TROUBLE-SHOOTING
COMBO-ORGANS

Vox Continental models
V301H, 301J, 303J

TOPICS

1. Examine for cold-solder joints

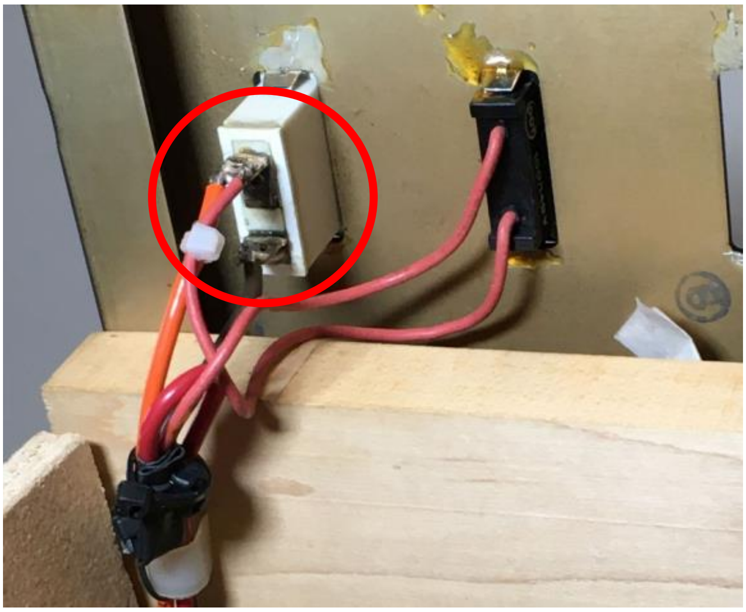
2. Repair a lifted track

3. Diagnose faulty transistors in a divider circuit (including use of a signal tracer).

4. Test a tuning coil

SAFETY

- Always power-down by disconnecting at the wall socket.
  DO NOT power-down using the instrument on-off switch as that leaves AC supply voltage still present in the machine.
- Always power-down before performing physical work on any components.
- Know where AC supply voltage is present in the instrument. Likely suspect points are at the termination of the AC supply cable, at on-off switches and power-on indicator lamps.
- Before working on an instrument, put an insulating barrier around any exposed AC supply connections. The barrier could be temporary, or consider a permanent fix such as fitting heat-shrink tubing.
- Look for any situations where AC supply and signal wires are mixed together. Aim to achieve reliable physical separation. This may also help with any hum or clicks and pops issues.



Exposed wiring at on-off switches is a common hazard

1. EXAMINE FOR BAD SOLDER JOINTS

Photo credit, Wikimedia Commons

Good solder joints have a bright surface finish and concave contour, with the lead wire protruding from the joint. The concave shape is the result of surface tension and is a positive indication that the solder has bonded to the component lead.

Be suspicious of any joints which appear as a 'blob' of solder with no lead protruding.

Photo credit, Wikimedia Commons

Cracked joints are not always this easy to spot.

Be suspicious of any joints which are mechanically stressed or subject to vibration. Examples are connectors, wire terminations or heavier components. These will be the first joints to give problems.

Less extreme cracking in a joint may only be visible under magnification with good lighting.

To repair a joint, first remove the existing solder. Examine and, if necessary, mechanically clean the surfaces before resoldering.

Some helpful items when fault-finding; jeweller's loupe, head torch and illuminated magnifying glass

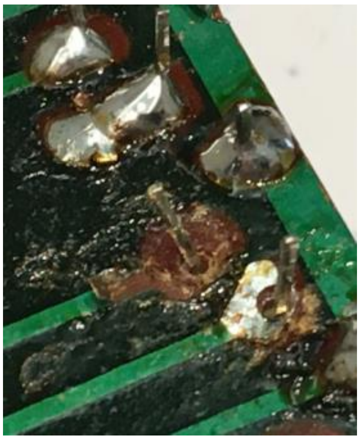
Use a temperature controlled soldering iron, set to around 450C.
While it may seem counter-intuitive, the possibility of track or component damage is reduced by having a hot iron, so getting the joint made quickly.
This is an 80 Watt unit which provides ample heating capacity for circuit card repairs.

The combination of good solder-sucker and fluxed copper-braid will greatly assist the removal of solder, especially where the card has copper tracks on one side only.

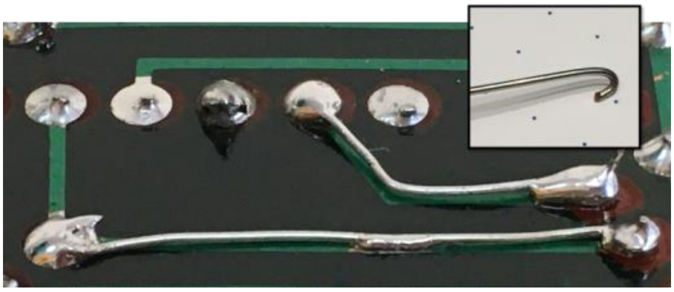
A hobby-blade is useful to (gently) scrape surfaces clean, backed up by a flux-pen to aid resoldering. The dried flux can be left in-place.

2. HOW TO PREVENT A LIFTED TRACK

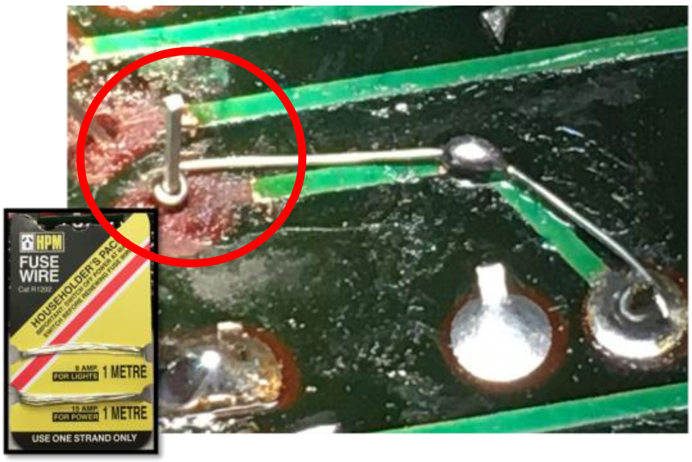
To avoid a lifted track, use your soldering iron and de-soldering aids with care and avoid any mechanical force which could push the copper track away from the card substrate.



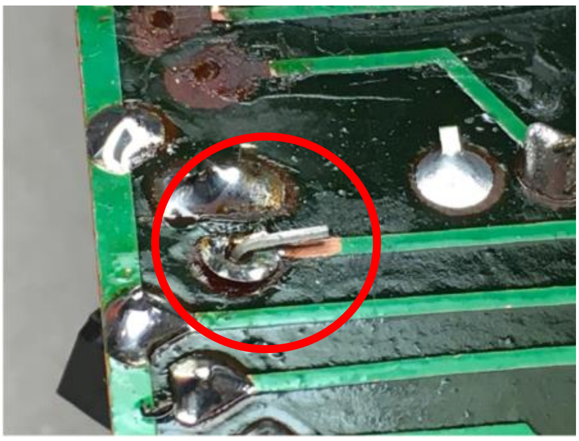
Accidents can still happen. This was the result of simply inserting the leads of a new component.



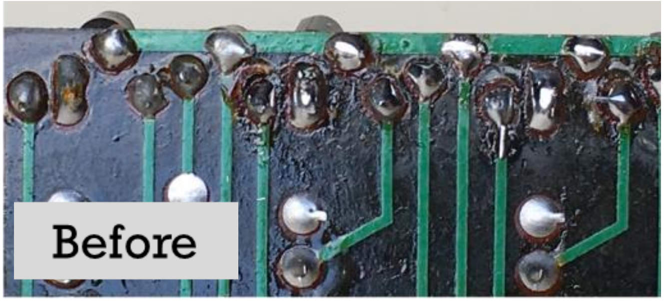
To make a repair, if using a heavier gauge tinned copper wire, form hooks to go around the component lead ends. For longer wires, solder the wire to the original track at one or more points.

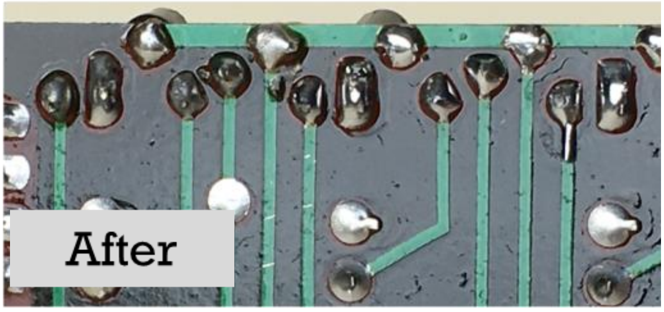


A card of fuse-wire can be a handy source of two smaller wire sizes. Wrapping the wire around the component leads achieves a good mechanical connection prior to soldering.



Alternatively, if the component lead is long enough, it can be bent over to form a bridge to a good section of track.





Both hand and machine soldered cards often were not cleaned in manufacture. The flux residue is safe to leave, but doesn't look great. Isopropyl alcohol is the best solvent. As a scrubbing tool a toothbrush works well, but should not be used where digital integrated circuits are involved. Special anti-static brushes are available in that situation.

Hold the card vertical to sluice the dirty fluids away, but ensuring that the fluids don't get onto, or in, any connectors.

A light spray of circuit board lacquer will leave your card looking better than new.

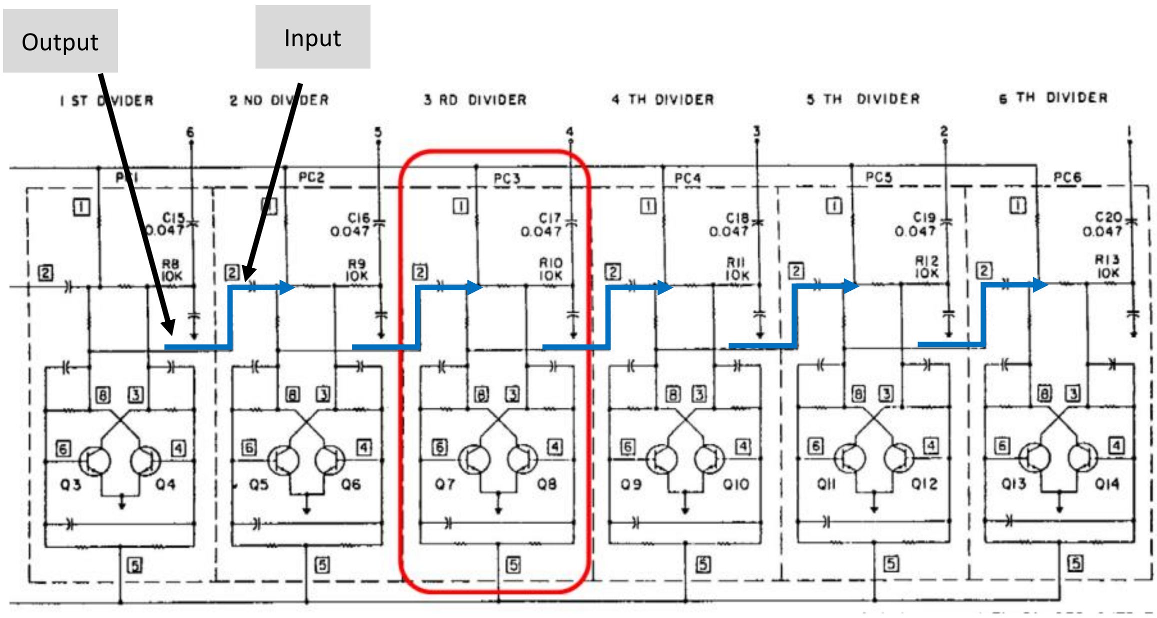
3. DIAGNOSE FAULTY TRANSISTORS IN A DIVIDER CIRCUIT

Many organ types use a series of divide-down circuits to derive the descending octaves of a given note.

A typical divide-down stage comprises a pair of transistors plus peripheral resistors and capacitors. Depending on how it's been drawn, it's usually possible to recognise the crossed-connection transistor pairs in an keyboard circuit diagram.

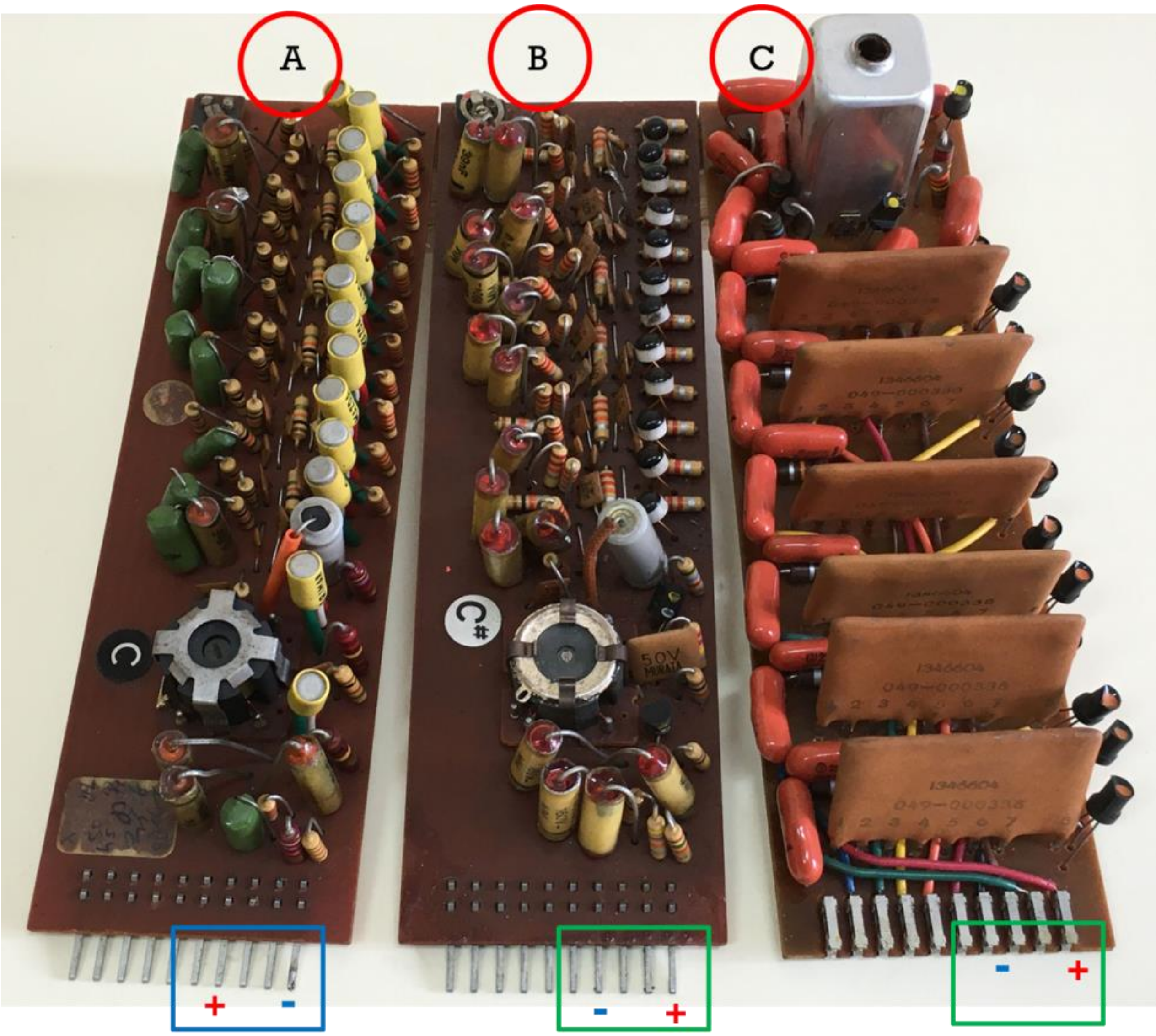
A divide-down stage is also known as a bistable flip-flop, or latch. It has two stable output states (off and on) and is triggered to change states by an input signal.

In a keyboard, the output of one stage is also the input to the next, each stage in turn producing the next lowest octave.



Example of a divide-down stage from a VOX Continental 301

VOX DIVIDER CARDS



VOX divider cards

Card A is from a UK manufactured Continental, circa 1965. It uses PNP transistors

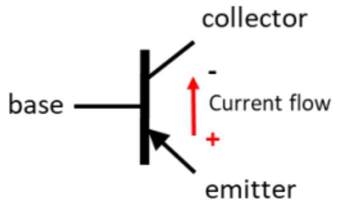
Card B is also from a UK manufactured double-manual Continental (with percussion).
It uses NPN transistors.

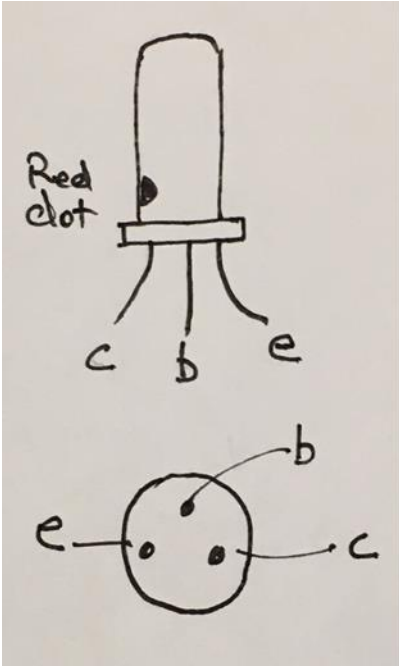
Both are built on the same printed circuit biscuit and have male pin connectors. However, they are not interchangeable as they have opposite power supply voltage polarities.

Card C is from a US manufactured Continental, model V301H, circa 1966.
It uses PNP transistors and has female socket connectors.

The following pages will explore PNP and NPN transistors.

PNP TRANSISTORS



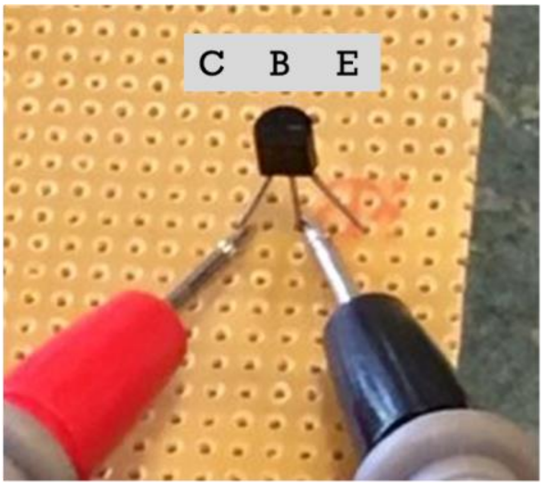


OC71
OC72

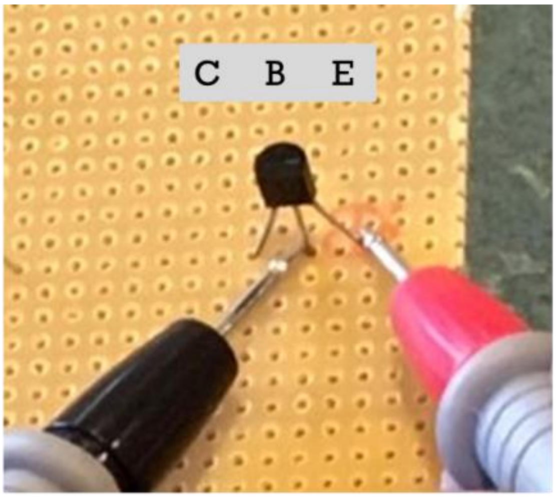
AC113

- Earlier transistors were based on germanium and were typically type PNP
- (Silicon PNP transistors are currently available)
- In circuits with PNP transistors it's typical for the d.c. supply voltage to be negative, with the ground/common positive
- Part no's OC71, OC72, AC113, BC556

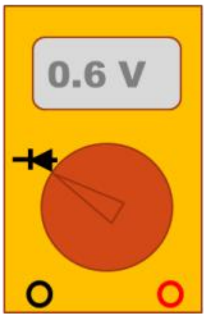
Testing a BC556 PNP transistor



Test of base – collector junction
Black lead to base,
red lead to **collector**



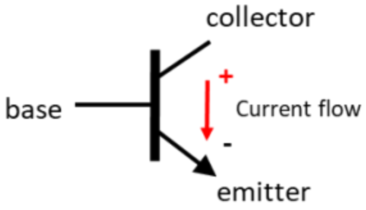
Test of base – emitter junction
Black lead to base,
red lead to **emitter**

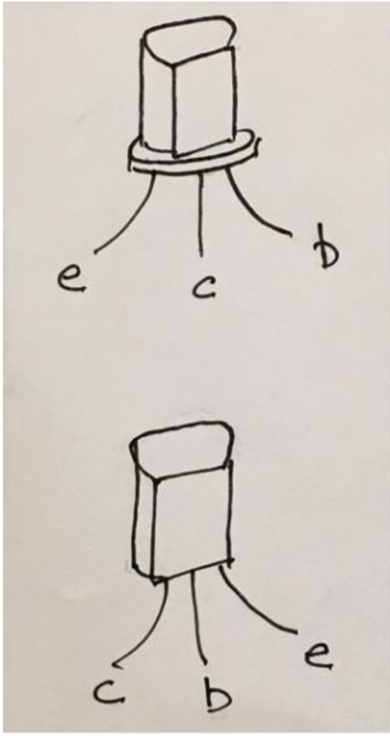


A good transistor will read, for both junctions, approximately 0.2V for germanium types or 0.6V for silicon.

Test can be done with devices in-circuit

NPN TRANSISTORS





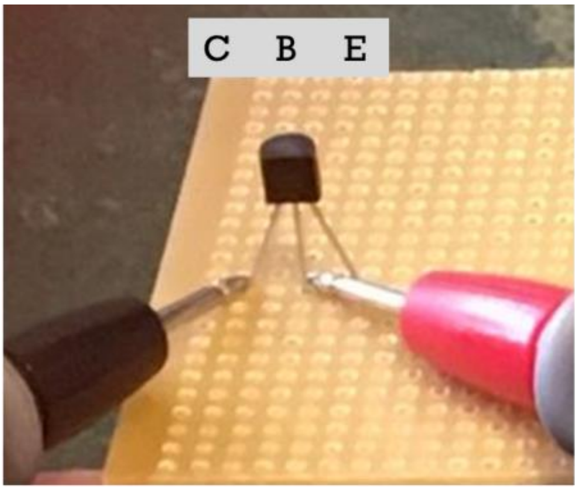
A1460
A1461

BC337
BC546
BC547

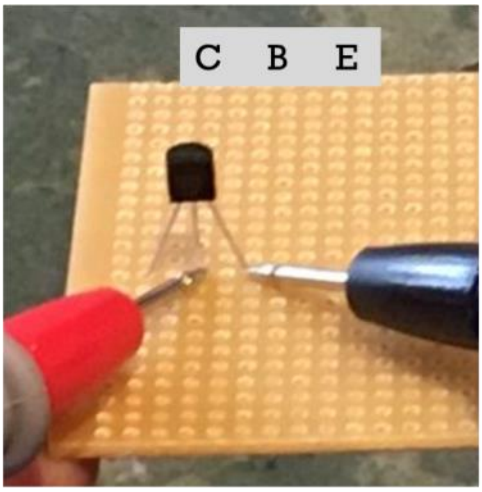
(Also PNP type BC556)

- Silicon based NPN transistors are now the most commonly used types
- In circuits with NPN transistors it's typical for the d.c. supply voltage to be positive, with the ground/common negative
- Part no's A1460 (orange dot), A1461 (yellow dot), BC337

Testing a BC337 NPN transistor

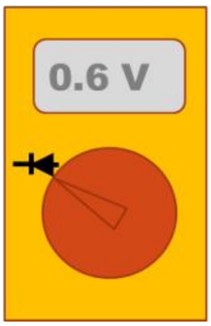


Test of base – collector junction
Red lead to base,
black lead to **collector**



Test of base – emitter junction
Red lead to base,
black lead to **emitter**

A good transistor will read, for both junctions approx. 0.6V (silicon).



Test can be done with devices in-circuit

With some experimentation, it’s possible to determine whether an unknown device is PNP or NPN, and which leg is the base.

The test will not differentiate between emitter and collector, but with reference to the circuit diagram it’s usually possible to identify these by observing what components are connected to that leg. (Often, the emitter will be connected to circuit ground, but it’s not guaranteed.)

Diodes and transistors are the two components which can be successfully tested in-circuit.

Attempts to test resistors and capacitors in-circuit will, at best, only give indicative readings. For an accurate result, first de-solder one leg of the component and lift it away from the circuit card track.

A Google search of the part number will usually find the data and pin-out info for any transistor.

Three methods of fault finding a divider card will be discussed in the following pages:

a) In the instrument, using the keyboard

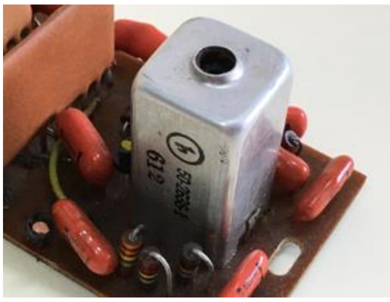
b) In the instrument using an audio probe

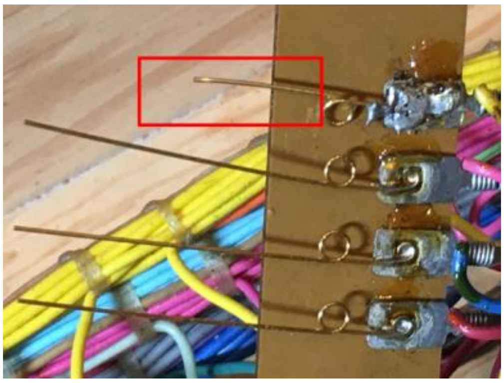
c) On the bench using an audio probe or oscilloscope

3a. DIAGNOSE A FAULTY CARD(S) USING THE KEYBOARD

- With only the 16’ drawbar out, play a descending chromatic scale. Listen for any notes which are missing, quiet, or the wrong octave
- Tag any faulty keys with masking tape, note the fault on the tape
- Repeat these two steps with only the 8’ drawbar out, then only the 4’ out
- At the end of this process, you will have a good picture of where any faults are located

If a note is missing in **all octaves and footages**, it’s likely you have a faulty oscillator.
This topic will be covered later in the document.





If a note is missing in **just one octave and one footage**, it’s likely to be the result of a broken contact spring.
Replacement of a broken spring is not covered here.

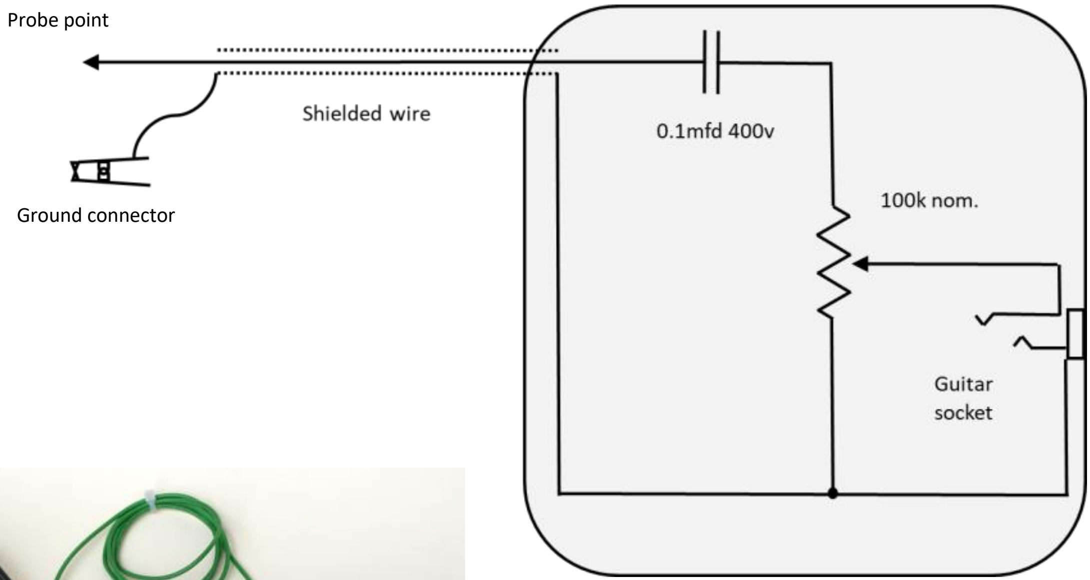
In all other cases, if you have a note (or notes) **not playing, or playing higher than it should be**, it’s likely to be due to at least one faulty divider stage.
In this case, remove the card for bench testing.

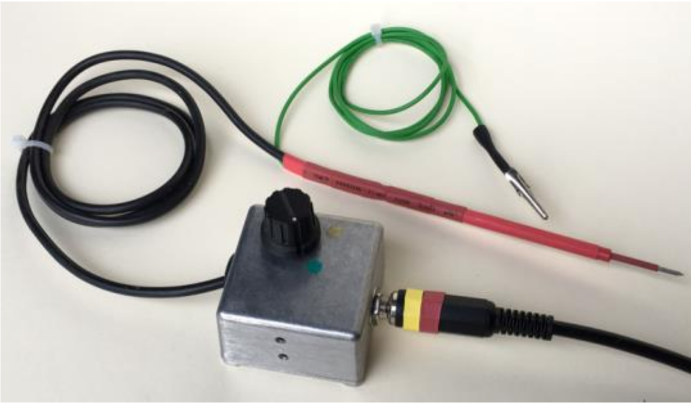
SIGNAL TRACER

An audio signal tracer is a simple, but useful, test tool which will be referred to in following pages. A quick Google search will find several design approaches to making your own.

In the example below a 0.1mfd 400 volt capacitor is used to block any DC voltage and a potentiometer included to allow the sensitivity to be readily controlled.

The components are housed in a small box complete with a guitar socket. In this way it can be used plugged into a small practice amp.





WARNING

A signal tracer must only be used to check low-level audio signals.

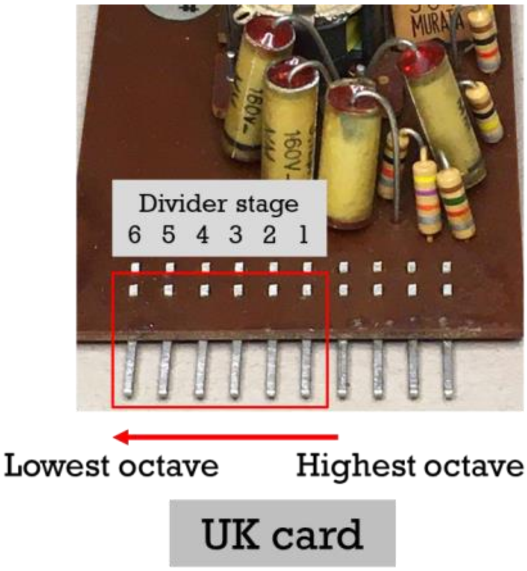
For your safety, DO NOT use an audio probe in circuit areas where mains AC voltage, or any high voltages, may be present.

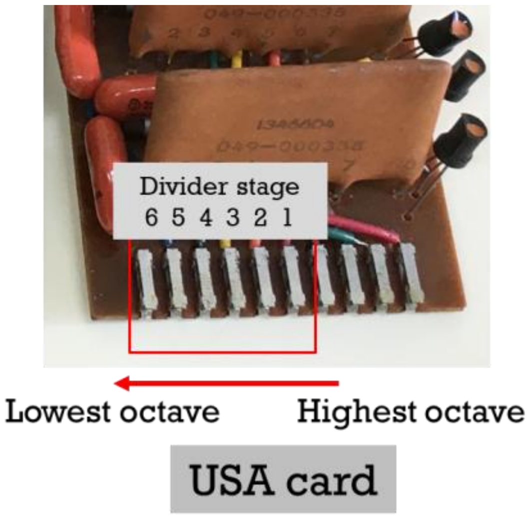
3b. DIAGNOSE A FAULTY CARD(S) USING A SIGNAL TRACER

With the cards in the instrument:

- Touch the probe on each of the six audio outputs of each card, moving from the highest to lowest octave
- Listen for an even progression of tones
- Tag any faulty cards noting the faulty octave (s)

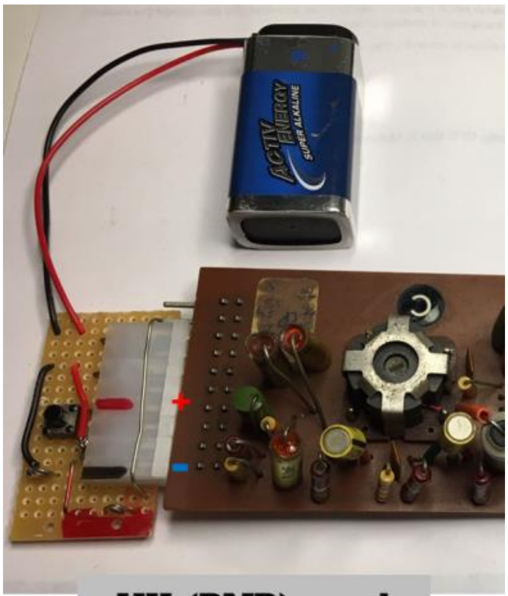
UK and USA cards have the same pinout arrangement for the six octaves the cards generate.





3c. BENCH TESTING

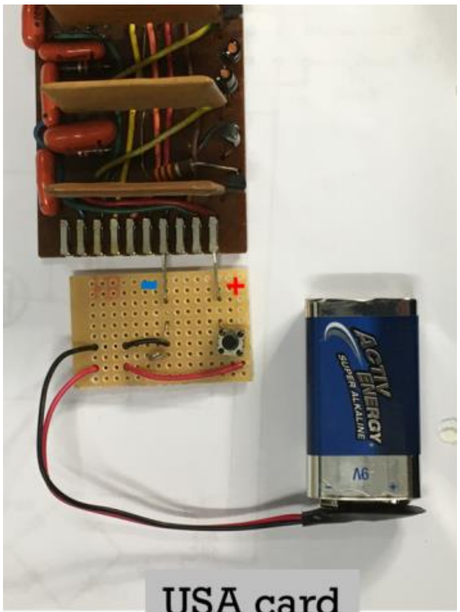
- The following checks can be done with an audio probe or oscilloscope.
- The cards can be safely powered from a 9 volt battery
- A simple test jig can be helpful. A small press-button switch in the battery circuit is useful when checking for reliable oscillator start-up and avoids constant connecting and disconnecting of the battery.



UK (PNP) card

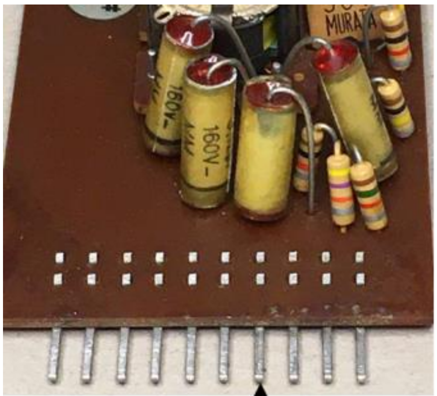
While not having the exact same pitch spacing as the card, a six or eight-way 'Molex' connector allows easy connection to the male pins.

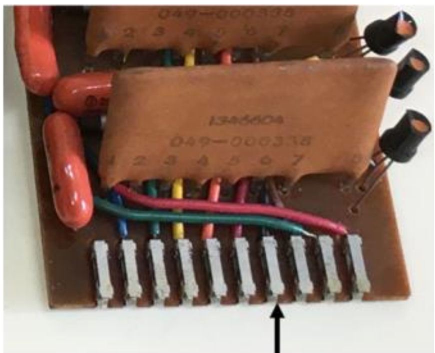
** The battery polarity shown here is for a PNP card.
Reverse the polarity for an NPN card



USA card

Here, a length of medium gauge tinned copper wire with the end folded over double makes an adequate male connector pin for testing purposes





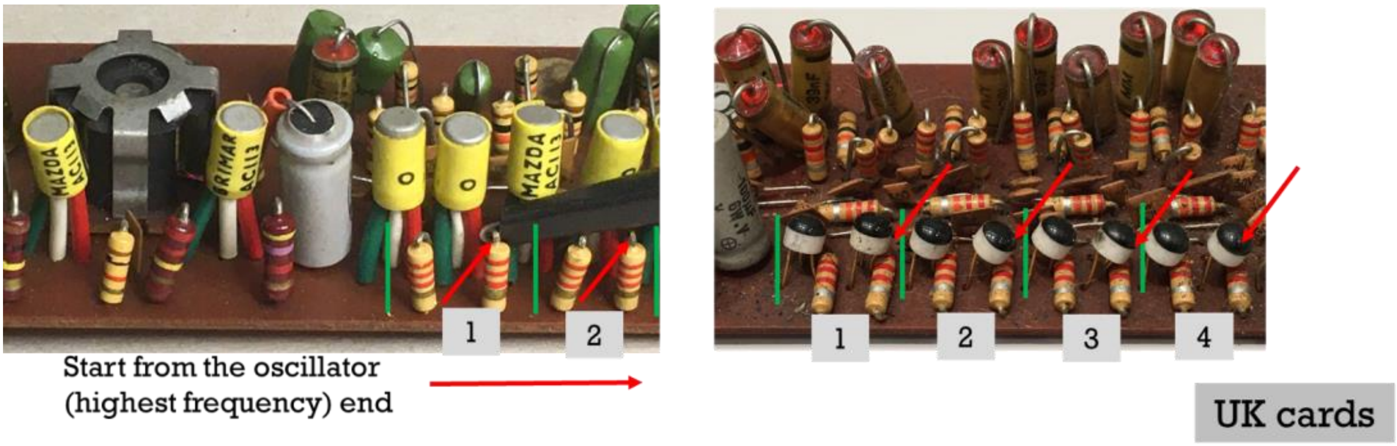
Ground pin

UK card

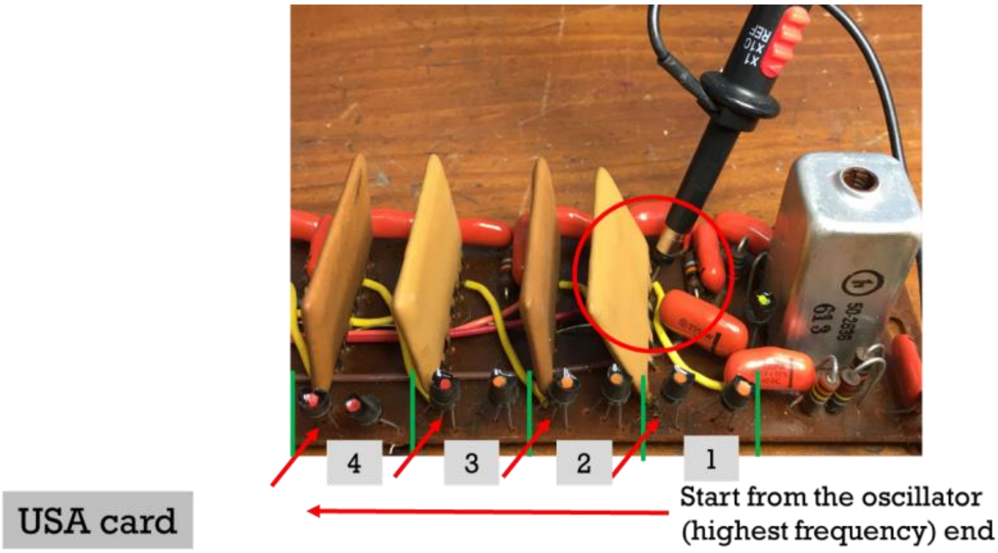
USA card

3c. BENCH TESTING cont.

Once it's been established that you have at least one faulty divider stage, you will need to locate the relevant components. For both UK and USA cards, the sequence of divider stages one to six begins nearest the oscillator circuit.

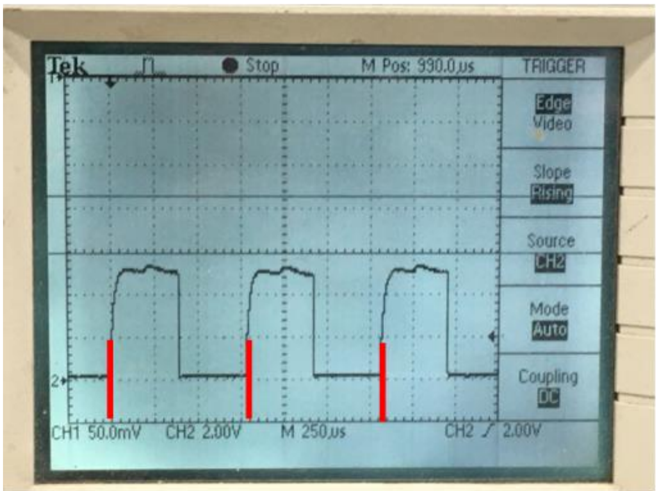


Identify each pair of transistors which comprise a divider stage. In the UK cards above, the output of each stage is on the collector of the right-hand-side transistor of each pair (where it connects to the 2K2 resistor) as shown by the red arrows.

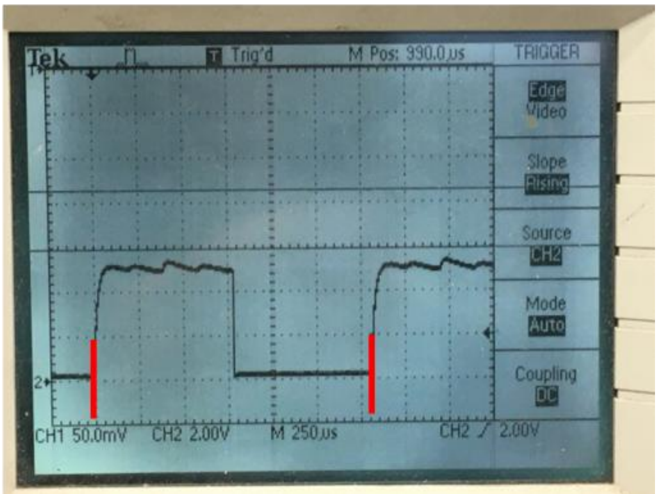


In the USA card above, several of the resistors and capacitors for each stage are located on the vertical 'couplates'. The yellow wires connect the output of one stage to the input of the next. The stage output can also be found on the centre leg (collector) of the left-hand-side transistor of each pair, as shown by the red arrows. Always start your testing from the highest frequency end, which in all cases is nearest to the oscillator.

INPUT

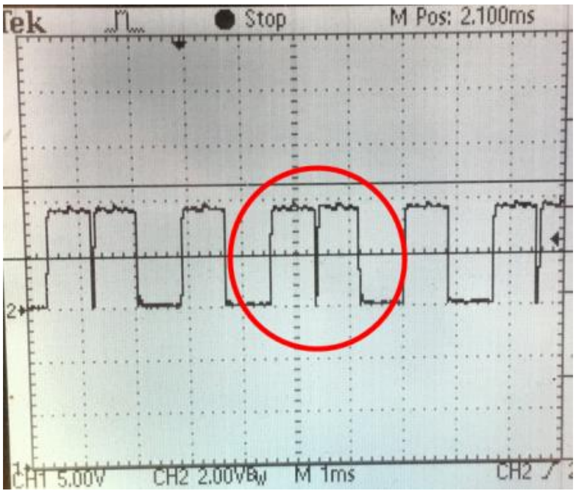


OUTPUT

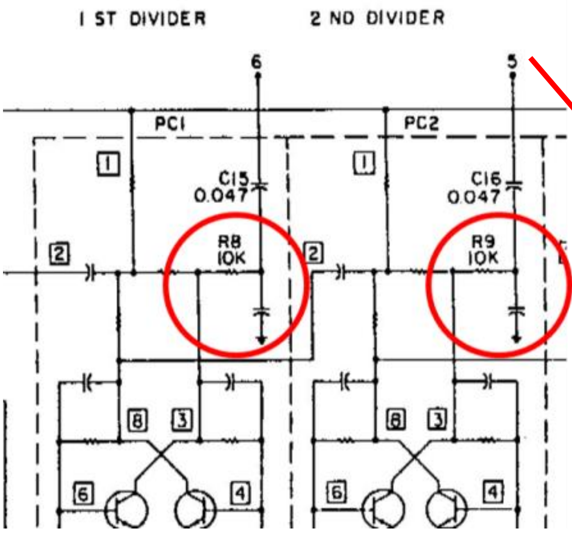


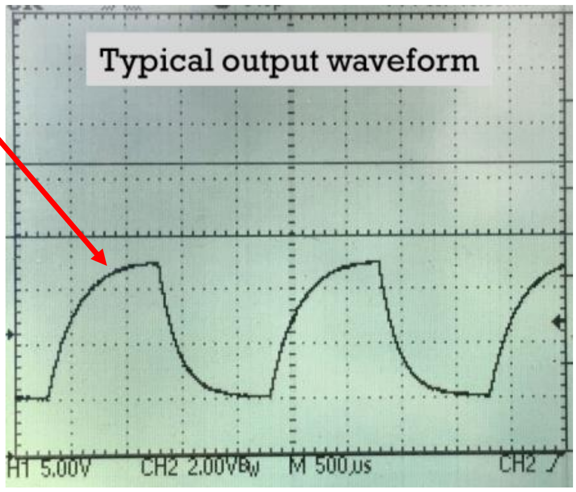
These oscilloscope traces illustrate a correctly working divider stage. Each rising edge (red line) of the input signal triggers a change of state in the output signal, so halving the frequency, which equates to lowering the note by one octave.

OUTPUT



Two fault conditions were seen in the instrument I repaired. Either the divider stage was not switching at all (flatlining) or the switching was not reliable (failure to latch) as shown in the trace. Either fault will affect all following stages.





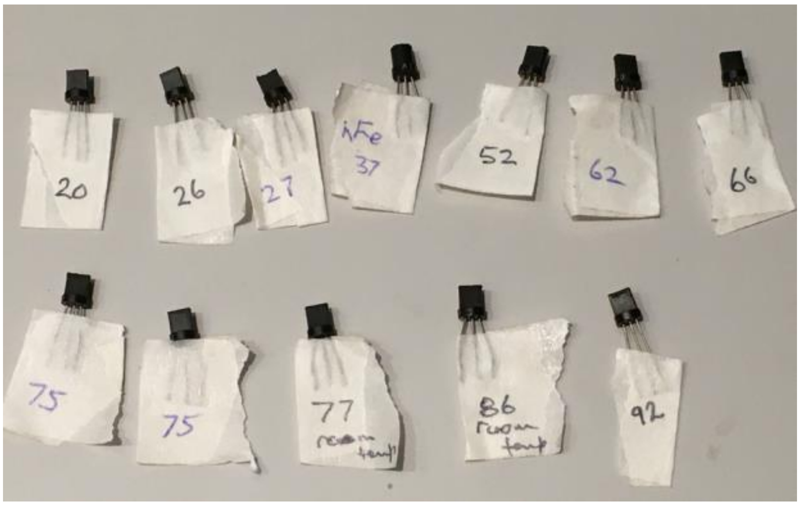
Each divider has a simple resistor-capacitor network which shapes the square-wave divider output into a, more musical, rounded sawtooth pattern, still rich in harmonics.

For all eight cards repaired from a USA manufactured Continental, low-gain transistors were the cause of every divider fault.

A transistor gain test function is included in many digital multi-meters. Select the correct test for the type of transistor you are working with (PNP or NPN) and be sure to insert the transistor leads into the correct sockets.

In technical literature, gain may be shown under the term 'hfe'. It is the ratio of collector current divided by the base current at some nominated test condition. The design gain of a transistor will be presented in a range (say 70-250).

Early type transistors as found in a Continental typically have gains considerably lower than can be expected from more modern devices. This example has a gain of sixty.



This group represents a typical range of gain values (20 –92) in transistors from a USA manufactured Continental. A gain of less than 30 will almost certainly cause faults in a divider stage. It seems likely that, at least for this generation of devices, the transistors may loose gain over time.

Note also that the gain of these transistors was measured at room temperature.

Room temperature

Chilled

The gain of a transistor is temperature dependant. In the images above, the same transistor is tested for gain at room temperature, then chilled with freeze spray.

This result suggests that chilling is not a useful test when looking for a marginal transistor, as the gain of even a ‘good’ transistor will be reduced to the point that it would cease to work in a divider stage.

However, to flush out any marginal transistors, it may be a useful to cool a divider card in a refrigerator before testing.

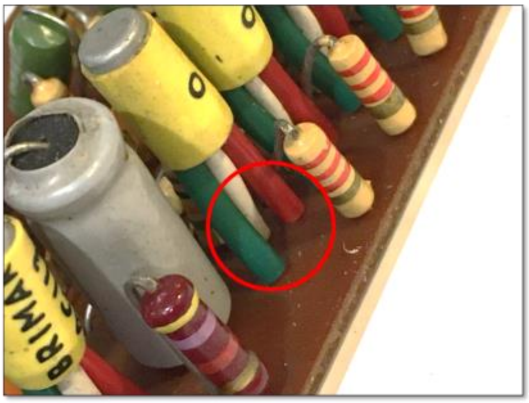
REPLACEMENT OF FAULTY TRANSISTORS

There are two options when replacing faulty transistors.

If you have access to transistors of the same part number, you may prefer to use those to maintain authenticity. Especially if your card has germanium PNP transistors, it would be prudent to source replacements of the same part number, or a near equivalent. Gain test the replacement parts before fitting, and select the higher gain devices for use.

If your card has silicon NPN transistors, then any modern general purpose NPN transistor should be fine as a replacement. Types BC337, BC546, BC547 have been used successfully.

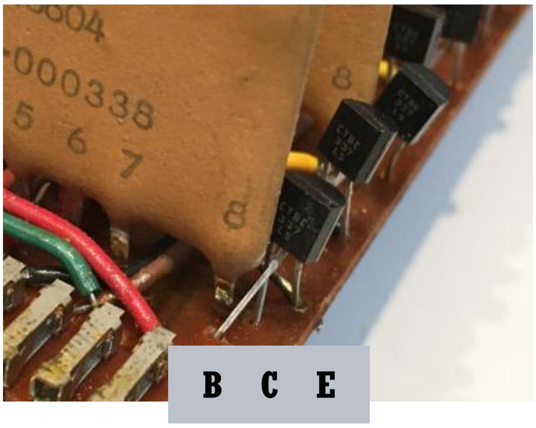
UK cards

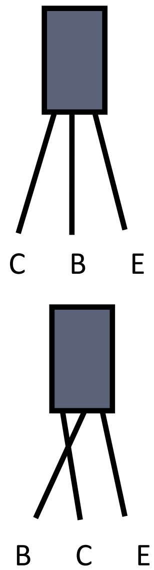


Green = Emitter **White = Base** **Red = Collector**

Transistor pin orientation for a UK manufactured card. The pin orientation is the same for both the PNP and NPN versions of the card.

USA card





Transistor pin orientation for a USA manufactured card.
Here, BC337 transistors have been fitted as replacements.
Note that the base and collector legs have been crossed to match the transistor pin orientation to the circuit card hole placement.

A CAVEAT.

In some cases, cards which, after repairs, worked perfectly on the bench (but which still had some original transistors) did not work reliably in the instrument.

With the card in the instrument, an audio probe was used to test the output pins to locate the faulty divider.

For the worst offending card, it became necessary to replace all the divider transistors.

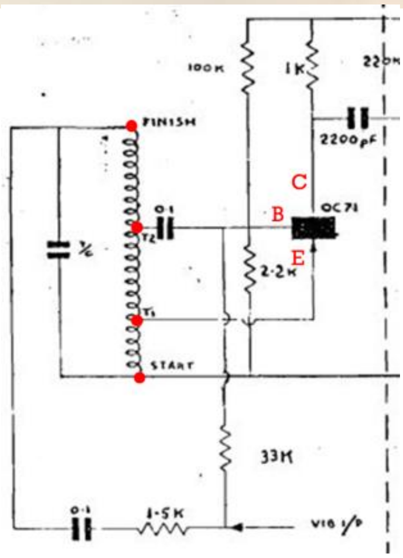
If you are aiming for a reliable studio/gigging instrument, replacement of all divider transistors may be a good option.

---

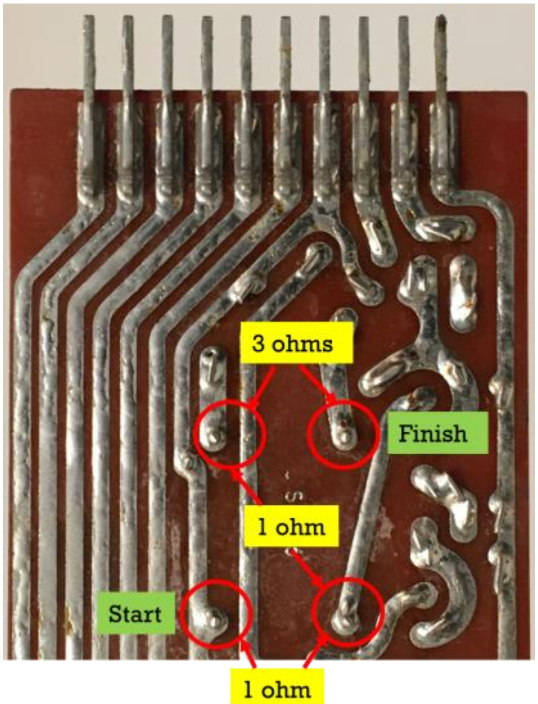
4. TEST A TUNING (OSCILLATOR) COIL

Although performing the same function, the UK and USA Continental cards have different oscillator circuits.

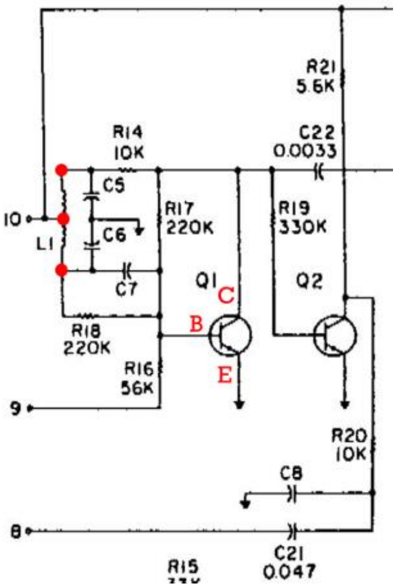
UK Oscillator



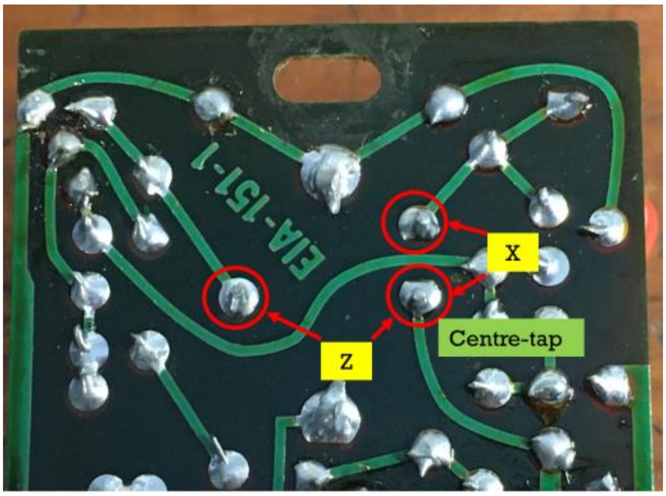
The coil of a UK card has four terminals. VOX documentation suggests four coil variants across the twelve cards. Check for coil continuity with an ohm-meter, resistances should be approximately as below.



USA Oscillator

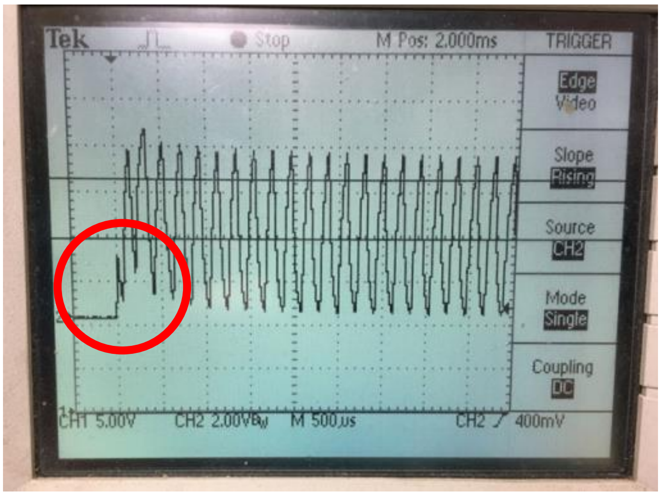


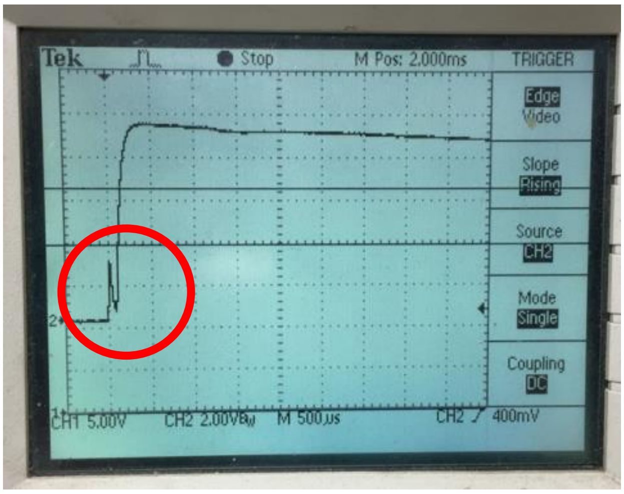
The coil of a USA card has three terminals.
There are two coil variants across the twelve cards.
Typical resistance measurements are shown below.



USA card uses two different coil windings
Notes C to F, Z = 190 ohms, X = 155 ohms
Notes F# to B, Z = 125 ohms, X = 100 ohms

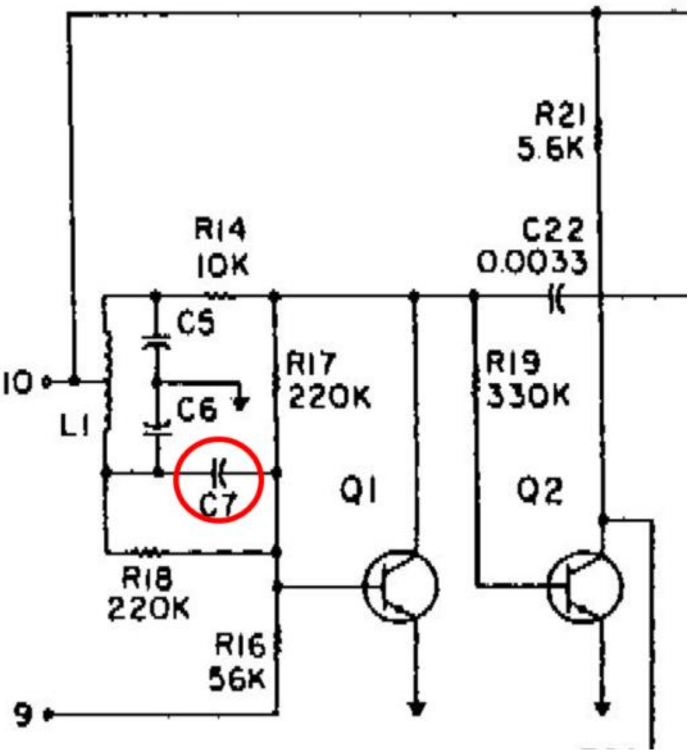
In some USA cards encountered, the oscillator did not start reliably. Two different causes were identified.





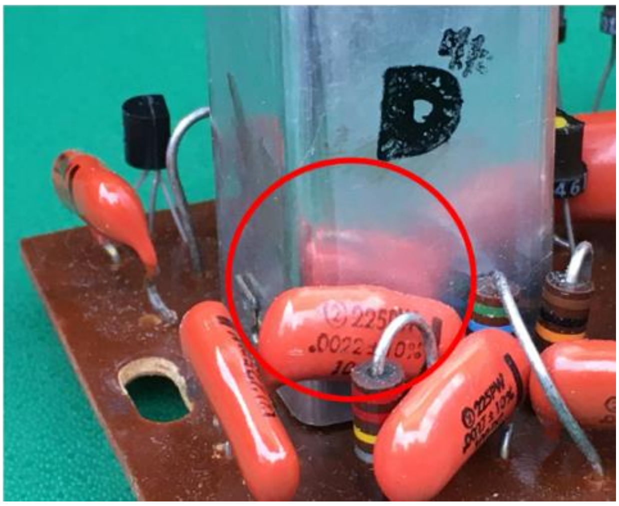
The left-hand trace shows the oscillator starting correctly. Note the circled initial pulse which initiates oscillation.

The initial pulse is present in the right-hand trace, but oscillation is not initiated.



	L1	C5, C6	C7	C8
C	300	0.015	0.0033	0.0033
C#		0.015	0.0033	0.0033
D		0.012	0.0027	0.0027
D#		0.012	0.0027	0.0027
E		0.01	0.0022	0.0022
F		0.01	0.0022	0.0022
F#	200	0.0082	0.0018	0.0018
G		0.0082	0.0018	0.0018

FAULT 1. C7 was identified as the ‘start’ capacitor. A chart in the VOX documentation gives the value of C7 for each of the twelve cards. C7 in a D# card should be 0.0027mfd (2.7nf) , however an incorrect value capacitor had been fitted in manufacture. Replacing this with a correct value capacitor corrected the fault in two cards.



Fault 2. There were two other instances where the oscillator was unreliable. Changing the oscillator transistor Q1 did not help, but fitting new capacitors to replace the original C5 and C6 cured the problem. C5 and C6 are part of the resonant circuit together with coil L1.

Curiously, the original parts tested to be within tolerance of their stated value.