‘Technical Shorts’

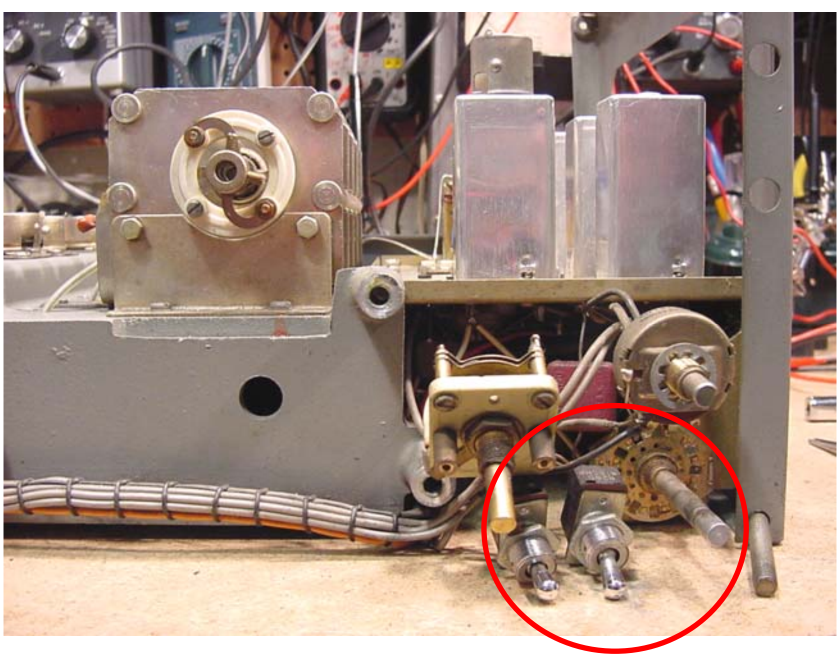
by Gerry O’Hara, G8GUH

‘Technical Shorts’ is a series of (fairly) short articles prepared for the Eddystone User Group (EUG) website, each focussing on a technical issue of relevance in repairing, restoring or using Eddystone valve radios. However, much of the content is also applicable to non-Eddystone valve receivers. The articles are the author’s personal opinion, based on his experience and are meant to be of interest or help to the novice or hobbyist – they are not meant to be a definitive or exhaustive treatise on the topic under discussion…. References are provided for those wishing to explore the subjects discussed in more depth. The author encourages feedback and discussion on any topic covered through the EUG forum.

Switches

Introduction

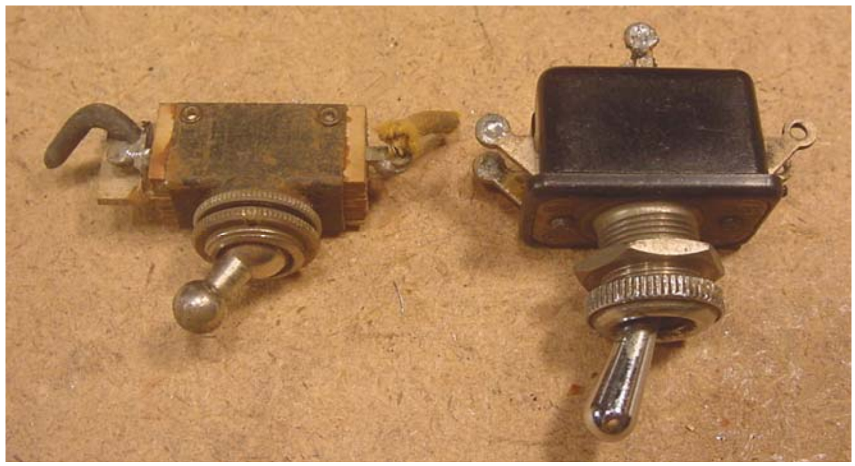
Ever since electrical current was first discovered there has been a need to control it – at least to be able to switch it on and off. This action is undertaken by a switch – a device for opening or closing an electrical circuit or for re-routing an electrical signal through a circuit. Switches can be mechanical (including electrically-operated switches, eg. relays) or electronic devices, these being either valve or semiconductor. This Technical Short deals only with a few of the most frequently-found mechanical switch types, these being commonly categorized into toggle, rotary, slide, snap, rocker, push-button, micro-switch, relay and reed (the latter actuated by a moving magnet).



The most common mechanical switches used in Eddystone valve receivers are of the toggle and rotary types (photo, left of an S.940 with the front panel removed – note the toggle switches used here for the AGC and Noise Limiter to the left of a rotary switch used for adjusting selectivity - circled), with occasional use of push and slide switches. A brief description of each of these switch types follows together with examples of their use in Eddystone valve receivers, a consideration of fault conditions that tend to arise and how to remedy these.

Toggle Switches

The lever ('dolly') of a basic toggle switch operates a spring-loaded linkage that promotes rapid contact transfer. This rapid transfer action reduces generation of an electrical arc (spark) as the contact is made/unmade. The contact arrangement may be one of a number of permutations, commonly single pole single throw (SPST), singe pole double throw (SPDT), double pole single throw (DPST) or double pole double throw (DPDT), depending on the circuit requirements. The action of the switch (the way any spring action biases the position of the contacts) may offer no preferred bias, eg. as in a mains on/off switch, or may hold the contacts in a preferred position, eg. as in a crystal calibrator on/off switch. Also, some double throw switches may have a centre-off position.



Above: Toggle-Switches, Left – older type DPST action 'Paxolin sandwich' body toggle switch with ball-tipped dolly, Right – later type DPDT action moulded plastic body switch.
Below Left: Modern sub-miniature DPDT toggle switch

Toggle switches are rated on the maximum switchable current and voltage they can tolerate and also the number of toggle actions the switch is designed for. Typical panel toggle switches are rated for up to 5amps at either 120v or 240v and over 250,000 toggle operations (or more, depending on the quality of the switch). The actual life of the contacts depends on a number of factors other than the nominal design of the switch itself, including the magnitude of the voltage and current being switched, whether it is AC or DC, nature of the load (resistive or inductive) and whether any precautions have been made to reduce arcing within the switch, eg. placement of a bleed resistor or suppression capacitor across the contacts. An interesting – and rather unexpected – phenomenon that occurs with long-term use of toggle switches is that their use in low-signal applications can be problematic, ie. where you would expect there to be less wear as no arcing would occur and therefore greater long-term reliability, erratic contact manifests itself. This phenomena results from the build-up of surface (oxide) films and contaminants on the switch contacts over time that the small voltages and currents present in a low-signal circuit cannot overcome. The selection of high-quality contact material switch types for these applications is therefore important.

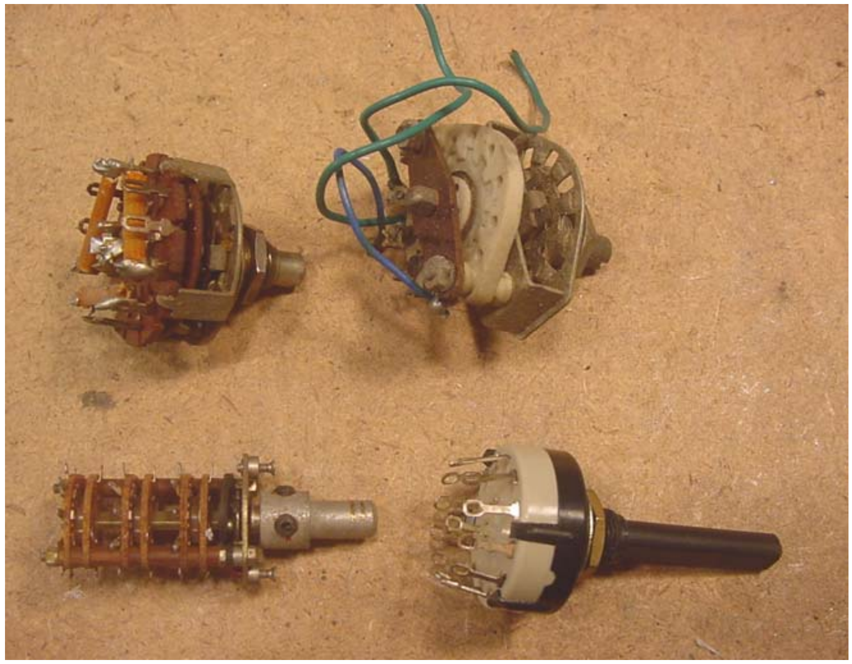
The switch body can be made from a plastic moulding in one or more parts, or, in some earlier units, from a sandwich of phenolic sheets ('Paxolin') riveted together and mounted onto a metal plate having a threaded bushing for mounting through a panel. Contacts may be silver-plated (most common) or may be comprised of other metals, such as palladium, gold alloy or silver-cadmium oxide.

Apart from possible erratic operation as the switch ages due to wearing of the silver coating on the contacts and ingress of contaminants, the other (much rarer) cause of failure of toggle switches is a mechanical failure – eg. failure or disengagement of the spring(s) or disengagement/breaking of the pivot assembly. This is typically a sign that the entire switch should be replaced rather than to attempt a repair – only in very rare cases have I found any repairs of this type to be successful. In particular, I would advise strongly against making any attempt to repair a switch that would be expected to carry a high voltage or current.

Regarding switch cleaning, the best approach depends on the switch construction and if the inside of the toggle switch body can be accessed. I successfully cleaned the toggle switches on my S.740 (which has the older-type 'ball-ended' toggle switches that do not seem to have any easy way of accessing their insides) by turning the set so its front panel faced upwards and then squirted some 'De-Oxit' switch cleaner into the area where the dolly enters the switch body, letting gravity draw it into the switch. I left the set in this position for an hour or so, occasionally spraying some more 'De-Oxit' into the switch and 'toggling' the switch many times. If you cannot find any 'De-Oxit', other electrical cleaners (eg. 'Servisol' or 'Electrolube') may work, but I have found that 'De-Oxit' works the best. If this does not work, then replace the switch with one of the same or higher voltage/current rating.

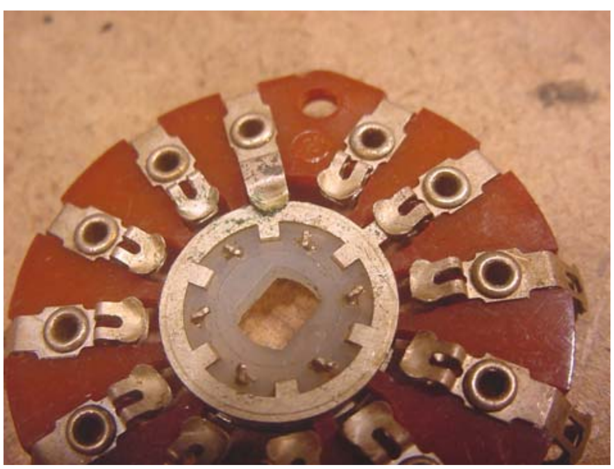
Rotary Switches

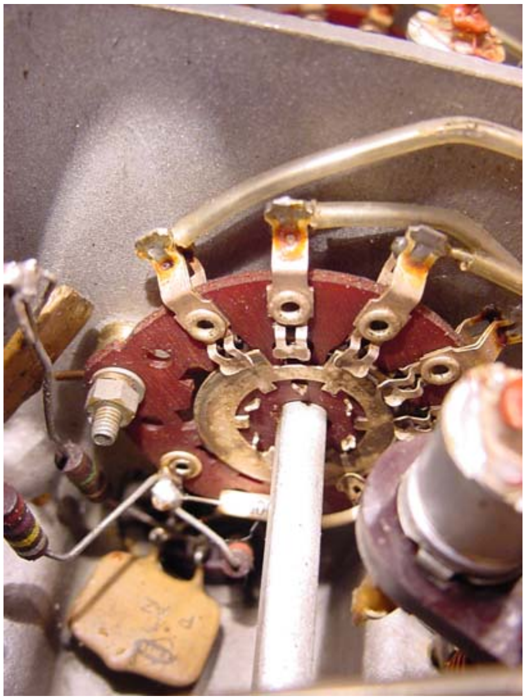
The construction of rotary switches is fairly standardised, typically comprising a keyed shaft passing through a bushing and retained within a metal plate that has detents for each position of the switch. A spring steel rotor, usually having small ball-bearings at each end that engage with the detent ring on the plate is fixed to the shaft (photo, right). The shaft extends sufficiently to pass through one or more switch 'wafers' held in place relative to each other and the metal plate with two (or more) stakes (steel rods). The switch is usually fixed to a control panel by a lock nut tightened onto the metal plate. The switches may be supplied as complete units or as kits to assemble into the desired configuration of wafers ('decks') to suit the application in hand. The switch diameter and contact size defines the maximum number of positions that may be accommodated. Individual wafers (including the rotor) may be supplied for many different permutations of switching options, eg. 1 pole 12 way, 2 pole 6 way, 3 pole 4 way etc. Typical applications in Eddystone receivers are bandchange switches (where many wafers may be present, often two for each RF, mixer and oscillator stage), mode change and selectivity.



Above: Variety of rotary switches with Paxolin, ceramic and plastic wafers. Below Left: Detail of blade and clip contact construction on a Paxolin wafer

Contact design in rotary switches are of two basic types: blade & clip or spring & stud. Both of these designs wipe as they make/break contact. This action tends to keep the contact surfaces clean of oxides and organic films. The most common design (and that found in Eddystone sets) is whereby the rotor blade wipes between stationary contact clips. In this double-wiping design (photo, left), the blade is forced between the compressed 'jaws' of the stationary clip, making contact with both sides of the blade. Each side of the clip is flared to guide and centre the blade on entering the jaws. The spring & stud design is more expensive to implement and is used only for high current/low contact resistance switches. The contacts may be arranged to be shorting or non-shorting (sometimes referred to as 'make-before-break' or 'break-before-make' respectively). In the former, the rotor blade is wide enough to bridge adjacent fixed contacts momentarily during rotation of the switch from one position to the other. This action is desirable in

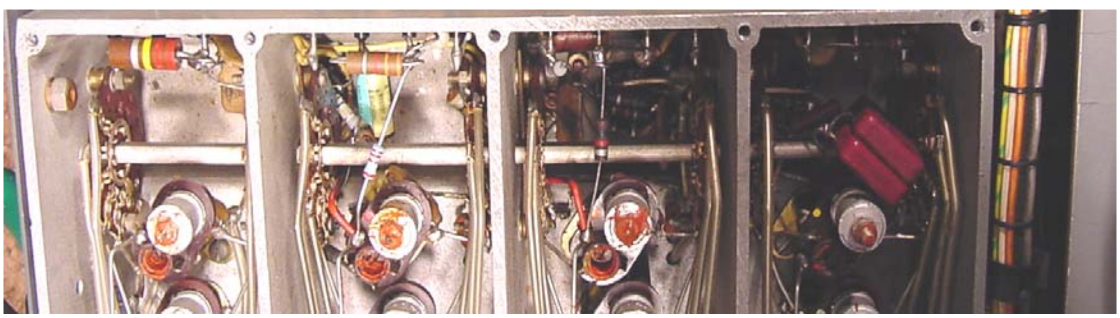




Above: Close-up of a wafer in the wavechange switch of an S.940. Below: the entire 8-wafer wavechange switch fitted in the coilbox of an S.940

audio applications to reduce noises when operating the switch. The latter action is required where such shorting action could damage the circuits.

The selection of contact material is based on four factors: the design switch life, characteristics of the load circuit (resistive or inductive), operating environment and cost. As for toggle switches, contact material selection is particularly critical for low-level current/voltage than it is for high currents as surface (oxide) films and contaminants can be more easily overcome by higher currents and voltages. Contacts are often made from brass or steel and only plated with the (precious metal) contact materials in order to reduce cost. For example, 1/10,000" silver-plated brass contacts would typically have a life expectancy of 6,000 to 10,000 cycles at a load of 0.5A at 110vac before the plating wore through. The contacts would still work after this time (brass to brass contact) but the operational reliability would suffer as the contact resistance becomes erratic. In comparison, solid silver-alloy contacts would typically have a life of 50,000 cycles at the same load and hard gold-overlay on nickel alloy contacts may exceed 100,000 cycles at similar loads.



The insulating material used for rotary switches is a major factor in both the performance and life-expectancy of a rotary switch. Dielectric strength and insulation resistance tend to reduce with switch use and ageing of some materials used. Insulation resistance between contacts gradually drops with use as a result of build-up of minute particles of materials rubbed off the contacts and deposited on the insulator surface, atmospheric moisture absorption, switch cleaner residues, stray mechanical lubricants, and deposition of other airborne contaminants, eg. tobacco smoke. Electrical breakdown of the insulation material is much less common and would normally result only from operating the switch beyond its design limit for voltage, however, degradation of the insulation material as described above can promote electrical 'tracking' over the surface of the insulation, eventually destroying the switch function. In extreme cases this may lead to overheating and burning of the insulation and/or cracking/flaking of the wafer material.

Paper-based phenolic resin ('Paxolin') was the most common insulation material used in the manufacture of commercial-grade rotary switches during the period of Eddystone valve receiver manufacture, followed by ceramics. Phenolic-based materials may be used up to around 85C and the minimum insulation resistance (new) is relatively low at some 1,000Mohms. It is not a good choice for high voltage or other applications where high insulation resistance is required. Ceramic is several times more expensive than phenolic but is stronger, more mechanically stable and has a higher maximum operating range (up to 150C) and a minimum insulation resistance (new) of over 10,000Mohms. Silicone fluid is often used during manufacture to treat the surface of the ceramic to reduce moisture absorption. The higher dielectric constant of ceramic results in a higher capacitance between contacts and this must be considered in higher-frequency RF circuits. Other insulation materials include epoxy-glass, which has similar properties to ceramic but with lower dielectric constant, silicone-glass, which has better RF characteristics, and diallyl phthalate, Kel-F and Mycalex, all having excellent properties but which are more expensive and therefore tend to be used only in critical applications.

Maintenance of rotary switches is usually straightforward: they can simply be squirted with a contact cleaner (eg. De-Oxit), but this can leave a rather messy residue. I prefer to clean carefully using good-quality Q-tips soaked in the cleaner. Alternatively, following spraying and working the switch several times, clean-up the residue with Q-tips, repeating this process until the Q-tips are clean. Occasionally a loose contact jaw develops and this may be re-tightened using fine-nosed pliers – however, great care is needed to do this and in my experience it will only effect a temporary repair until a replacement can be found (note: in some applications spare contact sets may be present on the same or other switch wafers that can be deployed) – see Ghirardi & Johnson, 1952.

Slide Switches

The basic slide switch consists of a spring-loaded strip of copper alloy as a moving contact that is slid back and forth over fixed contact studs mounted on a strip of insulating material, usually phenolic. The moving contact is affixed to a small knob which is retained and limited in

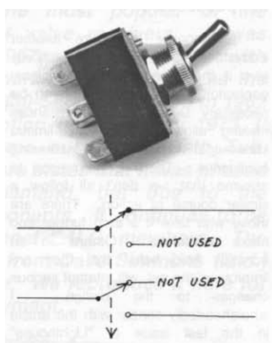
its travel by a metal or plastic housing that holds the switch together. The contacts are normally silver-plated and the switches are typically supplied in up to 3 pole, 4 position

configurations. This type of switch tends to be low-cost and not too reliable in long term use.

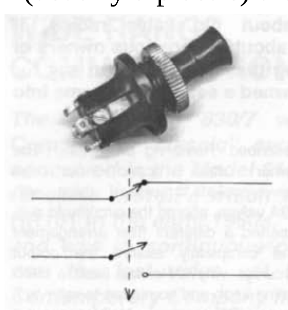
Slide switches are not used very frequently in Eddystone sets, the one application that springs to mind is the crystal in-out switch in the S.640 (circled on photos, base of previous page).

Push-Button Switches

These may be latching or momentary action, with their contacts either enclosed or open. The push button is coupled to a spring-loaded plunger fabricated from insulation material (usually a plastic) that has contacts mounted on it that connect to stationary, mating contacts housed within the switch body.



Robust Spring Toggle Switch


Original Equipment Painton Switch

Again, this type of switch is not encountered much in Eddystone valve sets. One notable exception is however the 100kHz crystal calibrator switch used in most versions of the S.830 (illustrations, above centre and right). These switches are four-terminal devices (photo, right) that are actually two independent single-pole single-throw switch mechanisms, arranged such that one is open while the other is closed. These proved unreliable in use – sometimes glowing red-hot and smoking - and have often been changed out to a more robust biased toggle type (illustration, above left) see Lighthouse article Issue 77, Page 26 by Graeme Wormald. Indeed, the S.830/4 I have had this done as a standard modification by its former Canadian government owners.

Other Switch Types

Other types of switches may occasionally be encountered in Eddystone valve sets. One common application is the form of rotary

Left: Three potentiometer-mounted rotary switches. Left and right are single pole, the centre example is double pole switch that is ganged with the AF gain or tone control in some sets (eg. S.740). This may be detachable from the potentiometer in some designs, not in others. These switches are usually problematic to service if they become erratic in use/fail and it can be difficult to find a replacement to fit the potentiometer. A complete potentiometer/switch assembly may therefore have to be fitted, however, the good news is that these are readily obtainable – just ensure that the switch rating is adequate for the application in hand.

The Eddystone VHF and UHF sets (S.770R and S.770U series) use a turret tuner assembly in place of a rotary switch to change bands. This is a bespoke assembly that is built like a battleship. The main problems that arise with its use and aging are adjustment of the detent system and tarnish of the contacts. The latter may be cleaned using Q-Tips and De-Oxit or other switch cleaning fluid (photo, right– note heavily soiled Q-Tip to the left after cleaning a set of the contacts).

Tips When Replacing a Switch:

- When soldering a rotary switch, it is best to solder ‘uphill’ where possible, ie. the switch is positioned so that solder and flux residues do not flow (by gravity) into the switch contacts (yuk);
- Make the solder joint as quickly as possible while still making a good joint, avoiding overheating the insulation (any type of switch) as this can lead to long-term unreliability by leaving weak point both electrically and mechanically;
- Place the switch in the position whereby the contact that you are soldering is connected (ie. in the ‘make’ position): this provides a metal path to conduct heat away from the soldered joint after soldering;
- When replacing a switch (particularly complicated multi-way rotary switches), consider photographing and/or drawing the switch and its wiring prior to unsoldering the old one. This can save lots of time and worry later when fitting the replacement. Another technique is to remove the old switch in its entirety, complete with wiring, fit the new switch (or wafer) and then unsolder one wire from the old switch at a time and connect it to the appropriate terminal of the new switch before moving onto the next one to avoid confusion;
- Always check for stray wires, solder bridging or spatter on rotary switch wafers after completing a repair – correcting as necessary;
- Consider using insulating sleeves (or heat-shrink) on wires connecting to a switch to avoid unwanted shorts proximal to the switch connections;
- Be carful when removing/replacing the retaining nut on the switches threaded collar – damage to the fingerplate is unsightly, annoying and unnecessary. Use a home-made guard washer placed between the fingerplate and the tool you use to remove/replace the nut. Use the correct size nut spinner to fit the retaining nut if possible rather than pliers or a wrench.

Closure

So even the humble switch has a story – and I have of course only scratched the surface of this subject in this article – there are many other types and variations on the types presented here plus several other switch genres not normally encountered in Eddystone sets. Even though they are relatively simple mechanical devices, most receive a lot of use/abuse in their lifetime and are one of the most common sources of faults in a radio – ranging from the simply annoying, eg. introducing noise into a circuit or having to be re-toggled to work, to catastrophic, eg. total failure or overheating to produce smoke.

Care and common-sense is paramount in maintaining and repairing switches, as is manual dexterity, the correct tools, eg. fine-nosed pliers, lockable, angled tweezers, a small soldering iron, and sometimes a little ingenuity. One over-riding consideration must be safety – any switch application that deals with high voltages must be given extra care, eg. do not take any chances with a 'dicky' mains switch – if in any doubt replace the unit with a known good one of the same or higher voltage and current rating.

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Some Useful References

- Elements of Radio Servicing, W Markus and A Levy, 1955 (2nd Ed. Chapter 12, pp 174, 175)
- Practical Wireless, Vol. 44 No. 10, pp764 - 767
- Radio Servicing: Theory and Practice, A. Markus, 1948 (Chapter 2, pp 119-121)
- Radio and Television Receiver Troubleshooting and Repair, Ghirardi & Johnson, 1952, (Chapter 19, pp 188, 558,676 – 679)
- Electronic Component Handbook, T H Jones, 1978 (Chapter 9)
- Article on Restoring an Eddystone S770R, downloadable from EUG web site
- Various sections of Eddystone manuals downloaded from the EUG web site and specific articles in Lighthouse including:

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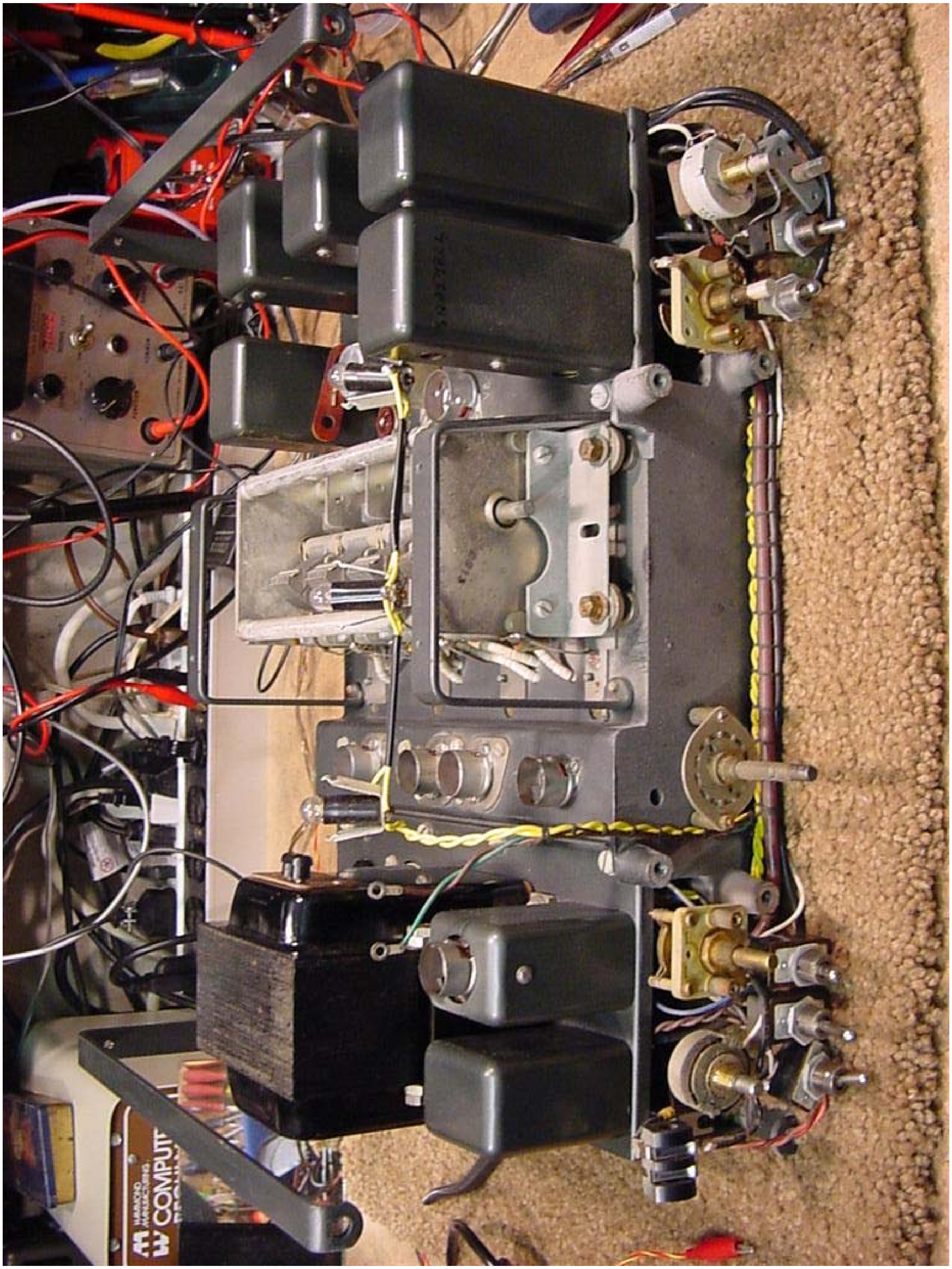

Above: An S.680X with the front panel removed – aaarghh, which switch is which?