Helios II/Persci 277 Alignment & Repair

Martin Eberhard Version 1.06 December 7, 2016

Revision History

Date	Document Revision	Author	Comments
17 May 2013	1.00	M. Eberhard	Initial Release
25 July 2013	1.01	M. Eberhard	
5 February 2015	1.02	M. Eberhard	Helios II/Hexer version
14 May 2015	1.03	M. Eberhard	Cleanup
23 June 2015	1.04	M. Eberhard	Add instructions for Persci removal. Improve spindle bearing service instructions. Some other edits.
28 June 2015	1.05	M. Eberhard	Note that if the positioner lamp is an LED, it is infrared. Correct adjustment procedure for IRLED version.
7 Dec 2016	1.06	M. Eberhard	Add note about newer Spindle Servo PCBA and Ejector Motor inductor repair. Include Ejector Motor inductor repair & voicecoil R&R, and a whole lot more.

Contents

Introduction

This paper describes inspection, repair, and alignment of a Persci 277 floppy disk drive, attached to a Processor Technology Sol-20 computer (or equivalent 8080 computer with Processor Technology's Subsystem B), with a Processor Technology Helios II disk controller.

Note that the Helios controller uses the S-100 system clock for its internal timing, including for writing data. The system clock on a Sol-20 is 2.054 MHz, 2% faster than most (2.000 MHz) 8080 machines. This means that using the Helios subsystem in anything but a Sol-20 will result in slightly incompatible disks.

Much of the adjustment procedures and most of the illustrations in this paper come from the "Common Problems with Persci Drives," which is part of a lost Processor Technology document for the service and maintenance of their Helios II disk subsystem. Alignment step numbers in this paper were deliberately kept the same as those in the Processor Technology document, though wording has been changed in many cases, to improve clarity.

Hexer was written by Martin Eberhard, and was inspired by Processor Technology's SIMU program, a Sol-20-based program for Helios II drive adjustment (which in turn was written to simulate a Persci disk drive exerciser). Hexer includes several commands that should have been part of SIMU. Refer to the Hexer Users Manual for details about this drive exerciser program.

In addition to the Processor Technology influences, this paper is based on the experience of restoring several old and non-functional Persci drives - both for use in Helios II subsystems and in Cromemco PFD subsystems.

Before You Align the Drive

How to Remove the Persci Drive from the Helios Cabinet

1. Remove the Helios key and set it aside.
2. Release the cabinet top by removing 3 Philips screws from the top and sides of the rear panel, and then sliding the black plastic latch on the top of the unit back. Lift the top cover off.
3. Remove the 4 Philips screws that hold the front panel PC board in place. There are four 1/2" stand-offs between this PC board and the front panel. (On earlier versions of the Helios, these are not attached and will fall out.) Note that the lower right-hand screw is either shorter than the other 3 screws, or has a stack of washers on it. Be sure to put this back the same way when reassembling.
4. Put the front panel PC board into a heavy-duty Ziploc bag, so that later on it will not short out to the chassis while you work.
5. Pry the two plastic "eject" button heads off. A small screwdriver can do this without marring the buttons or the black front bezel.
6. Use a 5/8" deep-set socket to remove the two nuts that hold the eject switches to the bezel.
7. Slide the front of the Helios over the edge of your workbench and remove the 3 Philips screws from the front edge of the bottom of the cabinet that hold the bezel in place.
8. On very old Helios units, there may be a screw on each side of the bezel, holding it to the bottom cabinet, and there may also be a screw at the top of the bezel, holding it to the Persci drive. If these screws exist, remove them.
9. Use a 9/64" Allen wrench to remove the two cap screws from the front of the bezel that hold the bezel to the Persci drive.
10. Pull the front bezel off of the cabinet. (It may be a little snug and require some wiggling to remove.)
11. Disconnect the ribbon cable and the power connector from the rear of the Persci drive.
12. Slide the front of the Helios cabinet over the edge of your workbench, holding it up with one hand, while you remove the Philips screws that hold the Persci drive to the bottom of the cabinet. There are usually 2 of these screws, but may be as many as 4 of them, in a line down the center of the drive.
13. Gently lift the Persci drive out of the cabinet.

This is a good time to fabricate an extension cable for the disk's power cable. About 12" is useful. You will need a 10-pin 0.156" Molex-type wafer connector, 9 contacts for the wafer connector, a 10-pin 0.156" male (PCB- mount) Molex connector, and some wire. Use heavy wire - at least AWG14. Be sure to insert a pin in the key position pin 4) of the female wafer connector, and clip pin 4 of the male connector, to prevent accidentally plugging wither connector backwards.

A small piece of plywood that can span the width of the open Helios cabinet is also useful. When you are ready to power up the drive (not yet!), set this on the open cabinet, and set the drive on the plywood. Use the power cable extension to connect power, and connect the ribbon cable, observing correct polarity. This plywood makes it easy to access the drive while adjusting it.

Preliminary Inspection and Repair

By the year 2015, most Persci 270 and 277 drives have failed. Before attempting to power-up an old Persci drive, the following items should be inspected, and components replaced.

1. Spin the spindle by hand, and listen to the bearings. If the spindle does not sound smooth, it may be either the spindle motor, or the spindle bearings. Gently remove the belt that connects the motor to the spindle. Spin the spindle bearings and listen to the sound.

   If the spindle bearings are noisy, they are probably bad. Replacing the spindle bearings requires a couple of different bearing pullers, and a fair bit of disassembly. Though not impossible, this is a fairly difficult task. See Appendix 1 for spindle bearing replacement.

   The motor will make much more noise when spun backwards than when spun forwards, because of a static discharge brush inside the motor. If the motor bearing is noisy when spun forward, the bearings can be replaced or cleaned and re-lubricated - also in Appendix 1.

   Re-install the spindle belt when done.

2. Remove the black plastic cover over the positioned scale and inspect the scale assembly. Possible failures include:
   - The scale may have become unglued. If not lost or broken, it can be re-glued carefully with epoxy. Clean both surfaces with alcohol before gluing. Make sure it is straight and positioned as it had been originally.
   - Missing, broken, or badly scratched scale. This will require finding a new one.
   - Dirty scale. Clean carefully with a cotton swab and isopropyl alcohol.
3. With the scale cover removed, slide the head assembly back and forth, making sure it can move smoothly. Correct any interference, and replace the scale cover.
   - Make sure the head cables don't catch on anything
   - Clean the metal rods on which the head assembly rides
   - Make sure the lamp assembly and the solar cell assembly are positioned correctly
   - If the carriage does not move smoothly, you may need to service the 6 bearing on which it rides. See Appendix 3 for this service.
4. Check the condition of both head-load pressure pads. If missing or is badly worn, replace the pad(s).
5. Clean both heads thoroughly with isopropyl alcohol and a cotton swab.
6. For the next several steps, remove the two screws that hold the Data and Interface PCB down, and tip the PCB up.
7. Remove the spindle servo photo-sensor assembly. Clean both the lamp and the photo-sensor with a cotton swab and alcohol. Replace the photo-sensor assembly.
8. Gently clean both sides of the spindle servo scale with alcohol and a cotton swab. Rotate the spindle by hand to clean it all the way around. Make sure that nothing (such as wires or loose components) can touch the scale as the spindle rotates.
9. Press each spindle cone in (to compress its spring), and spin it by hand. If it does not spin smoothly, then disassemble the cone assembly, remove the bearing. Then open, clean and repack the bearing, as described above for the head assembly bearings.
10. Manually push each spindle cone against the spindle and make sure they don't bind when released.
11. Check the condition of the two foam pads on the diskette side of each of the two arms that hold the spindle cones. These may be dried out and crumbling, or missing. If so, they can be replaced using two pieces of soft 3/8" x 3/8" weather-stripping insulation foam, available with an adhesive back:
    - Use needle-nose pliers to unhook the two springs that lift the pressure cone arm off of the spindle

Remove the two Allen screws that hold the front hinge block of the pressure cone arm in place
Be careful as you remove the the pressure cone arm from the rear hinge pin, as there is a spring on that hinge pin that will be loose when the arm is removed.
Completely clean any glue from the two original foam pads, using solvent as necessary.
Cut two 3/8" long (square) pieces of the new weather stripping material and stick them on the pressure cone arm in the same places as the originals. (There are marks on the arm indicating the correct locations for these pads.)
Reassemble the pressure cone arm. Be careful not to lose the spring, and not to pinch any wires beneath the front hinge block.

12. A very high percentage of the blue or orange tantalum capacitors throughout the drive that are exposed to 24V will have failed, <u>or will fail soon</u>. All of the following capacitors should be replaced if they are blue. (The orange variety seems to fare better.) Failure to replace these capacitors will most likely result in one or more smoked resistors later on during adjustment.
    On the Interface PCB: C10, C29, C33, C39 (Note that the orientation of these capacitors is inconsistent. Pay attention to the PCB markings!)
    On the Positioner Servo PCB: C9, C13
    On the Lamp Amp PCB: C4
    On the Data Separator PCB: C1
    On the older-type Spindle Servo PCB (Assy # 200134. This board does not have a crystal): C3
    On each ejector motor: 2 capacitors each
    When you replace the ejector motor capacitors, use an ohmmeter to check the continuity of the two inductors that are glued to the back of each motor. Sometimes a failed capacitor will cause these inductors to become discontinuous. These inductors can be repaired by prying them off of their glue, pulling the old wires out of the ferrite beads, and rewiring them with 8 turns of similar wire. Re-glue the inductors with silicone calk. (You can usually find this fine wire inside the small transformer of a junk AC wall adapter.)
13. Check the tightness of every connector along the top edge of the Data and Interface PCBA. If any slides off easily:
    Disconnect the connector from the Data and Interface PCBA
    Release each pin from the connector body using a small screwdriver. (Do these 1 pin at a time, so you know where they go.)
    Gently bend the contact open a tad with a small screwdriver
    Re-insert the pin into the contact body
    Reconnect the connector

Helios/Persci Disk Drive Jumper Settings

Persci changed some of the jumpers on the drive somewhere around serial number 1000. You can tell which chart to use by looking for the set of jumpers that are numbers 2,4,8,16, and 32. If there is just one such set of jumpers near U16, then use the first table. If there is a second set of these jumpers near U27, then use the second table.

These are the Helios jumper settings and option component values for early Persci drives - serial numbers below about 1000.

Locations	Nearest IC	Jumper	Locations	Nearest IC	Jumper
U11	U11	None	AL,AM,AN	U1	AL-AM
2,4,8,16,32	U16	32	AP,AR	U8	None
A,B,C	U17	A-B	AS,AT,AY	U3	AT-AY
D,E	U17	D-E	AU,AV,AW	U39	AV-AW
F,G	U17	F-G	BA,BB,BC	U10	BA-BB
H,J,Z	U4	H-J	BD,BE	U7	BD-BE
K,L	U8	None	BF,BH,BJ	U15	BH-BJ
M,N,P	U3	M-P	BK,BL,BM	Does not exist	
R,S,T	U3	R-S	**Components**	**Nearest IC**	**Install**
U,V	U9	None	R88	U10	36K
W,X,Y	U10	W-Y	R94	U10	11K
AA,AB,AC	U15	AA-AB	C40	U10	0.1 uF
AD,AE,AF	U10	AD-AF	C41	U10	1 uF
AH,AJ,AK	U10	AH-AK	U16		none

These are the Helios jumper settings and option component values for later Persci drives - serial numbers above about 1000.

Locations	Nearest IC	Jumper	Locations	Nearest IC	Jumper
U11	U11	None	AL,AM,AN	U1	AL-AM
2,4,8,16,32	U16	32	AP,AR	U8	None
2,4,8,16,32	U27	32	AS,AT,AY	U3	AT-AY
A,B,C	U17	A-B	AU,AV,AW	U11	Don't care
D,E	U17	D-E	BA,BB,BC	U3	BA-BB
F,G	U17	F-G	BD,BE	U7	BD-BE
H,J,Z	U4	H-J	BF,BH,BJ	U15	BH-BJ
K,L	U8	None	BK,BL,BM	U3	BK-BM
M,N,P	U3	M-P			
R,S,T	U3	R-S	**Components**	**Nearest IC**	**Install**
U,V	U9	None	R88	U10	11K
W,X,Y	U10	W-Y	R94	U10	11K
AA,AB,AC	U15	AA-AB	C40	U10	1 uF
AD,AE,AF	U15	AD-AF	C41	U10	1 uF
AH,AJ,AK	U10	AH-AK	U16		none

Preliminary Power-On Inspection

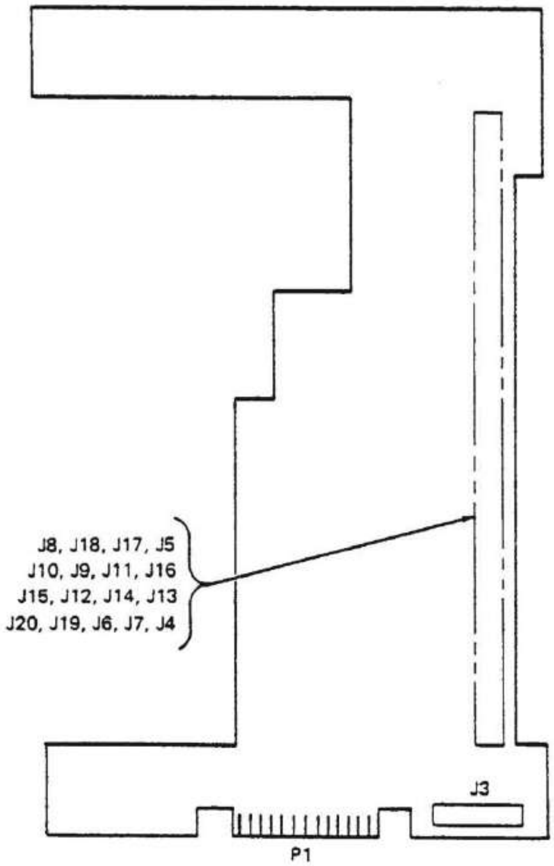
1. Connect power to the disk drive and check all of the power supply voltages. If the 24V supply is close to 0 volts or if you see smoke form a resistor, then you have probably missed one of the tantalum capacitors, or you have installed one backwards.
2. Look to see if the spindle servo lamp is lit. This should be visible through the right-side diskette entry slot. If it is not lit, power the drive off and debug.

3. The spindle motor will spin up for a few seconds when you powered the drive on. If the spindle bearing is bad, it will now be obvious by the sound.
4. Check the spindle cone bearings by inserting a diskette in each side of the drive. When a diskette is inserted, the spindle motor should start and the ejector motor should load the diskette by pressing the cone against the diskette. (If the ejector motor fails to load the diskette, see step 0 below.) At this point, the cone bearing is spinning, and you can listen to its sound. If it is loud, then the bearing probably needs to be replaced.

WARNING: Many of the Op-Amps (in 8-pin DIP packages) used in the Persci drive are powered by +24V. The outputs of devices often drive TTL devices, swinging between about 0V and about 4V. If you accidentally short the 24V supply pin (pin 8) of an Op-Amp to the adjacent output pin (pin 7), you will probably destroy every TTL device that is driven by the Op-Amp.

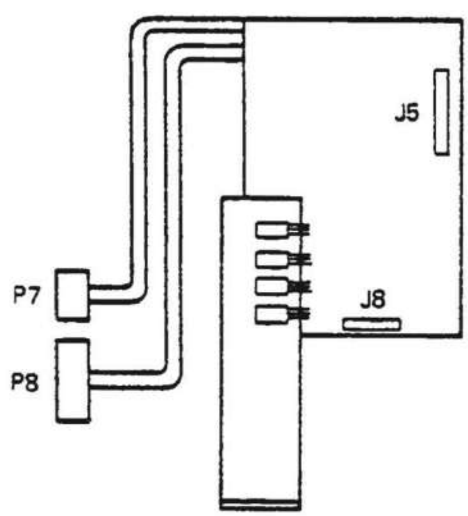
PCB Identification

The Data and Interface PCB is the large PCB on the right side of the drive:



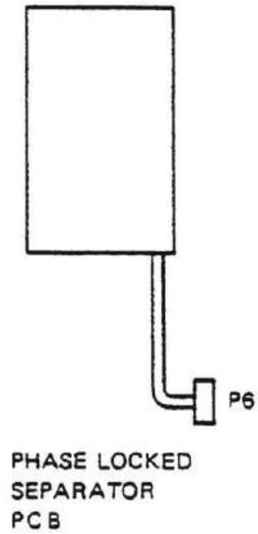
DATA AND INTERFACE PCB

The Positioner Servo PCB is the board at the back of the drive:

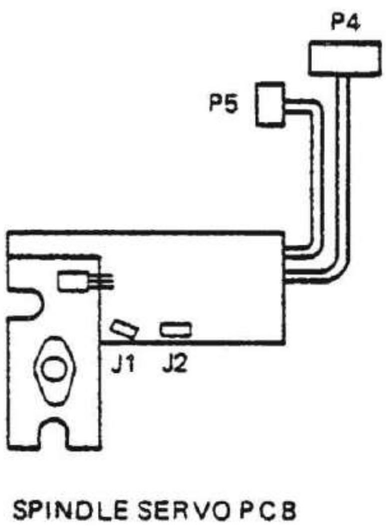


POSITIONER
SERVO PCB

The Phase Locked Data Separator PCB is on the left side of the drive, near the front if the drive:



The Spindle Servo PCB is beneath the Data and Interface PCB, on the right side of the drive. The newer-style Spindle Servo PCB (Assy 200227) has a large crystal to the right of J2. The older-style ones do not.



The Lamp Amp PCB is located above the positioner servo, accessible from the left side of the drive. (See picture in Step 1 below.)

Persci 277 Adjustment Procedure

The following is the recommended alignment procedure for the Persci Model 277 Disk Drive. This procedure requires the following components: A Sol-20 computer with SOLOS, or a 2 MHz 8080 computer configured with Processor Technology's Subsystem B, with CUTER

- At least 16K of available zero wait-state memory starting at address 0
- A Processor Technology Helios II disk controller board set, with its cables
- A Helios II or Helios IV chassis, including the Persci 270/277 disk drive and power supply
- Standard Helios cabling
- Martin Eberhard's Hexer program
- Schematic diagrams for the correct revision of Persci 277 drive
- A decent oscilloscope - 50 MHZ or better, at least dual trace with a third channel for triggering
- Several screwdrivers and Allen wrenches
- 95% Isopropyl alcohol and cotton swabs
- A Dysan SSSD alignment diskette
- A scratch 32-sector hard sectored, single-sided diskette (not a defective diskette!)

A general alignment is recommended under the following circumstances:

1. Disk drive has erratic seeking problems or just slams the head against the end-stop
2. Disk drive cannot read diskettes written on other units or written on the other drive in the same unit. (Incompatibility).
3. Spindle speed problems

Step 0: Ejector Cam Inspection and Adjustment

The ejector motors should load the spindle cone and the head when a diskette is inserted, and should unload the cone and the head, and eject the diskette when the eject button is pressed.

Because the ejector cam (which is mounted mounted over the two microswitches in front of the ejector motor) is made of plastic, and its set screw is steel, these cams sometimes come loose and misaligned. With time, these ejector cams also can crack, and must be replaced. If the cam is loose or cracked, the cone will not engage or disengage properly. To align the cam:

1. With the power off, loosen the cam's set screw
2. Turn the power on and press the eject switch. Rotate the cam manually until the door is fully unloaded.
3. With the door fully unloaded, rotate the cam until the set screw is pointing directly away from the drive, and tighten.
4. Manually trip the diskette presence detector switch, and check to see that the cone seats completely into the spindle. Readjust as necessary.
5. Check the adjustment by inserting and ejecting a diskette several times.

The ejector assemblies have several common failure modes:

1. The plastic cam that activates the microswitches may be cracked, and slip on its shaft. This may cause the shaft to spin continuously, or cause the ejector assembly to stop at the wrong position.
2. The spur gear on the motor shaft (inside the gearbox) is cracked, and either spins on its shaft (causing the motor to run continuously) or jams (causing the motor to draw current continuously). An early indication of this failure mode is a clicking sound from the gearmotor as it turns. Either the whole ejector gearmotor assembly must be replaced, or this spur must be replaced.

3. One or both of the plastic support frames for the ejector shaft may be cracked, or its screw holes have become stripped. This will cause portions of the ejector assembly to be loose or wobbly.

Any of these failures will require a replacement part - most likely scavenged from another Persci drive. See Appendix 2 for ejector gearmotor service.

Step 1: Positioner Lamp Voltage

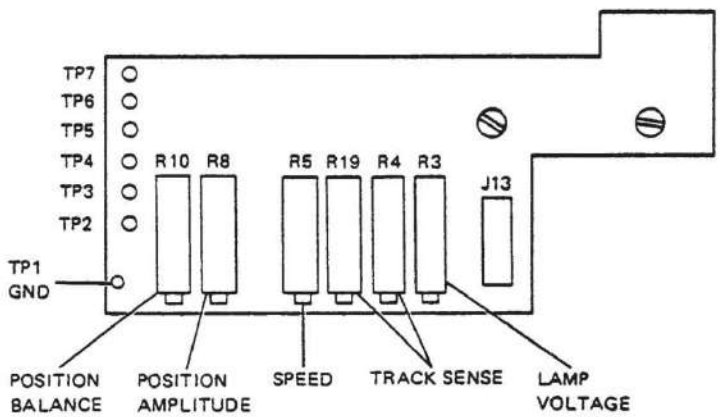
Note: At this point, it is necessary to have the Hexer program loaded and running on the computer. You should see the % prompt.

This adjustment affects all the other adjustments on the Lamp Amp, and should always be done first.

The positioner lamp is mounted on the Lamp Amp PCB, and provides the light source for the solar cells, which detect markings on the positioned scale. On earlier drives (before about serial number 15,000?) the positioner lamp is a low voltage "grain-of-wheat" incandescent lamp. On later drives (and drives that have been upgraded), it is an infrared LED (IRLED). On all but the earliest drives, the lamp voltage is limited by a series of three diodes to about 2.1V. You can tell whether your drive has an IRLED by looking at R15 and R21 on the Lamp Amp board. If R15 is 62 ohms and no component is loaded in R21, then your drive has an IRLED in its positioner servo. Otherwise, it has an incandescent lamp.

For servos with IRLEDs: Connect a 'scope probe to the junction of R15 and the collector of Q1. (This point is accessible on the bottom of the lamp amp PCB when the black plastic cover over the positioner scale is removed.) Adjust pot R3 on the Lamp Amp for a reading of 2.0V DC on the 'scope. (On some - but not all - Lamp Amp PCBAs, TP 7 has been moved to the junction between R15 and Q1.)

Note that the back of the IRLED is transparent. If your workbench light is shining on the back of the IRLED (obviously, with the Data and Interface PCB in the open position), then its light will interfere with the voicecoil servo, causing erratic behavior.



Lamp Amplifier PCB

For Servos with incandescent lamps: Connect a 'scope probe to TP 7 on the Lamp Amp PCB, set for DC coupling. Adjust pot R3 on the Lamp Amp for 1.5V DC at TP 7. (Do not exceed 1.6V, particularly for an early drive without the limiting diodes!) If the lamp voltage reads 2.1V (5V without the limiting diodes) and cannot be brought into spec, the most likely cause is a burned-out lamp. In this case, with the power turned off, the resistance between TP 7 and ground will be near infinite. The lamp should be replaced.

If the voltage does not adjust smoothly, or jumps around as you adjust R3, then R3 has become intermittent and should be replaced.

If you need to replace the positioner servo lamp, it is a "T1" style lamp, rated for 20 mA at 2.5V. This lamp should draw close to 100 mA at 1.5V (which is the lamp's operating voltage in the Persci drive). If you cannot find the exact lamp, you can substitute with a T1 lamp that is close, and then adjust the lamp voltage so that it draws the same power as the original, 150 mW. (You can measure the lamp's current by measuring the voltage across [R15 in parallel with R21], and then dividing by the combined resistance of these resistors (which is nominally 34 ohms, but you should measure them carefully).

I have done this successfully with a T1-style lamp that draws about 150 mA at 1.5 volts (which was far too bright). This lamp's current was reduced to 146 mA when I adjusted R1 to set TP 7 to 1.06 volts, for a lamp power consumption of 154 mW. With this adjustment, the drive works perfectly. I put a sticker on the positioner scale cover alerting future technicians that the correct adjustment voltage is 1.06 volts, rather than the specified 1.5V.

To replace the positioner servo lamp:

1. Remove the two screws at the bottom of the Data and Interface PCB, and swing this board open.
2. Remove the right-side head load paddle. (Release its two springs first.)
3. Remove the four small Philips screws from the black lamp housing.
4. Carefully de-solder the lamp leads from the Lamp Amp PCB. Avoid any splashing of solder!
5. Insert the new lamp and solder it in place
6. Re-install the black cover, the head-load paddle, and the Data and Interface PCB.

Step 2. Tach Voltage

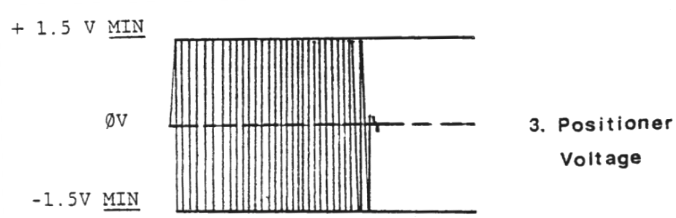
This adjustment is a course adjustment of the circuit which controls the speed at which the head seeks between two tracks.

Later in the procedure, this will be adjusted more accurately. Symptoms of a problem here are the head either seeking too slowly or too fast, and "hunting" for tracks.

With the power off, disconnect P8 from the Positioner Servo PCB to allow manual movement of the head assembly. Connect 'scope probe to TP 5 on the Lamp Amp PCB. Power up the drive and manually move the head assembly to the outside track (track 0) and note the voltage reading on the 'scope. Then, manually move the head assembly to the inside track (Track 76). Note the voltage reading on the 'scope. Adjust R5 for -1.5V difference from the track 0 reading.

Step 3. Positioner Voltage

This adjustment is to setup the correct voltage for the detent pulses (one sine wave cycle for every track the head moves), which enable the drive to "Know" how many tracks it has traversed. Symptoms of a problem here might be seek errors, "hunting", or the head slamming to extremes during seeks.



Leave P8 disconnected from the previous step. Connect 'scope to TP 2 on the Lamp Amp PCB. Manually move the head assembly back and forth between track 0 and track 76, and observe the voltage on the scope. The waveform should be centered at 0 volts, and the peak-to-peak voltage should be at least 3.0V, ideally 3.4V.

Adjust R10 to center the waveform at 0V, and adjust R8 to set the amplitude to 3.4V.

If the waveform does not adjust smoothly, or jumps around as you adjust R8 or R10, then the trim pot(s) has probably become intermittent and should be replaced.

Step 4. Track Sense Adjustments

The purpose of these adjustments is to allow the drive to sense track 0, and to sense the point at which it reaches track 43-1/2. (Starting at track 44, it is necessary to decrease the bias on the write head. This keeps the drive from over-saturating the media on the inner tracks, which are moving more slowly across the write head, but which are being written at the same clock rate.)

Step 4A. Track 43=1/2 Manual Adjustment

1. Place the 'scope probe on TP 6 on the Lamp Amp PCB.
2. Manually move the head assembly back and forth through the middle of its range, observing the waveform from TP 6.
3. Adjust R4 (gain) and R19 (balance) so that the voltage swings from +0.5V to -1.25V.
4. Reconnect P8 to the Positioner Servo PCB when done.

Step 4B. Track 43-1/2 Full-Speed Adjustment

(Requires Hexer)

1. Select the 'left' diskette in the Persci drive. Assuming the Persci drive is units 0 and 1, type:

   %SE U=0 <CR>

2. Disable track display:

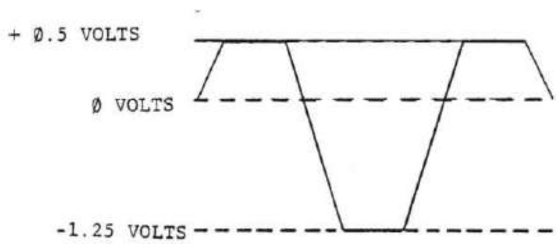
   %SE V=0 <CR>

3. Seek continuously between tracks 43 and 44:

   %SK 43 44 <CR>

   A (Select automatic mode)

   The head should now be seeking between tracks 43 and 44.



4. Track Sense

4. Adjust R4 (gain) and R19 (balance) so that the voltage swings from +0.5V to -1.25V.
5. Stop seeking by typing '**Q**'

If adjustment causes the signal to jump about, or the settings don't stay where you put them, then one or both of the trim pots has probably become intermittent and should be replaced.

If the drive fails to servo, it may be that R4 and R19 are very far out of adjustment. If so, redo step 4A.

Step 4C. Track 0 Sense Adjustment

Check the Track 0 sense. Type

% **SE U=0 <CR>** (Select unit 0, the left side of the Persci drive)

% **RE <CR>** (Restore to track 0)

If Hexer does not print an error message, then track 0 was sensed.

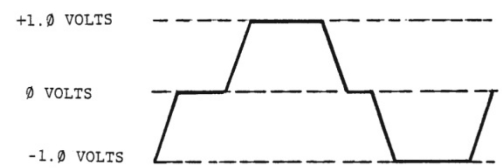
Step 5. Dirty Scale

The scale is sheltered from dust particles by the scale cover and the filtered air system of the Helios disk enclosure. However, over the years, the scale may have become dirty and must be cleaned. The wedge-shaped window on the bottom of the scale, which is used for tach output, is the most sensitive to dirt, which will cause erratic seek problems, skipping tracks, or slamming against the end stops.

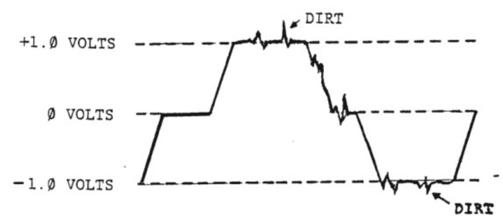
1. Connect the 'scope channel B to Seek Complete, P1 pin 10 (on the Interface PCB), and set the 'scope to trigger on the negative edge of channel B. Connect the 'scope channel A to U13 pin 7 on the Positioner Servo PCB.
2. Assuming Hexer is still set up from the previous step, start automatic seeking:

   %SK 0 76 <CR>

The head should be fast-seeking between tracks 0 and 76.



5. CLEAN SCALE (NO SPIKES)



5. Dirty Scale

3. Observe the 'scope channel A. Normally there will be a small amount of noise riding on this signal. Any spikes greater than 0.25V indicate excessive dirt on the scale.
4. The scale can be gently cleaned in place, using a cotton swab and alcohol. The left side is easily cleaned with the scale cover removed. The right side is a bit trickier. It can be cleaned by removing the solar cell assembly and cleaning the scale through the solar cell assembly hole, while manually moving the head assembly to reach the entire scale.
5. Stop seeking by typing '**Q**'

Step 6A. Seek Time (Track 0 to Track 76)

1. This course adjustment brings the full-stroke seek time into the specified maximum of 95 mSec.
2. Hook the channel A 'scope probe to TP 2 on the Lamp Amp PCB and the channel B 'scope probe to P1 pin 10 on the Interface PCB. Trigger the 'scope on the negative edge of channel B.
3. Start Hexer and set it for automatic seeking between tracks 0 and 76:

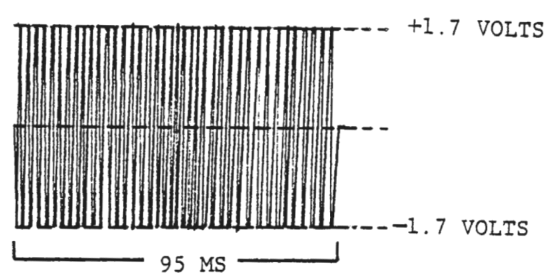
   %SE U=0 <CR> (select unit 0)

   %SE V=0 <CR> (disable track display)

   %SK 0 76 <CR> (Seek between tracks 0 and 76)

   A (Select automatic mode)

   The head should be seeking quickly between tracks 0 and 76.



6 A. SEEK TIME 0 - 76

4. Observe channel A on the 'scope. There should be a 3.4V peak-to-peak signal that is balanced around 0 volts, as adjusted in step 3 above. If not, re-adjust R8 and R10 on the Lamp Amp PCB to bring this signal into spec. (This is a dynamic adjustment while the head is in motion.)
5. Set the 'scope for 10 mS/division, and adjust the trigger to see the entire burst. Adjust R5 on the Lamp Amp PCB so that the burst is 95 mS long. (See illustration 6A.)
6. Type **'Q'** to stop seeking.

Step 6B. Seek Time (Track 0 to Track 1)

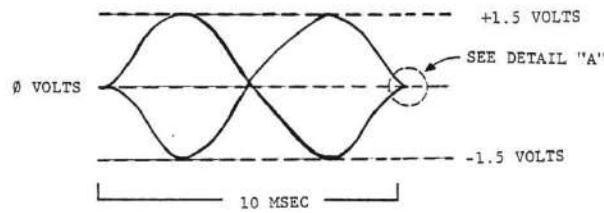
1. With the 'scope set up as in Step 6A, start seeking between tracks 0 and 1:

   %SK 0 1 <CR>

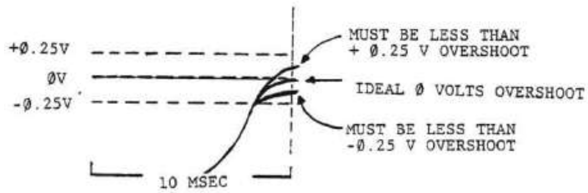
   The head should now be seeking rapidly between tracks 0 and 1.

2. Set the 'scope for 1 mS/division. Adjust the trigger to see one full cycle, as shown in the diagram. (You will actually see two superimposed sinusoidal waves, with one of them 180 degrees out of phase from the other.) These waves should have a duration of 10 mSec, and should be relatively symmetrical. Adjust R5 on the Lamp Amp PCB for speed variation, and adjust R33 on the Positioner Servo PCB for symmetry.
3. Type '**Q**' to stop seeking.

Again, noise during adjustment is an indication that the trim pot is failing and should be replaced.



6 B & C Seektime [Track 0–1 & 75–76]



Detail "A"

Step 6C. Seek Time (Track 75 to Track 76)

1. With the 'scope set up as in Step 6B, start seeking between tracks 75 and 76:

   %SK 75 76 <CR>

   The head should now be seeking rapidly between tracks 75 and 76.

2. Again, adjust R5 on the Lamp Amp PCB for speed variation, and adjust R33 on the Positioner Servo PCB for symmetry.
3. Repeat steps 6B and 6C as necessary to achieve a reasonable balance.
4. Type '**Q**' to stop seeking.

Step 6D. Step Seek and Overshoot

This is the most critical of the seek adjustments, checking the overall range of seeking (tracks 0 to 76), and correcting excessive overshoot and speed problems encountered throughout that range.

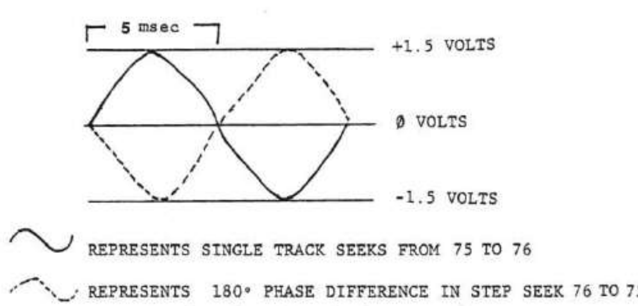
Leave the scope probes as they were in steps 6A through 6C.

1. This time, start stepping between tracks 0 and 76:

   %ST 0 76 <CR> (track-to-track step between tracks 0 and 76)

   The head should now be doing a rapid step-seek between track 0 and track 76. The head is actually stepping to each individual track, stopping, and then proceeding to the next track.

2. Set the 'scope for 2 mS/division, and adjust the trigger to see one full cycle. (The phase



6 D Step Seek Overshoot

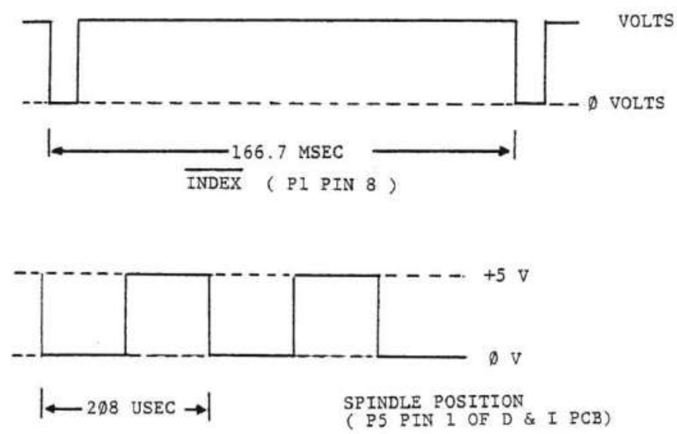
will change each time the head changes direction.)

3. Observe channel A. The period of the wave should be 10 mS, and should settle within 0,25 volts of 0 by the time 10 mS is up. (See diagrams.) If this is not the case, adjust R5 and R33 (as in previous steps) to bring it in spec.
4. Excessive jitter on the waveform may be an indication of excessive dirt on the positioner scale - repeat step 5 if so.
5. Type ‘**Q**’ to stop stepping.

Step 7. Spindle Speed

Spindle speed is controlled by a DC servo loop, which constantly monitors its speed. On newer Spindle Servo boards (those with an onboard crystal), the spindle speed is not adjustable. On older boards, it can be adjusted in step 3 below. The reference oscillator for this circuit is on the Interface PCB (on Page 3 of the Interface PCB schematic). This oscillator free-runs at about 200 kHz.

The most common problem in this circuitry is a worn motor or spindle bearing (usually preceded by noise), or the output transistors to the spindle motor itself. A very dirty spindle scale will also cause problems here.



7. Spindle Speed

1. Connect the ‘scope to pin 3 of P5, and observe the waveform. The frequency should be 200 KHz, even with no diskette inserted.
2. Insert a diskette in the left drive, and select it with Hexer:

   %SE U=A0 <CR> (Select the left drive)

   %MS <CR>

   Hexer will display the spindle speed when the motor is on, using the CPU clock as a reference.
3. If you have a frequency counter, use it to measure the index signal at P1 pin 8. Otherwise, use the Hexer speed measurements, which will not be as accurate. The spindle revolution time should be 166.67 mS/cycle. Adjust R154 on the Interface PCB as needed.
4. Type ‘**Q**’ to exit motor-control mode.

If you need to remove the Spindle Servo Board: Remove the two flat-head screws that fasten the disk guide that sits on top of the Spindle Servo Board’s power transistors. Lift the disk guide off, and lift out the two spacers that held the guide up, noting their orientation. Note the polarity of the 2-pin motor connector, and the routing of the cable to the 4-pin sensor connector, for reassembly. Unplug these two connectors. Remove the screw in the middle of the PC board, without losing its fiber washer. On older drives, there is also a fiber or aluminum spacer beneath the board that will be loose when this screw is removed. Find this spacer and set it aside. You should now be able to swing the Spindle Servo Board out to work on it. Reverse these steps to reinstall the Spindle Servo Board.

Step 8. Spindle Instantaneous Speed Variation

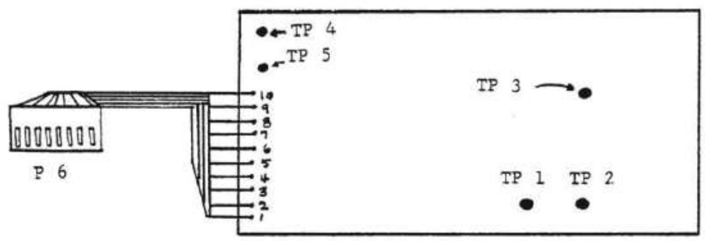
This is a check of the spindle servo to ensure that it can track the rotational speed of the spindle, and compensate for any variation in speed. There are no adjustments to be made. (Problems in this area are very rare.)

Connect the 'scope to P5 pin 1, and turn on the motor as in the last step. Adjust the scope so that you can see 10 cycles on the screen. Then go to 10X mode on the scope, and scroll to the end of the waveform. The pulse should not wander more than 3 divisions total.

Slow the diskette slightly with pressure on the diskette. The pulse should drift considerably with pressure, but should return rapidly to its original location when pressure is released, allowing the servo to lock again.

Step 9. Phase Lock Oscillator

The Persci drive is responsible for providing separated clocks and data to the Helios controller. To accomplish this, a phase-lock loop detects the pulses from the diskette. Problems in this area most often occur in this PLL circuit, and most can be eliminated by proper DC bias. (Rarely is there a problem in the Johnson Code Counter or the following 1-shots.)



PHASE LOCKED DOUBLE DATA SEPARATOR

Center the 'scope trace on the screen, and set it for 0.1 V/division, DC coupling, and 20 mS per division. Set the 'scope to invert channel B and add channels A and B. Connect 'scope channel A to TP 1, and channel B to TP 2, both on the Phase Lock Loop Data Separator PCB. Type:

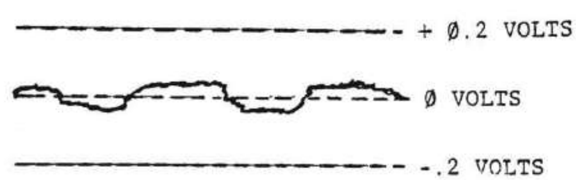
%SE U=0 <CR> (Selects drive 0)

%SK 40 <CR> (Seeks track 40)

%WT 00 FF <CR> (Sets up a track-write with alternating 00 FF pattern)

Make sure the write parameter look correct, insert a diskette (with write-enable tab installed) in drive 0, and press '**Y**'. This will write a pattern of 0F onto track 40. Now type:

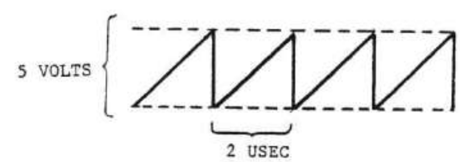
%HL 1 <CR> (loads head)



9. Phase Locked Loop DC Bias

You should see basically a DC level centered about the zero reference, with small fluctuations above and below 0. Adjust R13 on the PLL Data Separator PCB as necessary to set the DC level to 0.

With the 'scope set up for single-ended reading, connect the probe to TP3 on the PLL Data Separator PCB. You should see a relatively stable 500 KHz sawtooth waveform, tracking with diskette speed variations.



9. 500 KHz Sawtooth [TP 3]

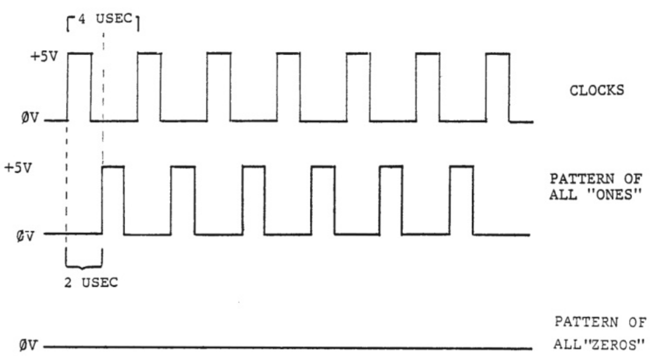
Step 10. Separated Clocks and Data

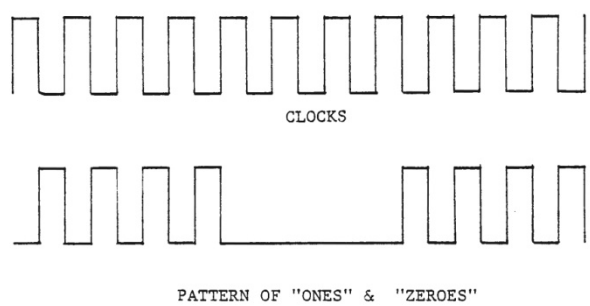
Whenever a pattern of data is written to the diskette, a series of clocks are also written to the diskette. It is between these clocks that we see the data. In the case of FM (single-density) recording, a one is represented by the presence of a pulse between the clock pulses, and a zero is represented by no pulse between the clock pulses.

Insert a scratch diskette into the left unit. (Most Persci 277 drives used in Helios subsystems do not have the write-protect option. If your drive has a cable plugged into connectors J19 and J20, then it has the write protect option. If so, then be sure the disk you insert <u>has its write protect notch covered</u> Note: Use a metallic sticker or a piece of black electrical tape to cover the write-enable notch. Paper stickers (such as diskette labels) are not sufficiently opaque, and may not be seen by the drive.)

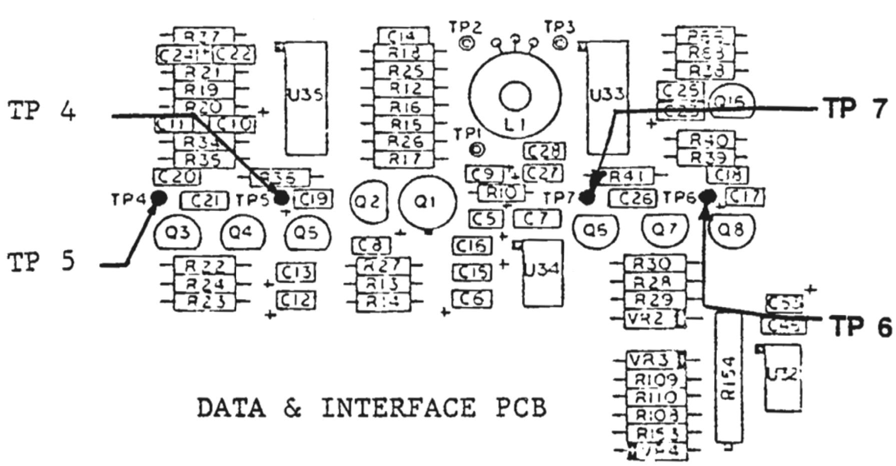
To write all ones, type:	**To write all zeros**, type:	**To write a pattern of ones and zeros**, type:
%TW FF <CR>	**%TW 00 <CR>**	**%TW 00 FF <CR>**
Press 'Y' after making sure everything looks right.	Press 'Y' after making sure everything looks right.	Press 'Y' after making sure everything looks right.
%HL 1 <CR> to load the head	**%HL 1 <CR>** to load the head	**%HL 1 <CR>** to load the head

With the 'scope set on alternate sweep, connect probes to TP 4 and TP 5 on the PLL Data Separator PCB. Sync on TP 4 (clock). Set the time base to 0.5 uSec/division, and the gain at 2 V/division. Write a pattern of all ones, as shown above. The data should be a positive pulse following 2.0 uSec after each clock pulse. Write a pattern of all zeros, as shown above. Note the absence of data pulses between the clock pulses. With a pattern of ones and zeros, you should see some data pulses present, and others missing.





The following steps are made with 'scope channels A and B connected across C21 (TP 4 and TP 5) on the Data and Interface PCB. The 'scope should be in Add mode, with channel B inverted. Both channels should be set for AC coupling and 0.2V/division. Channel C should be connected to the Index signal, P1 pin 20, and the 'scope should be triggered on Channel C.



Step 11. Resolution Unit 0

Insert a scratch diskette in unit 0, and type:

% **SE U=0 <CR>** (Select unit 0)

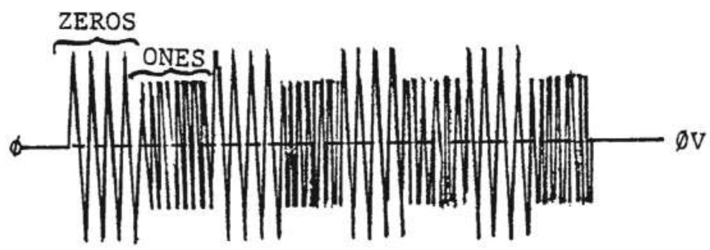
% **RE <CR>** (Restores to track 0)

% **HL 1 <CR>** (loads the head)

% **WT 00 FF <CR>** (Writes alternating pattern to diskette track)

(Check that the parameters look correct, and type ‘**Y**’)

The pattern on the scope should look like the illustration. At track 0, there should be at least a 10% difference between the two frequencies.



II. Resolution

Now type:

Q (exit motor mode)

% **SK 76 <CR>** (seek track 76)

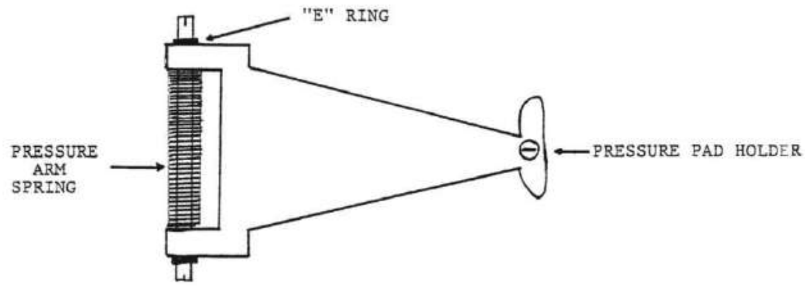
% **WT 00 FF <CR>** (Write pattern)

(Check parameters and type ‘**Y**’)

At track 76, there should be a minimum of 60% difference between the two frequencies.

Step 12. Head Contact Unit 0

Exit motor mode by typing ‘**Q**’. Leave the same diskette (with patterns on tracks 0 and 76) in the drive. Then type:



Pressure Pad Arm

% **SK 0 76 <CR>** (Initiate seeks between tracks 0 and 76)

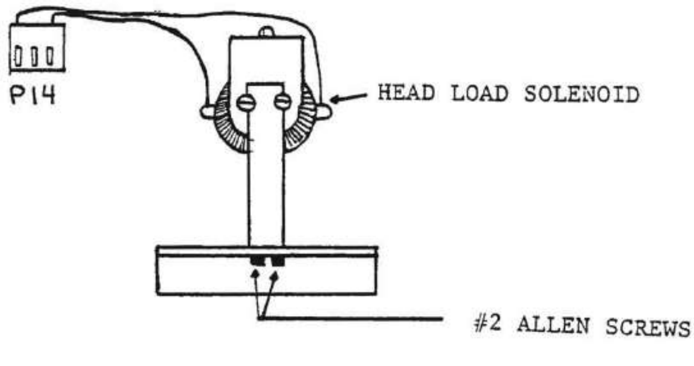
M (Select manual mode)

The drive will seek from track 0 to track 76 or from track 76 to track 0 each time you press the space bar.

Place a finger on the side=0 pressure pad arm, and apply slight pressure. The signal amplitude should decrease or remain the same. If the signal amplitude increases, rotate the pressure pad until there is no increase with pressure, or replace the pressure pad as necessary. Do this check on track 0 and track 77.

Note: Persci used two different types of pressure pads on the 277 drive. One type has fine rabbit hair, the other has a red synthetic material. Both appear to have good durability.

Step 13. Head Load Unit 0



13. Head Load ø

Exit seek mode by typing '**Q**'. Type:

% **RE <CR>** (restore to track 0)

% **HL <CR>** (enter head-load mode)

The head will load or unload each time you press the space bar.

Toggle the head load with the space bar, and check that the pressure pad lifts completely off the media. If it does not lift off the media, loosen the two #2 Allen screws on the underside of the head load solenoid arm and adjust. After making this adjustment, check at tracks 0 and 76 (using the SK command) to be sure the head load is even over the entire range.

Step 14. Cone Unit 0

Exit head-load mode by typing '**Q**'. Type:

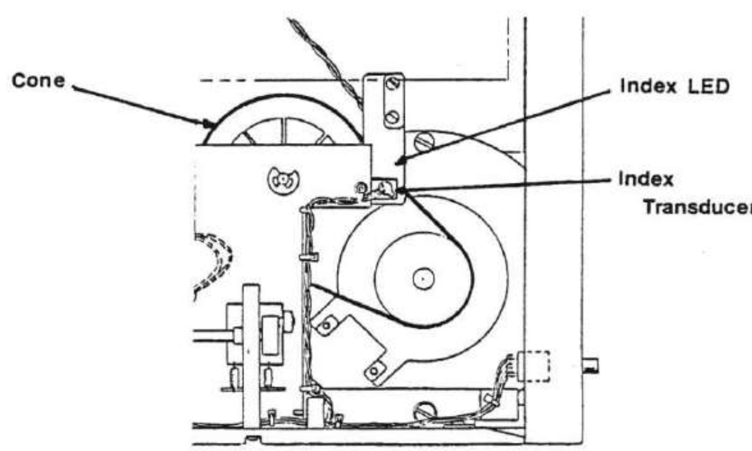
% **RE <CR>** (restore to track 0)

% **HL 1 <CR>** (load the head)

This check is to ensure that the cone is seating properly. With the 'scope still in the same configuration, observe the amplitude of ones and zeros that were written earlier. Remove and reinstall the diskette several times, each time noting the amplitude. If there is any change in the amplitude of the signal, replace or repair the cone. Also check that the cone is not sticking inside the spindle and releasing with a loud snap.

To remove the cone, remove the diskette, and then manually trip the diskette presence switch to bring the cone into the spindle. Remove the E-ring from the spindle shaft, and then press the Eject switch. The cone and spring should now be free to remove. Reverse this procedure to re-install the cone.

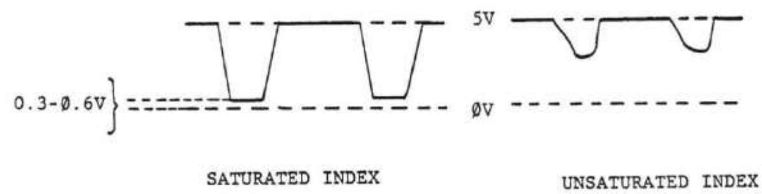
Step 15. Index Unit 0



15. Index ø

A.) The first part of this step is to align the index phototransistor with the light source that drives it. (they are both infrared.) The index phototransistor on unit 0 is located near the cone on the door, and is mounted with a #2 Allen screw. The LED transmitter section is mounted to the drive chassis with two slotted screws. When in perfect alignment, maximum saturation is achieved, and the steepest response curve is possible. Since index pulses are critical, the faster the op amps trigger, the more precise the timing.

Place the 'scope probe on P11 pin 2 on the Data & Interface PCB, and trigger on that channel. Set the gain for 1 volt/division. Insert a diskette and note the waveform. Every time the index hole passes over the phototransistor, there should be an excursion toward 0. Maximum excursion is about one diode drop above 0V (0.3V to 0.6V). If this is not the case, loosen the Allen that holds the light source and adjust as necessary.



I5. Index ø

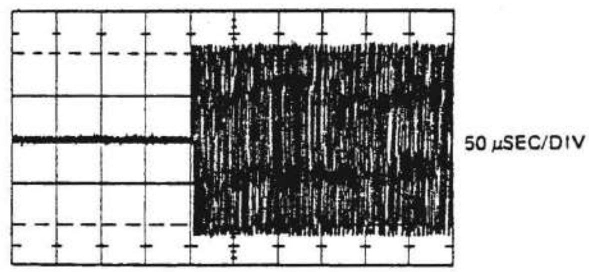
B.) This part of this step aligns the index sensor to the data burst written on the alignment diskette. Do not attempt this alignment unless you have an alignment diskette (or at least a diskette written on a known-good drive...)

Reconnect the scope across TP 4 and TP 5, with triggering on P1 Pin 20. Insert the Dysan alignment diskette, and type:

% **RE <CR>** (Restore to track 0)

% **SK 1 <CR>** (Seek track 1)

% **HL 1 <CR>** (load the head.)



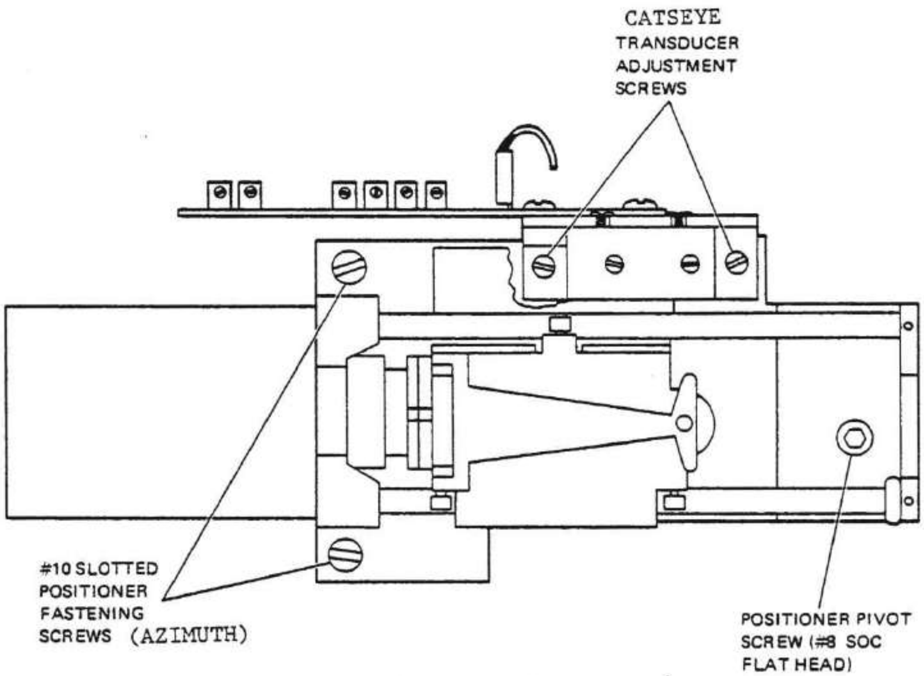
Index Pulse and Data Burst

Index & Azimuth [Units I & ø]

Observe the waveform, as illustrated. The data burst should occur 200 uSec after the trigger, plus or minus 20 uSec. if not, loosen the slotted screws that hold the infrared receiver and adjust its position so that the timing of the burst is in spec. Then perform step A again, and re-check this step B. Eject and re-insert the diskette several times to be sure that the alignment remains correct.

CAUTION

Do not over-tighten the screws or you will crack the plastic housings.



Positioner Track and Azimuth Adjustment (Side 0)

STEPS 16 and 17

Step 16. Azimuth Unit 0

This adjustment checks the index burst of the previous step on tracks 1 and 76.Ideally (i.e. when the azimuth adjustment is perfect), there should be no difference between the data bursts on these two tracks - both should occur 200 uSec after the index pulse. The adjustment is acceptable when there is no more than 20 uS difference between the two.

NOTE: If an adjustment is made here, then you must also adjust unit 1, since it is a slave to unit 0.

Insert the alignment diskette and type:

% **SK 1 76 <CR>** (seek mode between tracks 1 and 76)

The drive will seek from track 1 to track 76 or from track 76 to track 1 each time you press the space bar. Observe the time from the index pulse to the data burst at both extremes. If they are not within 20 uSec of each other, perform the following adjustment:

1. Loosen the two Allen screws that hold the brace to the positioner servo (the large black cylinder at the rear of the drive).
2. Loosen the two Allen screws that hold the positioner servo to the chassis.
3. With a screwdriver, gently pry up on the bottom of the servo mounting assembly (directly behind the diskette eject motor) where it meets the chassis.
4. Seek between tracks 1 and 76, and move the positioner servo up or down as necessary to bring it into spec.
5. Tighten the four screws, and check to be sure that the azimuth is still in spec after tightening.

Step 17. Catseye Unit 0

The purpose of this adjustment is to ensure compatibility between disk drives, so that diskettes written on one drive can be read on another. Track 38 (near the center) of the alignment diskette has a pattern referred to as a catseye (see diagram).

Note: these catseye patterns are a lot easier to see on an analog ‘scope - digital ‘scopes have a hard time reproducing them correctly.

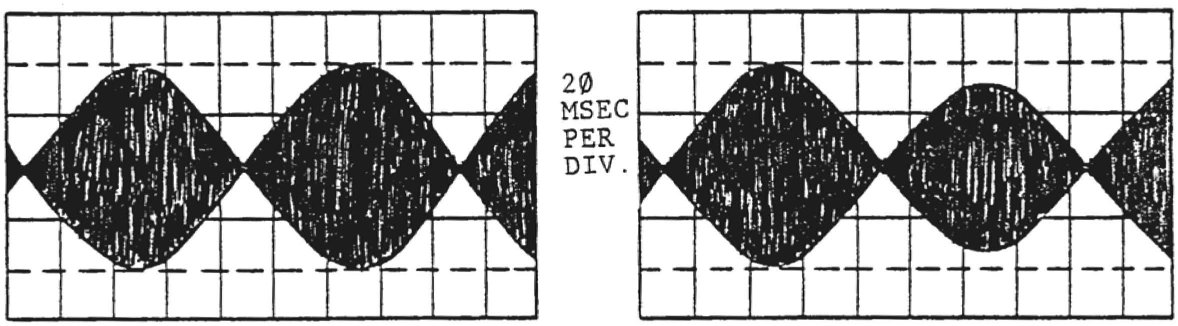
NOTE: If an adjustment is made here, then you must also adjust unit 1, since it is a slave to unit 0.

Leave the ‘scope probes on TP 4 and TP 5, set up for differential measurement, and triggered in Index, as in the previous steps. Set the time base for 20 mSec/division. Type the following:

% **RE <CR>** (restore to track 0)

% **SK 38 <CR>** (seek track 38)

% **HL 1 <CR>** (load the head)



EVEN AMPLITUDE 100% ON TRACK 80% AMPLITUDE 1 MIL OFF TRACK

CATSEYE Track Alignment

Observe the catseye pattern on the ‘scope. Ideally, the amplitude of the two “eyes” will be the same. The maximum allowable difference is 10%, which represents a ½ mil track error. If the catseye is out of spec, perform the following steps:

1. Restore to track 0 (% **RE <CR>**) and remove the black scale cover.
2. Use an Allen wrench that is protected with heat-shrink tubing along its length to loosen the two Allen screws mounting the black lamp housing to the chassis. (older drives may have slotted screws.)
3. Seek track 38 and load the head as above.
4. Gently tap the Lamp Amp PCB in the appropriate direction: toward the front to increase the left catseye, toward the rear to increase the right catseye.
5. Tighten the screws, and recheck the catseye. (Tightening tends to change the catseye.)

With a little effort, the catseye adjustment can be made close to perfect.

If no Dysan alignment diskette is available:

1. Restore to track 0 (% **RE <CR>**) and remove the black scale cover.
2. Insert a data diskette that was written by a known-good drive.

3. Type:

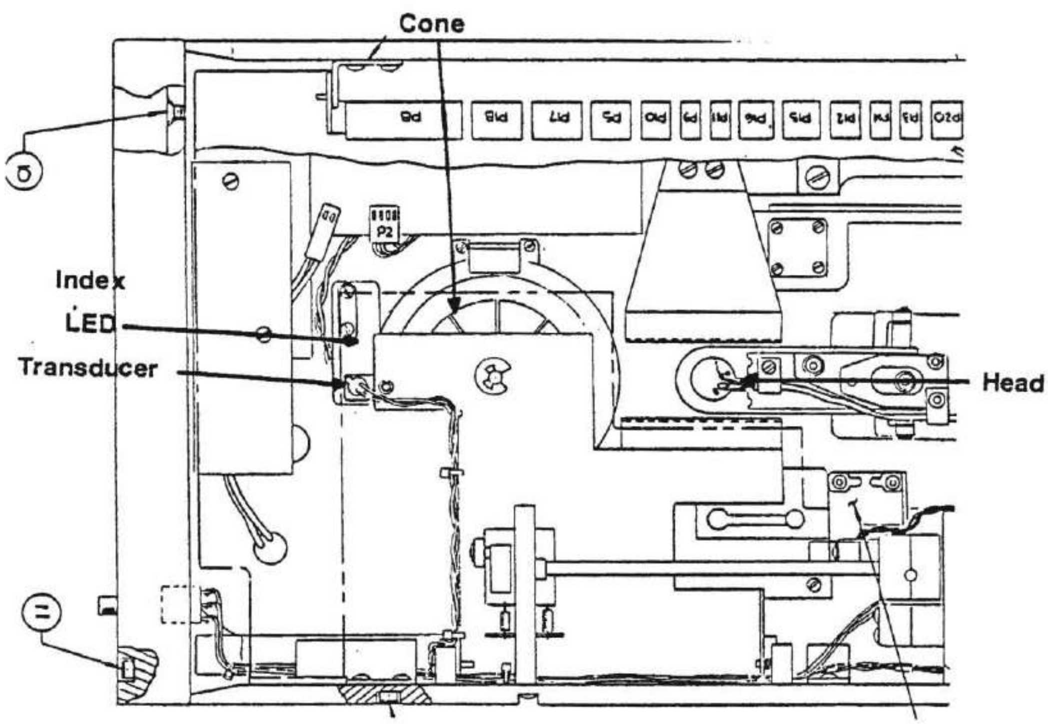
   % **HL 1 <CR>** (load the head)

   % **SK 0 38 76 38 <CR>** (The drive will seek through this list of tracks as you hit the space bar.)

4. Use an Allen wrench that is protected with heat-shrink tubing along its length to loosen the two screws mounting the black lamp housing to the chassis.
5. Gently tap the the Lamp Amp PCB each direction, to maximize the amplitude of the signal.
6. Do this at each of the tracks above: 0, 38, and 76. Find the best compromise for track data amplitude on all of these tracks.
7. Tighten the screws, and recheck the catseye. (Tightening tends to change the catseye.)

Aligning the drive this way will only be as good as the drive that wrote the diskette, at best.

The following steps are made with 'scope channels A and B connected across C26 (TP 6 and TP 7) on the Data and Interface PCB. The 'scope should be in Add mode, with channel B inverted. Both channels should be set for AC coupling and 0.2V/division. Channel C should be connected to the Index signal, P1 pin 20, and the 'scope should be triggered on Channel C.



Unit I Assembly

Step 18. Resolution Unit 1

Repeat step 11, except select unit 1 by typing

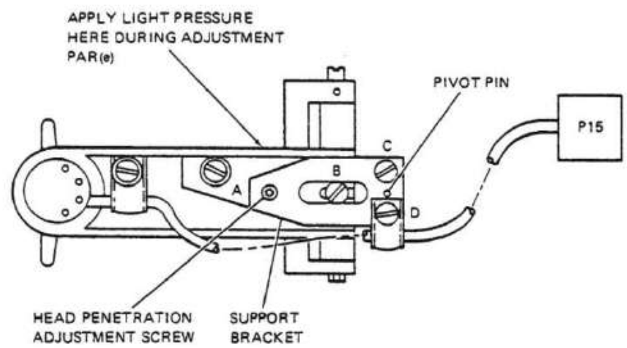
% **SE U=1 <CR>** (selects the right unit)

Step 19. Head Penetration Unit 1

First, check the condition of the pressure pad. If it is very worn, replace it.

Use the same commands as step 12 to seek tracks 0 and 76, and to load and unload the head. The signal should be reduced by at least 50% when the head is unloaded, both at track 0 and at track 76.

Unit 1 has an adjustment for head penetration, the #2 Allen screw in the center of the plastic arm on which the head is mounted. With the head unloaded, adjust the screw until the signal disappears (or is at least reduced by 50%). Check this at track 0 and at track 76. Make sure that the signal returns when the head is loaded, both at track 0 and at track 76. Caution is advised with this adjustment, as too much head penetration will cause problems with extreme wear on the diskette, and head contamination with diskette material.



A and B → Catseye

C and D → Azimuth

Steps 23 – 24

Step 20. Head Load Unit 1

Type the following:

% **SE U=1 <CR>** (select unit 1)

% **HL <CR>** (Unit 1's head will load or unload each time you press the space bar.)

With no diskette inserted, manually trip the diskette presence sensor. Use the space bar to load the head. When loaded, the pressure pad should be in direct contact with the head. When unloaded, the pressure pad should lift completely away form the head. If not, it is necessary to sharpen the bend in the paddle of the lift pad.

Step 21. Cone Unit 1

Repeat the procedure in Step 14 for unit 1.

Step 22. Index Unit 1

A) To adjust the Unit 1 LED, repeat the procedure in Step 15-A, but with the 'scope probe on P9 pin 2.

B) Put the probes back on TP 6 and TP 7 (across C26), with triggering on P1 pin 20 and insert the alignment diskette, and repeat the procedure in Step 15-B.

Step 23. Azimuth Unit 1

With the 'scope in the same configuration, insert the alignment diskette in unit 1. Observe the position of the data burst as you did in Step 16. If the data bursts are not within 20 uS of each other, then an adjustment is necessary.

There are two Allen screws (slotted screws on older drives) that mount the whole head assembly to the positioner servo. Loosen these screws until they are just short of snug. This will allow the head to pivot up and down. Use the space bar to seek between tracks 0 and 76, pivoting the head slightly as necessary to bring the azimuth into spec. Retighten the screws and re-check the azimuth.

Step 24. Catseye Unit 1

With the 'scope probes in the same position, insert the alignment diskette, seek track 38, and load the heads:

% **SE U=1 <CR>** (select the right unit)

% **SK 38 <CR>** (Seek track 38)

& **HL 1 <CR>** (load the head)

If the catseye is out of spec (more than 10% amplitude difference between the left and right catseyes), then an adjustment is necessary. To adjust the catseye, loosen the two Allen screws (slotted screws in older drives) in the center of the head arm, to allow the head to move horizontally, front to back. Adjust the head position the bring the catseye into spec, and retighten the screws. Recheck the catseye after tightening.

Note: The catseye, azimuth, and head penetration adjustments on unit 1 are all interdependent. If you adjust any one of these three, then re-check and re-adjust the others as needed. Repeat until all three adjustments are within spec.

Step 25. Presence Detect (both units)

Test the Unit 0 presence-detect circuitry by typing:

% **SE U=0 <CR>** (select unit 0)

Insert a diskette in the left unit, and type

% **SE <CR>** (Flexor's settings and the drive state will be printed.)

Among the drive status, you should see "Drive ready."

Eject the diskette, and type

% **SE <CR>** (Flexor's settings and the drive state will be printed.)

This time, you should see "Drive not ready".

If the ready/not ready messages are incorrect, then debug the circuit.

To test Unit 1, type:

% **SE U=1 <CR>** (select unit 1)

...and repeat the above test.

Appendix 1: Spindle Bearing and Motor Bearing Service

The spindles for the two sides of the 277 share a common shaft and two bearings. The bearings are NMB part number SSRI-1438ZZ, and are still available at the time of this writing.

The spindle motor contains two smaller bearings. These bearings can be cleaned and re-lubricated if they are dry, or they can be replaced if damaged.

This whole process - including re-greasing the spindle motor bearings, replacing the spindle bearings, and readjusting the right-side index position - should take about 2-1/2 hours, assuming you have the right tools on hand, and nothing extraordinary breaks along the way.

Spindle Bearing Removal

1. On the left side of the drive, unhook the two springs that lift the arm that holds the spindle cone.
2. Use a 3/32" Allen wrench to remove 2 cap screws that hold the front hinge bracket for this spindle cone lift arm, and remove the hinge bracket. Slide the spindle cone arm off the rear hinge, and recover the spring on that hinge, so it does not get lost.
3. The left spindle cone arm should now be connected only by the index sensor wires. Swing the spindle cone arm out of the way.
4. Lay the drive down so that the right side is facing up, and Swing the Data & Interface PCB open (2 screws).
5. Unhook the two springs that lift the right-side spindle cone arm.
6. Unscrew the right-side ejector mechanism (2 screws on each bracket). Retrieve the two small plastic blocks that were between the ejector motor bracket and the chassis. Swing the ejector motor up a little.
7. Remove the front hinge bracket for the right-side spindle cone lift arm (2 cap screws). Remove the hinge bracket. Slide the spindle cone arm off the rear hinge, and recover the spring on that hinge, so it does not get lost.
8. Remove the disk ramp that is above the spindle servo board (2 screws). Retrieve the two spacers that the screws passed through.
9. Disconnect the spindle motor and the index servo lamp/sensor from the spindle servo board (2 connectors).
10. Unscrew and swing aside the spindle servo board (1 screw, with a fiber washer on both sides of the board, located toward the rear of the board). (Note that on early drives, there may also be a metal spacer beneath this board that must be retrieved.)
11. Unscrew and remove the spindle servo lamp/sensor assembly - the assembly that connects to P2 (2 screws).
12. Unscrew and swing aside the right-side index LED assembly (2 screws). (It would be a good idea to photograph this assembly before removing it, so that you can put it back in close to the same position, to minimize the alignment job when you are done.)
13. Tip the drive up side down (so that the hinge of the Data & Interface PCB is down), and remove the spindle belt.
14. Using a wheel puller (such as a Posilok model 102), gently pull the left-side spindle off of its shaft.
15. Slide the right-side spindle, together with the shaft and the plastic servo disk, out of the bearings. Be very careful not to damage the plastic servo disk! If the shaft is tight, gently tap the left side shaft with a hammer.
16. Using a small inside-bearing puller (such as a small clutch pilot bearing puller), pull the right-side spindle bearing from the chassis. (Do not let the "foot" of the bearing puller press against the spindle motor!)

17. Use the same puller to remove the left-side spindle bearing, again avoiding pressing against the spindle motor.

Spindle Motor Service

This is a good time to check the spindle motor. If the motor bearings sound bad, service it first, before reinstalling the spindle. Note that it will normally make a scraping sound when turned backwards, due to its static discharge brush inside.

1. The spindle motor is mounted with three screws. There are probably some shim washers between the motor and the drive chassis - note where these shim washers belong as you remove the spindle motor.
2. Once removed, the spindle motor is only held together by the motor magnet. Carefully pry the motor shell apart.
3. The pancake rotor is held in place by the spindle belt pulley. Loosen the pulley's set screw using a 5/64" Allen wrench, and remove the pulley.
4. Beneath the pulley, there is a thrust washer. Remove this washer.
5. Carefully slide the rotor from the motor bearings. Be careful not to lose the other thrust washer and spring washer that are between the rotor and the housing.
6. Inspect the motor brushes, and replace if necessary. (It is very unlikely that they will need to be replaced.)
7. The motor bearings are pressed into the motor housing. They can be removed with a small bearing puller.
8. Clean the rotor and the inside of the housing at this point.
9. The motor bearings can also be cleaned and re-greased in place:
    a. Use a pointy tool to carefully removing the c-clips that hold the dust covers in place, and then remove the dust covers
    b. Thoroughly flush the bearings with solvent
    c. Press grease into the bearings with your thumb, and spin the bearings. Repeat this until the bearings are filled.
    d. Replace the dust covers and c-clips.
    e. Clean all excess grease. Spin the bearings to force out excess grease and clean them.
10. Once the bearings are good, reassemble the spring washer and thrust washer onto the rotor, and slide it into the bearings.
11. Install the outer thrust washer, and install the pulley. The pulley must be installed on the shaft as close as possible without causing it to bind when spun. (If it is too high, then the rotor will scrape against the motor magnet.)
12. Reassemble the motor case, making sure the alignment pins on the back housing align with the matching holes on the front housing.
13. Use an external power supply to apply 24V to the motor, and let it spin for a few minutes, to set the brushes.
14. Reinstall the motor into the disk driver chassis, replacing the spacer washer as they were originally installed.

Spindle Bearing Replacement

Before replacing the spindle bearings, clean everything! The drive is sufficiently disassembled that you can clean areas that are otherwise inaccessible. In particular, carefully and thoroughly clean both sides of the plastic spindle servo disk with alcohol and a cotton swab. Also, thoroughly clean the chassis hole where the spindle bearings will go.

1. Carefully align, and then tap into place the two new (or re-greased) spindle bearings. The handle of a small plastic screwdriver works well for this. Make sure the bearings go in perfectly straight! You should be able to tap them at least ¾ of the way in this way.
2. Use a large bolt, 2 washers, and a nut to press the two bearings completely in place. Pass the bolt through the two bearings, with a washer on either end, and then tighten the nut down until the bearing flanges are in firm contact with the chassis.
3. Clean the spindle shaft, and also the inside of the left-side spindle. Be sure to remove any residue of glue. “Goof-Off” works pretty well to remove the glue.)
4. Slide the spindle shaft through the bearings from the right side.
5. Test-fit the left-side spindle on the shaft. If the left-side spindle does not slide all the way on easily, then keep cleaning the glue from the shaft and the inside of the left-side spindle.
6. Put a small amount of crazy-glue all the way around the tip of the spindle shaft, and then immediately slide the left-side spindle all the way onto the shaft, such that both the left and right side spindles are against the spindle bearings.
7. Reinstall the spindle belt.
8. Lay the drive down so that the right side is up, and clean the plastic spindle servo disk with alcohol and a lint-free rag.
9. Reinstall the index LED assembly, as close to its original adjustment as you can.
10. Reinstall the spindle servo lamp/sensor assembly.
11. Spin the motor by hand, and observe the tracking of the belt:
    a. If the belt tracks too high, then it will scrape against the index sensor assembly. In this case, either remove a shim washer from the motor mounting screw that is farthest from the spindle bearing, or add a shim washer between the motor and the chassis for both of the other two motor mounting screws.
    b. If the belt tracks too low, then it will come off when spun, or nearly so. In this case, either remove a shim washer from both of the two motor mounting screws that are closest to the spindle bearing, or add a shim between the motor and the chassis for the motor mounting screw that is farthest from the spindle bearing.
12. Reinstall the spindle servo board, with a fiber washer on top and below the board, as it was when you removed it. (You may need to position the metal spacer below the board first.)
13. Reconnect the spindle motor and the index servo lamp/sensor to the spindle servo board. (The index servo lamp/sensor is keyed. The spindle motor connector should have the red wire closest to the spindle.)
14. Carefully position the two spacers for the disk ramp, and then reinstall the disk ramp.
15. Reinstall the spring onto the rear hinge pin for the right-side spindle cone arm, and then slide the spindle cone arm onto the hinge. Then reinstall the front hinge bracket, being careful not to pinch any wires with the bracket. (The wires to the ejector switch and to the index hole LED should pass through the slot in this bracket.)
16. Reinstall the right-side ejector mechanism. Don’t forget the two plastic spacer blocks. Again, be careful not to pinch the wires that pass through the slots in the ejector mechanism brackets.
17. Reattach the two springs that lift the right-side spindle cone arm.
18. Swing Data & Interface PCB back down and screw it in place.
19. Turn the drive over and reconnect the left-side spindle cone arm in the same was as you did the right side.
20. You probably will need to adjust the position of the right-side index sensor, particularly if this drive is used with hard-sectored disks. (Persci 277 Adjustment Procedure, Step 22, above)

Appendix 2: Ejector Motor Service

The two ejector gearmotors are not interchangeable because they are wired to turn in opposite directions. This means that the diodes and tantalum capacitors on the back of the motors are installed with opposite polarities, and opposite motor poles are connected to ground. However servicing the two gearmotors is similar.

The typical failure mode for these gearmotors is that the nylon spur gear on the motor shaft inside the gearbox has cracked, causing it to slip or jam, or to make a clicking sound with each revolution. It is possible to replace this spur gear, if you can find a replacement part.

You can also replace the gearmotor using one from another drive. If you are using a scavenged motor, it most either be from the same drive side, or you must flip the polarity of the diode and two capacitors on the rear of the motor, and move the grounding wire to the other motor pole.

Spur Gear Replacement

I have successfully printed replacement nylon spur gears. The spur gear specifications are as follows:

Teeth: 8
Thickness: 0.125” (3.2 mm)
Bore diameter: 0.06” (1.54 mm)
Pressure angle: 20 degrees
Diametrical Pitch: 48
Module: 0.5291
Shift: -0.012” (-0.305 mm) (shift tooth faces outward 0.012”)
Outside diameter: 0.224” (5.7 mm)
Root diameter: 0.13” (3.41 mm)

This section explains how to disassemble the ejector assembly enough to replace the gearmotor’s internal spur gear, and then how to reassemble the ejector assembly.

1. Use needle-nose pliers to unhook the two springs that lift the pressure cone arm off of the spindle
2. Remove the two Allen screws that hold the arm support (where the two springs were hooked) to the drive chassis
3. Remove the two screws that hold the gearmotor support to the drive chassis. Be careful to retrieve the two black plastic spacers that were between this support and the drive chassis. (The top one will be held in place by the gearmotor’s chassis-ground wire. but the other will fall out when the screw is removed.)
4. Lift the shaft-end of the gearmotor up enough that you can access the two screws holding the two microswitches to the gearmotor support bracket, and then unscrew these two screws. Leave these screws in the microswitches, to hold them together for reassembly.
5. You should now be able to swing the gearmotor out enough to service it.
6. Loosen the hex screw on the switch cam, and slide it out of the way.
7. Note the orientation of the gearmotor on its bracket, so you can put it back the same way.
8. Remove the 3 screws that hold the gearmotor to its support bracket and slide the support bracket down the shaft and out of the way.
9. Remove the 2 screws that fasten the cover of the gearbox and gently open the gearbox.
10. Be careful to observe the position of the spacers on two of the gear shafts. These spacers may be stuck to the grease inside the cover you just removed.
11. Slide the 3 gears ands 2 spacers off of their shafts, noting their original positions.
12. Each of the 3 shafts has a spacer beneath its gear. Leave these in place.

13. Pry the spur gear off of the motor shaft. (It is probably cracked between two of its teeth.)
14. The gearmotor grease is probably dried up, so now is a good time to remove the remaining grease and clean the gears.
15. Press the new gear onto the motor shaft.
16. Lubricate all 3 shafts with synthetic grease such as Molykote G-4700 Extreme Pressure Pure Synthetic grease
17. Slide the 3 gears and their spacers back onto their shafts, and lubricate their teeth generously with the same grease.
18. Put a little grease on the tip of the output shaft, and lubricate its gear.
19. Reinstall the gearbox cover and output shaft, and reinstall the gearmotor bracket.
20. Label the gearmotor “New Spur Gear <date>”.
21. Slide the switch cam down the shaft, and align it such that its pin is lined up with notch in the disk that holds the bearing for the head load actuator at the end of the shaft. Tighten its set screw.
22. Reattach the microswitches to the gearmotor bracket.
23. Loosely screw the gearmotor bracket the drive chassis, inserting the two black plastic spacers between the bracket and the chassis. Make sure the outer screw also captures the gearmotor’s ground wire. Be sure not to pinch any of the wires that pass between the bracket and the chassis.
24. Screw the arm support to the drive chassis. Be sure not to pinch any of the wires that pass between the support and the chassis. Tighten all 4 screws.
25. Use needle-nose pliers to re-hook the two springs that lift the pressure cone arm off of the spindle

Appendix 3: Voicecoil Service

The voicecoil assembly can be removed from the drive as a unit. This may be necessary for certain repairs or cleaning. You can put the assembly back in the same position (avoiding an azimuth adjustment), if you take one measurement before removing the voicecoil assembly.

How to remove the Voicecoil Assembly:

1. Unscrew the 3 screws that hold the Positioner Servo board in place. Disconnect P5 and P8 from the Positioner Servo Board, and swing the board out of the way.
2. Remove the 2 screws that hold the Data and Interface board, and swing the board up.
3. Unplug P15 and P16 from the Data and Interface board. Fish their wires free of the other wiring harnesses.
4. Unscrew the 2 clamps that capture the wires to the head assembly and voicecoil, setting aside the clamps and the cable guide that shares a screw with the rear clamp.
26. Turn the drive over so that the Data and Interface Board is down, use needle-nose pliers to unhook the two springs that lift the pressure cone arm off of the spindle.
5. Remove the two cap screws that hold the ejector arm hinge to the chassis, and lift the ejector arm out of the way, retrieving the spring that is on the rear hinge shaft.
6. Unscrew the 2 clamps that hold the wires to the other read/write head and the voicecoil.
7. Remove the 2 cap screws that hold the clamp around the voicecoil to the cross member. Remove the 4 flathead screws that hold the cross member to the sides of the drive, and remove the cross member.
8. Measure and record the size of the gap between the cast aluminum voicecoil assembly frame and the cast aluminum main drive frame. (You can use a set of hex wrenches to get a pretty good measurement.)
9. Remove the black plastic Positioner Scale cover.

10. Unscrew and swing aside the Side 1 head-load solenoid.
11. Remove the 2 cap screws that hold the Voicecoil Assembly to the main drive frame.
12. Loosen the flat-head hex-drive screw that holds the front of the Voicecoil Assembly to the main drive frame. (This may be very tight. If so, you can help loosen it by swinging the Voicecoil Assembly side-to-side as you apply torque to the hex wrench.)
13. The Voicecoil Assembly is rear-heavy, and will want to fall when this last screw is removed. Slide the head carriage into the voicecoil, and hold onto the rear of the voicecoil as you remove the last screw. Be very careful not to bump the glass positioner scale into anything as you lift the Voicecoil Assembly out of the drive.

Now that the voicecoil assembly is out of the drive, take the opportunity to clean the voicecoil assembly thoroughly! Pay particular attention to the backsides of the two rods on which the carriage assembly rolls, as well as the rolling surfaces of the 6 bearings.

Clean the drive chassis, particularly in areas that are hard to reach until the voicecoil assembly is removed.

This is also a good time to replace C4 (a 1 uF tantalum capacitor) on the Lamp Amp board.

If your drive has an IRLED (rather than an incandescent lamp) for the positioner servo, then this is also a good time to rework the connection to TP7. Cut the trace to TP7, and add a jumper wire from TP7 to the junction of R15 and the collector of Q1.

Perform whatever repairs are required to the voicecoil subassembly.

The head assembly (including the moving portion of the actuator voicecoil) rides on 6 small ball-bearing sets. If these are not rolling smoothly, they can be re-lubricated. Do this one bearing at a time. Be extra careful not to damage the glass positioner scale while you are removing or reinstalling bearings!

a. Remove the bearing from the carriage. (Each is held in place with a C-clip.)
b. Carefully remove both of the bearing's dust covers, which are held in place with C-clips. (These C-clips can be removed with a sharp sewing needle.)
c. Flush out the old grease with solvent
d. Re-packing the bearing with fresh grease
e. Reinstall the dust covers, and lock them in place with their C-clips
f. Spin the bearing in your fingers for a while, to expel any excess grease
g. Clean the outside of the bearing thoroughly
h. Reinstall the bearing.

How to reinstall the voicecoil assembly:

1. Set the drive chassis on your bench with the Data and Interface board down.
2. Carefully slide the voicecoil assembly in place, and loosely install the flathead hex-drive screw that attaches the front of the assembly to the chassis.
3. Loosely install the two cap screws that hold the rear of the assembly to the chassis.
4. Adjust the position of the voicecoil so that the size of the gap between the cast aluminum voicecoil assembly frame and the cast aluminum main drive frame is the same as when you removed it, and tighten the three screws that hold the assembly in place.
5. Reinstall the frame cross member with its 4 flat head screws, and reinstall the two cap screws that hold the voicecoil clamp to the cross member.
6. Reinstall the Side 1 head load solenoid and the black plastic Positioner Scale cover.

7. Route the wires to the read/write head and the voicecoil as they had been (below where the ejector arm will be), and screw their clamps in place. Slide the voicecoil back and forth to make sure the wires do not hinder voicecoil movement.
8. Reinstall the ejector arm hinge spring, and the ejector arm. Reinstall the front ejector arm hinge, being careful not to pinch the wires that travel beneath it.
9. Re-hook the two ejector arm springs.
10. Turn the drive over and swing the Data and Interface board up.
11. Reinstall the two read/write cable clamps and the cable guide, and make sure voicecoil movement is not hindered by the cable.
12. Re-route the two read/write head cables, and plug P15 and P16 into the Data and Interface board.
13. Reinstall the Positioner Servo board, and plug P5 and P8 back into this board.
14. Align the drive.