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The AWA PA1002 50W PA Amplifier

Boasting a power output of 50W RMS, the AWA PA1002 is a typical valve PA amplifier from the mid-1960s. It's a rugged, well-made unit with many useful features and is easy to troubleshoot and restore.

THE VERY FIRST PA systems used a straight tapered funnel arrangement, referred to as a bull horn, megaphone or loudhailer, without any form of electronic amplification. They certainly "reinforced" the user's voice to some extent but they were quite directional.

When valves later became readily available, PA amplifiers capable of a few watts were quickly developed. Those early units were used with carbon microphones, while the speakers were larger, more powerful versions of the horn speakers used with early receivers. Horn speakers were very efficient compared to modern loudspeakers but their frequency response was quite restricted and the distortion from these units was relatively high.

As a result, early PA systems were only suitable for voice communication.

PA amplifiers of various output powers were later used during World War II, some so big that they used radio transmitter valves in their output stages to feed the loudspeakers. By contrast, the commercial PA amplifiers used for the general public following the war were quite modest, with output powers ranging from around 5W up to about 25W.

As an aside, when I first worked in the radio service industry in the late 1950s, my employers hired out a PA system. This used a 25W amplifier (similar to the unit described here) and was teamed with a dynamic microphone, a record-playing turntable and up to four reflex-horn speakers. The speakers could be located some distance from the amplifier, as the output was fed to a 100V (medium impedance) speaker line.

The connecting cable consisted of a length of twin-lighting flex which had low losses at the speaker impedances used. Standing under the speakers when the unit was operating at full power was a deafening experience and it could be heard up to 3km away (depending on wind direction).

AWA PA1002 PA amplifier

My vintage radio collection includes several valve PA amplifiers, the largest of which is the AWA PA1002, a 50W unit from the mid-1960s. PA amplifiers improved considerably after World War 2 and top-end 50-100W valve PA amplifiers quickly reached the pinnacle of their development.

Unfortunately, I had no luck in obtaining a circuit diagram for the PA1002 although I do have circuits of other AWA PA amplifiers of the era. AWA obviously experimented with many different circuit designs because none of the circuits I have are anything like the PA1002. As I result, I eventually traced out the output and driver circuits of the amplifier and this revealed a push-pull output stage that's quite different to what's normally expected. In addition, the chassis has holes punched for two additional output valves, so that a 100W version could be manufactured using as much common circuitry as practical.

The amplifier itself weighs a hefty 14kg without any accessories and it measures 430 x 230 x 230mm (W x D x H), not allowing for the knobs and mounting feet. A feature of the unit is that there is plenty of room on top of the chassis for accessories, such as a monitor speaker and a radio tuner. These accessories are not fitted as standard but could be easily added as their connection sockets are already wired.

As can be seen from the photos, access to the parts for service (or restoration) is relatively easy. To gain access to the valves, it is only necessary to remove four screws from the ends of the chassis that hold the U-shaped perforated steel cover in place. It is then quite practical to carry the amplifier by one or both of the metal rods located at the top of the cabinet that attach the front and back panel to the chassis.

The circuitry under the chassis is accessed by turning the unit upside down and then removing the four self-tapping screws holding the rubber buffers and the bottom shield in place, followed by the baseplate itself. It's then quite easy to access most of the parts although some parts are tucked in under a ledge at the back.

The bottom of the cabinet is fitted with rubber anti-scuff buffers and there are also ventilation holes in the bottom cover sheet.

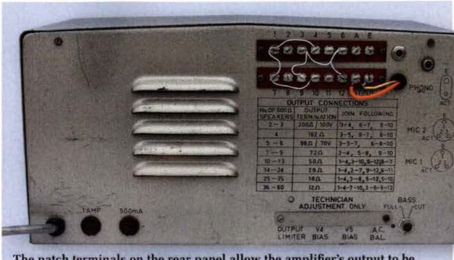
Inputs & controls

The PA1002 has inputs for two microphones and these are plugged into sockets on the lefthand end panel of the chassis. Another socket adjacent to these connects to the record player.

The various controls are conveniently located along the bottom edge of the front panel and (from left) include a volume control for each microphone plus another volume control for a record player or the optional radio tuner. These latter two units are selected by a phono/radio switch.

To the right of this is a tone control for the phono/radio channel, a small pilot light (for power) and an optional mains on/off switch, although the latter is not fitted to my unit (the hole location is "blanked off"). The final control is the monitor on/off switch but in my unit, someone in the past has rewired it to serve as the mains on/off switch.

In fact, none of the available accessories are fitted to my particular amplifier. However, the top section of the front panel has provision for their controls. At the left is a blanked-off hole that's intended to accommodate the dial for the radio tuner but the purpose of the blanked-off hole in the centre of the panel is a mystery. The perforations on the right are for the optional monitor speaker.



The patch terminals on the rear panel allow the amplifier's output to be matched to many different impedances for both 100V and 75V lines and are connected according to the table. In addition, there are two line output terminals plus antenna and earth terminals for the optional tuner.

An old exponential horn speaker as used in many PA systems during the 1960s. Similar speakers are still used in modern PA systems.

Rear panel facilities

A patch panel on the rear allows the amplifier's output to be matched to many different audio line impedances. There are 12 patch terminals in all and these are connected in various combinations according to a table.

There are also a couple of terminals and a couple of sockets to which the speaker lines are connected. Another two terminals are provided for an antenna and an earth for the tuner.

The bottom edge of the rear panel carries a number of controls and other features. At the left is the mains power lead, followed by a 1A mains fuse and then a 500mA high-tension fuse. An adjacent covered panel conceals four screwdriver adjustable preset controls: (1) signal limiter adjustment; (2) bias adjustment for the V4 output valve; (3) bias adjustment for V5; and (5) an AC balance control to null any residual hum in the audio output.

Finally, at extreme right is another screwdriver adjustable control. This is simply a 2-position switch which is labelled "Audio Bass Full/Cut". It very effectively removes any residual hum in the output.

Circuit details

Fig.1 shows the output section of the circuit. It's quite conventional in many areas but as mentioned above, the push-pull output stage is different to other circuits.

The two microphone outputs are fed to each half of a 12AU7 twin triode which amplifies these signals. Its outputs in turn drive the input of an EF86 signal limiter via level control potentiometers and mixing resistors. The signal from the radio tuner or the record player is also fed to this stage, again via a potentiometer and mixing resistor.

The EF86 signal limiter operates as follows. First, a small amount of the audio output is used to drive a small lamp and this illuminates an LDR (light dependent resistor) sealed inside a small lightproof tube. The LDR is connected across the grid resistor of the EF86 (see Fig.1), so the actual grid resistance decreases as the audio input increases.

Basically, the EF86's grid circuit has the LDR and its grid resistor in

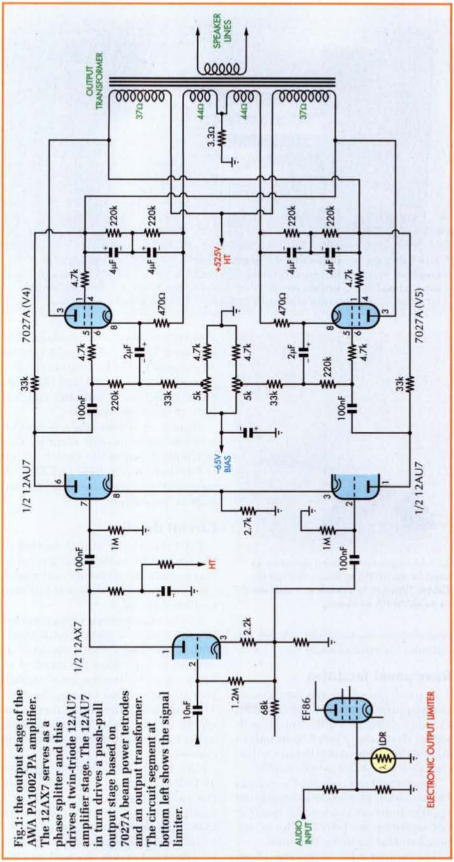


Fig.1: the output stage of the AWA PA1002 PA amplifier. The 12AX7 serves as a phase splitter and this drives a twin-triode 12AU7 amplifier stage. The 12AU7 in turn drives a push-pull output stage based on 7027A beam power tetrodes and an output transformer. The circuit segment at bottom left shows the signal limiter.

series with the resistors in the input-combining network. As a result, the LDR-resistor combination acts like an electronic volume control and even if someone bellows into a microphone, the amplifier will not be overloaded (assuming that the signal limiter is set up correctly).

By contrast with this arrangement, some PA amplifier circuits use an AGC voltage to control the EF86, even though it is a sharp cut-off valve. This involves altering the operating conditions for the EF86.

The next stage consists of a twin-triode 12AX7, with the first section used as an audio amplifier and the second section as a phase splitter. A twin-triode 12AU7 amplifier stage follows, with one section driving valve V4 and the other driving valve V5, both 7027A beam power tetrodes which form the push-pull output pair.

Most amplifiers of this type use the phase splitter to directly feed the two output valves in push-pull. However, in this amplifier, a higher input level is required for the output stage than such an arrangement could provide, as the output valves have quite a high negative bias applied to their grids (about -56V each). Hence the inclusion of the 12AU7 twin-triode stage.

The 7027A valve is an upgraded version of the older 6L6G and when used as a pure class-A single-ended amplifier, its operating conditions are almost identical. In this circuit, the bias for each valve is obtained separately from the bias supply so that it can be adjusted for performance variations between the individual valves.

Output transformer

The output transformer has a total of eight windings: four to match the output to the speaker line impedance plus another four in the plate/screen and cathode circuits. Each cathode winding has a resistance of around 44Ω, while the plate windings are about 37Ω.

It appears that the circuit has been designed with considerable negative feedback to stabilise it against the wide impedance variations reflected back into it from the long speaker lines. It's certainly an unusual circuit but it works very well. However, I do wonder why they went to so much trouble when a more conventional circuit would have done the job, as with many of AWA's other designs.

The power supply (Fig.2) uses a solid-state voltage-doubler circuit and this has an output of +525V DC with the high mains voltage (250V) at my place. The bias is obtained from a separate half-wave solid-state rectifier, which gives a maximum of -65V DC. As well as the windings shown in

Fig.2, the transformer also has a 6.3V heater winding with two 47Ω resistors across it to give an artificial centre-tap to earth, ie, one end of each resistor goes to the chassis.

Finally, the unit includes a circuit that artificially injects hum into the amplifying chain to cancel out and minimise hum in the output.

Restoration

Three badly overheated resistors were the most obvious fault when I removed the bottom cover from the amplifier. Two were on the screens of the 7027A output valves, so it was quite possible that these had also been damaged after such abuse.

This sort of problem often occurs if the speaker transformer primary winding goes open circuit, which removes the high tension (HT) from the plate of the output valve. The screen then tries to function as the plate and the valve is then often ruined due to excessive power dissipation in the screen circuit.

Most of the inter-coupling capacitors are polyester types so I didn't expect any problems with these. In fact, it was unlikely that there would be any major problems in the early stages at least, as nothing looked or tested faulty with the power off.

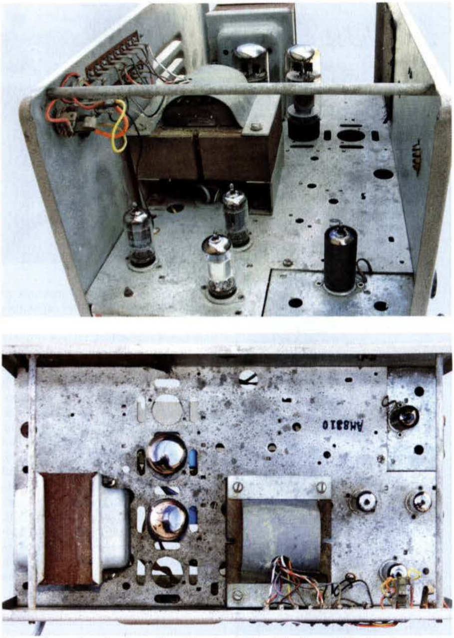
The output stage was a different story though, due to the badly-burnt resistors in the output valve screen circuits. To troubleshoot this problem, I decided that it would be best to remove the output valves and check all the voltages and components around that stage with power applied.

Insulation checks

Before applying power, I first needed to confirm that it was safe to do so. I also needed to check and reform the electrolytic filter capacitors on the HT line. These checks involved using a high-voltage insulation tester to check for leakage between the mains wiring and chassis and between the HT line and chassis.

These checks proved satisfactory. The mains-to-chassis resistance exceeded 200MΩ, while the HT-to-chassis resistance was greater than 50kΩ.

With these checks complete (and the output valves removed), I applied power for a second or two then turned it off for a few seconds. This allowed me to check how quickly the voltage built up and decayed on the HT line. This step was then continuously



These above-chassis views show the simplicity of the layout. The two large vacant holes are for additional output valves, as used in the 100W version.

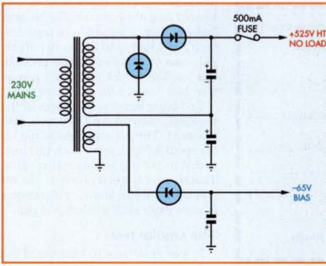


Fig.2: the HT rail is produced by a solid-state voltage-doubler and this can produce up to about 525V DC (if the high mains voltage is high). The -65V bias supply is derived via a separate winding on the transformer and a half-wave rectifier.

This view shows the two badly overheated resistors on the screens of the 7027A output valves. Fortunately, the cathode resistors had gone open circuit and saved the output valves from damage.

repeated for a couple of minutes to reform the electrolytic filter capacitors on the HT line.

If these capacitors charge quickly and then slowly discharge over a few seconds, it indicates that they have reformed correctly. In this case, it all worked out as expected so I reapplied power and checked the cathode voltages on the output valve sockets. They were both over +100V instead of the correct 0V, which wasn't good.

With the unit now disconnected from power, I checked the cathode resistors and found that they were both open circuit. In addition, both of the 2μF capacitors in the grid-to-cathode circuits were leaky, as were the 100nF coupling capacitors from the two 12AU7 valve plates to the respective grids.

Surprisingly, the screen resistors were still intact and measured 4.7kΩ and 5.6kΩ. In the end, I replaced all these resistors and capacitors. The original capacitors were paper and metallised-paper types and it was known that they eventually became leaky. In fact, it would have been better if AWA had used the more reliable polyester or polystyrene capacitors in this section of the amplifier, just as they had done in the front-end.

The other burnt resistor was in the feedback network and this was also replaced. The set was then wired on the speaker patch panel for a 12Ω line, to match my triple-cone test speaker. That done, I applied power to the set and adjusted the bias potentiometers to give about -50V at each grid pin.

The smoke test

It was now time to find out if the output valves had survived the rough treatment meted out by the faulty components. As a result, these valves were reinstalled and the power applied. The bias voltages remained roughly the same as before and both valves were drawing some current, determined by checking the voltage drop between each cathode and chassis.

At this point, I adjusted the bias pots until I had 16V between the cathodes and chassis. The fixed bias was now around -37V, which meant that the total bias was about -53V with respect to chassis.

The current drawn by each valve under these conditions is 32mA, which means that the dissipation in each valve is around 16W. This is well within the 35W plate dissipation rating for the 7027A valves. I don't know what cathode current AWA intended these valves to draw with no signal but 32mA and 16W dissipation seem to be safe values and the distortion in the output was low.

It's strange that the bias adjustments are hidden behind a plate on the rear. After all, it's also necessary to remove the cover under the chassis to gain access to the valve cathodes in order to measure the bias voltages. Surely it would have been more convenient to mount the bias adjustment pots adjacent to each cathode circuit?

Getting back to the restoration, the pots were all given a spray with Inox contact cleaner/lubricant to eliminate noise. The valve sockets were all in good order and did not require lubrication.

Once all that work had been completed, the old PA amplifier worked as normal. Some of the valves are a little noisy and there is a little induced hum but considering the gain of the amplifier, it really is quite acceptable. In this unit, the grid circuits are high impedance and these can be susceptible to induced hum from mains voltages.

Fortunately, it appears that the output valves suffered little in the way of damage and there's no point replacing them. They were probably saved from destruction by the 470Ω cathode resistors going open circuit.

It's probable that quite a few of these AWA PA1002 PA amplifiers were affected by leaky capacitors around the output stages. One website that I found has an under-chassis view of one of these amplifiers and the same resistors were burnt out in that unit as well!

Cleaning up

Like most PA amplifiers of the era, the PA1002 is housed in a steel cabinet painted a grey hammer-tone colour. The U-shaped cover on my unit had a number of marks on it, while the front and rear panels were relatively unmarked. The chassis itself is also far from pristine, with discolouration largely due to the ravages of oxidation on the plating.

I tried cleaning the chassis with a small paintbrush and a kerosene-soaked rag but there was little improvement in its appearance. It's quite typical of the deterioration that occurs with plating over time, especially in a slightly hostile environment.

The valves were relatively clean but I like them to look like new if possible. To achieve this, I first washed all the miniature valves in warm soapy water, taking care not to rub the type numbers off them. By contrast, the octal valves need to be cleaned more carefully; they cannot be immersed completely, otherwise water may get into the base and create electrical leakage paths.

For this reason, I only immerse the glass envelopes and not the bases of octal valves in the water and gently rub the envelopes with soapy water using my fingers. The valves are then rinsed in clean water and left to dry by either supporting them upside down (so water doesn't run into the bases) or by laying them on their sides.

By contrast, the miniature types are left to dry by standing them on their pins.

The U-shaped cover was restored by first sanding it down to remove any rust and discolouration in the paintwork. It was then given several light coats of a grey hammer-tone paint (called "Galmet") on the top and sides. It ended up looking as good as new.

The front and rear panels were tidied up by spraying them with Inox and then wiping away the excess. This removed most of the minor blemishes and these panels now look quite acceptable. I also sprayed and wiped the knobs and they came up looking like new.

Summary

The PA1002 is a well-built PA amplifier and is still capable of providing years of reliable service. The output stage is rather unusual but both it and the signal limiter stage work well. As expected, the cabinet is rather utilitarian but it's rugged and provides good protection for the internal parts.

My tests indicate that the PA1002 gives its rated output with little hum. The only thing that I can criticise is the use of those paper and metallised-paper capacitors around the output stage. As stated above, these eventually become leaky and cause serious problems. Of course, it's possible that polyester capacitors were unavailable in the values needed at that time, which is why the less-reliable paper types were used.

In my case, I was lucky that the cathode resistors had gone open circuit and saved the output valves from destruction. That said, the unit was easy to troubleshoot and restore and is a good performer. **SC**

The third overheated resistor was in the feedback network and was easy to spot.

All the faulty parts were in the push-pull audio output stage. They included five resistors and four capacitors.