SYSTEM 1

HARDWARE & OPERATING SYSTEM DESCRIPTION.

COMPANY CONFIDENTIAL.

DISTRIBUTION:

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SYSTEM I HARDWARE DESCRIPTION

DATE : OCT. 31 1984
BY : SAM LY

I. Microprocessors:

A. 68010 running @ 7.16 MHZ.
B. Program ROM:
- 256K word max. for 256k ROM (128k word max. for 128k ROM), including 16K word on the main board.

C. Program RAM:
- 4K word fixed on the main board.

D. Interrupt:
- Sound port (from 6502) - level 6
- Vblank - level 4.
- IRQ level 1 & 3 available for expansion on a cartridge.
- Analog joystick - level 2

E. 6502 runs at 1.78 mhz
- IRQ from timer of the YAMAHA sound chip. This is a programmable timer IRQ & IRQ acknowledge.
- NMI from the 68010 .

F. Input/output:
1. trak ball interface (see Leta.doc in DRAO:[general] for detail) readable by the 68010. The 8 inputs to the Leta can NOT be used to read reliably switch inputs as mentioned in the documenation LETA.DOC .
2. analog joystick:
the analog joystick is read by the 68010 through the 9 word addressed corresponding to 8 A to D channels. Each channel is controlled by a particular direction of movement (up, down, left, right) of the joystick.
Before reading any channel, a start conversion signal should be written to the A to D. Instead of separate addresses for the start conversion, reading the value of any address also automatically starts the conversion of the channel corresponding to that address.
At end of the A to D conversion is done, a signal will be sent to the 68010 as an interrupt. This interrupt can be masked by WRITING the address F40010
Reading the address of any channel will automatically clear the interrupt.

G. EEPROM:
A 512 byte EEPROM is used as a nonvolatile memory for the 68010 You can read or write the EEPROM just as a RAM, however, after a write to the EEPROM, you should wait a minimum of 10 msec. before accessing (read or write) the EEPROM again (For more info. read the EEPROM data sheet & application notes.)
Before writting to the EEPROM, you should enable the write by writting (any data) to UNLOCK (@ 8C0000) . You should not read the EEPROM after you UNLOCK until you have written something somewhere (any data, any location.)

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I. Graphics.

A. Display. - 336 x 240 pixels - standard res. monitor.
B. Playfield: - Size: 64 stamps x 64 stamps
- Visible screen: 42 stamps x 30 stamps

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- Stamp size: 8 pixels x 8 pixels
- Independent smooth scrolling horizontally & vertically (wrap-around).
- THE VERTICAL SCROLLING REGISTER SHOULD BE WRITTEN EVERY VBLANK. Ask your technician to put the vertical register mod. in the game board for game development.
- Max capacity: 2 banks of 32K stamps(assuming all graphics ROMs are playfield addressable by the graphics mapping PROM. This is the max. capacity provided by the main board. It varies depending on the cartridge used.)

Each stamp in the playfield is specified by one word in the playfield RAM as follows:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
H															
								PIC #							

H: Horizontal flip

Note: The playfield bank select bit (addr.$60000 D2)& the upper 7 bits of the PIC# feed into 2 PROMs which map the picture code into a graphics ROM location and define bit depth-palette number.

- Variable planes playfield, up to 8 bits deep.

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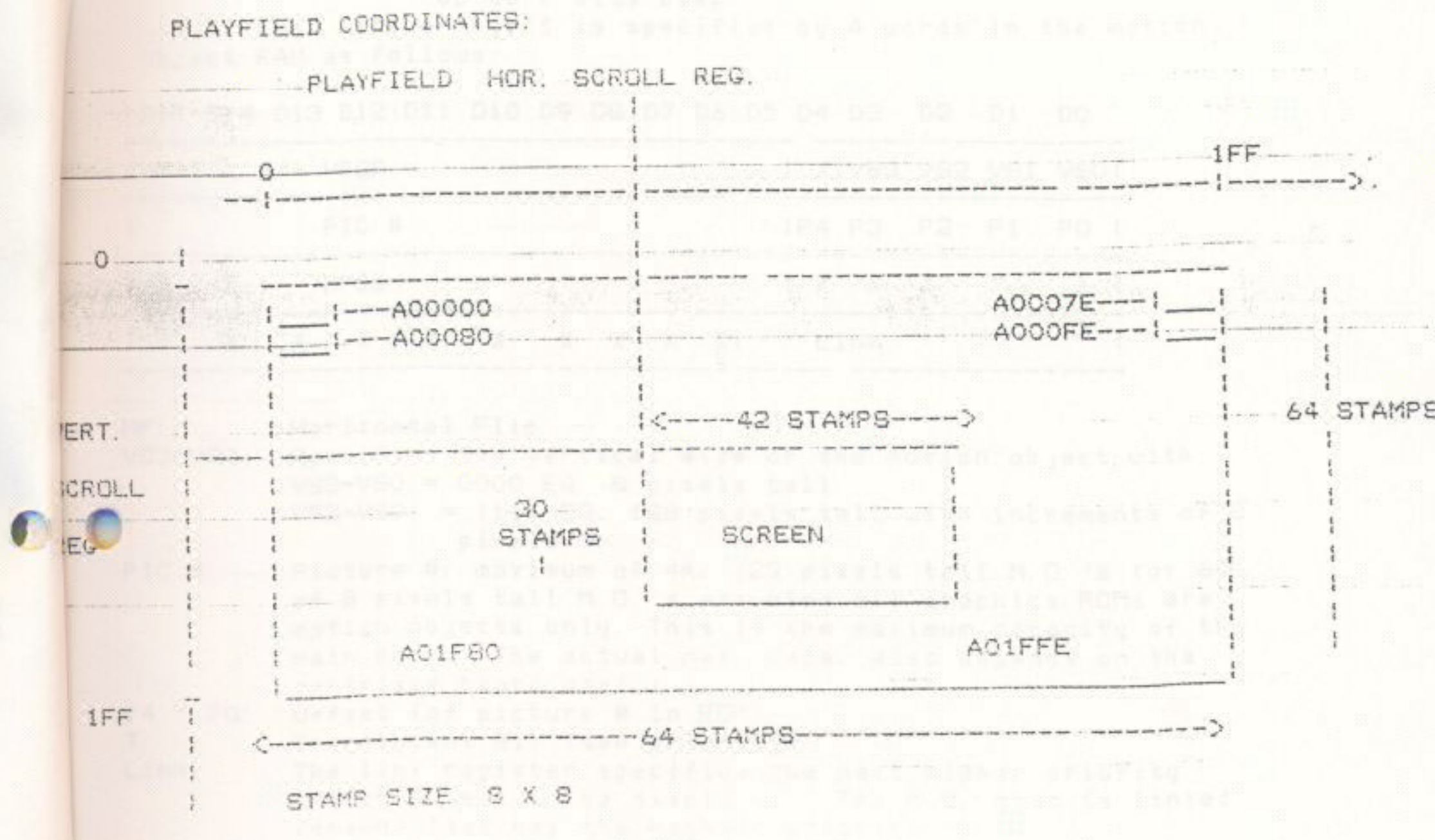
PLAYFIELD COORDINATES:



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C. Motion Objects: 56 M.O.'s visible
- "Linked" M.O.'s
- 8 motion object parameters buffers (of 64 M.O.'s each)
- 8 pixels wide x 8 N pixels tall up to 128
- Variable planes/M.O.'s pixels up to 7 bits deep.

Each motion object is specified by 4 words in the motion object RAM as follows:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
HF	X	VPOS									X	VS3	VS2	VS1	VS0
PIC #											P4	P3	P2	P1	P0
T	X	HPOS									X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	LINK					

HF: Horizontal Flip

VS3-VS0: Specifies the vertical size of the motion object with
VS3-VS0 = 0000 EQ. 8 pixels tall
VS3-VS0 = 1111 EQ. 128 pixels tall with increments of 8 pixels.

PIC #: Picture #, maximum of 4K, 128 pixels tall M.O.'s (or 64K of 8 pixels tall M.O.'s assuming all graphics ROMs are motion objects only. This is the maximum capacity of the main board. The actual max. capa. also depends on the cartridge board used.)

P4 ~ P0: Offset (of picture # in ROM)

T: Translucent BIT (see priority)

LINK: The link register specifies the next higher priority motion object to be displayed. The M.O. that is linked (drawn) last has the highest priority.

Note: the upper eight bits of the PIC (D15-D8) are fed into two PROMs which map the code into 256 of the 4096 locations and define its depth/palette number.

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II. Alpha-Numerics:

- 2 bits per pixel, up to 8 color palettes.
- Stamp size 8 pixels x 8 pixels
- Screen size 42 stamps x 30 stamps

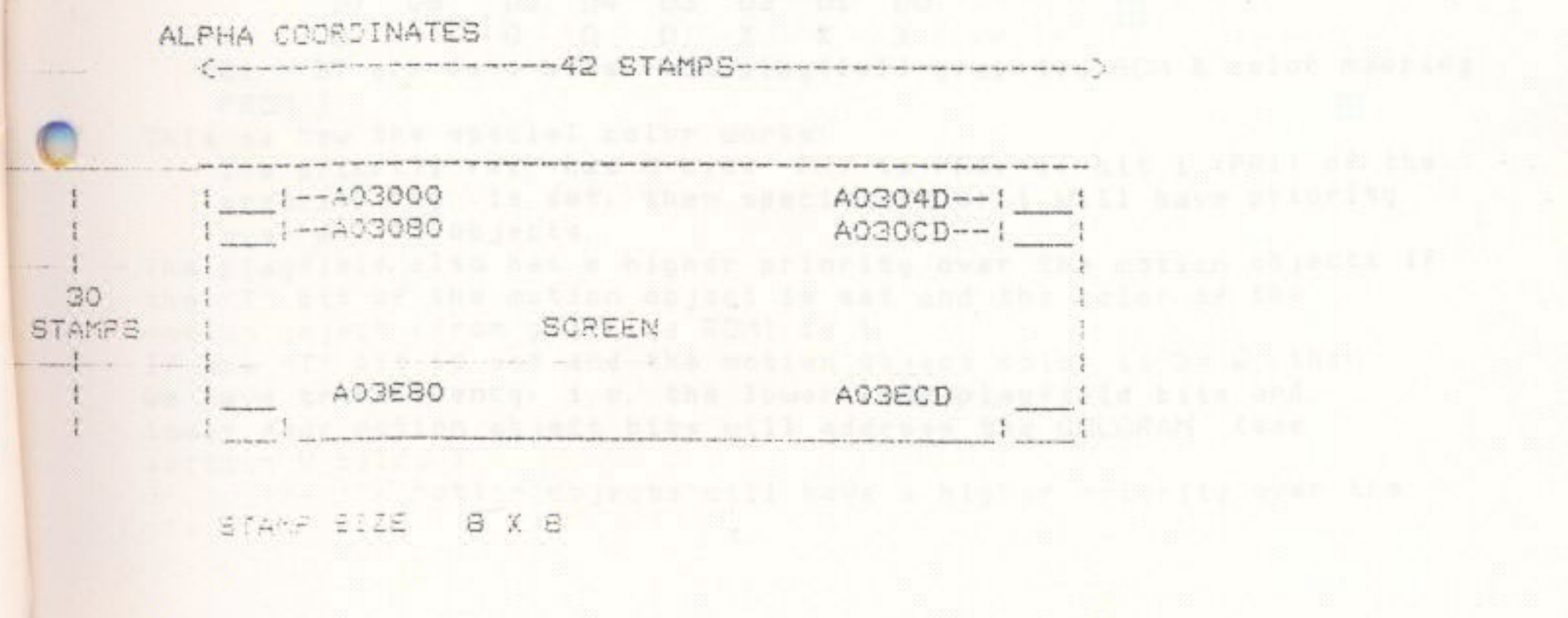
Every alpha stamp is specified by one word in the alpha numeric RAM as follows:

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
X	X	BG	C2	C1	C0	X	SHAPE								

BG: The whole alpha stamp (including background) will have a higher priority than M.O.'s or PF.

C2 ~ C0: Color Palette.

alpha-numerics ROM : 27128 , contains 2 banks of 512 alpha stamps(8x8.)



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V. Priority:

- Alpha-numerics have the highest priority.
- If the "BG" bit in the alpha parameter is set, the background color or alpha will have priority over all other graphics.
- Playfield has the second priority if there is no motion object or if there is only motion object background (see note 3 section VI)
- There are 8 colors that the playfield can have priority over M.O.'s (color 00-07) if the corresponding bits in the priority reg. (addr 840000) are set.
  These special 8 colors are:

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	X	X	X

(D0 ~ D7 are data bits from playfield graphics ROM & color mapping PROM.)

This is how the special color works:
The priority reg. has 8 bits PR7 to PR0. If bit i (PRi) of the priority reg. is set, then special color i will have priority over motion objects.

- The playfield also has a higher priority over the motion objects if the "T" bit of the motion object is set and the color of the motion object (from graphics ROM) is 1.
- If the "T" bit is set and the motion object color is >= 2 , then we have translucency, i.e. the lower four playfield bits and lower four motion object bits will address the COLORAM. (see section V below.)
- Only the true motion objects will have a higher priority over the playfield.

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COLORAM:

The coloram gets graphics information from four sources:
ALPHA, PLAYFIELD, MOTION OBJECT & "TRANSLUCENCY"

ALPHA COLORAM ADDR = B00000 + C2-C1-C0-ABIT1-ABIT0
where C2 to C0 are the color pallete bits specified in the alpha RAM . ABIT1, ABIT0 are the bits from the alpha ROM. hyphen "-" denotes binary concatination

TRANSLUCENT = B00600 + P3-P2-P1-P0-M3-M2-M1-M0
where p3 to p0 and m3 to m0 are the four low playfield ROM and motion objects ROM bits respectively.

PLAYFIELD COLORAM = B40000 + <P7:P0>
WHERE <P7:P0> are the 8 bits from the graphics ROM &/or the color pallette mapping PROM.

MOTION OBJECT COLORAM = B20000 +C-<M6:M0>
Where <M6:M0> are the 7 (seven) bits from the graphics ROM and/or the color mapping PROM.

Coloram data interpretation:

<D15:D12> Intensity
<D11:D8 > Red
<D7 :D4 > Green
<D3 :D0 > Blue

In all cases, 0000=OFF
1111=highest intensity.

VI . NOTES:

1. Graphics pixel data is low true!!!
PBCONVERT in the PPS utilities will automatically do a 1's complement for you.
2. The current cartridge board has a max. of 1k 128 pixel tall (or 16k 8 pixel tall) motion object graphics ROM (assuming all ROM are motion object addressable. The max playfield graphics ROM is 2 banks of 8k 8 stamps assuming all ROMs are playfield addressable.
3. If the four LSB's of a motion object color (from graphics ROM) are all 1's , the color is considered to be background regardless of what the upper 3 MSB's are (from color pallette ROM or graphics ROM.)

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68000 MEMORY MAP	ADDRESS	R/W	DATA	
Program ROM	000000~03FFFF	R	D15~D0	For 128K ROM 128 kwords
	000000~07FFFF	R	D15~D0	For 256K ROM 256 kwords
Program RAM	400000~401FFF	R/W	D15~D0	
Playfield Hor. Scroll	800000	W	D8~D0	
Playfield Vert. Scroll	820000	W	D8~D0	
Play. Special Priority Color	840000	W	D7~D0	Hi Enable
Sound Processor Reset	860000	W	D7	Low Reset
Trak Ball Test (LETA chip)		W	D6	Hi Test
Motion Obj Para. Buf. Select		W	D5~D3	
Playfield ROM Bank Select		W	D2	
Trakball resolution & test LED (LETA chip)		W	D1	(see LETA.doc) hi ON
Alpha ROM Bank Select	860000	W	D0	
Watch Dog	880000	W		(128 msec. timeout)
VBlank IRQ Acknowledge	8A0000	W		
Unlock	8C0000	W		
Cartridge External	900000~9FFFFF	R/W	D15~D0	
Playfield RAM	A00000~A01FFF	R/W	D15~D0	
Motion Object Vertical Pos.	A02000~A0207F	R/W	D15~D0	; M.O. parameter
Motion Object Picture	A02080~A020FF	R/W	D15~D0	; buffer 0
Motion Object Hor. Pos.	A02100~A0217F	R/W	D15~D0	; add 200 for next buffer
Motion Object Link	A02180~A021FF	R/W	D15~D0	
Motion Object Vertical Pos.	A02200~A0227F	R/W	D15~D0	; M.O. parameter
Motion Object Picture	A02280~A022FF	R/W	D15~D0	; buffer 1
Motion Object Hor. Pos.	A02300~A0237F	R/W	D15~D0	
Motion Object Link	A02380~A023FF	R/W	D15~D0	
Motion Object Vertical Pos.	A02E00~A02E7F	R/W	D15~D0	; M.O. parameter
Motion Object Picture	A02E80~A02EFF	R/W	D15~D0	; buffer 7
Motion Object Hor. Pos	A02F00~A02F7F	R/W	D15~D0	;
Motion Object Link	A02F80~A02FFF	R/W	D15~D0	
Alpha-Numerics RAM	A03000~A03FFF	R/W	D15~D0	
Colram Alpha	B00000~B001FF	R/W	D15~D0	
Colram Motion Object	B00200~B003FF	R/W	D15~D0	
Colram Playfield	B00400~B005FF	R/W	D15~D0	
Colram Unused	B00600~B0061F	R/W	D15~D0	
EEPROM	F00000~F00FFF	R/W	D7~D0	
Trak Ball	F20000~F20006	R	D7~D0	
Analog Joystick	F40000~F4000E	R	D7~D0	
Serial Interface IRQ Disable	F40010	R		
Sound Output Full (2 FE0000)	F60000	R	D7	Hi Full
Self-test	F60000	R	D6	Low test
Switch input	F60000	R	D5	
VBLANK	F60000	R	D4	Hi vblank
Switch input	F60000	R	D3	
Switch Input	F60000	R	D2	
Switch Input	F60000	R	D1	
Switch Input	F60000	R	D0	
Read Sound Processor (6502)	FC0000	R	D7~D0	
Write Sound Processor (6502)	FE0000	W	D7~D0	

Note: use word mode only for VIDEO RAM (motion object, playfield, alpha) and COLORAM. All other addresses can be accessed in byte or word mode.

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6502 MEM-MAP	ADDRESS	R/W	DATA	
Program RAM	0000~0FFF	R/W	D7~D0	
Cartridge External	1000~1FFF	R/W	D7~D0	
Yamaha	1800~1801	R/W	D7~D0	
Read 68000 Port	1810	R	D7~D0	
Write 68000 Port	1810	W	D7~D0	outbuf.
Self Test	1820	R	D7	
Outbuf full (@ 1810)		R	D4	hi full
Data avail (@ 1810)		R	D3	hi avail
Coin Aux		R	D2	
Coin Left		R	D1	
Coin Right		R	D0	
Yamaha Reset	1820	W	D0	Low Reset
LED	1824	W	D0	Low Active
LED	1825	W	D0	Low Active
Coin Counter Right	1826	W	D0	Hi Active
Coin Counter Left	1827	W	D0	Hi Active
Pokey	1870~187F	R/W	D7~D0	see pokey.doc
Program ROM	4000~FFFF	R	D7~D0	48k bytes.

Notes: NO 6502 watchdog (see 68010)
IRQ ACK : see SECTION I 6502 IRQ.
NO NMI mask for the NMI coming from the 68010. NMI is automatically acknowledged when the 6502 reads the input data buffer at location 1810

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SYSTEM I SOFTWARE DESCRIPTION.

1. Power On

System	Application (Game)
Quick RAM Test	
Quick ROM Test	
EEPROM Checksum	
RAM Cleared (Set to 00's)	
Stack Set	
Self Test? No----------> 10000	
Yes	
Full Tests - RAM/ROM/BUS Looping	
Diagnostics	
Statistics	
Application Tests	
Alpha IF 1002A <> 0	
Pf IF 10030 <> 0	
Mob IF 10036 <> 0	
Color Palette	

2. Vector Tables/Parameter Tables

68010 Address	Function	Returns
10000	Jump to Game Reset	No
10006	Jump to Game VBlank	RTE
1000C	Jump to Game IRQ1	RTE
10012	Jump to Game IRQ3	RTE
10018	Jump to Game Analog Joystick	RTE
1001E	Jump to Game Audio	RTE
10024	Jump to Hardware Exceptions	RTE or Restart
1002A	Jump to Alpha Test (0 if none)	RTS when finished
10030	Jump to PF Test (0 if none)	RTS when finished
10036	Jump to Mob Test (0 if none)	RTS when finished
1003C	Jump to Color Test (0 if none)	RTS when finished
10042	Jump to Control Reading Routine	RTS
10048	Jump to Game Specific Options (Screen Display)	RTS when finished
1004E	Jump to Game Specific Statistics (Screen Display)	RTS when finished
10054	Jump to EEPROM/COIN init Routine	SEIS STACK "RTS"
1005A to 1005F	Unused	
10060	Word Value of PF Blank Stamp	
10062	Word Value of PF Crosshatch Stamp	
10064	Word Value of PF Solid Color 1	
10066	Word Value of PF Solid Color 2	

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```
10068           Word Value of PF Solid Color 3
1006A           Start Motion Object Picture #
1006C           Ending Motion Object Picture #
                (Used for MOB picture #'s in
                 Self Test. Will use start thru
                 end inclusive repeating until all
                motion objects are displayed.)
        1006E   Unused
         to
        1007F

1007C0          Cartridge Configuration Block
                (See [MOORE.PACKRAT]ALSS1.MEM)
```

3. Support Software Available

	Programmer
-Message Routine	Mike Mahar
-Numeric Output	Mike Mahar
-Hex to Decimal Conversion	Mike Mahar
-Rad 50 Conversion	Mike Mahar
-Statistics	Mike Mahar
-Standard Self Test(s)	Mike Mahar
-EEPROM with Error Correction	Mike Albaugh
-All 6502 Code - RPM	Peter Lipson
Stripped Down Coins	
Test Mode	
-68000 Coin Handling	Mike Albaugh
-Graphics Mapping PROMs (VAX Utility)	Rich Moore

4. Application Software Required

-User Specific Statistics
  Including Table of Messages, Stat Value Pointer
-User Specific Options
  Including Table of Options/EEPROM Locations
-Routine to Incorporate Controls into Register D0
  4 Bits for Up/Down/Left/Right
    D15 = Up (Low True)
    D14 = Down
    D13 = Left
    D12 = Right

  2 Bits for 2 Buttons
    D1 = Button(1) (Low True)
    D0 = Button(2)

  Bit Pairs for
    1) Alphanumerics Test
    2) Playfield Test (Stamp Sets)
    3) Motion Object Tests
    4) Color Palets/Priorities Tests
-Define Tables for Vectors/Stamp Values
-Define Cart Configuration Block
    <Specification Forthcoming>

-Watchdog

5. Documentation Needed/To Do

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-Specifications/Calling Parameters of All System Software
-Table Definitions: 1) Configuration Block
2) Statistics Table
3) Option Table

-Specify Graphics Mapping PROMs

If there are any items I have left out, please let me know ASAP! Likewise, should any topic/item that has not been addressed become apparent, please let me know so I can assure that nothing falls through the cracks.

Distribution: Chris Downend, Mike Mahar, Mike Albaugh, Ed Logg, Packrat[Peter Thompson], Doom[Peter Li
Doom [Mark Cerny, Bob Flanegan]

ACTION LINE SYSTEM SOFTWARE 21-SEP-84
updated 1-Oct-84

This is to further Update you on the Software Status of the Action Line system:

1. As Promised, further input on the Configuration Format:
I propose the following format, please respond with other ideas, or comments:

Starting @ 10080 block_starting_addr,block_ending_addr,device_size,ram/rom_flag
(repeat for all specific game ram/rom memory areas)
0,0 -(flags end-of memory configuration area)

All entries are 32 bits wide. Device_size specifies the Rom or Ram size to step by when indicating RAM 0, RAM 1 ... or ROM 0, ROM 1 errors. RAM/ROM flag indicates memory type D23=0 => RAM, D23=1 => ROM.
For Example, with the entire Program Rom area occupied by 27128's and 16 pages of the cartridge external area decoded as RAM:

```
10080   010000,03FFFF,4000,800000
1008C   900000,900FFF,800,0
10098   0,0
```

I will adjust this format with any suggestions I receive, and Release this on the next memo.

2. Software Schedule:

Self Test	First Three Tests w/ 10000 vectoring	(1-Oct-84)
	First Pass/Complete	20-Sep-84
6502	RPM w/one POKEY, coin detect	(05-Oct-84)
EEPOM	Read/Write Routine w/Checksums	8-Oct-84

3. Address 10024 (Hardware Exceptions) will be used in the case of RAM/ROM errors on Power-On. Register D0 will indicate the reason of the exception whenever this vector is used. It is therefore up to the game to determine what to do with RAM/ROM errors at power-on, RECOMMENDED: display error status on screen, pushing any button continues into attract (or at least attempts it.)

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4. Special Graphics Proms. I forgot to cover this at our meeting, but you have to be aware of this anyway. There are two Proms on the Hardware which serve to Memory Map Picture Codes to actual Graphics Rom addresses (Prom 1) and to Select Palettes and specify Bit Plane Depth (Prom 2). I intend to write whatever Vax Utility is necessary to fill these Proms, but would very much appreciate your input as to how the User interface should be defined. In other words, speak now or get stuck with what I give you.

Some Background (perhaps old news):

-Graphics are up to 8 Bits (planes) deep.

-There are four (4) banks of Graphics Roms which serve as both Playfield & Motion Object Pictures.

-For Motion Objects, bit 8 (plane 8) serves as a Translucency Bit which implements a special color mapping, ala:

XXXX1111 = Clear (Playfield Shows through)
XXXX1110 = Cookie Cutter Clear (Playfield Shows through, underneath motion objects cut-out)

XXXX1101 to XXXX0000 combines with the Playfield low 4 bits to form the actual color (Transparency Mode)

BITS 7 6 5 4 3 2 1 0
PF_____ MO_____

- There are three (3) 256x16 Color Ram tables one for Motion objects, one for Transparency mode, and one for Playfield. Additionally there is one 16x16 table for the Alphanumerics.

MEMORY MAP PROM -

A0 - A7 determines one of 256. stamps in a block of 8x8's.
(equivalent to D0 - D7 of PIC # in MO or PF parameter field)

D8 - D14 of PF PIC # addresses this PROM
+ PF Bank Select Bit

D8 - D15 of MO PIC # addresses this PROM
+ P0 - P4 of MO Pic parameter indexes one of 32. stamps in a 32. stamp block (starting offset to fetch graphics regardless of the MO height. Note: graphics fetched wrap around within module 32. stamp block)

PROM is SIZED with A2 to A14 addresses as MO/PF(MF)

This allows max of 2**14 (16K) PF 8x8 stamps possible
2**15 (64K) MO 8x8 stamps possible

NOTE: with a 27128 in place of a 27256 (since only Mask ROMS), D3 out of the ROM must be high, thus with 27128's each Bank has 8 * 256. stamps (2K), while with 27256's each Bank has 16. * 256. stamps (4K)

ADDRESS	DATA	FUNCTION
876543210	7 6 5 4 3 2 1 0	
C00-CFF 0XXXXXXXX	B4 B3 B2 B1 BLOCK # --	PF Block Address
!!!!!!!!	^ ^ ^ ^	

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```
!!!!!!!!        all not true ( only 1 low at a time)
!!!!!!!!        B4=Bank 4, B3=Bank 3, B2=Bank 2, B1=Bank 1
!!!!!!!!
!!!!!!!^-------- D8 of PF picture #
!!!!!!^--------- D9 of PF picture #
!!!!!^---------- D10 of PF picture #
!!!!^----------- D11 of PF picture #
!!!^------------ D12 of PF picture #
!!^------------- D13 of PF picture #
!^-------------- D14 of PF picture #
^--------------- PF Bank Select Bit (D2 of 860000 of 8C000 memory map)

100-1FF 1XXXXXXXX       B4 B3 B2 B1 BLOCK # --      M0 Block Address
                         ^  ^  ^  ^
                        all low true ( only 1 low at a time)
          B4 = Bank 4, B3 = Bank 3, B2 = Bank 2, B1 = Bank 1

                    ^ D8 of M0 pic #
                   ^ D9 of M0 pic #
                  ^ D10 of M0 pic #
                 ^ D11 of M0 pic #
                ^ D12 of M0 pic #
               ^ D13 of M0 pic #
              ^ D14 of M0 pic #
             ^ D15 of M0 pic #
```

ALET SELECT -

Addressing of this PROM is identical to the Addressing of the Memory Mapping PROM above.

The Output of this Rom Determines the Presence of the top 4 bits (planes) of the graphics Roms. Thus,

D7 low indicates no ROM Plane 7
D6 low indicates no ROM Plane 6
D5 low indicates no ROM Plane 5
D4 low indicates no ROM Plane 4

NOTE: 8 planes max for Playfield, 7 planes max for Motion object. 16 palettes @ 4 bits (planes) for PF, only 7 palettes @ 4 bits for Motion objects.

Upper Nibble = Active Planes 4-7
Low Nibble = replaces respective upper bits for Depth 1-3 bits (Palette select; only one of eight may be selected for MOB's/ 1 of 16 for PF (both @ 4 bits))

Nibble Outputs	D7	D6	D5	D4	D3	D2	D1	D0	Function
	0	0	0	0	1	1	1	1	only 4 bits deep/palette 0
	0	1	1	1	0	1	1	1	7 bits deep/palette 1 (PF)
	0	0	0	0	1	0	1	0	4 bits deep/palette 5
	0	0	0	0	0	1	1	1	4 bits deep/palette 8 (PF only)
	0	0	0	1	1	1	0	1	5 bits deep/palette 1

NOTE: if DX is High where 7 >= X >= 4 then D(X-4) must also be High.