HP-41CV Repairs and Battery Upgrade

By Dmitri Faguet

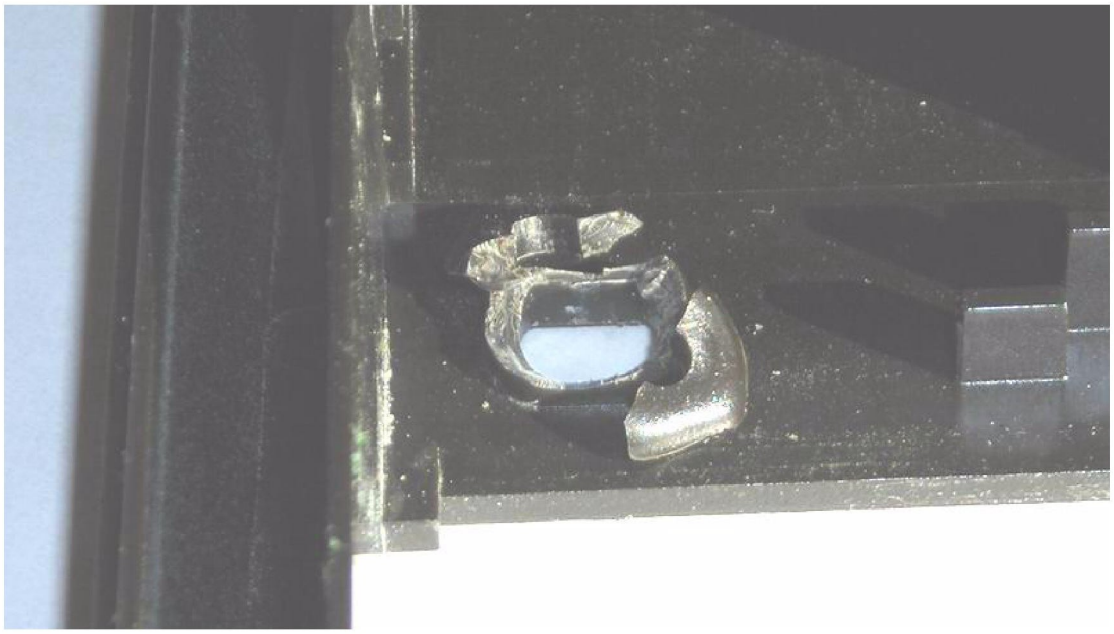
Introduction

This instrument with an interesting "historic" serial number 41776 was the latest addition to my small collection of HP calculators, and a potential rival to my favorite HP-15C, which I use for more than 20 years now. Both machines were made in late 1984, just four weeks apart. When my "new" HP-41CV with working card reader arrived (I bought it on eBay), my first impression was that the machine looks like new. Of course, I read several letters on hpmuseum forum before placing a winning bid, and was ready to "open the shell and fix cracked plastic posts", if necessary. Battery compartment corrosion was another concern and a typical point of discussions on eBay, in particular regarding the classical line of calculators such as HP-35, HP-65, and other models with LED displays and NiCad batteries. Unfortunately, HP-41 with its choice of N-type batteries (as a compromise between the small size and the required performance) is also vulnerable to this disease. My new HP-41CV was not unique in this sense, and gold-plated contacts showed moderate deterioration due to numerous battery replacements and leakage. I was ready to take radical steps regarding an alternative power source for my calculator, which drained batteries at high rate of 250 mA when reading magnetic cards, and consumed up to 10 mA when pressing keys or running programs. This is quite different compared with a highly economical HP-15C powered by three small silver-oxide wristwatch batteries, which last for many years in an idle mode and almost never leak. (In fact, some low quality wristwatch batteries can show salt residue on the sealing ring at the end of their life cycle, but in general this is rather uncommon).

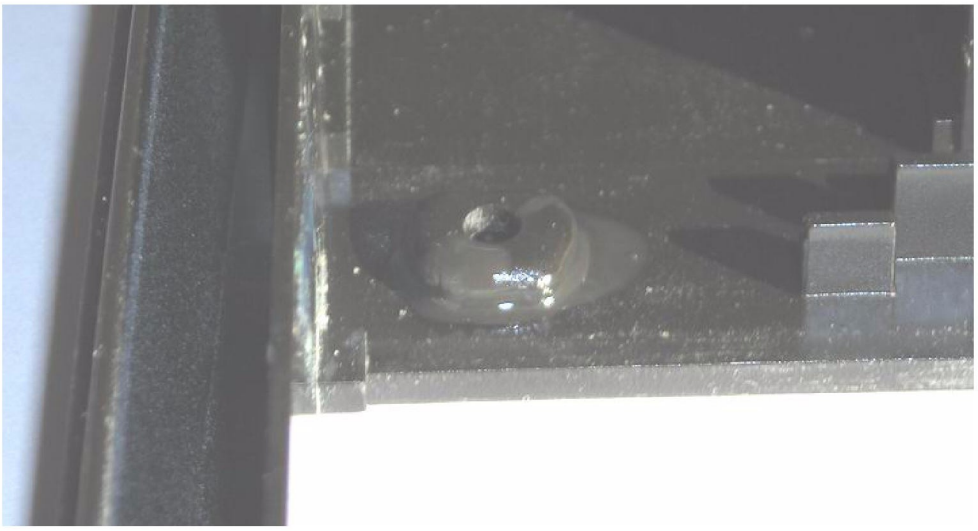
What follows is a brief discussion of a one-day project conducted by a person whose lifetime hobby is electronics, and whose formal profession is mathematics and finance. In other words, I am not an experienced technician whose job is repairing and maybe trading old HP calculators on a regular basis. Actually, this HP-41CV was the first calculator that I repaired in my home "laboratory".

The Shell

As you probably know, the HP-41 plastic shell is not as strong as that of the fabulous financial calculator HP-12C, or as Pioneer line calculators. At the same time, it holds together, via the elastic gold-plated connectors, the internal electronics (the CPU board in the lower part of the machine, and battery/four slot connectors' module in the upper part). As a result, the "cracked plastic posts problem" is the well-known HP-41 illness that develops with age. My calculator was no different, and the screws holding the upper part of the body seemed to be somewhat loose. However, when I removed four screws and opened the shell, I saw a different problem: broken plastic right under the screw heads, which can be seen when the battery connectors' module is separated from the back cover.



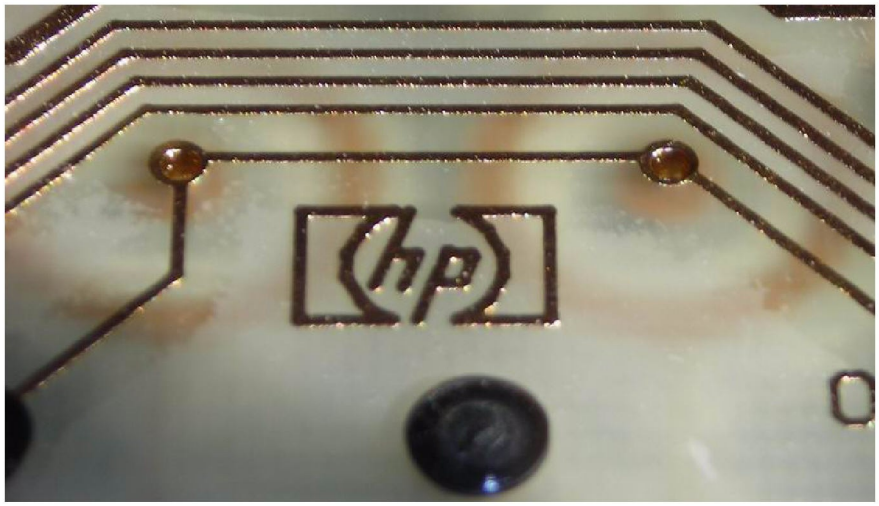
Possible explanation to this defect is the card reader. If this one is kept plugged in, and the computer is carried around and subjected to mechanical loads, this could easily lead to broken plastic. The solution to this problem was obvious: First, carefully hold together in place the loose pieces of plastic. Second, apply a drop of cyanoacrilic glue to fix broken plastic parts.



Third, fill the space around the repaired plastic with fast setting strong epoxy adhesive (I used the DoneDeal Adhesives Lab's brand, a 4-minute steel-based epoxy), and immediately fit back to its place the connector's module. Of course, this last operation permanently bonds together the connector's module and the back cover, but there is absolutely nothing wrong about it. These two parts are molded separately for technological and not for functional reasons, and there are no electronic components in the connectors' module that would potentially require replacement at later stage.

The Keyboard

Another small problem with my HP-41CV was connected with a couple of keys, which demanded stronger tap on them to achieve the required response (I gently pressed the CLX key to clear the display after keying in a number, and at first attempt there was no response). Clearly, the keyboard required proper lubrication or cleaning. Someone on HP forum already wrote about this problem and the way to solve it: to put small amount of cleaning liquid through tiny holes under the keys on the back of the PC board.

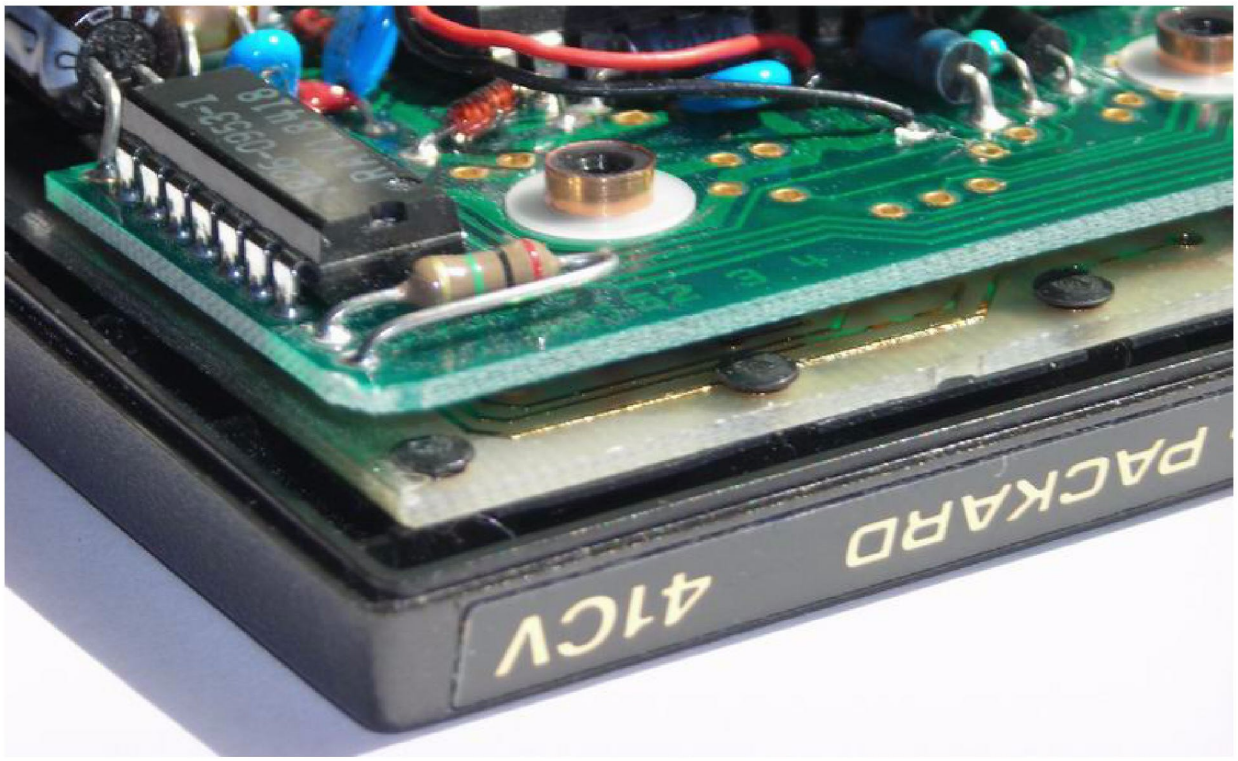


From my personal experience I know that the best remedy for electric contact problems is not just to clean contacts with solvents such as pure alcohol or lighter fuel, but rather to apply quality lubricant to contacting surfaces. So I took off the HP-41CV CPU board, and removed plastic cover sheet. Then I applied small drops of my long-time favorite high adhesive Teflon Lubricant from Radio Shack through the corresponding holes on the PC board as discussed above.

The interesting side effect of this procedure is the changed “click” sound when key is pressed: it becomes a bit muffled, which is a clear indication of the fact that lubricant did the required job and stays at the contact surface on the other (“invisible”) side of the PC board. Needless to say that all keys now worked perfectly!

Plastic Posts

Actually, the four plastic posts in my HP-41CV were in a good shape (the lower two showed hair type cracks, but they still worked). However, to avoid upcoming problems I decided to fix them properly. One possible solution was to fit a very thin-walled metal tubes on them (for example, cut from an appropriate telescopic antenna purchased at a hobby store), or to wrap several turns of fine wire around the posts as was already suggested by someone on HP Forum. Instead, I simply wrapped around each post several turns of a thin (0.02 mm) brass foil, and then fixed it with a drop of cyanoacrilic glue. This solved future “cracking posts problem” for my calculator.



The Battery

This was the most difficult and controversial part of the project. As you can see, the contact surfaces in the battery compartment inevitably suffer from frequent battery changes and possible leakage.

Unfortunately, battery contacts in HP-41 are too weak due to technological process used in the production (they are made not of solid metal, but rather look like thin gold plated copper traces on a thin flexible PC board). As a result, they cannot last long in principle.

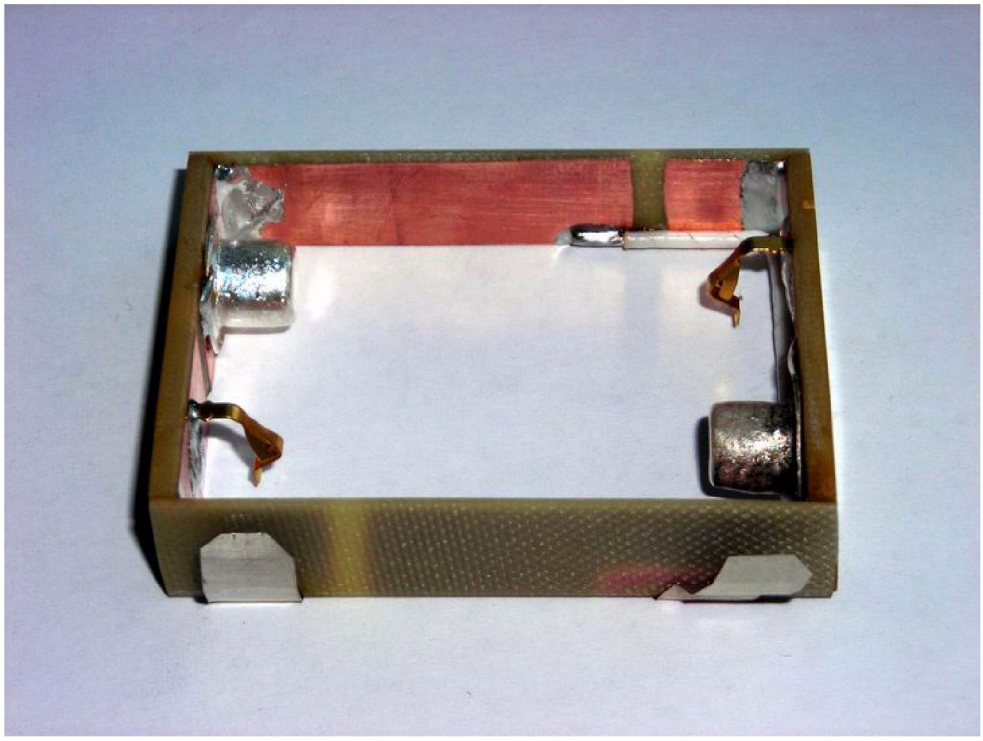
Another problem is the choice of N-type batteries to power the machine. Of course, from today's perspective this is not the best choice. These batteries are not too powerful to keep the HP-41 running for a long period of time and without possible leakage, especially when the card reader is used with the machine. Of course, when HP engineers designed the HP-41 technological marvel almost 30 years ago (and it IS a great calculator even today!), their choice of N-cells as power source was undoubtedly the right one, as the only optimal tradeoff between small size, availability, and reasonable electrical characteristics. One should keep in mind that 30 years ago we all lived without personal computers, cell phones, iPods, CD and DVD players, Internet, etc. It was probably the Stone Age from our kid's perspective. Obviously, there were no high-energy batteries readily available to public (we are not talking about special applications here), to power the HP-41 and other hi-tech gadgets of those days.

Let us briefly calculate average power requirements for HP-41, assuming 1-hour daily use of the machine. The Owner's Manual gives the following power consumption rates for HP-41CV: operating current 5 to 20 mA, idle current 0.5 to 2 mA, off current 0.01 to 0.05 mA. As for magnetic card reader, I made measurements myself to find out current drain of about 250 mA when motor pulls the magnetic card. Therefore, elementary calculations show that average daily energy consumption by HP-41 would be in the range of 10 mAh (assuming 45 min Idle, 15 min Operating, 1 min Reading/Writing, and 23 hours being switched off). Therefore, a fresh N-battery pack would last for about 2 months with its listed 500 mAh capacity, and standard rechargeable HP82120A pack with capacity of 65 mAh would last for just one week (!) between charges.

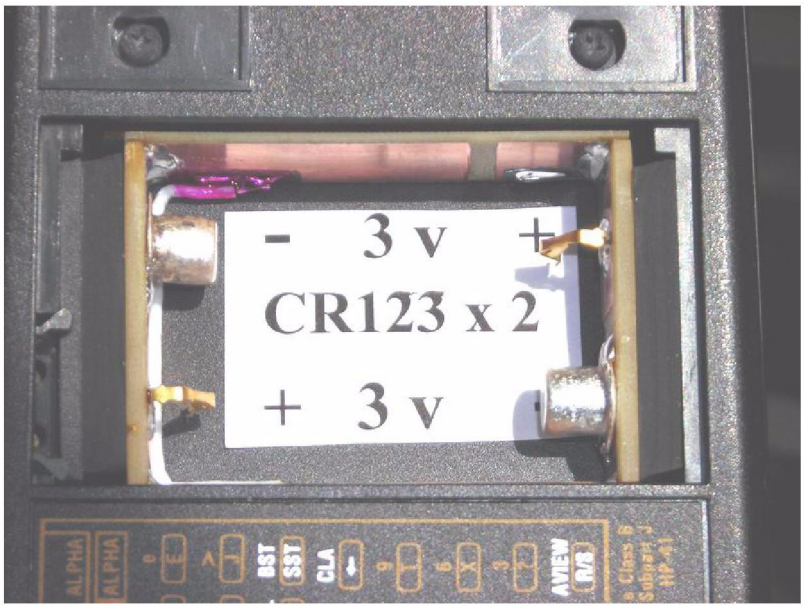
Today, the best batteries in terms of output voltage stability and low internal resistance (important consideration for high current applications such as HP-41 card reader) are Lithium cells. Moreover, with the HP-41 6-volt battery (4 cells of 1.5 volts each) this naturally suggests the use of two 3-volt Lithium cells, or possibly two LiIon rechargeable 3.7-volt batteries (with added diodes to cut off an excess of 1.4 volts). However, LiIon rechargeable batteries lose energy (due to self-discharge) much faster than regular Lithium batteries (which can provide the same electric energy after being shelf-stored for about 10 years). Therefore my decision was to stick to standard Lithium cells and to choose from the most popular types only (by the way, N-cells are much less common than standard AA cells!).

Unfortunately, the popular button-type Lithium cells (e.g. CR2032) are too "weak" to run the card reader, and also not too powerful to provide enough energy for HP-41 in principle. At the end I came up with a compromise: to fit in two CR123 Lithium cells commonly used in 35 mm film cameras and other equipment such as high power LED torches, etc. These batteries have high capacity of 1,300 mAh, they have excellent load characteristics for HP-41 card reader, they are inexpensive and available everywhere in the world, and (as far as I know) they never leak. The next step was to check how they would fit into HP-41 battery compartment. They almost did, and the only minor problem was the fact that one of two batteries (the one located in the "thinner" part of HP-41) would "stick out" for about 2 mm above the plane surface of the back cover of assembled HP-41. This was not good, but at the same time not critical, and I decided to live with it. At the end, I will use my HP-41CV for work and for pleasure, rather than store it for future generations. In any case, I thought that I would still keep the original battery holder intact and would not use its parts for my alternative design. Maybe some day the new non-leaking and ultrahigh capacity N-size batteries will become available, and I would then come back to using that original HP-41 battery holder.

As you can see in the photo below, the basic problem was to build a holding frame with high quality electric contacts to hold two CR123 cells in the HP-41 battery compartment, and to provide good electric contact with HP-41 battery terminals.



It took me about three hours to design and make this thing. I used copper-plated fiberglass board as base material (this material is commonly used to make PC boards), but one can replace it with any plastic or metal frame with proper insulation for battery terminals. Connection to HP-41 battery terminals was made with the help of silver-plated elastic brass contacts cut from 0.15 mm material used for shielding electronic RF devices, and I used suitable sterling silver and gold-plated hard brass terminals to connect CR123 cells in the frame. The next photo shows the frame fitted into HP-41CV battery compartment.



As one can see, even the potential risk of damage to HP-41 terminals (caused by unlikely case of CR123 cells' leakage) is completely eliminated with such design.

The last thing was to make a nice metal cover to the new battery compartment. For this purpose I used thin (0.4 mm) sheet of stainless steel, cut, bent, and properly soldered (with silver-bearing tin) to form the required shape.

This cover is strong enough to protect HP-41 battery compartment and to absorb reasonable loads during normal use of the calculator. Insignificant excessive height of the new battery compartment lid can be compensated by using a slightly higher (by about 1 to 1.5 mm) rubber feet instead of the existing ones, if necessary (one can also keep the original feet, as I did). The steel cover is hold in place by an additional piece of plastic and two small screws, as shown in the picture.