Hammond® Vintage

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Dead Percussion on B3/C3

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" Dead percussion on B3/C3 "

1. Forewords – Purpose of this article.

A lot of articles have been already written about unexpected 'dead percussion' on Hammond B3/C3 and the way to get rid of this situation.

As owner of several organs, inevitably I was facing the problem.

Here is what happens !
You start playing on your B3 or C3, select the Percussion tablet to 'ON' position and nothing comes out. Totally dead percussion without any apparent reason.
If you are on stage ready for a gig, you like the typical Jimmy Smith sound, your 'mood' may change at once and you start to curse and swear.

As an old good Hammond folks, since you anticipate events, you are always used to walk with a set of basic tools including 'just in case' spare tubes. Then you start replacing the three percussion tubes V5, V6 and V7, the last three tubes located at the right side of the AO-28 preamp seen from the rear side. You know that since years. Still no percussion. Things become really shitty now. You are cursing a little bit more....

No other choice, the gig is going on and you start to simulate a kind of " soft percussion " with the swell pedal, the best you can. What a torture to play like that since with the next tune you have to take the lead on ' A whiter shade of pale ' of Procol Harum where you need the Second Harmonic percussion.....That's reality.

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The purpose of this article is to analyse ' in depth' the reason of such sudden failures and provide several methods to prevent and fix this problem either <u>temporarily</u> or <u>definitively</u> .

We all know that dead percussions can be caused by several components such as defective caps around tubes V5, V6 and V7, faulty transformers T4, T5 and T6, defective tubes, bad contacts at percussion tablets, broken wires, etc....and last but not least by 'zincdendrites' or 'dendrites' for short.

The common repairs of percussion function are not taken into consideration and <u>this article is mainly focused on the impact of these bloody dendrites formations</u> which are really a pain in the neck on those vintage Hammond's.

This being said, this phenomenon of dendrites formation is not peculiar to Hammond organs. Many electronic equipment using this zinc-plated chassis and the like are facing similar situations. It's a recognized situation in the whole electronic industry.

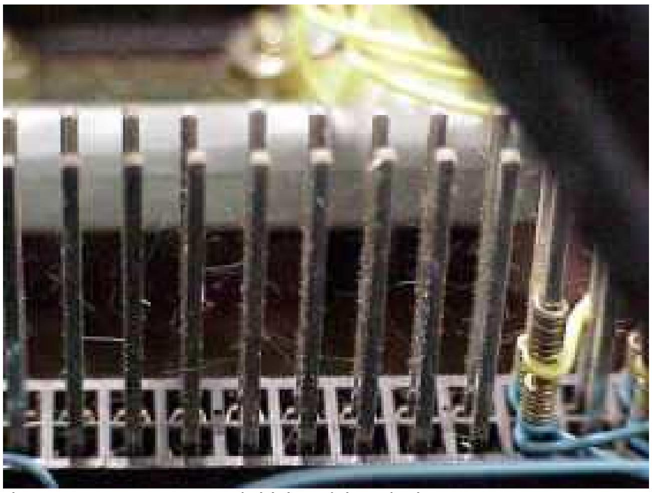
Before going any further, it has to be mentioned that, in any case, an adequate technical expertise is absolutely compulsory and it is recommended to understand what you are doing.
So this article is mostly addressed to qualified technicians endowed with sufficient know-how, dexterity and ... a lot of patience.

2. About " ZincDendrites ".

It is not the intention to develop a lot of theories on dendrites formation. Many scientists, including NASA, have already conducted in depth studies on the subject. For those who are interested by, just have a look to http://nepp.nasa.gov/whisker/ . Also on the well-known website http://www.dairiki.org/HammondWiki/ZincDendrites , it's easy to get a good idea of the importance of this problem.

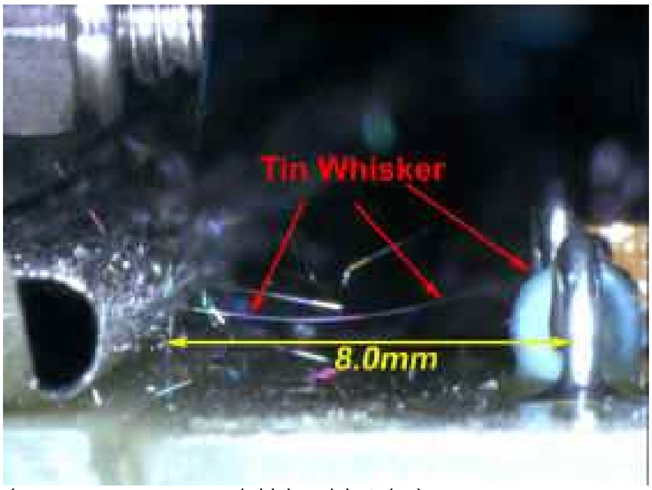
With aging, heat, humidity, oxidation, salt air, major temperature swings, shocks during transport...some thin whiskers start growing on zinc-plated metal components and since they are metallic, of course these whiskers are conductive and are therefore the cause of many troubles in electronic devices. The combination of these thin whiskers are called 'dendrites' or sometimes called 'magnetic dusts' or even 'magnetic particles'. Several photos are often more self-explanatory than long boring theories.

In this picture, thin whiskers are shorting the square zinc-plated post of this connector.



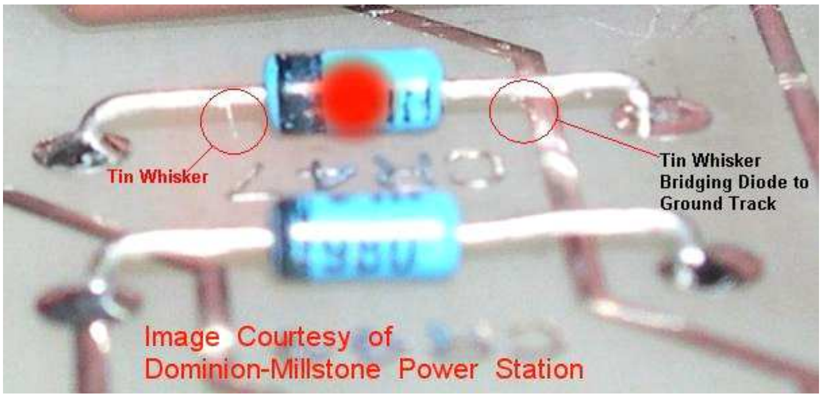
(source : nepp.nasa.gov/whiskers/photo/...)

On this picture, tin whiskers bridging two components at a distance of 8.0 mm !



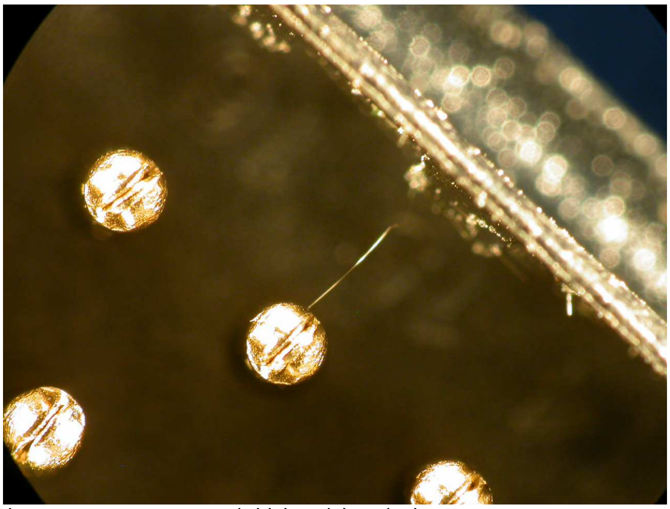
(source : nepp.nasa.gov/whiskers/photo/...)

On the next picture, short between one end of this diode and copper trace of PCB.

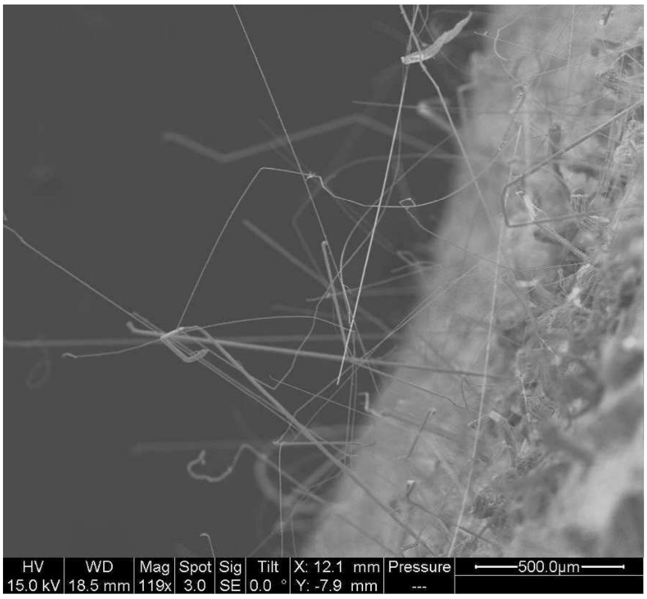


(source : nepp.nasa.gov/whiskers/photo/...)

...or shorts inside D-Sub connector shell


(source : nepp.nasa.gov/whiskers/photo/...)

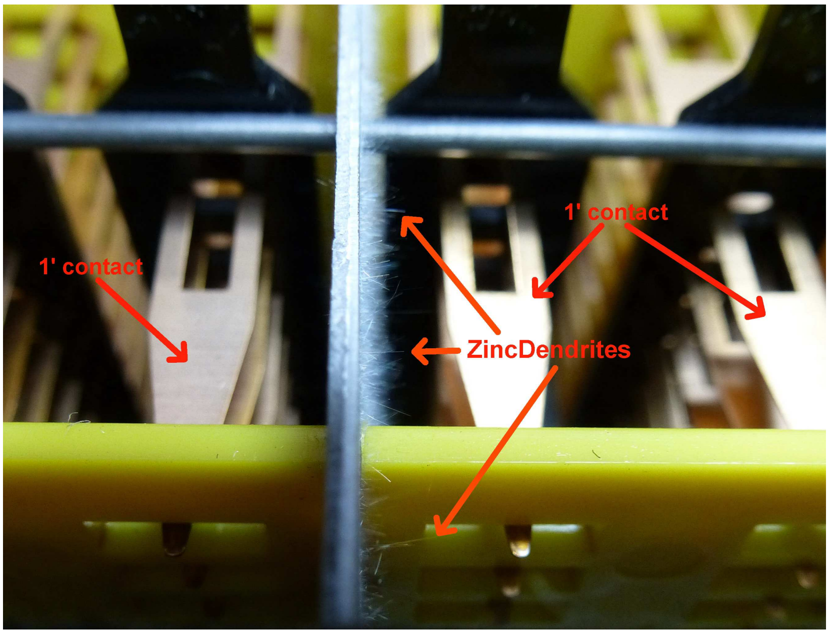
Dendrites (or whiskers) seen by microscope



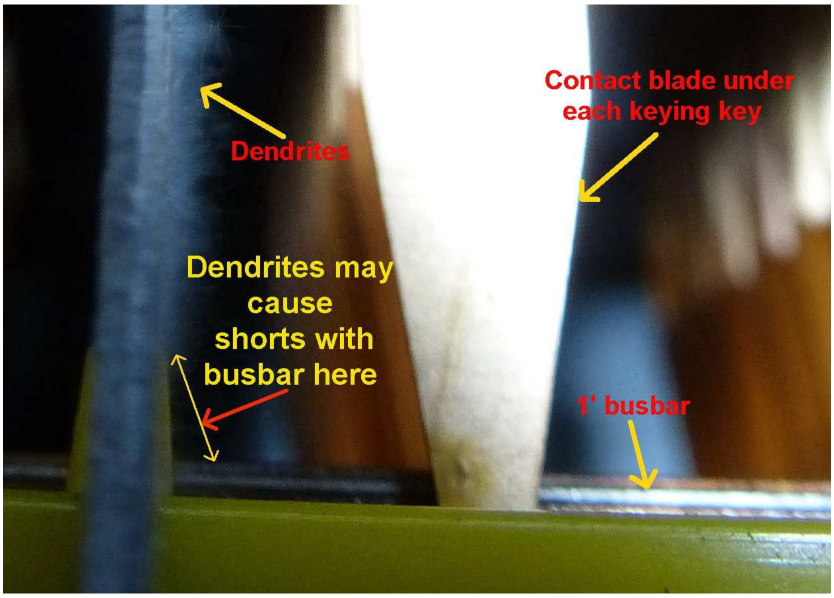
3. Dead percussion on B3/C3 and " Dendrites ".

This being seen, let's enter the sharp one of the subject with the impact of dendrites causing dead percussion.

Here again, pictures taken from on my own Hammond C3 are self-explanatory.



The little whiskers appearing on the zinc-plated metal plate when growing may touch the upper 1' contact blades **and** the 1' upper busbar....



....bridging so permanently the 1' upper busbar to ground when "B" adjust key is pressed !

4. What's happen exactly in the upper keyboard ?

Previous pictures have shown that whiskers may grow up to 8 mm length ! The distance between the busbars and chassis is far shorter and as a consequence of this zincdendrites may easily hit these busbars.

It is not the intention here to re-explain how the percussion circuit is operating. Refer to Appendix #1 extracted from Hammond B3/C3 Service Manual – Page 8 & 9. Nevertheless, it is interesting to understand what's happen exactly when zincdendrites are in contact with busbars.

When 'B' preset is down on upper keyboard and percussion tablet engaged, under normal operating condition, we measure a voltage of around +25 Vdc between terminal 'K' of AO-28 preamp and ground. When no key pressed, this terminal 'K' via the 1' busbar remains *'in the air'* and this +25 Vdc remains unchanged until any key of the upper manual is pressed.

When any key is pressed the related key-contact is in touch with the 1' busbar and it grounds practically this busbar through the tone generator filter.
The internal resistance of the tone generator filter is extremely low (it's a matter of ohms) and terminal 'K' is so grounded. The anode of tube V6 (connected as a diode) is put to ground and this diode becomes simply blocked.

The voltage at V7 grids drop from +25 Vdc to about +15 Vdc at a discharge time that is defined by the time constant C31 and R57 / R58. At the end of C31 discharge, <u>the percussion signal remains blocked and no further percussion is possible</u> until all keys of the upper manual are released and V7 control grids may rise again to + 25 Vdc. (info taken from B3/C3 Hammond service manual – see Appendix # 1).

This last sequence is important to keep in mind : *'playing one key on the upper keyboard will ground the 1' busbar, then voltage at terminal 'K' drops low enough to block V6 and block any percussion function.'*

That's exactly what zincdendrites are doing when hitting the 1' busbar with no key pressed on upper keyboard.
Personally, I have measured DC resistance at terminal 'K' in the range of 380 Ω, sufficient to block diode V6 and hence the whole percussion circuit.

Some may argue on the fact that dendrites may also hit the contact blades and it is correct. The point is *' then, why the corresponding tone that is so bridged can still be heard ? '* Good question indeed.

To answer this argumentation, it is necessary to recall some basics of electricity. Fortunately since the whiskers are so thin, it shows a the DC resistance that is not negligible.

Remember the Pouillet's law : $R = \dfrac{\rho \, . \, l}{A}$

in which R is the resistivity, ' ρ (rho) ' is the effective resistance (unknown), ' l ' is the length and ' A ' being the section of the whisker. Since ' A ' and ' l ' are very small, the resistance R is rather high ! That's why, we measure about 380 Ω.

Assuming a tone filter of TWG with a DC resistance of 20 Ω that is bridged by whiskers of about 380 Ω. Based on the parallel resistance formula, as a resultant ' R ', we get 19 Ω i.s.o. 20 Ω causing a very little drop in voltage output at the tone filter but not sufficient to cause drastic audible losses.

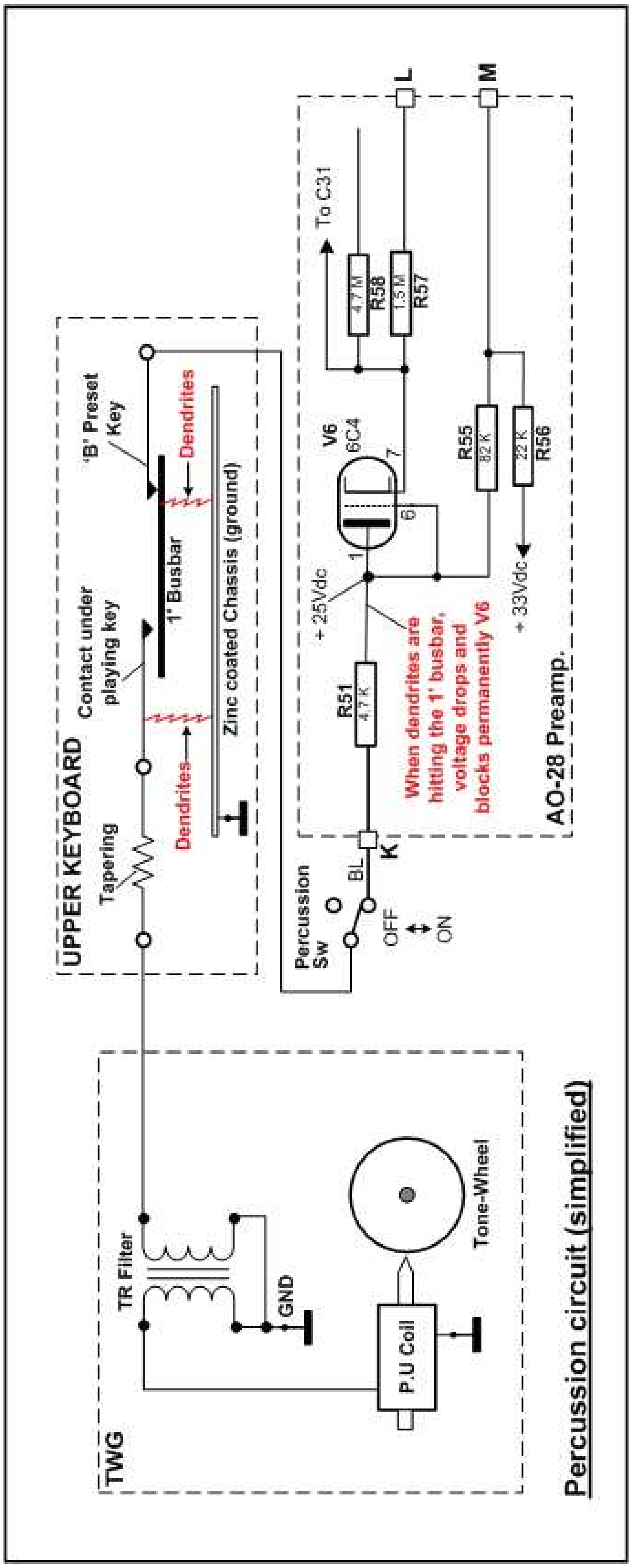
$R = \dfrac{Rt \times Rd}{Rt + Rd}$ as a resultant, we get $R = \dfrac{20 \times 380}{20 + 380} = 19\ \Omega$.

in which Rt is the internal resistance of the Tone generator filter and Rd is the resistance of the Dendrite whisker(s).

As a conclusion, for the above reasons, even being bridged or 'damped' by dendrites, 'hopefully' the output level of the tone generator will not be seriously disturbed by dendrides <u>in touch with blades key-contacts</u>.

However, inversely dendrides will block definitively the percussion circuit when in touch with the 1' busbar.

Refer also to simplified percussion circuit on next page for easier understanding.



Percussion circuit (simplified)

5. Other points to be checked .

5.1 Dendrites in the percussion switch assembly.

It is quite possible that dead percussion may be caused by shorts of dendrites found inside the percussion switch assembly (under the four percussion tablets).
The switch cover has to be removed and the interior of the housing has to be carefully checked and cleaned. To get good results, the entire switch assembly has to be dismantled from the back side. Re-installing of tablet switches is not so easy.

5.2 Preset percussion switch.

It may also happen that dendrites can be also found at the ' Preset Percussion Switch ' located just underneath the ' B ' preset key of the upper keyboard.
Less usual than those found in upper keyboard.

6. How to get rid of those zincdendrites ?

Based on my own experience on B3/C3, there are several alternatives :

6.1 Zapping method (also called " flashing ").

Zapping is probably the easiest way to get rid of those bloody dendrites for a short period of time (i.e. a few weeks, a few months) but be sure that it will reappear again unexpectedly. Moreover, this way of doing can be really harmful to the organ !
Better know what you are doing.

We have seen that dendrites do have a certain resistance in the range of a few hundreds ohms (effectively measured 385 Ω) and this value is sufficient for tube V6 to become non-conductive and block the entire percussion circuit.

By applying a certain DC voltage between this dendrite 'bridge' and chassis ground it is quite possible to " explode " this dendrite and eliminate so this ohmic bridge.
That's the principle.

Based on my experience, most of the time, dendrite bridging is located in the upper keyboard. Since it is not my intention *' to re-invent the wheel '*, I simply recommend to refer to the HammondWiki website – Percussion Troubleshooting -
http://www.dairiki.org/HammondWiki/PercussionTroubleshooting

Personally, I have used this method several times with good results.

As a summary, unsolder the blue wire at ' K ' terminal of the AO-28 preamp and measure with the ohmmeter the dendrite resistance value. Just to get an idea.
- firstly start flashing with low voltage batteries (two or three 9 Vdc in series) between the blue wire and ground.
- if ohmic value at blue wire remains unchanged, load a 100 µF/400 Vdc elco with 40 Vdc, then 60 Vdc... up to 100 Vdc via an external power supply and, if needed, restart flashing several times until dendrites blow and short disappears..
- resolder the blue wire at ' K ' terminal of AO-28 preamp.

This method is fast but is not the fain of the art because :

- it has a serious risk to create permanent damages to the organ. As an example, while being rather strong, tapering wires behind the contact keys may also blow during the elco discharge, then <u>your organ is in really bad shape</u>. Be sure what you are doing !

- anyhow, this solution is temporary. New dendrites will re-appear in the future with the time, rust, oxidation, salt atmosphere, humidity, major temperature swings, shocks during transport, etc... It's a simple matter of months !

6.2 Busbar cleaning.

We have previously demonstrated that dendrites are bridging the busbars in keyboards. Another way to get rid of dendrites is to remove the busbars from the keyboard, carefully clean and re-install the busbars after proper lubrication.
I got nice results with ' Tunerlub ' HF Lubricant from GC Electronis –USA.
Concerning busbar cleaning, it's a good idea to also refer to DVD 'Hammond Inside' – Part One – Care & Maintenance issued by Alain Kahn and available from Socadisc Europ Distribution.
Be warned, there is no guarantee that this lubejob will resolve the problem.

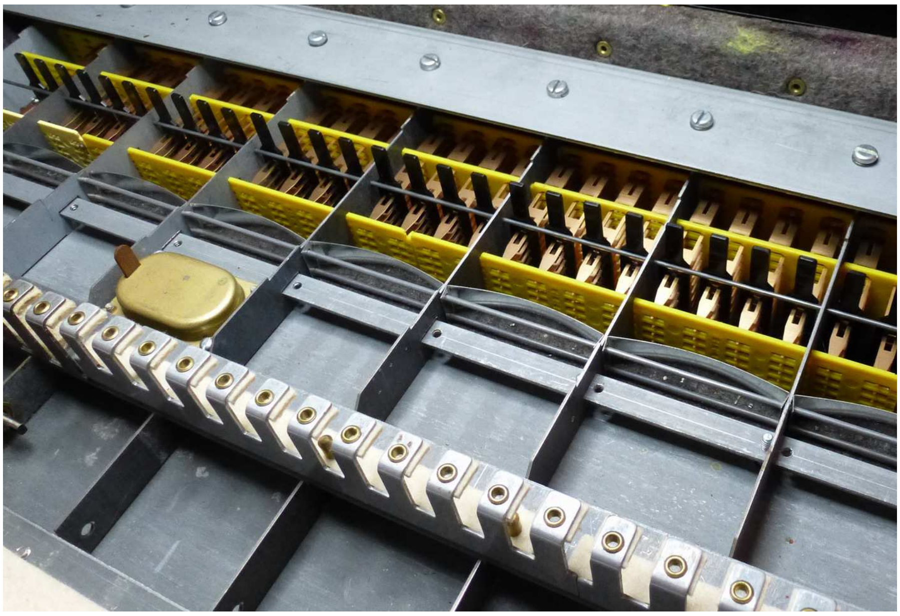
6.3 Cleaning the entire keyboards.

Previous pictures have shown that side metal plates between each cell of four key-contacts are found with a lot of conductive whiskers.

Now, the point is how to remove those bloody whiskers definitively.
Several attempts such as air-pressure, vacuum-cleaning, cleaning with flat paint brush...were tried but unsatisfactorily to my opinion.
Finally, a basic system was elaborated, may be somewhat rudimentary but providing excellent results.

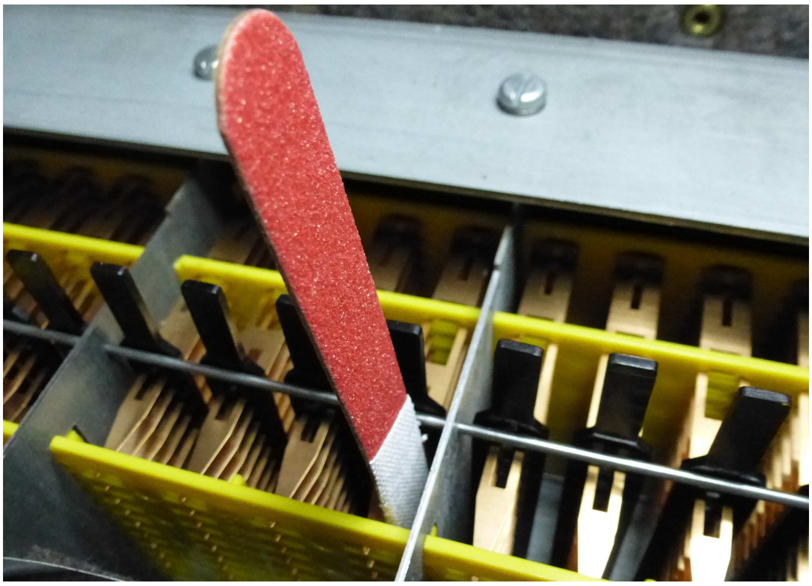
Again, this next job requires time, patience and a certain technical skill !

The entire keyboard must be dismounted. This means all keys removed as well as cover plate above the key-contacts. See next picture.

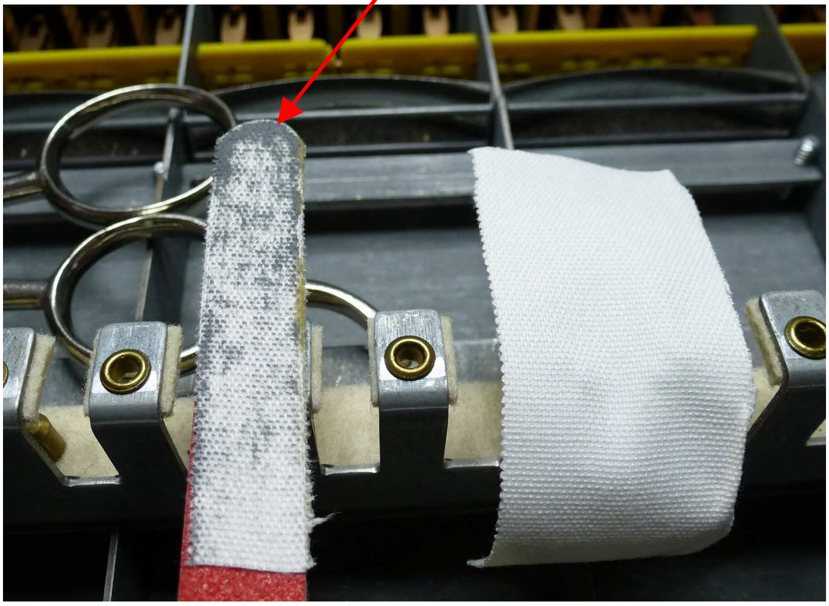


It is obvious that both keyboards have to be treated in the same way.

Prepare one cardboard fingernail file and cover it with sport tape (must be cloth-bound) and clean carefully each side of the metal plates in order to remove the dendrites.

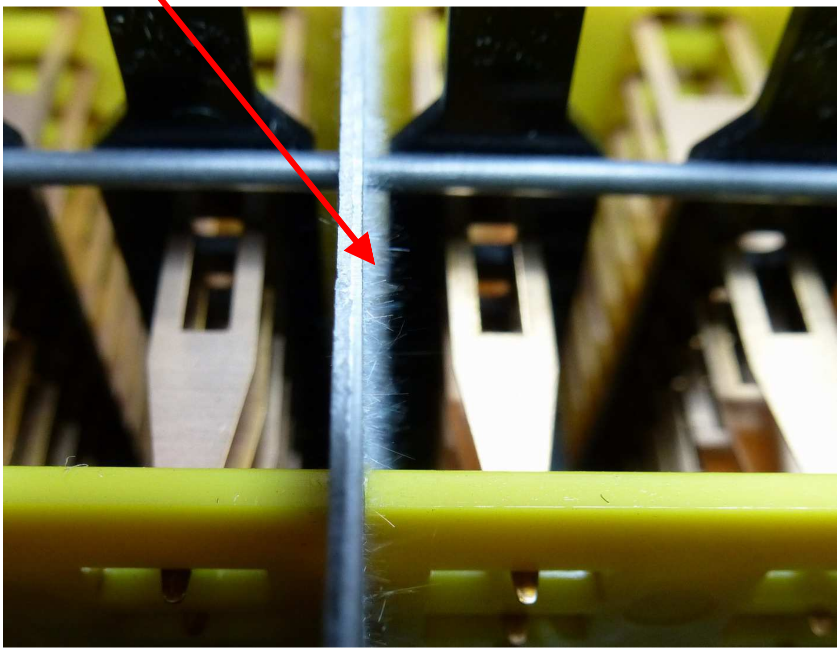


On the next picture, we can see the dendrite wastes (residues) that are removed by the tape during cleaning process.

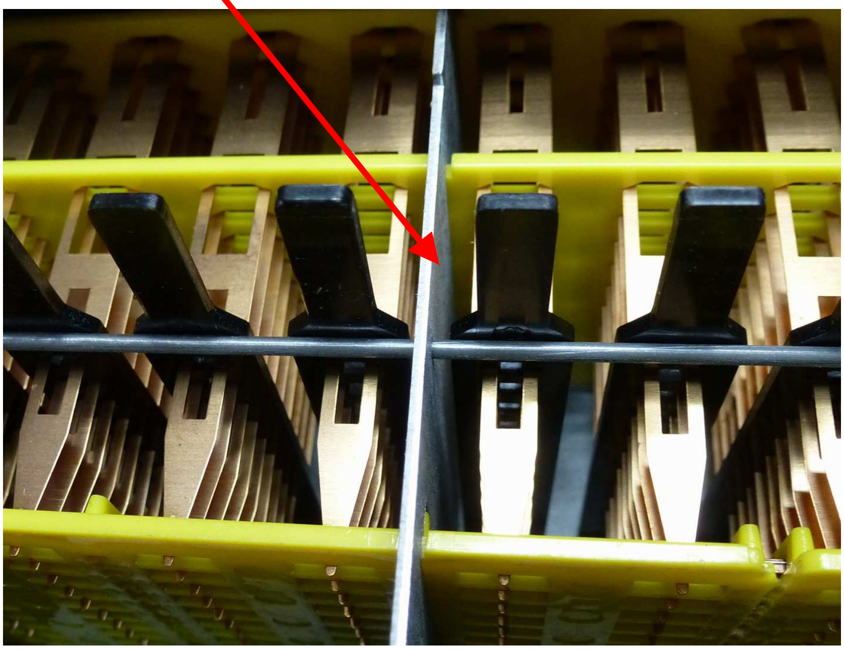


Now, let's see the results :

<u>Before cleaning</u>. Dendrites are covering the sides of the metal chassis.



<u>After cleaning</u>. All dendrites particles removed on both sides.



It takes at least two hours to clean carefully one keyboard without remounting and adjusting time of all keys. No rush, take it easy.

6.4. The ultimate Dendrite treatment.

For those who are happy so, the dendrites 'grand-cleaning operation' is now completed but, to my opinion, there is still a 'but'.

As a matter of act, we have learnt that metal sides near key-contacts have been cleaned and left as such <u>without any protective lacquer or coating treatment</u>.

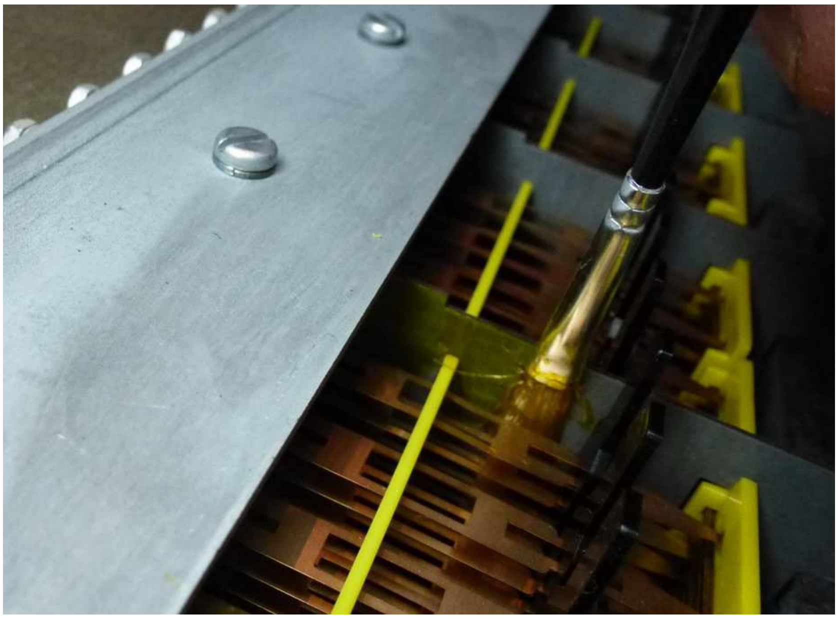
This also means that our old friend metal migration (zincdendrites) will again reappear in the future (nobody knows when) and same phenomenon will be reproduced....

Since I want to get DEFINITIVELY rid of those dendrites formation and the problems caused, I have decided to apply a protective coating on each side of the metal plates.

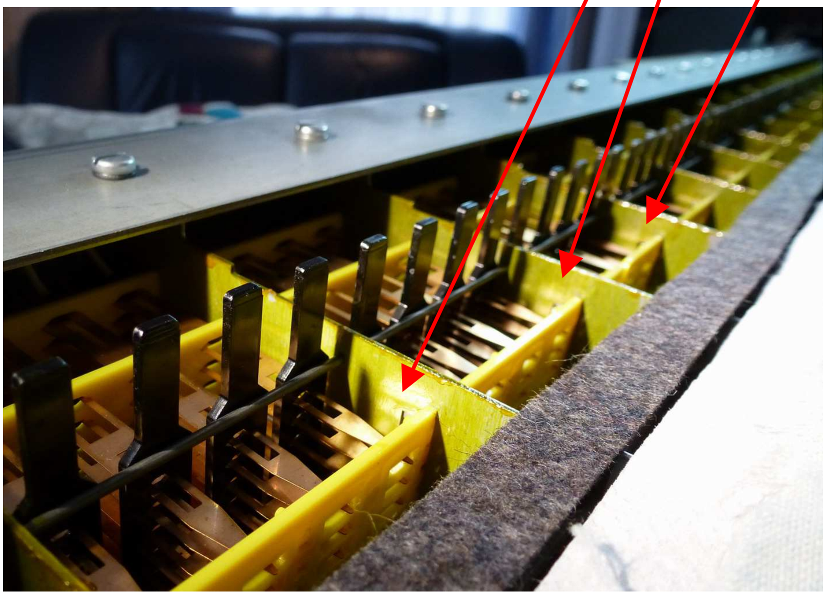
<u>Here again, this next operation requires time, patience and great care.</u>

A protective coating lacquer (corrosion-resistant) is applied with a small flat paint-brush on each side of the metal plates.

As already seen, <u>the areas alongside the busbars are the most critical ones</u> and the most important because it's exactly there that whiskers are bridging the busbars.



The next picture shows keyboard with metal sides totally coated with yellow protective lacquer.



The yellow coating lacquer used is provided by Edogawa Gosei Co – Tokyo.

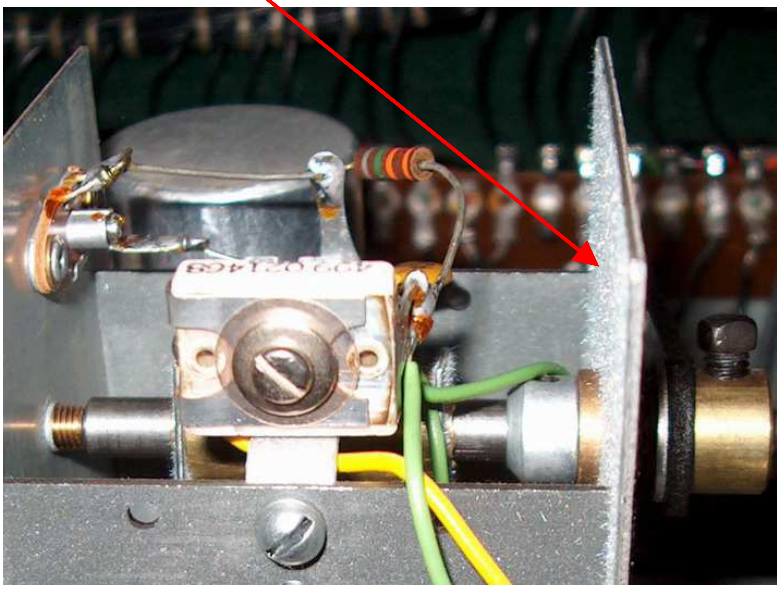
7. My conclusion .

It is obvious that the objectives of the major operation were :
- firstly to understand what happens exactly with those dendrites mostly in the keyboards and
- secondly to analyse several solutions in order to get finally rid of this " dendrites cancer " found in vintage Hammond organs.

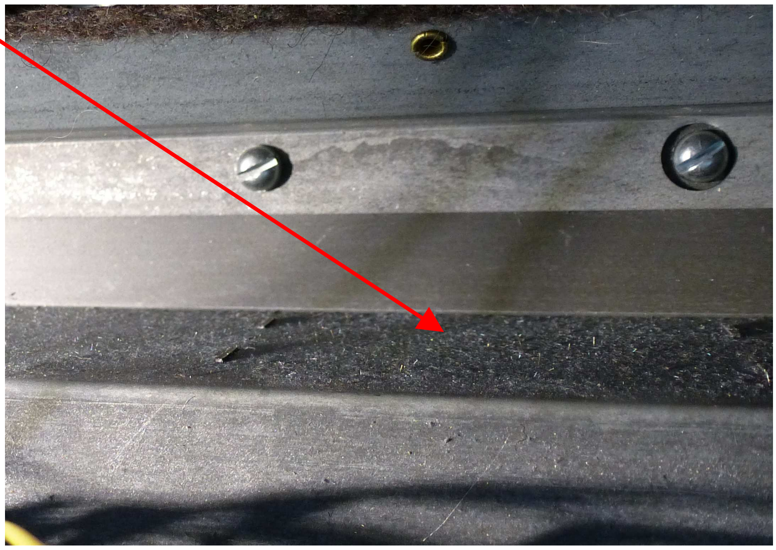
As already mentioned, the repetitive troubles caused by those boring dendrites are not only specific in keyboards but also in other metal areas of the organ.

A few examples :

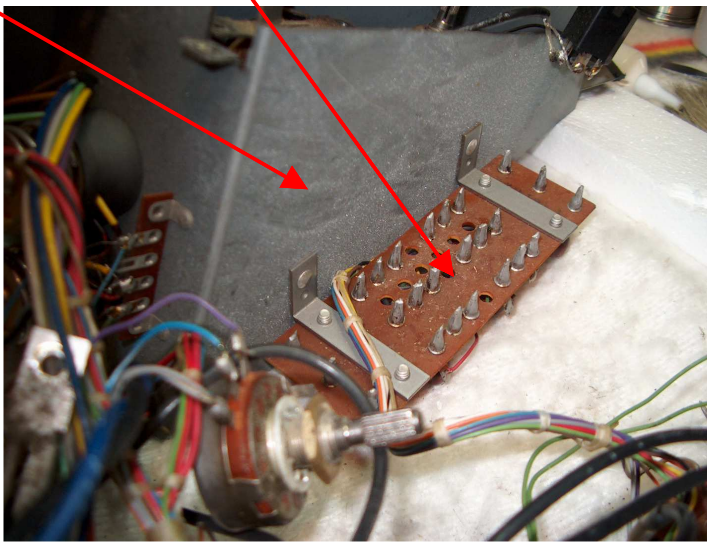
Just have a look to those awful dendrites found in the variable capacitor housing of the AO-28 preamp.



Dendrites found on keyboard chassis (external side) .



During restoring of my Hammond X66, a lot of troubles in the ' Special Effects ' unit due to dendrites (magnetic particles) bridging some posts on bakelite board, etc..



Again, zincdendrites are not particular to Hammond organs and are also found in many other electronic devices.

In the existing literature available on dendrites, we can read information such as *'shorts in keyboards'*, etc... but what does it mean in reality ? Where in keyboard ? How this happen ? Why ? etc...

I just wanted to spend time in investigating in depth the phenomenon to understand and come up with a clear information and definitive cure so that other 'Hammond nuts' like myself may take the benefit of this experience. That was the intention.

Last but not least, after completion of this operation, when playing, I have noticed that the overall sound behaviour of the whole organ has been improved.
Not so easy to explain but it sounds much clearer than before, less crosstalk and a kind of some more output level. Sound seems 'getting out' in a better way.
When playing, notes are less *'muffled'* as before, like playing on a brand new organ in showroom.

" It gives me the feeling that the organ is really back to its original sound."

After made reflection, this audible feeling makes sense and can be somewhat explained. We have seen that dendrides bridge the 1' percussion busbar and a the measured value of this resistive bridge was around 380 Ω but be sure that dendrides are also invading and hitting the other busbars as well in the same manner.

In other terms, almost the whole keyboard is somewhat 'damped' by these parasite dendrites. Needless to say that tone signals are so partially routed to ground via the dendrites resistances creating so new strange and uncontrolled chassis current flows generating so those losses in tone levels and increased crosstalk.

I just wanted to express my personal impression on that.

Of course, additional comments, remarks, constructive criticisms and the like are always welcome.

Trust having been of some help with this article.

Dan.

Disclaimer :

This information is simply for educational purposes only and no claims are made that this information will lead to any successful repair.

Dan Vigin assumes no responsibility to its use.

Thanks !

Special thanks to my friend Daniel Vermeulen who supported this project.

Sources :
- HammondWiki – Percussion Troubleshooting
- Benton Electronics – Percussion Quick Fix
- NASA website
- DVD of Alain Kahn ' Hammond Inside ' – Part One
- Hammond B3/C3 service manual

APPENDIX # 1

THE HAMMOND ORGAN WITH PERCUSSION.

Percussion tones are available only on the upper manual (with the B adjust key depressed) of all consoles with the suffix "3" in their model designation. These consoles, except for the four percussion control tablets in the upper right hand corner, look and function similar to consoles with the suffix "2" in their model designation, when the percussion effect is not in use.

1. THEORY OF OPERATION

The percussion tones are produced by borrowing the 2nd or 3rd harmonic signal from the corresponding drawbar (of the upper manual "B adjust key" drawbar group), amplifying it, returning part of it to same drawbar, and conducting the balance through push-pull control tubes, which when keyed cause the signal to fade away at a pre-determined rate.

2. GENERAL CIRCUIT OPERATION (All Reference Is To Figure 24 Section 2)

With percussion tablet "on", upper manual "B adjust key" and an upper manual playing key pressed, the 2nd or 3rd harmonic signal appearing on an upper manual busbar is conducted through "B adjust key" drawbar wire to input of percussion amplifier (terminal H) and amplified by T4 and V5. Besides providing push-pull signal for the control tube V7, the percussion input transformer T5 has a third winding which feeds the signal back to the 2nd or 3rd harmonic drawbar through equivalent key circuit resistor R50 and terminal J. Thus the signal that was borrowed from the 2nd or 3rd harmonic drawbar for the percussion amplifier is replaced.

When a key is depressed the signal first sounds loudly through the control tube, transformer T6, a high pass filter, and terminal D to the grid of V4. Immediately condenser C31 in the control tube grid circuit begins to discharge, causing the signal to fade away. Terminal K (approximately +25 volts) is connected to the 8th harmonic "B adjust key" drawbar wire which is connected to manual busbar. When an upper manual key is pressed, terminal K is grounded through the tone generator filters. This virtually grounds the plate of V6 (connected as a diode), stops conduction, and isolates cathode and control tube grid circuit. The grid then drifts from approximately +25 volts to about +15 volts, at a rate determined by the time required for C31 to discharge through R57 and R58. At the completion of this sequence the percussion signal is blocked. No further percussion effects occur until all keys of the upper manual are released and control grids can again rise to +25 volts. The rate of this rise is fixed by the time required to charge C31 to +25 volts through R55 and R56.

3. FOUR PERCUSSION CONTROL TABLETS, CUTOFF CONTROL, AND THEIR FUNCTIONS.

The Percussion On-Off Tablet when turned "on" does five things to the signals of the upper manual "B adjust key" drawbars.

(a) It disconnects the 2nd harmonic drawbar from its signal wire.
(b) It disconnects the 3rd harmonic drawbar from its signal wire.
(c) It connects the 2nd or 3rd harmonic drawbar signal wire (depending on position of Harmonic Selector Tablet) to input of percussion amplifier.
(d) It disconnects the 8th harmonic drawbar from its signal wire. This wire (connected through generator filters to ground when any key is pressed) is connected to terminal K. The 8th harmonic signal is not available on the upper

manual as long as percussion tablet is "on".

(e) It inserts resistor R1 in series with upper manual matching transformer (T2) secondary to reduce upper manual organ signal so that lower manual will musically balance with the combined upper manual organ and percussion signals.

The Preset Percussion Switch is not part of the control tablet assembly or percussion on-off tablet, but functions as an interlock with it. It is located under the upper manual "B adjust key". This switch insures that the full upper manual signal is restored by shorting out series resistor R1 introduced by the percussion "on" tablet when any other upper manual preset or adjust key is pressed.

The Volume Tablet in "soft" position shunts resistor R46 across the percussion output transformer, reducing percussion signal, and also shorts out upper manual matching transformer compensating resistor R1 thus restoring upper manual signal strength to provide proper balance between the manuals.

The Decay Tablet in "fast" position shunts resistor R57 across the slow decay resistor (R58) reducing time for decay capacitor C31 to discharge and for V7 control grids to reach cut-off. Also to preserve the same effective loudness in "fast decay" position as in "slow decay" the control tube bias is reduced by disconnecting R59 and allowing control tube grids to become more positive which increases output signal about 50%.

The Harmonic Selector Tablet does three things to the signals of the upper manual "B adjust key" drawbar group:

In "Second" Position:

(a) It connects the 2nd harmonic signal wire to percussion amplifier input.
(b) It connects the 3rd harmonic signal wire to the 3rd harmonic drawbar.
(c) It connects the signal from terminal J to 2nd harmonic drawbar.

In "Third" Position:

(a) It connects the 3rd harmonic signal wire to the percussion amplifier input.
(b) It connects the 2nd harmonic signal to the 2nd harmonic drawbar.
(c) It connects the signal from terminal J to 3rd harmonic drawbar.

The Percussion Cut-off Control which is located on the amplifier should be readjusted as follows whenever control tube V7 is replaced:

> Set expression pedal wide open, both volume tablets "normal", percussion "on", percussion decay "fast", and harmonic selector in either position. Depress any key in upper half of upper manual and then adjust cut-off control exactly to the point where signal becomes inaudible.

Partial view of B3/C3 schematic diagram.