Agenda
Philips / Commodore Meeting
15 April 1994

9:00	Introductions / Organizations and Objectives Commodore / Philips
9:15	Commodore Products and Technology Roadmap Commodore: Lew Eggebrecht
10:30	HOMBRE Overall Goals and Strategy Commodore: Ed Hepler
11:00	HOMBRE Needs Commodore: Allan Havemose
11:30	HOMBRE Chip Set and System Configurations Commodore: Ed Hepler
12:00	Lunch
1:00	HOMBRE Chip Set Details Commodore: Ed Hepler
2:00	HOMBRE Software Details Commodore: Allan Havemose
3:00	HOMBRE Performance Estimates Commodore: Allan Havemose / Ed Hepler
3:30	Discussion / Wrapup Commodore: Lew Eggebrecht

Dr. Edward L. Hepler

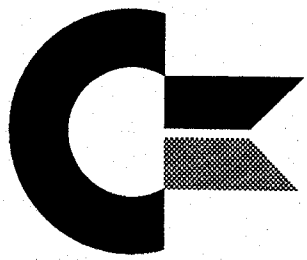
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Hombre Goals

- **Produce the Next Generation Product Family**
  - **RISC Processor based**
- **Direct Support for 3D Animation**
- **Define a Clean Architecture**
- **Target Wide Product Line**
- **Dovetail with higher end architecture**

Dr. Edward L. Hepler

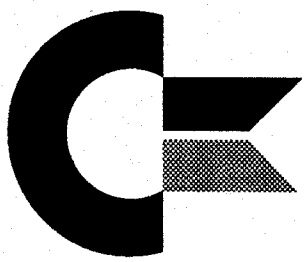
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Ground Rules

- **Late 1994 "First Silicon" Availability for 1995 Production**
  - Must be a player in the Christmas 1995 offerings
- **Cost effective solution**
  - Chip Set < $40.00
  - Low-end to have 32-bit memory
  - Execute out of display memory
- **Flexible enough to support a number of products**
  - CD based Game Machine
  - Cable TV Set Top Box
  - MPEG Player
  - Home Computer
  - PCI based Graphics Accelerator
  - Desktop or Tower Based System
- **Target 0.6 micron - 3 level metal CMOS - 3.3 Volt process**

Dr. Edward L. Hepler

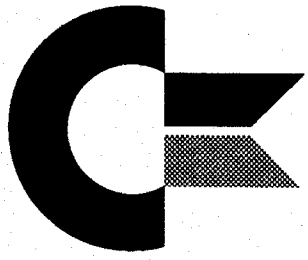
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Observations

- **Rendering is different for photorealistic imaging versus real-time animation**
- **Various levels of detail required**
  - Some portions of image relatively stable over many frames
  - Other portions change on a frame-by-frame basis
  - Only application (programmer) knows for sure
  - Trade-off detail with computational requirements
- **16-bit pixels are good enough**
- **Multiple playfields are useful**
- **Software Developers either want *many* sprites or none...**

Dr. Edward L. Hepler

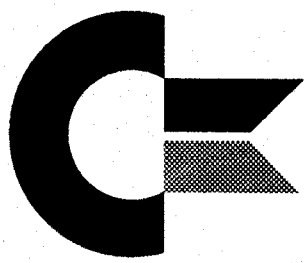
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Hombre Implementation Strategy

- **Select a RISC architecture to base the system upon:**
  - **Business/Competitive Issues**
    - **Number of other implementations using processor family?**
    - **Would we be playing into the hands of a competitor (or potential competitor)?**
    - **Are there complementary systems to fill out high end?**
  - **Performance Issues**
    - **Code Density**
    - **Support for graphics operations, etc.**
    - **Support Chip(s) required (cache) to achieve performance**
    - **Bus Size required to achieve performance**
  - **Implementation Issues**
    - **Ease of implementing Integer Core with other functions**
    - **Ability to add customized instructions**
  - **Cost Issues**
    - **License fees?**
    - **Chip costs**
- **Integrate RISC Integer Core with key system functions**
- **Build 2 or 3 chip low end system**

Use commercial RISC chip as add-in performance enhancer with low end, chip-set based system as intelligent peripheral sub-system

Dr. Edward L. Hepler

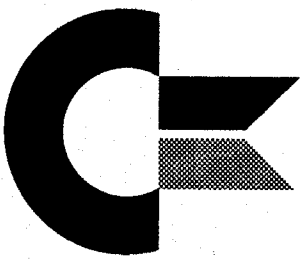
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

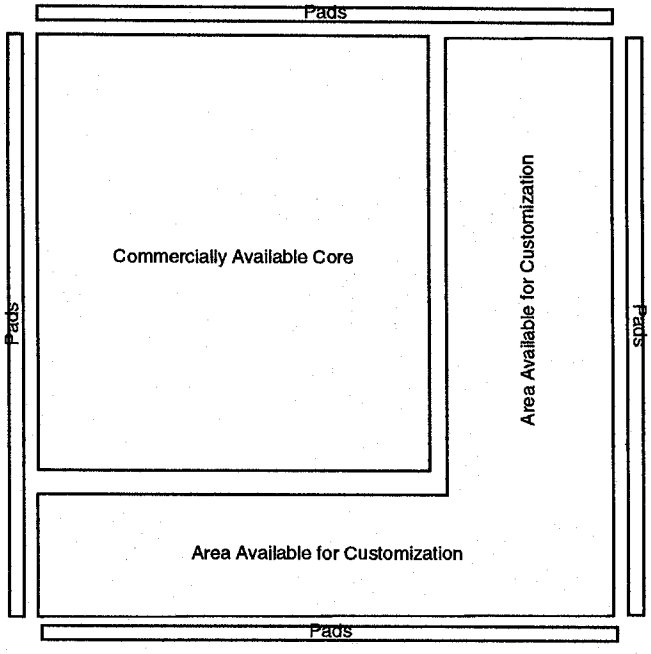
Created: October 18, 1993

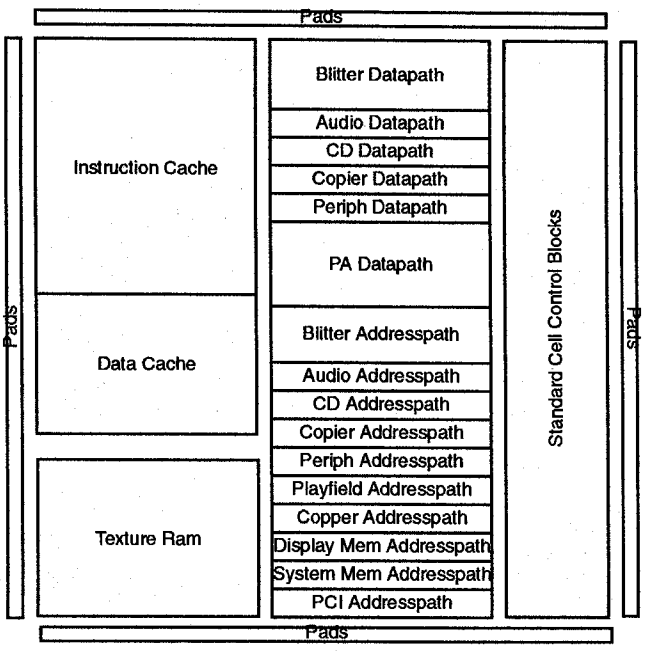
Why an Embedded Processor?

- **Reduced Chip count should produce a reduced cost.**
- **Desire multiple simultaneous memory access paths:**
  - **Graphics Update**
  - **Blitter, other DMA access**
  - **CPU fetches**

Why Design our own core?

- **Ability to add instructions for graphics**
- **Easier to "mate" to other functional units**
- **Ability to control aspect ratio and positioning of blocks**





Dr. Edward L. Hepler

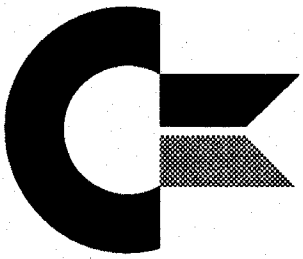
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Why PA-RISC?

- Performance is very high compared to other RISC processors at similar clock rates.
- Code density enhanced by:
  - Powerful instruction set
  - Nullification
  - Atomic modification of addresses during load/stores
- SFU instruction expansion capability
- Demonstrated Low Cost Implementation
- Growth Path for future enhancements
- HP's operating system availability
  - UNIX
  - Windows/NT
- HP has a line of PA-RISC workstations which complement Commodore's offerings
- Development Tools available
  - GNU Tools available via ftp (we already have them...)
  - HP has its own software development tools
  - Can use HP workstations as cross-development platforms

Dr. Edward L. Hepler

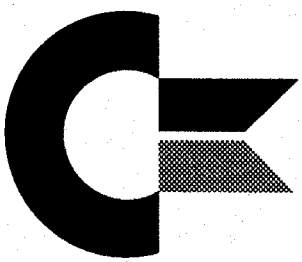
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

RISC Code Comparison (Addr Mod)

From: Jim Hull and Martin Whittaker, "The Advantages of the PA-RISC Architecture in Embedded Control Applications"

```
int max, temp, value[100], *ptr;

max= 0;
for(ptr= value; ptr < value + 100; ) {
    temp= *ptr++;
    if(max < temp) {
        max= temp;
    }
}
```

PA-RISC

```
        ldo       -56(%r30),%r23  ; r23= value+100
        ldo       -456(%r30),%r31 ; ptr= value
        copy      %r0,%r25        ; max= 0
        ldws,ma   4(0,%r31),%r24  ; temp= *ptr++

loop:   comclr,>= %r25,%r24,%r0   ; if(max >= temp) nullify
        copy      %r24,%r25       ; max= temp
        comb,<<,n%r31,%r23,loop   ; if((ptr<value+100) loop
        ldws,ma   4(0,%r31),%r24  ; temp= *ptr++ (next)
```

SPARC

```
        add   %fp,-400,%i5   ; ptr= value
        mov   0,%i3          ; max= 0
        ld    [%i5],%i4      ; temp= *ptr

ly2:    inc   4,%i5          ; ptr++
        cmp   %i3,%i4        ; if(max >= temp)
        bge,a ly3            ; branch to end
        cmp   %i5,%fp        ; if(ptr < value + 100)
        mov   %i4,%i3        ; max= temp
        cmp   %i5,%fp        ; temp= *ptr (next)

ly3:    bcs,a ly2            ; if(ptr < value+100) loop
        ld    [%i5],%i4      ; temp= *ptr
```

MIPS

```
        addiu r24,sp,32      ; ptr= value
        addiu r2,sp,432      ; r4= value+ 100
        move  r3,r24         ; r3= ptr
        move  r5,r0          ; max= 0

$32:    lw    r2,0(r3)       ; temp= *ptr
        addiu r3,r3,4        ; ptr++
        slt   r1,r5,r2       ; check if max < temp
        beq   r1,r0,$33      ; if not,br to end
        sltu  r1,r3,r4       ; check if ptr < value+100
        move  r5,r2          ; max= temp
        sltu  r1,r3,r4       ; check if ptr < value+ 100

$33:    bne   r1,r0,$32      ; if ptr < value, loop
        nop                  ; nop in delay slot
```

Instruction Count	PA-RISC	SPARC	MIPS	68030
Static	8 (32 bytes)	11 (44 bytes)	13 (52 bytes)	? (22 bytes)
Dynamic	404	803	904	

Dr. Edward L. Hepler

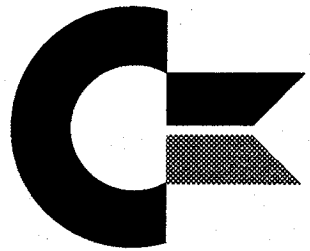
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

RISC Code Comparison (Nullification)

From: Jim Hull and Martin Whittaker, "The Advantages of the PA-RISC Architecture in Embedded Control Applications"

```
proc(value, limit, alarm, overload)
    int value,limit,*alarm,*overload; {

    if(value > limit) {
        *alram= 1;
        *overload= value;
    } else {
        *alarm= 0;
    }
}
```

PA-RISC

```
      comb,<=,n%r26,%r25,ELSE; if(value <= limit) br
      ldi     1,%r31           ; *alarm= 1
      stws    %r31,0(0,%r24)   ; store to memory
      bv      0(%r2)           ; return
      stws    %r26,0(0,%r23)   ; *overload= value

ELSE: bv      0(%r2)           ; return
      stws    %r0,0(0,%r24)    ; *alarm= 0;
```

SPARC

```
      cmp   %o0,%o1    ; test if (value <= limit)
      ble,a LE33       ; branch to ELSE
      st    %g0,[%o2]  ; if br, *alarm= 0
      mov   1,%o4      ; *alarm= 1
      st    %o4,[%o2]  ; store to memory
      st    %o0,[%o3]  ; *overload= value

LE33: retl             ; return
      nop              ; nop in delay slot
```

MIPS

```
      slt   r1,r4,r3     ; test if value <= limit
      beq   r1,r0,ELSE   ; branch to ELSE
      nop                ; nop in delay slot
      li    r14,1        ;
      sw    r14,0(r5)    ; *alarm= 1
      jr    r31          ; *overload= value

ELSE: sw    r0,0(r5)     ; *alarm= 0
      jr    r31          ; return
      nop                ; nop in delay slot
```

Instruction Count	PA-RISC	SPARC	MIPS
Static	7	8	10
Dynamic value > limit	5	8	7
Dynamic value <= limit	4	5	6

Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

Modified:April 12, 1994

Created: October 18, 1993

Hombre Function Partitioning

CPU Chip

PA-RISC Integer Core with MMU/Cache

Blitter (Raster-ops, Lines, Fills (Textured, Shaded))

Copper (Video Line synchronized)

Audio (AAA style, with serial inputs and outputs)

CD-ROM interface

Memory Block copy

Peripheral Bus Interface (4 8-bit peripherals)

DMA Control

Real time clock and interval timer

External Processor Interface

PCI bus interface

DRAM/VRAM controllers

Video Chip

Playfield Line buffers

Cursor Memory

Horizontal and Vertical Video Counters

Monitor Control

Video Output Logic

Color Lookup Table

Mouse/Joystick Logic

Genlock, Sampling Logic

- **Amiga-like functionality will ease transition**
- **Bonding Options for lower cost packaging**

Dr. Edward L. Hepler

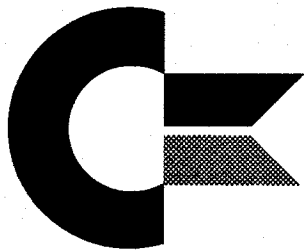
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

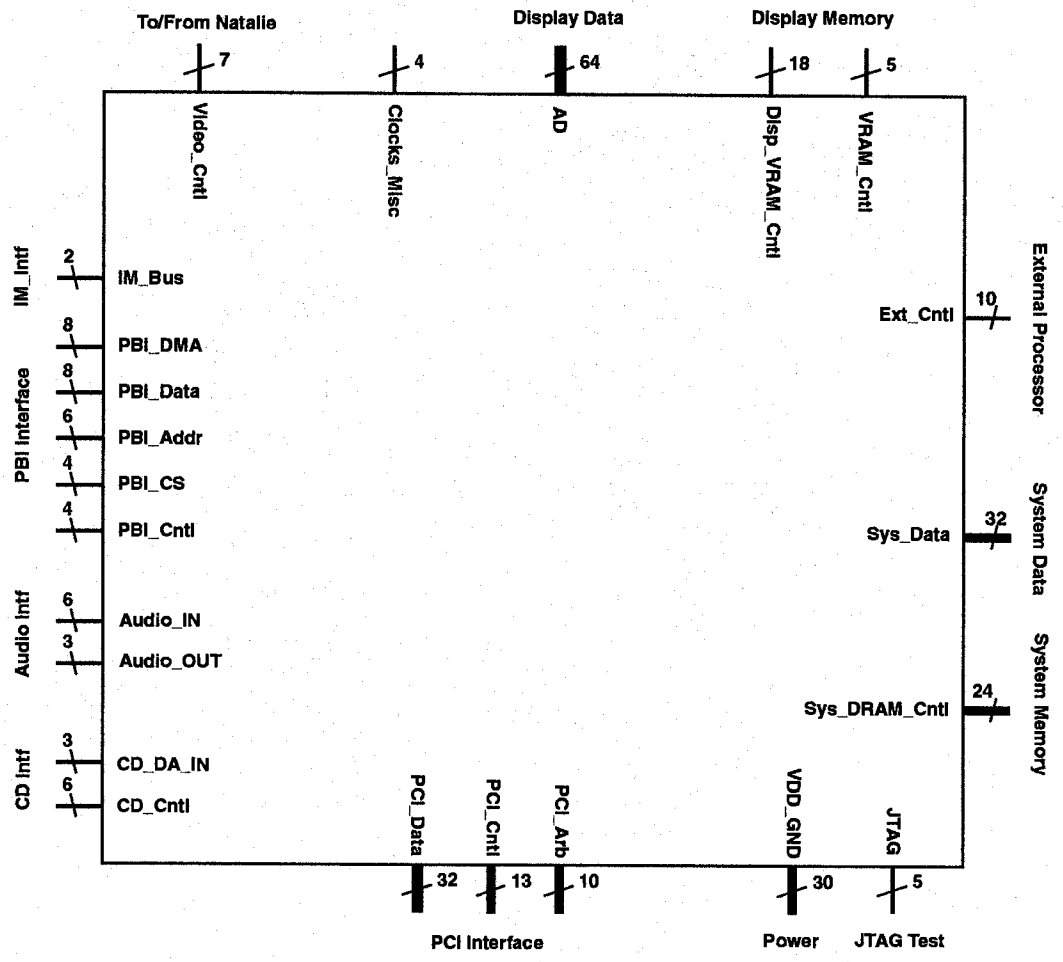
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

CPU/Rendering Chip (Nathaniel)



- **Functions:**
  - RISC Int. Core (MMU/Cache)
  - Blitter/Renderer
  - 8-bit DMA Interface
  - Audio Processor
  - CD-ROM Interface
  - PCI Bus
  - Memory Copier
  - Copper
- **Interfaces:**
  - 32/64-bit Display Memory Interface
  - 32-bit System Memory Interface
  - 32-bit PCI Interface
  - 8-bit Peripheral Bus Interface
  - 2-bit IM Bus Interface
- **274 Signals / 30 Power-Ground**
  - 304 PQFP (313 BGA)

Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

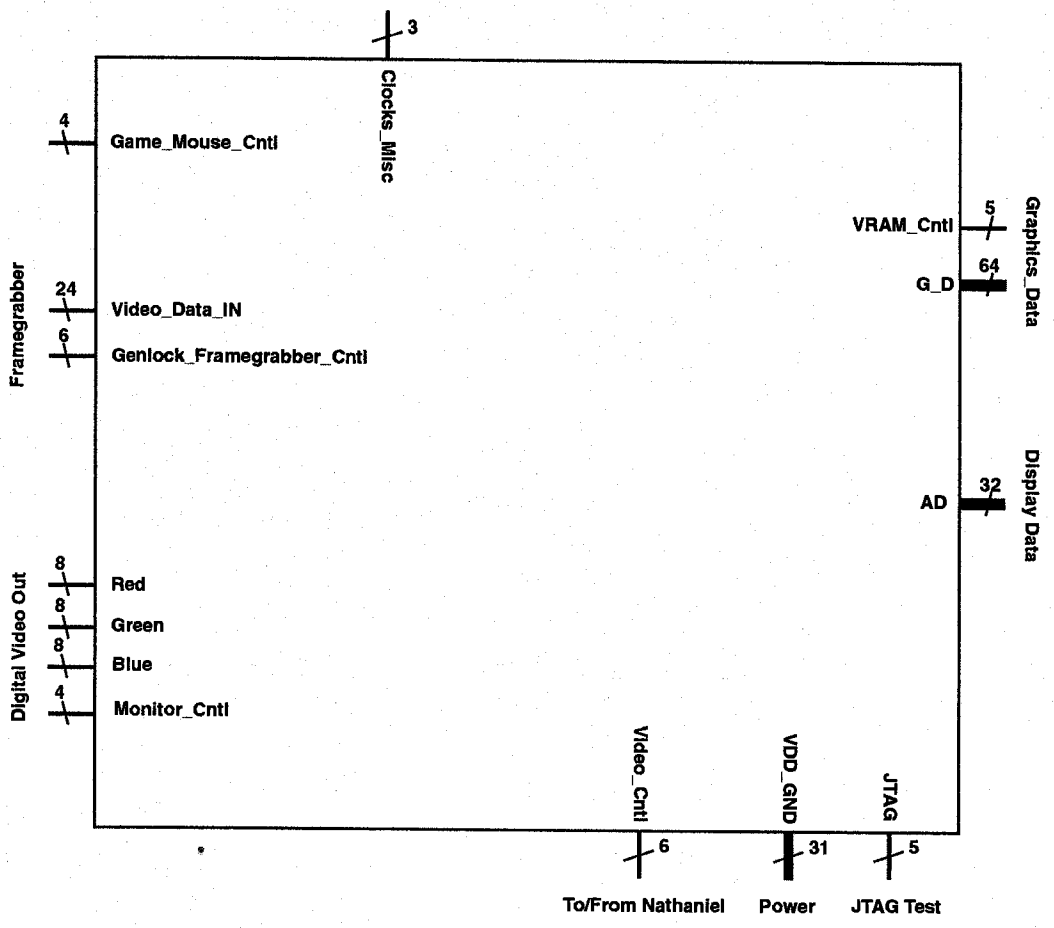
(610) 431-9298

hepler@commodore.com

Modified:April 12, 1994

Created: October 18, 1993

Video Chip (Natalie)



- **Functions:**
  - Line Buffers
  - Cursor Ram
  - 512 x 25 CLUT
  - Framegrabber
  - Genlock
  - YUV -> RGB (MPEG)
  - Mouse/Game Cntrlr Intf
- **Interfaces:**
  - 32/64-bit Graphics Data (VRAM)
  - 32-bit Display Memory (high 32)
  - 24-bit Digital RGB out (ext D/A)
  - 24-bit (option to 8+16) Video IN
  - Serial Mouse - Game Control
- **177 Signals / 31 Power-Ground**
  - 208 PQFP (225 BGA)

Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

Modified:April 12, 1994

Created: October 18, 1993

Multiple Products
from a Single Chip Set

- CD based Game Machine
- Cable TV Set Top Box
- MPEG Player
- Home Computer
- PCI based Graphics Accelerator
- Desktop or Tower Based System

Dr. Edward L. Hepler

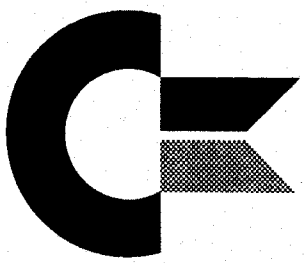
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

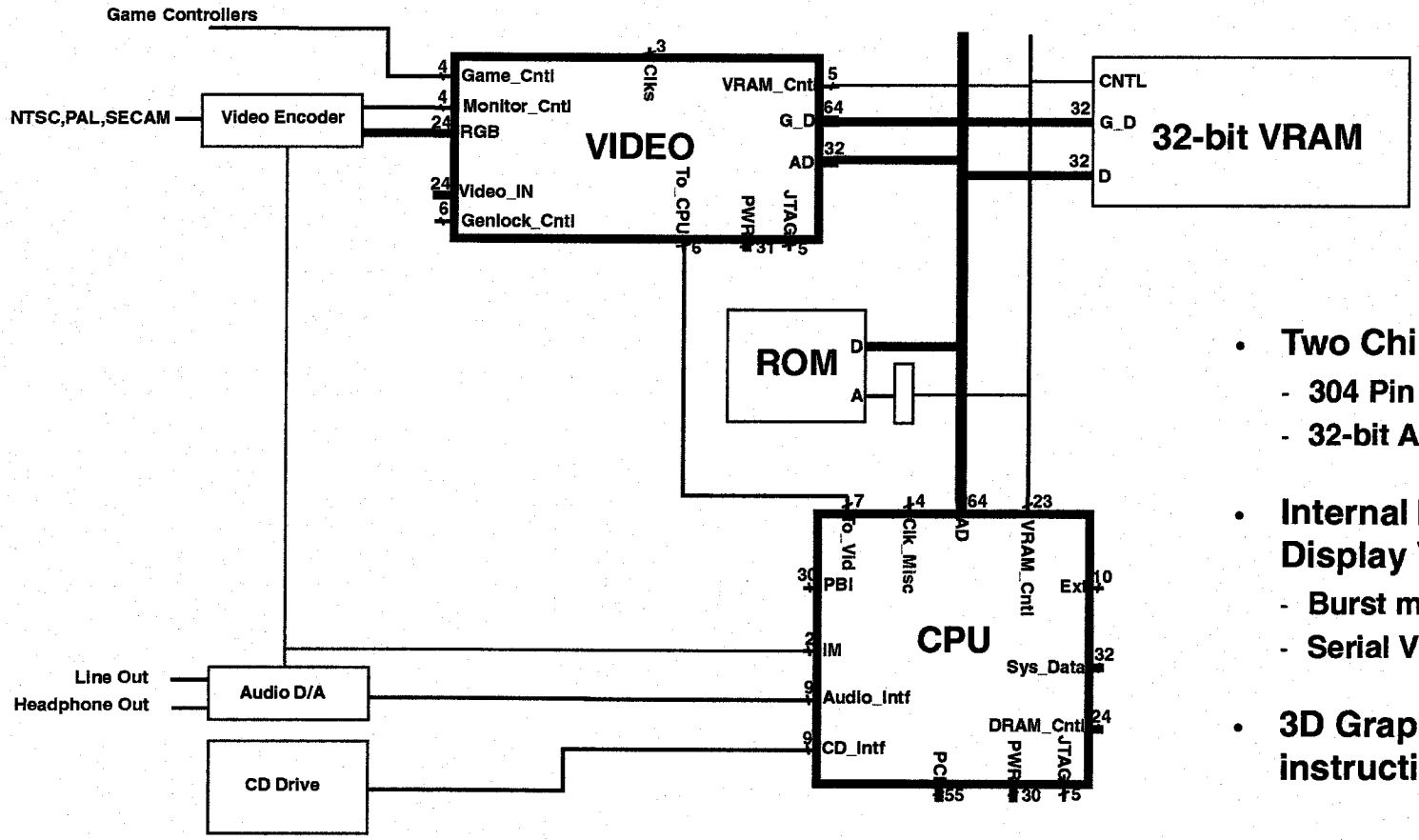
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Next Generation CD based Game Machine (Minimal)



- **Two Chip Solution**
  - 304 Pin CPU, 208 Pin Video
  - 32-bit AD bus - 32-bit Graphics bus
- **Internal PA-RISC executes from Display VRAM/ROM**
  - Burst mode DRAM: 80 Mbytes/sec
  - Serial VRAM: > 150 Mbytes/sec
- **3D Graphics hardware and instruction support**

Dr. Edward L. Hepler

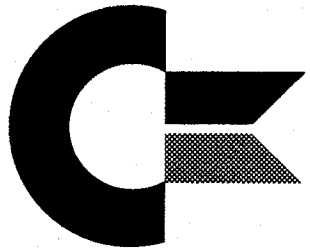
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

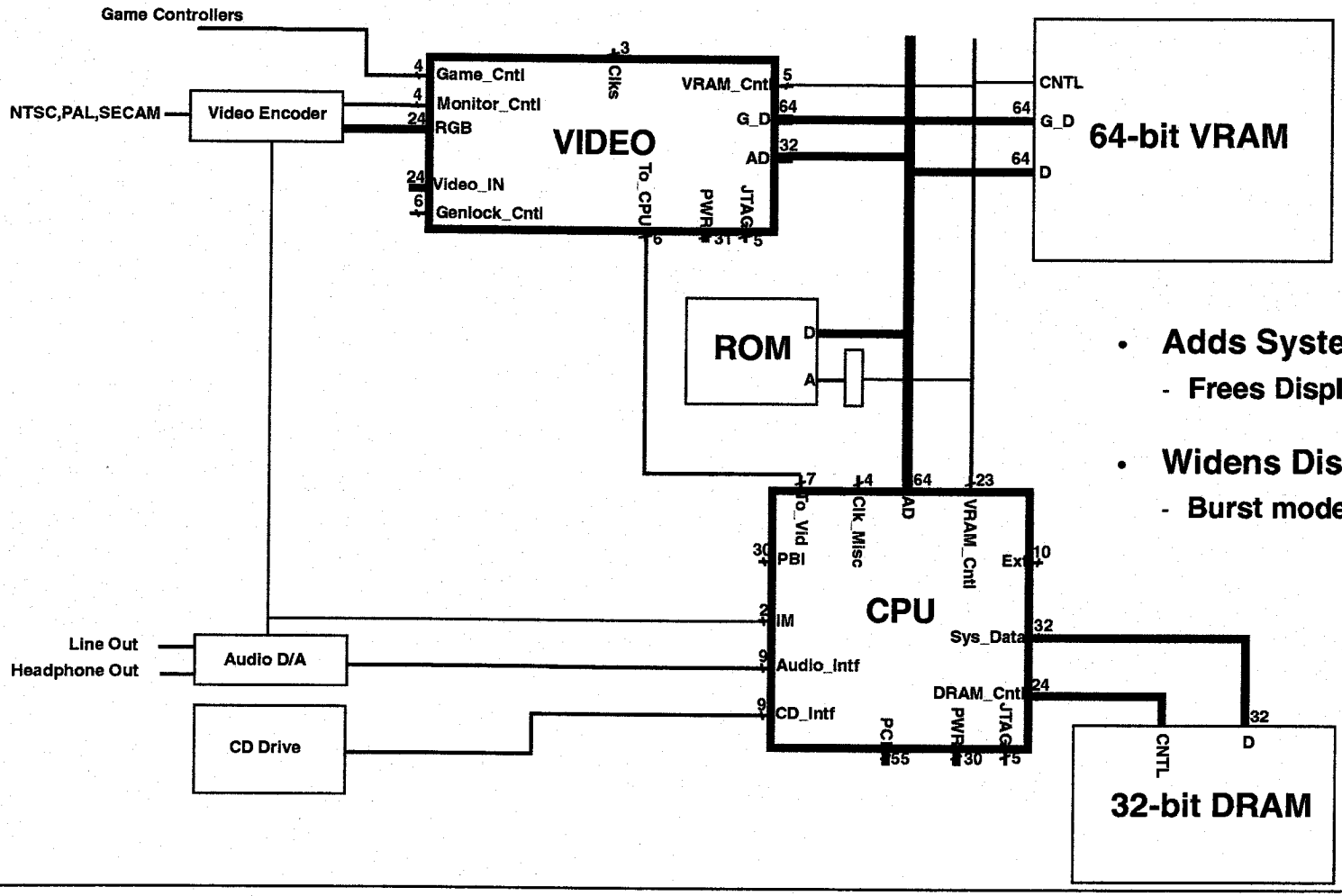
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Next Generation CD based Game Machine (Expanded)



- **Adds System DRAM**
  - **Frees Display DRAM port for blitter**
- **Widens Display VRAM**
  - **Burst mode DRAM: 100 Mbytes/sec**

Dr. Edward L. Hepler

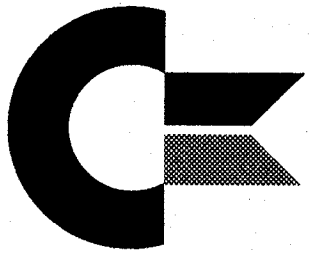
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

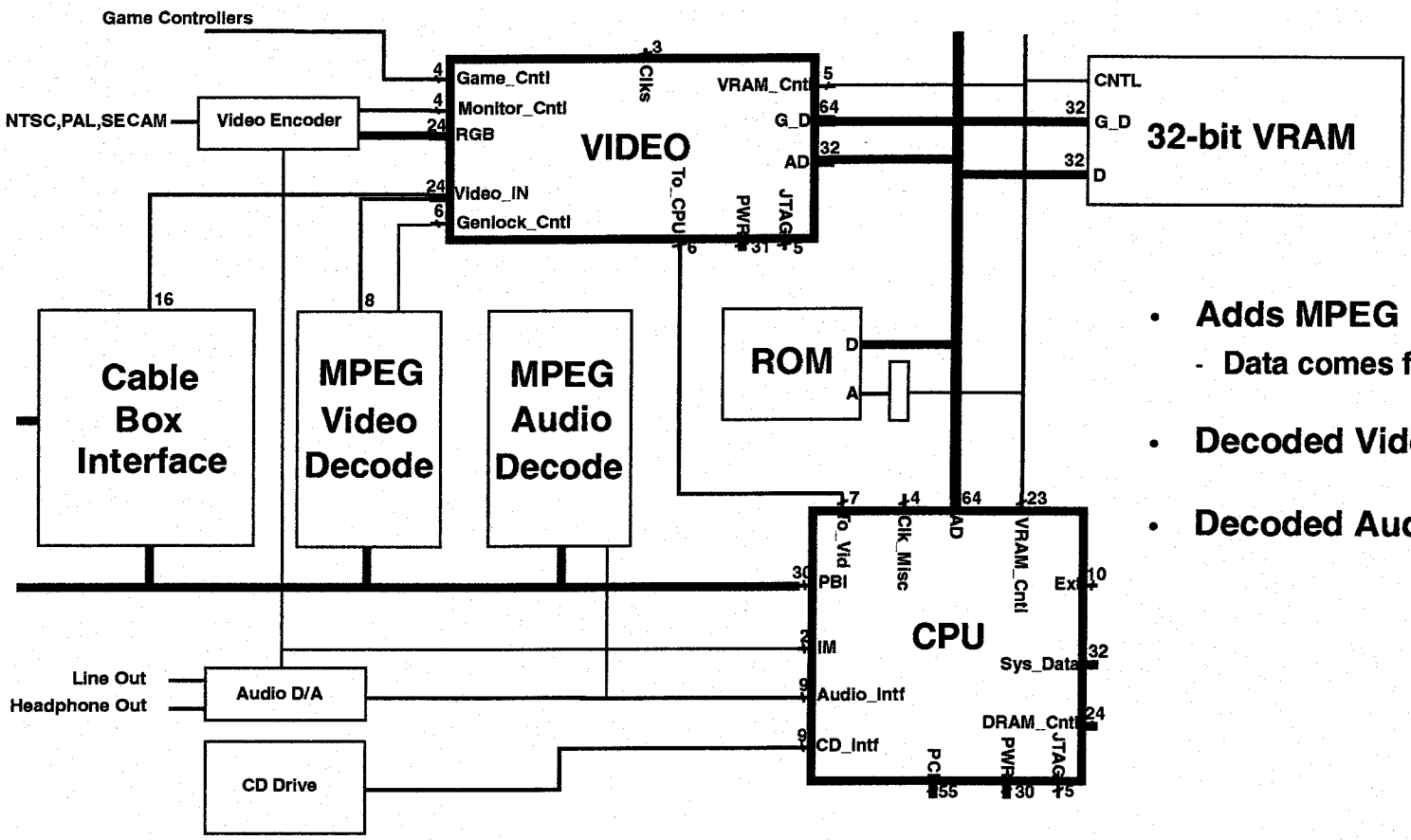
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

MPEG Player or Cable Box (Minimal)



- **Adds MPEG Intf via PBI**
  - Data comes from CD or Cable Intf
- **Decoded Video merged in Video Chip**
- **Decoded Audio merged in CPU Chip**

Dr. Edward L. Hepler

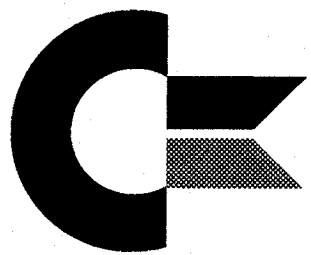
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

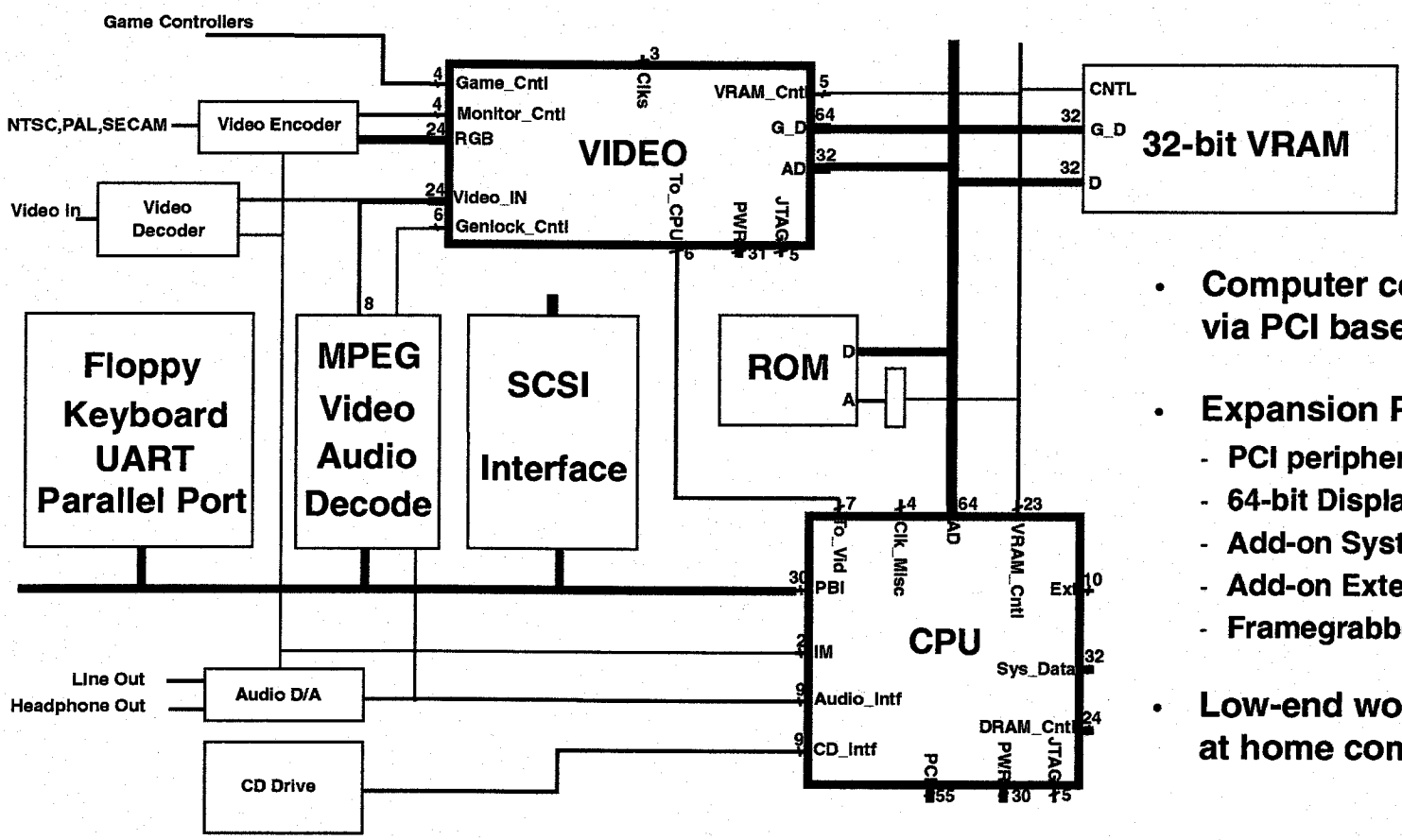
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

A1200 Class Home Computer (via PBI)



- Computer could also be achieved via PCI based ASIC
- Expansion Possible:
  - PCI peripherals
  - 64-bit Display VRAM
  - Add-on System DRAM
  - Add-on External Processor
  - Framegrabber
- Low-end workstation performance at home computer costs

Dr. Edward L. Hepler

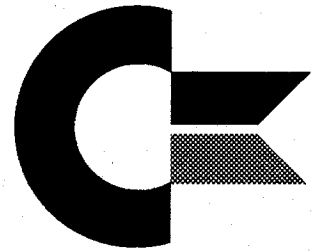
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

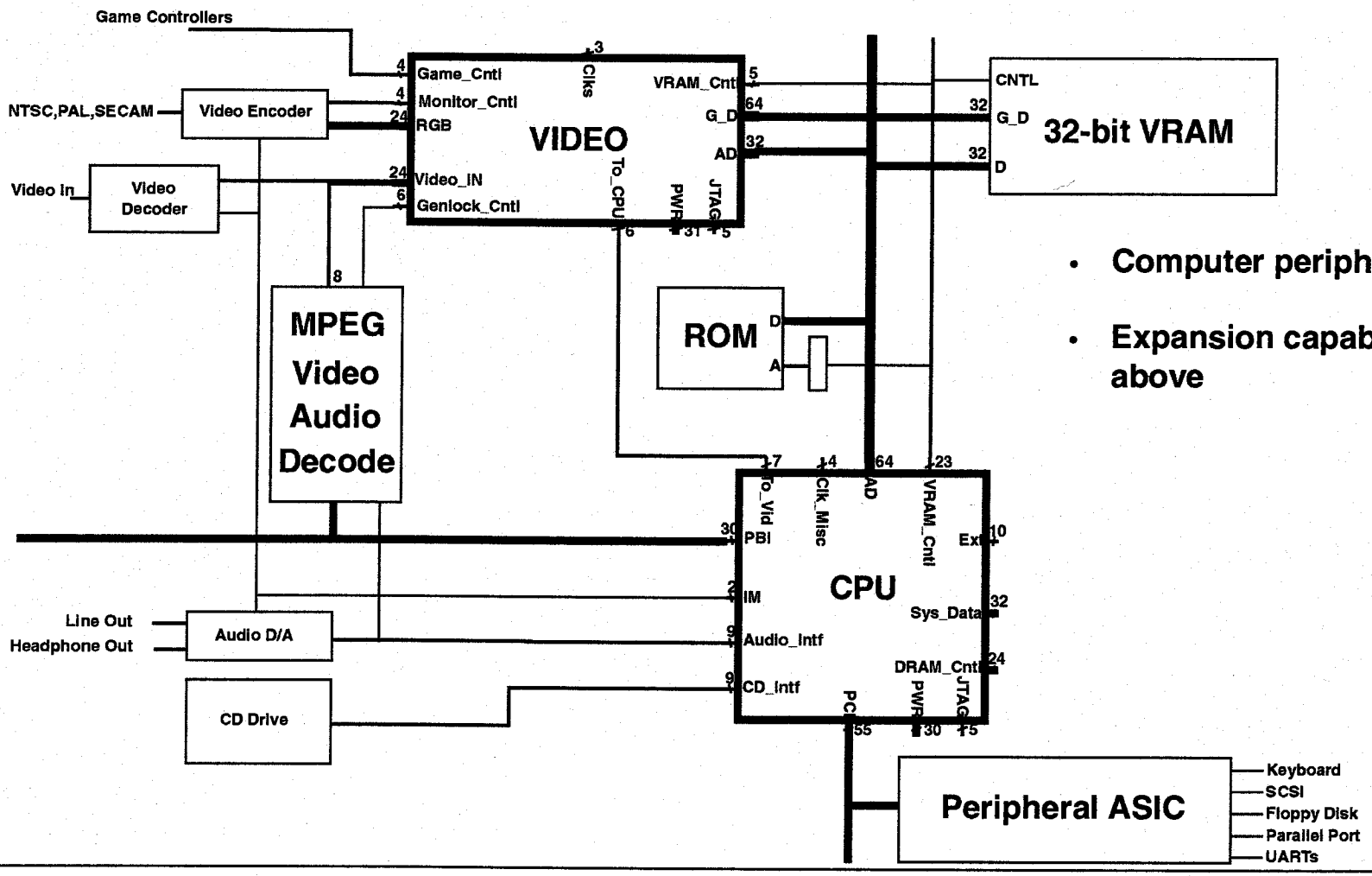
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

A1200 Class Home Computer (via PCI)



- Computer peripherals via PCI
- Expansion capabilities as shown above

Dr. Edward L. Hepler

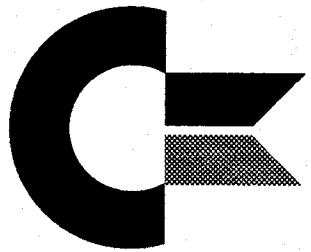
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

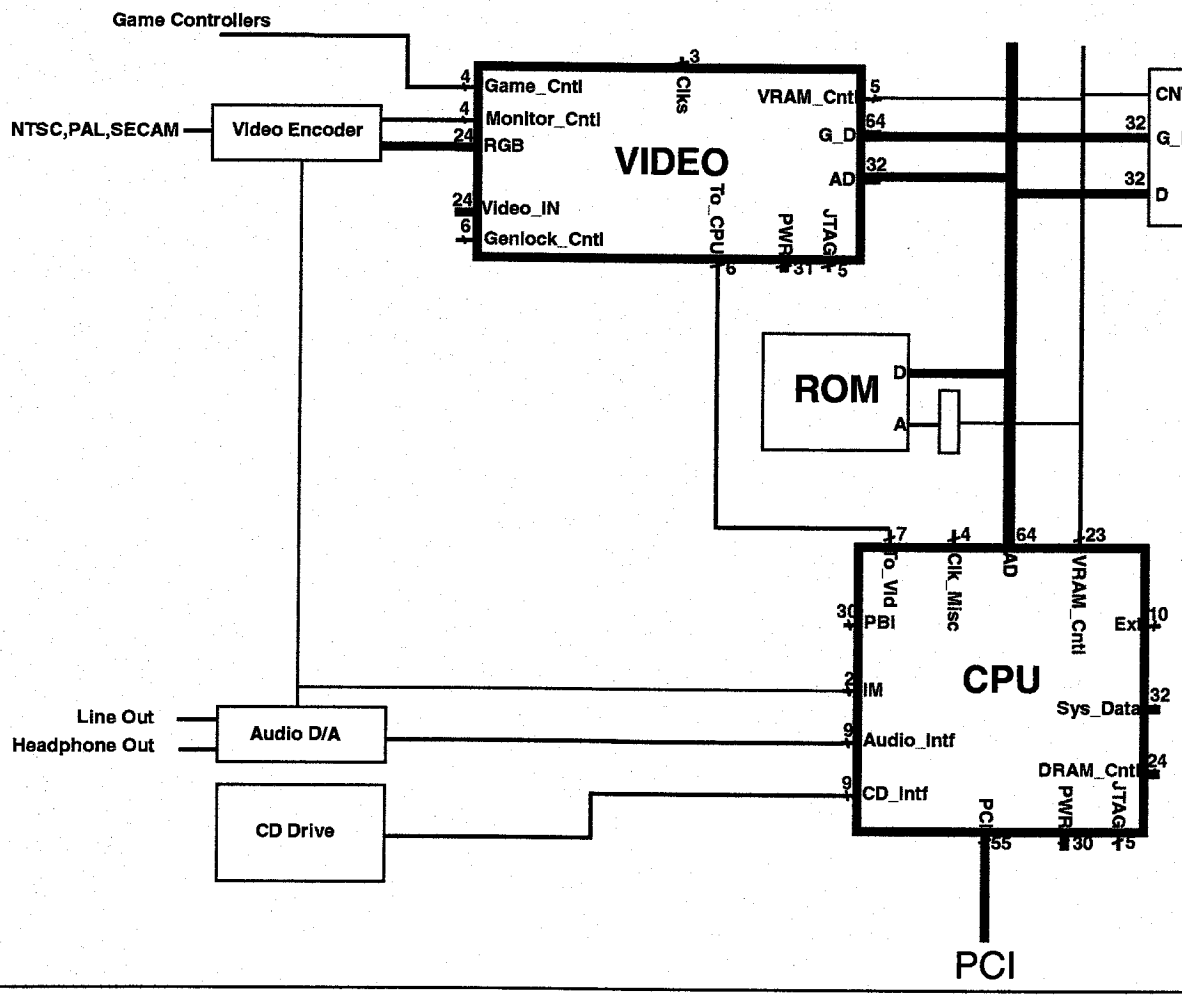
hepler@commodore.com



Modified: April 12, 1994

Created: October 18, 1993

Multimedia Graphics Accelerator



- PCI primarily slave interface
- Possible to "download" code
  - X-windows driver
  - Display PostScript Interpretter
- "Architectural-Link" to HP high-end workstations
- Accelerator for PC or MAC workstations
- All the expansion possibilites shown with the home computer chart...

Dr. Edward L. Hepler

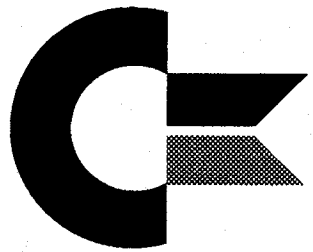
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

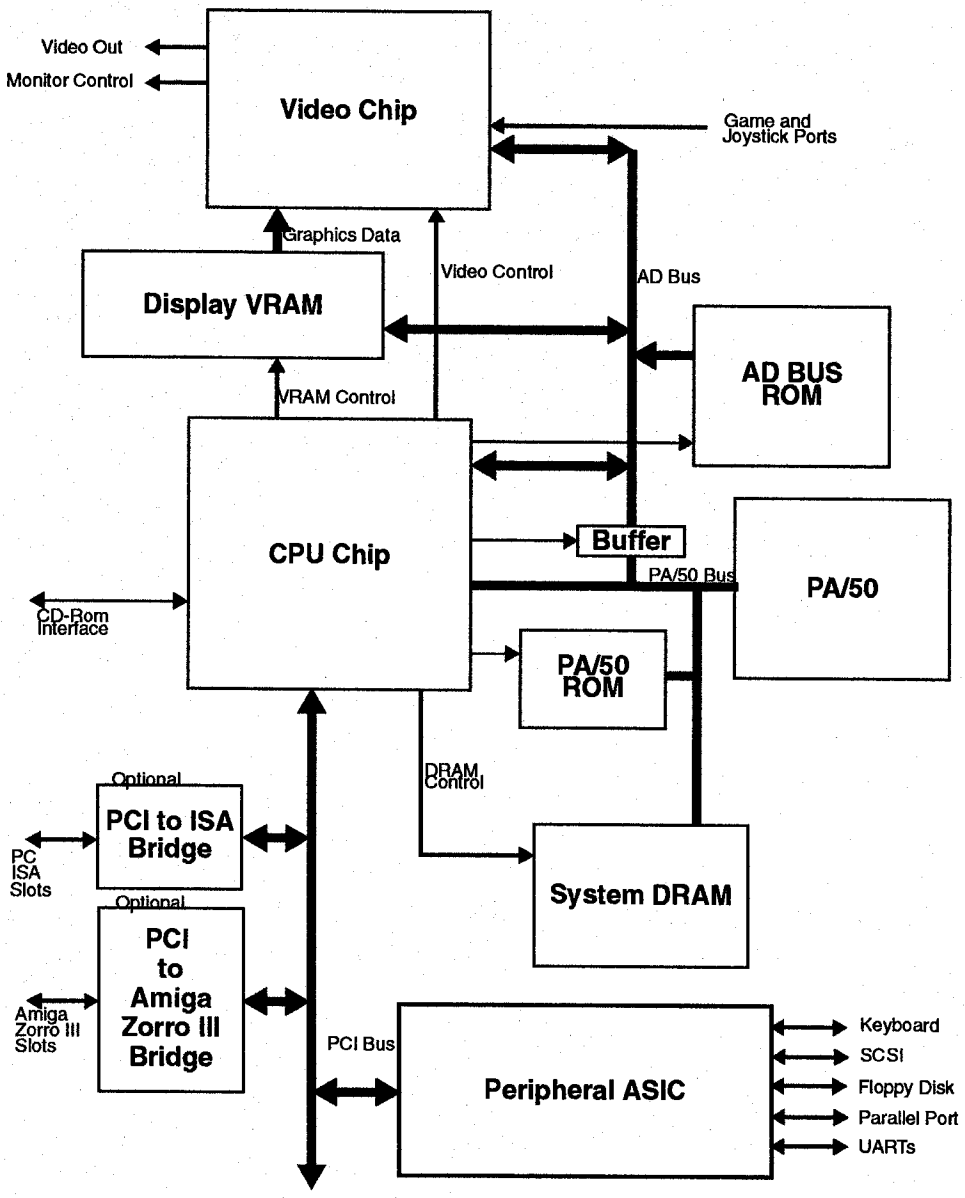
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Desktop and/or Tower Systems



- **Ext. PA/50 Proc., Additional DRAM, and Bus intf. added**

Dr. Edward L. Hepler

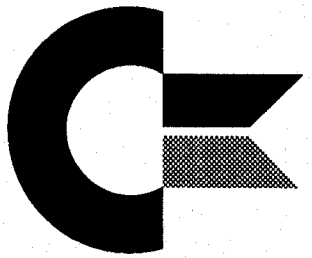
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

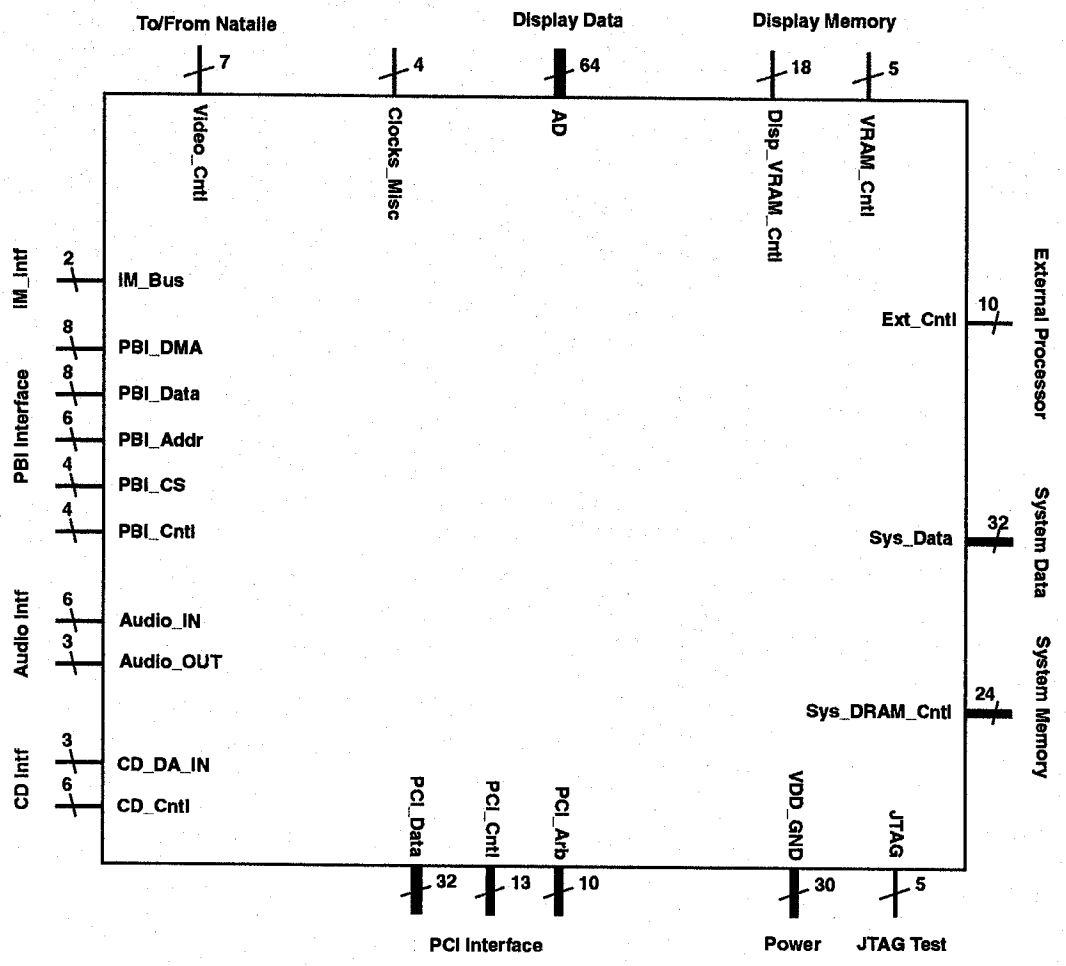
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

CPU/Rendering Chip (Nathaniel)



- **Functions:**
  - RISC Int. Core (MMU/Cache)
  - Blitter/Renderer
  - 8-bit DMA Interface
  - Audio Processor
  - CD-ROM Interface
  - PCI Bus
  - Memory Copier
  - Copper
- **Interfaces:**
  - 32/64-bit Display Memory Interface
  - 32-bit System Memory Interface
  - 32-bit PCI Interface
  - 8-bit Peripheral Bus Interface
  - 2-bit IM Bus Interface
- **274 Signals / 30 Power-Ground**
  - 304 PQFP (313 BGA)

Dr. Edward L. Hepler

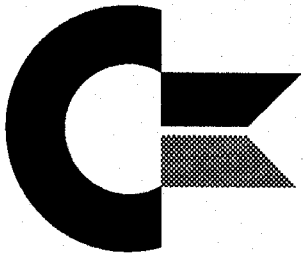
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

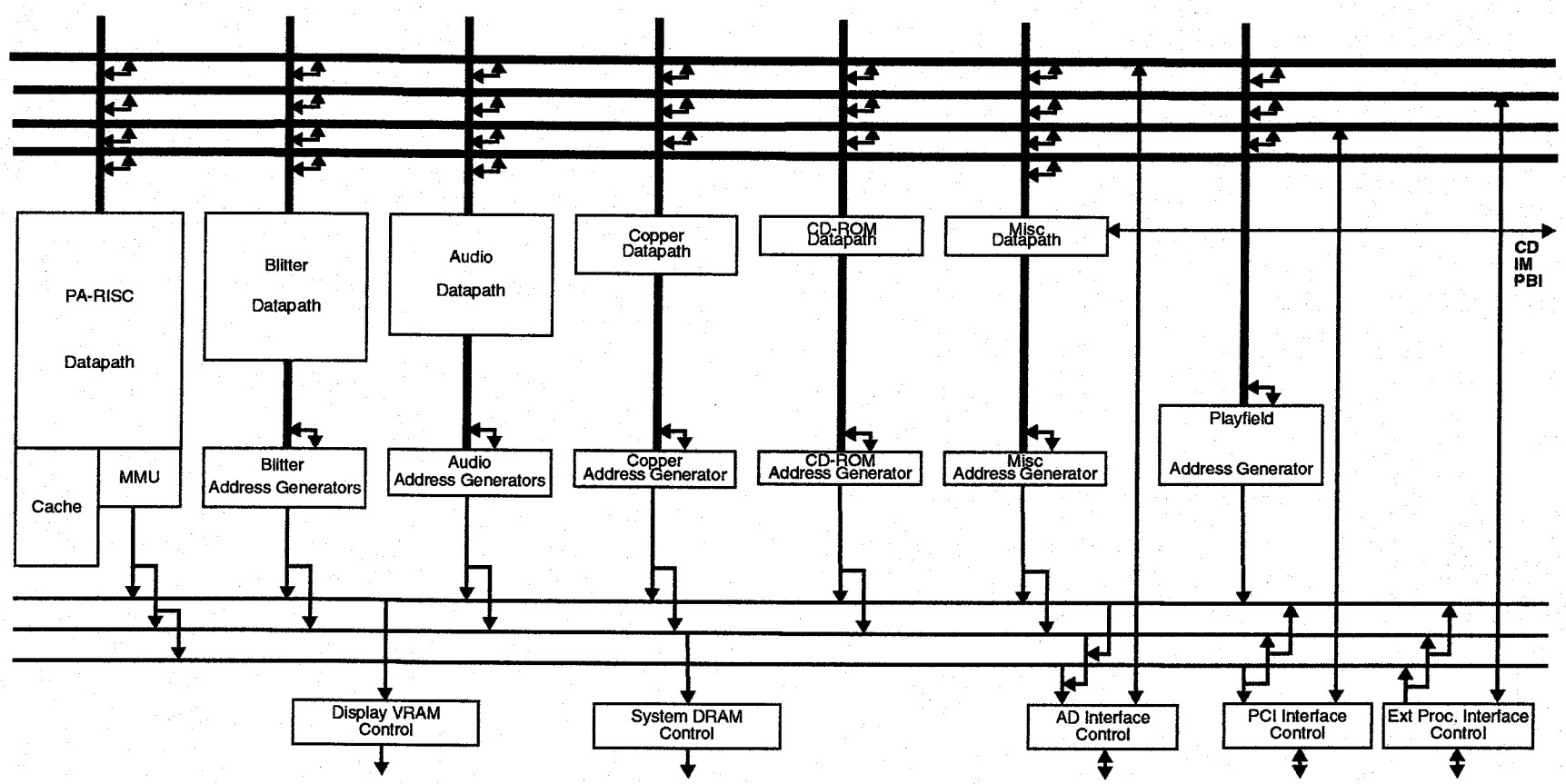
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Functional Block Diagram of CPU



Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

Commodore Confidential

Modified: April 12, 1994

Created: October 18, 1993

PA-RISC Implementation

- **Level 1 implementation - Integer only**
- **5 Stage Integer Pipeline**
- **Datapath widened to 64 bits**
  - **Even-odd register pairs may be accessed**
- **Execution Stage includes graphics functional unit**
- **Would like to add support for simple floating point functions.**

Dr. Edward L. Hepler

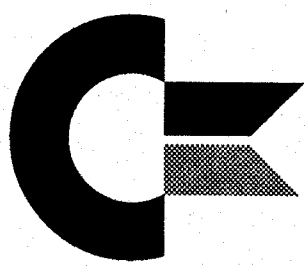
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

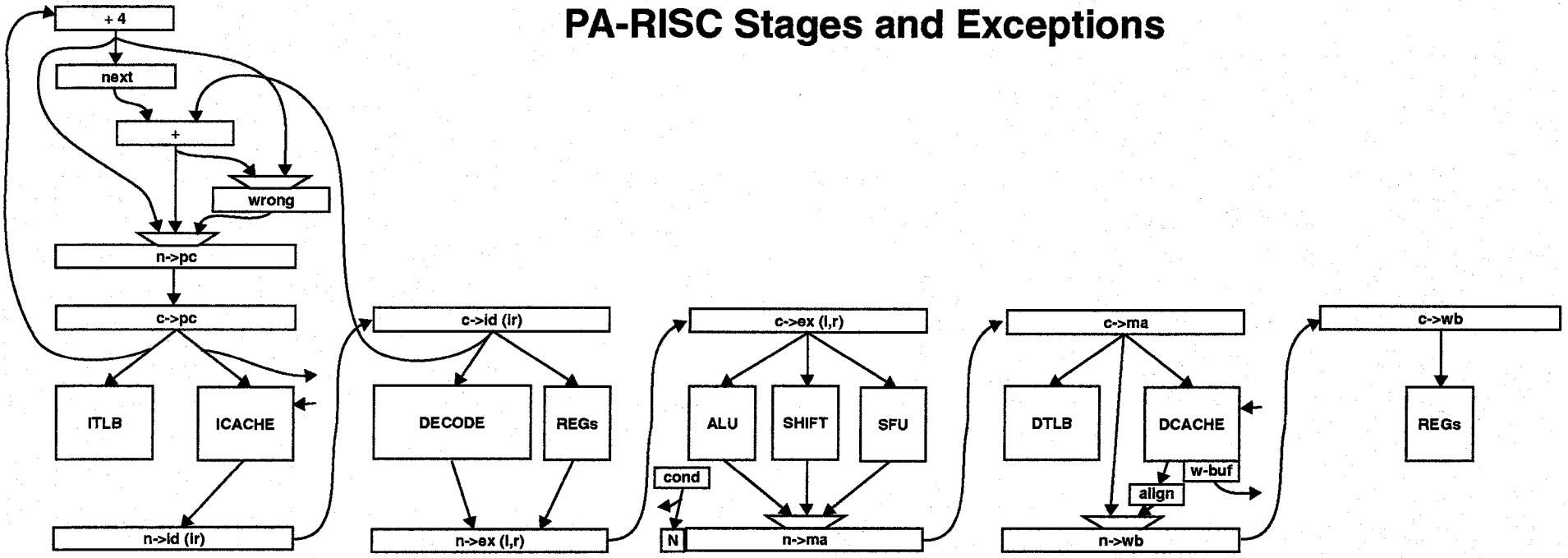
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

PA-RISC Stages and Exceptions



- ITLB miss (6)
- MEM prot (7)
- Taken Br (25)

- Illegal Instr Trap(8)
- Break Instr (9)
- Priv Op Trap (10)
- Priv Reg Trap (11)
- Assist (22)
- Higher Priv (23)
- Lower Priv (24)
- Taken(25)

- Overflow Trap (12)
- Cond Trap (13)
- Assist Exec Trap (14)

- DTLB miss (15)
- Non Access DTLB (17)
- Mem Access Rights (26)
- Mem Prot (27)
- Unaligned Access (28)
- Mem Prot (18)
- Mem Break (19)
- TLB Dirty (20)
- Page Ref (21)
- Non Access ITLB (16)

- Recovery Cnt (3)
- Ext Intr (4)
- Perf Mon (29)

Dr. Edward L. Hepler

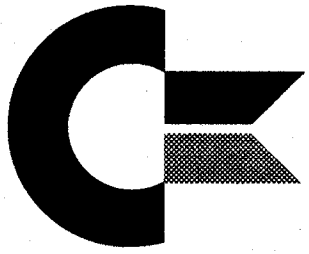
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

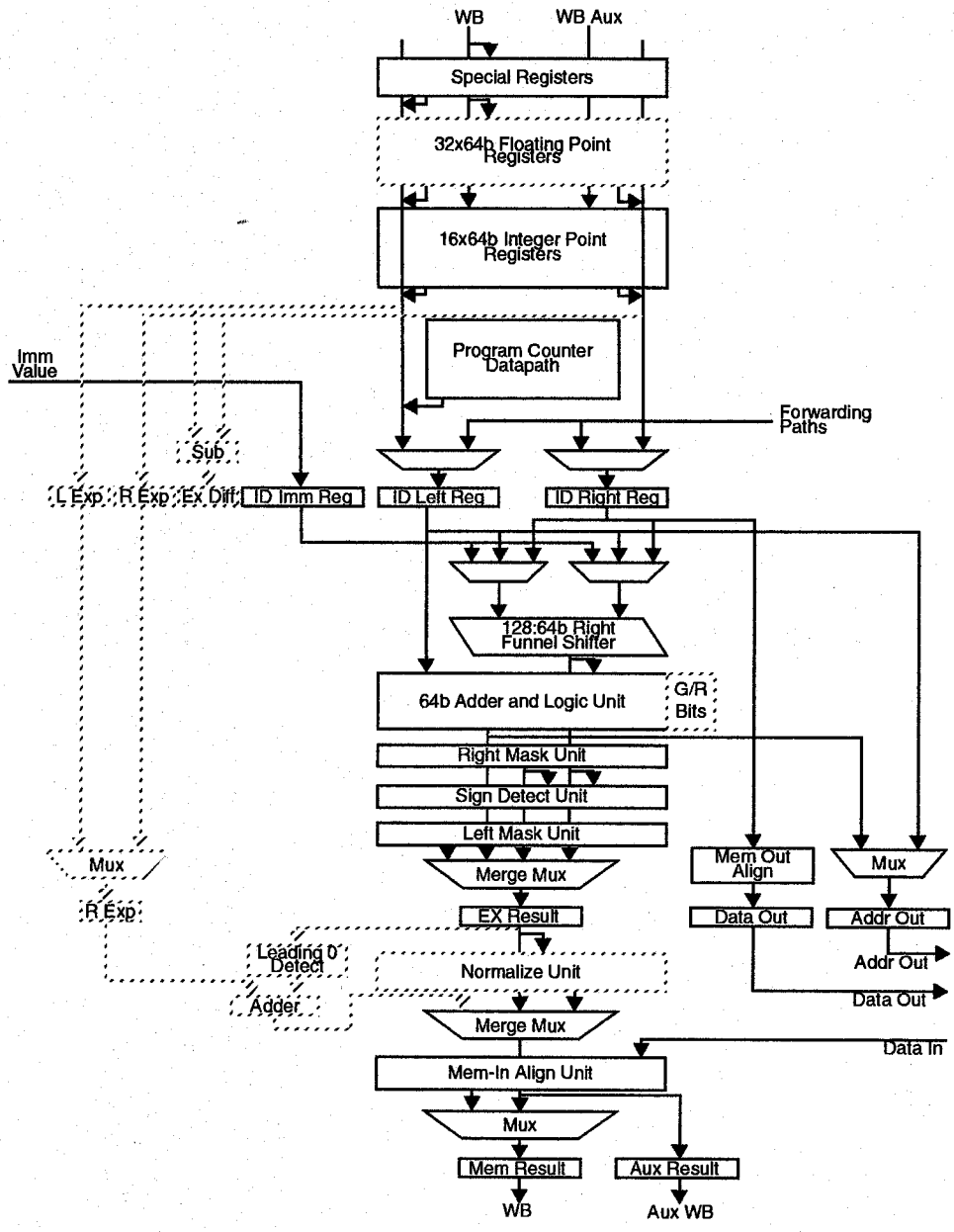
hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Internal PA-RISC Datapath



Dr. Edward L. Hepler

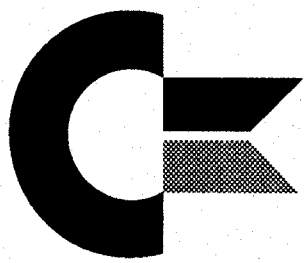
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

PA-RISC MMU Implementation

- **Level 1 Implementation**
  - **16-bit space registers**
- **Separate ITLB and DTLB**
  - **ITLB:**
    - **2 Block Entry (Operating System Code, Shared Libraries)**
    - **8 Page Entries**
  - **DTLB:**
    - **2 Block Entries (Frame Buffers)**
    - **8 Page Entries**

Dr. Edward L. Hepler

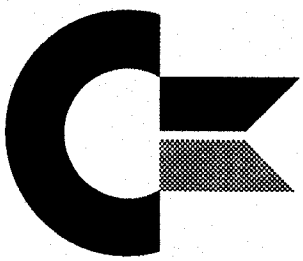
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

PA-RISC Cache Implementation

- **Separate Instruction and Data Caches**
- **Both:**
  - **2-way set associative**
  - **32-byte line size (4 64-bit accesses per line)**
- **Data Cache:**
  - **32 lines (1 Kbytes) (Hope to increase to 64 lines (2 Kbytes))**
  - **Write-back storage policy**
  - **1 line write buffer**
- **Instruction Cache:**
  - **64 lines (2 Kbytes) (Hope to increase to 128 lines (4 Kbytes))**

Dr. Edward L. Hepler

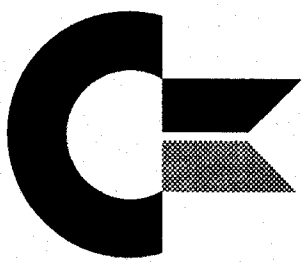
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

PA-RISC Extensions

- **SFU Instructions to support:**
  - Graphics
    - Graphics coordinate manipulation
    - Shading inner-loop manipulation of 5-5-5 pixels
    - Outcode clipping support
  - CD-ROM error correction
  - 64-bit accesses
- **Combined Integer/Floating Point support:**
  - Necessity?
  - Support for emulation?

Dr. Edward L. Hepler

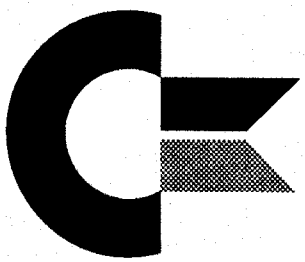
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Hombre SFU Instructions

GR_ARITH_5

04	r2	r1	01	3	sfu=1	0	rt
6	5	5	5	2	3	1	5

GR_ARITH_8

04	r2	r1	03	3	sfu=1	0	rt
6	5	5	5	2	3	1	5

GR_ARITH_5_5

04	r2	r1	02	3	sfu=1	0	rt
6	5	5	5	2	3	1	5

GR_ARITH_8_8

04	r2	r1	04	3	sfu=1	0	rt
6	5	5	5	2	3	1	5

GR_CLIP_SUB

04	r2	r1	05	3	sfu=1	0	t
6	5	5	5	2	3	1	5

GR_TEST

04	0	0	06	3	sfu=1	1	x
6	5	5	5	2	3	1	5

GR_MTCL

04	r2	00	07	3	sfu=1	0	0
6	5	5	5	2	3	1	5

GR_PACK_5_5

04	r2	00	08	3	sfu=1	0	t
6	5	5	5	2	3	1	5

GR_PACK_8_8

04	r2	00	09	3	sfu=1	0	t
6	5	5	5	2	3	1	5

GR_LDDX

0B	b	x	s	u	0	cc	0	uid=1	m	t
6	5	5	2	1	1	2	1	3	1	5

GR_STDX

09	b	x	s	u	0	cc	1	uid=1	m	r
6	5	5	2	1	1	2	1	3	1	5

GR_LDDS

0B	b	im5	s	a	1	cc	0	uid=1	m	t
6	5	5	2	1	1	2	1	3	1	5

GR_STDS

09	b	im5	s	a	1	cc	1	uid=1	m	r
6	5	5	2	1	1	2	1	3	1	5

Dr. Edward L. Hepler

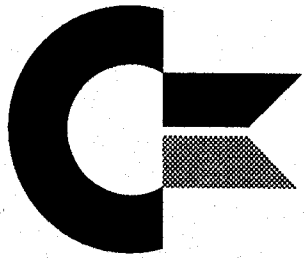
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified:April 12, 1994

Created: October 18, 1993

Blitter

- **General**
  - Operates on 8, 16, or 24(32) bit pixels
  - All control registers (except function) are shadowed
  - Uses plane mask
  - Uses burst mode for faster accesses
  - Uses intelligent RMW cycles for faster accesses
  - Transparency mode permits easy insertion
- **Rectangular Blits**
  - Combines 0, 1, or 2 sources with destination rectangle
  - Uses one of 256 Boolean Functions
  - Forward and Reverse fetching
- **Expands**
  - 1:8, 1:16, 1:24(32) expands
  - Clipping optional
- **Line Draws**
  - Uses Breshenham algorithm
  - Pattern Register permits patterned lines
  - Clipping optional
- **Fills**
  - Shading is performed using fixed-point arithmetic
  - Texture mapping also uses fixed-point arithmetic
  - Clipping optional

Dr. Edward L. Hepler

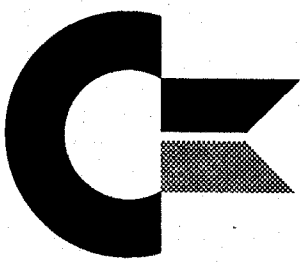
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

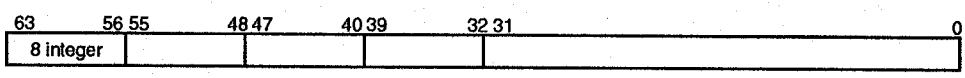


Modified:April 12, 1994

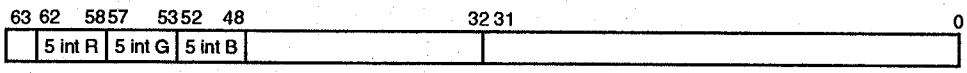
Created: October 18, 1993

Pixel Data Types

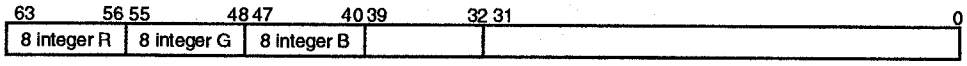
- **During Display:**
  - **8-bit palette, HAM8:**



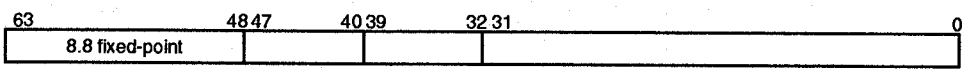
  - **16-bit RGB (Hi-color):**



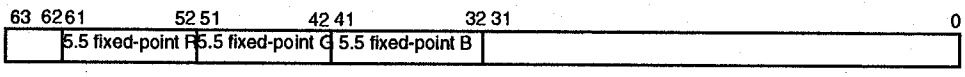
  - **24(32)-bit RGB (True-color):**



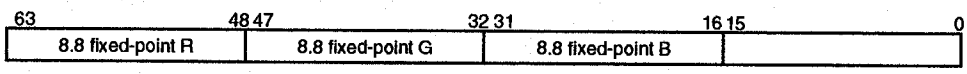
- **During Calculations:**
  - **8-bit palette:**



  - **16-bit RGB (True-color):**



  - **24(32)-bit RGB (True-color):**



Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

Modified:April 12, 1994

Created: October 18, 1993