Introduction

In the October of 2002 an agreement was reached with IBM for loan of an original magnetic disk drive, the RAMAC, to the Magnetic Disk Heritage Center (MDHC) at Santa Clara University. The purpose is to restore the drive electromechanical access mechanism and magnetic disk recording capabilities to some functional level of operation. The original vacuum tube control unit will be implemented in semi-conductor electronics, as the technical significance of the device is associated with the above features.

This effort to restore a major historical artifact has aroused great interest and if we are successful it is anticipated the unit will be shown widely to the general public and become a centerpiece for an envisaged City of San Jose Technical Museum at 99 Notre Dame, the birthplace of the magnetic disk drive in 1952. The first two months were spent in tracking down and obtaining as many documents as possible dealing with the design and maintenance of the device. While source information is limited it was felt adequate to support initial investigations into the state of the hardware.

In January, two students at SCU were engaged to start development of three-dimensional models using computer aided design programs. The initial results were available in February. This work will provide excellent graphics representations illustrating the actual operation of the access mechanism of the RAMAC and provide detailed insights into its design features and performance characteristics.

In February Dave Bennet (IBM) and Jack Grogan (IBM) two pioneers who worked on such drives in the past, volunteered to participate actively in this restoration project on a regular basis. They have been examining the current state of the hardware and planning the first steps to be taken in determining the operational status of the various components.

This engineering notebook is the first of several that are to be a log of the tasks undertaken and serve as a chronicle or journal of this adventure. The initial group meeting to coordinate efforts took place on 2/13/03 and the first entry following this introduction, starting on page 3, reflects the beginning of first hands-on activity on the disk drive undertaken.
On this page are first listed the
volunteers & students forming the
original group that was formed on 2/13/03.
At that meeting it was agreed to
start by holding a weekly group meeting
every Thursday afternoon.
As additional individuals participate
their signatures will be added to this page
with the date they came on board.

All 12/03 2/13/03
John M. Turner 2/13/03
Barry Kalink 2/28/03
David Bennett 2/13/03
ATTEMPTED, UNSUCCESSFULLY, TO REMOVE BROKEN AIR PIPES FROM UNDERSIDE OF AIR MANIFOLD (MOUNTING FOR 5 SKINNER AIR VALVES). EZ OUT BROKE, MAKING IT NECESSARY TO REMOVE MANIFOLD.

2) DISCONNECTED 5 AIR TUBES, 1 FROM EACH AIR VALVE. PLACEMENT FOR REASSEMBLY TO BE DETERMINED BY LENGTH OF TUBING.

b) DISCONNECTED WIRES FROM 4 OF 5 TAPPED PIN BLOCKS ON AIR MANIFOLD CHASSIS AS FOLLOWS:

1.

2.

3.

4.

5.

NOTE: 3 CONNECTIONS IN ANY COLUMN ARE COMMON

David J. Beatty
2/13/03
AIR FITTING REMOVED FROM MANIFOLD AND REPLACED WITH NEW AIR FITTINGS. AIR MANIFOLD REPLACED ON CHASSIS.

WHILE MANIFOLD ASSEMBLY WAS REMOVED, CIRCUITS ON EDGE CONNECTORS WERE PROBED AS FOLLOWS (REFER TO PREVIOUS PAGE FOR EDGE CONNECTOR NOMENCLATURE)

EDGE CONNECTOR

1. [A] HEAD SOLENOID
   - Brown Wire (Cable Harness)
2. [B] WIRE (3A)
   - 330 Ω (2A)
   - Diode ←→ (2A)
3. [C] .5 μF (2C)
   - 330 Ω (2B)
   - Diode ←→ (2B)
4. [D] TRACK EVEN SOLENOID
   - .5 μF (2D)
   - Brown Wire (Harness)
5. [E] WIRE (3E) (COMMON)
   - 330 Ω (2D)
   - Diode ←→ (2D)
6. [F] Diode ←→ (2E)
   - .5 μF (2H)
   - 330 Ω (2E)
7. [G] WIRE (3E) (COMMON)
   - 330 Ω (2H)
   - Diode ←→ (2H)
8. [H] TRACK ODD SOLENOID
   - .5 μF (2H)
   - Brown Wire (Harness)

Date and sign every entry. Have every possibly important entry witnessed. Submit an Invention Disclosure of anything possibly new and inventive.
EDGE CONNECTOR

- **A**
  - DIODE (1B)
  - 330Ω (1B)
  - 0.5 μF (1A)

- **B**
  - 330Ω (1C)
  - WIRE (3B) (COMMON)
  - DIODE (1C)

- **C**
  - BROWN WIRE (HARNESS)
  - 0.5 μF (1C)
  - DISK IN SOLENOID

- **D**
  - DIODE (1E)
  - 330Ω (1E)
  - 0.5 μF (1D)

- **E**
  - DIODE (1F)
  - 330Ω (1F)
  - WIRE (3D)

- **F**
  - BROWN WIRE (HARNESS)
  - 0.5 μF (1F)
  - DISK OUT SOLENOID

- **G**
  - NOT USED

- **H**
  - 0.5 μF (1H)
  - DIODE (1G)
  - 330Ω (1G)

**NOTE:** All points common on Connector C

- WIRE (1E)
- HEAD SOLENOID
- WIRE 3B-C-D-E-F-G

- **B**
  - WIRE (2B)
  - DISK IN SOLENOID
  - WIRE 3A-C-D-E-F-G-H

- **C**
  - DISK OUT SOLENOID
  - TRACK EVEN SOLENOID
  - 3A-B-D-E-F-G-H

- **D**
  - TRACK ODD SOLENOID
  - WIRE (2E)
  - 3-A-B-C-E-F-G-H
EDGE CONNECTOR

3. (E) Wire (IE)
   Wire (IG)
   3 A-B-C-D-E-F-G-H

4. BROWN WIRE (HARNESS)
   BROWN WIRE (HARNESS)
   3 A-B-C-D-E-F-G-H

5. BROWN WIRE (HARNESS)
   NOT USED
   3 A-B-C-D-E-F-G-H

6. BROWN WIRE (HARNESS)
   BROWN WIRE (HARNESS)
   3 A-B-C-D-E-F-G

4. NOTE: NOT PART OF SOLENOID CIRCUIT

A. Diode - (4D)
   Thyristor (?) (5E)
   NOT USED

B. 
   NOT USED

C. 
   NOT USED

D. Diode - (4A)
   Diode - (5D)
   NOT USED

E. Diode - (4H)
   Thyristor (?)
   NOT USED

F. 
   NOT USED

G. 
   NOT USED

H. Diode - (5H)
   Diode - (4E)
   NOT USED
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EDGE: CONNECTOR

(1) WIRE (5F)
- THYRISTOR (?) (4A)
3 WHITE WIRE (HARNESS) (CONNECTOR C, PIN BB)

(2) NOT USED

(3) BLUE WIRE (HARNESS)
- DIODE (4D)
- BLUE WIRE (HARNESS) (INNER HARNESS)

(4) NOT USED

(5) WIRE (SB)
- THYRISTOR (?) (4D)
- WHITE WIRE (HARNESS) (BOTH CLUTCHES)

(6) NOT USED

(7) BLUE WIRE (HARNESS) (OUTER CLUTCH)
- DIODE (4H)
- BLUE WIRE (HARNESS)

Solenoid Circuits

(4A) HEAD

(4D) 330 TRACK EVEN

(4H) 330 TRACK ODD
1. TODAY (2/20/2003) WE APPLIED AIR PRESSURE (50 PSI) AND 48 VOLTS DC TO THE TOP SOLENOID "TRACK ODD", PIN 14. THE SOLENOID APPLIED AIR PRESSURE AT ITS OUTLET.

2. NEXT, WE ATTACHED THE OUTLET TUBE, "TRACK ODD" TO THE TOP SOLENOID, AND WITH AIR & 48 VDC APPLIED, THE DETENT WAS OBSERVED TO MOVE INTO THE HEAD ACCESS RACK.

3. THEN WE DETACHED THE "TRACK ODD" TUBE FROM THE TOP SOLENOID AND ATTACHED "TRACK EVEN" TUBE INSTEAD. THE SECOND DETENT WAS OBSERVED TO MOVE INTO ENGAGEMENT IN THE HEAD ACCESS RACK.

Dave's Bennett
2/20/2003
Clutch inductance is 1.037 H. Resistance measurements inconclusive due to dirt on slip rings. Appears we will have remove clutch for good measurement.

Harry Kahn 2-17-03

PREPARING TO REMOVE CLUTCH SHAFT:

1. REMOVED UPPER & LOWER CABLES ENVELOPE 1

2. REMOVED ACCESS MECHANISM DRIVE MOTOR PINION ROLLER, SPRING, KEY - ENVELOPE 2

3. OBSERVED THAT 2 of 3 MOUNTING BOLTS FOR END PLATE, ALSO SECURE ACCESS ASSEMBLY

4. DECIDED THAT ASSEMBLY MUST BE SECURED ONE BOLT AT A TIME, WITH SHORTER BOLTS, SO THAT ACCESS ASSEMBLY REMAINS SECURE

5. JACK GROGAN TOOK PINION ROLLER TO INVESTIGATE GETTING IT RECAST. IT IS DETERIORATED, HARD & UNUSABLE

2/27/2003

JOHN SHEPARD
ANDREW GIUSTINI
JACK GROGAN
HARRY KAHN
DAVE BENJON
3/06/03

REMOVING CLUTCH SHAFT

NECESSARY TO DRIVE TACHOMETER END FROM FLEX BELLOWS COUPLING

SUCCESSFULLY REMOVED SHAFT
CLEANED SLIP RING S & DRIVING SURFACES OF CLUTCHES

MEASURED CLUTCH RESISTANCE
317 Ω ( BOTH) cleaned slip rings & wipers

REMOVED O-RING FROM DISK OUT SOLENOID WILL NEED REPLACEMENT

POTENTIAL Clutch Driver Transistor 2SC 4953 Vce = 14.3V
NPN 40V 50A Panasonic Pkg T0-220D price 1.73 ea. available from Digikey (possibly elsewhere)
WAITING FOR CATALOG FROM Apex Microtechnology for pre amp to drive the 2SC 4953.

Al Hoagland
Jack Grogan
Harry Kahn
John Shepard
Andrew Giustini
Dave Bennett

Dave Bennett
4/03/03

- CLUTCH SHAFT BEARINGS REPLACED
- SLIP RINGS OF INBOARD CLUTCH HAVE BEEN TURNED TO REMOVE PITTING FROM ARcing.

CONTINUING TO PLAN FOR CONTROL SYSTEM.

MESAURED PINION AS FOLLOWS

PINION WILL NEED TO BE RECAST IN RUBBER MATERIAL

AL HOAGLAND
HARRY KAHN
JOHN SHEPARD
ANDREW GIUSTINI
DAVE BENNET

Clutch amplifier and driver have been breadboarded.
6/12/03

REMOVED FROM HEAD ARM

HEAD LIFTER SPRING (UPPER)
UPPER HEAD
3 PISTONS
UPPER HEAD COVER

HEAD COVER IN ENVELOPE HERE

LOANED TO FRED SCOTT FOR
HEAD EXPERIMENTS & REPRODUCTION
(SPRINGS & PISTONS)

Jack Grogan

Dave Bennett
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TRACED WIRES FROM FOUR MAIN CONNECTORS

- CONNECTOR A has connections for the disk potentiometer strip, numbers 27-52, in alphabetical order on the connector.
- CONNECTOR B has connections for the disk potentiometer strip, numbers 1-26 in alphabetical order. Ex. B:A-1; first pot. strip, connector B, pin A.
- CONNECTOR C PIN connects to (color)
  
  A: top and bottom overtravel crash stop (br)
  B: NOWIRE
  C: Top and bottom overtravel crash stop (br)  
  - A+C broken only when stops are hit
  D: 1H from solenoid box (br)
  E: 3H2 (shortest) from solenoid box (4K)
  F: 2C From solenoid box (br)

Pat Connolly
IBM Technical Notebook

PIN
H: 0D from solenoid box (br)
J: 0F from solenoid box (br)
K: 0A from solenoid box (br)
L: out to tachometer (blue, next to black)
M: (wh)
N: 5F1 (longest) from solenoid box (blk)
P: 5H (longer) from solenoid box (blue)
R: (blue)

CONNECTOR D ALL PINS CONNECT TO CARRIAGE MALE

TRACK DETENT RELAY

1: 0-L
2: 0-M
3: 0-P

WHEN NO AIR APPLIED, 2+3 ARE CONNECTED
WHEN EITHER TRACK DETENT ENERGIZED, 1+3 ARE CONNECTED
OTHERWISE 2+3 ARE CONNECTED

TRACK POTENTIOMETER

MAY NEED CLEANING
VERY BAD CONNECTION

A: 0-A
B: 0-B
C: 0-C
D: 0-D
E: 0-E
F: 0-F
K: 0-K
L: NO WIRE
M: NO WIRE
N: NO WIRE

A, B, L, M NOT FOUND (7-14-03)

Pat Connolly

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HEAD CABLE

A: D-U  C: D-W  E: D-AA  H: D-CC
B: D-BB  D: D-Y  F: D-DD

DISK DETENT SWITCH

1: D-R  3: D-N
2: D-AP

2+3 CONNECTED WHEN DETENT LOCKED

DISK POTENTIOMETER SENSOR (WIPER)

- BROKEN BLACK WIRE BY DISK DETENT SWITCH, MATCHES WITH D-S
- REMOVED TOP DISK COVER

- REMOVED/REPLACED SECTOR SENSOR PLUG

- REMOVED ACCESS ARM
  1. loosened track bar crash stop
  2. removed red head cable and mount from access arm
  3. loosened upper and lower carriage pulleys
  4. slid out reader arm

- REMOVED BOTTOM HEAD
  1. SLID Head cover off
  2. Cut air hose to head
  3. removed head, headspring from arm

- CLEANED ACCESS ARM

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7-16-03

- CLEANED HEAD COVER, SPRING (lower)
- OILED ACCESS ARM
- REMOVED ARM ROLLER BEARING, CLEANED, OILED, AND REPLACED
- REMOVED DISK MOTOR ENDPLATE (6 bolts)
- REMOVED INNER BASE PLATE (3 ALLEN BOLTS)
  → No luck removing motor
- REMOVED UPPER AND LOWER CARRIAGE ROLLER BEARINGS;
  CLEANED, OILED, AND REPLACED
  → LOWER BEARING MISSING "E" CLIP RETAINER FOUND 7-17
  → INSTALLED COOLING FANS FOR CLUTCH AMPLIFIER
- INSTALLED ACCESS ARM (W/O HEADS)
  → PULLEYS AND CRASH STOP NEED ADJUSTING
- APPLIED AIR PRESSURE TO DISK DETENTS TO UNLOCK
  AND LOCK CARRIAGE (50 psi)
- CLEANED CARRIAGE WITH HIGH PRESSURE AIR
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**7-21-03**

**CONNECTOR C - REWIRED, 26 PIN CONNECTOR**

<table>
<thead>
<tr>
<th>A-</th>
<th>B-</th>
<th>C-</th>
<th>D-</th>
<th>E-</th>
<th>F-</th>
<th>AA-</th>
<th>BB-</th>
<th>CC-</th>
<th>DD-</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-SOLENOID 5 H (blk)</td>
<td>W-SOLENOID 1 A (br)</td>
<td>X-SOLENOID 2 F (br) DISK OUT</td>
<td>Y-SOLENOID 0 D (br) EVEN TRACK</td>
<td>Z-SOLENOID 0 F (blk)</td>
<td></td>
<td>TACHOMETER (blue)</td>
<td>SOLENOID 5 B (wh)</td>
<td>SOLENOID 5 H (blue)</td>
<td>SOLENOID 5 D (blue)</td>
</tr>
<tr>
<td>R- UPPER AND LOWER CRASH STOPS (br)</td>
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<tr>
<td>S-SOLENOID 2 C (br) DISK IN x1</td>
<td>T-SOLENOID 1 H (br) TRACK 22</td>
<td></td>
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<tr>
<td>U- UPPER AND LOWER CRASH STOP (br)</td>
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CONNECTOR C CABLE
- PINS A⇒P correspond to 1-13 on subDshell
- PINS R⇒DD " " 20-32 " "

ALL OTHER CABLES A⇒DD = 1-26

CLUTCH DRIVER CIRCUIT FOR +5/± activation,
BASIC STAMP POWERED

DISC DETENT CIRCUIT
- PIN LOW, RELAY ON
- PIN HIGH, OFF