VINTAGE RADIO

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Vibrators: the death knell of heavy, expensive dry batteries; Pt.1

Vibrator-operated power supplies were well-established by the mid 1930s, being used initially in car radios and later in domestic battery-powered receivers. Here's a look at how they work.

Vibrators were developed rather early in radio history and were first used in telephone exchanges in one form or another. However, they were not used in radios until the advent of the car radio.

Car radios were initially very similar to ordinary domestic battery-powered radios. That meant that they used a low-voltage accumulator for the "A" supply for the valve filaments (or heaters) and a string of HT batteries for the high-voltage "B" supply. However, manufacturers quickly realised that lugging a large domestic style set and a bank of batteries into a car was hardly likely to catch on with the general public.

This photo shows HMV's 2V vibrator power supply with the covers on. Note the shielded power supply leads which were necessary to reduce interference.

The problem had to be attacked on two fronts. First, car radios had to be made relatively small, they had to be sensitive enough to work from a small aerial and they had to be rugged enough to withstand being jolted. This was quite a challenge which significantly exercised the talents of car radio designers.

Second, manufacturers had to devise a better method of supplying the filament\heater voltages and currents, and the high voltages necessary for the valve anodes and screens. And that meant getting rid of all the extra batteries and relying solely on the vehicle's battery instead.

6.3V heaters

During the early 1930s, valves came with all sorts of different heater/filament voltage ratings. However, cars in the USA at that time used a 6V battery. As a result, many valves were redesigned so that their filaments/heaters could be run from 6.3V which meant that the vehicle's battery could be used.

For example, the 6A7 was produced as a 6.3V heater version of the 2A7 (2.5V heater). Why 6.3V? – well, a 6V battery has three cells and these produce around 2.1V per cell, or 6.3V total.

Of course, it was also quite practical to use the 6V heater valves in domestic battery-operated and AC mains-operated sets as well as car radios. So 6.3V heaters quickly gained widespread popularity.

As an aside, filament valves (ie, valves with directly heated cathodes) were initially tried in car radios but were found unsatisfactory for two reasons. First, the filaments were rela-

Vibrators – How They Work

A vibrator, or vibrator cartridge, is a plug-in device, somewhat similar to a valve and made that way for much the same reason; it had a limited life and was expendable. It even used a standard valve socket, different types using 4-pin, 6-pin and 7-pin sockets.

By using a vibrator, it was possible to make a radio power supply which required only one battery. Compared to a straight battery receiver with 135V of dry cell batteries, a vibrator set was a lot cheaper and more convenient to run, if one had the means to recharge the battery.

In practice, the vibrator's task is to change the low DC voltage from the battery into low voltage AC, in the form of a square wave at approximately 100Hz. This is done by using two sets of electrical contacts mounted on each side of a vibrating reed. The vibrating part is similar in construction and operation to an electric buzzer or bell.

The vibrator contacts switch the DC voltage alternately between opposite ends of a centre-tapped transformer, so that the current flows alternately in opposite directions through the primary – see Fig.1.

After transforming the switched DC to a higher voltage, it must then be rectified and effectively filtered to smooth DC before it can be used as a hum-free high-tension voltage. This can be done in several ways.

One way is to use a rectifier valve as would normally be used in a mains-operated receiver. The type of vibrator that uses a separate rectifier has two sets of switching contacts and is known as a non-synchronous vibrator.

The non-synchronous vibrator was usually used in valve car radios, together with an ordinary AC-type rectifier valve. In car radios, power consumption was of little consequence and they normally used AC-type valves throughout.

Domestic vibrator radios were usually more economical in their operation and used mostly battery valves and a synchronous vibrator which has two additional sets of contacts inside it. These extra contacts were used in conjunction with a centre-tapped transformer secondary to mechanically rectify the stepped-up voltage and thus produce the HT without using a rectifier valve – see Fig.2.

Of course, the resulting HT rail required very effective filtering to eliminate the considerable amount of "hash" that would otherwise have been produced. Note too that the vibrator cartridges usually had a limited life. Even so, replacing the odd vibrator unit must have been considerably less expensive than paying for all those dry cell batteries.

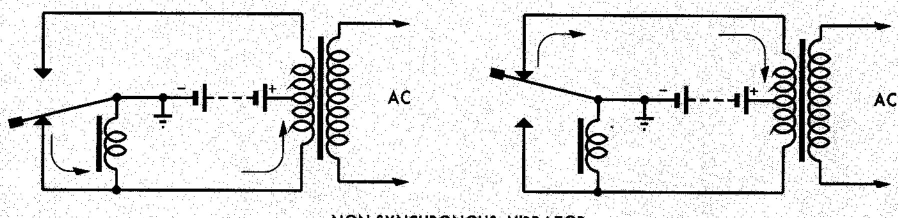


Fig.1: basic scheme for a non-synchronous vibrator. The vibrator contacts switch the DC voltage alternately between opposite ends of a centre-tapped transformer, so that the current flows alternately in opposite directions through the primary. The resulting AC output was then fed to a rectifier.

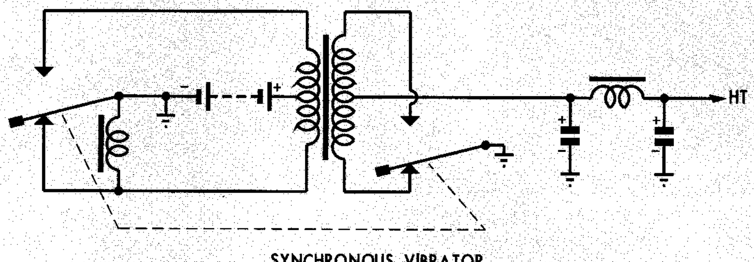


Fig.2: the synchronous vibrator arrangement. This type of vibrator employed a second set of contacts which were used to mechanically rectify the high tension current in conjunction with a centre-tapped transformer secondary.

tively fragile and often created microphonic noise in the receiver's output. In addition, the car's electrical system and the equipment connected to it (eg, the ignition system) produced a lot of noise which was difficult to filter out of the filament supply.

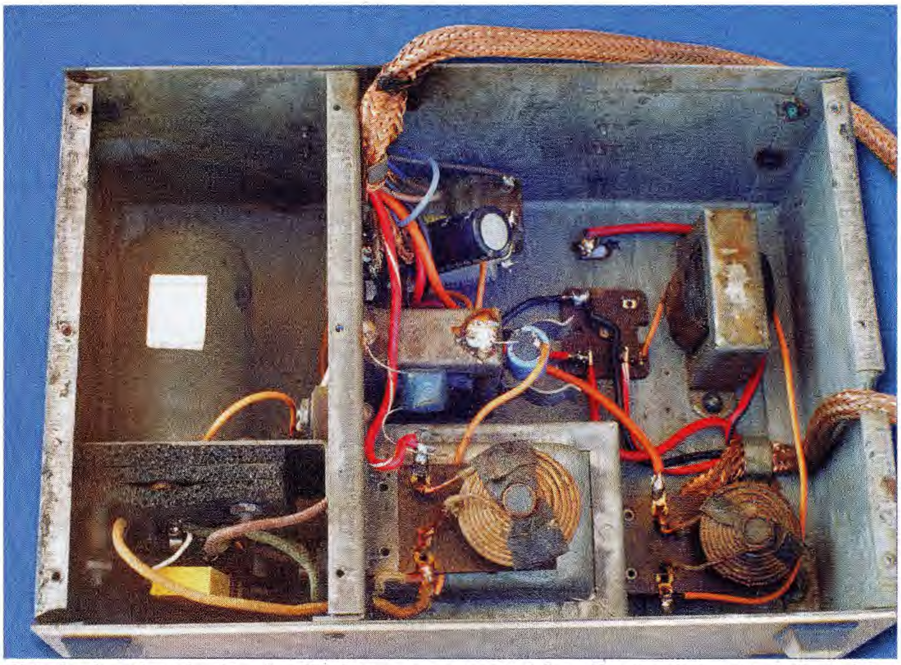
HT voltages

Having solved the low voltage supply problem, the high tension (HT) voltage had to be obtained – again from the car's battery if possible. At this time, there were three different methods that could be used to supply the HT voltage: (1) dry batteries, (2) genemotors and (3) vibrators.

The first two methods were well-established and worked well, except that batteries were bulky and expensive, while the genemotor was expensive, mechanically noisy and inefficient. Vibrators were also being used in cars around 1932 but were in need of development to make them more reliable.

In fact, reliability was their main disadvantage at that stage. However, the reliability was improved and vibrator power supplies were well-established in car radios in America by 1935. However, they never quite achieved the same reliability as batteries or genemotors.

On the other hand, vibrator power supplies did prove to be efficient, economic and reasonably reliable as design improvements occurred. Their relatively low cost also meant that it was quite economical to replace them as you would a valve, as both are "plug-in" items (except for very early


This is the view inside the HMV power supply. The vibrator is on the left and is enclosed in a rubber "sock" (marked with a white sticker). A rubber-mounted socket is also used for the vibrator, to further reduce mechanical noise.

in their development).

That said, the vibrators in some of my sets have never required replacement, despite a lot of use since 1944. This proves that very good results were achievable provided the power supply was correctly designed.

Vibrators in domestic radios

Having got car radios off to a good start with vibrator power supplies, the manufacturers decided to see if domestic battery-operated sets could be run from them as well.

Although efficiency was not of paramount importance in car radios, vibrator sets intended for use in the home had to draw as little current from the battery as possible. This was necessary so that the battery didn't have to be recharged more than once or twice a month. Remember, many country homes did not have electricity connected in the 1930s, 1940s and 1950s.

Most battery-operated sets during this era had a 2V lead-acid cell (battery) for the filaments, three 45V dry batteries for the HT and maybe a bias battery as well. The owners of these sets were prepared to have the 2V cell charged about once a month at the local garage and garages in country towns did quite good business doing just that.

The manufacturers soon realised that if they made a vibrator "power pack" that ran from 2V, it could run be run from the 2V cell (battery) and supply the high voltage normally provided by the three 45V batteries. This would save owners from having to buy expensive 45V batteries.

Unfortunately, these vibrator supplies were not very efficient due to the low supply voltage. Nor did they have a very high output.

The Oak V5289 split-reed vibrator was a typical example. It was designed to power the HMV 601 battery valve set, draws 1.2A (which includes the filament current) and weighs in at a hefty 3.5kg.

1.5V vibrators

Around 1940, the Americans experimented with an even lower voltage vibrator power supply. It was designed to run from a 1.5V No.6 cell and provided 90V at 9mA for a set using the relatively new 1.4V filament valves. Interestingly, an article on this appeared in "Radio & Hobbies" at the time.

Whether or not these 1.5V vibrator supplies were ever put into production is unknown. In fact, the "Radio & Hobbies" article expressed doubts about the viability of running a vibrator supply from a No.6 cell.

That's because the vibrator supply and the filaments in a 4-valve receiver would draw around 1.2A from the cell, assuming that the vibrator supply had an efficiency of 65%. A No.6 cell has an amp-hour capacity of 17-30Ah, depending on the load. And that meant a battery life of just 10-20 hours, depending on the usage per day.

Although the article stated that the supply was "quite free of both mechanical and electrical hum", no mention was made about vibrator hash interference. The circuit, shown in Fig.3. was quite basic and had virtually no RF filtering, so it was probably capable of causing significant interference to the receiver.

Vibrator-powered house sets

The next step by the manufacturers was to design vibrator receivers that operated from a 6V lead-acid "radio battery" (or deep-cycle battery). Of course, it was necessary to keep the current drain down, so that the 6V battery only needed recharging once or twice a month with normal use. Some farmers charged their 6V radio batteries from a car or truck electrical system, while others had them recharged at the local garage.

However, not all battery-powered receivers used a 6V battery. A few used a 4V battery and even fewer used a 2V cell.

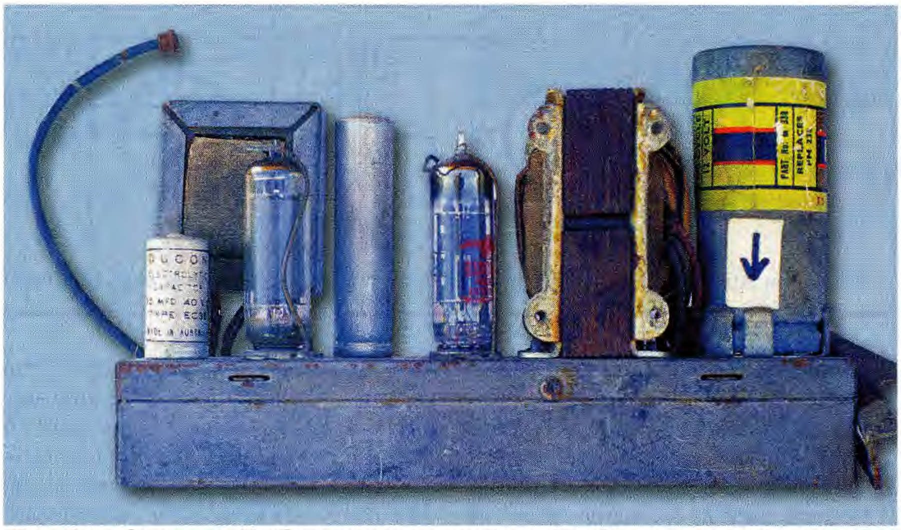
Vibrator power supplies

Most restored vintage radios are mains-operated. As a result, many collectors are either familiar with the operation of this type of power supply or, at the very least, know how to check that it is functioning correctly.

A mains power supply is quite straightforward and usually includes a transformer with at least three windings: the 240VAC primary winding, a 6.3VAC heater winding and a centre-tapped high tension (HT) winding. This is followed by a full-wave valve rectifier, usually followed by a filter choke, two electrolytic filter capacitors and perhaps a back bias resistor.

The power supply for a battery-operated set is even simpler, consisting purely of batteries that need replacing all too often – usually at considerable expense. No maintenance is required for such a supply other than battery replacement.

By contrast, a vibrator power supply is much more complicated than a



This view shows a 12V vibrator power supply and audio output stage, as used in an Astor DRM car radio. Note the arrow pointing to the clips holding the vibrator in place. These clips also bond the shielded vibrator case to the chassis to reduce any interference generated by the vibrator.

mains power supply. It uses a vibrator and a step-up transformer as the essential components of the supply. The vibrator is usually employed to act as an electromechanical rectifier as well as a generator of square-wave AC voltage.

By using a synchronous vibrator - see Fig.2 – to achieve this function, designers could save on the cost of a rectifier and the heater power that it used (a 6X4 rectifier valve uses nearly 4W of heater power).

As well as the vibrator, it was also necessary to have the usual high-tension (HT) filters – ie, electrolytic capacitors and a filter choke. It's also worth noting that the low-tension (LT) supply to the valve filaments had to be well filtered to remove any ripple that would otherwise be caused by the vibrator's operation. This typically involved using an iron-cored filter choke with a very low resistance winding, along with a couple of low-voltage electrolytic capacitors wired in a similar configuration to the HT filter system.

Additionally, sparking at the vibrator points – although minimal in a well-designed vibrator power supply – created RF interference. To combat this, additional RF filters were used on both the LT and HT lines to remove any interference from these supply lines.

The actual physical layout of a vibrator supply is also much more critical than for a mains power supply. The supply is generally shielded inside a metal box to minimise RF interference and "single-point" earthing is also often used to overcome interference problems as well. It must be remembered that a vibrator supply is a potent generator of RF interference which operated in relatively close proximity to the receiver's antenna terminal. Of course, some designs were better suppressed than others.

The vibrator supply box may also be rubber mounted – or at least the vibrator itself may be rubber mounted – so that mechanical vibrations don't cause an irritating hum or buzz. In fact, some vibrator supplies are mechanically very quiet.

The buffer

There is one other component that is vital for efficiency and long operational life from a vibrator power supply and that is the "buffer". This buffer typically consists of one or more capacitors wired across the primary and/or secondary of the vibrator power transformer. The buffer "tunes" these windings for minimum sparking at the vibrator points and for minimum current consumption by the supply when it is not supplying current to the receiver.

Without this buffer, the supply would draw very high currents and the vibrator would be destroyed within a very short time. The actual value of the capacitor(s) depends on the inductance of the transformer winding and the frequency of the vibrator's mechanical oscillation (usually either 100Hz or 150Hz).

The buffer in Astor car radios, for example, was wired across the secondary of the transformer. In later versions, this was a 0.008μF paper capacitor rated at 2000V. And no, I didn't make a mistake on the voltage rating – the transient voltages developed across the windings when the vibrator contacts open are extremely high, so a high voltage rating really was necessary.

Even so, these capacitors proved to be unreliable and when a vibrator was replaced so was the buffer, otherwise the replacement vibrator only lasted a short time. Earlier Astor car radios used a 0.004μF mica capacitor and

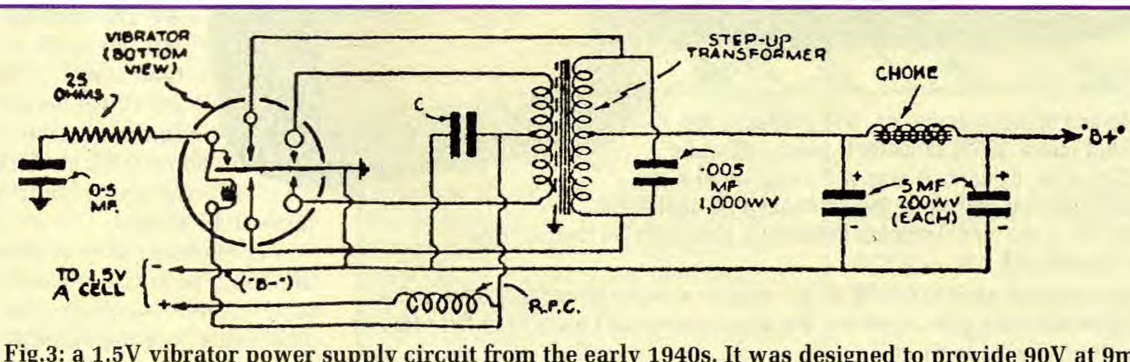


Fig.3: a 1.5V vibrator power supply circuit from the early 1940s. It was designed to provide 90V at 9mA for sets using 1.4V filament valves.

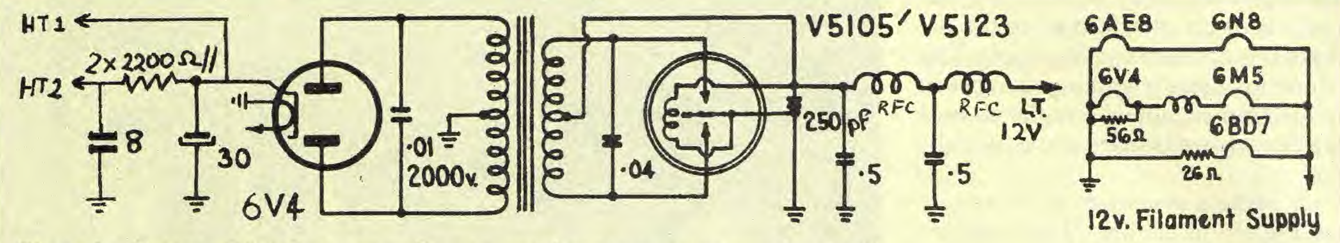


Fig.4: the Autovox Five 1955 car radio non-synchronous power supply circuit.

this was quite reliable, unlike the later 0.008μF paper capacitor.

Fig.4 shows the circuit of a non-synchronous vibrator power supply as used in a 1955 Autovox 5 car radio. It is quite similar to many other car radio power supplies.

It's worth noting that vibrators, being mechanical devices, usually didn't last as long as the other components in the set. However, it did depend very much on the actual design of the vibrator power supply and some sets had vibrator supplies that just kept on going for ever. For example, Operatic receivers had very good vibrator life, the unit rarely needing to be replaced. I also have a Radio Corporation set that has never had a vibrator replacement and it has done a lot of work.

By the way, vibrators were nominally designed for an operational life of between 1500 and 2000 hours, which equates to approximately 500-1000 million cycles of operation.

Eliminating the vibrator

A car radio can be powered by removing the vibrator and feeding low voltage AC to the heaters and around 250+ volts to the rectifier cathode. These voltages can be obtained from a 1950's era mantel receiver, providing the host receiver's valves are removed (but not the rectifier). If the car radio runs off 6V, its rectifier can be removed. However, if series parallel heater wiring is used, as in 12V sets, the rectifier needs to remain in place because its filament will be part of the heater string.

It isn't as easy to provide power to sets using battery valves. Raw AC on the valve filaments will cause the low voltage electrolytics to overheat and possibly explode, resulting in damage to the power supply and the set – so don't even think of trying this. However, it is practical to power sets from battery eliminators. These supply the HT and LT filament voltages as required. The vibrator pack can sit there with the vibrator removed, if repair is not practical.

The following voltages and current drains are typical in 6V vibrator sets. If 2V valves are used, the filament drain is 0.24A at 6V DC and the HT voltage is 135V at no more than 20mA. Alternatively, if 1.4V valves are used, the filament current will be about 0.1A at 6V DC and the HT voltage is about 90V at no more than 15mA.

A convenient way of powering the filaments is to use a small plugpack supply. Note, however, that the plugpack must be a regulated type, as the output from unregulated types rises alarmingly on light loads. The fila-

Photo Gallery: STC Model 5210/4 Dual-Wave Receiver

STC Model 5210/4

STC Model 4110

Towards the end of the Bakelite era, STC produced the Model 5210/4 (circa 1952) in walnut, black, off-white and possibly other colours. It was a 5-valve, dual-wave receiver and featured four large thumb knobs in a contrasting colour. The "/4" in the model number indicated a change in the rectifier type used – ie, to a 6X5-GT.

The unit is somewhat similar in line to the smaller 4-valve (broadcast-band only) model 4110 of the same year. However, the larger set doesn't quite have the same appeal.

(Restored by Maxwell L. Johnson, Tasmania; photo by Ross Johnson).

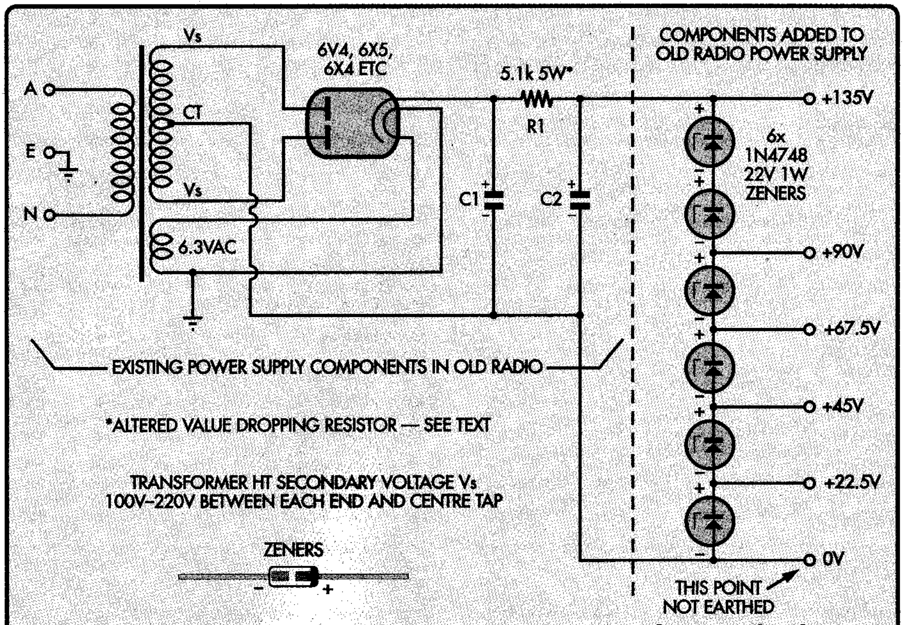


Fig.5: this diagram shows how the power supply in an otherwise derelict valve radio can be modified to provide a range of HT voltages.

ments in battery valves cannot withstand voltages more than about 20% above their ratings, so you risk burning the filaments out if they are powered from an unregulated plugpack.

Make sure the voltage applied to the filaments is 2V for a 2V valve and 1.4V for a 1.4V valve. The problem here is that regulated plugpacks only go down to 3V but that's easily overcome with some series diodes. Just install two diodes in series with the 3V supply rail from the plugpack for 2V filaments and three diodes in series for 1.4V filaments. In addition, take care with the supply polarity – the negative rail should go to earth.

Building your own

Many small power supply circuits have also been published in SILICON CHIP and some of these can be adapted to power the valve filaments in battery receivers. For example, The "Multi-Power Bench Supply" (April 2002) could be easily modified to do the job. The LM317T regulator circuit shown second from the top in the schematic diagram is the one to use – just modify the resistor values for the 3V range to get the output down to 2V.

The easiest way is to simply substitute a 1kΩ trimpot for the 680Ω resistor and adjust the pot to give the desired voltage output.

The HT voltage can be derived from a derelict valve radio power supply. Fig.5 shows how a typical valve radio power supply can be modified to provide a range of HT voltages. Make sure the supply is fully floating so that back bias can be used with battery or vibrator sets, if required.

When selecting a derelict receiver, choose one that has an output of about 250V (or preferably less) at the cathode of the rectifier when supplying around 40-50mA. The rectifier's output will rise to around 270V if the load is around 25mA, as provided by R1 and the six zener diodes in series.

When testing the supply, install a milliamp meter in series with the zener diodes and adjust the value of R1 until a current of around 20-25mA is shown on the meter. Note that the voltages shown on the terminals are approximate and depend on the current drawn and the actual characteristics of each particular zener diode. The valve rectifier can be replaced with two 1N4008 diodes if so desired but the output voltage will be higher than from a valve rectifier.

A solid state "vibrator", if available, may be the best answer for some sets. Resurrection Radio in Melbourne can supply these, as can Nostalgic Wireless. They are around $US35 which equates to around $A70-$80 landed in Australia. Old "as-new" mechanical vibrators can also be supplied at around $20 each.

Next month we'll take a closer look at vibrator power supplies and describe how to service them. **SC**