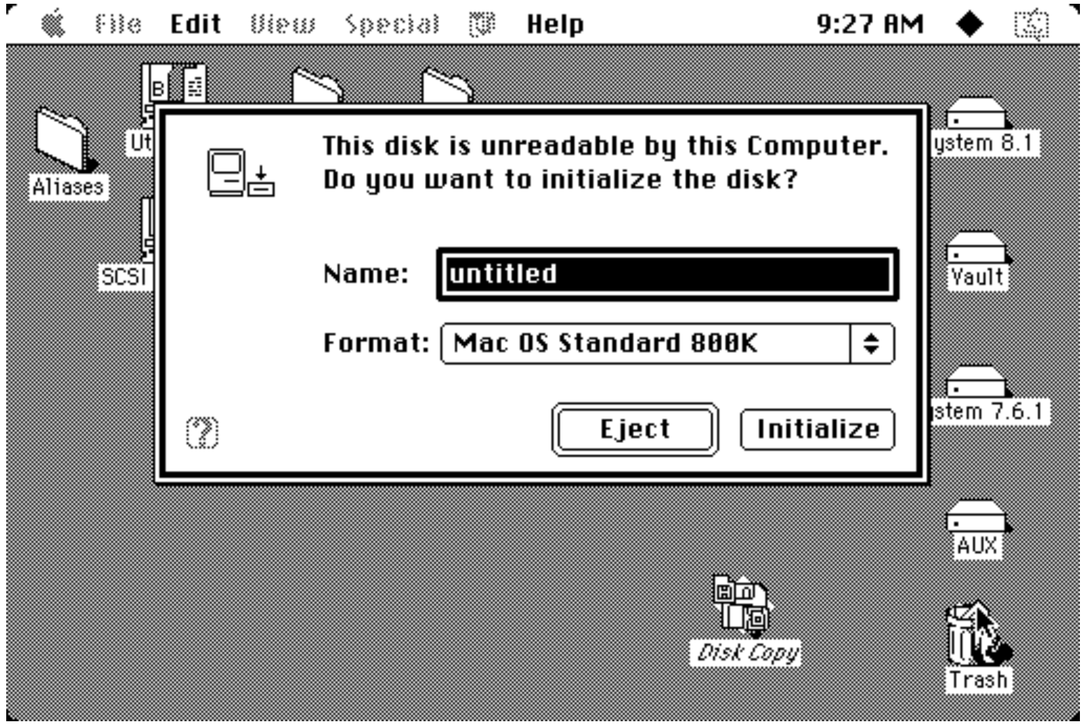
Zero Track Alignment

Paolo Bertolo - Feb 2022

The symptoms

- You just got a new vintage Mac, and you soon realize that the floppy drive can’t read “known good” floppies…

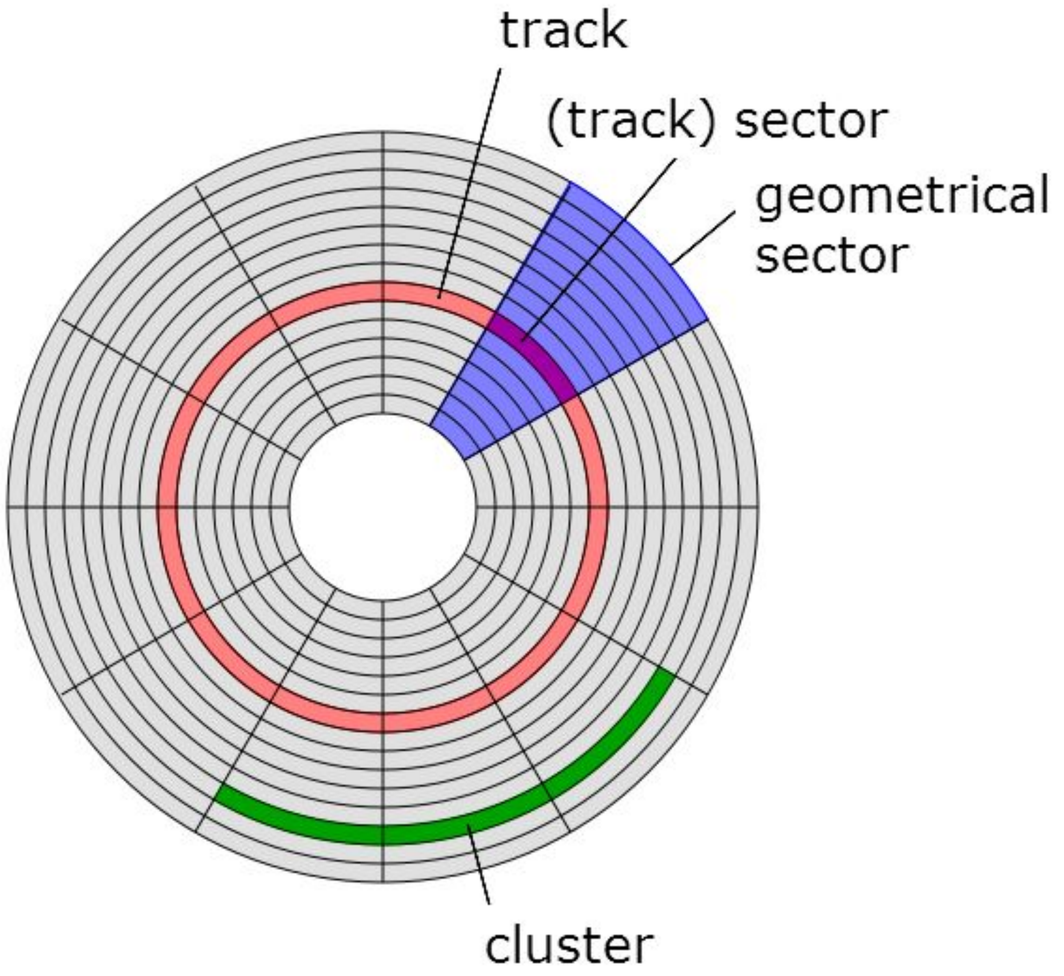


The symptoms

- So, you try to format the disk, but it fails…

The root cause

- Most of the times, it’s just a matter of readjusting the “zero track alignment”.

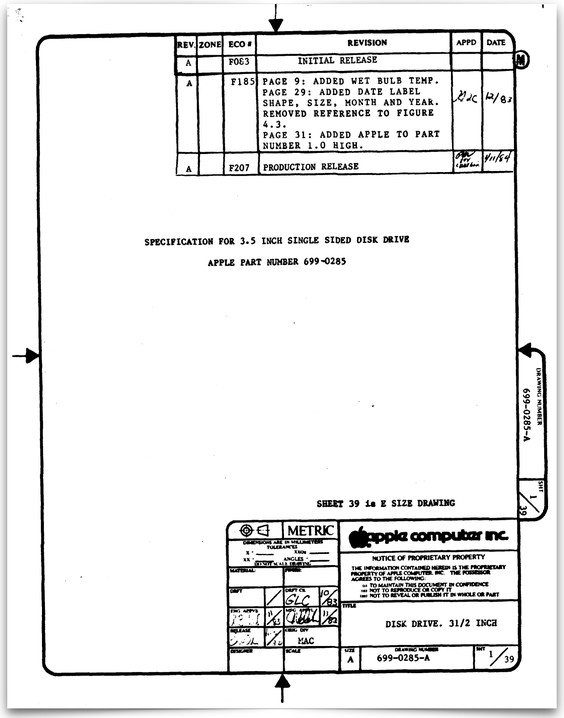


Some Numbers…

- 3.5” = 80.89 mm Diameter of the disk, Radius = 40.445 mm

Some Numbers…

- All Apple 3.5” floppy disks are formatted in 80 tracks (from track 0 to track 79, track 0 is the outermost one).



REV.	ZONE	ECO #	REVISION	APPD	DATE
A		F063	INITIAL RELEASE		
A		F185	PAGE 9: ADDED WET BULB TEMP. PAGE 29: ADDED DATE LABEL SHAPE, SIZE, MONTH AND YEAR. REMOVED REFERENCE TO FIGURE 4.3. PAGE 31: ADDED APPLE TO PART NUMBER 1.0 HIGH.		
A		F207	PRODUCTION RELEASE		

SPECIFICATION FOR 3.5 INCH SINGLE SIDED DISK DRIVE

APPLE PART NUMBER 699-0285

SHEET 39 is E SIZE DRAWING

699-0285-A

SHT 1 / 39

METRIC

apple computer inc.

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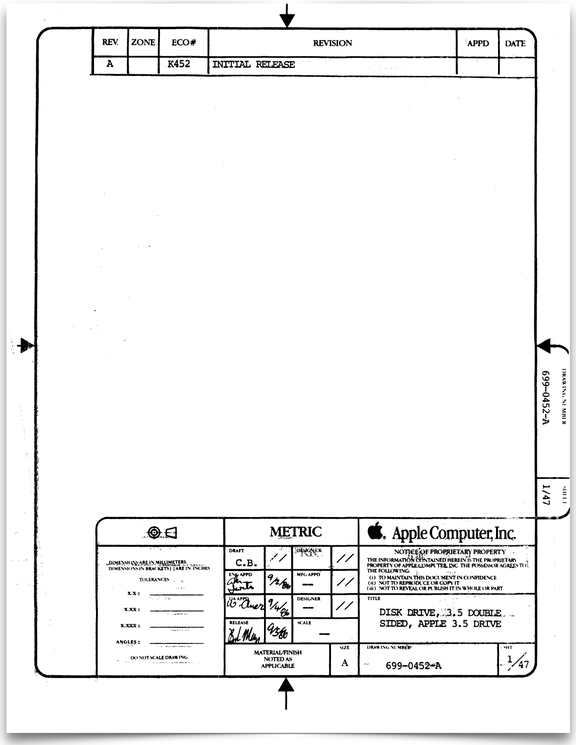
DRAFT GLC 10/83
ENG. APPR. 11/83
RELEASE 11/83
DESIGNER
MFG. DIV. MAC
SCALE

TITLE: DISK DRIVE. 31/2 INCH

SIZE A | DRAWING NUMBER 699-0285-A | SHT 1 / 39



REV.	ZONE	ECO#	REVISION	APPD	DATE
A		K452	INITIAL RELEASE		

699-0452-A

METRIC

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DRAFT C.B. 9/2/86
ENG APPR. 9/2/86
RELEASE 9/3/86
DESIGNER —
SCALE —

TITLE: DISK DRIVE, 3.5 DOUBLE SIDED, APPLE 3.5 DRIVE

MATERIAL/FINISH NOTED AS APPLICABLE | SIZE A | DRAWING NUMBER 699-0452-A | SHT 1/47

Some Numbers…

- Each track is 0.1875 mm wide.
- Track position is given by this simple formula:

$$RN = 39.5 - 0.1875 * N \ [mm]$$

- Positioning tolerance is 0.035 mm, so approximately +/- 10% of the width of the track.

2.11 Alignment Accuracy

Track position is defined by:

RN = 39.5 — 0.1875 x N

Where RN: Absolute track position from disk center
N: Track number from 0 to 79

Alignment Accuracy at track 40 shall be: +/-0.020 mm

Alignment Accuracy at all other tracks shall be: +/-0.035 mm

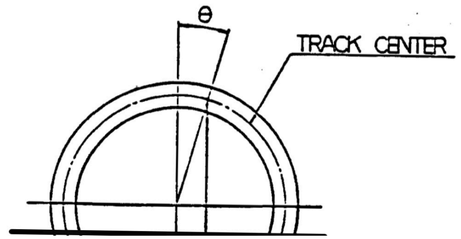
2.12 Azimuth Angle

Azimuth Angle shall be;

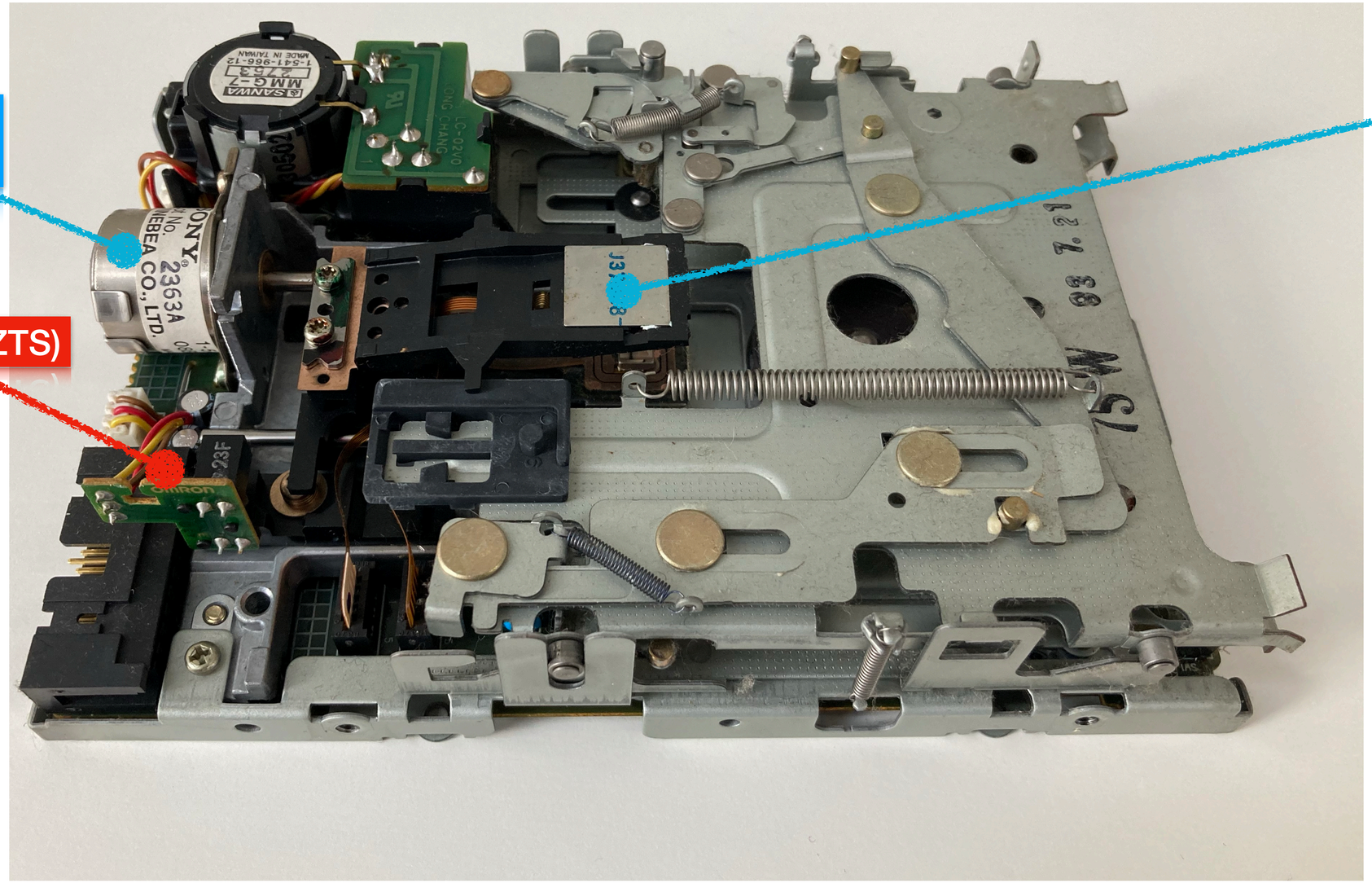
Angle = arcsin (0.35 / (X - YN)) +/- 0 degrees 30'

where : X = 39.5
Y = 0.1875
N = Track number (0 to 79)

Azimuth angle is defined in Figure 2.4.

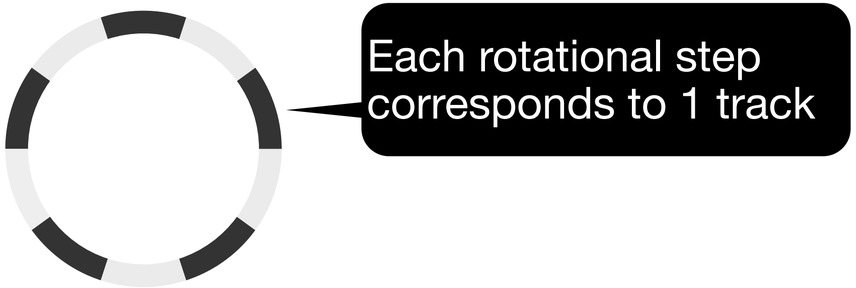


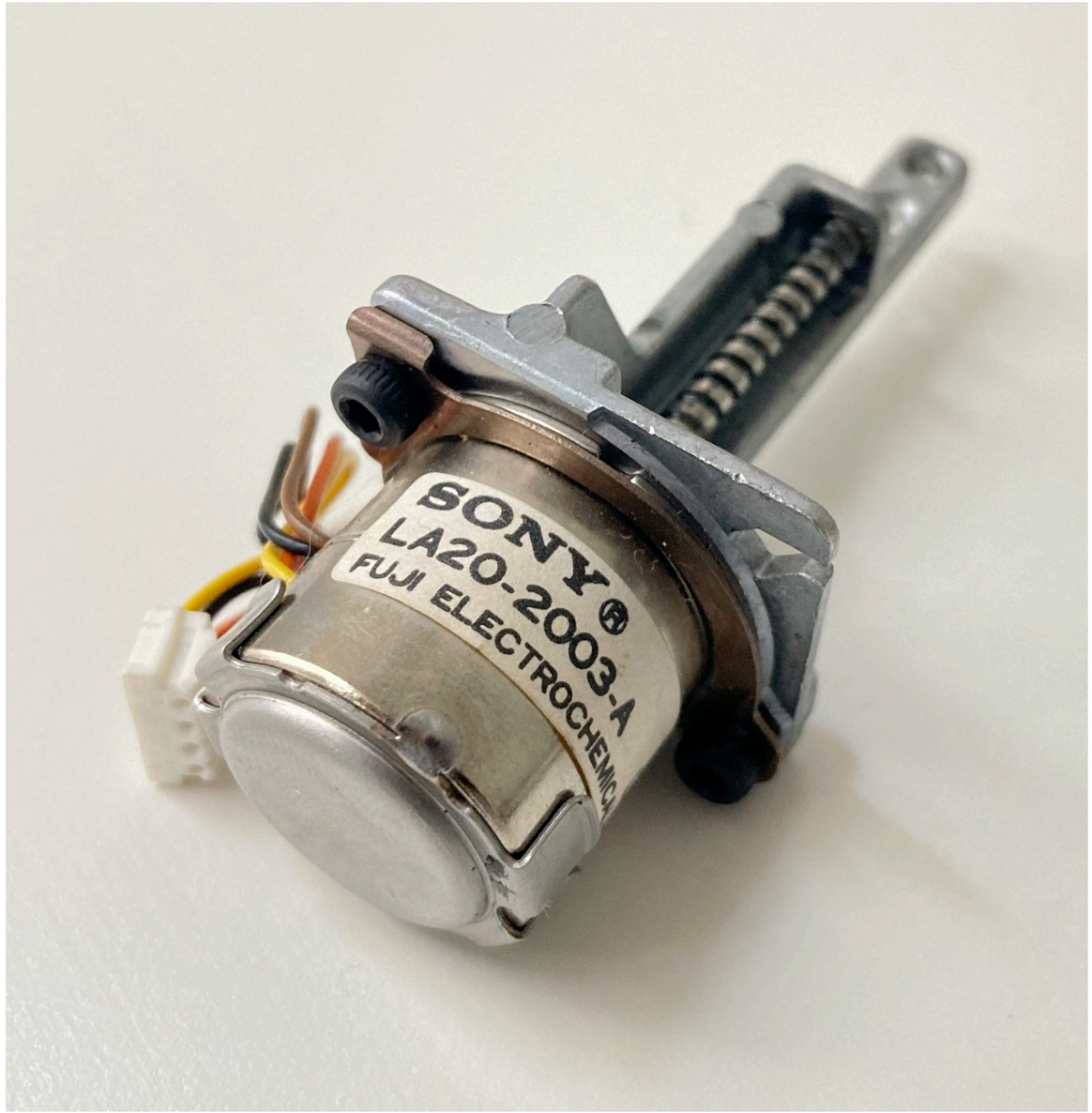
The floppy drive



The stepper motor

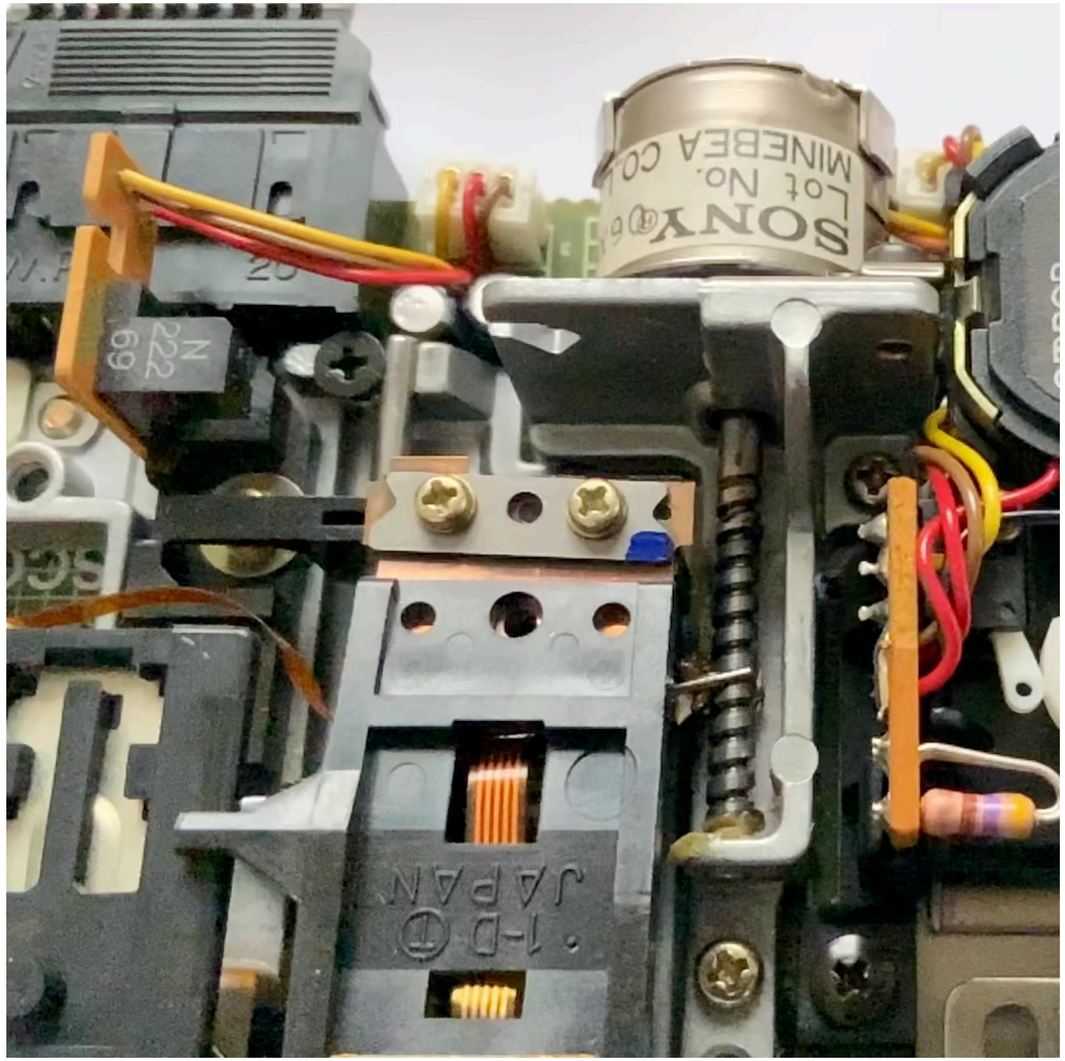
- This motor controls the position of the read/write head.
- Rotation is not continuous, but happens in steps.
- Each revolution is split into 10 steps (36 deg each).





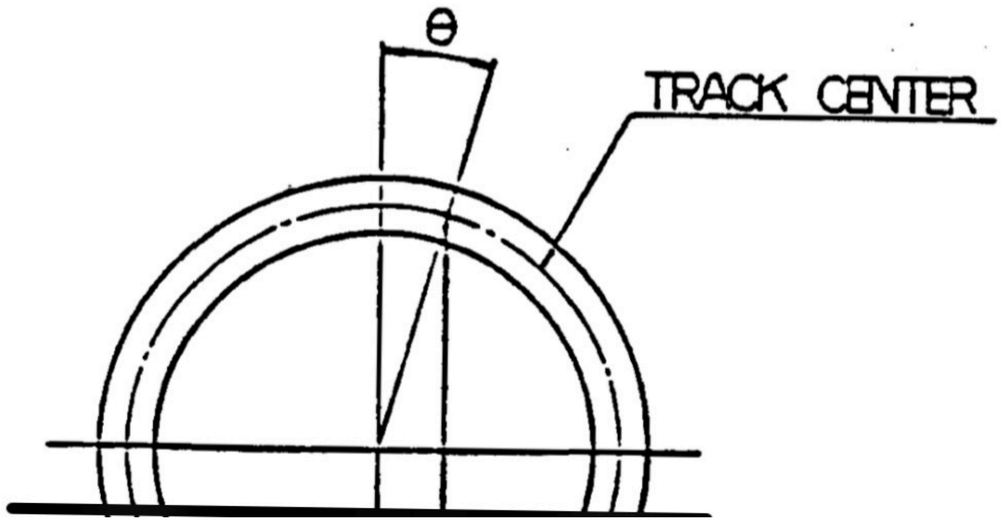
How it works

- When a disk is inserted, the read-write head moves back (step by step) till the ZTS gets triggered and sends a signal halting the stepper motor.
- At that point, if the head is not aligned with the 0 track as formatted in the magnetic media, the Mac cannot read any consistent data and throws an error.



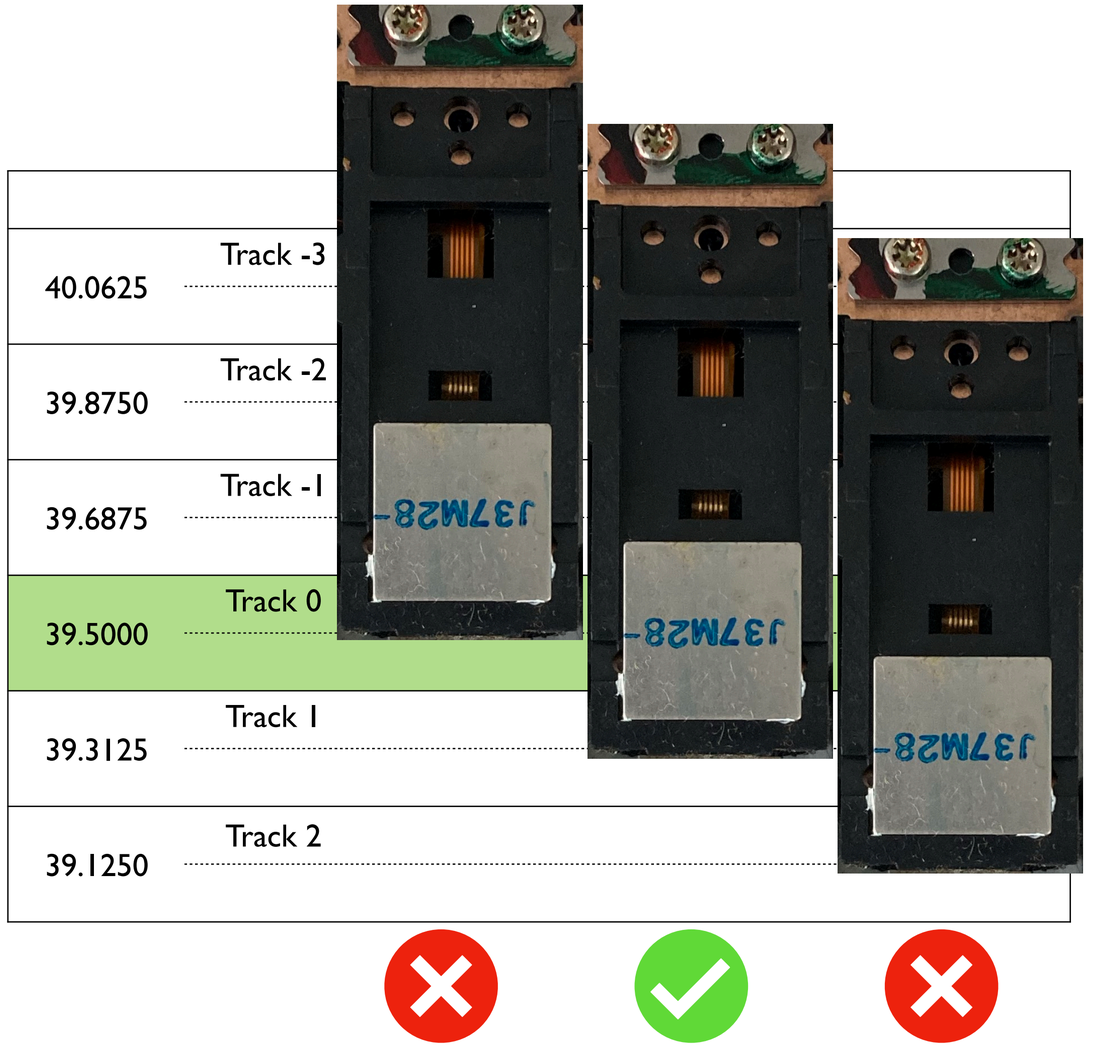
How it works

- 0 track center line should be at 39.5 mm +/- 0.035 mm from the disc center.
- As the disk platter is 40.445 mm, in theory there’s space for 3 more tracks (let’s call them “faux tracks” -3, -2 and -1)



The issue

- The movement of the head is controlled by the stepper motor and the whole mechanism has a positioning accuracy of +/- 1 track.
- So, you can only have an integer number of tracks misalignment.

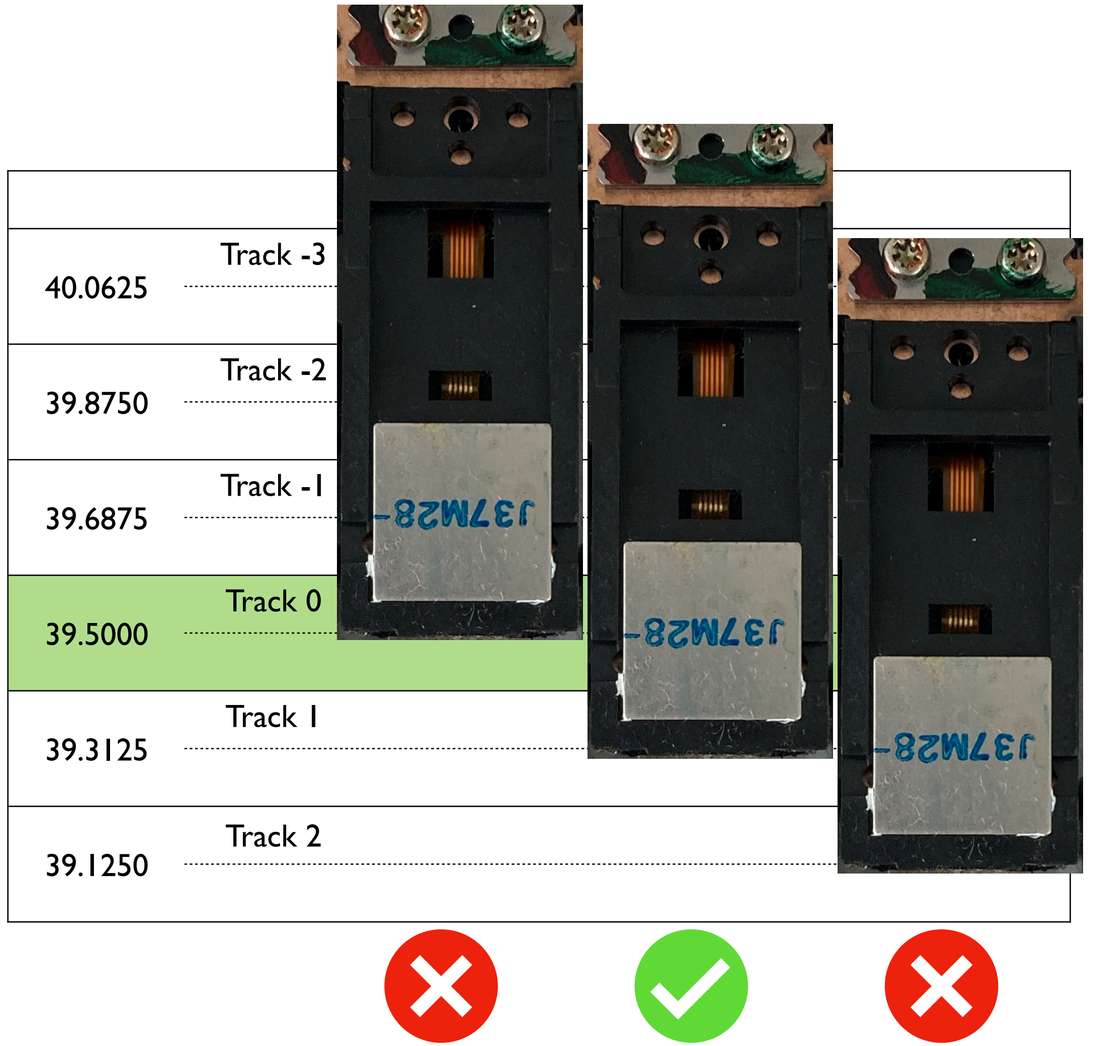


The issue

- The track at which the head stops when a disk is inserted depends on the position of the ZTS.

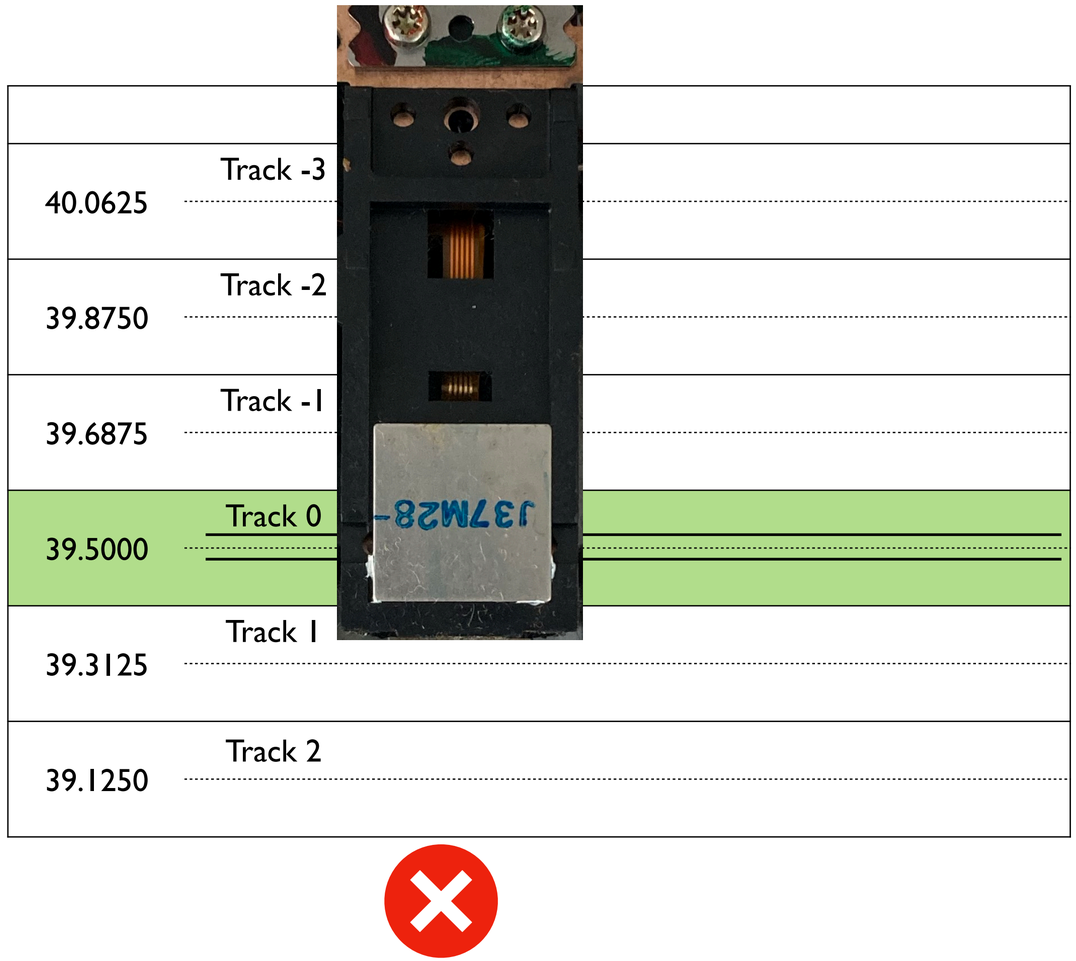
  Due to aging (or other reasons), it might be that the head is no longer stopping at the 0 track, but (most likely) at track 1 or -1.

- This issue can be easily addressed by adjusting the ZTS position.



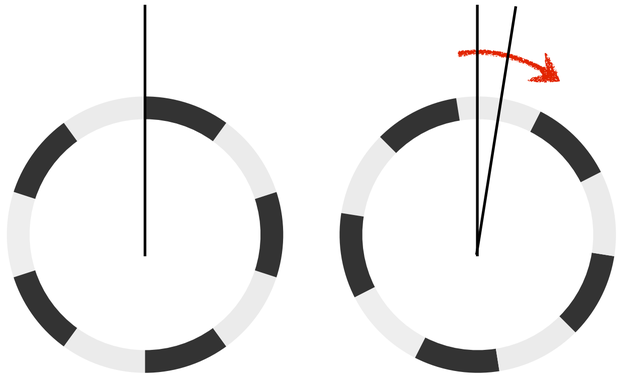
The issue

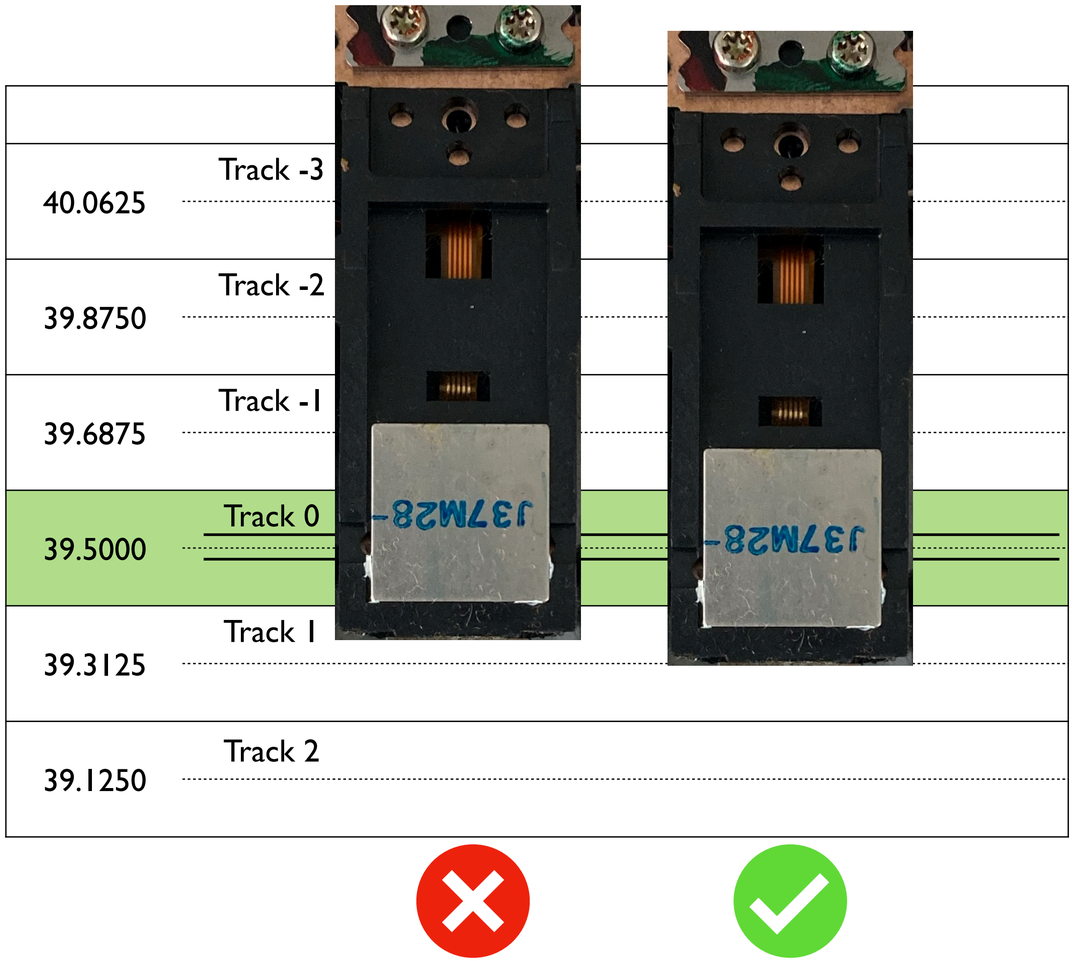
- But… Wait… How about this situation?
- What if the head stops within the right track, but outside the mandated tolerance about the center line?
- You would need to compensate this positioning error by rotating the stator and the rotor (together) of the stepper motor…



The issue

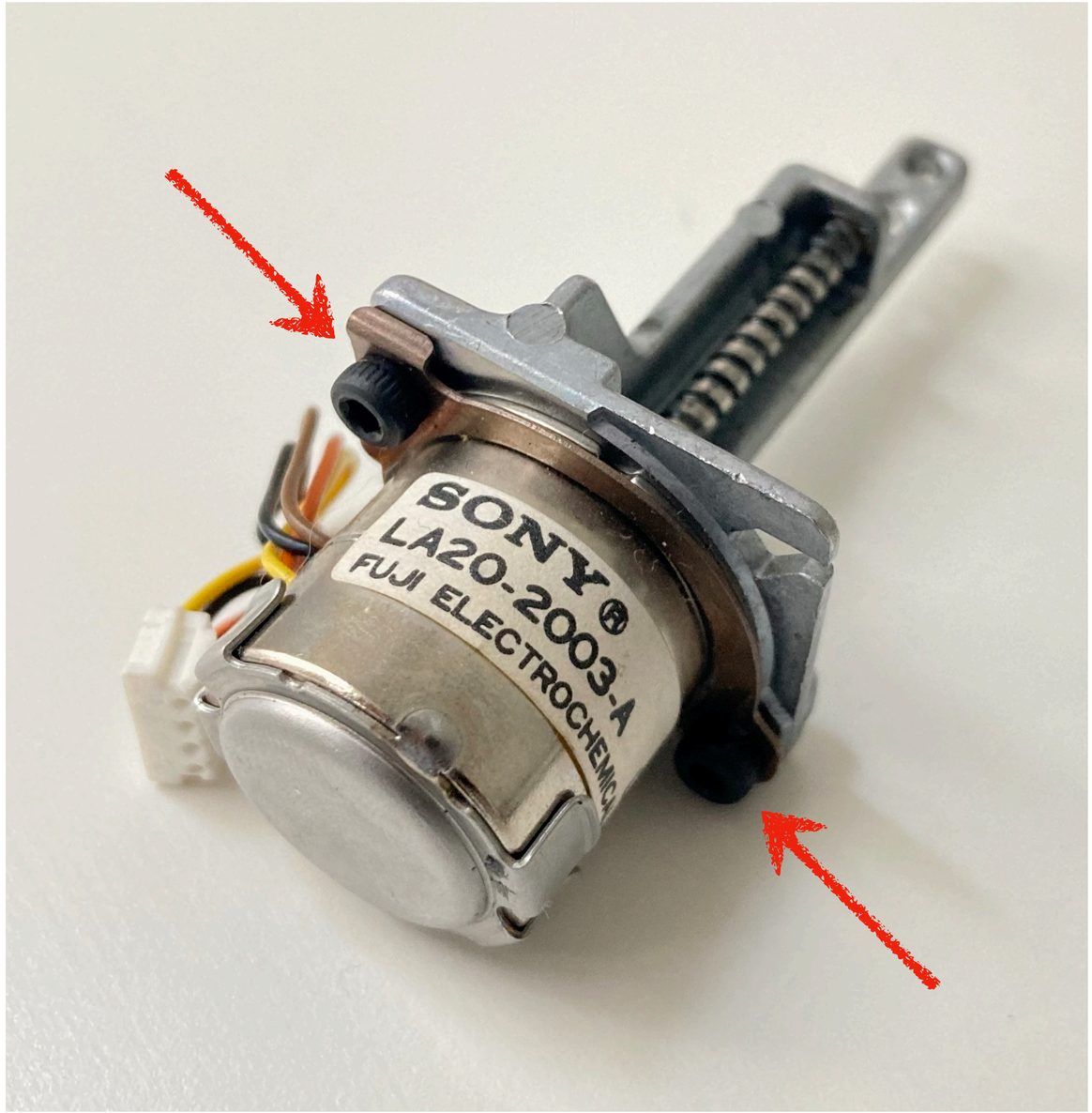
- One revolution of the stepper motor is split into 10 steps of 36 deg each, so 1 degree rotation of stator and rotor together would correspond to 0.0052 mm.





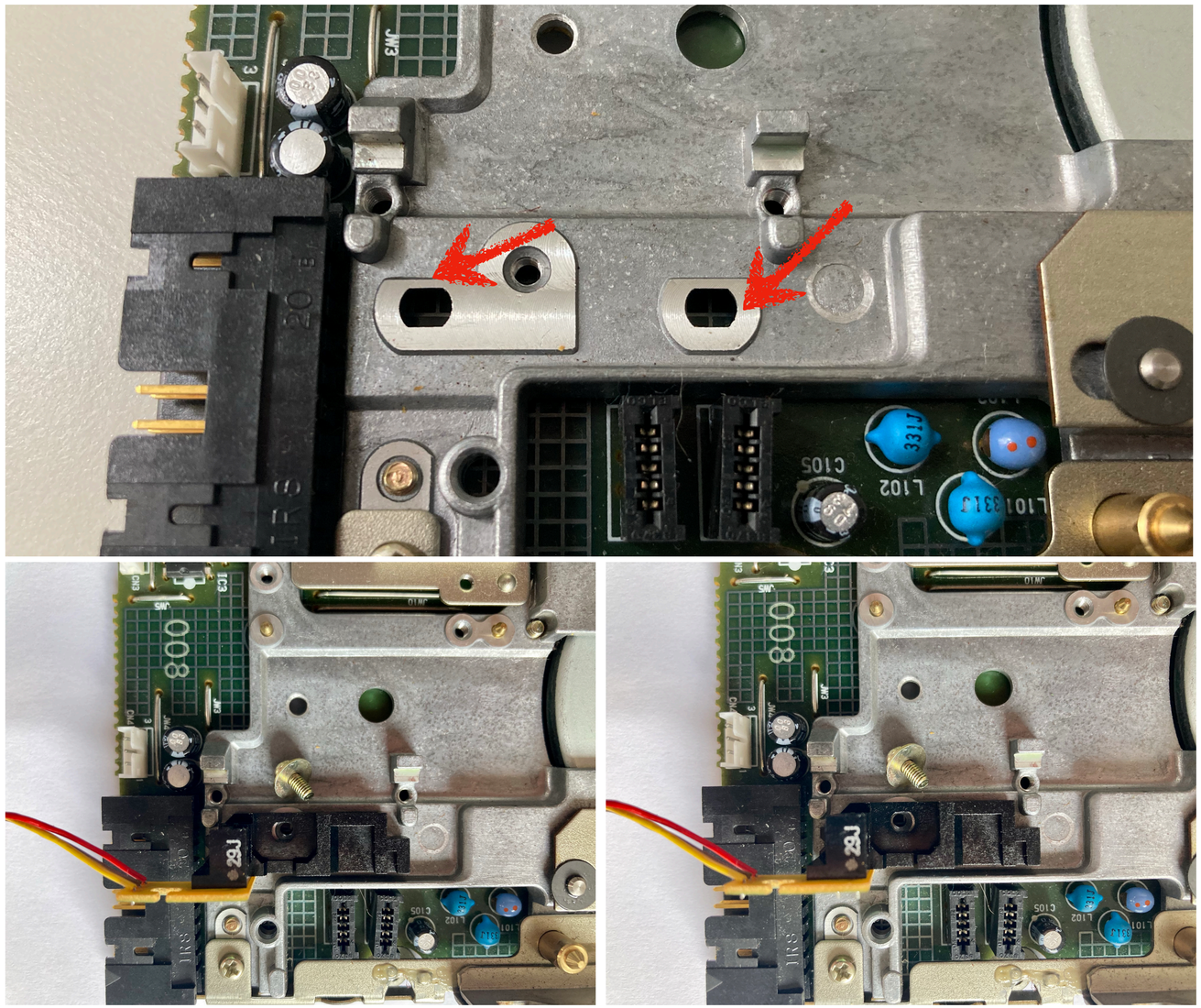
The issue

- However, such a situation is extremely unlikely, since the stepper assembly was factory calibrated and sealed against accidental rotational drifting.
- So, unless someone has messed it up, you just don’t want to touch it!



The fix

- All you want to do is to adjust the position of the ZTS in such a way the head stops again at the 0 track of a reference disk.
- The sensor assembly allows an adjustment of approx 0.5 mm, exactly for this purpose.



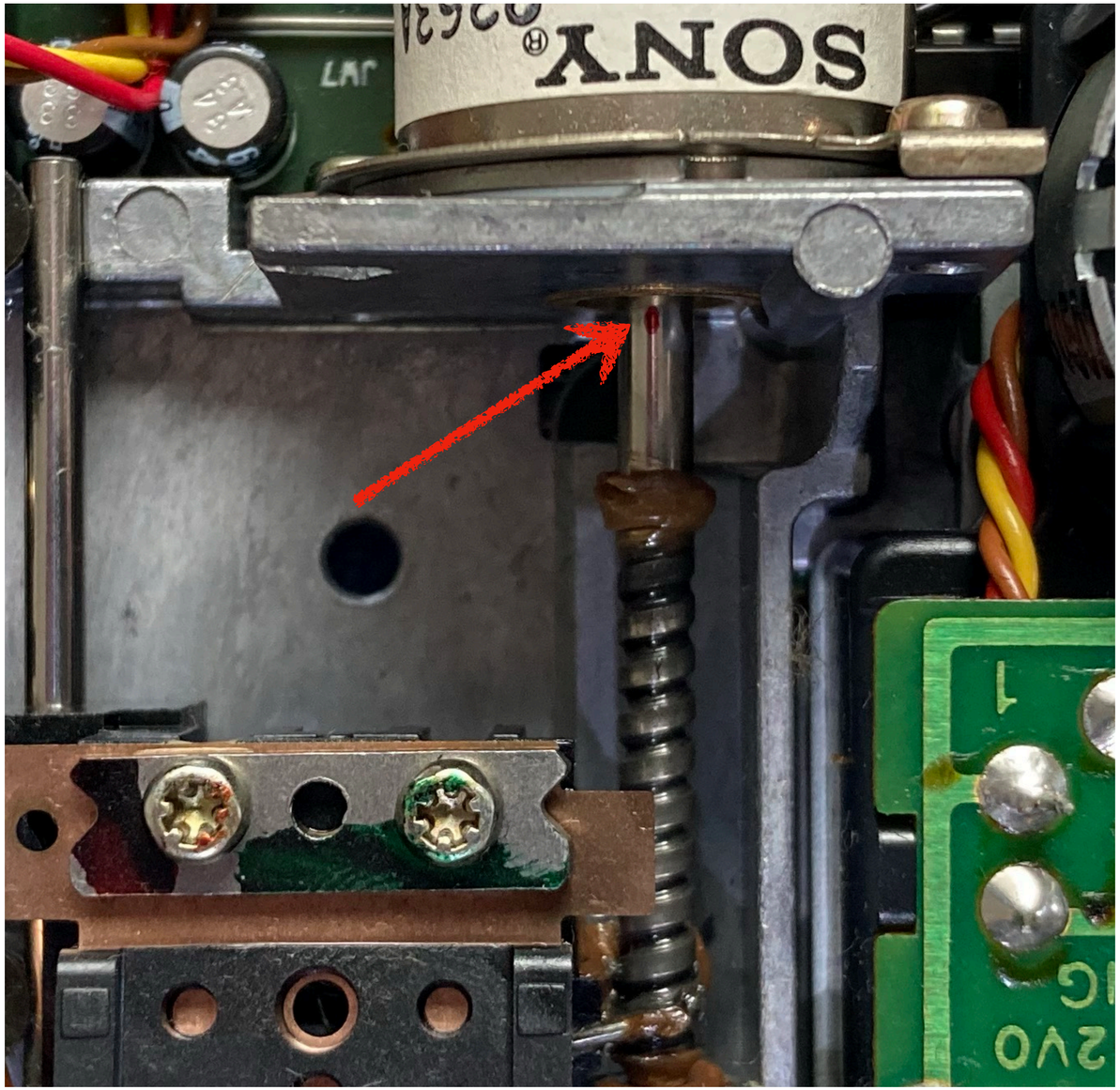
The fix

- These are very tiny numbers, which can only be appreciated by precision tools.
- Workshop calipers usually have +/- 0.01 mm precision, micrometers +/- 0.001 mm.
- So, how to control such small adjustments?

The fix

- The point is that you don’t want to measure the position of the sensor, you just want to be able to check <u>if and by how many tracks</u> the head is changing its initial position as a consequence of the sensor adjustment.

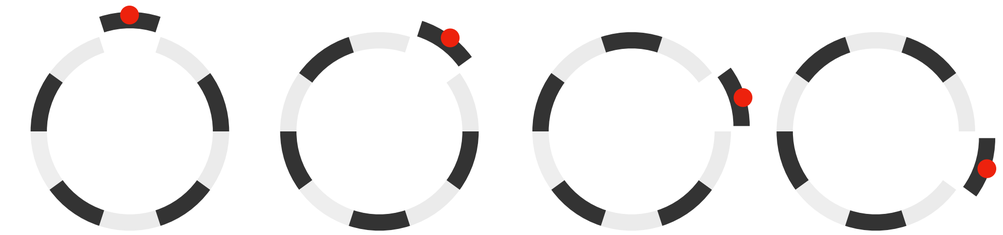
- As 1 track corresponds to 1 rotational step, the moment you mark the initial position of the shaft with a tiny dot, you can have a direct, visual feedback of the direction the adjustment is taking.

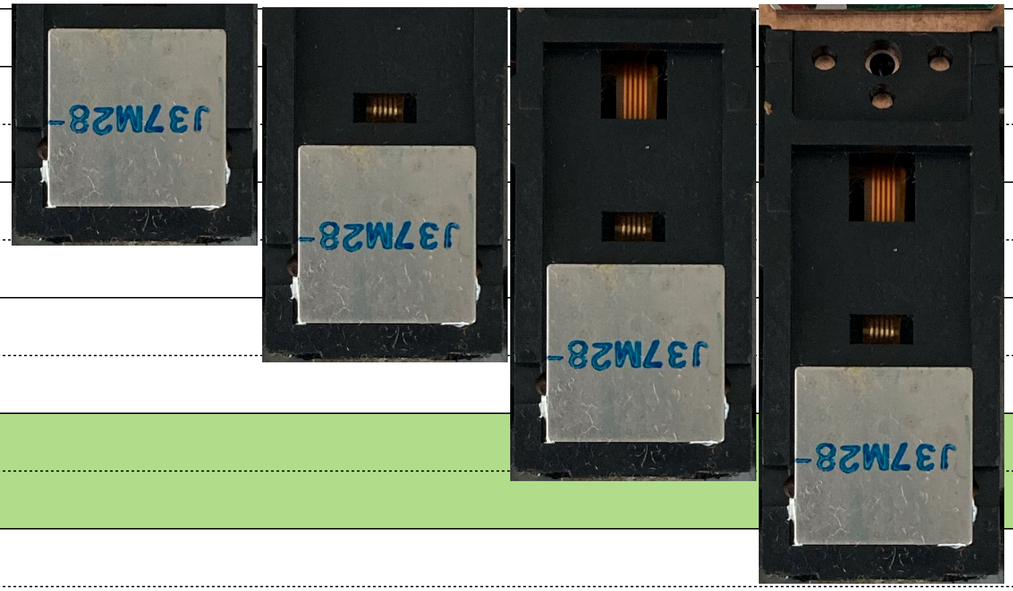


Zero track adjustment

Suggested Procedure

- Clean up and oil / grease the mechanical bits.
- Make a reference disk with a good drive.
- Loosen up the screw and move the ZTS all the way to the back.
- Now insert the disk and let the head move all the way back, too (it will probably stop at track -3).
- Mark the reference position of the rotor with a tiny dot (fine tip permanent marker). If it’s difficult to reach, you can first (software) eject the disk, since the stepper responds with an exact number of revolutions (4) to the eject command.
- Now, with the drive unloaded, slightly move the ZTS forward.
- Insert again the disk and check if at the end of the loading, the mark is now in a different angular position. If so, it means the adjustment to the ZTS has sorted some effect.
- You will need some practice for stepping exactly one track at a time.
- Proceed until the reference disk can be mounted: my experience is that just 4 rotational steps from the very back are sufficient (i.e. skipping the “faux tracks” -3 to -1 for landing on track 0).





40.0625	Track -3
39.8750	Track -2
39.6875	Track -1
39.5000	Track 0
39.3125	Track 1
39.1250	Track 2

Zero track adjustment

- Eventually, you will be able to mount a reference floppy, format it and exchange floppies with other good drives.