



Magnetic Disk Heritage Center

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 first 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.

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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.

Al Hoagland	2/13/03
John M. Hogan	2/13/03
Harry Kalene	2- 18 -03
David Bennett	2/13/03

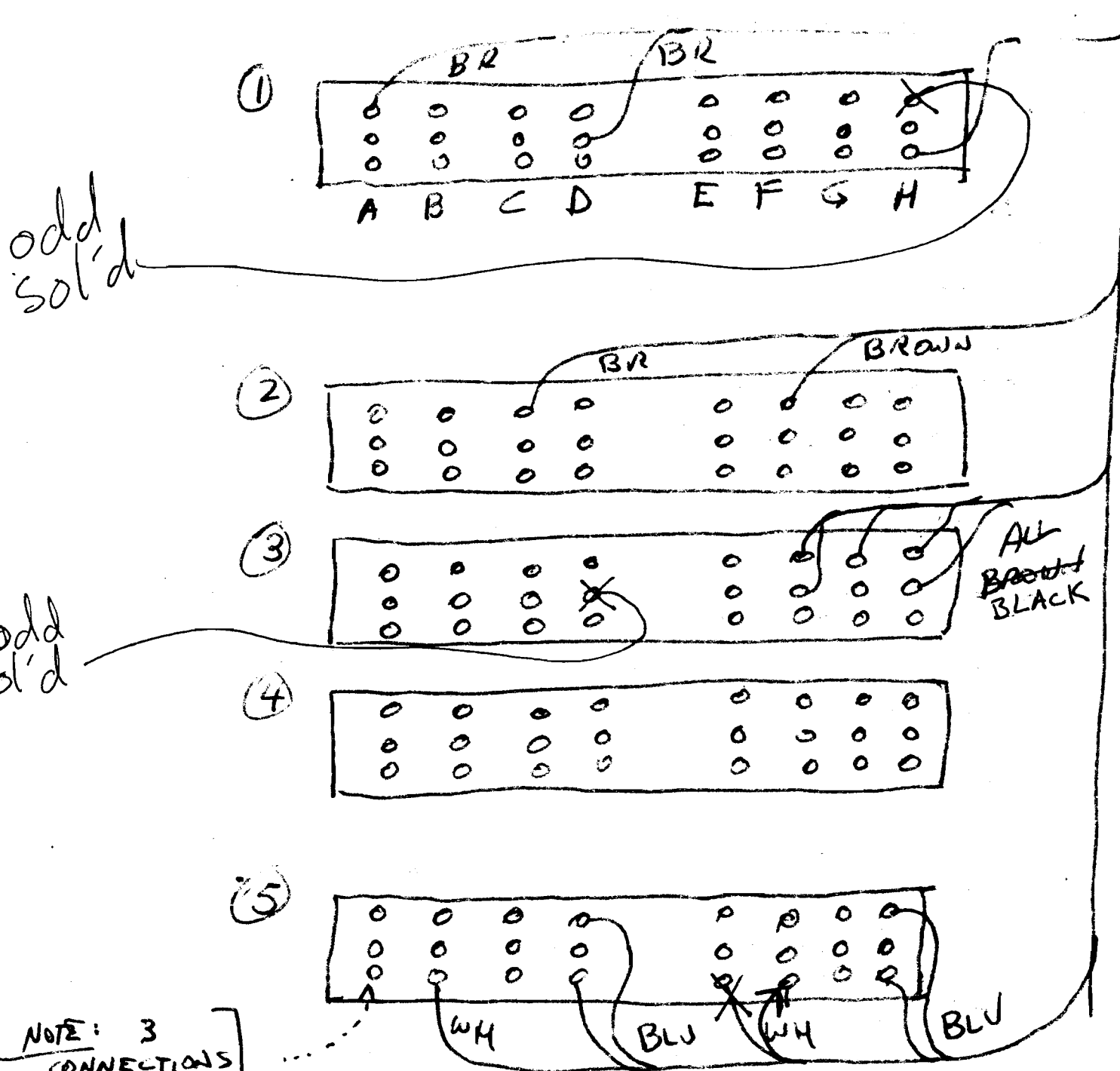
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2/13/2003

ATTEMPTED, UNSUCCESSFULLY, TO REMOVE BROKEN AIR
PIPE 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

4. DISCONNECTED WIRES FROM 4 OF 5 TAPER PIN
BLOCKS ON AIR MANIFOLD CHASSIS AS FOLLOWS



NOTE: 3
CONNECTIONS
IN ANY
COLUMN ARE
COMMON

David R. Bount
2/13/03

4

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2/20/2003

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 ①
 - HEAD SOLENOID
 - .5 μ f (2A) ← ----- OTHER SIDE OF THIS COMPONENT
 - BROWN WIRE (CABLE HARNESS)
- ② ②
 - WIRE (3A)
 - 330 Ω (2A)
 - DIODE ~~→~~ (2A)
- ③ ③
 - .5 μ f (2C)
 - 330 Ω (2B)
 - DIODE ~~→~~ (2B)
- ④ ④
 - TRACK EVEN SOLENOID
 - .5 μ f (2D)
 - BROWN WIRE (HARNESS)
- ⑤ ⑤
 - WIRE (3E) (COMMON)
 - 330 Ω (2D)
 - DIODE ~~→~~ (2D)
- ⑥ ⑥
 - DIODE ~~→~~ (2E)
 - .5 μ f (2H)
 - 330 Ω (2E)
- ⑦ ⑦
 - WIRE (3E) (COMMON)
 - 330 Ω (2H)
 - DIODE ~~→~~ (2H)
- ⑧ ⑧
 - TRACK ODD SOLENOID
 - .5 μ f (2H)
 - BROWN WIRE (HARNESS)

David Burnett

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EDGE CONNECTOR

- ② (A) • DIODE ~~+~~ (1B)
- 330Ω (1B)
- .5μf (1A)
- (B) • 330Ω (1C)
- WIRE (3B) (COMMON)
- DIODE ~~+~~ (1C)
- (C) • BROWN WIRE (HARNES)
- .5μf (1C)
- DISK IN SOLENOID
- (D) • DIODE ~~+~~ (1E)
- 330Ω (1E)
- .5μf (1D)
- (E) • DIODE ~~+~~ (1F)
- 330Ω (1F)
- WIRE (3D)
- (F) • BROWN WIRE (HARNES)
- .5μf (1F)
- DISK OUT SOLENOID
- (G) } NOT USED
- (H) • .5μf (1H)
- DIODE ~~+~~ (1G)
- 330Ω (1G)

③ (A) NOTE: ALL POINTS COMMON ON CONNECTOR (3)

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

David S. Freund

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EDGE CONNECTOR

- (3) (E)
 - WIRE (1E)
 - WIRE (1G)
 - 3 A-B-C-D-F-G-H
- (F)
 - BROWN WIRE (HARNESS)
 - BROWN WIRE (HARNESS)
 - 3 A-B-C-D-E-G-H
- (G)
 - BROWN WIRE (HARNESS)
 - NOT USED
 - 3 A-B-C-D-E-F-H
- (H)
 - BROWN WIRE (HARNESS)
 - BROWN WIRE (HARNESS)
 - 3 A-B-C-D-E-F-G

(4) NOTE: NOT PART OF SOLENOID CIRCUITS

- (A)
 - DIODE ~~→~~ (4D)
 - THYRISTOR (?) (5B)
 - 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

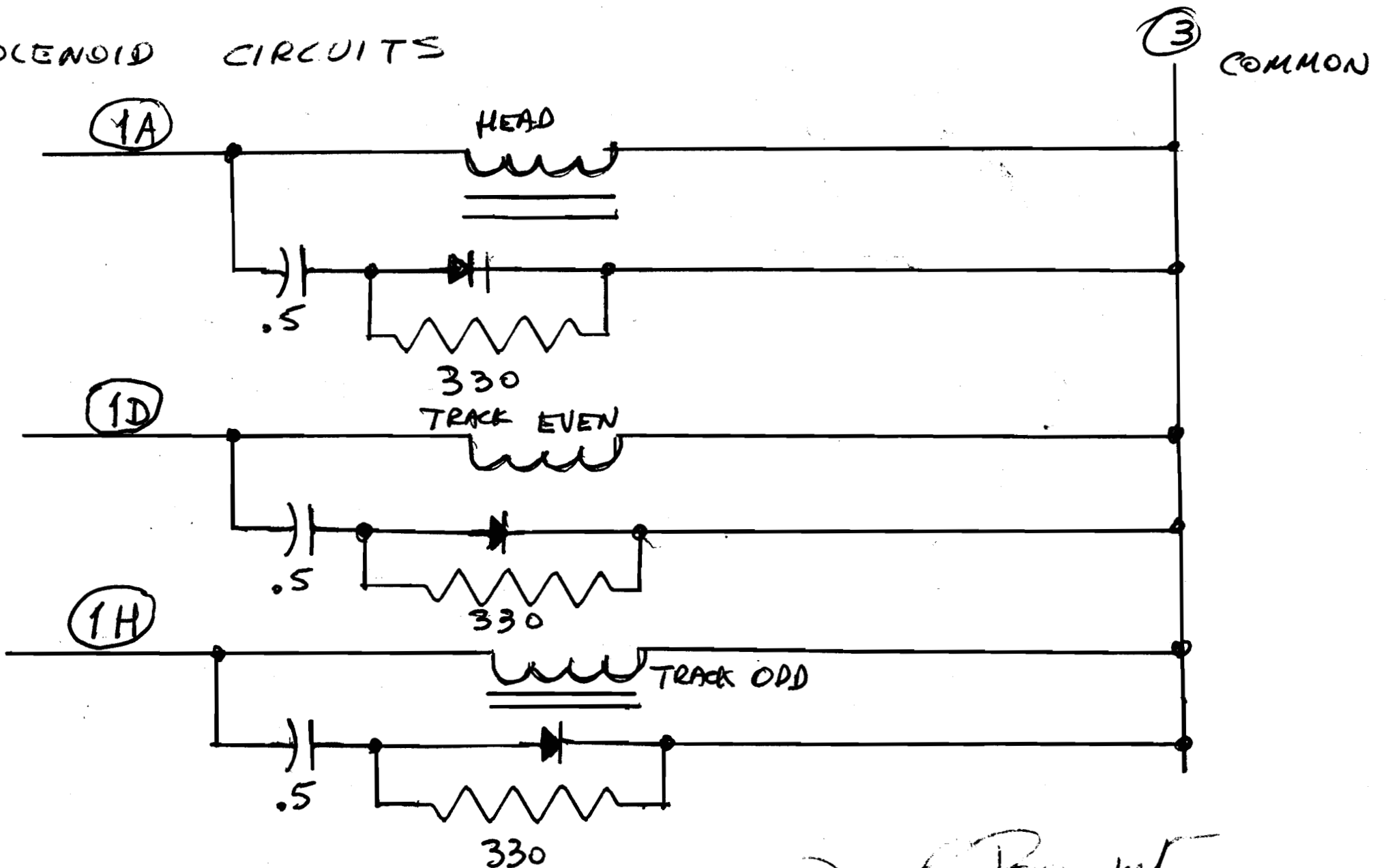
David Bennett

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EDGE CONNECTOR

- ⑤ (A) NOT USED
- (B)
 - WIRE (5F)
 - THYRISTOR (?) (4A)
 - WHITE WIRE (HARNES) (CONNECTOR C, PIN BB) CLUTCH COM
- (C) NOT USED
- (D)
 - BLUE WIRE (HARNES)
 - DIODE → (4D)
 - BLUE WIRE (HARNES) (INNER HARNES) CLUTCH
- (E) NOT USED
- (F)
 - WIRE (5B)
 - THYRISTOR (?) (4D)
 - WHITE WIRE (HARNES) (BOTH CLUTCHES)
- (G) NOT USED
- (H)
 - BLUE WIRE (HARNES) (OUTER CLUTCH)
 - DIODE → (4H)
 - BLUE WIRE (HARNES)

SOLENOID CIRCUITS

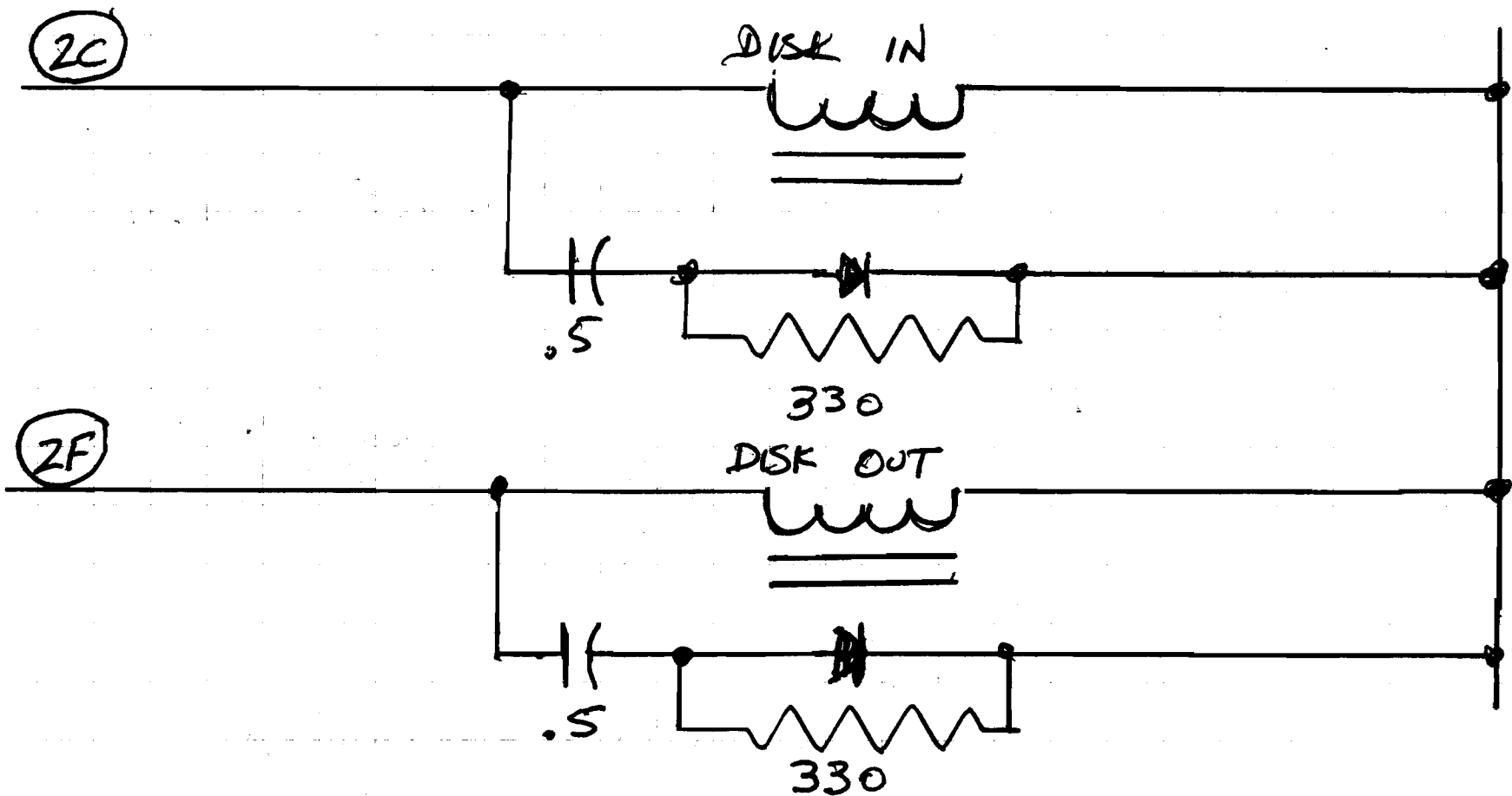


David Bennett
 1/10/2003

8

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SOLENOID CIRCUITS (CONT)



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.

David Burnett
2/20/2003

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9

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 2-19-03

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 BENNET

David Bennett

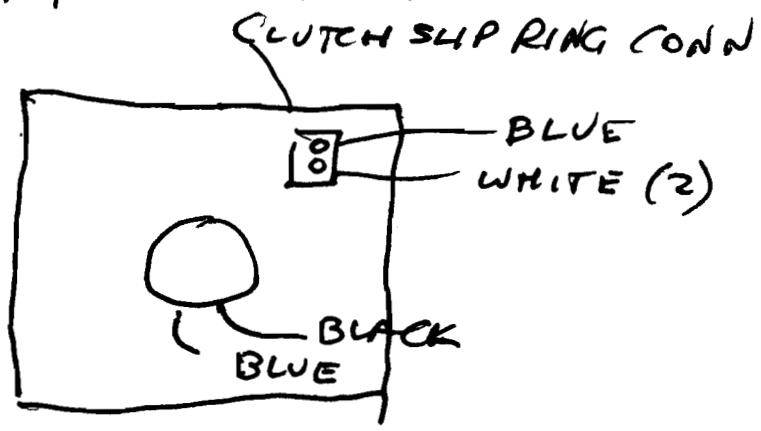
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3/06/03

REMOVING CLUTCH SHAFT



NECESSARY TO DRIVE TACHOMETER END FROM FLEX BELLOWS COUPLING

SUCCESSFULLY REMOVED SHAFT
CLEANED SLIP RINGS & 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 2SC4953 $V_{ce} \approx 1.3V$
NPN 400VCE0 3A Panasonic pkg TO-220D price 1.22
ea. available from Digikey (possibly elsewhere)
waiting for catalog from Apex Microtechnology
for pre amp to drive the 2SC4953.

- AL HOAGLAND
- JACK GREGAN
- HARRY KAHN
- JOHN SHEPARD
- ANDREW GIUSTINI
- DAVE BENNET

Handwritten signature

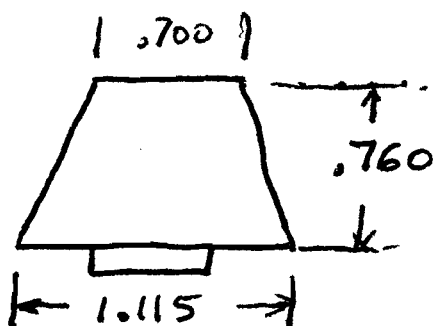
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4/03/03

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

CONTINUING TO PLAN FOR CONTROL SYSTEM.

MEASURED PINION AS FOLLOWS

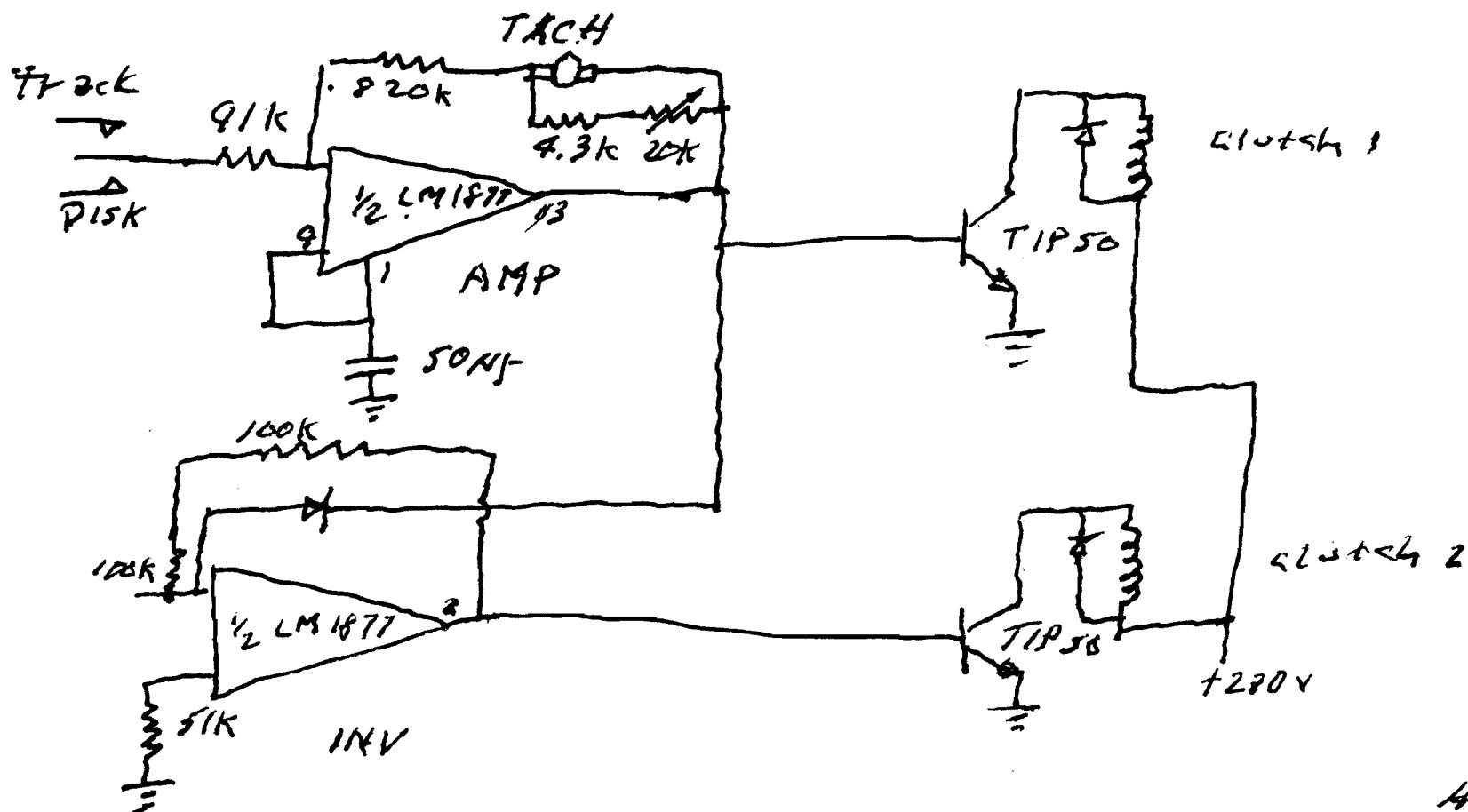


PINION WILL NEED TO BE RECAST IN RUBBER MATERIAL

- AL HOAGLAND
- HARRY KAHN
- JOHN SHEPARD
- ANDREW GIUSTINI
- DAVE BENNET

David Bennett

Clutch amplifier and driver has been breadboarded.



Harry Kahn

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12

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6/12/03

REMOVED FROM HEAD ARM

HEAD LIFTER SPRING (UPPER)

UPPER HEAD

3 PISTONS

UPPER HEAD COVER

ALL PARTS BUT ^{HEAD COVER} ABOVE TO BE

LOANED TO FRED SCOTT FOR

HEAD EXPERIMENTS & REPRODUCTION

(SPRINGS & PISTONS)

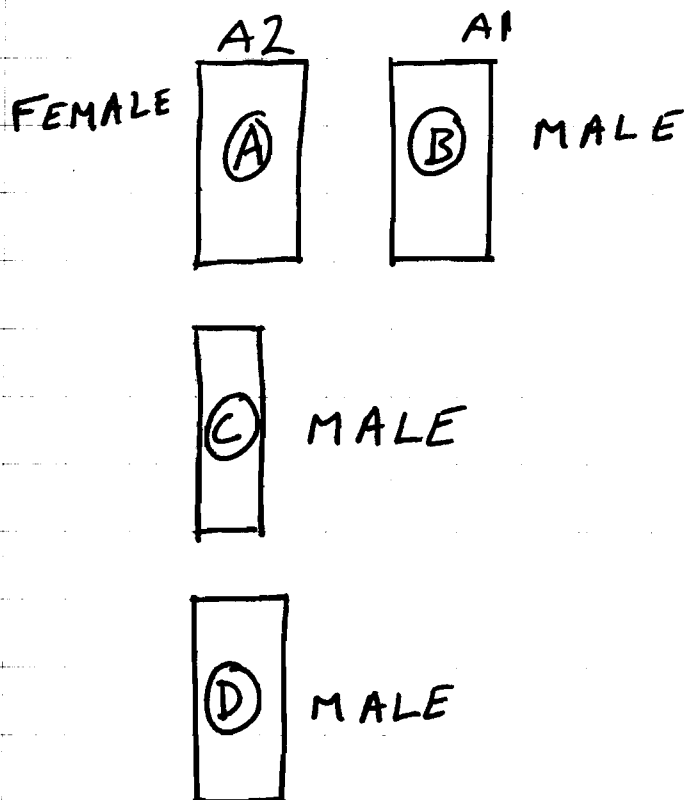
HEAD COVER IN ENVELOPE HERE

JACK GROGAN

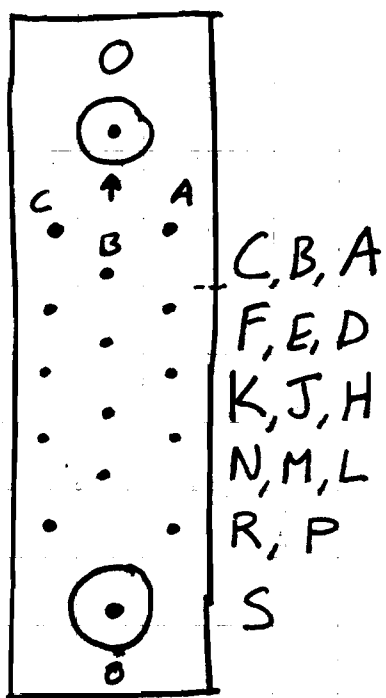
Dave Beunt

7-14

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 over travel crash stop (br)
- B: NO WIRE
- C: Top and bottom over travel crash stop (br)
 - A+C broken only when stops are hit
- D: ① H ~~(shortest)~~ from solenoid box (br)
- E: ③ H₂ (shortest) from solenoid box (4k)
- F: ② C from solenoid box (br)

Pat Connolly

14 7-14-03

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PIN
 ↓

H: ① D from solenoid box (br)

J: ② F from solenoid box (br)

K: ① A from solenoid box (br)

L: out to tachometer (blue, next to black)

M: (wh)

N: ③ F⁵ (longest) from solenoid box (blk)

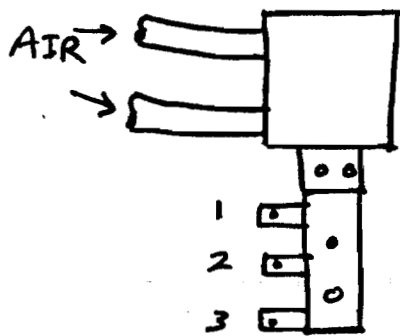
P: ⑤ H (longer) from solenoid box (blue)

R: (blue)

CONNECTOR ① ALL PINS CONNECT TO CARRIAGE MALE

TRACK DETENT RELAY

WHEN NO AIR APPLIED, 2+3 are connected



1: ①+L

WHEN EITHER TRACK DETENT ENERGIZED, 1+3 are connected

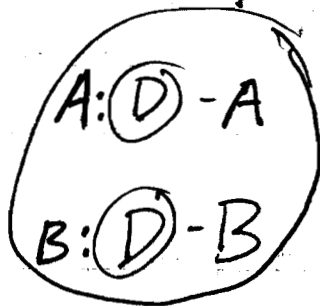
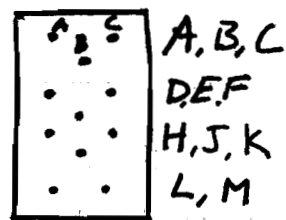
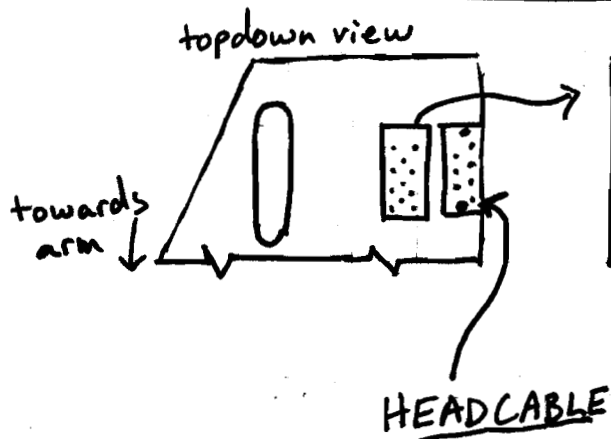
2: ①-~~M~~ M

OTHERWISE 2+3 ARE CONNECTED

3: ①-~~A~~-~~P~~

TRACK POTENTIOMETER

MAY NEED CLEANING
 VERY BAD CONNECTION



E: ①-E

K: ①-K

F: ①-F

L: NOWIRE

C: ①-C

H: ①-H

M: NOWIRE

D: ①-D

J: ①-J

A, B, L, M Not Found (7-14-03)

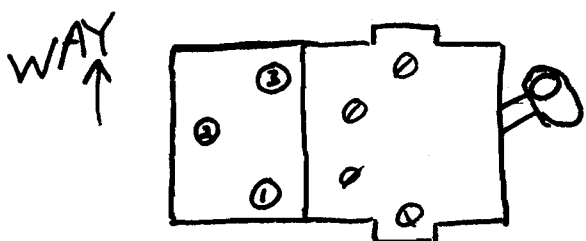
Pat Connolly

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)-~~AA~~ P

2+3 CONNECTED
WHEN DETENT LOCKED

DISK POTENTIOMETER SENSOR (WIPER)

- BROKEN BLACK WIRE BY DISK DETENT SWITCH, MATCHES WITH (D)-S

Pat Connolly

16

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7-15-03

- REMOVED TOP DISK COVER
- REMOVED/REPLACED SECTOR SENSOR PLUG
- REMOVED ACCESS ARM
 1. loosened track bar crash stop
 2. removed rtd 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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17

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

Pat Connolly

7-21-03

CONNECTOR C - REWIRED, 26 PIN CONNECTOR



- A- V-SOLENOID (3) H (blk) ^{40V}
- B- W-SOLENOID (1) A (br) ^{HEADSOLENOID}
- C- X-SOLENOID (2) F (br) ^{DISK OUT}
- D- Y-SOLENOID (1) D (br) ^{EVEN TRACK}
- E- Z-SOLENOID (3) F (blk)
- F- AA-TACHOMETER (blue)
- H- BB-SOLENOID (5) B (wh) ^{CLUTCH COM}
- J- CC-SOLENOID (5) H (blue) ^{OUTER CLUTCH}
- K- DD-SOLENOID (5) D (blue) ^{INNER CLUTCH}
- L-
- M-
- N-
- P-
- R- UPPER AND LOWER CRASH STOPS (br)
- S- SOLENOID (2) C (br) ^{DISK IN 21}
- T- SOLENOID (1) H (br) ^{TRACK ODD 22}
- U- UPPER AND LOWER CRASH STOP (br)

CONNECTED UNLESS EITHER CRASH BAR IS HIT

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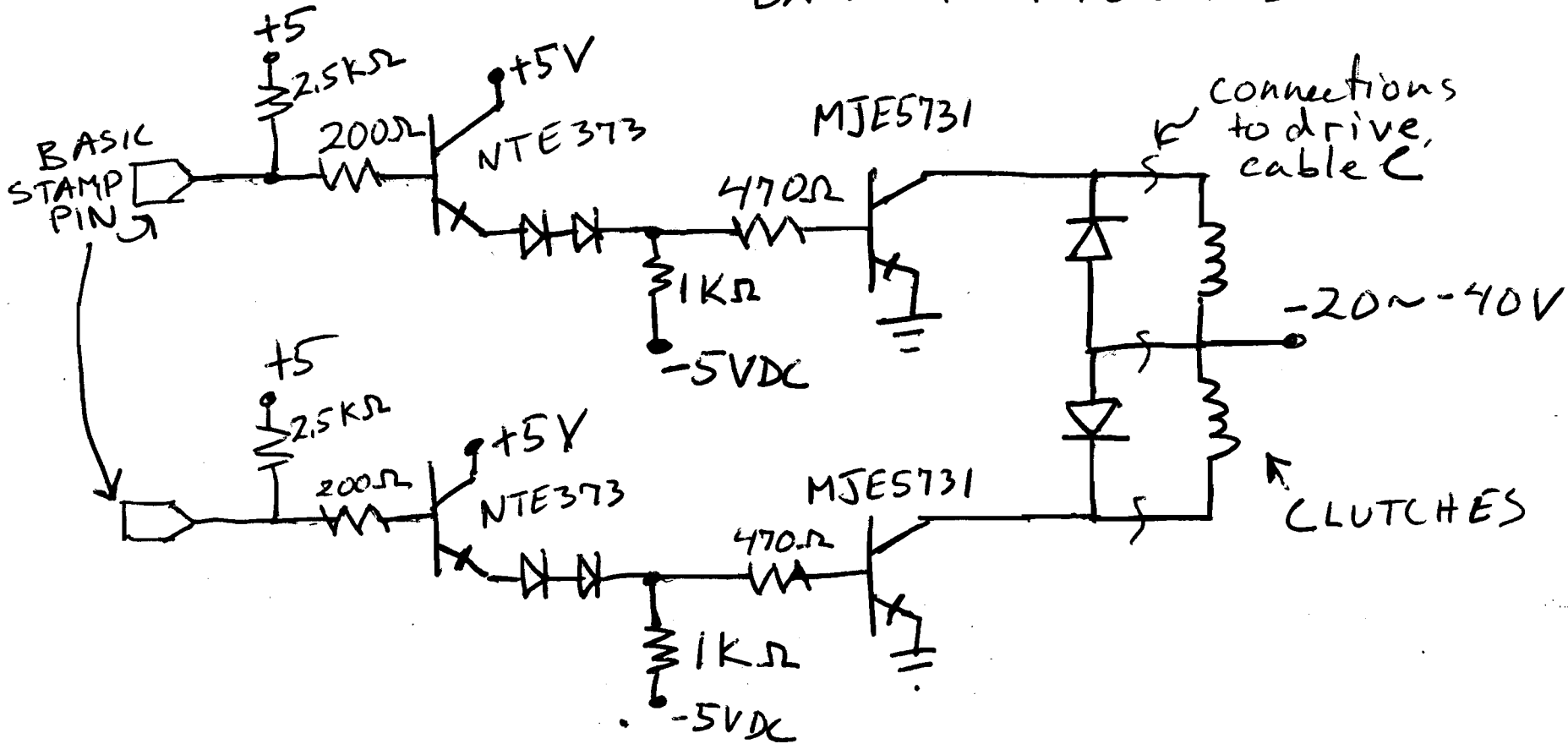
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CONNECTOR C CABLE

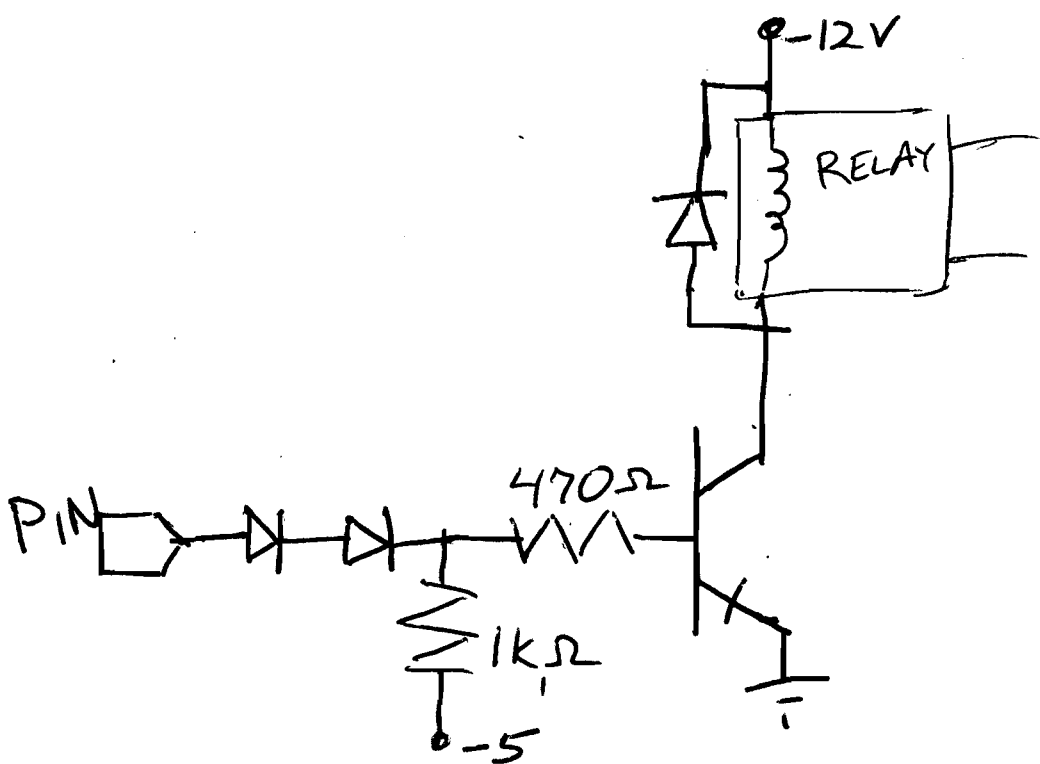
~~A → DD~~ PINS A → P correspond to 1-13 on sub D shell
 PINS R → DD " " 20-32 " " "

ALL OTHER CABLES A → DD = 1-26

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



DISC DETENT CIRCUIT +5/±



PIN LOW, RELAY ON
 PIN HIGH, OFF