Lisa repair

written by Sergio Gervasini for ESOCOP
The European Society for Computer Preservation
https://www.esocop.org/

in collaboration with All About Apple Museum
https://www.allaboutapple.com/

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License

References

FAQ gathered from a variety of sources:

https://lisafaq.sunder.net/

Good Things to Know About Lisa:

http://www.applerepairmanuals.com/lisa/goodthings.pdf

Lot of documentation about Apple machines:

https://ftp.apple.asimov.net

Useful things

Floppy Emu, emulator for floppy disk:
https://www.bigmessowires.com/floppy-emu/

ESP32-based emulator and diagnostic tool for ProFile and Widget hard drives:
https://github.com/alexthecat123/ESProFile/

BLU (Basic Lisa Utility). Useful to analyze and diagnose.
http://sigmasevensystems.com/BLU.html

Utility for widget hard disk diagnose and fix.
https://github.com/stepleton/NeoWidEx

Introduction

Sergio Gervasini, Vicepresident of European SOciety for COmputer Preservation

When the All About Apple Museum in Savona (Italy) asked us to help them to let one or more of the Apple Lisas that were lying in their warehouse working again, I said to myself that it was a great opportunity to also fix the Lisa, sorry, Macintosh XL, that was in our exhibition but still not working, at that time I didn't even imagine the problems I would encounter!

Unfortunately during last years the machines had been opened, probably to attempt repairs, many pieces had been left separate from the machines themselves and some had the words "do not use" written on them. Starting from this situation I began to doubt getting many of them working again, but I didn't imagine that it would also become a kind of puzzle.

Not having a specific experience with the Lisa, I initially obtained all the available documentation, which, fortunately, can be found online and is quite exhaustive, even if the information is often fragmentary and needs to be cross-referenced between documents.

This led me to decide to approach the problem with caution, but with rigor, especially from the historical point of view; with this approach we started to identify the available parts, and to re-associate them with the relative machines, in order to have coherence between the different typologies, the relative hardware parts and serial numbers (which are not only present on the chassis, but on the internal CPU cards too).

This initial work took a lot of time, more than I expected, but it allowed us to work by concentrating the work itself on each individual machine, identifying the faulty parts from time to time, perhaps temporarily exchanging components between machines of the same typology.

Studying the technique of these machines, however, led me to become passionate about the history and especially about how and why the Apple Lisa evolved into different versions, making me appreciate more and more the work done by Apple in those years.

In all of this I have to thank Alessio Ferraro, President of All About Apple, for the support, patience and availability shown in these months of work, also allowing us to access their warehouse in search of the missing pieces, as if we were looking for ... the Lost Ark.

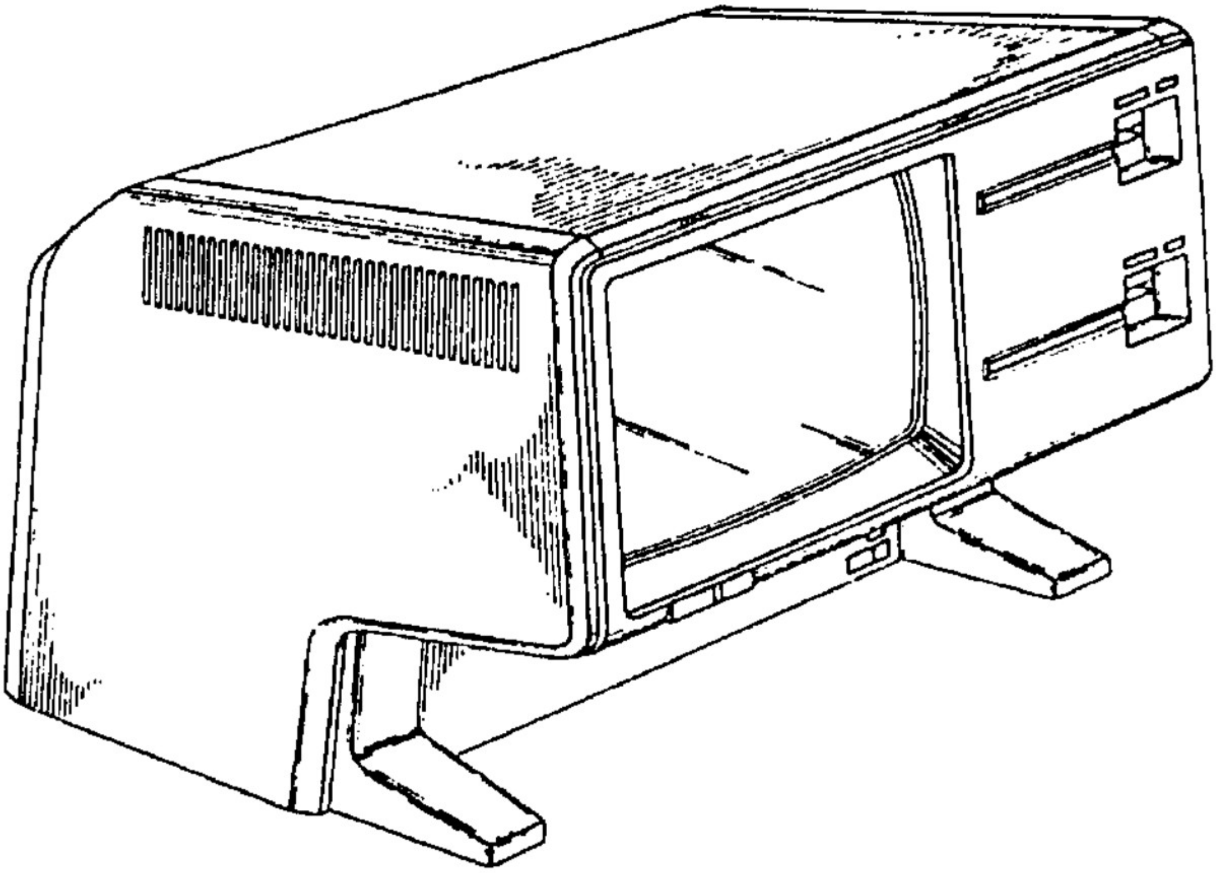
First Apple Lisas arrived at our headquarters. Other arrived later on.

Alessio Ferraro, President of All About Apple Museum

For me, the Lisa represented an ideal starting point, the symbolic element from which the Apple Museum project took shape. It was, in a certain sense, the seed that gave rise to everything: from that beginning, starting in 2002, an idea developed that progressively involved people, energy and resources, until it became a structured and recognized initiative, well beyond the initial forecasts.

The path undertaken, as stimulating as it was, was characterized by a strong organizational and informative drive, which sometimes led to privileging the collection, conservation and above all the public use of the devices, with a particular emphasis on their functionality. This inevitably led to practical choices that could not always adequately take into consideration the technical and philological value of the individual specimens. Moreover, there were constraints related to financial availability, continuous moves, operational difficulties and the absence, in some phases, of figures with specialized technical skills.

The comparison with you represented a precious opportunity to reconsider many aspects of that heritage in a more conscious light. Your expertise, your historical and technical vision, have allowed us to grasp more precisely the real importance of some machines, in particular the Lisa, highlighting their variants, original components and rarity, aspects that had not previously been sufficiently explored. It is in this perspective that I consider the work done together as a moment of growth and clarification, which I hope will not remain isolated. In fact, I believe that there are still many opportunities to continue along this line, with a view to historical and technical valorization that remains, today more than ever, fundamental to give the right meaning to what has been collected and preserved over time.



A little bit of history

Development of project "LISA" began in 1978 as an effort to create a more modern version of the more traditional Apple II.

The inspiration for the graphical interface, the true great innovation of the machine, came after a visit by Steve Jobs to Xerox's Palo Alto Research Center (PARC) where an easier way to make human interaction with the computer had already been studied for several years.

The development of the machine required the work of dozens of people for several years and it is estimated that the relative cost was about $ 50 million; Steve Jobs himself participated in the project but was excluded in 1980 because his continuous requests for more features and the search for perfection were creating tension in the team and slowing down the work.

The name Lisa is said to be derived from the name of his first daughter, a rumor confirmed by Jobs himself several years later, but for the launch on the market had been created the acronym "Local Integrated Software Architecture", even if later, privately, some developers and experts conceived other much less serious acronyms such as: "Lisa: Invented Stupid Acronym" o "Let's Invent Some Acronym".

Apple Lisa was announced on January 19, 1983. It seems that sales forecasts were 10,000 machines that year and 40,000 the following year. There are no official sales data, but various sources speak of a total of about 80,000 machines sold in the various versions, data therefore quite in line with forecasts.

However, from the beginning the Lisa suffered from several difficulties that undermined its image: too expensive, lack of software, unreliable floppy disks. This last point was probably one of the major causes of troubles, indeed already at the project start it was realized that the majority of floppy drives that came off the production line did not work well and moreover this delayed the delivery of the first machines until May.

Furthermore, in January 1984 Apple presented a computer that entered into direct competition with the Lisa: the MacIntosh, launched as a cheaper and faster machine, thus cannibalizing its own market.

After just over 2 years and despite the replacement of the original floppy disks with the more reliable 3"1/2 ones, Apple abandoned the production of the Lisa; some machines in stock (between 5000 and 7000 units) were sold to Sun Remarketing who would update and resell them as MacIntosh XL, while the last 2700 units were destroyed by bulldozers at the end of 1989 in a landfill in Logan (Utah), in order to receive a tax deduction on unsold inventory.

For the reasons above, the Lisa is considered by many people to be a failure, but from a technical point of view the machine had several advanced features that made it a milestone in the history of computers: up to 2Mb of memory (further expanded in the latest versions), expansion slots, high-resolution display, operating system with memory protection and, above all, the human-machine interface in which the use of the mouse became an integral part of a graphical mode which was only seen on a few experimental machines at that time.

How many different versions?

When we talk about Apple Lisa we usually think of 2 versions of the same machine: the so-called Twiggy Drive, characterized by 5"1/4 floppy disks and later called Lisa 1 to distinguish it from the subsequent ones, and version 2 with a single 3"1/2 floppy disk.

I also naively thought that this distinction was enough and that I could easily exchange parts between the machines of this last version (the machines available were all with small floppy disks), but the more I studied the documentation, comparing it with the machines I had available, the more I realized that such an approach would not have worked.

However, if we go over again the history of these machines we must distinguish at least 5 different types, and this becomes very important when it comes to restore them in the most correct way both from a historical and functional point of view.

Lisa	Lisa 2	Lisa 2/5	Lisa 2/10	Macintosh XL
January 1983	*January 1984*	*January 1984*	*January 1984*	*January 1985*
$9,995	$3,495	$4,495	$5,495	$3,995
1 MB RAM, external 5 MB ProFile hard disk (not pictured), two Twiggy drives	512 KB RAM, no hard disk, one 3.5-inch drive, slightly different faceplate	external 5 MB ProFile hard disk	internal 10 MB Widget hard disk, slightly different internal design	essentially a renamed Lisa 2/10 with MacWorks (Mac OS emulator) as a default OS, and sometimes a modified ROM (with square pixels among other changes)

To better identify them I will ignore the official names, but I will adopt a more descriptive approach.

Apple Lisa "1"

The progenitor machine, only a few remain (we'll see why later) is characterised by the presence of the double 5"1/4 floppy drive called "Twiggy", designed by Apple itself and which uses special floppy disks with a double window.

Apple Lisa "1" converted in "2"

Given the poor reliability of the Twiggy drives, when version 2 was released on the market, the conversion to this new version was also proposed to owners of the first version.
Therefore a kit was created to update the existing machines and this led to the creation of a model that, while maintaining the original electronics, was able to adopt 3"1/2 floppy drive instead of Twiggy drives.

Since the conversion was free, even if for a limited period of time, many people joined this proposal and therefore many Lisa "1"s became Lisa "2"s, while maintaining many of the parts of the old machine inside them.

The conversion involved changing some parts, such as: cage assembly for floppy disk, Lisa 2 front panel, 2 CPU board ROM, 1 I/O board ROM.

Inside the "cage assembly" for the floppy there is, in addition to the 3"1/2 400k drive (made by Sony, the same used in the very first MacIntosh), also a small card called "Lisa Lite Adapter Disk Interface Card" that allows you to adapt the signals previously intended for Twiggy drives.

Apple Lisa "2" (with or wihout 5Mb Profile external hard disk)

Officially called 2 and 2/5, they have a single 3"1/2 drive and optionally an external unit called Profile with a 5Mb hard disk (rarely 10Mb) connected to the parallel port.

They are based on the same architecture as the Lisa "1", and are practically indistinguishable from the previous ones, the difference is only given by a historical fact: the machines already sold were converted aftermarket, while those still in Apple (finished or not yet assembled) were transformed in the factory before being sold.

Apple Lisa "2" with internal 10Mb hard disk ("Widget")

Called Lisa 2/10 (although the name seems to be common to the machine with the 10mb Profile), it includes a 10Mb internal hard disk housed above the floppy drive.

The motherboard and the I/O card are different and there is no parallel port the Profile was connected to in the previous version; so in this case we are dealing with machines born with this configuration and not converted.

Apple Macintosh XL

Basically a 2/10, but with several hardware and software changes to make the Lisa run the same software as the MacIntosh.

The modifies included: changing ROMs, adding a "screen kit" to accommodate the new video resolution, and installing the MacWorks software, which later became MacWork Plus when development was taken over by Sun Remarketing.

Let's see the differences

Motherboard

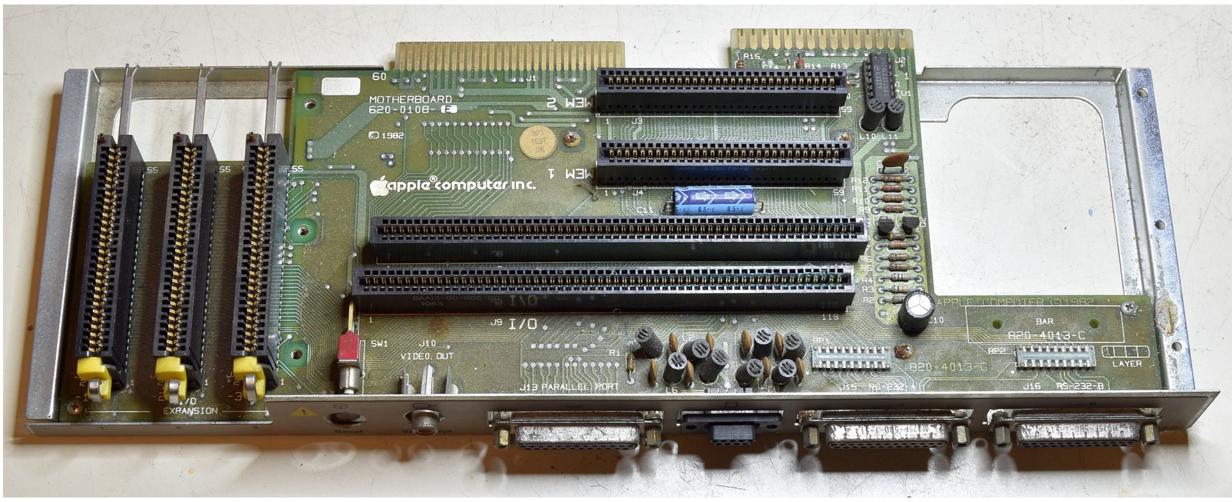
Back panel Lisa 1 – 2 - 2/5

Back panel Lisa 2/10 – MacIntosh XL

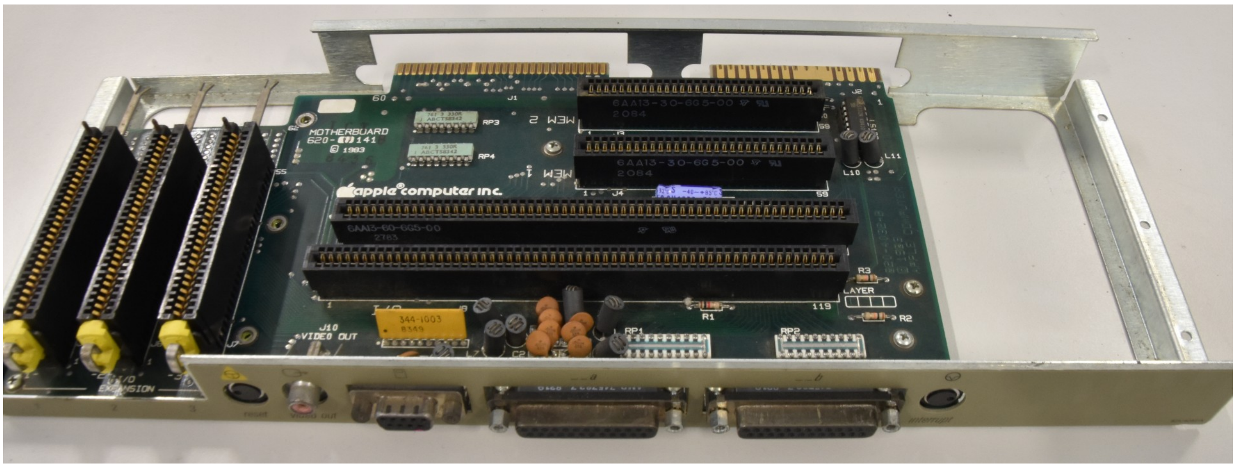
As you can see, in the later versions it was decided to eliminate the parallel port, which can only be added as an option with a dedicated card, on the other hand a new button called interrupt appeared.

Also note the mouse connector, in the first models it allowed the insertion of only its custom mouse, while later a more standard DE-9 was adopted which also allows the use of MacIntosh mouse.

Lisa 1 mouse connector



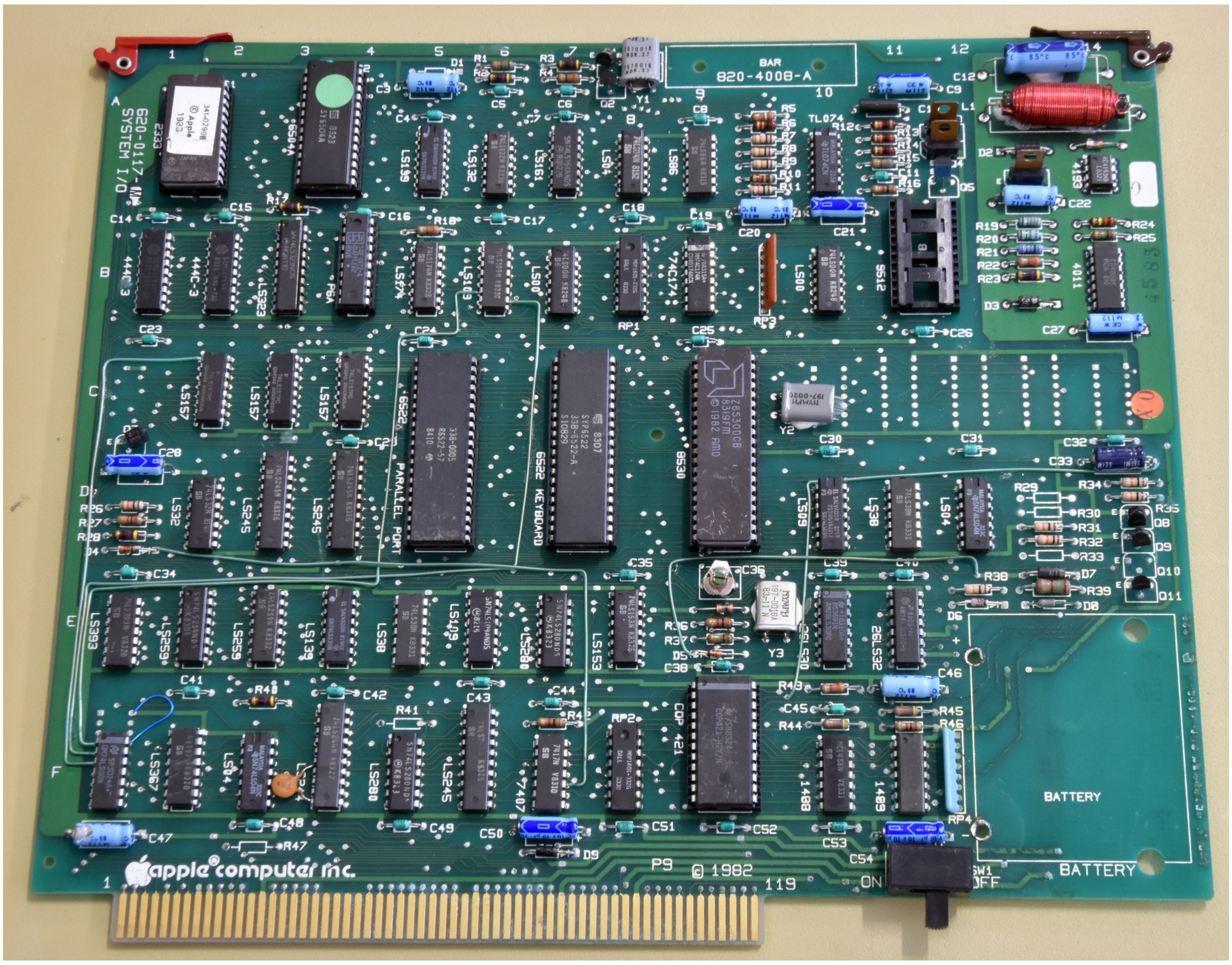
Motherboard Lisa 1 – 2 - 2/5



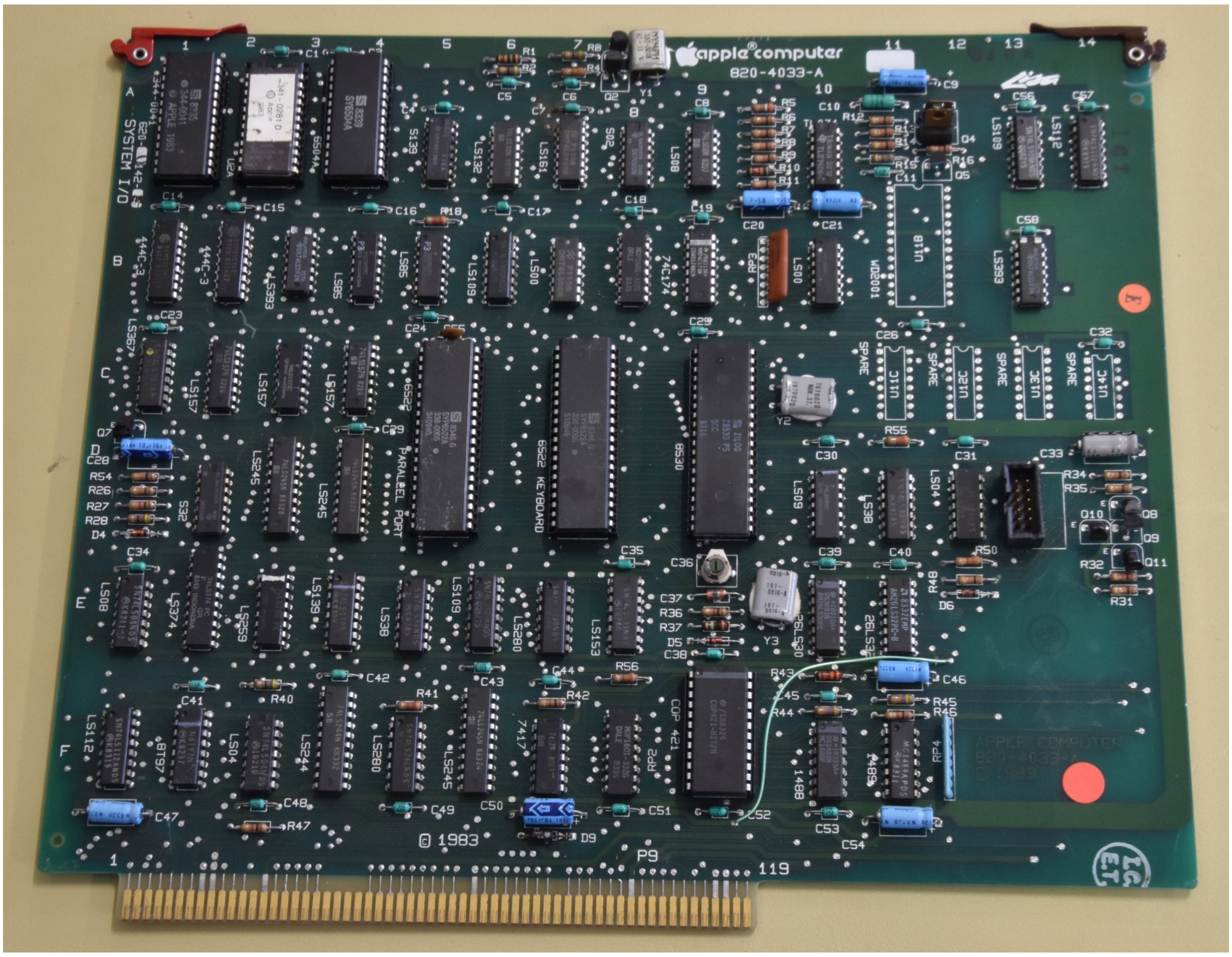
Motherboard Lisa 2/10 – MacIntosh XL

Given the elimination of the parallel port, it was possible to save on the size of the printed circuit board and move the block of external connectors to the left.

I/O Card



Lisa 1 - 2 - 2/5 I/O Card



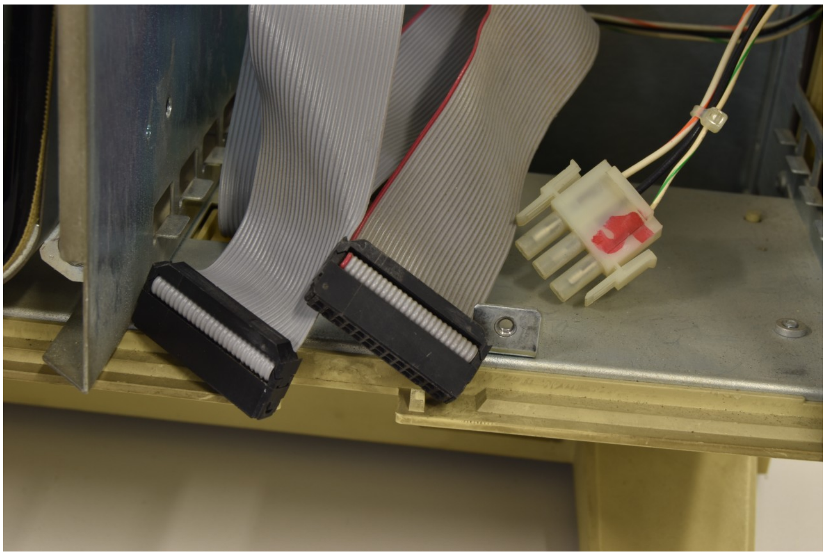
Lisa 2/10 – MacIntosh XL I/O Card

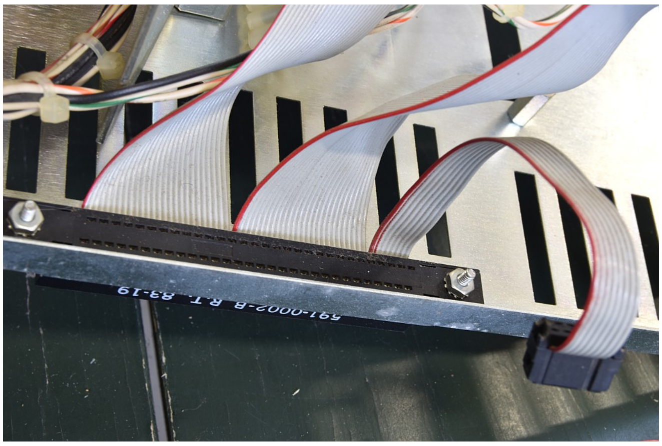
The I/O board has been deeply revised compared to the first version, first of all the batteries have been eliminated, the controller for the 3"1/2 floppy disks has been added.

The two boards are therefore absolutely not interchangeable between the various models, also because the wiring of the machines is different (see later).

Cabling and chassis

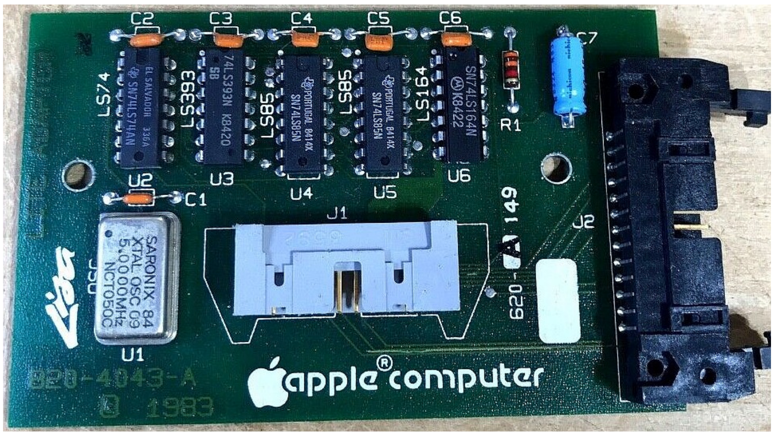
Another difference can be seen internally, in the area where the Twiggys are housed in the Lisa 1 and where the 3"1/2 floppy disk is located in the later versions. In the Lisa 1 there are 2 flat cables of equal width, where the Twiggys are connected, plus a power connector.



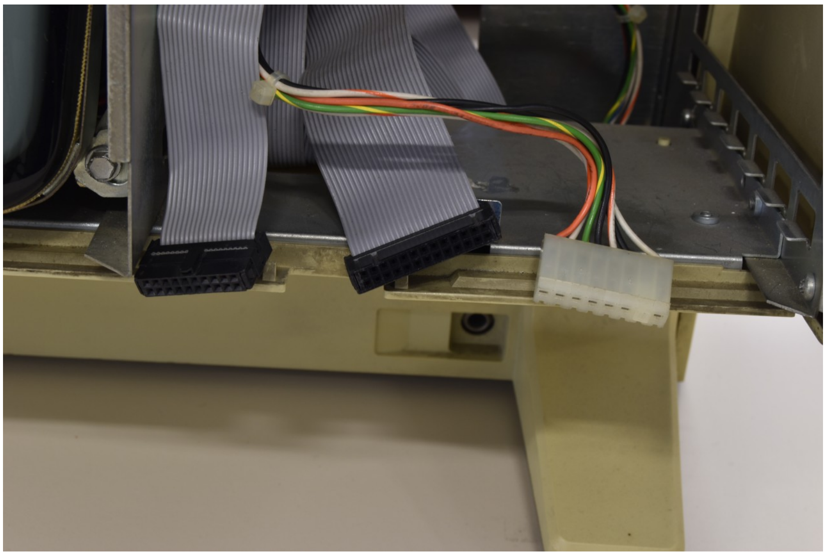


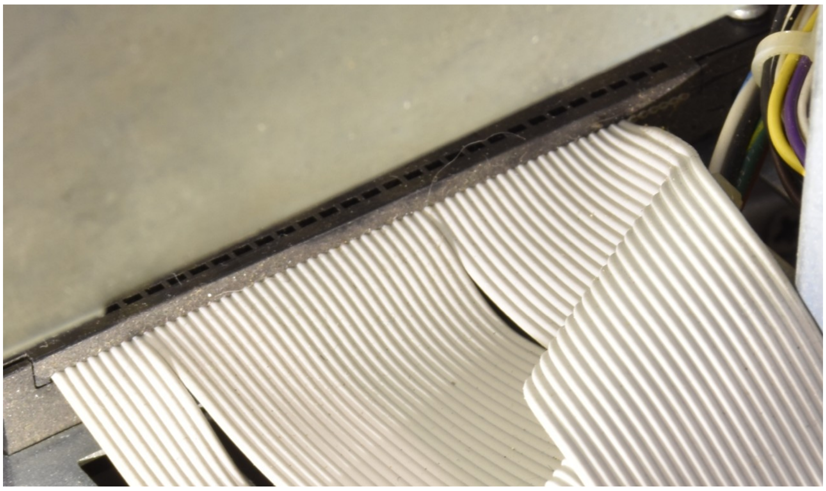
Detail of the connection of the flat cables on the motherboard connector in a Lisa 1

The conversion from Lisa 1 to 2 also involved the insertion of this adapter card to allow the connection of the 3"1/2 floppy disk



In later versions the two cables have different widths, as they are used to connect the 3"1/2 floppy disk and the Widget, the internal hard disk. Furthermore, the power connector is larger as it carries different voltages.

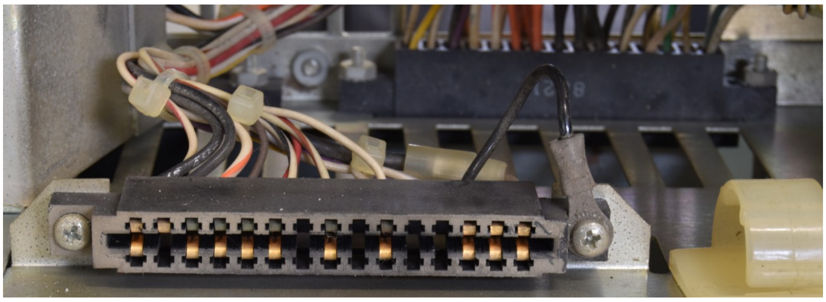




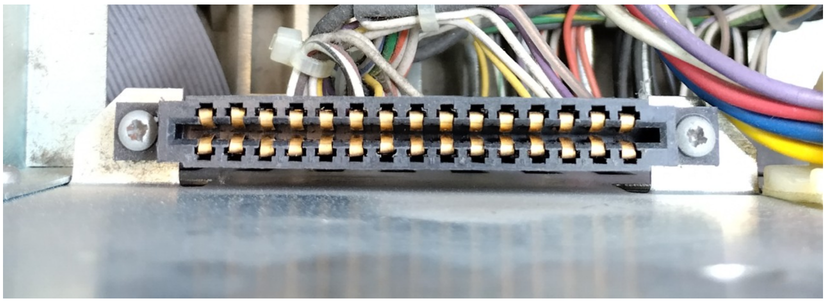
Detail of the connector of a Lisa 2, where we can see that the narrower flat cable (which connects the floppy disk) is obtained by cutting the excess part.

Other notes

A curious peculiarity found on a first series machine is the presence of connectors in which only the contacts to which the cables are connected are present...

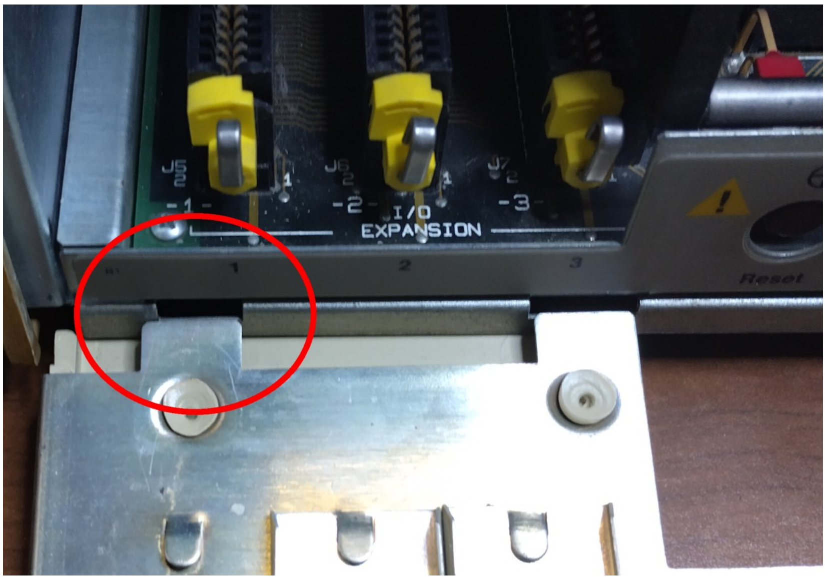


...which is not found in other machines.



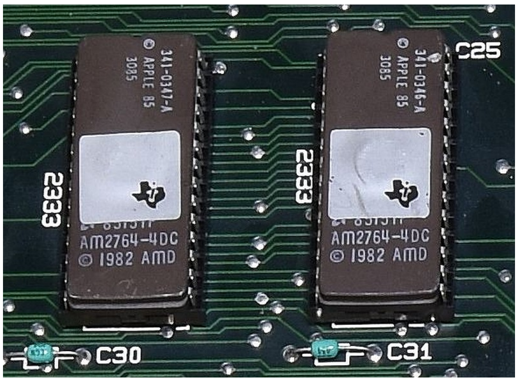
One last curious thing is the different size on the chassis of the compartment that should house one of the flaps on the rear cover compared to the flap itself.

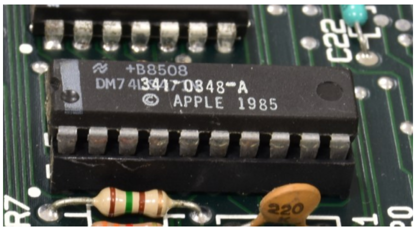
Unfortunately one of the machines was missing the rear cover, which was probably the one adapted to this difference in size.

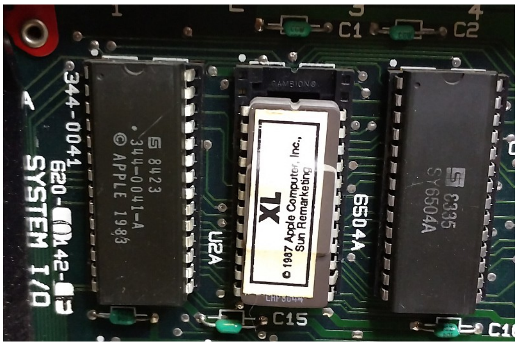


Macintosh XL

The MacIntosh XL, had a different BIOS and prom on the CPU board, and a different EPROM on the I/O board. It is also distinguished by the presence of a transformer glued to the right side near the video card, necessary to change the horizontal width; on some machines it has been removed but often the marks of the adhesive used remain.







Pratically, the MacIntosh XL is a very different machine from the Lisa altough it maintains its hardware, since the changes to the PROM/EPROM revolutionize its operations (so much that the basic Lisa software no longer works) and also involve changes in the video resolution.

In this way the Lisa 12" video is used despite the 9" Mac's obtaining an higher resolution (608x432 compared to 512x342). Moreover when using MacWorks (software for MacIntosh emulation) square pixels are used, instead of the rectangular pixels typical of the Lisa and this allows you to have correctly proportioned images.

The repairs

The first step when working on an old computer is to check the power supplies, in the case of the Lisa you are dealing with two different power supplies, with different powers depending on the versions.

Other different parts are the I/O cards, and the serial numbers on the CPU cards; to make a philologically correct restoration, especially when you have cards mixed between the machines, it is important to correlate the serial numbers of the chassis with those of the CPU cards, since this data is also present on a prom.

Last, but not least, it is necessary to correctly identify the type of Lisa, among the 5 we have listed, to avoid confusion between the cards, chassis and accessories.

Then it is a question of identifying the faulty parts and repairing them; having different machines helps by exchanging the cards, but always being careful to maintain consistency between these and the type of machine.

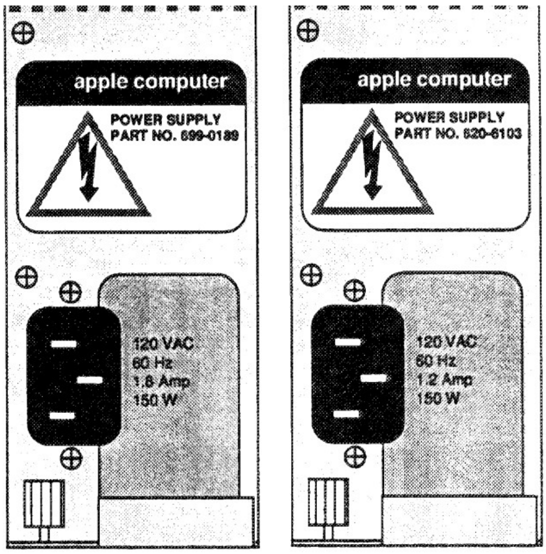
Power supply

The power supplies, as mentioned, are of 2 different types: one 1.2A, used in machines without an internal hard disk, and another 1.8A for later machines.

They are easily removed from the chassis, just unscrew the knurled screw at the bottom and once free, pull firmly on the flap next to the screw, possibly levering it with a screwdriver (see photo).

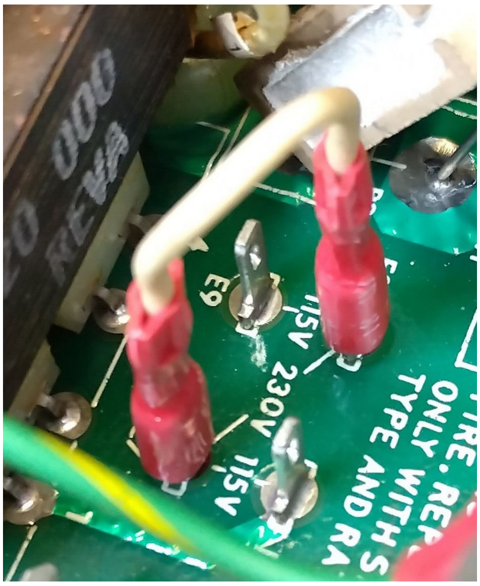
Do not use two potentiometers at the top to help yourself, they are very delicate and could break.

Even though they are different, strangely the declared power is 150W for both models, in the manuals they are indicated in this way:



In our case we are dealing with machines suitable for European voltages, so the names changes and the amperes are 1 and 0.7 (but remains confusion regarding the 150W):

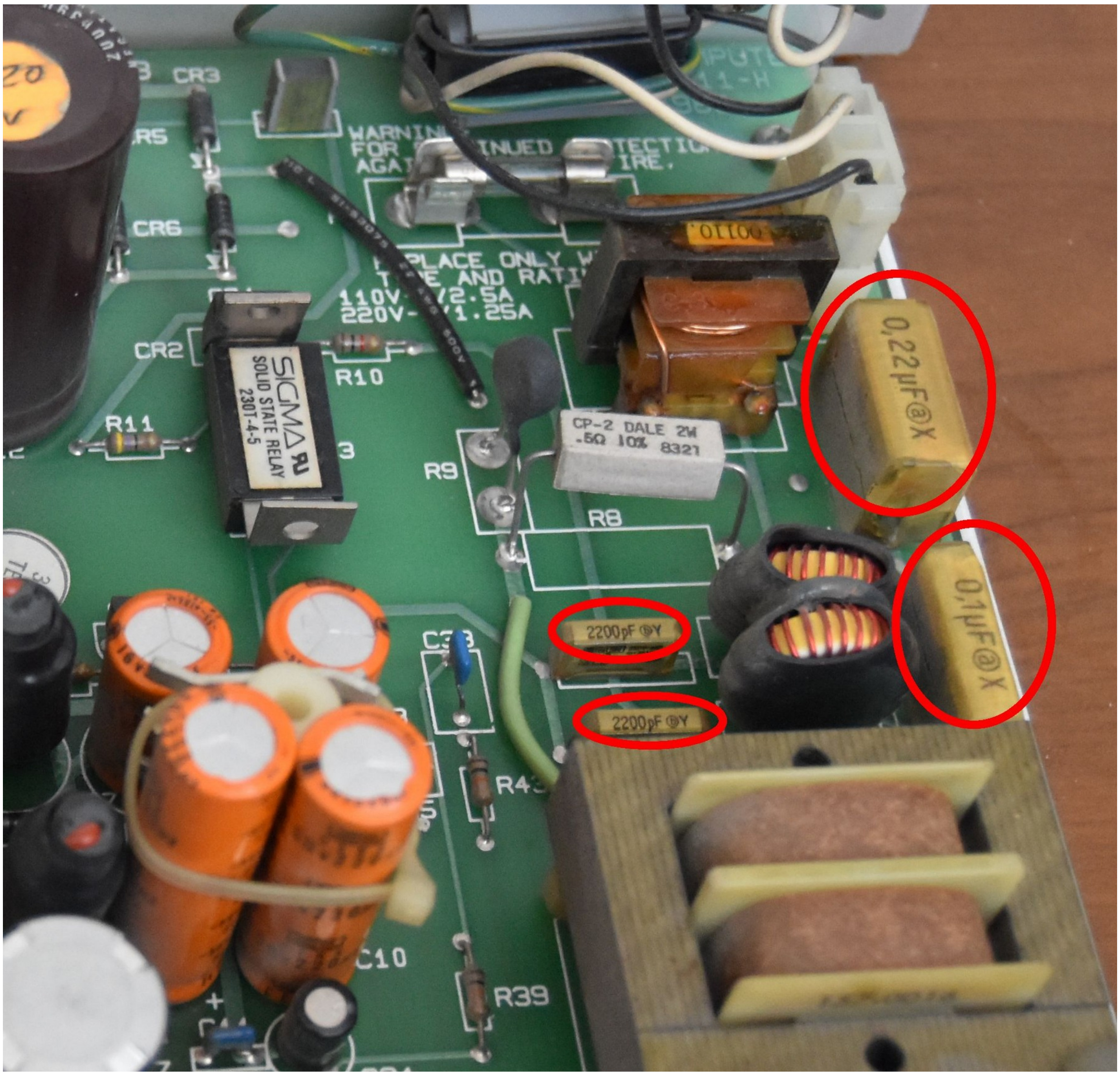
In the 1.8A power supplies there is also the possibility to switch the voltage through 2 jumpers inside, which is not possible with the 1.2A ones.



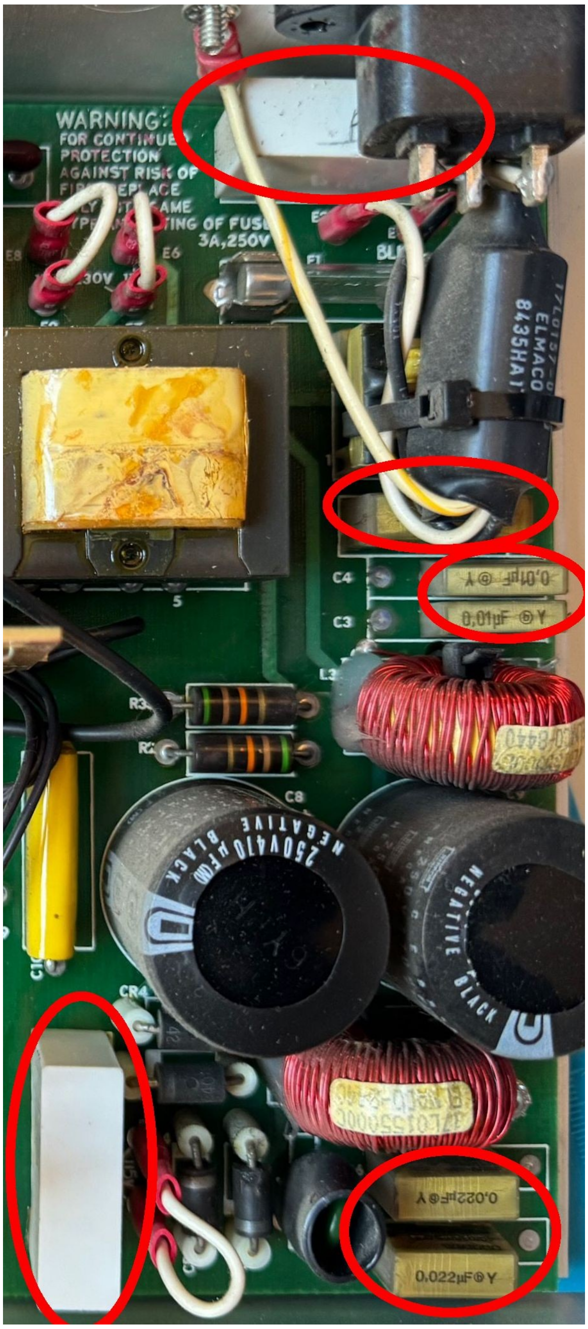
Power supplies usually do not cause major problems, as long as all RIFA filter capacitors are replaced, otherwise they will explode with a smelly smoke that stagnates for hours.
Apart from the fear caused by the bang, normally no other damage occurs and therefore they can be replaced without problems even afterwards!

In the photos some examples of exploded RIFAs ....

These are the capacitors to replace on the 1.2A power supply:



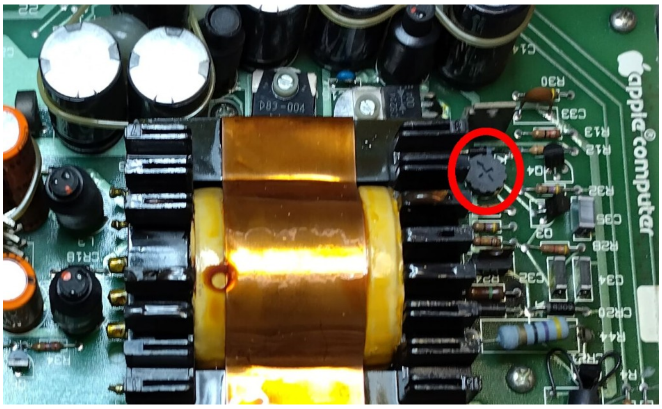
These are to be replaced on the 1.8A power supply, some are a bit hidden and the white ones are already the replacements:



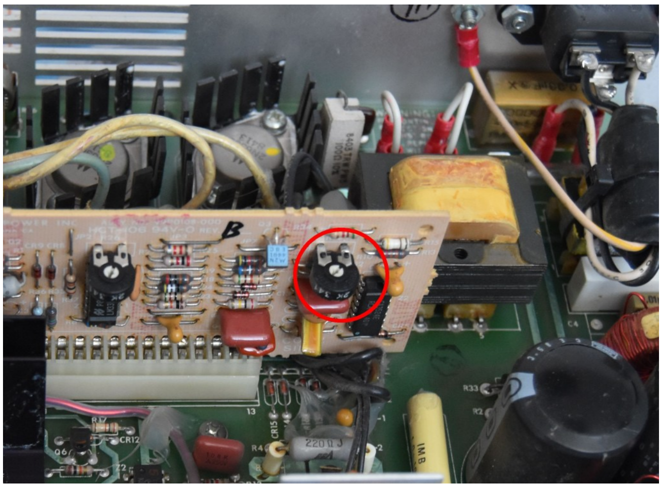
Unlike many vintage power supplies, it does not seem necessary to replace the electrolytic capacitors, there are no leaks or swelling and, being produced in Japan, they are not affected by the "capacitor plague". (https://en.wikipedia.org/wiki/Capacitor_plague).

Particular attention should be paid to the internal trimmers that regulate the output voltage, normally it should not be necessary to touch them, but a check is always useful and the voltages, in particular the 5V, should be checked with the machine turned on.

This is the trimmer on the 1.2A power supply:



The trimmer on the 1.8A power supply would be accessible even without removing the cover, as there is a hole that allows access with a screwdriver, but unfortunately it is not easily visible, nor it is possible to adjust the voltage while powered on, so if it'd be necessary to touch it, it would be better to open the cover itself:



In this model, you can see that the trimmer is mounted on a vertical board that has a seemingly solid connector. Unfortunately, that type of connector is instead subject to false contacts, especially after years of inactivity. To solve the problem, simply unplug the board and put it back a few times to clean the contacts and thus avoid instability.

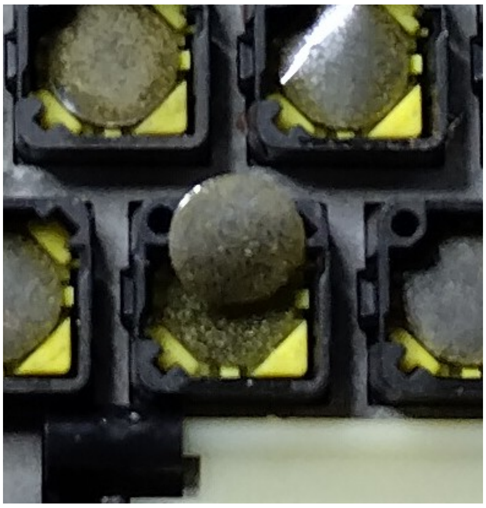
Keyboard

On the old computers, especially in the 70s and 80s, Keytronics keyboards, like those used in the Lisa, were often used, the reason was mostly about they did not have electrical contacts but were based on a capacitive effect and were therefore considered "eternal".

For many years it worked this way, but for us who repair old computers, the definition of "eternal" it's quite funny, since these keyboard often do not work anymore.

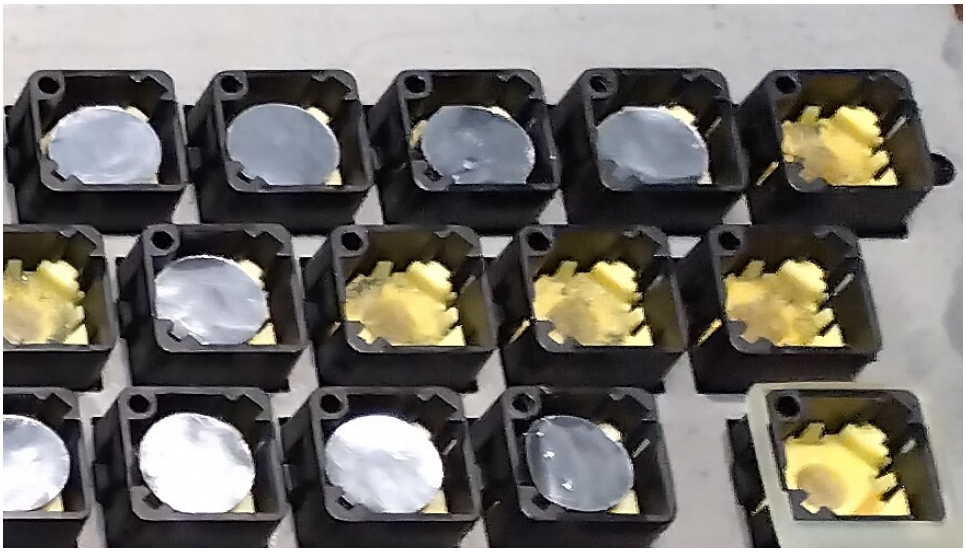
The problem it's quite easy to understand: over the years, the sponge under each key pulverizes and therefore no longer allows the approach of the "thin plastic" that enable the capacitive effect to the card below, simply it does not work any more.

In order to rapair these keyboards, we just need to remove them completely and replace the sponges and the relative layer of mylar (that is the material of which is composed the "thin plastic").



Detail of a key where the sponge has disgregated.

Some enthusiasts have found a way to solve the problem by preparing replacement "buttons", which replace the part of the key that creates the capacitive effect. They are offered for sale on retrocomputing e-commerce sites, but they can be made at home, albeit with a lot of patience as you can find here: https://www.esocop.org/docs/RestorationKeytronicsKeyboards.pdf



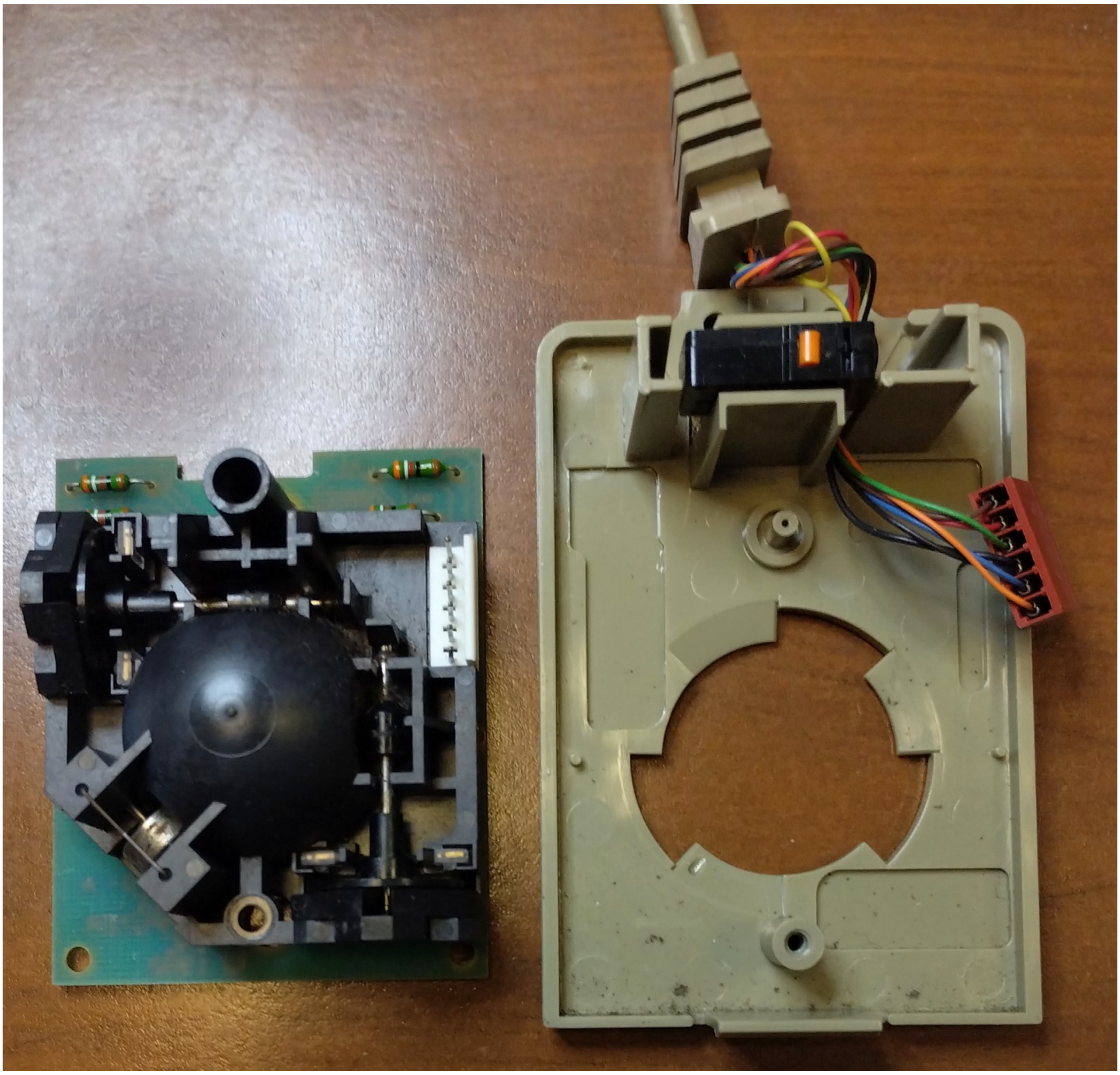
And here it is the keyboard during the replacement work, the operation itself it's quite simple but almost tedious because it must be repeated for all the keys.

Mouse

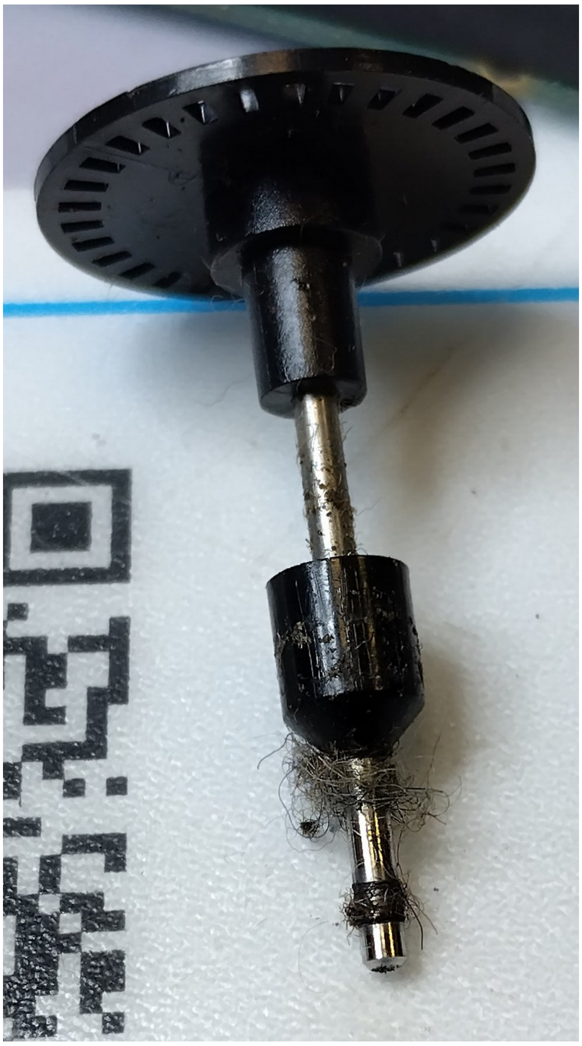
The "thin button" mouse typical of the first Lisas now it's almost impossible to find, especially if in its original box:

For this reason, as soon as we noticed that it wasn't working well (it didn't slide well vertically) we decided to clean it from the inside, obviously taking all the necessary precautions.

Disassembling it is simple, there are 2 screws on the outside and one on the inside, here it is what you find:

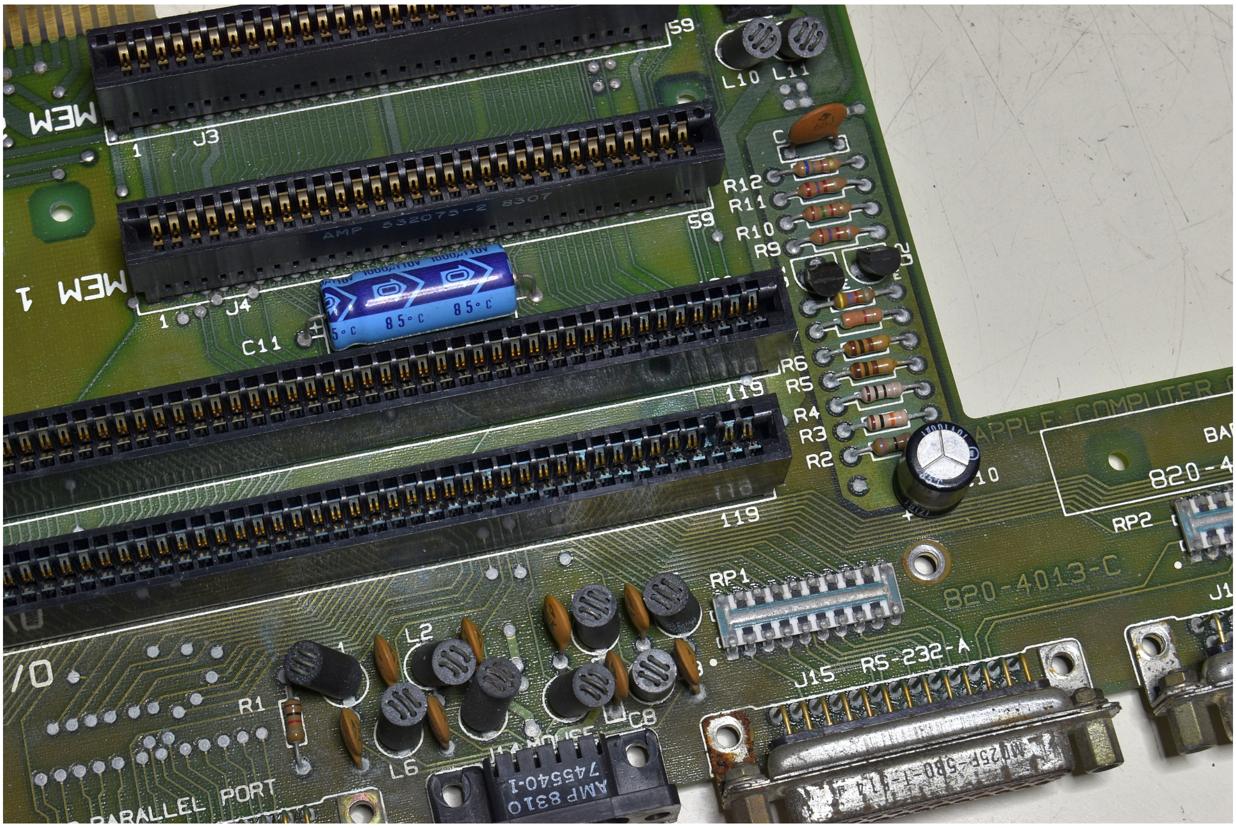


Of course, a good cleaning was enough...



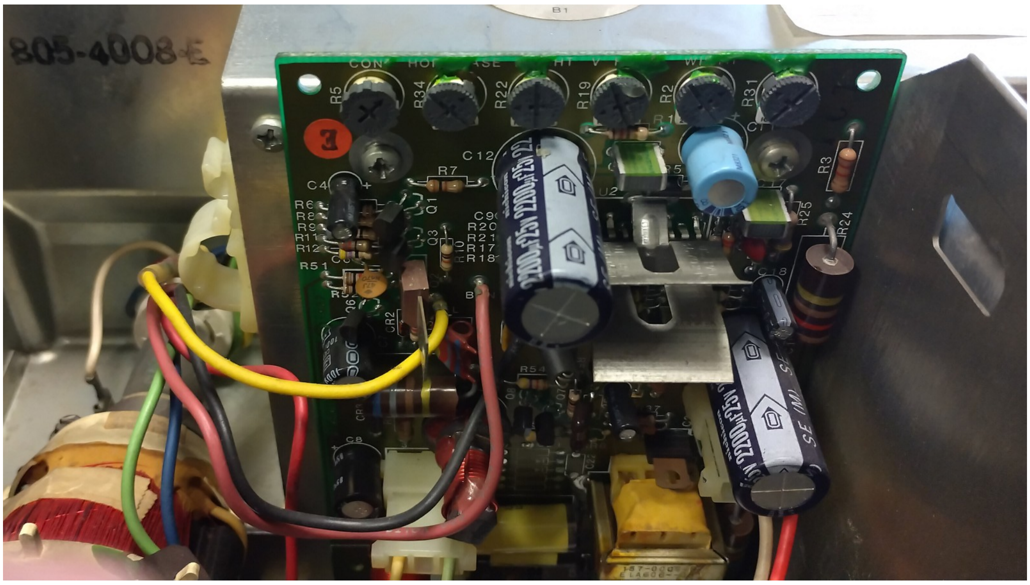
Motherboard

As mentioned, motherboards are different depending on the type of machine. In the first versions, the I/O board also housed a battery that over the years lost acid, so it happens that you have damage not only on the I/O board but also on the motherboard connector where the board itself was housed.



In this case, as you can see, the corrosion has even caused one of the contacts to be lost. Unfortunately, the only solution is to change the connector itself, a fairly complex job as it involves a 120-pin card edge connector which, among other things, are not easy to find.

Video Board

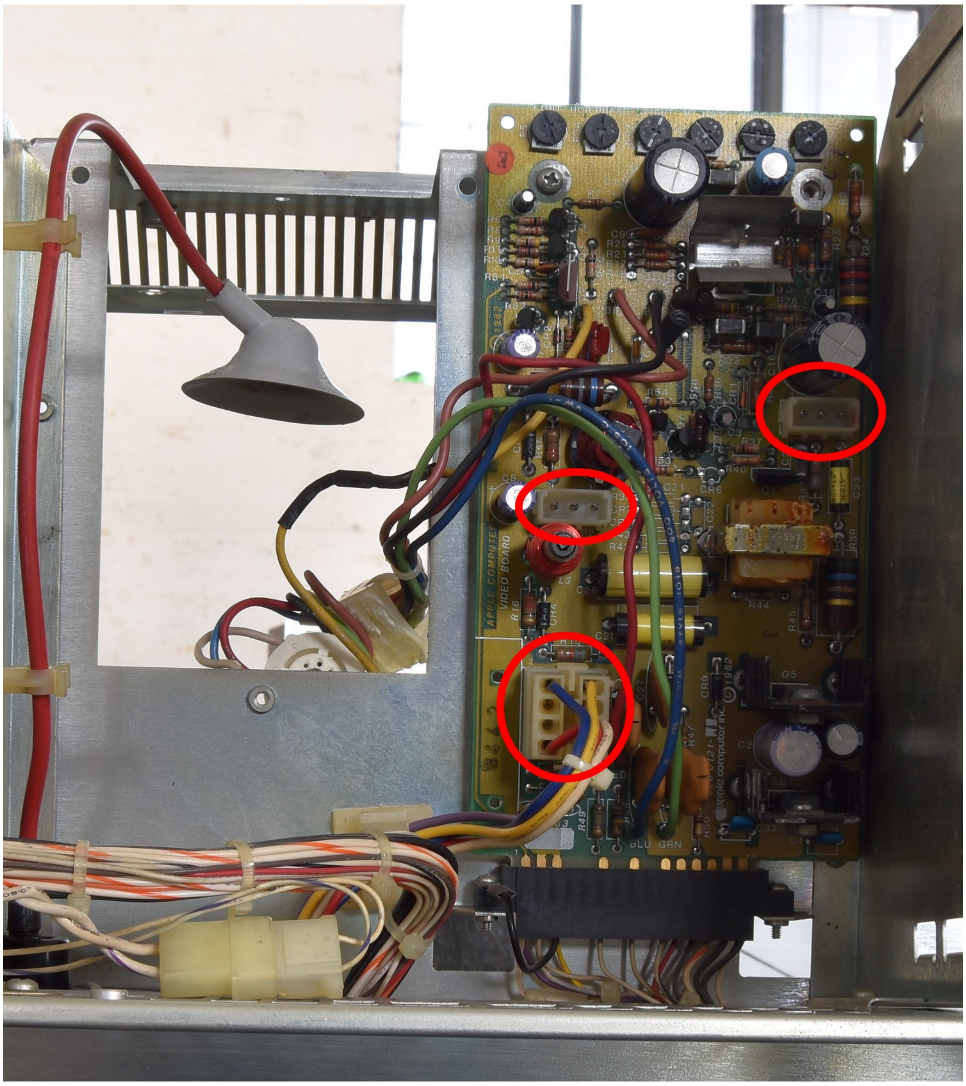


The CRT control video card inside the Lisa

Normally these cards should not cause major problems ... on the contrary a huge amount of unforeseen troubles have arisen. In case of failures, taking measurements is practically impossible, given the position of the card, so you have to remove them from the chassis hoping to find the broken component with cold measurements.

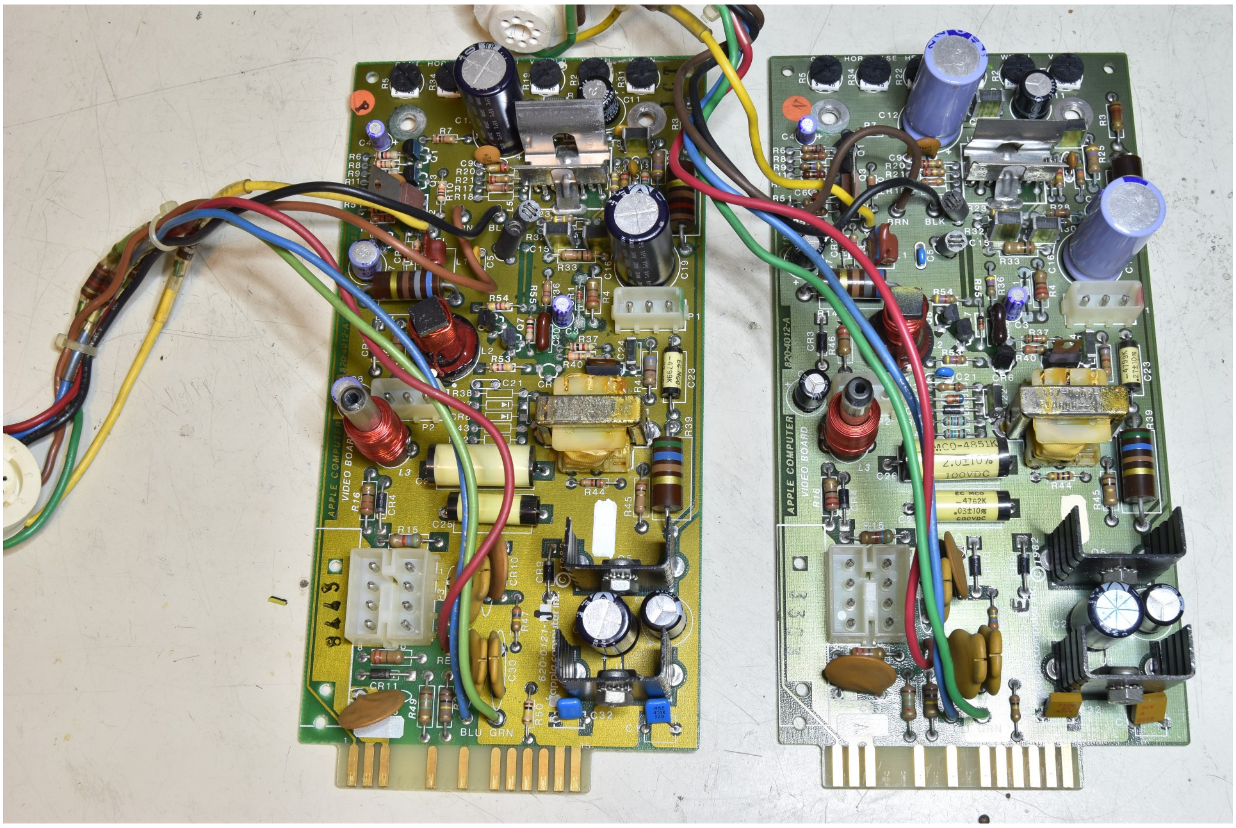
Dismantling this board is complicated because it is not enough to unscrew the two screws that fix it to the chassis, but you also have to detach 3 connectors lower down and the space is limited.

In the following photo, taken after having dismantled the CRT too, the connectors are highlighted, the lowest one is the largest and most difficult to detach, in fact you can still see it connected in this photo :)



In addition to the connectors, you need to detach the socket that goes to the CRT. To do this, you need to remove the protective screen located behind the CRT itself (in the previous photo it has already been removed).

At the end of the operations we finally have the card in our hand, in the photo we see 2 of different releases:



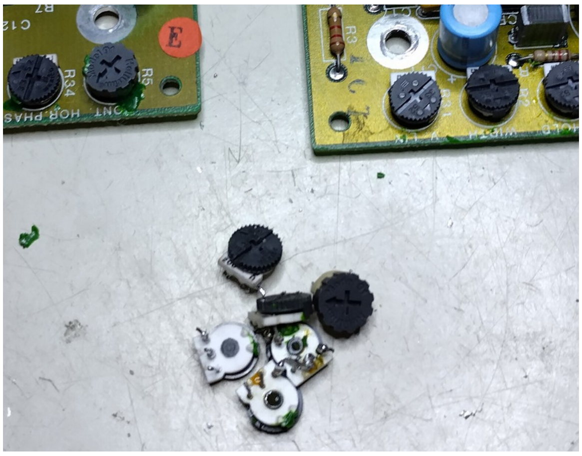
In the diagrams found online we can understand the differences between the various releases, which are actually quite limited:

REV.	ZONE	ECO #	REVISION	DATE	APPD
A	—	B085	INITIAL RELEASE		—
B	4C	B098	PIN 3 WAS PIN 2, ADDED PIN 2 ADDED SHIELD ON TTL VIDEO	23 June 82	MB PB
C	3D,C 3B,A	B176	C14 WAS 47pF, C2 WAS 220 50V, R33+45 WERE 1.2 OHM.		[illegible]
D	3D	B203	C1 & C2 WAS 100V 5%	2 MAY 83	MW for B.N[illegible]
E	3C,A 1A	B230	R24 WAS 150Ω, CR12 WAS R55, ADDED CAP TO P.S.		MB 13 June 1983
F	2A 2A	B356	C25 VALUE WAS 0.03 DELETED COIL L3, U1 & L2 VALUE CHANGE	10/19/83	T.S. for G.B.
H	3C 4C 3A 3A	B400	TDA1170N WAS TDA1170; DELETED NOTE 7. ALSO DELETED HORIZONTAL SHUT DOWN CIRCUIT. ADDED R18 AND R55.		MB 29 Nov 1983

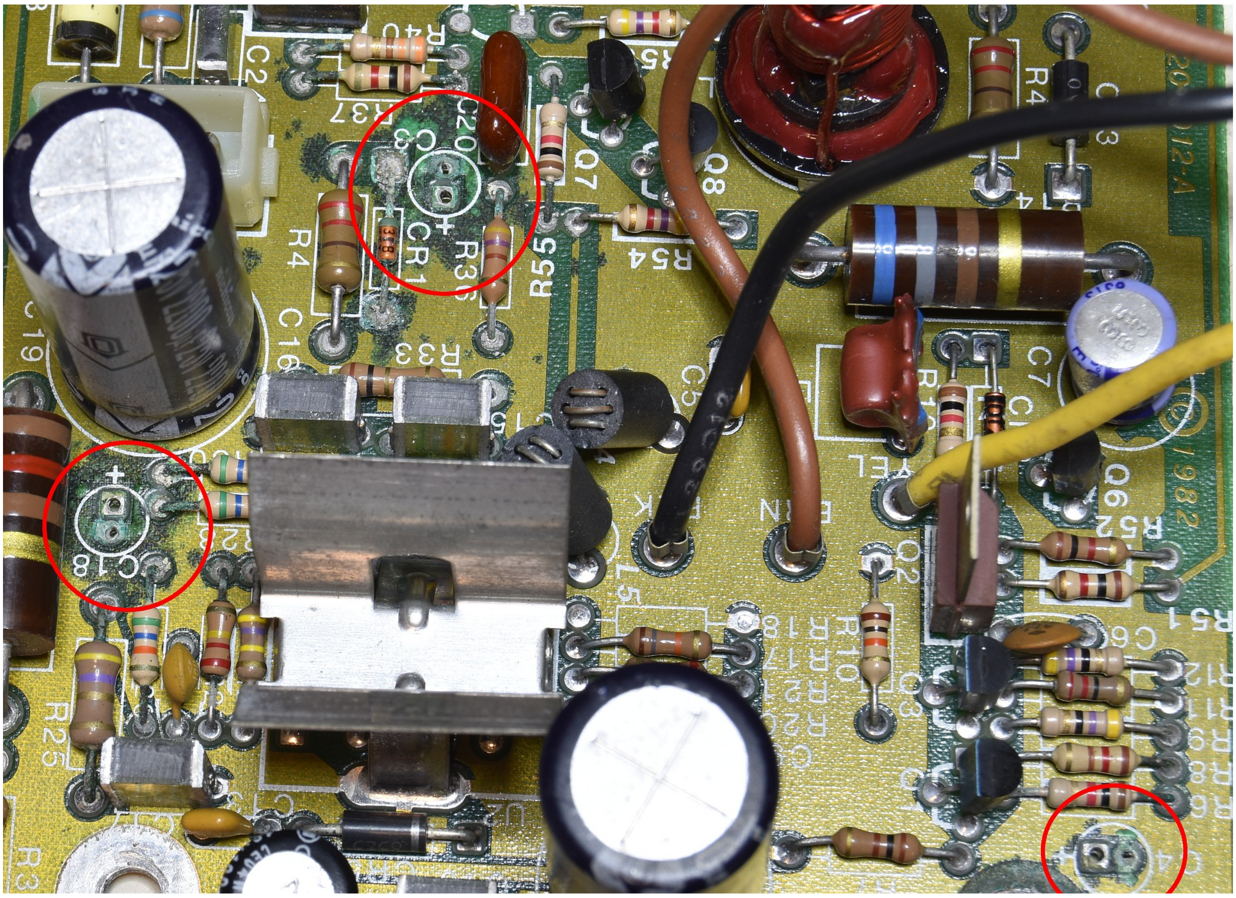
NOTE: UNLESS OTHERWISE SPECIFIED

1. RESISTOR VALUES ARE IN OHMS; 1/4 WATTS ±5%.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. ALL COMPONENTS SHOWN OFF THE BOARD ARE FOR REF ONLY.
4. POLARITY DOT ON LINEARITY COIL.
5. PC BOARD GROUND CONNECTED TO CHASSIS GROUND BY MOUNTING SCREWS.
6. CRT EXTERNAL CONDUCTIVE COATING AND ARC-GAP SOCKET ARE GROUNDED TO CHASSIS FRAME.
7. ~~RESISTOR R18 NOT USED WITH TDA1170 VERTICAL I.C.~~

The problems encountered are different, at first a certain instability was noted in the 6 trimmers present, since we have found them new and identical on the market we preferred to replace them all.



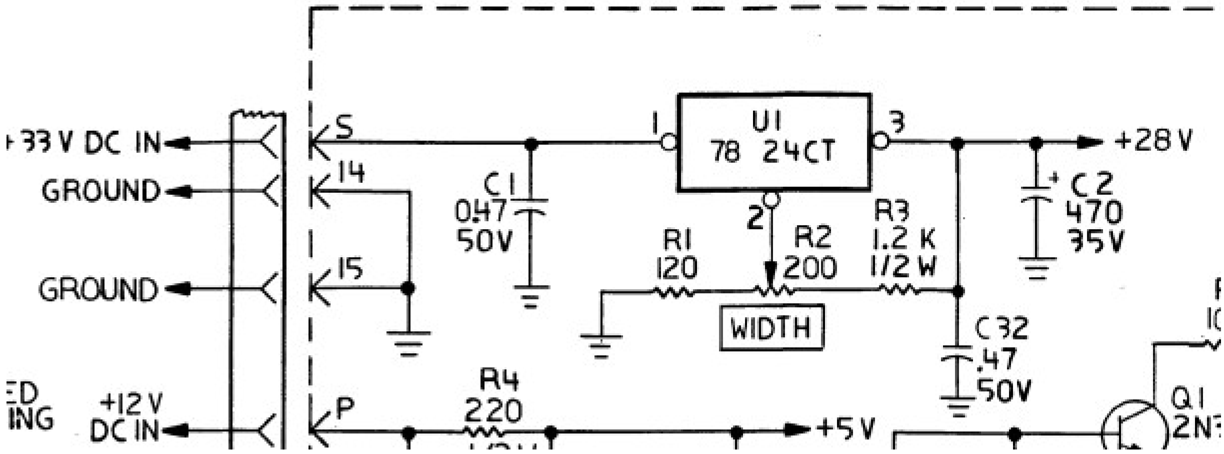
Looking carefully at some boards, however, a certain corrosion was noticed near some 10μF capacitors which were therefore replaced, of course after having carefully cleaned the area. Note that other boards were found to be healthy.



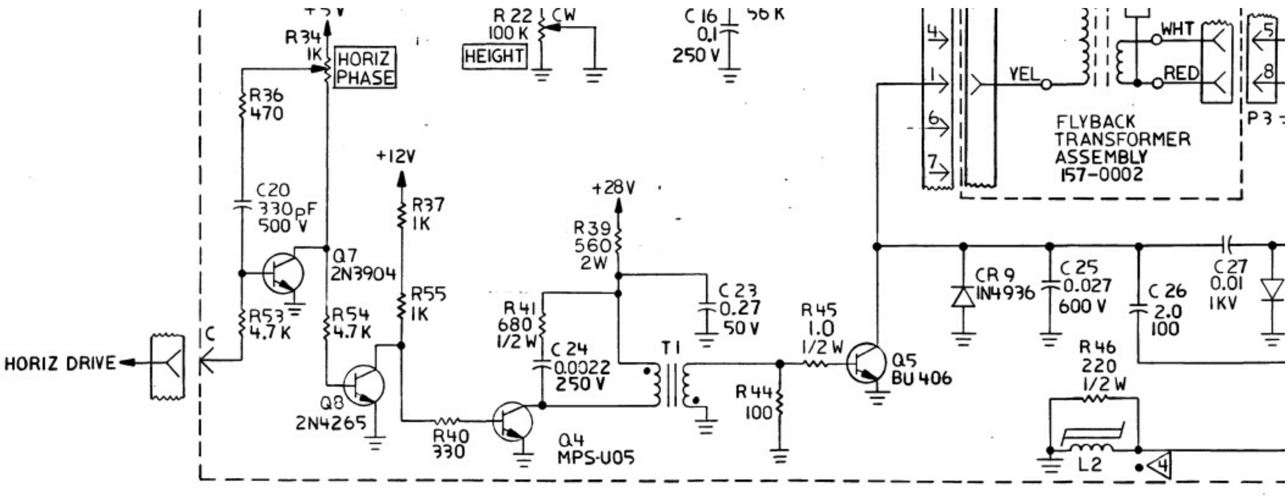
Another problem occurred during the various tests performed, when a resistor started to smoke. Obviously the power was immediately interrupted and the fault was investigated.

The resistor in question is R1 120Ω, but the other 2 resistors (R2 and R3) gave correct results when measured, so we assumed a fault in the voltage regulator U1. To be safe, therefore, in addition to replacing U1, we also changed R1 and R3, in this way the board started to work correctly again.

This case occurred on 2 different boards, so it would seem that U1 is very delicate, which is quite strange given the type of component.



Another board stopped working, no longer giving EAT voltage to the CRT. The related circuit is derived from the horizontal amplifier:



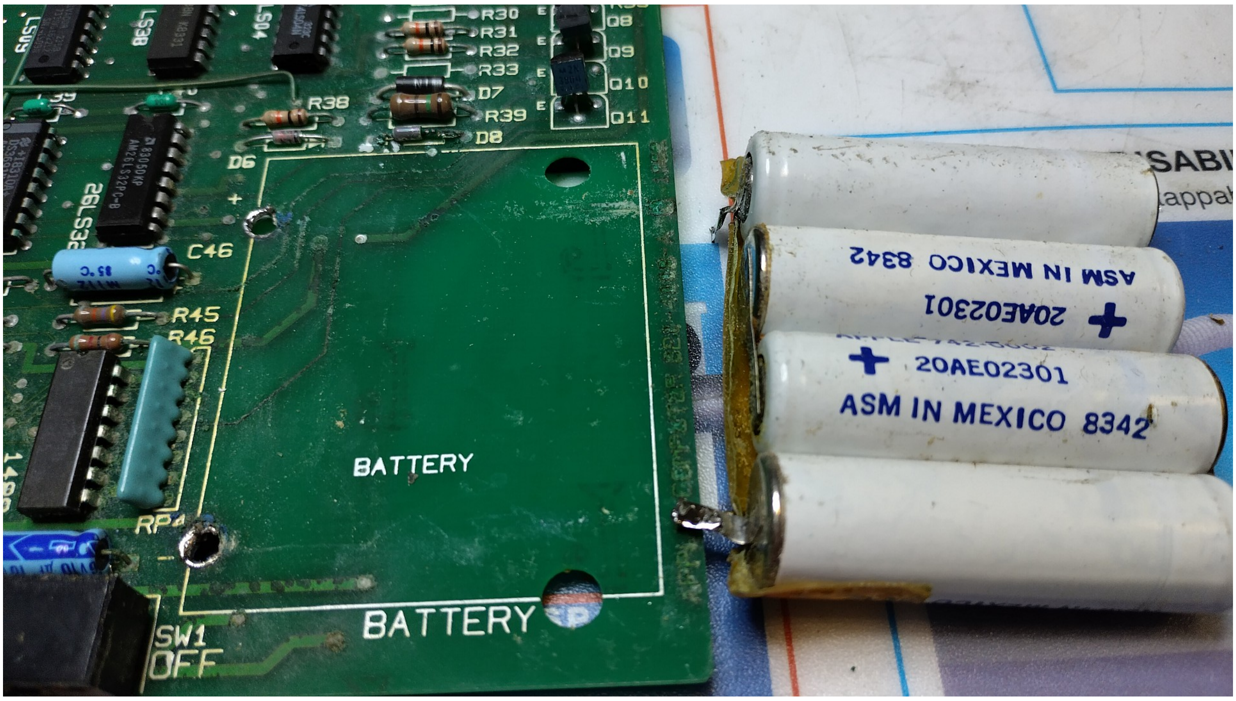
From measurements taken, Q8 was found to be faulty, but it was not possible to find the 2N4265, so it was replaced with a 2N2222, which have very similar characteristics and worked very well after a small adjustment of the R34 trimmer.

I/O board

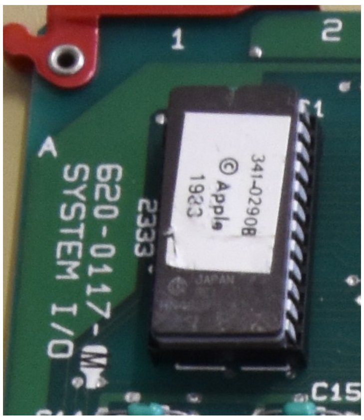
As you can see, the I/O cards are of different types depending on the type of machine, and in general they do not cause problems, except for the corrosion generated by the batteries on the first series, if they were not removed in time.

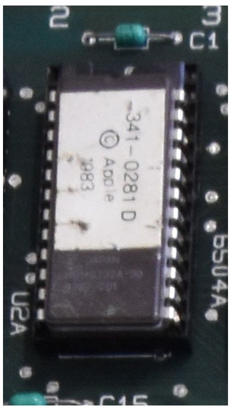
In the photo we see one of the cards from which the batteries were removed, with evident signs of corrosion on the tracks.

After careful cleaning and checking the continuity of the connections, the card started working correctly again.



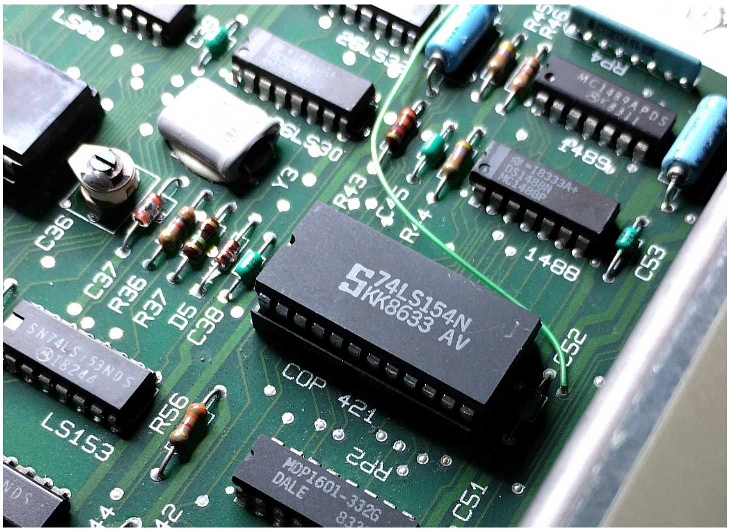
On these cards there is also an Eprom that controls their functioning, obviously it is different depending on the type and the machine:





As a curiosity, we point out a board to which instead of the COP 421, a processor dedicated to the circuits for switching on and managing the keyboard and mouse, a normal 74LS154 had been inserted.

Obviously the machine did not work and it remains a mystery as to what happened to this board in the past.



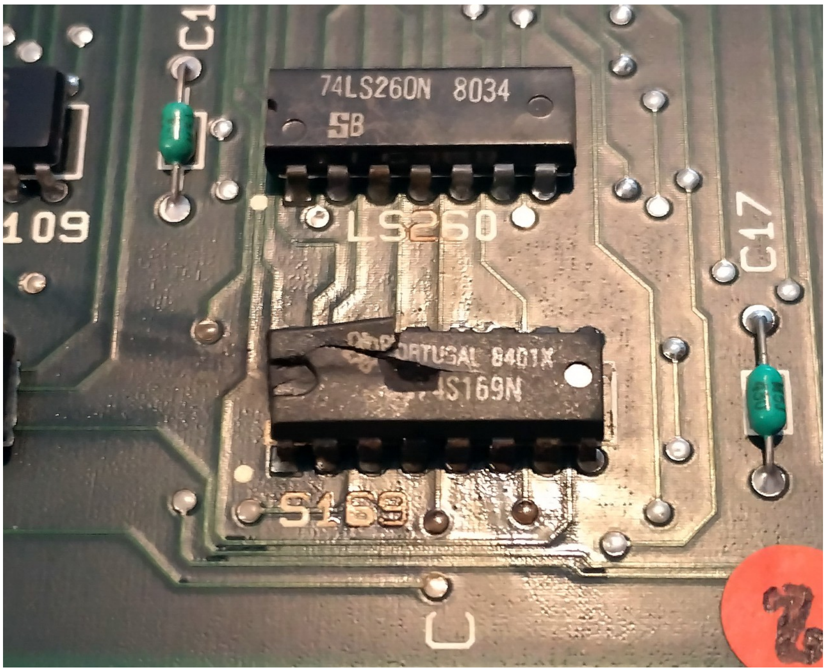
The COP 421 is a 4-bit microcontroller, customized with dedicated software exclusively for the Apple Lisa, and normally marked with the acronym COP 421-HZT/N (Apple P/n 341-0064A). Nowadays finding the controller is very difficult, if not impossible.

Of course some enthusiasts have tried to create an emulator:
http://john.ccac.rwth-aachen.de:8000/patrick/COPSreader.htm

We haven't tried it, but we're confident it will work fine if needed.

CPU Board

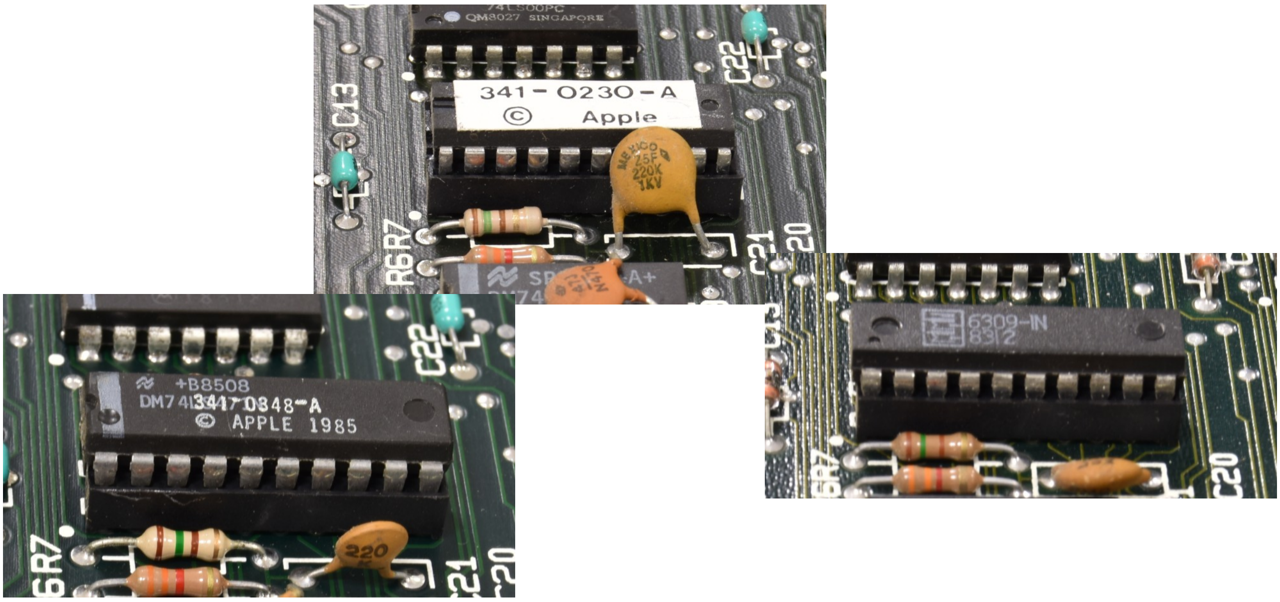
The CPU cards also generally work without problems, only on one we found a very evident fault:



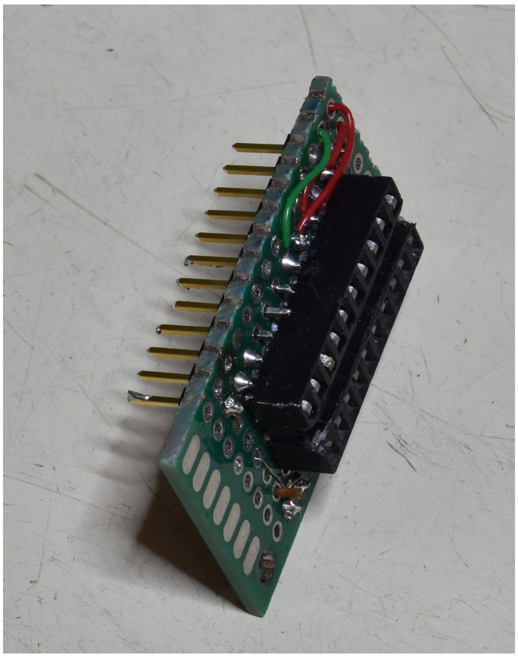
Despite the chip replacement the board still did not work, probably some other chip were damaged, but not so obviously as the one shown in photo.

Unfortunately it is not possible to take measurements on the board while turned on because it is inaccessible when the machine is running, so this board was set aside and put together with other parts that are not easily repairable, for example the I/O board of the missing COP 412 that we talked about before.

About CPU cards it is useful to talk about some peculiarities, such as the firmware release and the PROM containing information on the video part and serial numbers. Let's start with the PROMs, these are 2048-bit chips, organized in 256 bits x 8 (256 bytes), they are programmed in the factory and, as you can see from the photos, they are of different types (6309 / 82S135 / 74LS471).



In order to analyze the content we built a small adapter able to adapt the pinout of the PROMs to the pinout of a standard Eprom 2716 and then use a normal Eprom programmer to read them.



As mentioned in these PROMs there are two types of information: the programming of the video part and the serial number of the Lisa, but to obtain this last data it is necessary to "decrypt" the content, which an enthusiast has done by writing a small program in C:

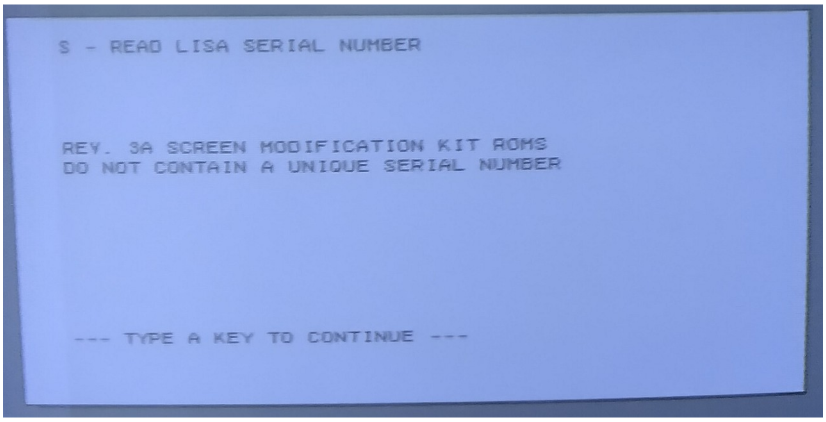
```
/*******************************************************************************\
*                   Decode Apple Lisa VSROM Serial Number                       *
*       Copyright (C) 2021 by Ray Arachelian, All Rights Reserved               *
*                       https://lisaem.sunder.net                               *
*                                                                               *
*                Released under the terms of the GNU GPL 3.0                    *
*             see: https://www.gnu.org/licenses/gpl-3.0.en.html                 *
*                                                                               *
*             "Oh boy, here I go codin' again! I just love codin'"              *
*                                                                               *
\*******************************************************************************/

#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define OUT stdout

unsigned char vsrom[256];

int main(int argc, char *argv[])
{
  FILE *ROM;
  int i;

  #define SIZE 32

  unsigned char sn[33];

  // VSROM is 256 bytes, serial is 16 bytes, applenet is also another 16 bytes after

  #define RESET (1)
  #define VSYNC (2)
  #define BIT2  (4)
  #define BIT3  (8)
  #define CSYNC (16)
  #define VSIR  (32)
  #define HSYNC (64)
  #define SERNO (128)


  puts(" ================================================================================" );
  puts(" =                                                                              =" );
  puts(" =                  Decode Apple Lisa VSROM Serial Number                       =" );
  puts(" =       Copyright (C) 2021 by Ray Arachelian, All Rights Reserved              =" );
  puts(" =                      https://lisaem.sunder.net                               =" );
  puts(" =                Released under the terms of the GNU GPL 3.0                   =" );
  puts(" =                                                                              =" );
  puts(" =             see: https://www.gnu.org/licenses/gpl-3.0.en.html                =" );
  puts(" =      https://lisalist2.com/index.php/topic,193.msg1485.html#msg1485          =" );
  puts(" =                                                                              =" );
  puts(" ================================================================================\n" );

  if (argc!=2) {
     fprintf(stderr,"Usage: decode-vsrom videostate.rom\n\n");
     exit(1);
  }

  ROM=fopen(argv[1],"rb");
  i=fread(vsrom,256,1,ROM);

  memset(sn,0,32);

  for (i=0; i<256; i++)
   {
    if (vsrom[i ^ 128] & SERNO) sn[i/8] |=1<<(7-(i & 7));

/*  printf("%3d:%02x RST:%d VSYNC:%d CSYNC:%d VSIR:%d HSYNC:%d SERNO:%d 2:%d 3:%d\n",i,vsrom[i],
     (vsrom[i] & RESET) ? 1:0,
     (vsrom[i] & VSYNC) ? 1:0,
```

```
      (vsrom[i] & CSYNC) ? 1:0,
      (vsrom[i] & VSIR ) ? 1:0,
      (vsrom[i] & HSYNC) ? 1:0,
      (vsrom[i] & SERNO) ? 1:0,
      (vsrom[i] & BIT2 ) ? 1:0,
      (vsrom[i] & BIT3 ) ? 1:0   ); */
   }

  fclose(ROM);

  fprintf(OUT,"240 Serial #: ");
  for (i=0; i<32; i++) {
     if ((i & 15)<8) fprintf(OUT,"%02x%02x ",(sn[i] & 0xf0)>>4,sn[i] & 0x0f);
     if (i==15) fprintf(OUT,          "\n260 AppleNet: ");
     //else if ((i & 7)==7) fprintf(OUT,"\n              ");
  }
  fprintf(OUT,"\n\n");

}
```

Furthermore, a program has been made that does the reverse operation, i.e.: it creates the image of a PROM starting from the serial number:
https://github.com/rayarachelian/lisaem/blob/livedev/src/tools/src/mkvsrom.c

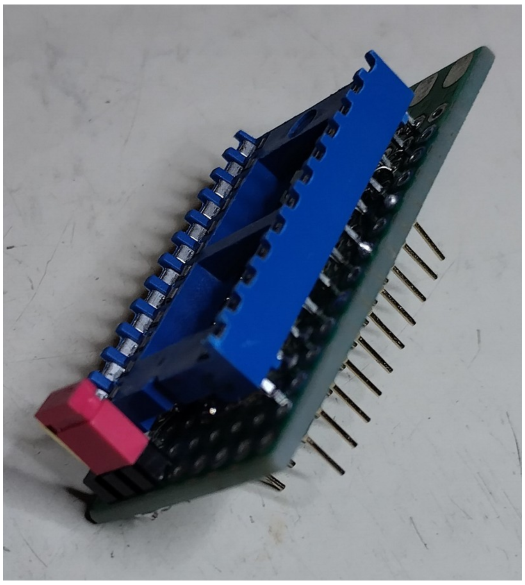
We have not gone deeply in the video part, but it is important to know that in the case of the Macintosh XL the data entered is very different because you have to change the horizontal and vertical resolutions to be able to use MacWorks without deformations.

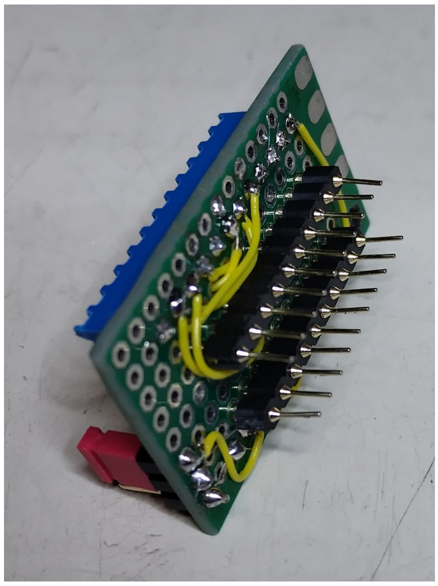
Also in the case of the MacIntosh XL the serial number is no longer entered because the MacWorks software, unlike Lisa Office System, no longer checks this information, indeed if you try to read the serial, for example using BLU (Basic Lisa Utility), you get this:



One last note, finding virgin PROMs is not easy, you can find equivalent memories, for example the TPB28L22 from Texas Instruments, but normal memory programmers are not able to manage them.

The approach that we have instead successfully adopted on a machine was to build an adapter that allows you to use normal Eprom 2716 instead of PROMs, this also allows you to have up to 8 different configurations with a switch (in the photo there is a jumper to switch between 2).





The pinout for the adapter is:

PROM	Eprom 2716	Description
19	1	A7
18	2	A6
17	3	A5
5	4	A4
4	5	A3
3	6	A2
2	7	A1
1	8	A0
6	9	D0
7	10	D1
8	11	D2
10	12	Ground
9	13	D3
11	14	D4
12	15	D5
13	16	D6
14	17	D7
15	18	-CE or -G1
	19	(A10, image selector or ground)
16	20	-OE or -G2
	22	(A9, image selector or ground)
	23	(A8, image selector or ground)
20	21 - 24	Vcc

As for the firmware, resident in 2 Eproms of 64kbit (8Kbytes) each, you can find images of the different releases online, the latest in chronological order was H, from the notes found online these are the different releases:

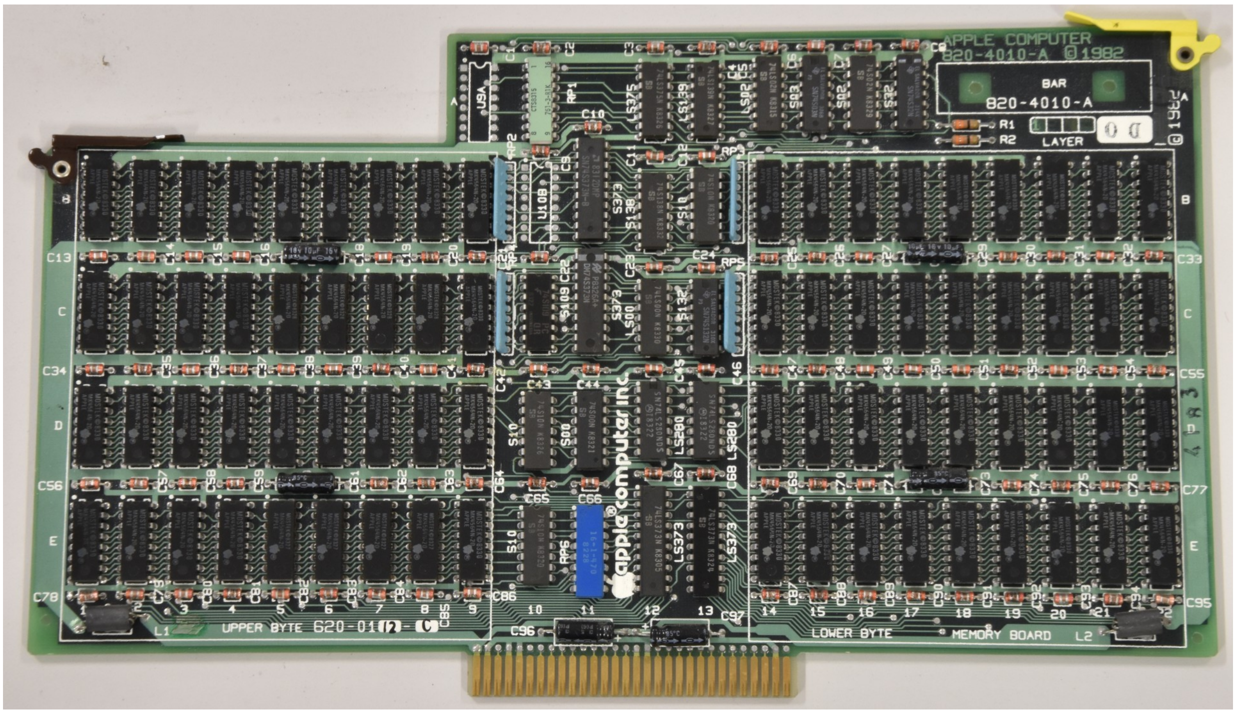
Release	Part Number	Description
3A	341-0346A 341-0347A	indicates a screen modification kit has been installed for use with MacWorks. Also, the Lisa Video state ROM has been changed for the new video timing, and (usually) a transformer has been installed between the video board and the CRT. 3A ROMs will NOT work with Lisa Office System, Workshop, Xenix, etc.
H	341-0175H 341-0176H	the latest ROM for Lisa Office System. Also compatible with MacWorks and Xenix.
G	341-0175G 341-0176G	Very Rare - development only?
F	341-0175F 341-0176F	Early Lisa 2 ROM for Lisa Office System. Also compatible with MacWorks and Xenix
E	341-0175E 341-0176E	Very rare - development only
D	341-0175D 341-0176D	somewhat common, might work with both 3.5" floppy as well as Twiggies
C	341-0175C 341-0176C	Lisa 1 ROM (rare)
B	341-0175B 341-0176B	Lisa 1 ROM (very rare) - development only?
A	341-0175A 341-0176A	Lisa 1 ROM (very rare) - development only?

In general we tried to install the H release on all machines, but in one case it did not work and by trying previous versions we verified that the F version worked correctly; we did not investigate the problem further.

Memory Boards

Apple boards

The standard memory cards of the Lisa are 512Kb each, in the first versions there was only one, later on 2 cards were installed for a total of 1Mb.



In the event of memory errors, typically 70 or 71, on a card with so many chips it is difficult to identify the one that is causing problems, and after all the card is inside the machine, so it is practically impossible to make measurements.

But the "service mode" of the machine comes to our aid, which allows us to analyze the contents of the memory and, looking in some memory locations, to identify the faulty chip.

All this is possible because during the initial self test the result is stored in some memory locations, doing analysis on them and referring to what is described here: https://lisafaq.sunder.net/lisafaq-hw-mem_error.html , the fault shall be identified.

We copy here the content of the link in order to have an easier understanding:

The Lisa's power-on self-test checks the RAM relatively thoroughly. In addition to reporting Error 70 or 71, it also attempts to provide information for repairing memory boards, so yes, repairing a memory board is often possible without a huge effort.

However, before embarking on an effort to repair a memory board, ensure it is truly the memory board that is the problem. A poor connection at the card-edge connector of the CPU board or Memory board can be the cause of errors 70 and 71 (as well as many other error codes). Clean the card-edge connectors (see lisafaq-hw_general_tests.html) and swap around and in/out your memory boards to be sure a particular memory board has a problem.

During the self test, the results of the memory test are stored in some low memory locations (accessible from service mode). Using this information, it is often possible to localize a memory error to a single chip (designated by a row letter and column number), and with some desoldering expertise, the bad chip can be replaced and the memory board repaired.

The low memory locations of the memory test data begin at address $186. There are 16 words of memory bit error information; these 16 words correspond to the sixteen 128K blocks in the 2MB RAM address space.

An examination of the Apple 512K RAM board reveals the memory chips are configured in an array of 4 rows, labelled B,C,D,E and 18 columns (arranged as two groups), labelled 1-9 and 14-22.

Apple 512K memory boards have 4 rows of chips, each row being 128K. This means that 4 of the 16 test result words will exactly correspond to the 4 rows of a single 512K memory board... ie. one word per row.

Each 16 bit word contains bad bit information... a bad data bit is reported by the corresponding bit set to 1 in the word corresponding to the 128K memory block where it was found.
Columns

It is easy to associate the bad data bits with the coordinates of a column of 4 chips on the memory board; from the schematic: bit 0 is column 22, bit 7 is column 15, bit 8 is column 1 and bit 15 is column 8.

If there is just one bit set (ie. only one bad chip in a 128K block/row), then there are 16 possible values for the word, which map to memory board columns as follows:

```
  Word  Bit# = Column
  0001   0   =  22
  0002   1   =  21
  0004   2   =  20
  0008   3   =  19
  0010   4   =  18
  0020   5   =  17
  0040   6   =  16
  0080   7   =  15
  0100   8   =   1
  0200   9   =   2
  0400  10   =   3
  0800  11   =   4
  1000  12   =   5
  2000  13   =   6
  4000  14   =   7
  8000  15   =   8
```

If there is more than one bad chip in a 128K block, there will be more than one bit set and you'd get a character other than 1,2,4,8, or more than one non-zero character in the word.

Rows
The rows of 128K are designated B, C, D, and E by the coordinates on the board. However there is a complication or two...

The 16 words in memory are arranged according to logical address, not physical address, and it is, of course, a physical chip we're looking for. The complication is that the physical rows are mapped to logical addresses in a different order depending on which slot the board is in.

If you have one 512K memory board, regardless of which slot it is in, it will always be associated with the first 4 words... $186 - $18C.

If you have two 512K memory boards, the first 4 words are associated with slot MEM 2, and the next 4 words are associated with slot MEM 1.

The last 8 words are never used with 512K memory boards, since they correspond to the second MB of the logical address space. They would be used if you have more than 1MB of memory.

The four rows of the memory board are always mapped in BCDE or EDCB order (depends on the slot), so you can be confident that a single bit error maps to one of two rows... if the error is in the first or last of four words, then the problem is row B or E. If the error is in the second or third word, then the problem is C or D.

To figure out which of the two rows is the problem, you can read-up on the physical-logical address mapping scheme in the Lisa Hardware Reference Manual, and cross-reference that through the schematic to determine which physical row is going to correspond to which logical address block.

Or you can use a rule of thumb determined by observation...
It has been observed that *for slot MEM 1, the order is BCDE, and for slot MEM 2, the order is EDCB.*
The rows corresponding to the first 8 words starting at $186 are used as follows:

1 board in slot MEM 1
```
  B C D E   x x x x
```

1 board in slot MEM 2
```
  E D C B   x x x x
```

2 boards
```
  MEM 2     MEM 1
  E D C B   B C D E
```

Examples:

A. 1 RAM board installed, error reported in first 4 words...
- 0000 4000 0000 0000
- error in bit 14 which is column 7
- if the board is in MEM 2, the second word corresponds to Row D
- if the board is in MEM 1, the second word corresponds to Row C

B. Error in second 4 words...
- 0000 0000 0000 0000 0020 0000 0000 0000
- this might happen if you have 1MB of RAM - 2 boards
- error in bit 5 which is column 17
- the second 4 words corresponds to MEM 1 when 2 boards are present
- the first word (of the second 4) corresponds to Row B of MEM 1

<u>Parity Error 71</u>

You may have noticed something missing... there are 18 columns of chips, not 16. The extra 2 are for parity bits, one for each byte.

If there was a parity error, then all the data bits might be clean, represented by 0 in all 8 words at $186. In this case, you will get error 71 instead of 70 from the memory test.

In the case of a parity error:
- one byte at $27C contains a number that corresponds to the row as follows:

```
  00 = row B when the problem board is in MEM 1, with MEM2 empty
  01 = row C when the problem board is in MEM 1
  02 = row D when the problem board is in MEM 1
  03 = row E when the problem board is in MEM 1

  04 = row B when the problem board is in MEM 1, with 512K in MEM2
  05 = row C when the problem board is in MEM 1
  06 = row D when the problem board is in MEM 1
  07 = row E when the problem board is in MEM 1

  00 = row E when the problem board is in MEM 2, regardless of MEM1
  01 = row D when the problem board is in MEM 2
  02 = row C when the problem board is in MEM 2
  03 = row B when the problem board is in MEM 2
```

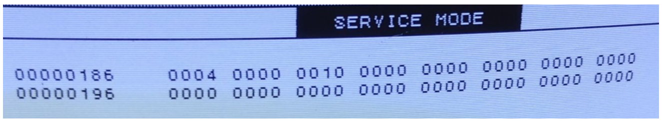
- one byte at $27D contains $09 or $14, which correspond directly to the board coordinate column of the bad parity chip, column 9 or 14. If this byte is zero, exit service mode by typing 7, then type apple-1 to run the self-test again; it seems that sometimes this is necessary to obtain the parity error data.
- long word $270 contains the logical address where the error occurred

<u>Miscellaneous</u>

- To enter service mode, type Apple-S after the memory error is reported
  - To display the 16 words at $186 type: 1186 20<return>
  - To display 8 words beginning at $27C type: 127C<return><return>
- If your memory board has a serious problem in Row B or E, then the Lisa might not work at all, since it needs some working memory to do the self-test. In this case, try moving the board to the other slot, and/or add a good board in the other slot. These will change the logical address of the bad row and may allow the Lisa to work well enough to perform the self-test.
- This information applies to the long test. There is a short test that is performed after a warm reset; I believe it consolidates all the bit errors into the one word at $186, ie. the row(s) are not decoded. To make sure you are getting the long test, first turn off the Lisa, and if you have batteries on your I/O board, turn off the switch (and check the FAQ about removing the batteries to prevent corrosion damage).
- This information is specific to the 512K Apple memory boards. If you have a different memory board you'll still get the error results, but mapping them to a physical chip is not addressed here.

To enter "service mode" you have to press the <apple>S keys, from the menu select item 1 and then give 186<space>20<enter>, to view the contents of the memory in question.

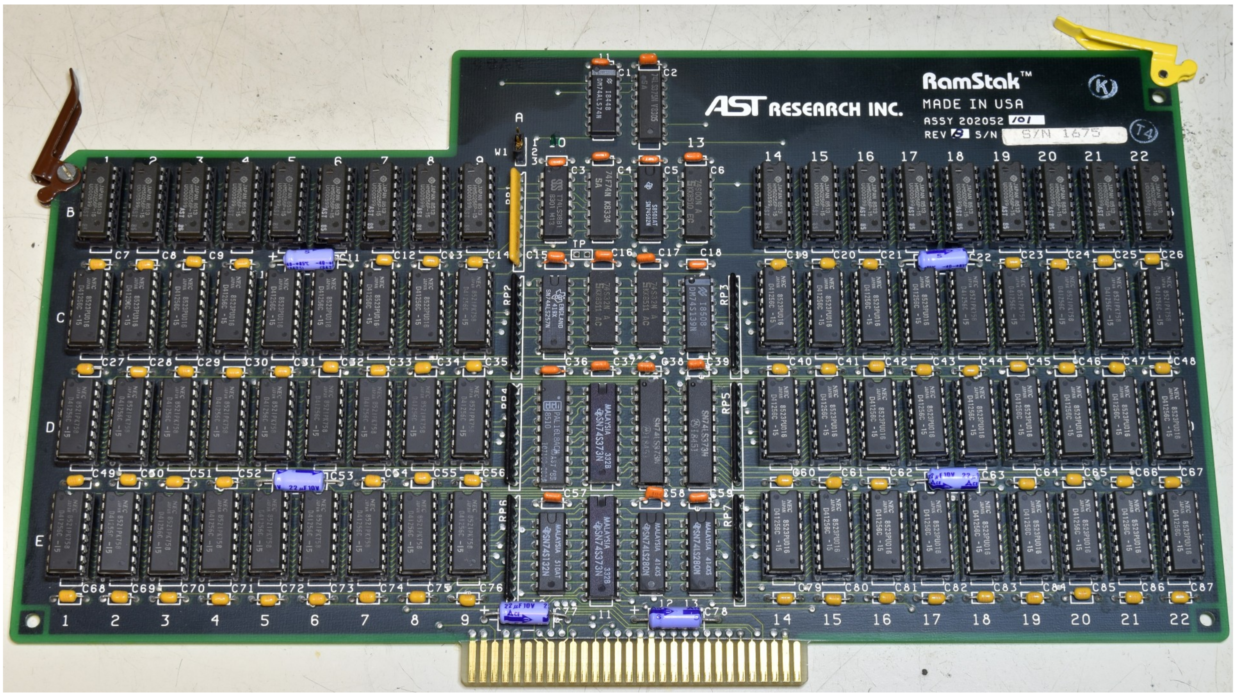
In our case one of the cards was reporting error 70, going to look at the memory we found this:



Following the instructions it was therefore quite simple to identify the 2 faulty chips by following the silkscreen printing on the board itself: those present in column 20 row B and column 18 row D

AST Research RamStak board

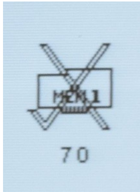
The addressable memory capacity, as mentioned, is 2Mb, and some independent manufacturers have produced cards with higher capacities, for example a card found in our Association's MacIntosh XL called RamStak from AST Research has a capacity of 2Mb.



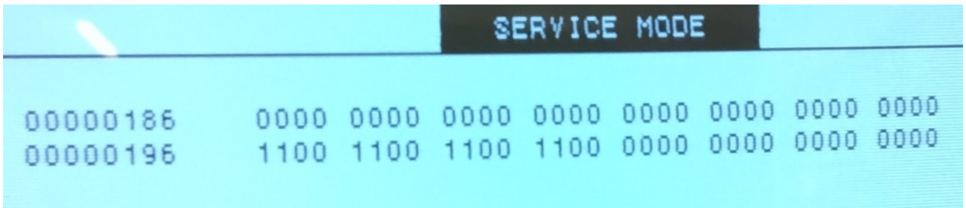
In this case, however, the procedure seen before does not work, or rather, it gives results that must be interpreted differently.

This card also gave errors, and so we had to invent a solution to identify which of the 72 256Kb chips was faulty; luckily the chips are all socketed and therefore it is possible to exchange them easily.

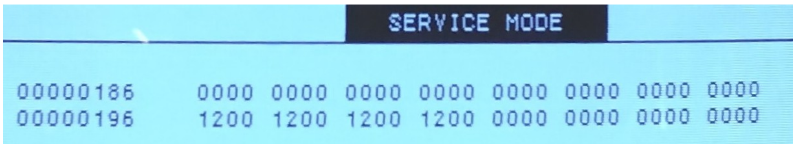
In order to be able to run tests without having results distorted by other causes, we inserted this single memory card into memory slot no. 1, leaving the other empty, we turned it back on and the classic code 70 appeared:



Analyzing the memory with the methods already seen, this was the initial situation:



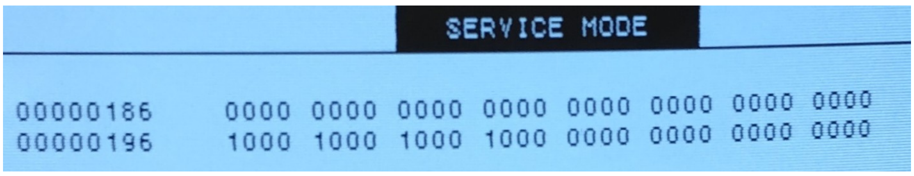
After swapping all the chips in column 1 with those in column 2 we got this:



The situation did not change when we swapped all the chips in column 1 with those in column 3, so one of the faulty chips is definitely in column 2.

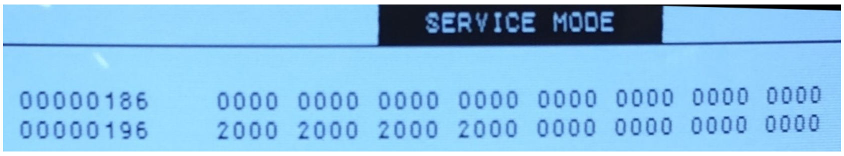
We did swap the chips in positions B1 and B2 and we returned to the initial condition, so the guilty is definitely B1.

A further test is to swap B1 with B9, accordingly move the fake chip to the parity bank. In this way one of the errors has disappeared:

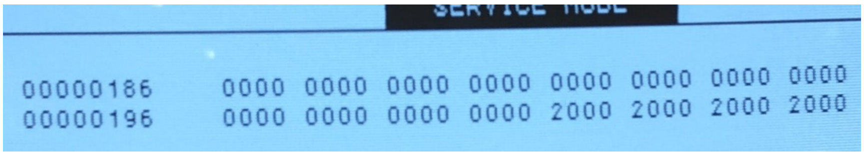


We'll come back to this problem later when the machine does its parity checks, at the moment we can focus on the other error. Let's try swapping B4 with B5:

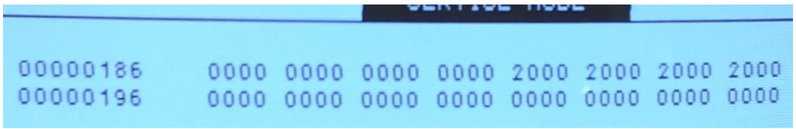
... and voila' . We see that the position of the error changes. So we try to swap B4 with B6 and the situation changes again, so the guilty is B6 (if it had been B5 there would have been no change):



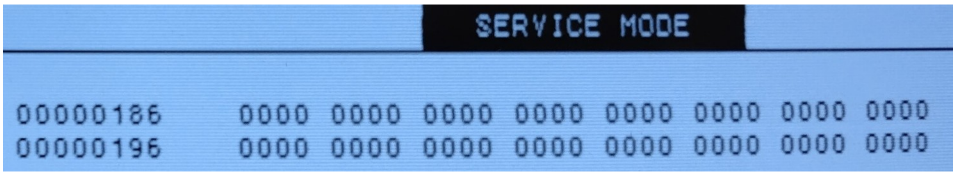
Once we have identified the other broken chip, we take the opportunity to identify the banks by moving it, for example putting B6 in place of C6:



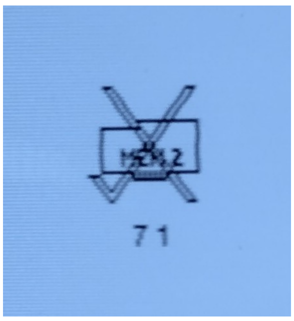
In this way we have identified that bank C is the last group of 4 words, and moving it further we see that bank D is the second group:



Thus, by exclusion, bank E is the first 4 word group and currently the "fake" chip is in D6, so we move this chip back to D9, and finally the memory check does not fail.

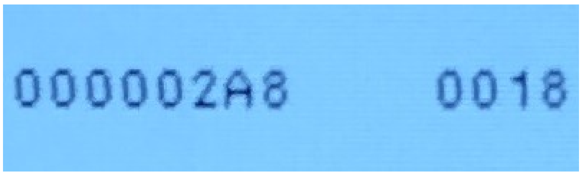


Of course, the parity check fails, the error is no longer 70, but 71:



Since we did not have spare chips available, we decide to completely give up a 512Kb bank and therefore have only 1.5Mb; to comply we put aside the faulty chips, we filled the banks B, D, E, leaving therefore the bank C empty, and finally we no longer have memory errors.

At this point we are curious to know if 1.5Mb of memory are actually available; to check it's enough to consult the content of location 2A8 with the methods already seen, which gives:



Value that, according to this table, is equivalent to 1.5Mb, as we had expected:

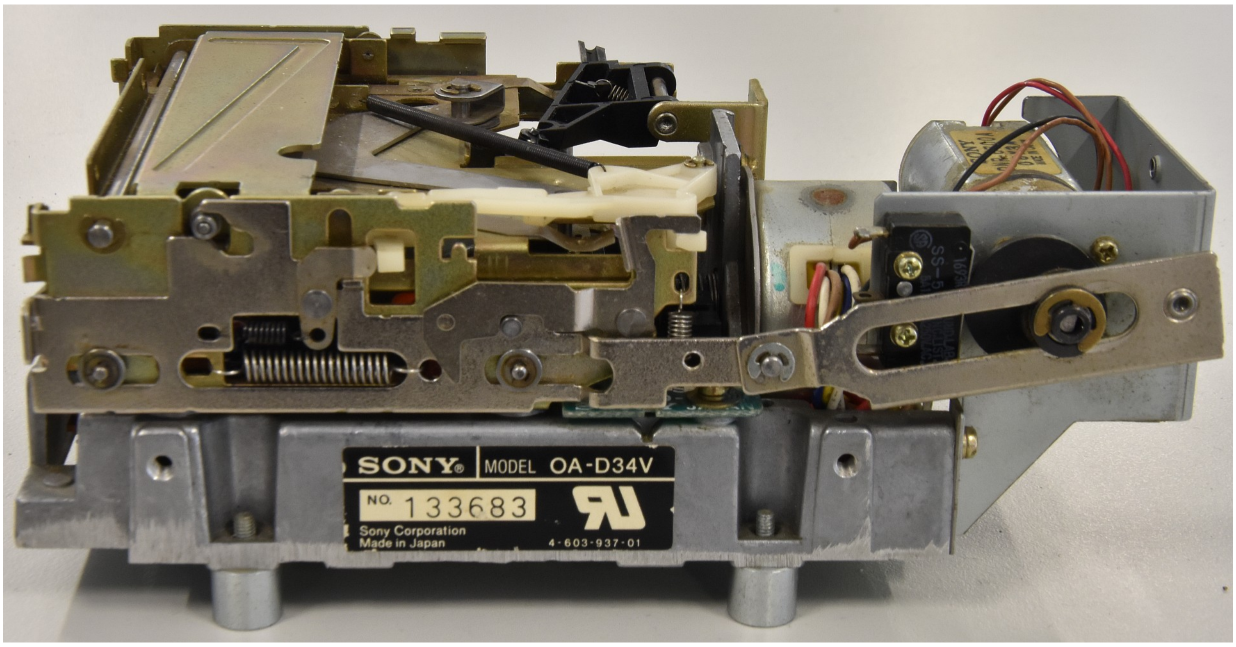
512K	0008
1M	0010
1.5M	0018
2M	0020
4M	0040

Note that, according to this table, we could even get to 4Mb, but this is only possible with firmware 3A, which is specific for the MacIntosh XL.

Floppy disk drive

Not having a Lisa 1 to analyze the famous (and infamous) Twiggy, we tackled the 3"1/2 drives used on the later Lisa series.

Having been abandoned for years in places not always suitable for preserving the electronic and mechanical parts, the floppy disks needed an overhaul, especially in the mechanical part.



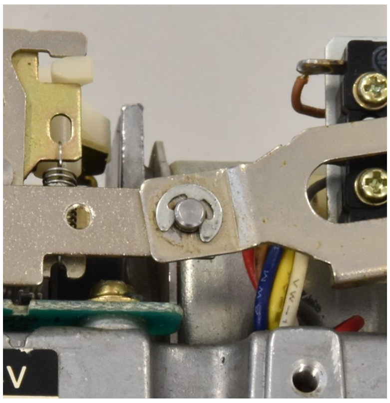
Information on how and where to carry out the lubrication and to put the mechanisms back into operation is easy to find online, especially regarding the ejection system that tends to get stuck, but even without documentation the operations are quite intuitive: basically it is a matter of degreasing and lubricating all the moving parts.

Equip yourself with a can of WD40 and use it without parsimony as it allows, in addition to lubrication, also to clean the glued parts from the grease that is now many years old!

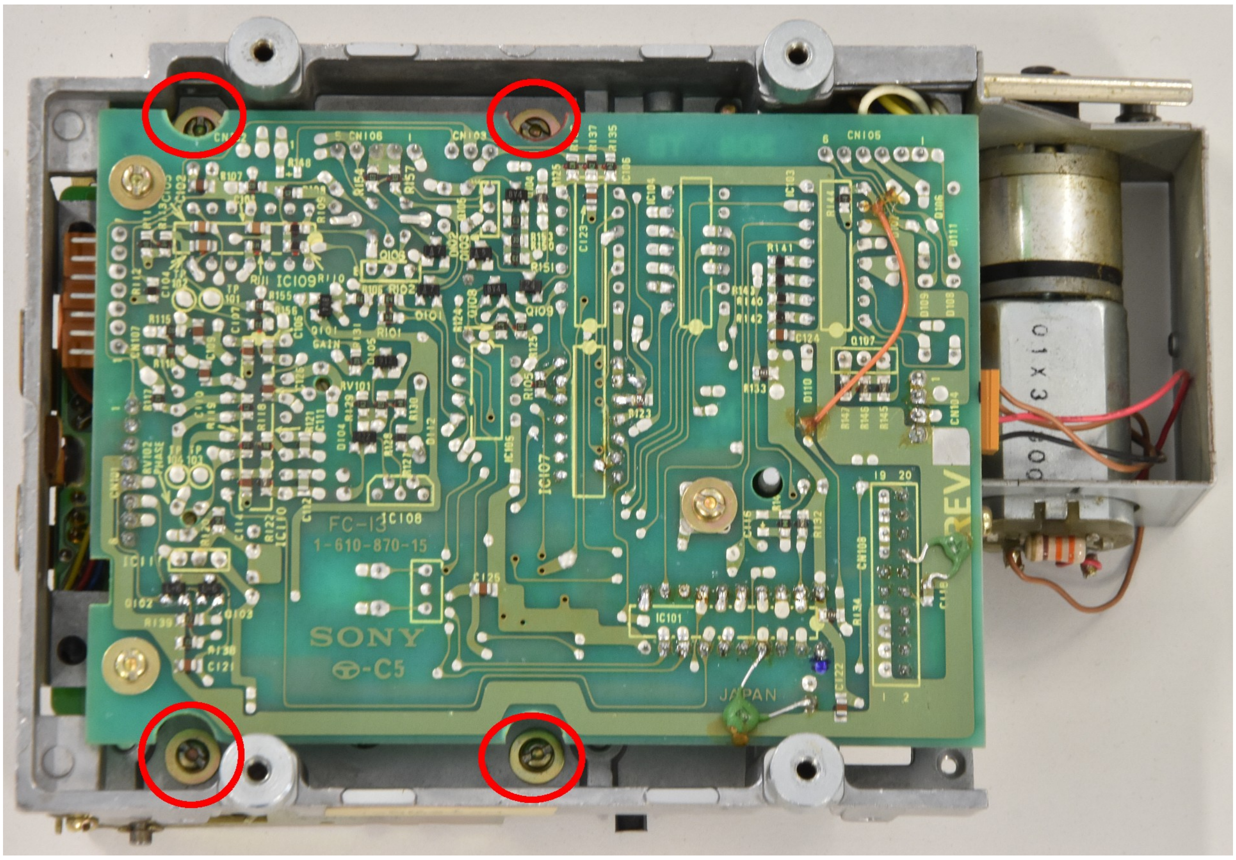
To help with lubrication it is advisable to disassemble the mechanism that guides the disk inside the drive and that also provides for its ejection.

Disassembling it is quite simple, first of all the top cover must be removed, it is a matter of unscrewing a screw located at the back (in the photo the cover has already been removed).

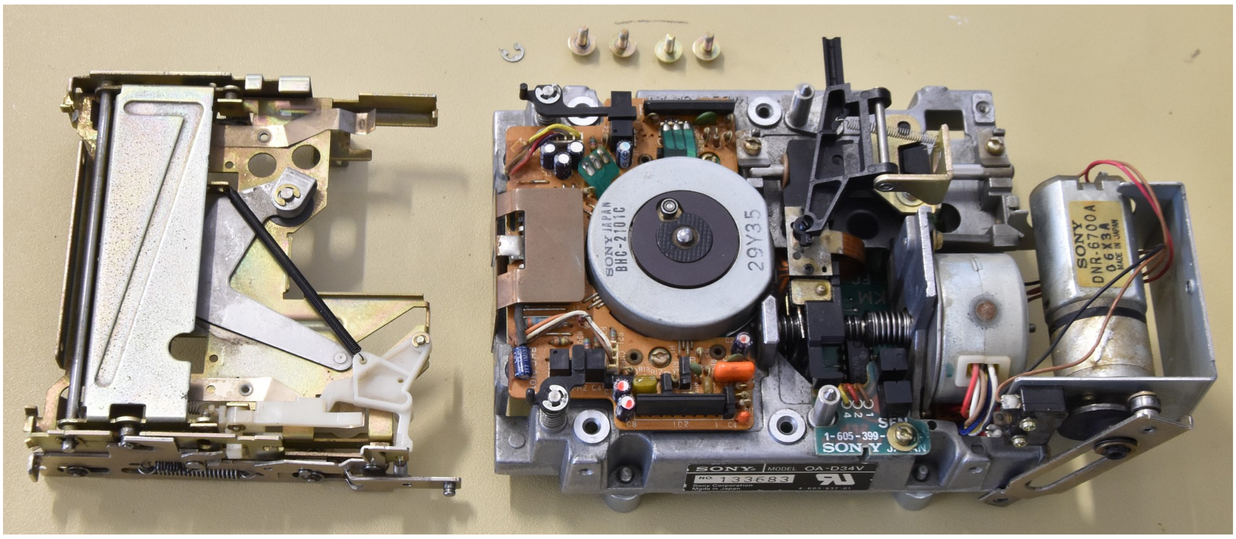
Then it's a matter of removing the C-ring that is on the lever of the ejection mechanism.



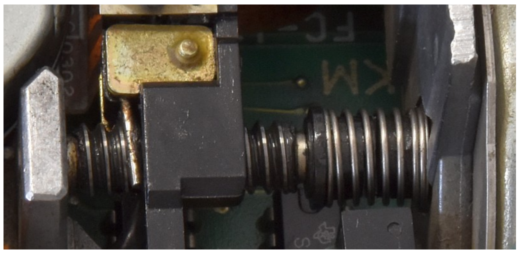
then turn the floppy over and unscrew the 4 screws highlighted:



So, by delicately removing it, you will have the floppy disk holder which is the most important part to clean and lubricate, make sure that all movements are carried out without forcing and once finished clean the excess of WD40.

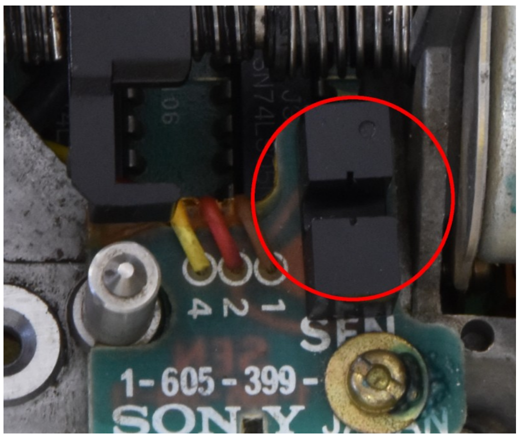


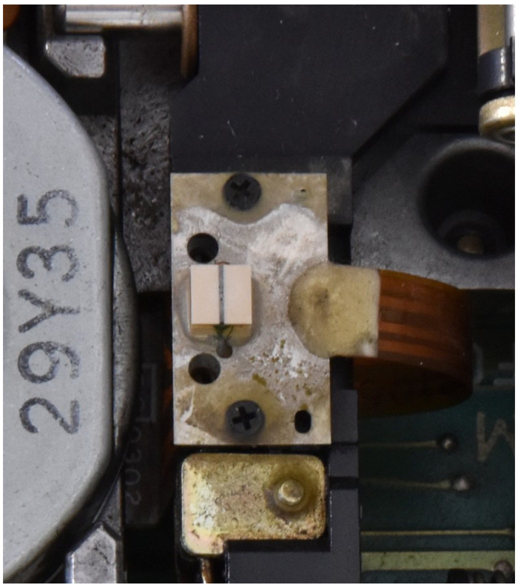
Another part worth lubricating is the worm screw that moves the head. Spray WD40 and rotate the screw with your finger to move the head back and forth a few times.



However, one of the floppy disks had a strange defect: when turned on, the head would advance to the center of the floppy disk and from there it would try to go further, making a series of clicking noises due to these attempts.

Studying the symptom we came to the conclusion that the track 0 sensor was not working fine, it was enough to clean it to put everything back in order.

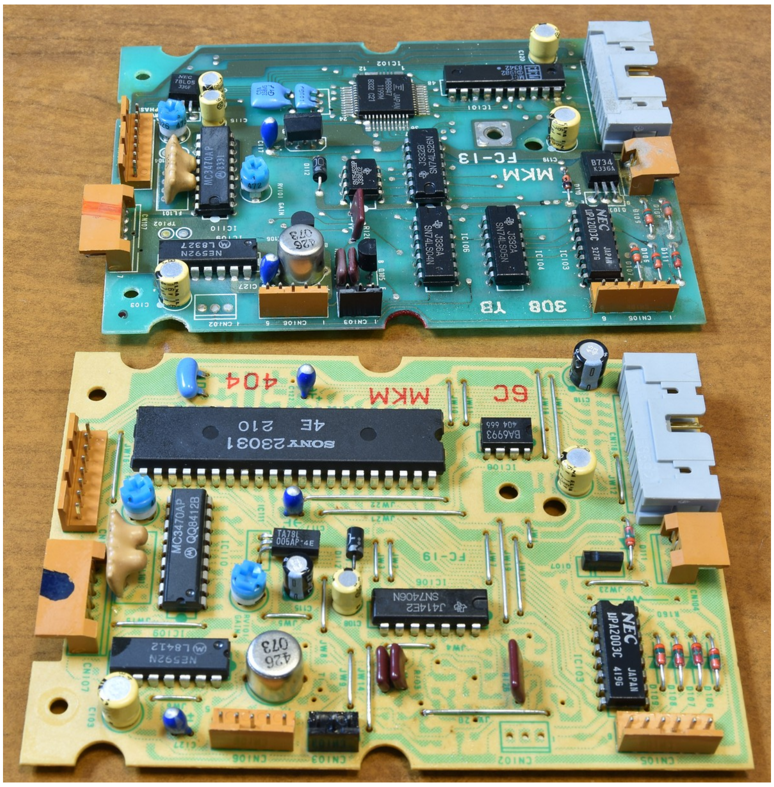




Having dismantled the entire mechanism, it is worth also cleaning the head with a cotton ball and isopropyl alcohol (no WD40 here!), delicately, I recommend!

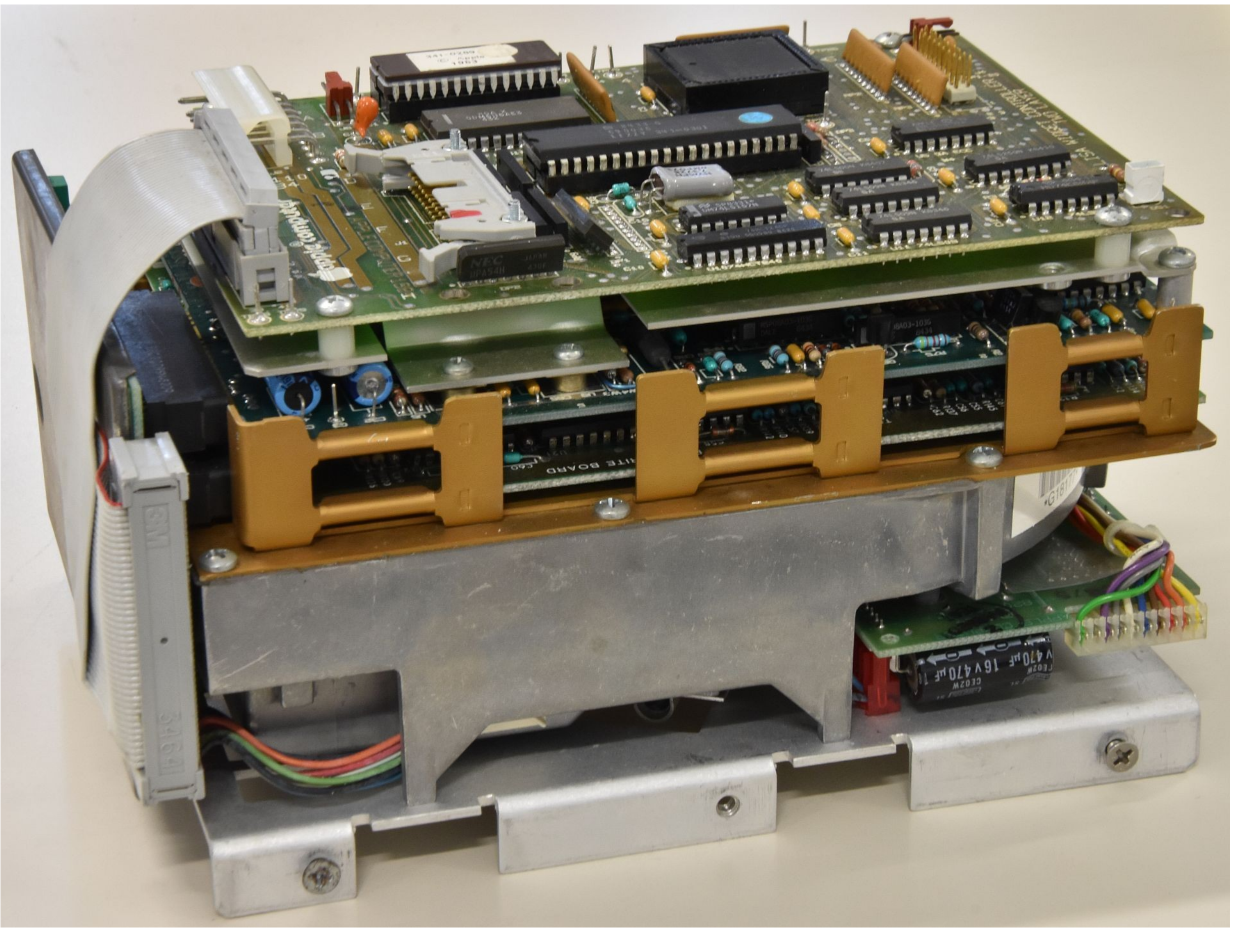
With these steps you will probably have solved 90% of the problems related to floppy drives. Of course we also had an electronic failure ...

Another floppy drive was behaving randomly faulty, with no apparent logic, to discriminate whether the problem was within some sensor or with the logic itself. We tried to replace the electronic part with a working one, so we discovered that the logics are not all the same:



Having established that the problem was related to the electronics and not to one of the surrounding chips, we decided to put aside the faulty floppy disk since finding the custom chips to be replaced is a task bordering on the impossible.

Widget, the Apple internal Hard Disk

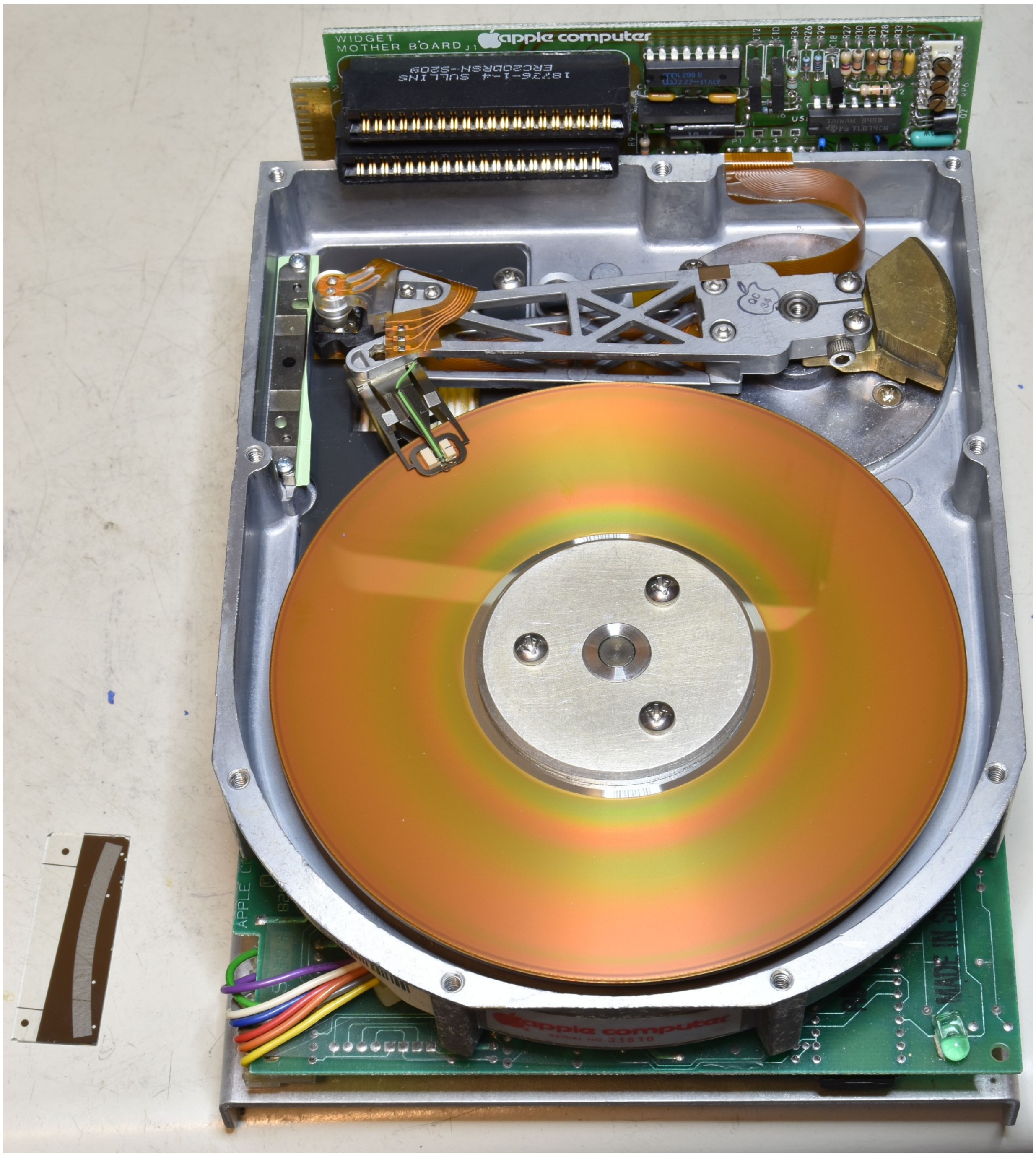


The 2/10 version and, consequently, also the MacIntosh XL, include a 10Mb hard disk inside instead of the external Profile such as the previous versions.

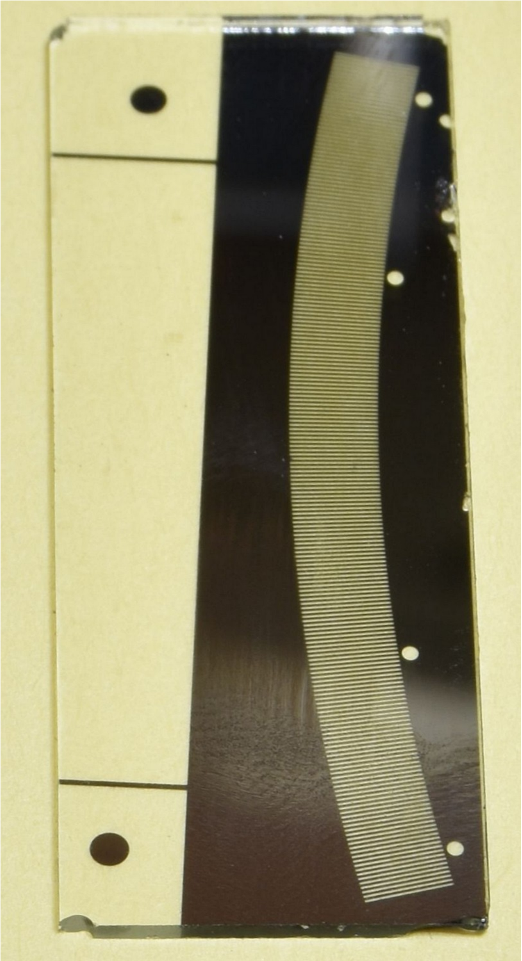
The system is quite complex, and has no parts comparable to other commercial disks of the time, so working with it is quite difficult.

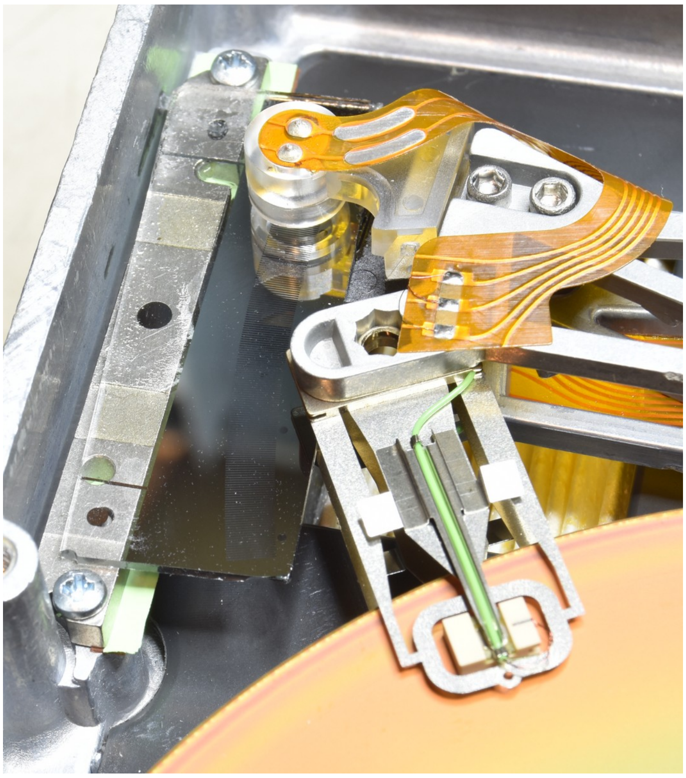
Furthermore, to access the disk it is necessary to completely disassemble all the electronics, which consists of several cards placed one above the other, this prevents you from being able to work "open-hearted", that is with the disk rotating in sight, something that it's possibile with other hard disks of the time, even if with certain precautions.

In the photo you can see an open disk; this particular disk had a problem: when shaking it you could hear an object, visible on the left side of the hard disk in the photo, rattling inside.



Detail photo: this is the grid which, through a photocell, defines the positioning of the heads on the different tracks.





With a specific glue for glass and metal it was glued back into place.

Given the electronic complexity, we limited ourselves to discriminating which hard disks were working and which were not based on simple observations on the disk startup.

When you turn on the machine with the disk connected there are a series of operations that it performs before becoming operational:

• you can hear the start of rotation (if this does not happen, you can try to intervene, see below)

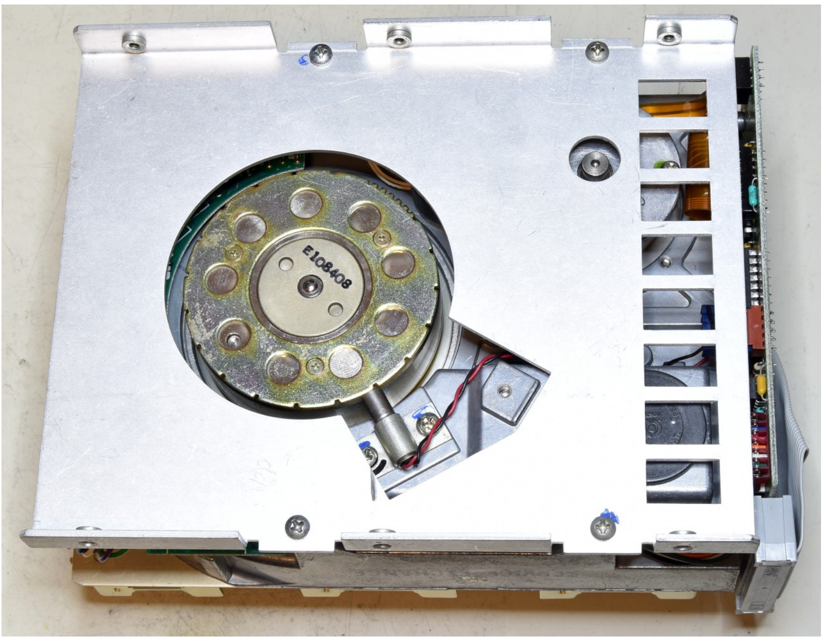
• the upper LED flashes for a while waiting for the rotation speed to reach the correct speed and stabilize.

• the head release relay takes a sharp shot.

• the disk LED starts to flash, in practice the head slides along the entire disk to verify that everything is okay.

The process lasts a few minutes and if it finishes completely we can almost say that the disk works; obviously at this stage you should not hear any strange noises, such as rubbing.

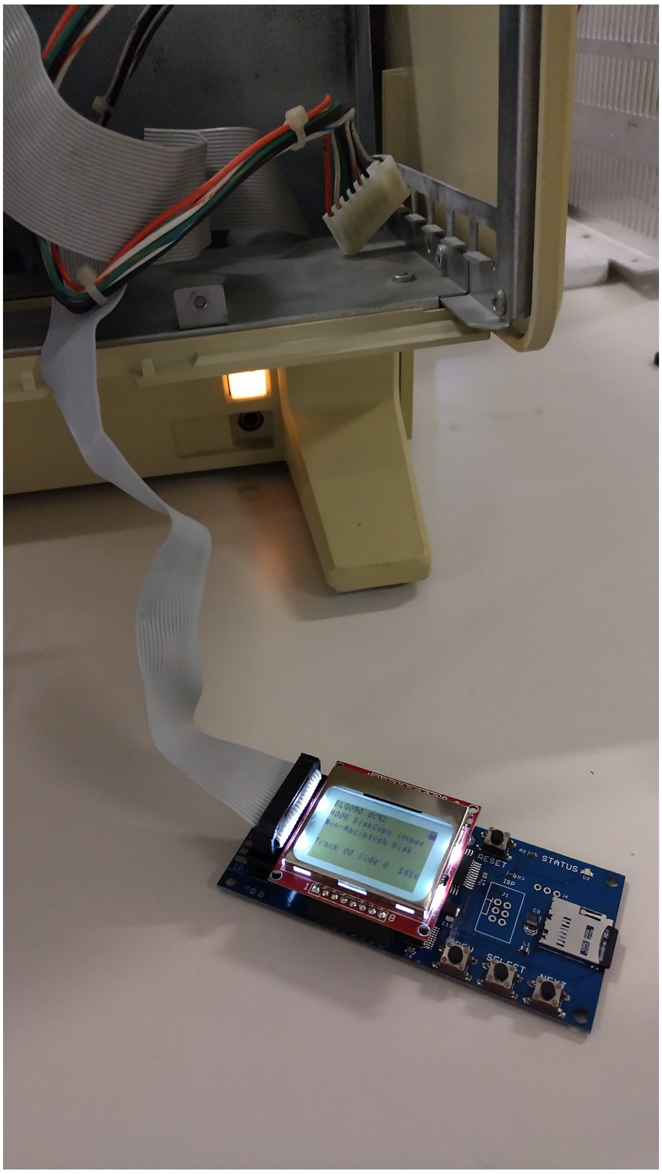
One of the discs did not started turning when powered on; as the flywheel with the rotation sensor is accessible (see photo) we tried to help it with a finger and after that the disk started to work correctly, even after several turns off and on again and again.



Once you have identified the working disks, it is advisable to do a low-level formatting, using BLU (Basic Lisa Utility) or NeoWidEx and then reinstall the operating system.

Useful things

In addition to the software tools mentioned, it is important to point out and examine in depth some objects that are particularly useful both in diagnostics and, possibly, as substitutes for the floppy or hard disk: Floppy Emu and ESProFile.



FloppyEMU, as the name suggests, is a floppy disk emulator for all Apple models, from the Apple II to the MacIntosh, and is therefore an extremely powerful and flexible tool.

The disk images are copied onto an SD card, when the emulator is connected to the machine you can select the disk you want to "insert".

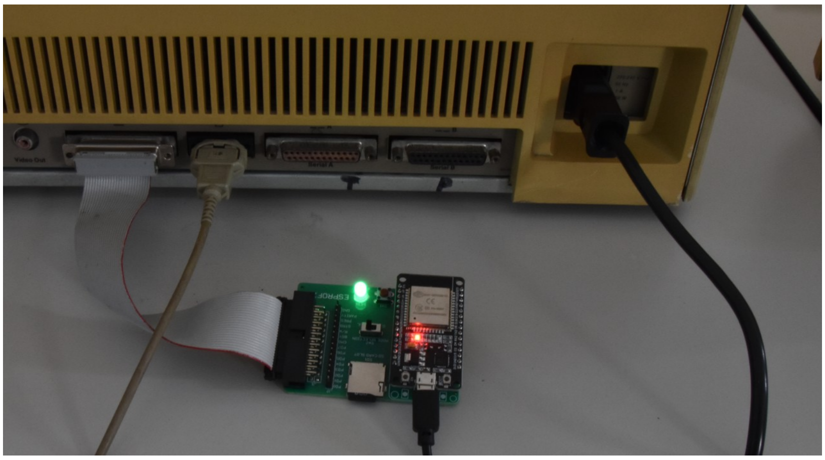
In the photo the emulator connected to a Lisa 2/10, with the BLU utility disk active.

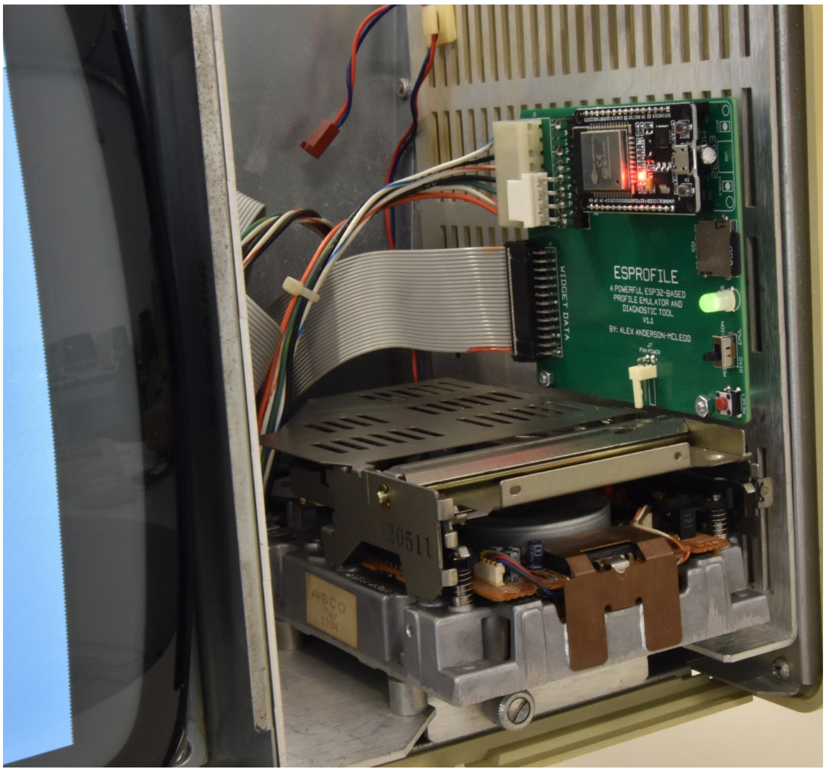
Hard disks, as everyone know, are subject to frequent breakdowns, and no matter how careful you are, it is almost impossible to keep them efficient for long periods, which is why ESProfile was created, it is an emulator for Apple Profile (the external Apple disk, used for both the Lisa and the Apple ///), but which can also emulate the Widget.

It cannot be bought ready-made, or rather the open source project provides that it can be ordered from companies that make printed circuit boards and that, if necessary, also assemble the components; however, consider that the minimum order in this case is 5 pieces.

It is based on a module similar to Arduino called ESP32 that is mounted directly on the base that also includes the few external components needed.

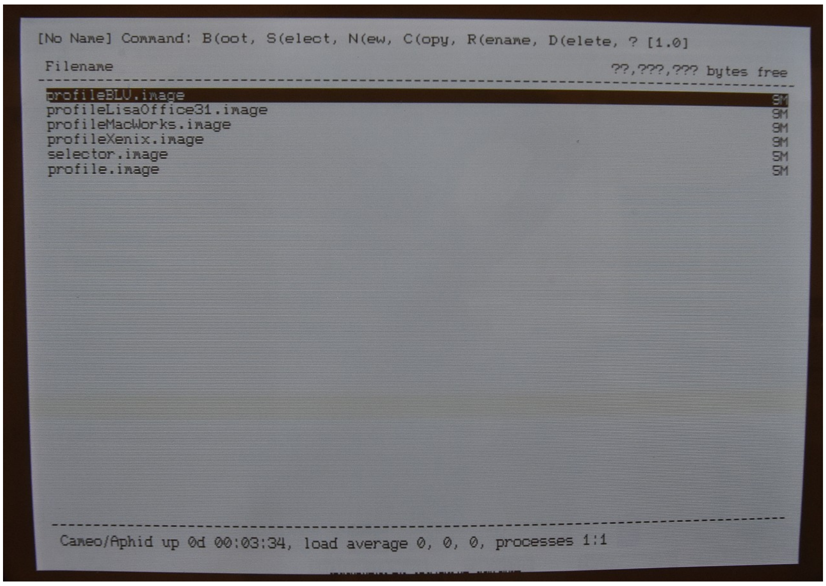
2 versions are available: an external one, which connects with a cable to the Lisa's parallel port replacing the Profile ...





... and the other, an internal one that is mounted in the same place of the Widget; in this last case the "disk activity" LED is positioned exactly where the equivalent hard disk LED is, therefore making it visible from the front panel.

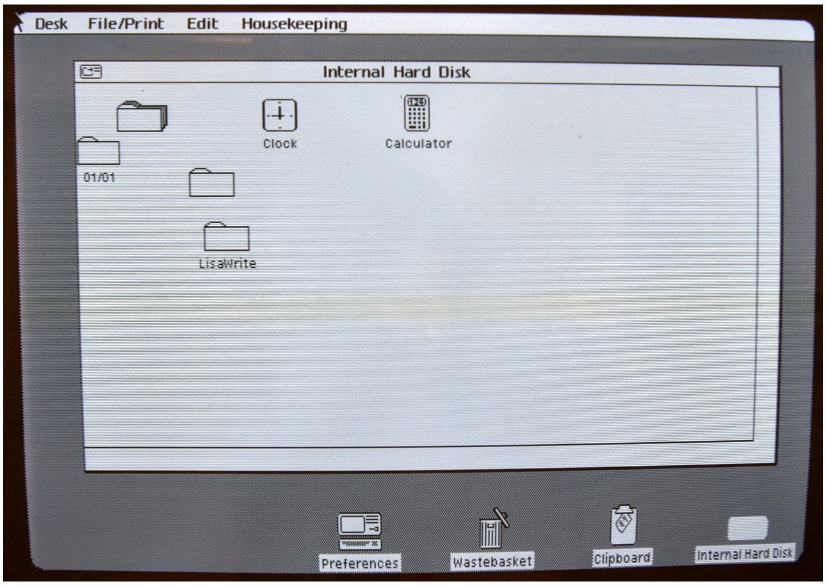
Another very interesting feature is the ability to load different disk images at startup, in order to have various operating systems ready to use; for example, we have created images for Lisa Office System, MacWorks, Xenix and BLU; as mentioned, the latter is not a real operating system, but it is possible to load it on the emulator, in this case it becomes useful for testing on floppy disks.



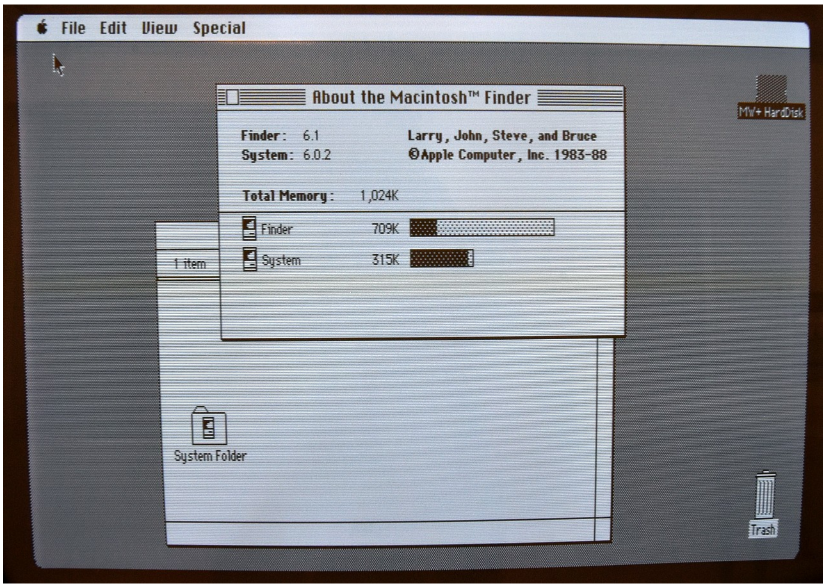
Last but not least, an interesting feature is to use it in diagnostic mode, in practice you can connect it on one side to the parallel port of an Apple Profile and on the other side to a PC via USB. From the PC you can give commands to do various activities, including low-level formatting (which however requires a change of CPU within the Profile itself too) without the need to connect the disk to a machine.

Operating Systems

With the possibility of using different floppy and hard disk images, thanks to the emulators described above, we also had fun installing the available operating systems:



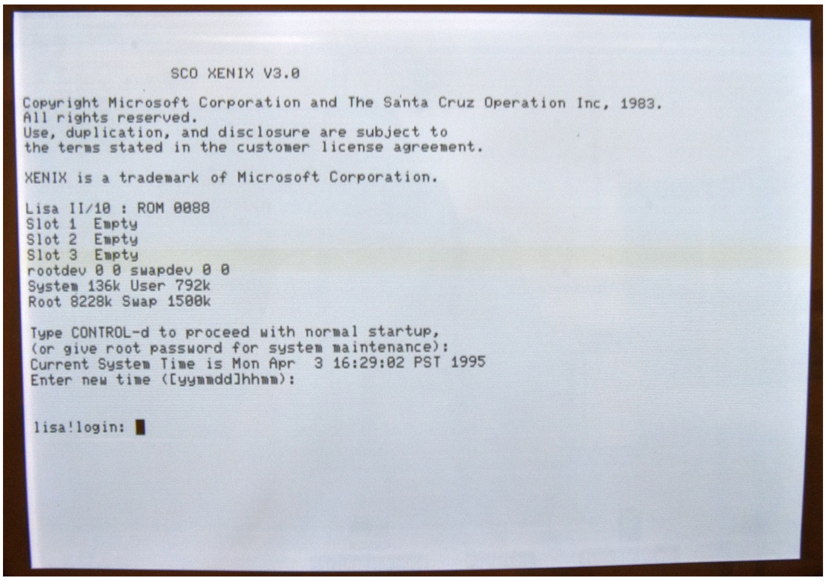
Office System 3.1, the original Lisa operating system



Mac Works for MacIntosh emulation, here running on a Lisa 2/10.

Note the oblong shape of the icons, which is corrected in the MacIntosh XL with the changes to the video circuitry previously described.

And finally SCO Xenix, which does not exploit the graphic potential of the machine and therefore has an "old style" look.



Conclusion

Restoring the Apple Lisa belonging to the All About Apple Museum and the European Society for Computer Preservation had been really a challenge.
But we are very proud being able to repair, restore, and made working again 8 Lisa over 9.
Only 1 is left, but we do not have all the hardware to fix it, probably missing before it had been donated to the Apple Museum.
Now two "Lisa 1 converted in 2", two XL, four Lisa 2/10 with widget hard disk are perfectly working, and they can be seen permanently at the All About Apple museum in Savona, Italy ,and in the EsoCoP exhibitions in Switzerland and Italy.