results.

The operations are performed in bitwise fashion, this means that each bit of the result is obtained by examining the bit in the same position for each argument.

The following truth table shows the logical relationship between bits:

OPERATOR	ARG. 1	ARG. 2	RESULT
AND	1	1	1
	0	1	0
	1	0	0
	0	0	0

(cont.)

OPERATOR	ARG. 1	ARG. 2	RESULT
OR	1	1	1
	1	0	1
	0	1	1
	0	0	0
NOT	1	-	0
	0	-	1

EXAMPLES: *(In all of the examples below, leading zeroes on binary numbers are not shown.)*

63 AND 16=16	Since 63 equals binary 111111 and 16 equals binary 10000, the result of the AND is binary 10000 or 16.
15 AND 14=14	15 equals binary 1111 and 14 equals binary 1110, so 15 AND 14 equals binary 1110 or 14.
-1 AND 8=8	-1 equals binary 1111111111111111 and 8 equals binary 1000, so the result is binary 1000 or 8 decimal.
4 AND 2=0	4 equals binary 100 and 2 equals binary 10, so the result is binary 0 because none of the bits in either argument match to give a 1 bit in the result.
4 OR 2=6	Binary 100 OR'd with binary 10 equals binary 110, or 6 decimal.
10 OR 10=10	Binary 1010 OR'd with binary 1010 equals binary 1010, or 10 decimal.
-1 OR -2=-1	Binary 1111111111111111 (-1) OR'd with binary 1111111111111110 (-2) equals binary 1111111111111111, or -1.
NOT 0=-1	The bit complement of binary 0 to 16 places is sixteen ones (1111111111111111) or -1. Also NOT -1=0.
NOT X	NOT X is equal to -(X+1). This is because to form the sixteen bit two's complement of the number, you take the bit (one's) complement and add one.
NOT 1=-2	The sixteen bit complement of 1 is 1111111111111110, which is equal to -(1+1) or -2.

A typical use of the bitwise operators is to test bits set in the ALTAIR's inport ports which reflect the state of some external device.

Bit position 7 is the most significant bit of a byte, while position 0 is the least significant.

For instance, suppose bit 1 of I/O port 5 is 0 when the door to Room X is closed, and 1 if the door is open. The following program will print "Intruder Alert" if the door is opened:

```
10 IF NOT (INP(5) AND 2) THEN 10
20 PRINT "INTRUDER ALERT"
```

This line will execute over and over until bit 1 (masked or selected by the 2) becomes a 1. When that happens, we go to line 20 .

Line 20 will output "INTRUDER ALERT".

However, we can replace statement 10 with a "WAIT" statement, which has exactly the same effect.

```
10 WAIT 5,2
```

This line delays the execution of the next statement in the program until bit 1 of I/O port 5 becomes 1. The WAIT is much faster than the equivalent IF statement and also takes less bytes of program storage.

The ALTAIR's sense switches may also be used as an input device by the INP function. The program below prints out any changes in the sense switches.

```
10 A=300:REM SET A TO A VALUE THAT WILL FORCE PRINTING
20 J=INP(255):IF J=A THEN 20
30 PRINT J;:A=J:GOTO 20
```

The following is another useful way of using relational operators:

```
125 A=-(B>C)*B-(B<=C)*C
```

This statement will set the variable A to MAX(B,C) = the larger of the two variables B and C.

STATEMENTS

Note: In the following description of statements, an argument of V or W denotes a numeric variable, X denotes a numeric expression, X$ denotes a string expression and an I or J denotes an expression that is truncated to an integer before the statement is executed. Truncation means that any fractional part of the number is lost, e.g. 3.9 becomes 3, 4.01 becomes 4.

An expression is a series of variables, operators, function calls and constants which after the operations and function calls are performed using the precedence rules, evaluates to a numeric or string value.

A constant is either a number (3.14) or a string literal ("FOO").

NAME	EXAMPLE	PURPOSE/USE
DATA	10 DATA 1,3,-1E3,.04	Specifies data, read from left to right. Information appears in data statements in the same order as it will be read in the program. IN THE 4K VERSION OF BASIC, DATA STATEMENTS MUST BE THE FIRST STATEMENTS ON A LINE. Expressions may also appear in the 4K version data statements.
	20 DATA " F00",Z00	*(8K Version)* Strings may be read from DATA statements. If you want the string to contain leading spaces (blanks), colons (:) or commas (,), you must enclose the string in double quotes. It is impossible to have a double quote within string data or a string literal. (""MITS"" is illegal)
DEF	100 DEF FNA(V)=V/B+C	*(8K Version)* The user can define functions like the built-in functions (SQR, SGN, ABS, etc.) through the use of the DEF statement. The name of the function is "FN" followed by any legal variable name, for example: FNX, FNJ7, FNKO, FNR2. User defined functions are restricted to one line. A function may be defined to be any expression, but may only have one argument. In the example B & C are variables that are used in the program. Executing the DEF statement defines the function. User defined functions can be redefined by executing another DEF statement for the same function. User defined string functions are not allowed. "V" is called the dummy variable.
	110 Z=FNA(3)	Execution of this statement following the above would cause Z to be set to 3/B+C, but the value of V would be unchanged.
DIM	113 DIM A(3),B(10)	Allocates space for matrices. All matrix elements are set to zero by the DIM statement.
	114 DIM R3(5,5),D$(2,2,2)	*(8K Version)* Matrices can have more than one dimension. Up to 255 dimensions are allowed, but due to the restriction of 72 characters per line the practical maximum is about 34 dimensions.
	115 DIM Q1(N),Z(2*I)	Matrices can be dimensioned dynamically during program execution. If a matrix is not explicitly dimensioned with a DIM statement, it is assumed to be a single dimensioned matrix of whose single subscript

		may range from 0 to 10 (eleven elements).
	117 A(8)=4	If this statement was encountered before a DIM statement for A was found in the program, it would be as if a DIM A(10) had been executed previous to the execution of line 117. All subscripts start at zero (0), which means that DIM X(100) really allocates 101 matrix elements.
END	999 END	Terminates program execution without printing a BREAK message. (see STOP) CONT after an END statement causes execution to resume at the statement after the END statement. END can be used anywhere in the program, and is optional.
FOR	300 FOR V=1 TO 9.3 STEP .6	(see NEXT statement) V is set equal to the value of the expression following the equal sign, in this case 1. This value is called the initial value. Then the statements between FOR and NEXT are executed. The final value is the value of the expression following the TO. The step is the value of the expression following STEP. When the NEXT statement is encountered, the step is added to the variable.
	310 FOR V=1 TO 9.3	If no STEP was specified, it is assumed to be one. If the step is positive and the new value of the variable is <= the final value (9.3 in this example), or the step value is negative and the new value of the variable is => the final value, then the first statement following the FOR statement is executed. Otherwise, the statement following the NEXT statement is executed. All FOR loops execute the statements between the FOR and the NEXT at least once, even in cases like FOR V=1 TO 0.
	315 FOR V=10*N TO 3.4/Q STEP SQR(R)	Note that expressions (formulas) may be used for the initial, final and step values in a FOR loop. The values of the expressions are computed only once, before the body of the FOR....NEXT loop is executed.

```
320 FOR V=9 TO 1 STEP -1
```
When the statement after the NEXT is executed, the loop variable is never equal to the final value, but is equal to whatever value caused the FOR...NEXT loop to terminate. The statements between the FOR and its corresponding NEXT in both examples above (310 & 320) would be executed 9 times.

```
330 FOR W=1 TO 10: FOR W=1 TO :NEXT W:NEXT W
```
Error: do not use nested FOR...NEXT loops with the same index variable.
FOR loop nesting is limited only by the available memory.
(see Appendix D)

GOTO

```
50 GOTO 100
```
Branches to the statement specified.

GOSUB

```
10 GOSUB 910
```
Branches to the specified statement (910) until a RETURN is encountered; when a branch is then made to the statement after the GOSUB. GOSUB nesting is limited only by the available memory.
(see Appendix D)

IF...GOTO

```
32 IF X<=Y+23.4 GOTO 92
```
(8K Version) Equivalent to IF...THEN, except that IF...GOTO must be followed by a line number, while IF...THEN can be followed by either a line number or another statement.

IF...THEN

```
IF X<10 THEN 5
```
Branches to specified statement if the relation is True.

```
20 IF X<0 THEN PRINT "X LESS THAN 0"
```
Executes all of the statements on the remainder of the line after the THEN if the relation is True.

```
25 IF X=5 THEN 50:Z=A
```
WARNING. The "Z=A" will never be executed because if the relation is true, BASIC will branch to line 50. If the relation is false Basic will proceed to the line after line 25.

```
26 IF X<0 THEN PRINT "ERROR, X NEGATIVE": GOTO 350
```
In this example, if X is less than 0, the PRINT statement will be executed and then the GOTO statement will branch to line 350. If the X was 0 or positive, BASIC will proceed to execute the lines after line 26.

INPUT	3 INPUT V,W,W2	Requests data from the terminal (to be typed in). Each value must be separated from the preceeding value by a comma (,). The last value typed should be followed by a carriage return. A "?" is typed as a prompt character. In the 4K version, a value typed in as a response to an INPUT statement may be a formula, such as 2*SIN(.16)-3. However, in the 8K version, only constants may be typed in as a response to an INPUT statement, such as 4.5E-3 or "CAT". If more data was requested in an INPUT statement than was typed in, a "??" is printed and the rest of the data should be typed in. If more data was typed in than was requested, the extra data will be ignored. The 8K version will print the warning "EXTRA IGNORED" when this happens. The 4K version will not print a warning message. *(8K Version)* Strings must be input in the same format as they are specified in DATA statements.
	5 INPUT "VALUE";V	*(8K Version)* Optionally types a prompt string ("VALUE") before requesting data from the terminal. If carriage return is typed to an input statement, BASIC returns to command mode. Typing CONT after an INPUT command has been interrupted will cause execution to resume at the INPUT statement.
LET	300 LET W=X 310 V=5.1	Assigns a value to a variable. "LET" is optional.
NEXT	340 NEXT V	Marks the end of a FOR loop.
	345 NEXT	*(8K Version)* If no variable is given, matches the most recent FOR loop.
	350 NEXT V,W	*(8K Version)* A single NEXT may be used to match multiple FOR statements. Equivalent to NEXT V:NEXT W.
ON...GOTO	100 ON I GOTO 10,20,30,40	*(8K Version)* Branches to the line indicated by the I'th number after the GOTO. That is: IF I=1, THEN GOTO LINE 10 IF I=2, THEN GOTO LINE 20 IF I=3, THEN GOTO LINE 30 IF I=4, THEN GOTO LINE 40.

If I=0 or I attempts to select a non-existent line (>=5 in this case), the statement after the ON statement is executed. However, if I is >255 or <0, an FC error message will result. As many line numbers as will fit on a line can follow an ON...GOTO.

```
105 ON SGN(X)+2 GOTO 40,50,60
```

This statement will branch to line 40 if the expression X is less than zero, to line 50 if it equals zero, and to line 60 if it is greater than zero.

ON...GOSUB

```
110 ON I GOSUB 50,60
```

(8K Version) Identical to "ON...GOTO", except that a subroutine call (GOSUB) is executed instead of a GOTO. RETURN from the GOSUB branches to the statement after the ON...GOSUB.

OUT

```
355 OUT I,J
```

(8K Version) Sends the byte J to the output port I. Both I & J must be >=0 and <=255.

POKE

```
357 POKE I,J
```

(8K Version) The POKE statement stores the byte specified by its second argument (J) into the location given by its first argument (I). The byte to be stored must be =>0 and <=255, or an FC error will occur. The address (I) must be =>0 and <=32767, or an FC error will result. Careless use of the POKE statement will probably cause you to "poke" BASIC to death; that is, the machine will hang, and you will have to reload BASIC and will lose any program you had typed in. A POKE to a non-existent memory location is harmless. One of the main uses of POKE is to pass arguments to machine language subroutines. (see Appendix J) You could also use PEEK and POKE to write a memory diagnostic or an assembler in BASIC.

PRINT

```
360 PRINT X,Y;Z
370 PRINT
380 PRINT X,Y;
390 PRINT "VALUE IS";A
400 PRINT A2,B,
```

Prints the value of expressions on the terminal. If the list of values to be printed out does not end with a comma (,) or a semicolon (;), then a carriage return/line feed is executed after all the values have been printed. Strings enclosed in quotes (") may also be printed. If a semicolon separates two expressions in the list, their values are printed next to each other. If a comma appears after an

		expression in the list, and the print head is at print position 56 or more, then a carriage return/line feed is executed. If the print head is before print position 56, then spaces are printed until the carriage is at the beginning of the next 14 column field (until the carriage is at column 14, 28, 42 or 56...). If there is no list of expressions to be printed, as in line 370 of the examples, then a carriage return/line feed is executed.
	410 PRINT MID$(A$,2);	*(8K Version)* String expressions may be printed.
READ	490 READ V,W	Reads data into specified variables from a DATA statement. The first piece of data read will be the first piece of data listed in the first DATA statement of the program. The second piece of data read will be the second piece listed in the first DATA statement, and so on. When all of the data have been read from the first DATA statement, the next piece of data to be read will be the first piece listed in the second DATA statement of the program. Attempting to read more data than there is in all the DATA statements in a program will cause an OD (out of data) error. In the 4K version, an SN error from a READ statement can mean the data it was attempting to read from a DATA statement was improperly formatted. In the 8K version, the line number given in the SN error will refer to the line number where the error actually is located.
REM	500 REM NOW SET V=0	Allows the programmer to put comments in his program. REM statements are not executed, but can be branched to. A REM statement is terminated by end of line, but not by a ":".
	505 REM SET V=0: V=0	In this case the V=0 will never be executed by BASIC.
	506 V=0: REM SET V=0	In this case V=0 will be executed
RESTORE	510 RESTORE	Allows the re-reading of DATA statements. After a RESTORE, the next piece of data read will be the first piece listed in the first DATA statement of the program. The second piece of data read will be the second piece listed in the first DATA statement, and so on as in a normal READ operation.

RETURN	50 RETURN	Causes a subroutine to return to the statement after the most recently executed GOSUB.
STOP	9000 STOP	Causes a program to stop execution and to enter command mode. *(8K Version)* Prints BREAK IN LINE 9000. (as per this example) CONT after a STOP branches to the statement following the STOP.
WAIT	805 WAIT I,J,K 806 WAIT I,J	*(8K Version)* This statement reads the status of input port I, exclusive OR's K with the status, and then AND's the result with J until a non-zero result is obtained. Execution of the program continues at the statement following the WAIT statement. If the WAIT statement only has two arguments, K is assumed to be zero. If you are waiting for a bit to become zero, there should be a one in the corresponding position of K. I, J and K must be =>0 and <=255.

4K INTRINSIC FUNCTIONS

ABS(X)	120 PRINT ABS(X)	Gives the absolute value of the expression X. ABS returns X if X>=0, -X otherwise.
INT(X)	140 PRINT INT(X)	Returns the largest integer less than or equal to its argument X. For example: INT(.23)=0, INT(7)=7, INT(-.1)=-1, INT (-2)= -2, INT(1.1)=1. The following would round X to D decimal places: INT(X*10↑D+.5)/10↑D
RND(X)	170 PRINT RND(X)	Generates a random number between 0 and 1. The argument X controls the generation of random numbers as follows: X<0 starts a new sequence of random numbers using X. Calling RND with the same X starts the same random number sequence. X=0 gives the last random number generated. Repeated calls to RND(0) will always return the same random number. X>0 generates a new random number between 0 and 1. Note that (B-A)*RND(1)+A will generate a random number between A & B.

SGN(X)	230 PRINT SGN(X)	Gives 1 if X>0, 0 if X=0, and -1 if X<0.
SIN(X)	190 PRINT SIN(X)	Gives the sine of the expression X. X is interpreted as being in radians. Note: COS (X)=SIN(X+3.14159/2) and that 1 Radian =180/PI degrees=57.2958 degrees; so that the sine of X degrees= SIN(X/57.2958).
SQR(X)	180 PRINT SQR(X)	Gives the square root of the argument X. An FC error will occur if X is less than zero.
TAB(I)	240 PRINT TAB(I)	Spaces to the specified print position (column) on the terminal. May be used only in PRINT statements. Zero is the leftmost column on the terminal, 71 the rightmost. If the carriage is beyond position I, then no printing is done. I must be =>0 and <=255.
USR(I)	200 PRINT USR(I)	Calls the user's machine language subroutine with the argument I. See POKE, PEEK and Appendix J.

8K FUNCTIONS *(Includes all those listed under 4K INTRINSIC FUNCTIONS plus the following in addition.)*

ATN(X)	210 PRINT ATN(X)	Gives the arctangent of the argument X. The result is returned in radians and ranges from -PI/2 to PI/2. (PI/2=1.5708)
COS(X)	200 PRINT COS(X)	Gives the cosine of the expression X. X is interpreted as being in radians.
EXP(X)	150 PRINT EXP(X)	Gives the constant "E" (2.71828) raised to the power X. (E↑X) The maximum argument that can be passed to EXP without overflow occuring is 87.3365.
FRE(X)	270 PRINT FRE(0)	Gives the number of memory bytes currently unused by BASIC. Memory allocated for STRING space is not included in the count returned by FRE. To find the number of free bytes in STRING space, call FRE with a STRING argument. (see FRE under STRING FUNCTIONS)
INP(I)	265 PRINT INP(I)	Gives the status of (reads a byte from) input port I. Result is =>0 and <=255.

LOG(X)	160 PRINT LOG(X)	Gives the natural (Base E) logarithm of its argument X. To obtain the Base Y logarithm of X use the formula LOG(X)/LOG(Y). Example: The base 10 (common) log of 7 = LOG(7)/ LOG(10).
PEEK	356 PRINT PEEK(I)	The PEEK function returns the contents of memory address I. The value returned will be =>0 and <=255. If I is >32767 or <0, an FC error will occur. An attempt to read a non-existent memory address will return 255. (see POKE statement)
POS(I)	260 PRINT POS(I)	Gives the current position of the terminal print head (or cursor on CRT's). The leftmost character position on the terminal is position zero and the rightmost is 71.
SPC(I)	250 PRINT SPC(I)	Prints I space (or blank) characters on the terminal. May be used only in a PRINT statement. X must be =>0 and <=255 or an FC error will result.
TAN(X)	200 PRINT TAN(X)	Gives the tangent of the expression X. X is interpreted as being in radians.

STRINGS *(8K Version Only)*

1) A string may be from 0 to 255 characters in length. All string variables end in a dollar sign ($); for example, A$, B9$, K$, HELLO$.

2) String matrices may be dimensioned exactly like numeric matrices. For instance, DIM A$(10,10) creates a string matrix of 121 elements, eleven rows by eleven columns (rows 0 to 10 and columns 0 to 10). Each string matrix element is a complete string, which can be up to 255 characters in length.

3) The total number of characters in use in strings at any time during program execution cannot exeeed the amount of string space, or an OS error will result. At initialization, you should set up string space so that it can contain the maximum number of characters which can be used by strings at any one time during program execution.

NAME	EXAMPLE	PURPOSE/USE
DIM	25 DIM A$(10,10)	Allocates space for a pointer and length for each element of a string matrix. No string space is allocated. See Appendix D.

LET	27 LET A$="F00"+V$	Assigns the value of a string expression to a string variable. LET is optional.
= > < <= >= <>		String comparison operators. Comparison is made on the basis of ASCII codes, a character at a time until a difference is found. If during the comparison of two strings, the end of one is reached, the shorter string is considered smaller. Note that "A " is greater than "A" since trailing spaces are significant.
+	30 LET Z$=R$+Q$	String concatentation. The resulting string must be less than 256 characters in length or an LS error will occur.
INPUT	40 INPUT X$	Reads a string from the user's terminal. String does not have to be quoted; but if not, leading blanks will be ignored and the string will be terminated on a "," or ":" character.
READ	50 READ X$	Reads a string from DATA statements within the program. Strings do not have to be quoted; but if they are not, they are terminated on a "," or ":" character or end of line and leading spaces are ignored. See DATA for the format of string data.
PRINT	60 PRINT X$ 70 PRINT "F00"+A$	Prints the string expression on the user's terminal.

STRING FUNCTIONS *(8K Version Only)*

ASC(X$)	300 PRINT ASC(X$)	Returns the ASCII numeric value of the first character of the string expression X$. See Appendix K for an ASCII/number conversion table. An FC error will occur if X$ is the null string.
CHR$(I)	275 PRINT CHR$(I)	Returns a one character string whose single character is the ASCII equivalent of the value of the argument (I) which must be =>0 and <=255. See Appendix K.
FRE(X$)	272 PRINT FRE("")	When called with a string argument, FRE gives the number of free bytes in string space.
LEFT$(X$,I)	310 PRINT LEFT$(X$,I)	Gives the leftmost I characters of the string expression X$. If I<=0 or >255 an FC error occurs.

LEN(X$)

```
220 PRINT LEN(X$)
```

Gives the length of the string expression X$ in characters (bytes). Non-printing characters and blanks are counted as part of the length.

MID$(X$,I)

```
330 PRINT MID$(X$,I)
```

MID$ called with two arguments returns characters from the string expression X$ starting at character position I. If I>LEN(I$), then MID$ returns a null (zero length) string. If I<=0 or >255, an FC error occurs.

MID$(X$,I,J)

```
340 PRINT MID$(X$,I,J)
```

MID$ called with three arguments returns a string expression composed of the characters of the string expression X$ starting at the Ith character for J characters. If I>LEN(X$), MID$ returns a null string. If I or J <=0 or >255, an FC error occurs. If J specifies more characters than are left in the string, all characters from the Ith on are returned.

RIGHT$(X$,I)

```
320 PRINT RIGHT$(X$,I)
```

Gives the rightmost I characters of the string expression X$. When I<=0 or >255 an FC error will occur. If I>=LEN(X$) then RIGHT$ returns all of X$.

STR$(X)

```
290 PRINT STR$(X)
```

Gives a string which is the character representation of the numeric expression X. For instance, STR$(3.1)=" 3.1".

VAL(X$)

```
280 PRINT VAL(X$)
```

Returns the string expression X$ converted to a number. For instance, VAL("3.1")=3.1. If the first non-space character of the string is not a plus (+) or minus (-) sign, a digit or a decimal point (.) then zero will be returned.

SPECIAL CHARACTERS

CHARACTER	USE
@	Erases current line being typed, and types a carriage return/line feed. An "@" is usually a shift/P.
←	*(backarrow or underline)* Erases last character typed. If no more characters are left on the line, types a carriage return/line feed. "←" is usually a shift/O.

CARRIAGE RETURN — A carriage return must end every line typed in. Returns print head or CRT cursor to the first position (leftmost) on line. A line feed is always executed after a carriage return.

CONTROL/C — Interrupts execution of a program or a list command. Control/C has effect when a statement finishes execution, or in the case of interrupting a LIST command, when a complete line has finished printing. In both cases a return is made to BASIC's command level and OK is typed.
(8K Version) Prints "BREAK IN LINE XXXX" , where XXXX is the line number of the next statement to be executed.

: (colon) — A colon is used to separate statements on a line. Colons may be used in direct and indirect statements. The only limit on the number of statements per line is the line length. It is not possible to GOTO or GOSUB to the middle of a line.

(8K Version Only)

CONTROL/O — Typing a Control/O once causes BASIC to suppress all output until a return is made to command level, an input statement is encountered, another control/O is typed, or an error occurs.

? — Question marks are equivalent to PRINT. For instance, ? 2+2 is equivalent to PRINT 2+2. Question marks can also be used in indirect statements. 10 ? X, when listed will be typed as 10 PRINT X.

MISCELLANEOUS

1) To read in a paper tape with a program on it (8K Version), type a control/O and feed in tape. There will be no printing as the tape is read in. Type control/O again when the tape is through. Alternatively, set nulls=0 and feed in the paper tape, and when done reset nulls to the appropriate setting for your terminal. Each line must be followed by two rubouts, or any other non-printing character. If there are lines without line numbers (direct commands) the ALTAIR will fall behind the input coming from paper tape, so this in not recommending.

Using null in this fashion will produce a listing of your tape in the 8K version (use control/O method if you don't want a listing). The null method is the only way to read in a tape in the 4K version.

To read in a paper tape of a program in the 4K version, set the number of nulls typed on carriage return/line feed to zero by patching location 46 (octal) to be a 1. Feed in the paper tape. When

the tape has finished reading, stop the CPU and repatch location 46 to be the appropriate number of null characters (usually 0, so deposit a 1). When the tape is finished, BASIC will print SN ERROR because of the "OK" at the end of the tape.

2) To punch a paper tape of a program, set the number of nulls to 3 for 110 BAUD terminals (Teletypes) and 6 for 300 BAUD terminals. Then, type LIST; but, do not type a carriage return.
Now, turn on the terminal's paper tape punch. Put the terminal on local and hold down the Repeat, Control, Shift and P keys at the same time. Stop after you have punched about a 6 to 8 inch leader of nulls. These nulls will be ignored by BASIC when the paper tape is read in. Put the terminal back on line.
Now hit carriage return. After the program has finished punching, put some trailer on the paper tape by holding down the same four keys as before, with the terminal on local. After you have punched about a six inch trailer, tear off the paper tape and save for later use as desired.

3) Restarting BASIC at location zero (by toggling STOP, Examine location 0, and RUN) will cause BASIC to return to command level and type "OK". However, typing Control/C is preferred because Control/C is guaranteed not to leave garbage on the stack and in variables, and a Control C'd program may be continued. (see CONT command)

4) The maximum line length is 72 characters.** If you attempt to type too many characters into a line, a bell (ASCII 7) is executed, and the character you typed in will not be echoed. At this point you can either type backarrow to delete part of the line, or at-sign to delete the whole line. The character you typed which caused BASIC to type the bell is not inserted in the line as it occupies the character position one beyond the end of the line.

*CLEAR	CLEAR	Deletes all variables.
	CLEAR X	*(8K Version)* Deletes all variables. When used with an argument "X", sets the amount of space to be allocated for use by string variables to the number indicated by its argument "X".
	10 CLEAR 50	*(8K Version)* Same as above; but, may be used at the beginning of a program to set the exact amount of string space needed, leaving a maximum amount of memory for the program itself.
		NOTE: If no argument is given, the string space is set at 200 by default. An OM error will occur if an attempt is made to allocate more string space than there is available memory.

**For inputting only.

APPENDIX L

EXTENDED BASIC

When EXTENDED BASIC is sent out, the BASIC manual will be updated to contain an extensive section about EXTENDED BASIC. Also, at this time the part of the manual relating to the 4K and 8K versions will be revised to correct any errors and explain more carefully the areas users are having trouble with. This section is here mainly to explain what EXTENDED BASIC will contain.

INTEGER VARIABLES These are stored as double byte signed quantities ranging from -32768 to +32767. They take up half as much space as normal variables and are about ten times as fast for arithmetic. They are denoted by using a percent sign (%) after the variable name. The user doesn't have to worry about conversion and can mix integers with other variable types in expressions. The speed improvement caused by using integers for loop variables, matrix indices, and as arguments to functions such as AND, OR or NOT will be substantial. An integer matrix of the same dimensions as a floating point matrix will require half as much memory.

DOUBLE-PRECISION Double-Precision variables are almost the opposite of integer variables, requiring twice as much space (8bytes per value) and taking 2 to 3 times as long to do arithmetic as single-precision variables. Double-Precision variables are denoted by using a number sign (#) after the variable name. They provide over 16 digits of accuracy. Functions like SIN, ATN and EXP will convert their arguments to single-precision, so the results of these functions will only be good to 6 digits. Negation, addition, subtraction, multiplication, division, comparision, input, output and conversion are the only routines that deal with Double-Precision values. Once again, formulas may freely mix Double-Precision values with other numeric values and conversion of the other values to Double-Precision will be done automatically.

PRINT USING Much like COBOL picture clauses or FORTRAN format statements, PRINT USING provides a BASIC user with complete control over his output format. The user can control how many digits of a number are printed, whether the number is printed in scientific notation and the placement of text in output. All of this can be done in the 8K version using string functions such as STR$ and MID$, but PRINT USING makes it much easier.

DISK I/O EXTENDED BASIC will come in two versions, disk and non-disk. There will only be a copying charge to switch from one to the other. With disk features, EXTENDED BASIC will allow the user to save and recall programs and data files from the ALTAIR FLOPPY DISK. Random access as well as sequential access will be provided. Simultaneous use of multiple data files will be allowed. Utilities will format new disks, delete files and print directories. These will be BASIC programs using special BASIC functions to get access to disk information such as file length, etc. User programs can also access these disk functions, enabling the user to write his own file access method or other special purpose

disk routine. The file format can be changed to allow the use of other (non-floppy) disks. This type of modification will be done by MITS under special arrangement.

OTHER FEATURES Other nice features which will be added are:

Fancy Error Messages
An ELSE clause in IF statements
LIST, DELETE commands with line range as arguments
Deleting Matrices in a program
TRACE ON/OFF commands to monitor program flow
EXCHANGE statement to switch variable values (this will speed up string sorts by at least a factor of two).
Multi-Argument, user defined functions with string arguments and values allowed

Other features contemplated for future release are:

A multiple user BASIC
Explicit matrix manipulation
Virtual matrices
Statement modifiers
Record I/O
Paramaterized GOSUB
Compilation
Multiple USR functions
"Chaining"

EXTENDED BASIC will use about 11K of memory for its own code (10K for the non-disk version) leaving 1K free on a 12K machine. It will take almost 20 minutes to load from paper tape, 7 minutes from cassette, and less than 5 seconds to load from disk.

We welcome any suggestions concerning current features or possible additions of extra features. Just send them to the ALTAIR SOFTWARE DEPARTMENT.

APPENDIX D

SPACE HINTS

In order to make your program smaller and save space, the following hints may be useful.

1) Use multiple statements per line. There is a small amount of overhead (5bytes) associated with each line in the program. Two of these five bytes contain the line number of the line in binary. This means that no matter how many digits you have in your line number (minimum line number is 0, maximum is 65529), it takes the same number of bytes. Puting as many statements as possible on a line will cut down on the number of bytes used by your program.

2) Delete all unnecessary spaces from your program. For instance:

```
10 PRINT X, Y, Z
```

uses three more bytes than

```
10 PRINTX,Y,Z
```

Note: All spaces between the line number and the first non-blank character are ignored.

3) Delete all REM statements. Each REM statement uses at least one byte plus the number of bytes in the comment text. For instance, the statement 130 REM THIS IS A COMMENT uses up 24 bytes of memory.

In the statement 140 X=X+Y: REM UPDATE SUM, the REM uses 14 bytes of memory including the colon before the REM.

4) Use variables instead of constants. Suppose you use the constant 3.14159 ten times in your program. If you insert a statement

```
10 P=3.14159
```

in the program, and use P instead of 3.14159 each time it is needed, you will save 40 bytes. This will also result in a speed improvement.

5) A program need not end with an END; so, an END statement at the end of a program may be deleted.

6) Reuse the same variables. If you have a variable T which is used to hold a temporary result in one part of the program and you need a temporary variable later in your program, use it again. Or, if you are asking the terminal user to give a YES or NO answer to two different questions at two different times during the execution of the program, use the same temporary variable A$ to store the reply.

7) Use GOSUB's to execute sections of program statements that perform identical actions.

8) If you are using the 8K version and don't need the features of the 8K version to run your program, consider using the 4K version instead. This will give you approximately 4.7K to work with in an 8K machine, as opposed to the 1.6K you have available in an 8K machine running the 8K version of BASIC.

9) Use the zero elements of matrices; for instance, A(0), B(0,X).

STORAGE ALLOCATION INFORMATION

Simple (non-matrix) numeric variables like V use 6 bytes; 2 for the variable name, and 4 for the value. Simple non-matrix string variables also use 6 bytes; 2 for the variable name, 2 for the length, and 2 for a pointer.

Matrix variables use a minimum of 12 bytes. Two bytes are used for the variable name, two for the size of the matrix, two for the number of dimensions and two for each dimension along with four bytes for each of the matrix elements.

String variables also use one byte of string space for each character in the string. This is true whether the string variable is a simple string variable like A$, or an element of a string matrix such as Q1$(5,2).

When a new function is defined by a DEF statement, 6 bytes are used to store the definition.

Reserved words such as FOR, GOTO or NOT, and the names or the intrinsic functions such as COS, INT and STR$ take up only one byte of program storage. All other characters in programs use one byte of program storage each.

When a program is being executed, space is dynamically allocated on the stack as follows:

1) Each active FOR...NEXT loop uses 16 bytes.

2) Each active GOSUB (one that has not returned yet) uses 6 bytes.

3) Each parenthesis encountered in an expression uses 4 bytes and each temporary result calculated in an expression uses 12 bytes.

Answers to Most Often Asked Software Questions

1. Q. How many decimal digits of precision do 4K and 8K BASIC have?

   A. Six digits. Extended (12K) BASIC also has 16 digit double precision variables as well as six digit single precision variables.

2. Q. When will BASIC have multi-user capabilities?

   A. Perhaps by the middle of 1976. It will be a non-swapping system with user memory allocated in fixed partitions.

3. Q. Does BASIC allow you to format numeric output precisely with a certain number digits before and after the decimal place, for example?

   A. In the 8K BASIC, only by converting a number to a string and then manipulating the string. Otherwise numbers are printed in a default format described in the BASIC manual. In Extended BASIC, PRINT USING allows the user to precisely format both numeric and string output fields.

4. Q. What about BASIC matrix MAT statements? Are they available in the 8K or Extended versions?

   A. No, and there are no plans to implement them at this time.

5. Q. What file capabilities are available in 8K or Extended BASIC?

   A. In 8K BASIC, the user can save or load programs files from cassette or paper tape. In Extended BASIC, the user can also save programs and data on the floppy disk.

6. Q. When will BASIC be available on ROM?

   A. Late December or early January.

   Q. What are the features and memory requirements of the different versions of BASIC?

   A. See the Software Information Package.

8. Q. What is the cost of upgrading between different versions of BASIC?

   A. The charge for an upgrade is the difference in price plus a copying charge of $15. For example, an upgrade from 4K to 8K BASIC would cost $30, for an upgrade from 4K to Extended BASIC the charge would be $105. etc.

9. Q. What type of string manipulation is available in BASIC?

   A. Very extensive powerful string manipulation is available in 8K and Extended BASIC. See Software Information Package.

10. Q. Can owners of BASIC let other owners of our machines make copies of his BASIC?

    A. No, they should buy their own copies. Copying the software in this manner is considered a "RIP-OFF".

11. Q. Is there any limit to the number of nested FOR loops or levels of parenthesis in BASIC?

    A. The only limit imposed on the nesting of FOR loops or parenthesis is the amount of available memory. Each nested FOR loop entry requires approximately 16 bytes and each nested parenthesis requires 6 bytes.

12. Q. Can BASIC be used with the line printer?

    A. Yes, we have a special version of 8K or Extended BASIC that has LLIST and LPRINT statements to make program listings or write output on the line printer. These commands are available for an extra charge of $30.

13. Q. Is there a special version of BASIC with the command to switch from one terminal to another?

    A. Yes, there is a CONSOLE command which allows the user to switch from one terminal to another and back again. The extra charge is $30.

14. Q. Are any other languages besides BASIC available?

    A. Not at this time. We may have FORTRAN available sometime next year.

15. Q. What can you tell me about the floppy disk?

A. Each floppy drive can store approximately 300,000 bytes of information. The floppy disk controller can handle up to 16 drives. The controller takes up two card slots in the mainframe. Transfer rate of the floppy disk is approximately 32,000 bytes/sec and a random access to any part of the floppy disk takes approximately 1/3 second. Extra floppy disks may be obtained from MITS at a cost of $15; one floppy disk is included with each kit or assembled drive.

16. Q. What are the features and memory requirements of the Editor, Assembler and Monitor? Capabilities?

A. See the Software Information Package.

17. Q. What is MITS' policy when new versions of the software replace old versions?

A. The new versions may be obtained for a copy charge of $15.

18. Q. Are any cross-assemblers available from MITS?

A. Yes, an ANSI standard cross-assembler is available as a listing ($15) or as a listing and ASCII paper tape ($30). It does not have macros or conditional assembly.

19. Q. Can our machine run other 8080 software?

A. Yes, it can run most 8080 programs with no change or perhaps a slight change in the I/O conventions used. PL/M programs, for instance, may be run on an ALTAIR.

20. Q. Why is delivery of software sometimes delayed?

A. Often software is not shipped because it appears on the same invoice as other hardware (memory boards, etc.) and the software is not shipped until the hardware is ready. Also, software has not been shipped until the user's Software License Agreement (SLA) was received. We have now discontinued the use of SLAs and the user is shipped his software immediately.

21. Q. In what forms are BASIC and Package I (assembler, monitor and text editor) available?

A. At this time, binary paper tapes and cassettes are being shipped. In the future, software will be available on floppy disk. BASIC on ROM is also planned.

22. Q. What types of BASIC accounting packages, inventory packages, will be available for use with Extended BASIC?

A. At the present time, MITS does not offer any such packages. However, early next year we will make available such packages licensed or purchased from software houses.

23. Q. What is the price for the source listings of BASIC and Package I?

A. 4K and 8K BASIC - $3000
Extended BASIC - $5500
Package I - $500

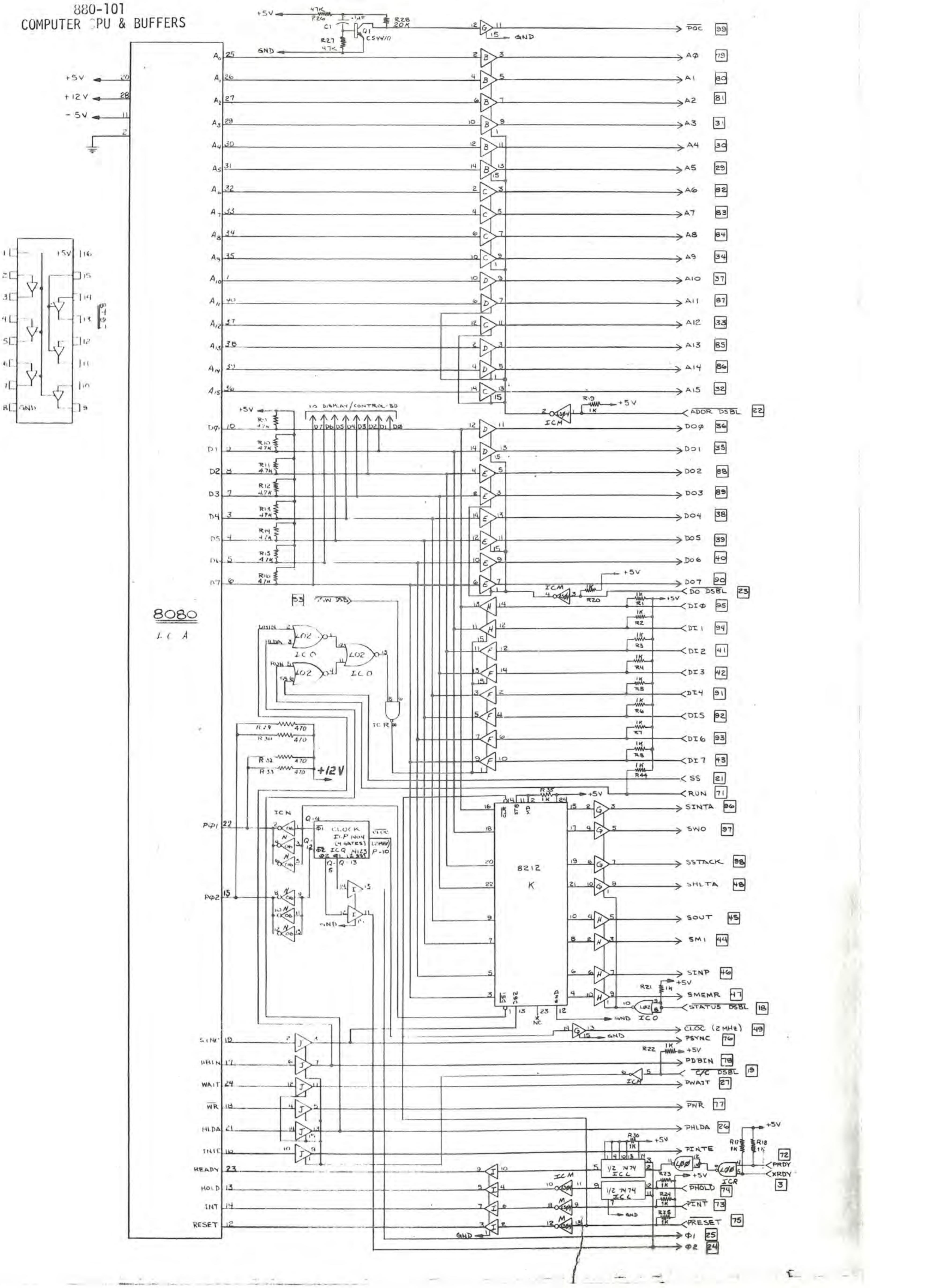
24. Q. What should a customer do if he has a bad cassette or paper tape?

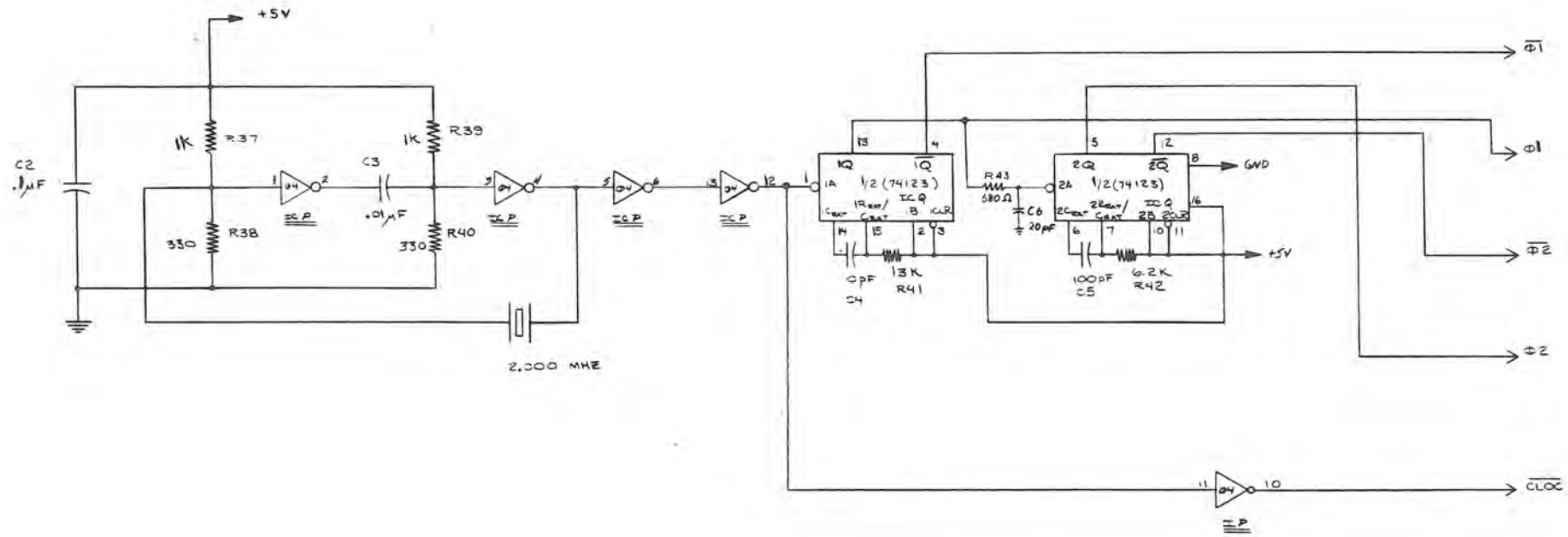
A. Send the bad one back and we will ship him a new one. Cassettes are checked at the factory before we ship them.

25. Q. When will the bootstrap loader be available on PROM?

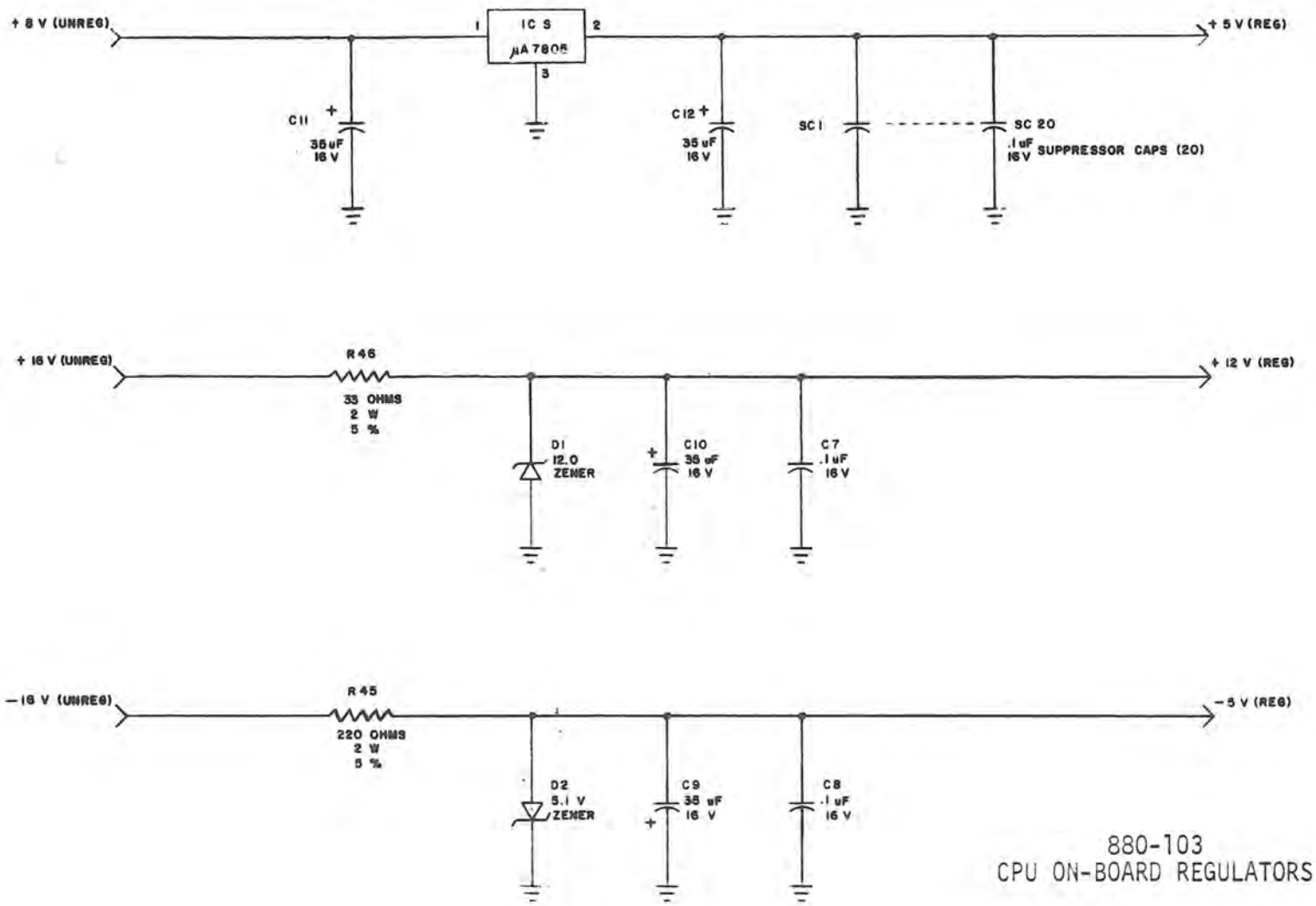
A. The PROM boards will be available by December and PROMs with the bootstrap programmed on them will cost $15 more than the cost of the PROM.

880-101
COMPUTER CPU & BUFFERS





880-102
SYSTEM CLOCK



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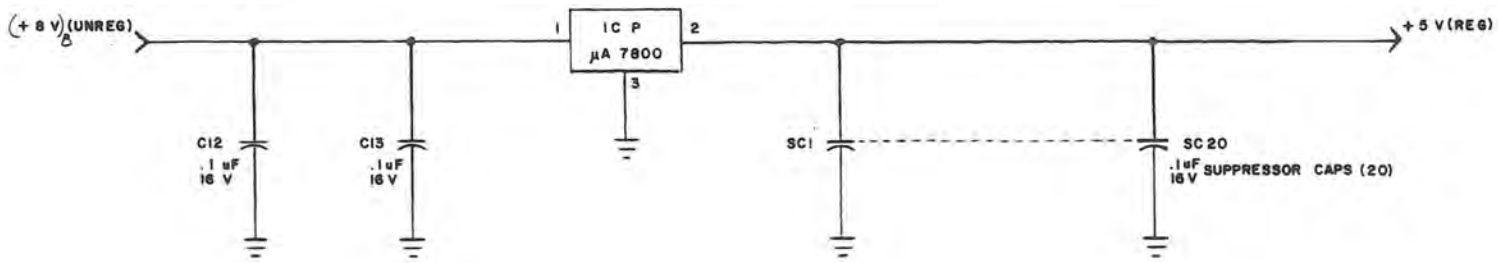
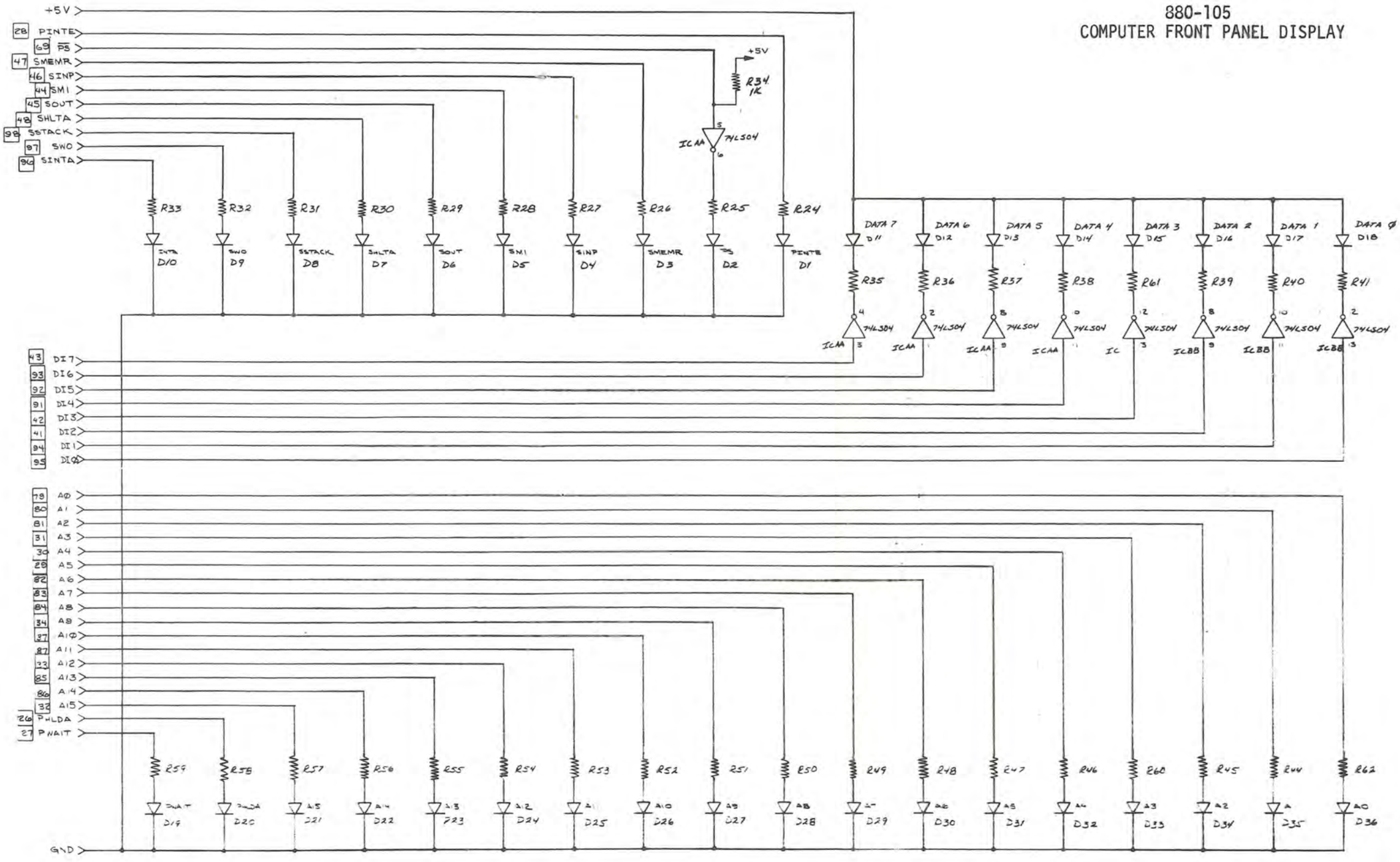
CPU ON-BOARD REGULATORS

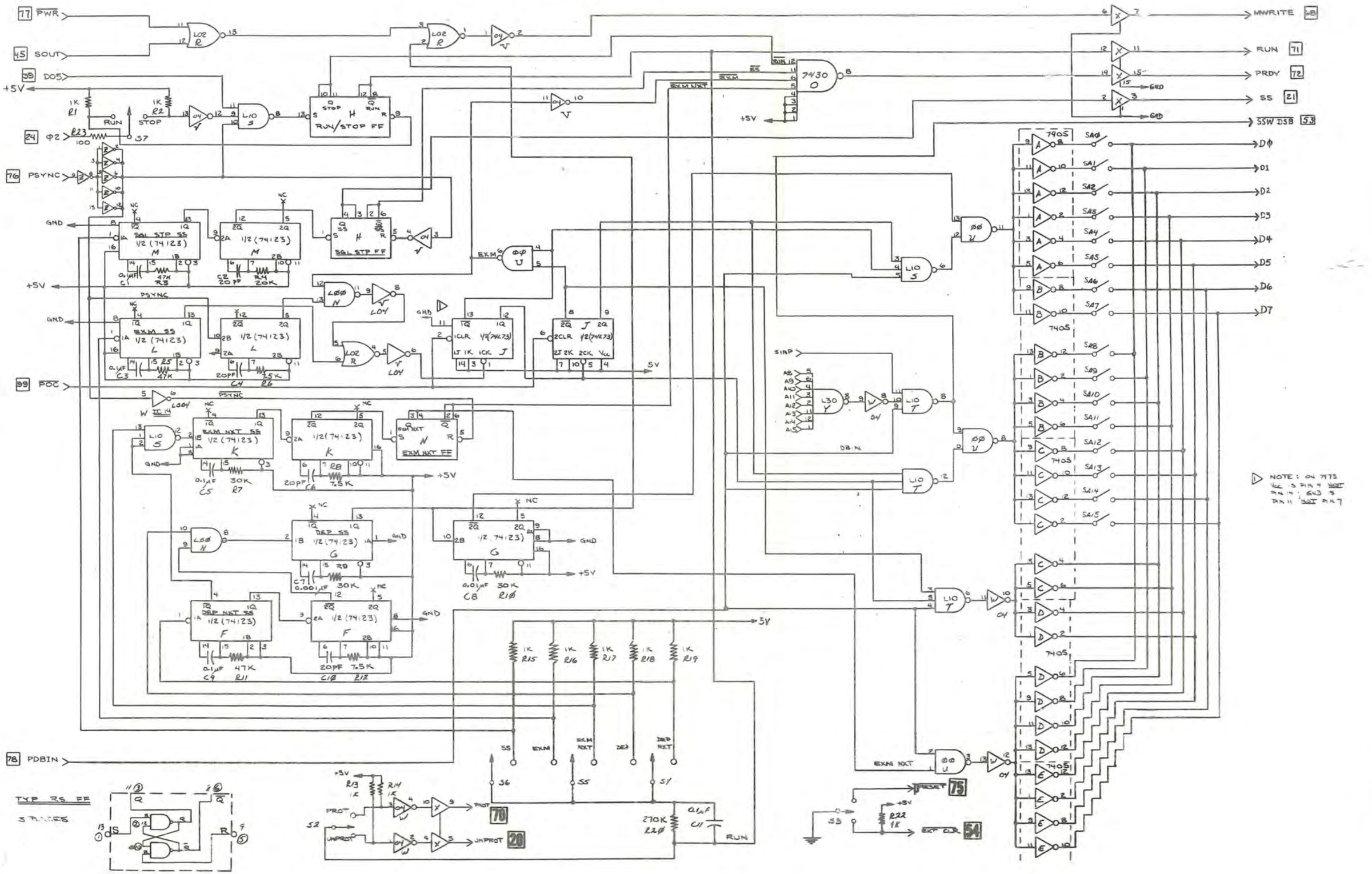


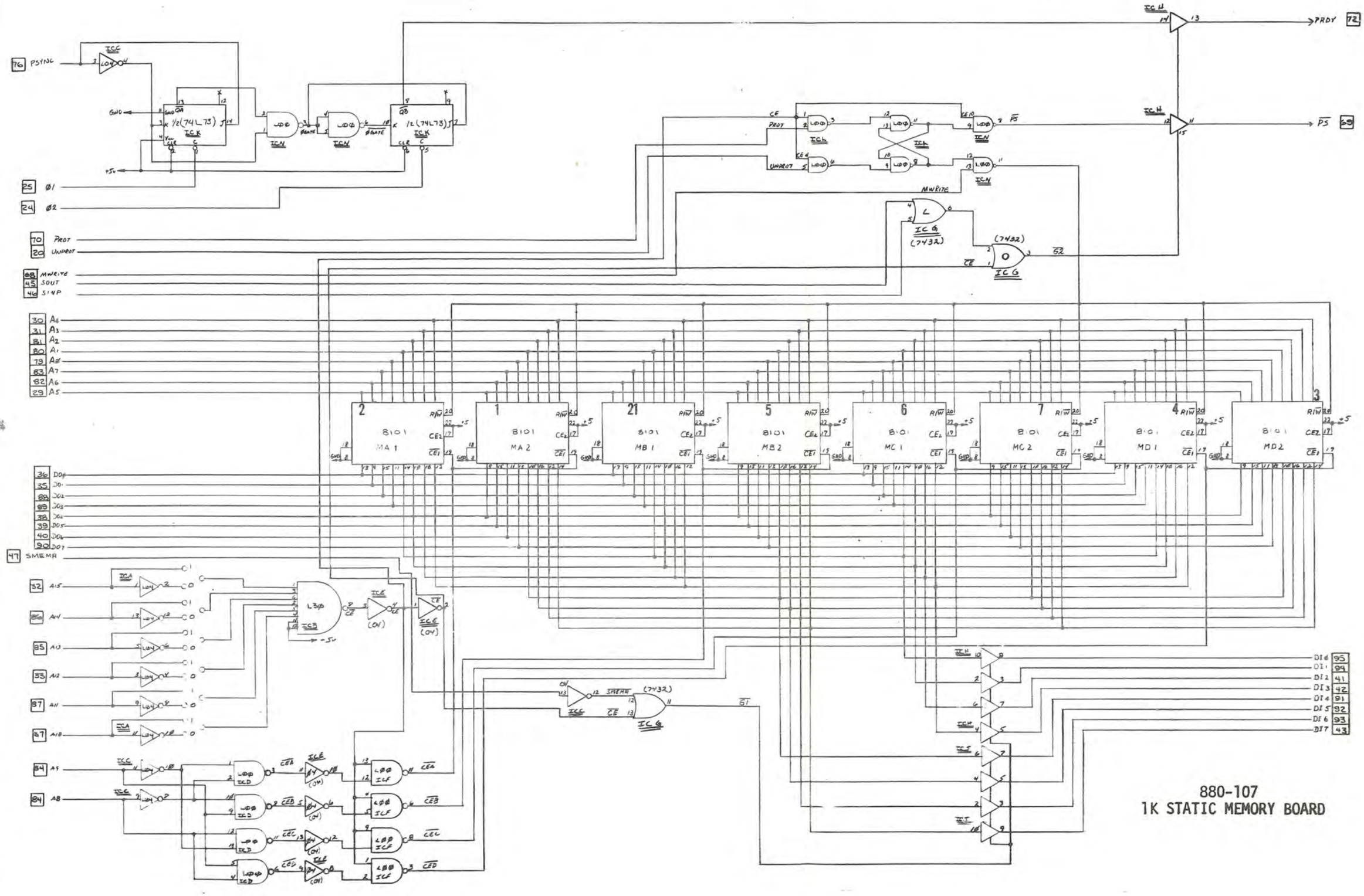
'880-104
DISPLAY/CONTROL ON-BOARD REGULATOR

880-105
COMPUTER FRONT PANEL DISPLAY

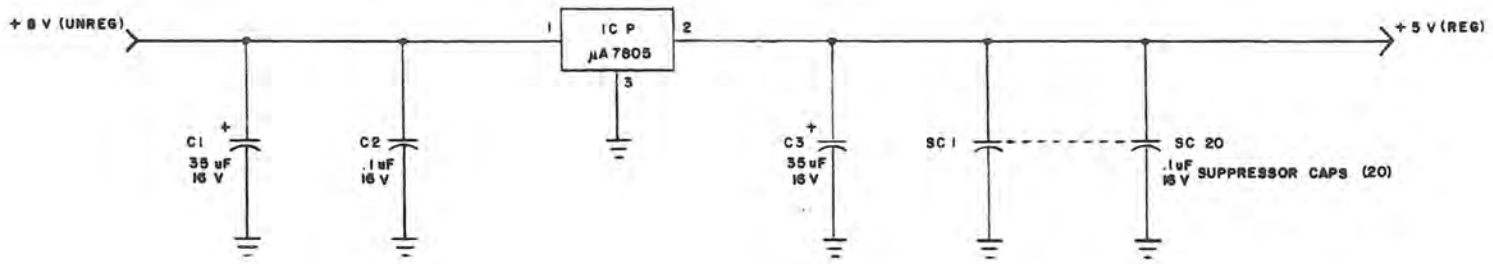


880-106
COMPUTER FRONT PANEL CONTROL

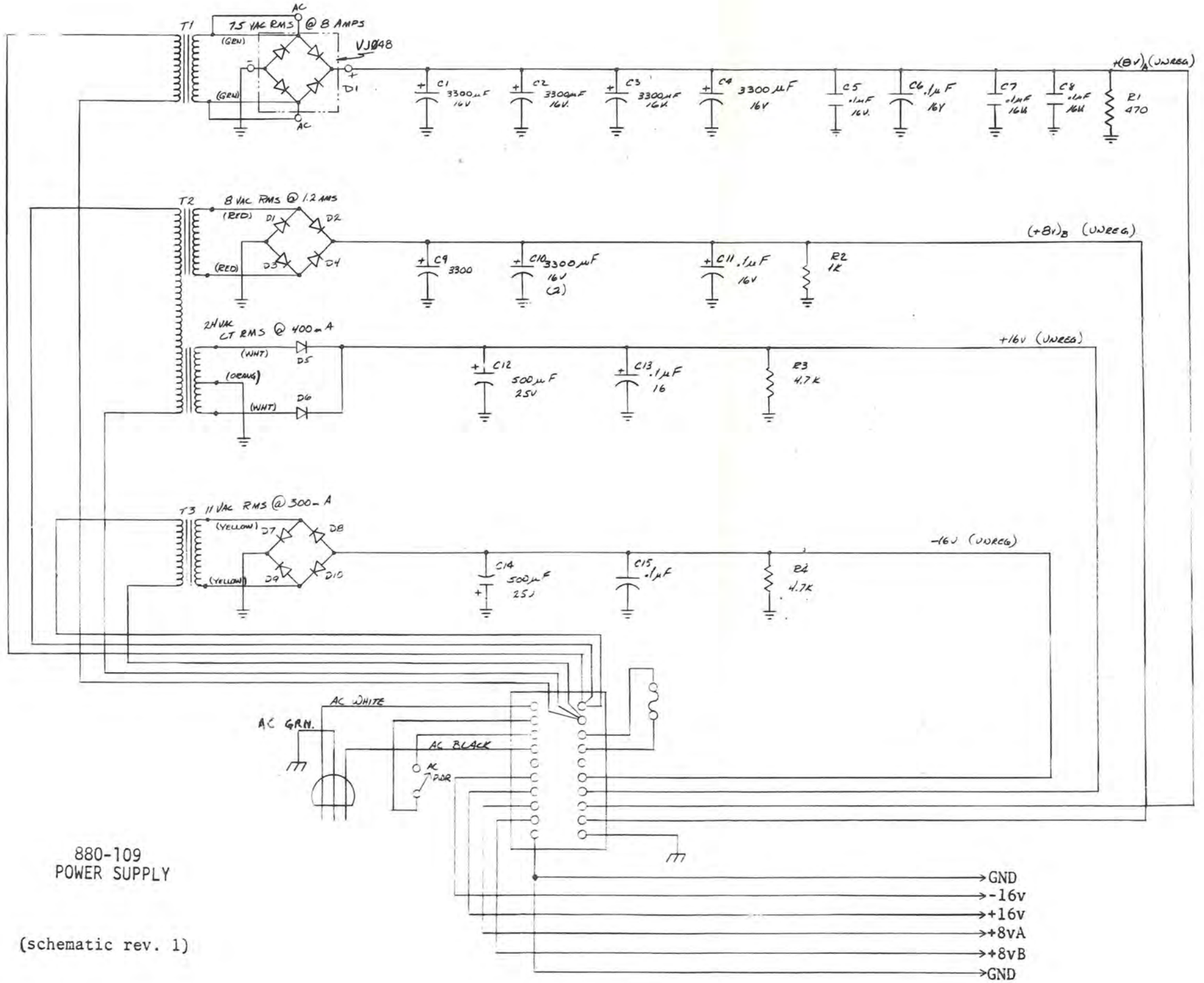




880-107
1K STATIC MEMORY BOARD



880-108
1K STATIC MEMORY ON-BOARD REGULATOR



880-109
POWER SUPPLY

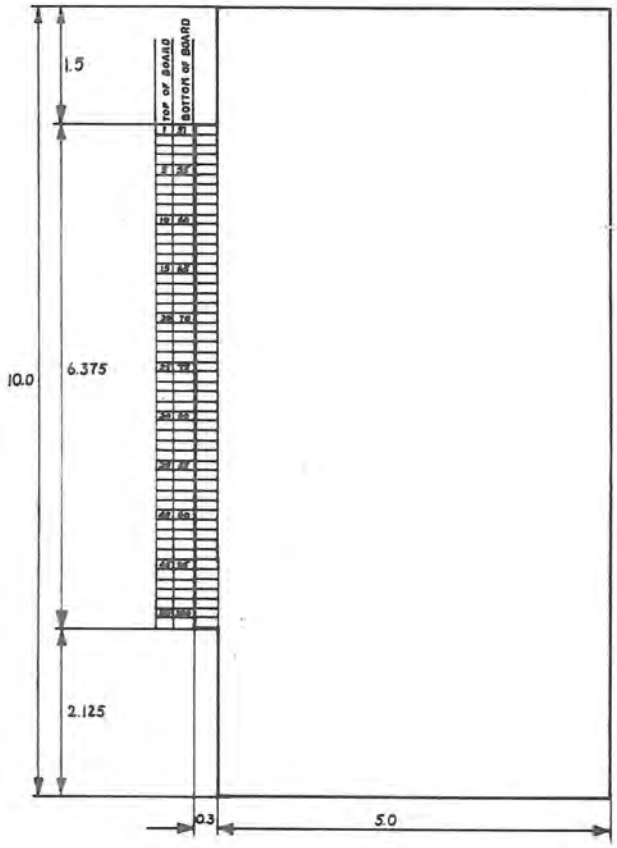
(schematic rev. 1)

TOP OF BOARD

1	+5 V
2	+15 V
3	XRDY
4	VI 0
5	VI 1
6	VI 2
7	VI 3
8	VI 4
9	VI 5
10	VI 6
11	VI 7
12	
13	
14	
15	
16	
17	
18	STAT DISABLE
19	CIC DISABLE
20	UNPROTECT
21	SS
22	XDMA DISAB
23	DMA DISAB
24	Φ 2
25	Φ 1
26	PHLDA
27	PWAIT
28	PINTE
29	A5
30	A4
31	A3
32	A15
33	A12
34	A9
35	DO 1
36	DO 0
37	A10
38	DO 4
39	DO 5
40	DO 6
41	DI 2
42	DI 3
43	DI 7
44	SMI
45	SOUT
46	SINP
47	SMEMR
48	SHLTA
49	CLOCK (2 MHz)
50	GND

BOTTOM OF BOARD

51	+5 V	A
52	-15 V	B
53	SSW DSB	C
54	EXT CLR	D
55		E
56		F
57		H
58		J
59		K
60		L
61		M
62		N
63		P
64		R
65		S
66		T
67		U
68	MWRITE	V
69	PS	W
70	PROTECT	X
71	RUN	Y
72	PRDY	Z
73	PINT	a
74	PHOLD	b
75	PRESET	c
76	PSYNC	d
77	PWR	e
78	PDBIN	f
79	A 4	h
80	A 1	j
81	A 2	k
82	A 6	l
83	A 7	m
84	A 8	n
85	A 13	p
86	A 14	r
87	A 11	s
88	DO 2	t
89	DO 3	u
90	DO 7	v
91	DI 4	w
92	DI 5	x
93	DI 6	y
94	DI 1	z
95	DI 0	AA
96	SINTA	AB
97	SWO	AC
98	SSTACK	AD
99	PUC	AE
100	GND	AF



880-110
SYSTEM BUS STRUCTURE