VIP SUPERSOUND SYSTEM

by Joe Weisbecker

July 1978

INTRODUCTION

You can now convert your COSMAC VIP into a music and sound effects computer. With the VIP Supersound printed circuit card and appropriate software you can make your VIP play any song from "Oh Susannah" to the "Maple Leaf Rag." You can compose or arrange your own music and let your VIP play it for you. If you play an instrument you can program your VIP to back you up.

The VIP Supersound card provides two separate sound channels. This is like a two piece combo that can be programmed to suit your taste. Special provisions have been made to record 3 perfectly synchronized tracks on a four track tape recorder. This lets you program up to 6 individual parts. The same synchronizing system permits multiple VIP's to play in parallel giving you unlimited ability to experiment with real time harmony effects. A third optional drum channel can easily be added and is supported by the Pin-8 (Play It Now) program described here.

The VIP Supersound system does not limit you to one musical scale and each channel has well over a four octave range. No frequency (tuning) adjustments are required. The only adjustment is for tempo.

MUSIC SYNTHESIS

Conventional music is broken up into notes. Each note has a frequency (pitch) and duration. Three basic variables contribute to what a note sounds like:

1. Frequency (pitch) - This variable determines how high or low the note is. A piano keyboard consists of groups of 12 notes. Each group of 12 notes is called an octave. Each 12 notes in the next higher octave is twice the frequency of the equivalent notes in the next lower octave. Octave number 4 begins with middle C on the piano.

2. Frequency Waveshape - This variable determines the quality of the note. Different instruments provide frequencies with varying wave shapes. A square wave has a different sound than a sine wave of the same frequency. The harmonic content of complex wave shapes differ markedly.

3. Volume Envelope - How the frequency varies in volume (amplitude) over the duration of a note makes a large difference in how it sounds. Percussion instruments (piano, bell, etc.) provide maximum volume (amplitude) at the beginning of the note. The volume then decays exponentially during the life of the note.

The VIP Supersound circuits provide programmed control of frequency and volume for two independent channels (A & B). No provision for frequency waveshape control exists. These circuits plug into the VIP 44-pin external interface socket.

The VIP Supersound system is a low cost approach to dual channel digital sound synthesis. It will not produce the same effects as some very expensive analog systems. You will, however, find it much easier to use and be amazed by the range of effects achievable with such a simple system.

CIRCUIT DESCRIPTION

The Supersound circuits are shown in Figs. 1 and 2. When using them with your VIP disconnect the normal VIP sound speaker. Since the Supersound circuits may not always provide keyboard tones with the operating system and CHIP-8 language, you may want to add a switch to your normal VIP speaker. This permits you to switch the normal VIP speaker back in when using the operating system or CHIP-8 language.

IC1 and IC2 are programmable frequency generators. An 8-bit code latched into an internal register determines the division factor for the frequency applied at pin 2. The divided frequency appears as a square wave on pin 14. The hex codes that must be internally latched for various notes are shown in Figure 3. The frequency shown is the desired note frequency. The maximum percentage frequency error is indicated to the right of the hex codes (see CDP1863 data sheet to calculate hex codes for any frequency).

IC4 is a crossbar switch. It can be set to provide any one of 4 frequencies as input to each divider. Each of these frequencies is double the next lower frequency. This permits setting the octave ranges for the notes as shown in Figure 3. Note that each sound channel (A/B) can be independently varied over a 4 octave range.

IC3 and the associated resistor network permit independent, programmed volume (or amplitude control of each frequency (A/B). A 4-bit code set into IC3 determines amplitude of the appropriate A/B frequency. Amplitude is varied from 0 to full in 16 equal steps. Hex 0 = 0 amplitude while hex F = full amplitude.

The two amplitude controlled frequencies are combined and fed to the input of your audio amplifier. The two frequencies could be optionally fed to separate inputs of a stereo amplifier if desired. This would permit specialized stereo effects to be programmed. Because of the wide range of frequencies possible, wide range amplifiers and speakers work best. For this reason we did not bother to provide an unsatisfactory card mounted small speaker.

In Figure 1 the sound is gated with the COSMAC Q line. Q must always be set to have an audible sound output.

In Figure 2, IC7 decodes various memory addresses to select appropriate sound circuits. All sound circuits are treated as memory locations. Frequency, octave, and volume for each channel are programmed by writing to specific memory locations as follows:

WRITE XX TO M (8001) - SETS A FREQUENCY = XX
WRITE XX TO M (8002) - SETS B FREQUENCY = XX
WRITE 0X TO M (8010) - SETS A AMPLITUDE = X
WRITE 0X TO M (8020) - SETS B AMPLITUDE = X

The octave crossbar switch (IC4) is programmed as follows:

WRITE 00 TO M (8003) - RESET A OCTAVE = 2 SWITCH
" 01 " " 3 "
" 02 " " 4 "
" 03 " " 5 "

WRITE 04 TO M (8003) - RESET B OCTAVE = 2 SWITCH
" 05 " " 3 "
" 06 " " 4 "
" 07 " " 5 "

WRITE 10 TO M (8003) - SET A OCTAVE = 2 SWITCH
" 11 " " 3 "
" 12 " " 4 "
" 13 " " 5 "

WRITE 14 TO M (8003) - SET B OCTAVE = 2 SWITCH
" 15 " " 3 "
" 16 " " 4 "
" 17 " " 5 "

For proper circuit operation the hex sequence 00-01-02-03-04-05-06-07-08-09-0A-0B-0C-0C-0E-0F must be written to M(0003) at the beginning of each program to clear the crossbar switch. Two "A" switches or two "B" switches should never be left set at the same time.

IC9 and IC10 provide a gated variable oscillator that provides COSMAC interrupt signals at a rate determined by the tempo control. This rate should lie in the range of 50 to 250 cycles/second. Rates in excess of 250/second can cause programs to malfunction.

After appropriate COSMAC registers have been set by a program, interrupts are initiated by writing 01 to M(8030). Interrupts are turned off by writing 00 to M(8030). When programs are synchronized to the interrupt routine the manual tempo adjustment can be used.

Note that breaking the X-Y link in Figure 2 permits one VIP to drive other VIP interrupts for synchronous sound generation.

PIN-8 PROGRAM (FOR 2K BYTE RAM SYSTEM)

The pin-8 program listing and flow chart are provided in Appendix I. Pin-8 lets you program music by setting up tables of musical notes in memory (using the VIP operating system). These tables can be saved on cassette tapes for later use. Pin-8 lets you program 3 channels of sound. Separate note tables are provided for A & B sound channels. Tables for the optional drum channel are also provided. See Figure 4 to add this I/O port drum option hardware. Pin-8 is a machine language program designed for high-speed, real time control of the 3 sound channels.

Figure 5 illustrates how the pin-8 tables are constructed to play a tune. A lot of music is available in single line form as shown at A (top left). The circled numbers (C, D7) represent background chords while the notes represent the melody line. The chords can be expanded into runs of individual harmonizing notes as shown at B. Add a rhythm pattern as shown at D for the drum option.

To program channel A, use the note tables shown in Figure 6. Assign the proper 2-hex digit note code to each note as shown. Now construct the A-note table for the two measures shown by listing the note codes within each measure. Label the measure entry points in this table (AM1, etc.). If two measures are identical the measure only has to be entered and labeled once in the note table. (See sample drum table for example of repeated measure.) The A-note table starts at M(0401) and ends at M(04FF). You can program up to 255 notes broken into measures in this table.

Now construct the A-measure table by listing the low order bytes of the addresses of measure starting points from the A-note table. End the A-measure table with a 00 code. When you run the pin-8 program, it will go to the A-measure table to find the sequence of note codes for the first measure of the tune. It will then play this sequence of notes obtained from the A-note table. Upon completion of the last note in the measure, the program will obtain the address of the next note sequence from the measure table. When a 00 code is found in the A-measure table, the program branches to a special subroutine that uses the break table.

The break table consists of groups of 7 control bytes. These control codes set the A & B octave ranges and specify how the notes will sound. See Figure 7 for a description of these codes. The 7th byte in each break table group specifies whether to stop or continue playing the tune.

The break table begins at M(0270) and ends at M(02AE). The first 7 bytes (at 0270-0276) are used prior to beginning to play the tune. In Figure 5, the A channel is set to octave 4 (code 12) and a normal (steady) pitch with an amplitude envelope shown as CF in Fig. 7 is specified for each subsequent A channel note. The B channel is set to octave 2 (14 code) and a normal (steady) pitch with an amplitude envelope shown as BF (chime) in Figure 7 is specified for each subsequent B note. The 00 code in the sample break table causes the two measures of Figure 5 to be repeated indefinitely.

Breaks can be inserted between any two measures of a tune without affecting playing time. This provides you with the ability to change the way the A & B channel notes sound at various points in the tune.

Figure 5 shows how the B channel notes are programmed in a similar manner using the B-note table and B-measure table. Figure 8 summarizes the location of all tables in memory.

The optional drum channel (**D**) is programmed as shown in Figure 5 using the drum note codes of Figure 9.

The notes in each measure must always total a whole note (4 quarter notes) for 4/4 time tunes. The notes in each measure must always total a 3/4 note (3 quarter note) for 3/4 time tunes. This is important for proper note sequencing. You must also set the measure time byte at M(0259) as shown below the note code table (Figure 6) for proper operation.

CONCLUSION

There are many excellent beginner music books. You will find these helpful in understanding musical notation, chord structure, etc. The VIP Supersound system provides unlimited opportunities for experimenting with rhythm patterns, two part harmony, etc. With multiple VIPs or a four channel recorder more complex musical arrangements can be explored.

The note amplitude envelopes can be changed to suit your needs. These envelope tables are located in memory as follows:

B0	C0	D0	E0	F0
02BF	02CF	02DF	02EF	02FF
⋮	⋮	⋮	⋮	⋮
02B0	02C0	02D0	02E0	02F0

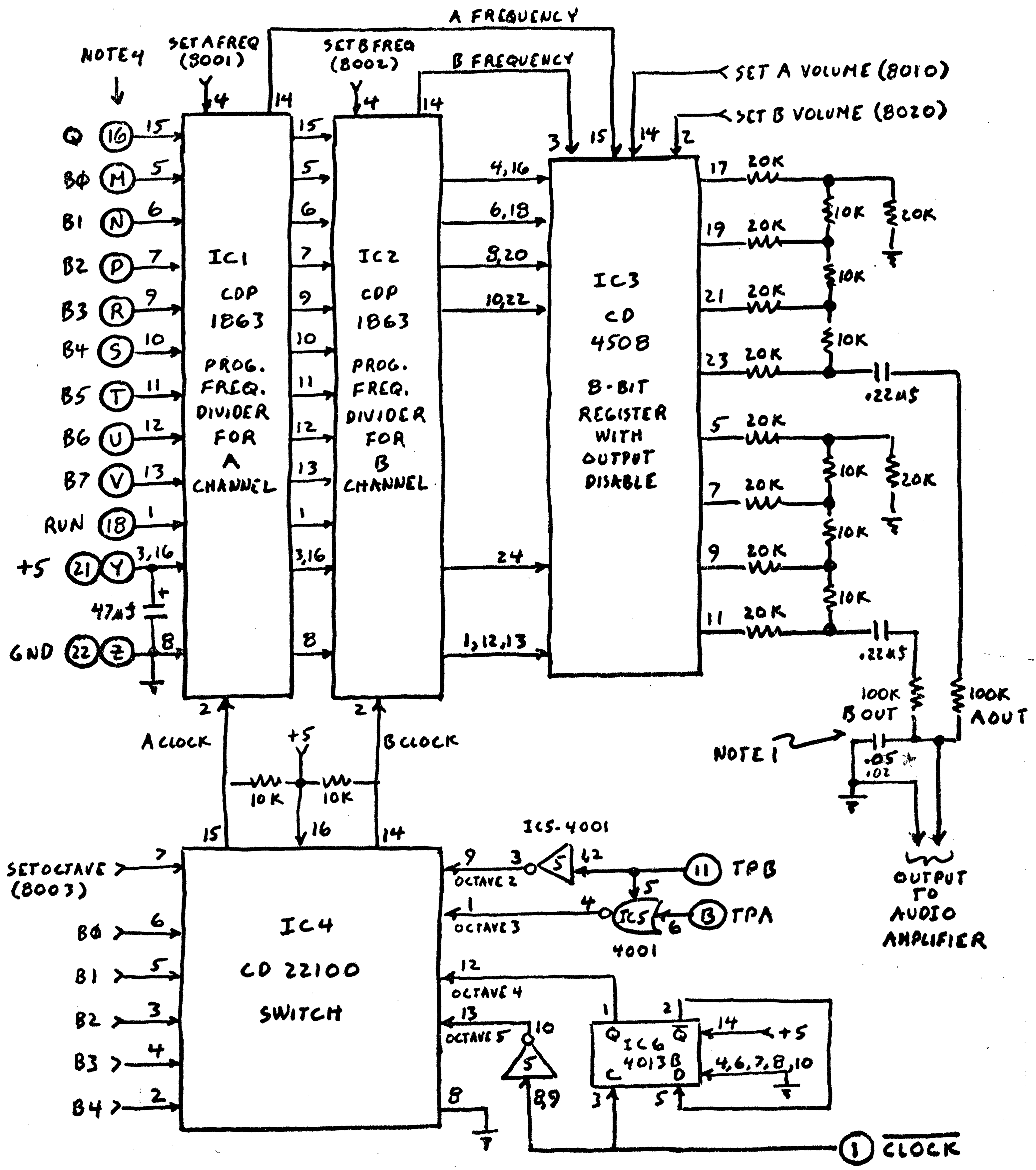
The 16 bytes in the specified table are used to set the channel amplitude (volume) sequentially. The amplitude is changed sixteen times per note. The bytes are sequenced from highest to lowest address. A 00 byte sets amplitude to 0 (inaudible) while an 0F byte sets maximum amplitude (loudest).

The note table for the note sequence shown in Figures 3 and 6 is located at M(01E1) to M(01FB). Non-conventional scales can be created by changing this frequency table.

By all means try the sample music programs provided in Appendix II. You'll be amazed at what can be done with the equivalent of two fingers at a keyboard.

For readers who want to try computer music generation, use CHIP-8 to write a program that generates the A & B note and measure tables. Then load the pin-8 program to play your computer composed tune.

If you would like to experiment with weird sounds try the program in Appendix III.

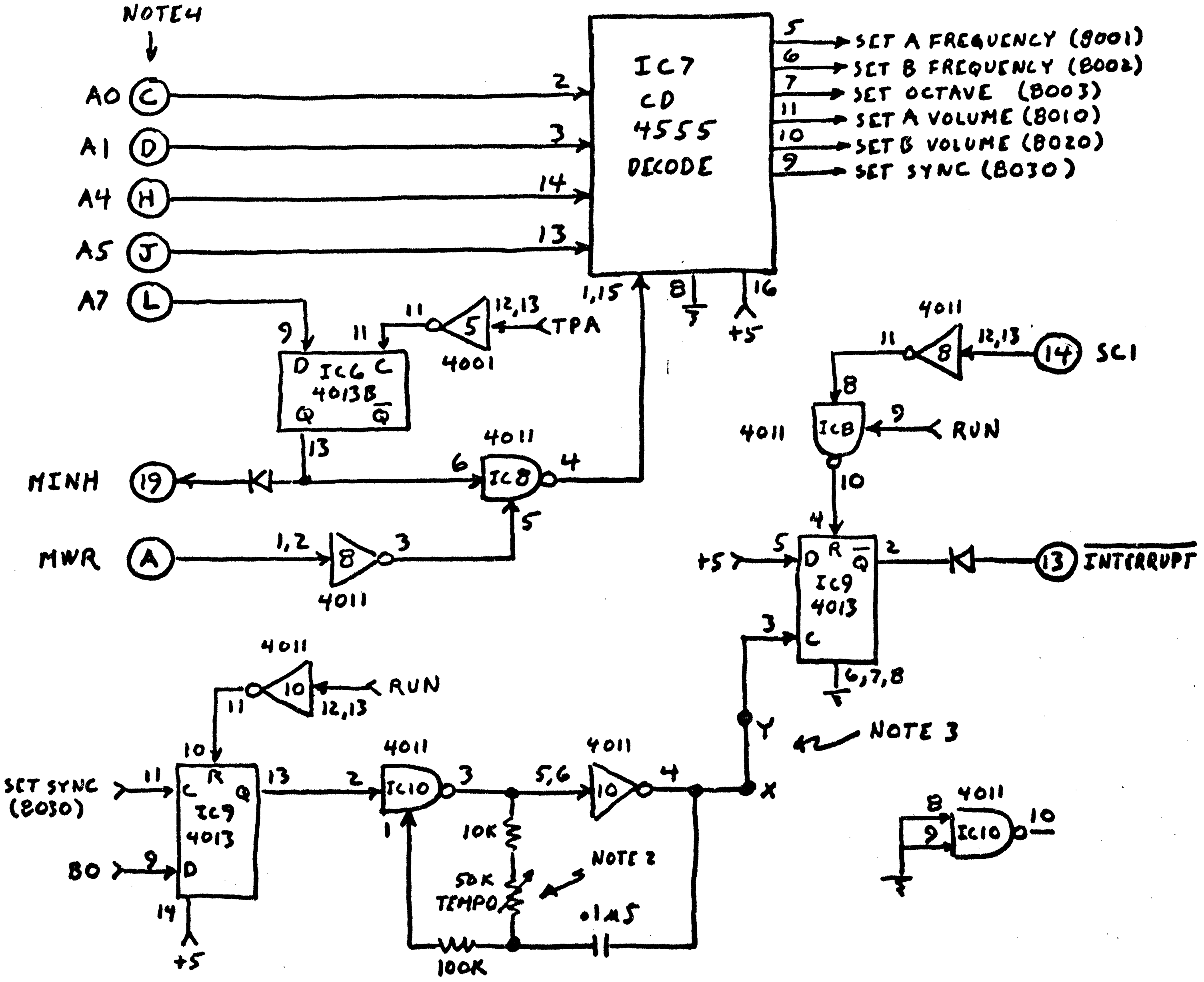


* MAY BE DECREASED IF BRIGHTER HIGHS DESIRED

VIP SUPERSOUND CARD (1/2)

FIGURE 1

JAW 6-78



NOTE 1- A+B OUTPUT RESISTORS CAN BE INCREASED/DECREASED TO MATCH AUDIO AMPLIFIER INPUT. SEPARATE 2 CHANNEL OUTPUT IS POSSIBLE.

NOTE 2- INTERRUPT RATE CAN BE VARIED FROM 50/SEC. TO 250/SEC. THIS RATE SETS TEMPO.

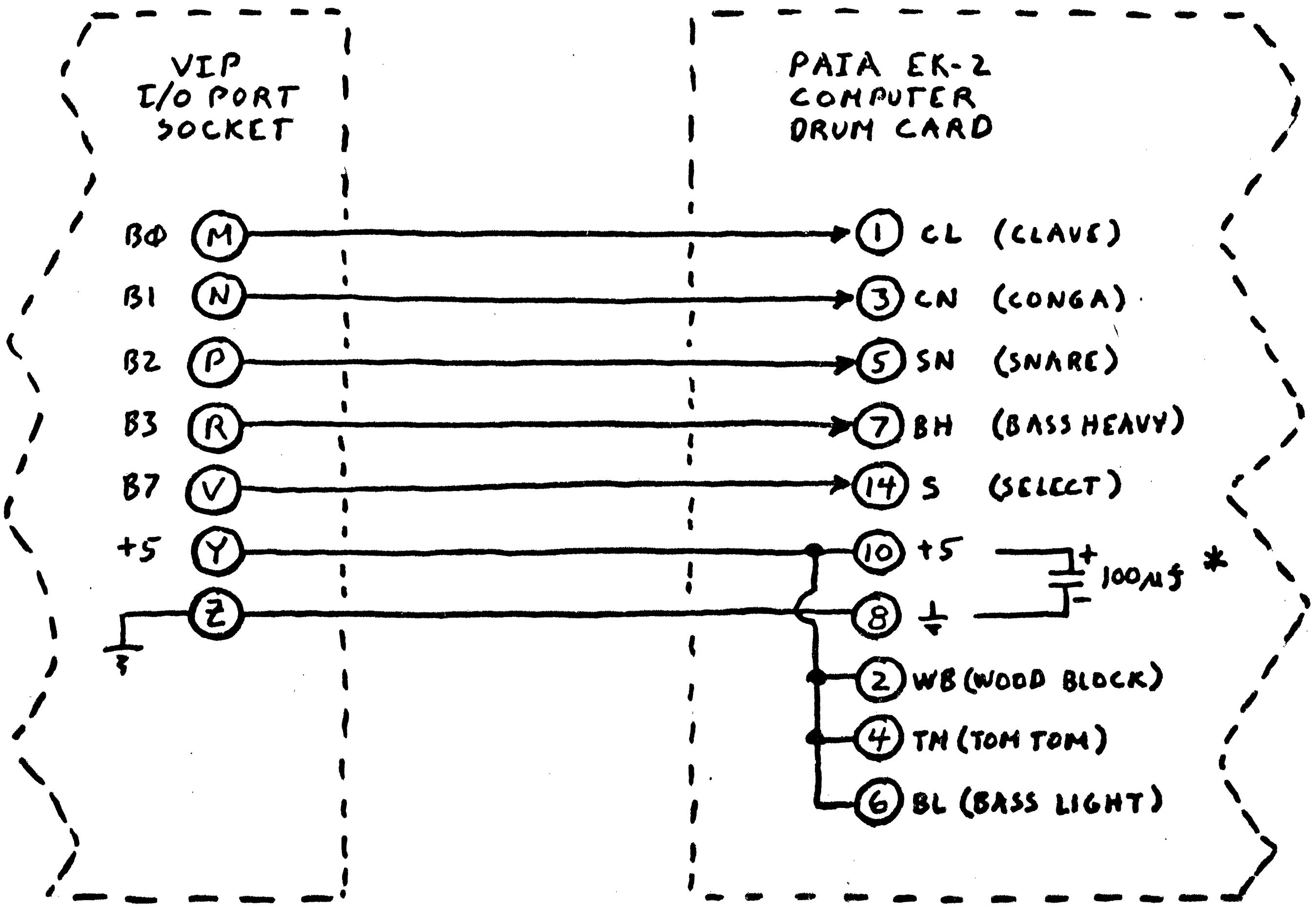
NOTE 3- WHEN USING MULTI-TRACK TAPE RECORDER, X-Y CAN BE BROKEN AND Y DRIVEN FROM PRERECORDED SYNC. TRACK INSTEAD OF INTERNAL OSCILLATOR. THIS INSURES PERFECT SYNC. BETWEEN TRACKS. A 4 TRACK RECORDER PERMITS 6 CHANNEL SOUND.

NOTE 4- CIRCLED PIN NUMBERS REFER TO COSMAC VIP 44-PIN EXTERNAL INTERFACE SOCKET.

VIP SUPERSOUND CARD (2/2)

FIGURE 2

JAW 6-78



NOTE: INSTRUCTION 63 = MX → DRUMS, RX+1
BIT 0=0= CLAVE, BIT 1=0=CONGA, BIT 2=0=SNARE, BIT 3=0=BASS
BIT 7=1 FOR STRIKE PULSE.

*ADD THIS CAPACITOR TO EK-2 CARD

EK-2 COMPUTER DRUM CARD KIT AVAILABLE FROM PAIA ELECTRONICS, 1020 W. WILSHIRE BLVD., OKLAHOMA CITY, OK 73116 ... PRICE UNDER $30.

PAIA DRUM OPTION FOR
VIP SUPERSOUND SYSTEM

FIGURE 4

JAW 6-78

OCTAVE	NOTE	FREQUENCY	HEX CODE
1/2/3/4	A	55.000	F9 (<.3%)
	A#/Bb	58.270	EB
	B	61.735	DE
2/3/4/5	C	65.406	D1
	C#/Db	69.296	C5
	D	73.416	BA
	D#/Eb	77.782	B0
	E	82.407	A6
	F	87.307	9D
	F#/Gb	92.499	94
	G	97.999	8B
	G#/Ab	103.83	83
	A	110.00	7C
	A#/Bb	116.54	75
	B	123.47	6E
3/4/5/6	C	130.81	68
	C#/Db	138.59	62 (<.3%)
	D	146.83	52 (<1%)
	D#/Eb	155.56	57
	E	164.81	52
	F	174.61	4E
	F#/Gb	185.00	49
	G	196.00	45
	G#/Ab	207.65	41
	A	220.00	3D
	A#/Bb	233.08	3A
	G	246.94	37 (<1%)

NOTE FREQUENCY TABLE

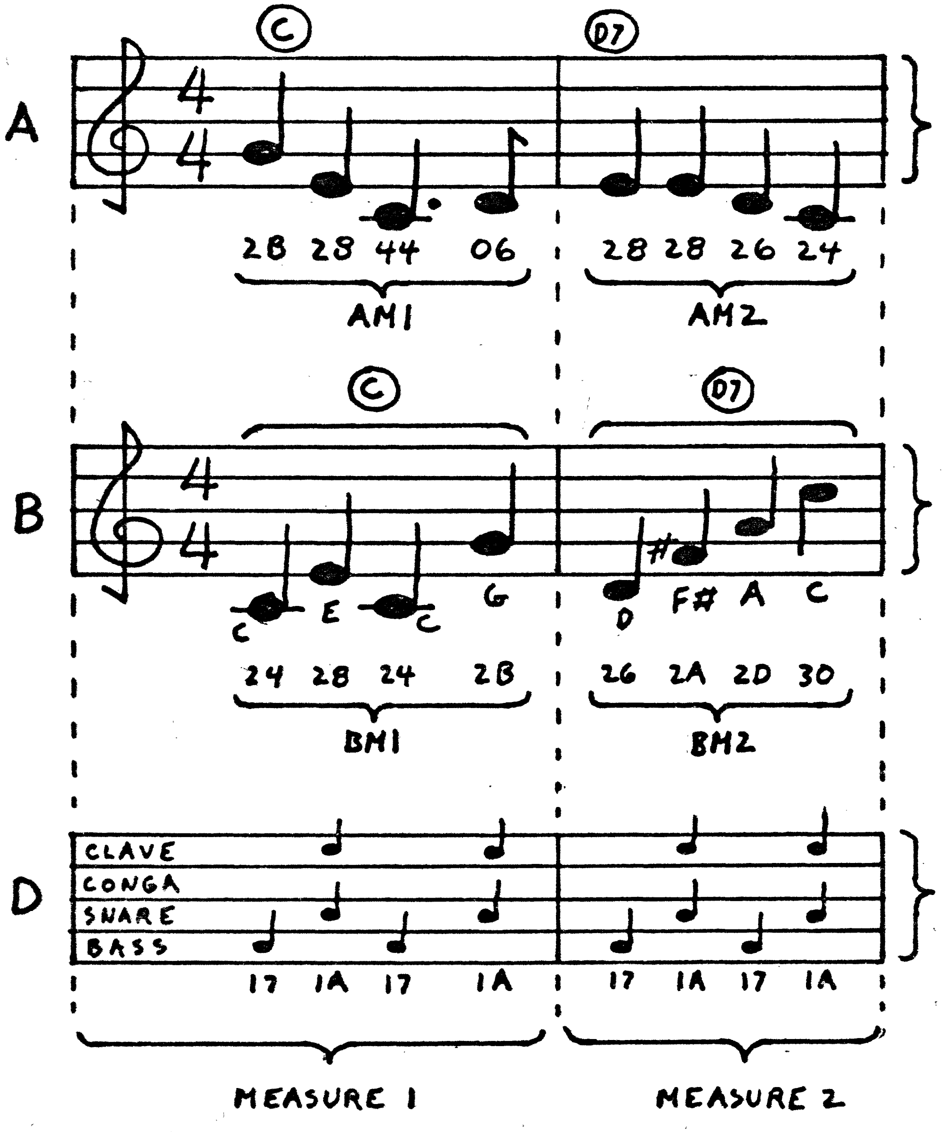
FIGURE 3

TABLE	MEMORY LOCATIONS
A - NOTE	0401 - 04FF (255 NOTES)
A - MEASURE	0300 - 037F (128 MEASURES)
B - NOTE	0501 - 05FF (255 NOTES)
B - MEASURE	0380 - 03FF (128 MEASURES)
D - NOTE	0681 - 06FF (127 NOTES)
D - MEASURE	0600 - 067F (128 MEASURES)
BREAK	0270 - 02AE (9 BREAKS)

TABLE MEMORY LOCATIONS

FIGURE 8

JAW 7-78



A-NOTE TABLE

AM1 → 0401 = 2B
0402 = 28
0403 = 44
0404 = 06
AM2 → 0405 = 28
0406 = 28
0407 = 26
0408 = 24

A-MEASURE TABLE

0300 = 01 (AM1)
0301 = 04 (AM2)
0302 = 00 (BREAK)

B-NOTE TABLE

BM1 → 0501 = 24
0502 = 28
0503 = 24
0504 = 2B
BM2 → 0505 = 26
0506 = 2A
0507 = 2D
0508 = 30

B-MEASURE TABLE

0380 = 01 (BM1)
0381 = 05 (BM2)
0382 = 00 (BREAK)

D-NOTE TABLE

DM1 → 0681 = 17
0682 = 1A
0683 = 17
0684 = 1A

D-MEASURE TABLE

0600 = 81 (DM1)
0601 = 81 (DM2)
0602 = 00 (BREAK)

FAST 4/4 TIME : SET M(0259) = 7F

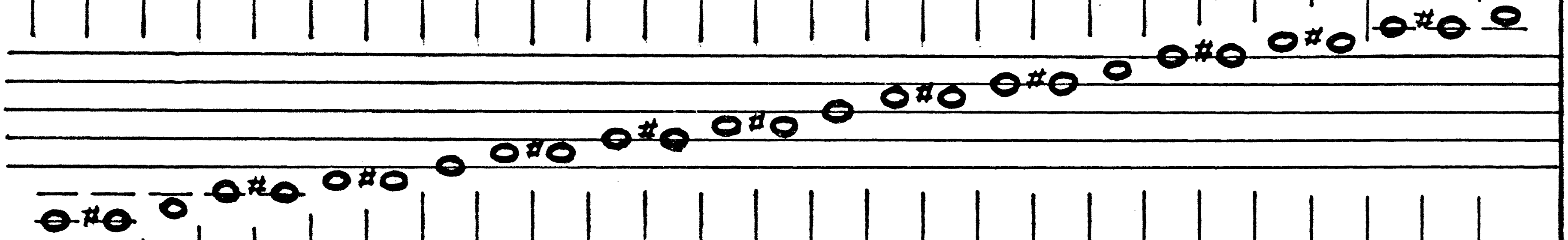
BREAK TABLE

0270 = 12 (A OCTAVE)
0271 = 01 (A MODE)
0272 = ~~EF~~ C0 (A ENVELOPE)
0273 = 14 (B OCTAVE)
0274 = 01 (B MODE)
0275 = ~~BE~~ B0 (B ENVELOPE)
0276 = 00 (BREAK CONTROL)

MUSIC CODING EXAMPLE

FIGURE 5

JAW 7-78



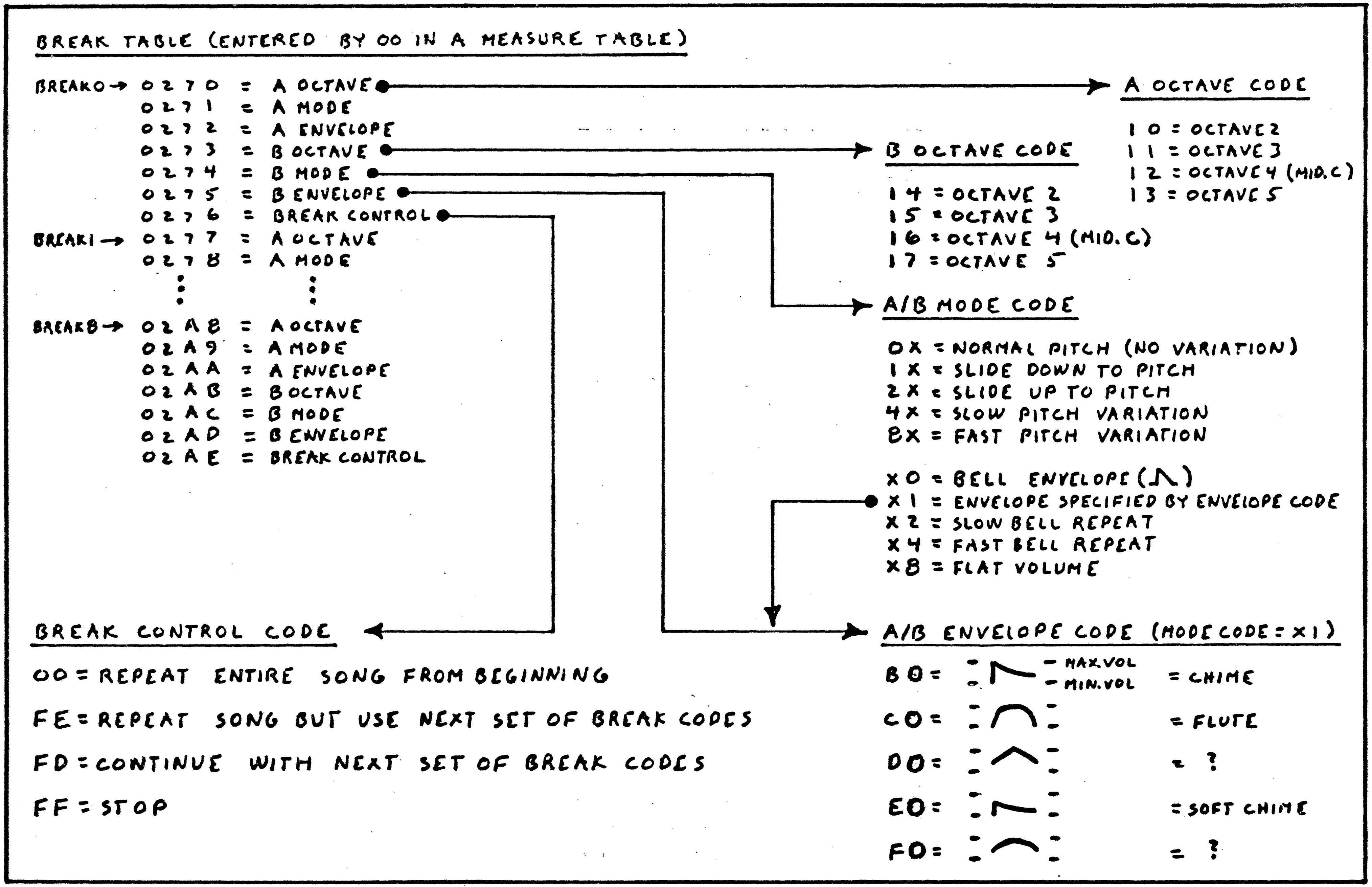
← FAST TIME *	← SLOW TIME **	← REST	A	Bb A#	B	C	Db C#	D	Eb D#	E	F	Gb F#	G	Ab G#	A	Bb A#	B	C	Db C#	D	Eb D#	E	F	Gb F#	G	Ab G#	A	Bb A#	G
♪	𝅘𝅥𝅯	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	14	15	16	17	18	19	1A	1B
♩	♪	20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F	30	31	32	33	34	35	36	37	38	39	3A	3B
♩.	♪.	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	54	55	56	57	58	59	5A	5B
𝅗𝅥	♩	60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F	70	71	72	73	74	75	76	77	78	79	7A	7B
𝅗𝅥.	♩.	80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F	90	91	92	93	94	95	96	97	98	99	9A	9B
𝅝	𝅗𝅥	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB
𝅝.	𝅗𝅥.	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB
𝅝‿𝅝	𝅝	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB

NOTE CODE TABLE

* FAST 4/4 TIME: SET M(0259) = 7F – FAST 3/4 TIME: SET M(0259) = 5F
** SLOW 4/4 TIME: SET M(0259) = FF – SLOW 3/4 TIME: SET M(0259) = BF

FIGURE 6

JAW 7-78



BREAK TABLE CODES

JAW 7-78

FIGURE 7

	BASS SNARE CONGA CLAVE	𝅘𝅥𝅮	𝅘𝅥	𝅘𝅥.	𝅗𝅥	𝅗𝅥.	𝅝	𝅝.	𝅝⁀𝅝	← FAST TIME	
		𝅘𝅥𝅯	𝅘𝅥𝅮	𝅘𝅥𝅮.	𝅘𝅥	𝅘𝅥.	𝅗𝅥	𝅗𝅥.	𝅝	← SLOW TIME	
	X X X X	00	10	20	30	40	50	60	70		
	X X X -	01	11	21	31	41	51	61	71		
	X X - X	02	12	22	32	42	52	62	72		
	X X - -	03	13	23	33	43	53	63	73		
	X - X X	04	14	24	34	44	54	64	74		
	X - X -	05	15	25	35	45	55	65	75		
	X - - X	06	16	26	36	46	56	66	76		
●	X - - -	07	17	27	37	47	57	67	77		●
	- X X X	08	18	28	38	48	58	68	78		
	- X X -	09	19	29	39	49	59	69	79		
	- X - X	0A	1A	2A	3A	4A	5A	6A	7A		
●	- X - -	0B	1B	2B	3B	4B	5B	6B	7B		●
	- - X X	0C	1C	2C	3C	4C	5C	6C	7C		
●	- - X -	0D	1D	2D	3D	4D	5D	60	70		●
●	- - - X	0E	1E	2E	3E	4E	5E	6E	7E		●
●	- - - -	0F	1F	2F	3F	4F	5F	6F	7F		●

DRUM CODE TABLE

FIGURE 9

JAW 7-78

JOE WEISBECKER
1220 WAYNE AVENUE, CHERRY HILL, NJ 08002

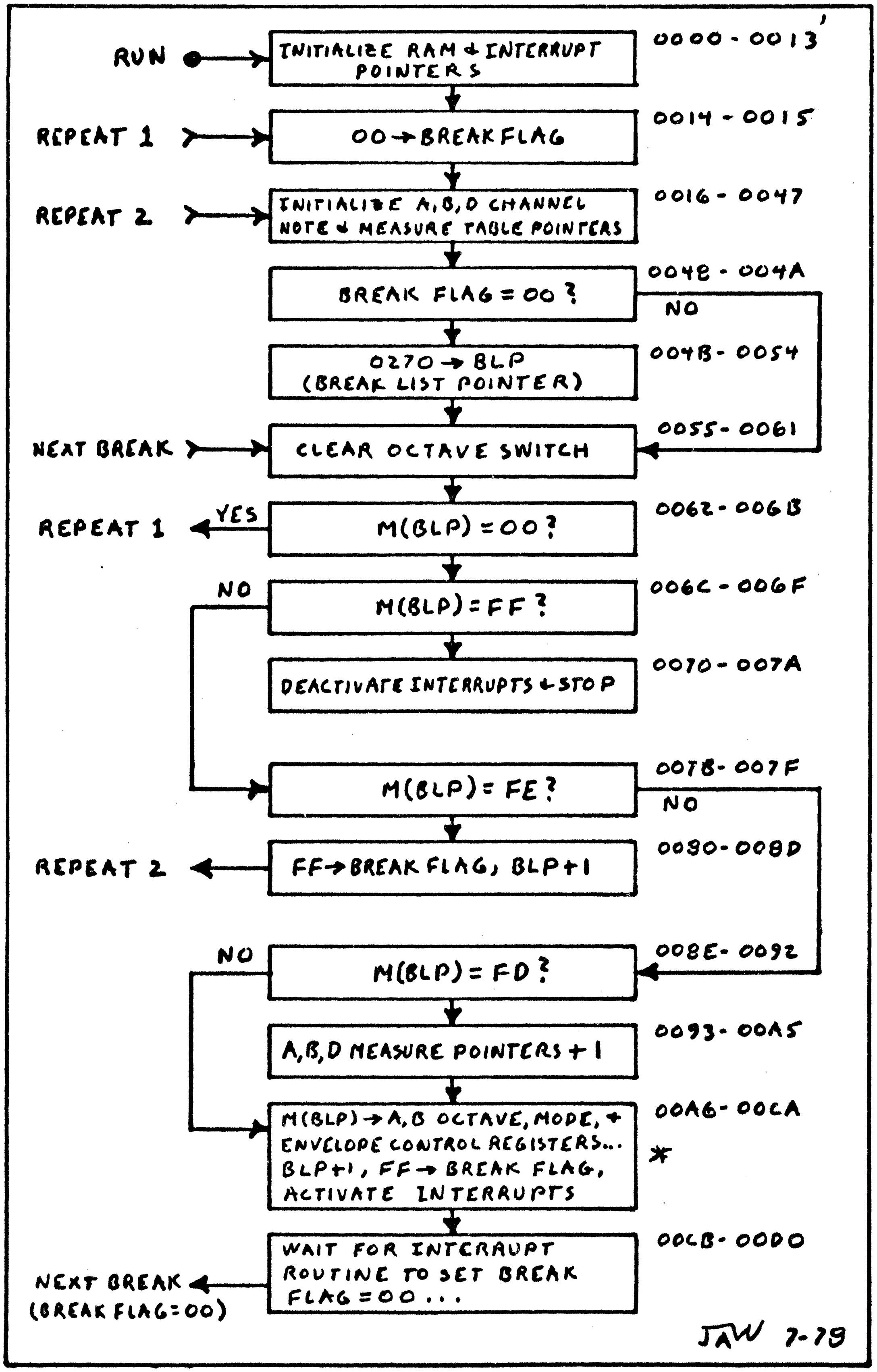
APPENDIX I

PIN-8 PROGRAM LISTING
&
FLOWCHART

PIN-8 BY JOE WEISBECKER

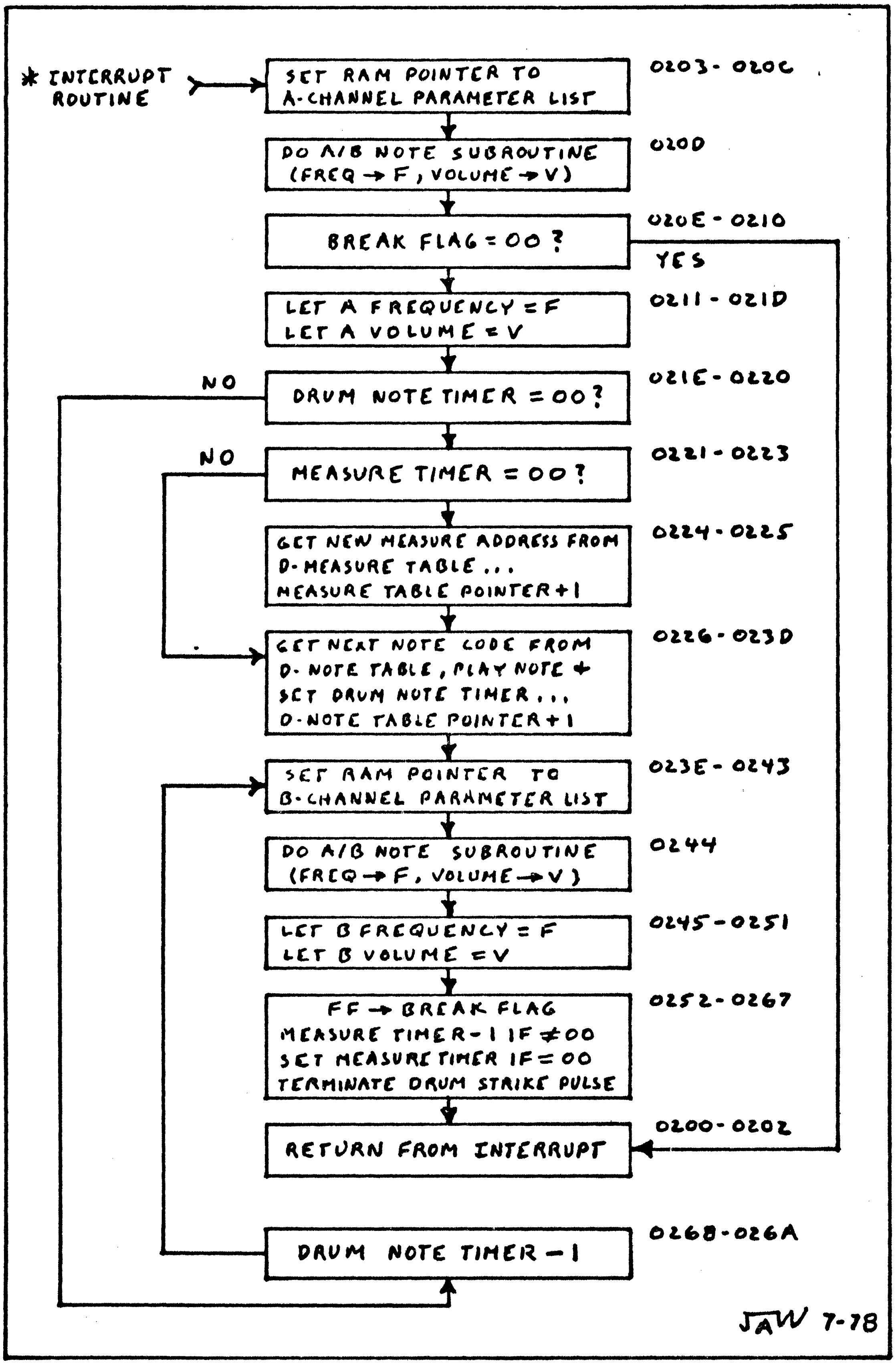
```
ADDR

0000   F8 07 B2 BE F8 FF A2 F8
0008   01 B3 A3 F8 02 B1 F8 03
0010   A1 F8 02 B5 90 B9 F8 1F
0018   AE 2E 90 5E 8E 3A 19 F8
0020   02 AE F8 03 5E 1E 90 5E
0028   1E F8 04 5E F8 12 AE F8
0030   03 5E 1E F8 80 5E 1E F8
0038   05 5E F8 06 BA 90 AA F8
0040   06 BB F8 80 AB 90 AC AD
0048   99 3A 55 F8 20 AE F8 02
0050   5E 1E F8 70 5E F8 80 BF
0058   F8 03 AF F8 10 FF 01 5F
0060   3A 5D F8 20 AE 4E B4 0E
0068   A4 04 32 14 FB FF 3A 7B
0070   F8 30 AF F8 80 BF 90 5F
0078   7A 30 79 04 FB FE 3A 8E
0080   F8 FF B9 14 F8 20 AE 94
0088   5E 1E 84 5E 30 16 04 FB
0090   FD 3A A6 F8 FF B9 14 F8
0098   03 AE 0E FC 01 5E F8 13
00A0   AE 0E FC 01 5E 1A 44 5F
00A8   90 AE 44 5E 1E 44 5E 44
00B0   5F F8 10 AE 44 5E 1E 44
00B8   5E F8 20 AE 94 5E 1E 84
00C0   5E 7B F8 30 AF F8 FF B9
00C8   F8 01 5F 00 99 32 55 30
00D0   CB 00 00 00 00 00 00 00
00D8   00 00 00 00 00 00 00 00
00E0   00 00 00 00 00 00 00 00
00E8   00 00 00 00 00 00 00 00
00F0   00 00 00 00 00 00 00 00
00F8   00 00 00 00 00 00 00 00

0100   D1 4E B4 4E A5 4E B6 4E
0108   A6 4E B7 4E A7 4E A4 4E
0110   B8 4E A9 84 3A 3B 8D 3A
0118   1E 46 A7 B9 32 00 47 BD
0120   FA 1F F9 E0 AF 0F B8 9D
0128   F6 F6 F6 F6 F6 F9 D0 AF
0130   0F A4 FA 0F A9 84 F9 0F
0138   A4 30 3C 24 84 BD 89 AF
0140   8F 32 49 2F 9D F6 BD 30
0148   40 98 EE A8 5E 3A 52 BD
0150   30 9B 94 FE 3B 5C 84 FA
0158   03 F3 30 72 FE 3B 62 9D
0160   30 57 FE 3B 6B 9D F6 F6
0168   F4 30 72 FE 3B 73 9D F6
0170   F6 F5 A8 94 F6 3B 80 9D
0178   5E 85 F1 A5 05 BD 30 9B
0180   F6 3B 87 84 BD 30 9B F6
0188   3B 8F 84 FE BD 30 9B F6
0190   3B 9B F8 0F BD 30 9B 00
0198   00 00 00 2E EE 89 73 98
01A0   73 84 73 87 73 97 73 86
01A8   73 96 73 2E 94 5E 30 00
01B0   00 00 00 00 00 00 00 00
01B8   00 00 00 00 00 00 00 00
01C0   00 00 00 00 00 00 00 00
01C8   00 00 00 00 00 00 00 00
01D0   00 11 22 32 53 73 B4 F4
01D8   00 00 00 00 00 00 00 00

01E0   00 F9 EB DE D1 C5 BA B0
01E8   A6 9D 94 8B 83 7C 75 6E
01F0   68 64 5D 57 52 4E 49 45
01F8   41 3D 3A 37 00 00 00 00

0200   E2 42 70 22 78 22 52 F8
0208   01 BF F8 00 AE D3 99 32
0210   00 F8 80 BF F8 01 AF 88
0218   5F F8 10 AF 9D 5F 8C 3A
0220   68 8D 3A 26 4A AB 4B BC
0228   F6 F6 F6 F6 F9 D0 AF F8
0230   01 BF 0F F9 0F AC 9C F9
0238   80 BC E2 22 52 63 F8 01
0240   BF F8 10 AE D3 F8 80 BF
0248   F8 02 AF 88 5F F8 20 AF
0250   9D 5F F8 FF B9 8D 3A 5D
0258   F8 FF AD 30 5E 2D E2 22
0260   9C FA 7F BC 52 63 30 00
0268   2C 30 3E 00 00 00 00 00
0270   12 21 B0 15 01 E0 00 00 }
0278   00 00 00 00 00 00 00 00 }
0280   00 00 00 00 00 00 00 00 }
0288   00 00 00 00 00 00 00 00 }  BREAK
0290   00 00 00 00 00 00 00 00 }  TABLE
0298   00 00 00 00 00 00 00 00 }
02A0   00 00 00 00 00 00 00 00 }
02A8   00 00 00 00 00 00 00 00 }
02B0   04 04 04 05 05 05 06 06
02B8   07 08 09 0A 08 0D 0F 00
02C0   00 05 09 0B 0C 0D 0D 0D
02C8   0D 0D 0D 0C 0B 09 05 00
02D0   00 02 04 06 08 0A 0C 0E
02D8   0E 0C 0A 08 06 04 02 00
02E0   01 01 01 02 02 02 03 03
02E8   03 04 04 05 06 07 08 00
02F0   09 0A 0B 0C 0D 0D 0D 0D
02F8   0D 0D 0D 0D 0C 0B 0A 09

0300   01 03 05 07 09 0B 0F 13 }  A-MEASURE
0308   14 03 05 16 09 1A 1C 1F }    TABLE
0310   20 20 20 20 00 00 00 00 }

0380   E0 01 01 05 05 09 09 05 }  B-MEASURE
0388   05 01 01 05 05 09 09 05 }    TABLE
0390   0D 0D 0D 0D 00 00 00 00 }

0400   00 C0 6B AD B0 D5 6D AB }
0408   B0 D4 70 8F 2D 6F 70 72 }
0410   72 75 75 F4 D0 6B 6B 6B }  A-NOTE
0418   70 70 CF 70 74 B2 6F F0 }  TABLE
0420   E0 00 00 00 00 00 00 00 }

0500   00 69 6D 69 70 64 68 64 }  B-NOTE
0508   6B 6B 6F 6B 72 E0 00 00 }  TABLE

0600   87 81 81 81 81 81 81 81 }  D-MEASURE
0608   81 81 81 81 81 81 81 81 }    TABLE
0610   81 81 81 81 00 00 00 00 }

0680   00 37 1A 1A 3D 1E 1E 7F }  D-NOTE
0688   00 00 00 00 00 00 00 00 }  TABLE
```

JAW 7-78



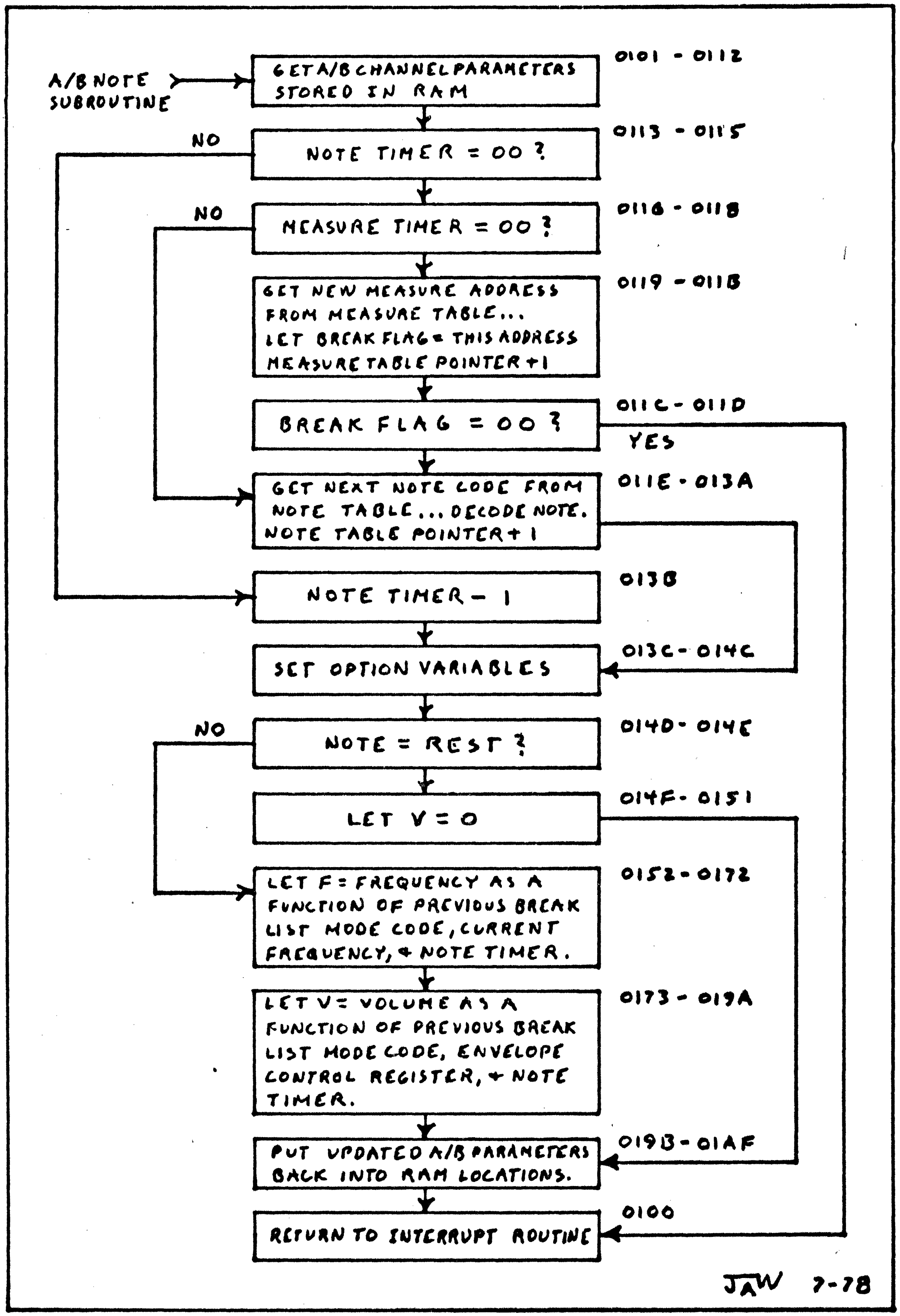
PIN-8 PROGRAM FLOWCHART

* A + B OCTAVE SWITCHES SET HERE, MODE + ENVELOPE CODES USED LATER



PIN-8 INTERRUPT ROUTINE FLOWCHART

* INTERRUPTS OCCUR 50-250 TIMES/SEC. DEPENDING ON TEMPO CONTROL SETTING



PIN-8 A/B NOTE SUBROUTINE