



Converting a 240VAC set to 32V DC operation

A 240VAC to 32V DC conversion? You must be kidding? Well, no – this project was undertaken to discover the differences in design and performance between sets using a “normal” 200-250V high tension (HT) supply and those with just 32V HT.

Converting a 240VAC set to 32V DC operation is really doing things backwards these days. After all, how many people have a 32V DC supply available to power such a set? However, as well as checking out the performance dif-

ferences after the conversion, I also wanted to determine which valves worked best with low HT voltages, particularly in the audio section.

A redundant 240VAC mantel set was chosen as the guinea pig for this task. It

proved to be an extremely interesting project, with some unusual challenges in design. A set with only 32V HT is not as “tame” as many might think. It ended up being a really hot performer – better, in fact, than the original set and still with only five valves.

Ho-hum circuitry

The design of typical 4/5 valve mains-operated receivers is rather “ho-hum” to most restorers. Typically, they include a 6BE6/6AN7 converter, 6BA6/6N8 IF amplifiers, a 6AV6/6BD7 detector/first audio stage, a 6AQ5/6M5 audio output stage and a 6X4/6V4 rectifier. The circuitry is all fairly predictable, with 200-250V HT on the plates and about 85V on the screens of the RF valves. The bias is usually obtained from a back-bias network.

Of course, there can be quite a lot of variations in the circuitry and valves used but it’s usually nothing out of the ordinary.

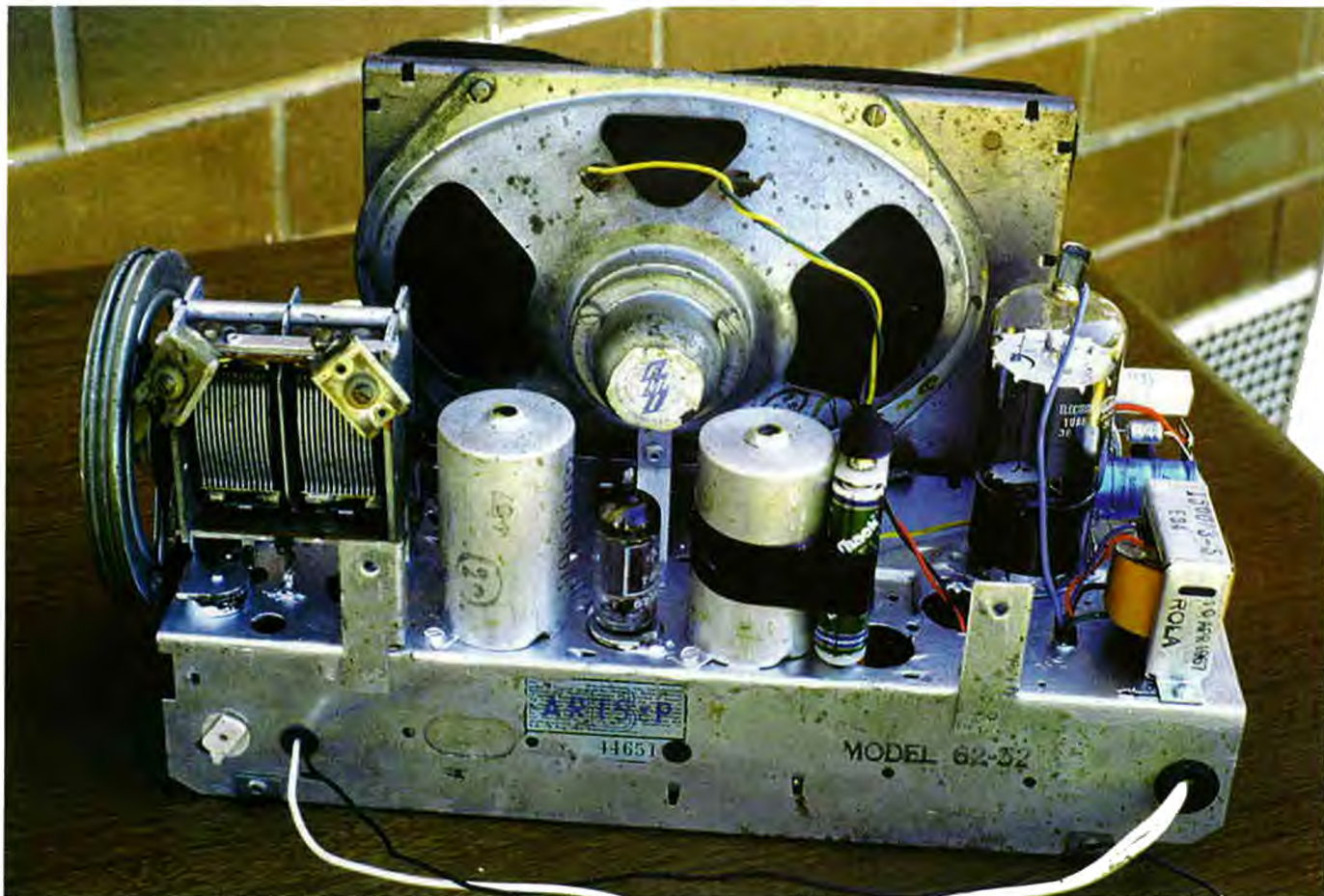
32V DC sets

During the years between the 1930s and the 1950s, many radios were designed to operate from 32V DC lighting plants. That’s because many country areas did not have access to 240V AC mains until the early 1960s.

There were two ways of supplying power to a set connected to a 32V lighting plant. The first method was to wire the valve heaters (sometimes filaments) in series parallel across the 32V supply (to keep the current drain down) and to supply the plate and screen voltages from batteries or later on, from genemotors (small motor generators) or vibrator power supplies.



This view shows the chassis layout of the converted 32V receiver, with the white arrow (top left) indicating the new 6BA6 RF stage. A chassis photo of a similar main-powered version of this set is on page 81 of the September 2004 issue.



Above: rear chassis view of the converted 32V receiver, with the bias battery taped to the second IF transformer. Note that the 12DQ6A audio output valve is sitting where the power transformer was originally fitted.

This meant that only minor modifications had to be made to a normal AC mains-powered set as far as the amplifying circuitry was concerned. Instead, the only section that required major alterations was the power supply. This scheme worked quite well, with many fine highly sensitive 32V sets produced. In fact, they had to be good performers, as the average 32V set was located well out in “the sticks”.

The second method of supplying HT power to the set was quite different to the first, with the HT being taken directly from the 32V. This meant that a fair amount of redesign was needed to get reasonable performance, since there was now just 32V on the plates of the valves compared to 250V for

mains-operated sets.

Radio Corporation, in particular, produced a number of quite high-performance sets with 32V HT. However, a set with 32V HT required eight valves to achieve the same performance as a 5-valve vibrator-powered set. Radio Corporation sets typically used an RF stage, a converter, two 455kHz IF stages and three audio stages – the latter using two valves in push pull – to get the performance desired. Even then, only around 300mW of audio output was obtained from a pair of 25L6GT valves operating in push-pull.

The conversion

In order to simplify the task of con-

structing a set with 32V HT, I decided to convert a typical 240VAC mantle set. A run-down HMV 61-51 mantle set was selected to be the guinea pig. I had no less than seven of these and I really wouldn't miss one if the project was a flop!

The first step in the conversion involved removing the power transformer and rectifier valve, which were now redundant. However, the most critical sections of the set are the IF and the audio output stages. Initially, several valve data books were consulted to find out which output valves

Bias	32V HT		36V HT		40V HT		44V HT	
	35L6GT	12DQ6A	35L6GT	12DQ6A	35L6GT	12DQ6A	35L6GT	12DQ6A
-1.5V	10mA	30mA	13mA	35mA	18mA	45mA	21mA	50mA
-3.0V	-	16mA	-	-	-	-	-	23mA

Table 1: plate current for the 35L6GT and 12DQ6A valves at different HT voltages.

HIS MASTER'S VOICE 61-51

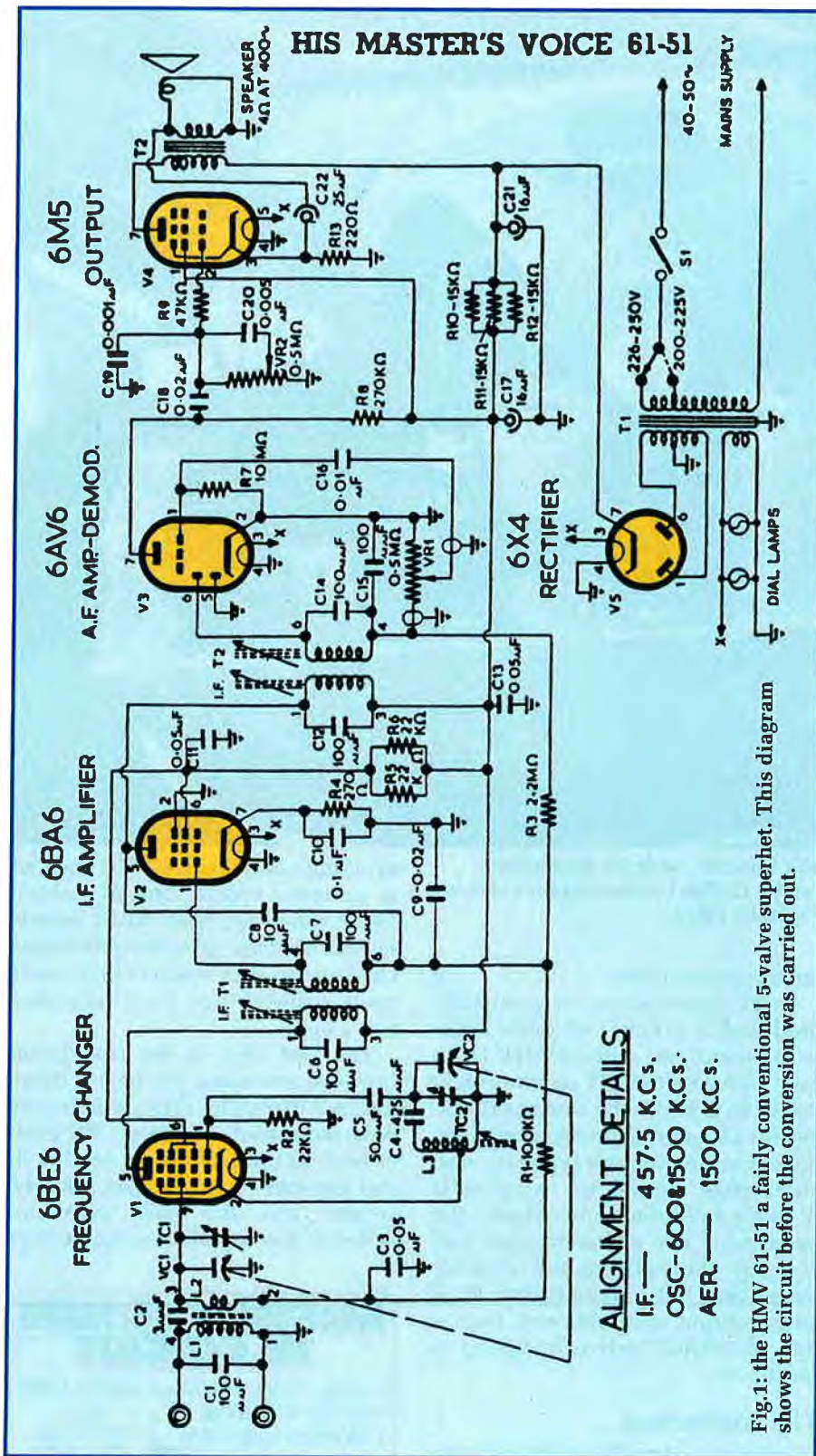


Fig.1: the HMV 61-51 a fairly conventional 5-valve superhet. This diagram shows the circuit before the conversion was carried out.

would draw the most current with a HT supply of 32V.

25L6GT and 35L6GT valves have commonly been used in push-pull in the audio output stages of these sets but I wanted to carry out some tests before committing myself. In

the end, a test set-up something like a simple valve tester was constructed to measure the current drawn by various valves with 30-45V on the plates and screens and with various control grid bias voltages.

Comparative tests were run on the

35L6GT and 6DQ6A/12DQ6A valve types and as shown in Table 1, the 12DQ6A draws more current at low voltages which was the characteristic sought. Using just one audio output valve (12DQ6A) would also eliminate the need to use a couple of audio transformers – after all, I wanted to keep it as near as practical to the original circuitry.

To maximise the voltage across the valve, cathode bias was eliminated and the local oscillator was originally used to provide bias. This wasn't successful and so another method had to be devised. The impedance of the audio output transformer also had to be altered from my original calculation – more on these two problems later.

Initially, I also thought that the first audio stage would need a lower value for the plate resistor, since the voltage across it would be lower. This was tried but when the amplifier was fed with audio, the output was very distorted.

R7 – a 10MΩ grid resistor – was used to develop contact potential bias. This was too high in this instance, so this resistor was reduced to 1MΩ, the valve now running on virtually zero bias. In addition, plate resistor R8 was increased to 330kΩ and the audio from this stage was then quite satisfactory, an oscilloscope showing little distortion.

It was now time now to get the output stage working properly. This had a few problems, as mentioned earlier. I had expected to be able to use a bias of -1.5V, plus a 600Ω speaker transformer (the nearest I had to 1kΩ) which had an output of 3.5Ω to suit the speaker.

Unfortunately, the output was still distorted. I tried substituting my 16Ω workshop loudspeaker for the set's speaker to see if that was causing the problem and the audio improved considerably.

I also experimented with the bias on the 12DQ6A and found that -3V also produced better audio quality – both from listening tests and as observed on the oscilloscope. Because the valve was now drawing less current, the speaker transformer impedance was recalculated and now came out at around 2kΩ. As a result, a new transformer was installed and this then gave good results with the set's original loudspeaker.

I had expected to be able to tap off -3V from the local oscillator's grid re-

Fig.2: this is the circuit of the HMV 61-51 after conversion to 32V operation. Note the added 6BA6 RF stage and the modified audio output stage which is now based on a 12DQ6A. There are lots of other changes as well, including additional RF filtering, a modified AGC circuit and bias changes to the 6BA6 IF stage.

sistor, to bias the 12DQ6A. However, due to the low level of oscillator activity, there was insufficient voltage available to bias the output valve. I then tried increasing the oscillator activity but that caused other problems, so the oscillator circuit was left as it was.

Another approach is to use cathode bias with the 12DQ6A. However, the audio output would drop by about 20% when the 32V battery was down to 28V and there is only just enough audio output as it is. Some 32V sets actually used a battery to provide the bias and in the end, this is what I elected to do. It should last for years – in fact, those in some sets are 10-20 years old.

Parasitic oscillation

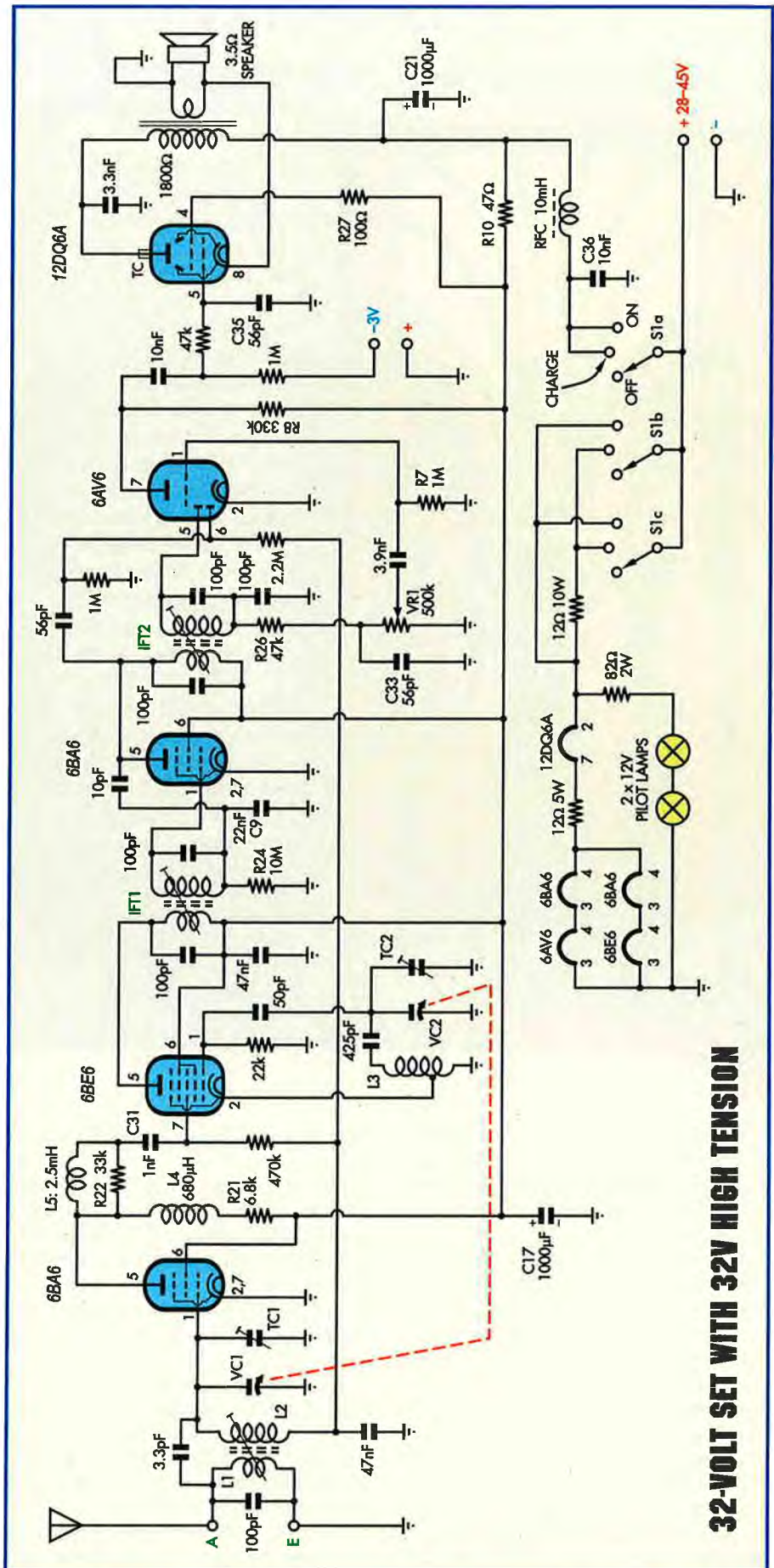
Although the audio quality was now much better, the oscilloscope showed that the output valve was going into parasitic oscillation over part of the audio signal, thus causing distortion. This was cured by connecting a 3300pF capacitor (C34) between the plate of the 12DQ6A and earth. It's worth noting that the 6DQ6/12DQ6 valves are quite high performance valves and have to be treated with care to prevent spurious oscillation.

When the set was subsequently tested at 45V (which some lighting plants developed when at the end of the battery charge), the audio once again distorted on the peaks. I then remembered that some of these high-performance valves require a screen stopper to overcome such problems and in this case, a 100Ω resistor (R27) completely cured the audio distortion.

Once this was all done, the 12DQ6A really worked well and the audio output was more than adequate. When it comes to doing design work and finding weird and wonderful faults, an oscilloscope is an invaluable piece of equipment!

IF filtering

Another worthwhile improvement involved fitting additional IF filters in



32-VOLT SET WITH 32V HIGH TENSION

Photo Gallery: AWA Radiola 120



Manufactured in 1933, the Radiola 120 (and its table model companion the 120) were AWA's first AC-powered super-heterodyne models. The set was one of the few AWA designs to use an autodyne mixer, the company reverting to conventional mixer/oscillator circuits for all subsequent designs. Another unusual aspect of the design involved mounting the 8-inch (20cm) electrodynamic speaker above the chassis, in the upper section of the cabinet. The valves fitted were: 57 autodyne mixer; 58 175kHz IF amplifier; 57 anode bend detector; 59 audio output; and 280 rectifier. Photo: Historical Radio Society of Australia, Inc.

the audio stages. This prevents 455kHz IF signals from being amplified and then re-radiated back into the front end of the set where they can cause instability.

The extra components involved here are C33, C35 and R26. Some sets have these components installed as standard but many manufacturers decided they could get away without them. This usually didn't cause any problems but some sets do have instability problems due to this lack of IF filtering.

Once again, the oscilloscope was handy here. It was able to show the amount of IF signal getting through each audio stage and indicate the ef-

fectiveness of the additional filtering components.

The converter and IF stages were treated as a single unit and the only modification involved shorting out the screen dropping resistors (R5 and R6). The set was then turned on and although it actually worked, the 6BA6 was found to be faulty and was replaced.

That done, the set was aligned and although the sensitivity was fair, it was hardly adequate for remote country areas. And that meant that some further work would have to be done to solve this problem.

Because most 32V radios have an RF stage, I decided to fit one to this

set. However, since there is only a 2-gang tuning capacitor, any RF stage would need to be untuned – unless a 3-gang capacitor and an RF coil could be fitted.

Once again, I didn't feel like carrying out major surgery, so I opted to install an untuned RF stage. The design of this RF amplifier is similar to the video amplifier stages used in old valve TV receivers. In this case, I designed the untuned amplifier to have a cut-off frequency of around 2MHz (note: the 1948 Philips portable model 111 used this technique as well).

As shown in Fig.2, a 6BA6 was selected as the RF amplifier and the "video" circuit was designed to couple the 6BA6 to the following 6BE6. These untuned amplifiers are rather different in design to a "normal" tuned amplifier. They aren't particularly complex and require no tuning but their total gain is lower because the circuit is broadband.

Once installed, the RF amplifier stage boosted the performance of the set such that it now equals almost any other 32V set with an RF stage. The components forming the matching and peaking network between the RF amplifier and the converter are R21, R22, L4, L5 and C31.

AGC tweaks

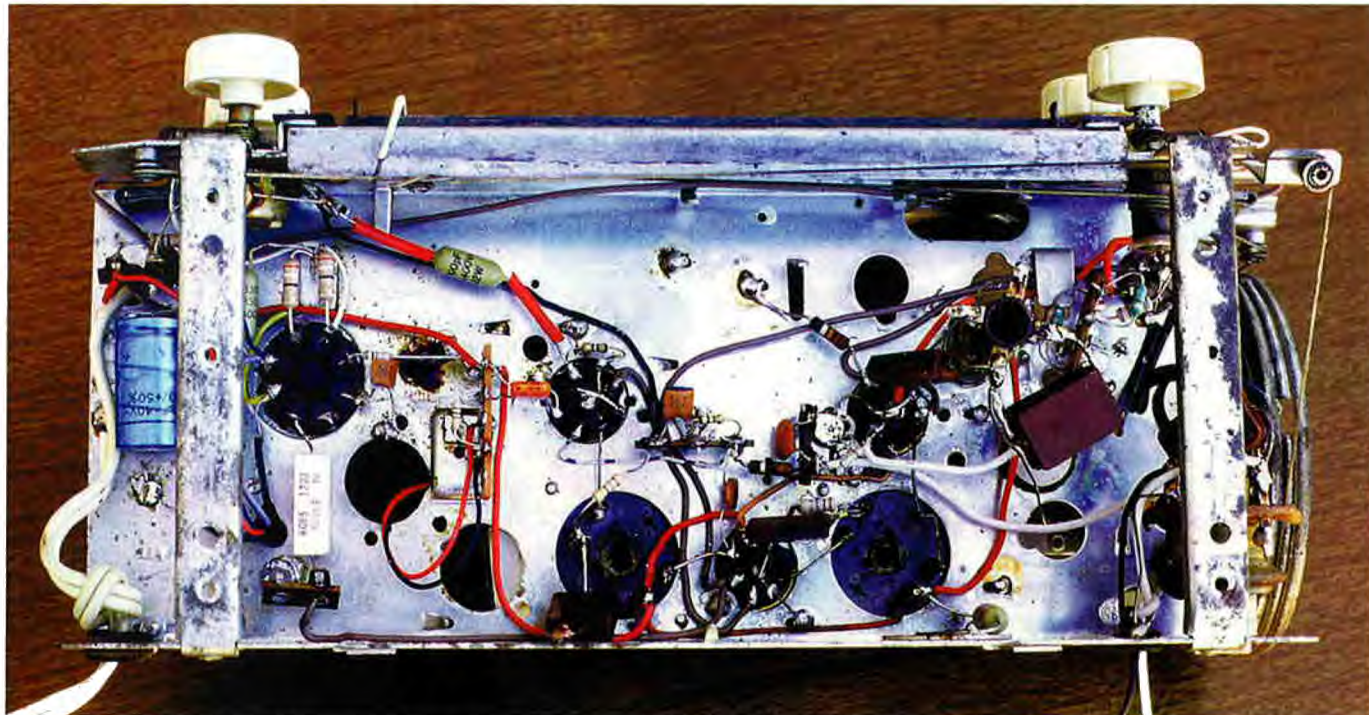
By now, the set was beginning to show real promise. However, further testing revealed that the sound distorted on strong stations.

This is a sign of problems with the AGC system and with such a low HT voltage, the IF stage(s) are particularly sensitive to too much or too little bias voltage. The IF stage was overloading so to overcome this problem, the AGC was removed from this stage and contact potential bias was obtained using a 10M Ω resistor (R24) in the grid lead. Capacitor C9 functions as the RF bypass for the IF transformer.

In addition, by taking the signal for the AGC diode from the plate of the 6BA6 IF valve, a higher AGC voltage was obtained. This meant that the IF valve was no longer overloaded, even when high signal levels were encountered. As before, the oscilloscope was very useful for determining where the overload was occurring, which made it easier to find a solution.

Power supply

The power supply circuit for a set



An under-chassis view of the converted receiver, with the RF inter-stage coupling components visible near the tuning drive. The 12DQ6A audio output stage wiring is at the lefthand end of the photograph.

that uses 32V DC as the HT voltage is very simple. The voltage supplied from a 32V electric lighting plant is nominally 32V but does vary widely, depending on the state of charge of the battery bank. Typically, with 16 cells, it will vary between about 28V with a flat battery bank (allowing for voltage drop in the power cables) to around 40V (ie, 2.5V per cell) at the end of charging.

In some cases, to overcome the voltage drop in the power cables under load, one or two additional cells were added to the bank. This meant that the voltage would rise to 45V at the end of a charge.

This variation is really too much for the valve heaters, so the on/off switch in most 32V sets is a 3-position switch, with the third position labelled "charge". The switch positions in order are "off", "charge" and "on".

In the "charge" position, a resistor is

placed in series with the heaters and dial lamps to limit the voltage applied to them when the battery bank is on charge (in this set, S1 performs that function). Note that in many vibrator-powered sets, the current to all sections of the set is usually fed through a 10Ω resistor to drop the voltage to around 32V when the batteries are on charge.

To minimise electrical noise (interference) entering the set and causing problems, a filter consisting of capacitor C36 and a 10mH choke is installed. The audio ripple on the 32V line when charging is taking place is removed by capacitors C17 and C21.

Finally, note that decoupling resistor R10 is quite low in value, to minimise the HT voltage drop.

Summary

Several main points have emerged from this very useful exercise:

(1) A set with only 32V HT on the plates and screens of the valves can perform as well as a set with a HT voltage of 250V.

(2) To achieve good sensitivity, five stages are needed compared to four stages in a normal mains-operated receiver.

(3) Care is needed to ensure minimum voltage losses, particularly in the plate and screen circuits.

(4) Only minimal RF bypassing is required. The sets are remarkably stable, due largely to the relatively low gain per stage.

(5) The AGC circuit needs to be carefully designed, to avoid overloading the IF stage(s).

(6) A valve which draws reasonable currents on low voltages is required for the audio output stage.

(7) Careful design is required in some sections of the circuit to achieve good results on low voltages.

That's it – a fun project just to show what the differences are between sets running on normal HT voltages and those running on low voltages. **SC**