Vintage Radio

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The Leak TL/12 Plus Valve Amplifier

British manufacturers built some superb high-end audio amplifiers during the 1950s and 1960s and the Leak TL/12 was one of these. It's a 5-valve mono amplifier with some interesting design features and is reasonably easy to service.

This view shows the fully restored audio amplifier. Note the new capacitor can at the back, between the two transformers.

IF WE LOOK AT the circuits of early 1920s receivers we see that triodes were used to amplify the audio signals, with 1:3 to 1:5 audio step-up transformers between each stage. The triode output stage was then coupled to an output transformer which in turn fed the loudspeaker.

In cheaper receivers, the limited output from the triode output stage often fed a high-efficiency, high-impedance horn speaker. These speakers looked beautiful but the audio quality left a lot to be desired.

Certainly until well into the 1930s, the audio reproduction that was obtained could hardly be called "high fidelity" (or hifi). Even in 1935, "Modern Radio Servicing" by Alfred Ghirardi quoted high fidelity as the reproduction of the frequency range from 50 to 7500 cycles at 5% distortion. That's truly dreadful by today's standards.

A typical "high-fidelity" amplifier of the 1930s still used triodes in all amplifying stages plus an output transformer. The output transformer matched the high impedance of the triode push-pull output stage to a level suitable for the speaker(s). In addition, some amplifiers also included a push-pull audio driver transformer to act as a phase splitter and driver to the triode output stages.

Even when tetrode and pentode output valves became common, the highest quality audio was still obtained from triodes. Negative feedback also became common during the 1930s. This involved taking a proportion of the output from the secondary of the audio output transformer and feeding it back in anti-phase to an earlier stage in the amplifier.

This negative feedback reduced the gain of the amplifier at all frequencies but more so at the frequencies that had the greatest amplification. This smoothed out the gain across the audio band and reduced distortion. It did, however, mean that such amplifiers

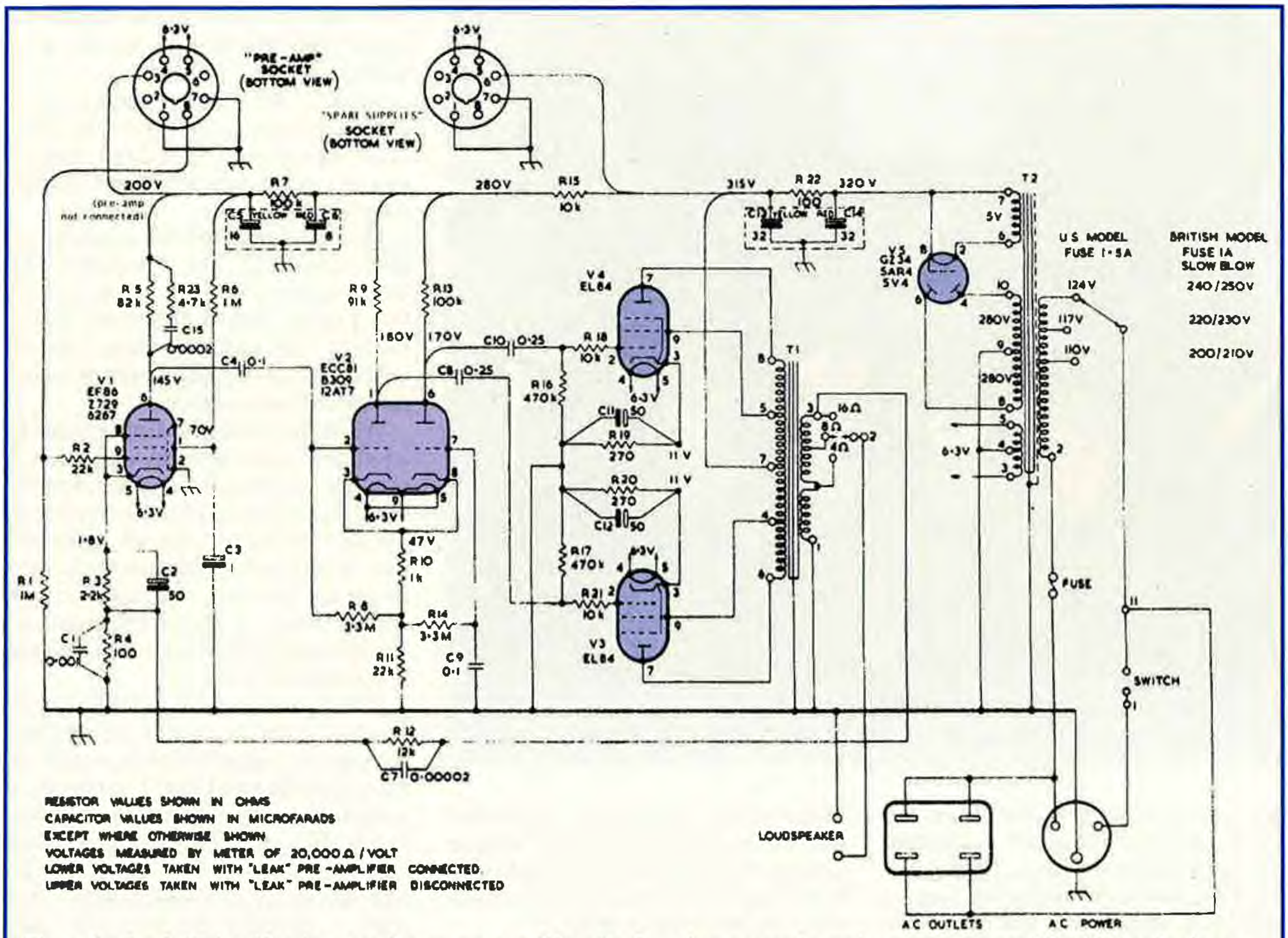


Fig.1: the Leak TL/12 Plus is a 5-valve mono amplifier. V1 functions as an input/preamp stage, while V2 is wired as a phase splitter. The latter drives V3 & V4 which, together with transformer T1, operate as a push-pull output stage.

usually required an extra stage to make up for the lost gain due to negative feedback. Even so, the advantages of negative feedback made it well worth having.

As time went by, manufacturers became increasingly keen to use tetrodes and pentodes in the output stages of audio amplifiers, as they had higher gain than triodes and were more efficient. However, the audio quality of early amplifiers using these valves was not as good as those using triodes.

Subsequently, in the 1950s and 1960s, a modified audio output stage was developed that had high gain and efficiency but also relatively low distortion levels. This amplifier circuit configuration was called "ultra-linear" and it used tetrodes or pentodes in a semi-triode type circuit.

In the ultra-linear circuit, the valve screens were connected to taps part way along the audio output transformer. This became a very popular method of obtaining good-quality audio output while relying on the added efficiency of tetrode and pentode valves. In fact, the Leak amplifier featured here uses an ultra-linear output stage.

The weak link

The audio output transformers were (and still are) the weak link in valve amplifiers, particularly when it comes to producing high-quality audio over an extended frequency range. In fact, good-quality transformers are specially wound to ensure a good frequency response and to reduce spurious resonances.

By the 1960s, valve hifi amplifiers had come a long way and the Leak described in this article was one of the best. After that, transistor and FET audio amplifiers quickly outstripped valve amplifiers in audio quality, total audio output, distortion figures and total efficiency.

Of course, some audiophiles will disagree with me and tell me that valve amplifiers have qualities that make them better than solid-state equivalents. That of course is a personal view but not one with which I concur.

The Leak TL/12 Plus amplifier

The Leak amplifier featured here was given to me some time ago. Unfortunately, though, it didn't come with its preamplifier or the perforated metal cover which fits over the top of the chassis.

This particular unit had been pulled out of the PA system in a local church after many years of faithful service. It is not a particularly powerful amplifier but is typical of the high-end 10-12W amplifiers that were developed in the early 1960s.

When I first got the amplifier, it was immediately obvious that a few rather odd alterations had been done to it. It was certainly not the standard of work you would expect on a high-quality

This is the Leak amplifier before restoration. The original capacitor can had been removed and replacement capacitors fitted under the chassis.

piece of equipment. For example, the main supply electrolytic capacitors had been replaced but instead of being fitted into a can above the chassis, had been attached to the underside of the chassis with silicone sealant. However, since the repair, they had subsequently parted company with the chassis, so that they were just floating on their leads.

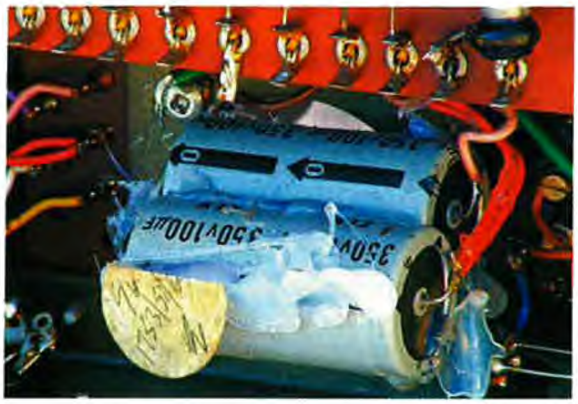
They looked terrible and would have still looked terrible even if the silicone had held fast.

Other electrolytic capacitors looked as though they had just been "thrown in" too, in various other parts of the amplifier. In fact, it looked like all the electrolytic and paper capacitors had been replaced.

My first step was to replace all the high-voltage electrolytic capacitors with more suitable values and voltage ratings. At the same time, I made sure that these were installed in a much more professional fashion.

It's worth noting that the ones I removed didn't suit the amplifier, although they were still working OK. For example, C13 and C14 (the main supply filter capacitors) were both 100μF capacitors instead of 32μF, as specified on the circuit. In particular, C14 should not have been increased to 100μF as the peak charging current through rectifier valve V5 would have exceeded its rating and shortened the life of the valve.

In addition, someone had modified the input circuit, probably to cater for a transistor preamplifier. The additional parts were removed and the audio input stage restored to its standard configuration.



The replacement capacitors had been secured with silicone sealant but this had since parted company with the chassis.

Next, I decided to improvise a chassis-mount can to house the fresh 32μF capacitors (C13 & C14). A small can of mushrooms was just the right size for this job.

Having consumed the mushrooms and cleaned the tin, I soldered two solder lugs to it at the open end, so that I could later bolt it down to the chassis. The can was then sprayed with matt black spray paint to match the rest of the amplifier.

While the paint was drying, I checked all the resistors in the amplifier. A number of these were considerably out of tolerance and so were replaced. These components are all mounted on a large tag strip and are quite easy to get at. However, for some strange reason, many of the components are not grouped close to the valve stage that they attach to.

Next, I cut a small section of perforated board to mount underneath the chassis, directly below where the capacitor can would sit. The new electrolytic capacitors were then installed inside the can and held in place with contact adhesive, foam plastic sheet and electrical insulation tape. That done, I mounted the new can, complete with the capacitors, onto the chassis and wired the components into circuit via the perforated board (see photo).

The top of the chassis now looks almost the same is it did when the amplifier was new.

Circuit details

Fig.1 shows the circuit details of the Leak TL/12 Plus. It's quite conventional and so most faults would be easy to find.

The first stage is an EF86 (V1), which is a low-noise audio pentode. It receives its signal via the "preamp" socket which is located on top of the chassis. R2 is included prevent RF signals from causing problems in the stage.

The cathode circuit and the plate circuit both deserve some comment. As shown in Fig.1, the feedback signal from the output transformer is applied to the cathode circuit by connecting it across a 100Ω resistor and a 1nF capacitor. The latter tailors the feedback signal to correct any phase problems.

Capacitor C15 and resistor R23 in the plate circuit are included to give a small amount of top cut into the supersonic region.

V1's output is applied via capacitor C4 to the grid of the first triode in V2. This valve is a twin triode 12AT7 and it functions here as a phase splitter.

Because there is no bypass capacitor across resistor R10, the cathode of the first triode tends to follow the voltage fluctuations on the grid due to the input signal. In addition, because the two triodes in V2 have their cathodes commoned, the cathode of the second section is forced to follow the cathode voltage of the first section.

However, the grid of the second triode is effectively earthed as far as the signal is concerned by capacitor C9. This means that if the first triode has a positive-going signal applied to its grid, it will draw more plate current as the cathode tries to follow it in a positive direction. As a result, the plate voltage will drop because of the increased voltage across R9 (due to the increased plate current).

This in turn means that a negative-going signal is fed via C8 & R21 to the grid V3 (EL84).

At the same time, the cathode in the second section of V2 also swings in a positive direction. However, the grid voltage is maintained at its original level, so more negative bias is applied to this section.

In this situation, this valve section moves towards cut-off and so the voltage on its plate rises. As a result, a positive-going signal is applied to the grid of V4 (via C10 & R18). This means that a push-pull signal is effectively applied to the two output stage grids.

Push-pull output stage

V3 and V4 (EL84s or 6BQ5s) are connected into the circuit as push-pull amplifiers in the ultra-linear mode. Conventional PA amplifiers would have the screens of these valves wired to pin 7 of the output transformer whereas in the ultra-linear mode, they are wired to pins 4 & 5 respectively.

Note that the output transformer has tappings on its secondary for 4, 8 and 16-ohm loudspeaker systems. The negative feedback line is taken from the 16-ohm terminal of the output transformer and applied via R12 and C7 to the cathode circuit of V1, as mentioned previously.

This under-chassis view shows the amplifier before restoration. Note how the replacement electrolytic capacitors at the bottom had come adrift, giving an untidy appearance. The parts on the tag board are easy to replace.

The EL84s (or 6BQ5s) operate most of the time as push-pull class A amplifier stages but operate in class AB1 at high volume.

One point to note is that, throughout the amplifier, the plate to grid coupling capacitors have larger values than those found in valve radios. This is so that audio frequencies down to about 20Hz can be reproduced.

In domestic radios, the audio response rarely extends below around 150Hz. Basically, there was no point in extending the response lower than this because the modest speakers fitted to mantel receivers have very little baffling and do not work well below that frequency.

In fact, this was rather convenient as it meant that the designers and manufacturers could restrict the frequency response of the amplifier and eliminate any hum problems that might otherwise be present. This also kept the manufacturing costs down.

The things people do – cutting the earth lead to a mains plug is never a good idea!

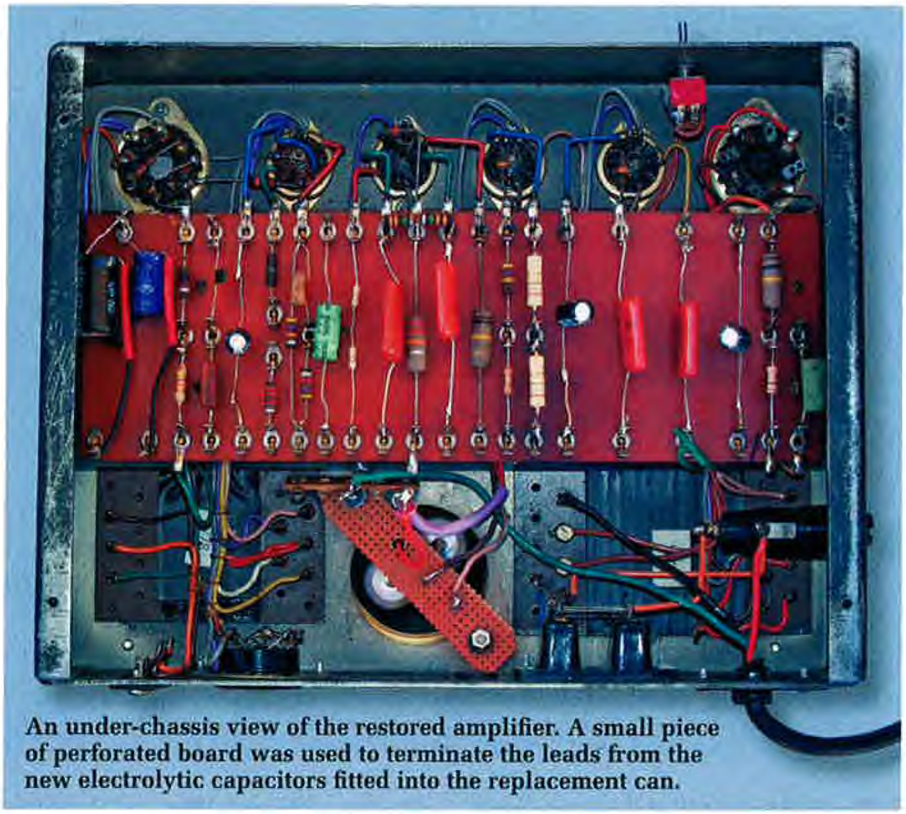
Power supply

The power supply is conventional and uses a 5V4G indirectly heated rectifier valve (V5). This produces the high-tension (HT) supply for the valve plates and screens.

The advantage of using an indirectly heated rectifier is that it begins operating at about the same time as the other valves. This means that the peak output voltage on the filter capacitors is almost the same as the working voltage and so lower rated capacitors can be used. Filtering and decoupling on the HT line is extensive, with R7, R15 & R22 doing the decoupling and C5, C6, C13 & C14 doing the filtering.

The 6.3V AC heater output from the mains transformer is centre-tapped, with the centre tap going to earth. This helps cancel out any induced hum from the heaters into other valve elements.

Several years ago, I had cause to service a Geloso amplifier with similar output power to the Leak. It was a PA amplifier but had some interesting features in the power supply. There was a winding on the power supply that gave a voltage rail of 25V when rectified.



An under-chassis view of the restored amplifier. A small piece of perforated board was used to terminate the leads from the new electrolytic capacitors fitted into the replacement can.

This supply had its positive side earthed and it provided bias for the 6BQ5 valves via a potentiometer. This DC voltage also fed the heaters of two 12AX7 valves in the early stages and it very effectively overcame any problems of hum leakage in the low-level sections of the amplifier. It was a nifty idea that wasn't copied by many manufacturers.

Testing

Before going for the smoke test, I carefully checked all the wiring, terminals and components and all looked to be in order – with one critical exception. When I checked the wiring to the power plug, I found that there was no continuity between its earth pin and the chassis.

A quick check at the amplifier end showed that the earth lead was securely attached to the chassis so I removed the cover from the 3-pin mains plug. And that revealed the problem – as shown in one of the photos, the earth lead had been cut off.

Of course, it couldn't be left like that, since that would leave the chassis without an earth which would be dangerous. Cutting the end off the mains cable and re-attaching the plug quickly solved that problem.

So why had the earth lead been cut off? This was not uncommon in the 1950s and 1960s when "earth loops" or "hum loops" were encountered in audio amplifier installations. Typically, there would be a turntable, a reel-to-reel (or cassette) tape recorder and an AM radio tuner all attached to the amplifier. These items would all have separate earths and circulating earth currents could find their way into the sensitive input stages via the shielded connecting cables.

As a result, these mains frequency signals would then be amplified and would appear as a loud hum.

One of the methods used to overcome this problem was to remove the mains earth connection on one or more pieces of equipment – a quite illegal and potentially dangerous practice. A far better method was to use 1:1 audio transformers. These isolated the signal earth of each piece of equipment and hence interrupted the earth or hum loop.

Getting back to the Leak amplifier, with the valves installed and the power turned on the voltages rose to about what would be expected. I then checked the power consumption and it was 58W which again is about what was expected.

The amplifier was also completely quiet with no hum or buzzing noises but when a finger was placed on the input a healthy "blurt" of hum was heard from the loudspeaker. The amplifier was working.

I don't normally do any tests on the audio amplifiers in domestic radios unless the sound quality is unpleasant. In this case, however, I decided to do some tests to see how well this amplifier performed and to see if I could spot any performance problems.

I began by connecting my audio oscillator to the input, then connected a good-quality 8-ohm loudspeaker and an oscilloscope across the output terminals. That done, I varied the oscillator frequency from 20Hz to 24kHz and found that the response was substantially flat from around 20Hz to 12kHz. It dropped off after 12kHz but there was still substantial output at 24kHz, as observed on the oscilloscope.

There were no signs of supersonic oscillation on the oscilloscope pattern, which indicated that the amplifier was stable. In addition, as the input signal was increased, the amplifier clipped symmetrically on the negative and positive excursions of the waveform.

Next, I connected an 8-ohm load resistor and checked the output level just before distortion became observable. This gave a power output of 10W RMS, which again is about what I expected. New output valves may give slightly more output but there are probably many more hours of life left in the existing valves, so there was little point in replacing them.

So, despite its age, the Leak TL/12 was still giving good performance.

Summary

This Leak amplifier is a good performer and is reasonably easy to service. However, some of the components on the tag board are a bit remote from their associated valve stage, which means that identifying a particular part can sometimes require a bit of circuit tracing.

Fortunately, the parts are easy to get at and the component board is not mounted over the top of the valve sockets, as was done in the "Pee Wee" receiver described in the September 2008 issue.

In summary, it is a great little amplifier and well worthwhile having in a collection. It's just a pity that it didn't come complete with the preamplifier and its chassis cover. SC