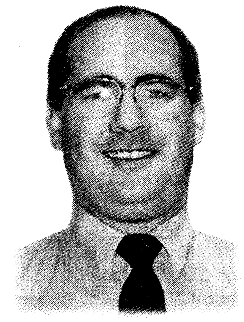
VINTAGE RADIO

by Roger Johnson



Tapped Volume Controls and Bass Boost

Radio Corporation, which produced the Monarch, Peter Pan and Astor brand names, released a series of mantel radios which employed complex reflex circuits incorporating tapped volume controls for bass boost. They weren't the only manufacturer to do so, of course; Philips and HMV did as well. This month we're looking at what these circuits were designed to do, how they work, and what can be done when they fail...

AS I'VE MENTIONED here before, in the years from the end of WW2 to about 1950, Australians were hungry for anything and everything that was new. Radios were no exception. As a result of technological progress due to WWII, radio manufacturers had developed new and efficient coils, better magnets and injection moulding, all of which were incorporated into post war design. Quite compact mantel sets were produced, which were very complicated when compared to their pre-war counterparts.

The small cabinets, together with other features such as very small output transformers and 5" speakers, all lifted the 'roll off' (sometimes called 'bass cut-off') frequency higher and higher. It should be noted that a frequency of merely 130Hz or thereabouts is 'Tenor C' (or C below middle C) and 260Hz is middle C.

In short, then, the bass frequencies were becoming quieter and quieter, to the extent that just about any sound in the bass registers resulted in a soft 'boomf'. It was up to our sub-conscious musical interpretation to reconstruct those faint bass notes. However, there is a limited solution to this problem, which was overcome by a degree of bass lift or boost, incorporated into the electrical design. This is where tapped volume controls enter the scene: to enable engineers to design bass boost circuits that overcame the limitations described above.

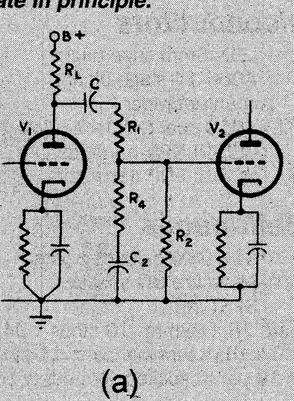
There are however limiting factors. The bass boost can't be excessive, because in those small sets with 5" speakers, too much boost will cause distortion. Bass boost should give a reduction in harmonic distortion, but this condition only holds over a limited frequency range. Another limiting factor was the cheap output transformers, which had a low inductance such that the output valve can only provide a small fraction of its mid-frequency undistorted output, before distortion becomes serious at frequencies below 100Hz.

Bass boost is by no means simple, and there are many many inter-related factors. For example, it has been determined that a receiver with 4W maximum undistorted output and a bass boost of merely 12dB at some frequency below 100Hz, (which we will call F(bst) will be easily overloaded at the bass boost frequency. In fact given these constants, and assuming that F(bst) is 100Hz, and also that the power output at low frequencies is the same as mid frequencies (which it is invariably not), then an input which will give a tiny 300mW output at mid-range will cause overload at F(bst)! Notice that feedback has not even been mentioned yet.

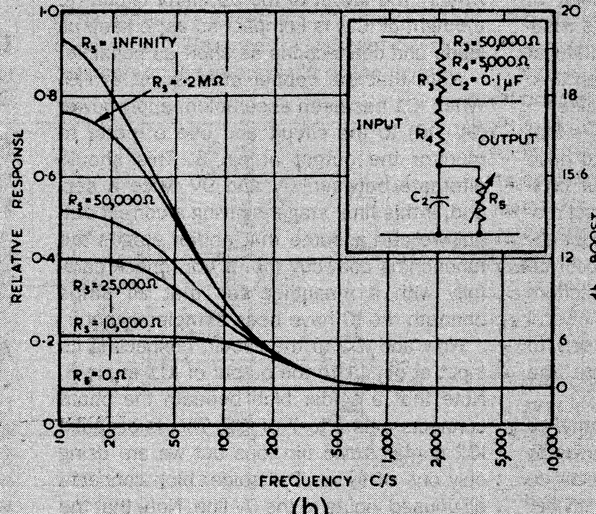
If the bass boost frequency is set too high, say at 150Hz, reproduction becomes boomy and unpleasant to listen to. Even worse is excessive gain at frequencies lower than the bass resonant frequency of the loudspeaker. In this instance, the fundamentals cannot be reproduced at all, and any output is due to mainly the second harmonic.

The trick therefore was to introduce carefully designed bass boost at low listening levels, and then to have the radio assume 'normal' frequency response as the listening level is increased. But how was this achieved?

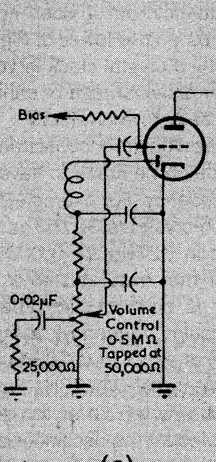
Fig.1: Three diagrams, taken from the fourth edition of Langford-Smith's 'Radiotron Designers Handbook', showing how bass boost circuits operate in principle.



(a)



(b)



(c)

Tone compensation

In order to understand this we must look at the various forms of tone compensation. Most people are familiar with the simple treble attenuation tone control fitted to most receivers, consisting of a 47nF or 0.1uF capacitor in series with a 50kΩ pot, connected from the anode of the output valve to earth. The potentiometer is there to control the amount of treble cut to suit the listener. In other words, the higher frequencies which are dependant upon the R/C combination, are bypassed to earth to a greater or lesser degree.

Bass boost, on the other hand, is greater relative amplification of the lower frequencies, generally taken to be below 1kHz, and expressed in dB per octave. Needless to say bass boost can be achieved with or without negative feedback, which is a full subject in its own right.

The theory of bass boost is quite simple. By a combination of resistance and capacitance as shown in Fig.1(a), we produce what is a variable voltage divider, for different audio frequencies. At middle and higher frequencies, capacitor C2 has a relatively low impedance (reactance), and the audio signal fed from the plate of V1 to the grid of V2 will be attenuated by the divider formed by R1 in the upper leg, and R4 in parallel with grid resistor R2 in the lower leg. However at low frequencies, the impedance of C2 rises and gradually removes R4 from the divider — leaving only R1 and R2, which together provide much less attenuation. This gives a higher output, so the lower frequencies are effectively boosted.

When incorporated into a receiver circuit, there are two methods; plate shunt boost and grid shunt boost. Plate boost is important for limited bass boost at lower listening levels, and where and why we have a tapped potentiometer. If we look at the R1/R4/C2 part of Fig.1(a), and place across C2 a 0.5MΩ pot (R5), the amount of boost can be adjusted according to the setting. Fig.1(b) shows the relative response for different settings of R5.

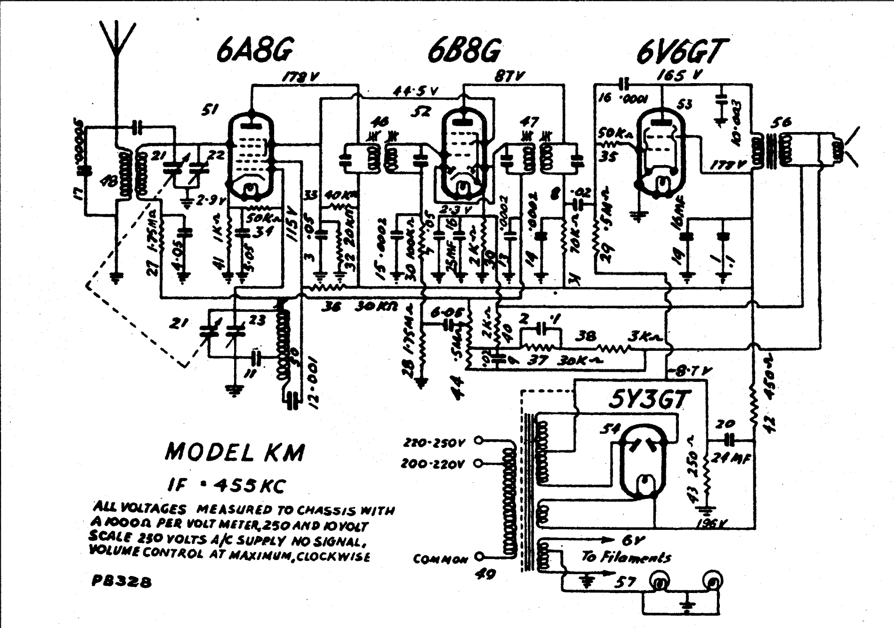


Fig.2: The circuit for an Astor Model KM with bass boost and feedback — one of many such models.

Now if this 0.5MΩ pot just happened to be part of the volume control, we can now see the beginnings of variable bass boost at low listening levels.

Limited bass boost

Fig.1(c) shows how this kind of circuit was added to a conventional receiver volume control, at the output of a diode detector, using a tapped potentiometer for the volume control. As you can see a series capacitor and resistor of carefully chosen value were connected to ground from a predetermined 'tap' on R5, and this caused bass boost to be introduced when the wiper was turned down toward the earthy end of the pot — i.e., for low volume levels.

This was in fact how the bass boost feature was provided in many of the commercial radios, especially Astor models. The 0.02uF (20nF) capacitor is essentially C2 of Fig.1(a), while the 25k series resistor is R4. At maximum volume, i.e., when the wiper of the volume control is toward the top, the boost is minimal. But as the wiper moves down and approaches the tapping, boost is at a maximum, and is still high as the wiper passes the tapping.

However, in moving down towards earth (or cathode) potential, the slider is also causing greater attenuation of *all* signals, including the bass frequencies. This automatically achieves the desired aim of preventing the bass boost from causing the rest of the audio circuit to overload.

Fig.2 is the audio end of many a small 'Astor' 3/4 receiver. The particular one chosen is the model KM — the famous 'Mickey'. (The KK is the radiogram version, which apart from the gramophone mechanism and the radio/gram switch, used virtually the same circuit.) But how does the volume control and bass boosting part of this circuit resemble anything like the circuit of Fig.1(c)?

Well, let's re-draw the circuit, leaving out component numbers (2), (37) and (38) along the way, as these don't play a part at this stage — although their importance can't be overlooked, as we'll see shortly.

Fig.3(a) shows the re-drawn bass boost circuit of the KM. Hopefully you can see how the basic circuit now resembles Fig.1(c), especially when you realise that because the speaker voice coil and output transformer

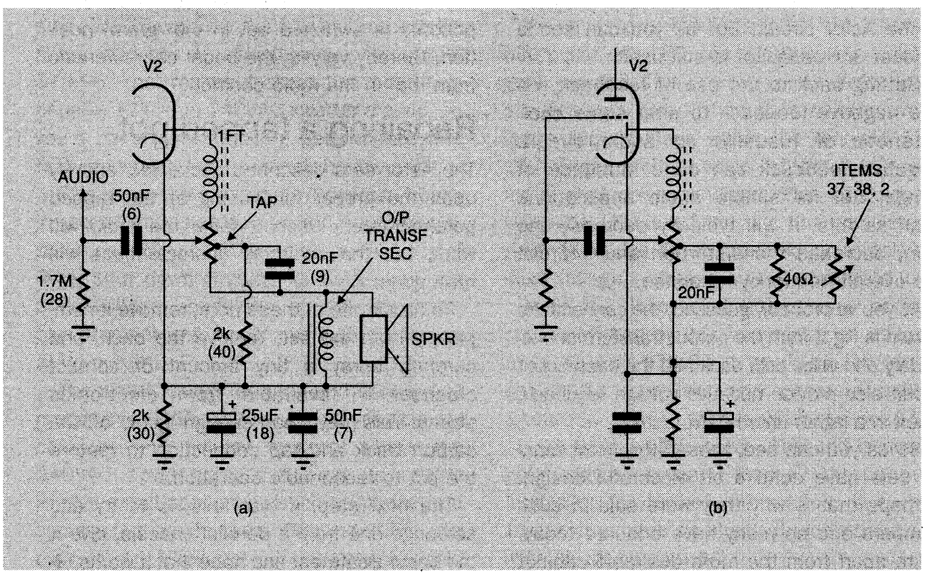


Fig.3: The bass boost sections of Fig.2, redrawn to help explain the function of the various components.

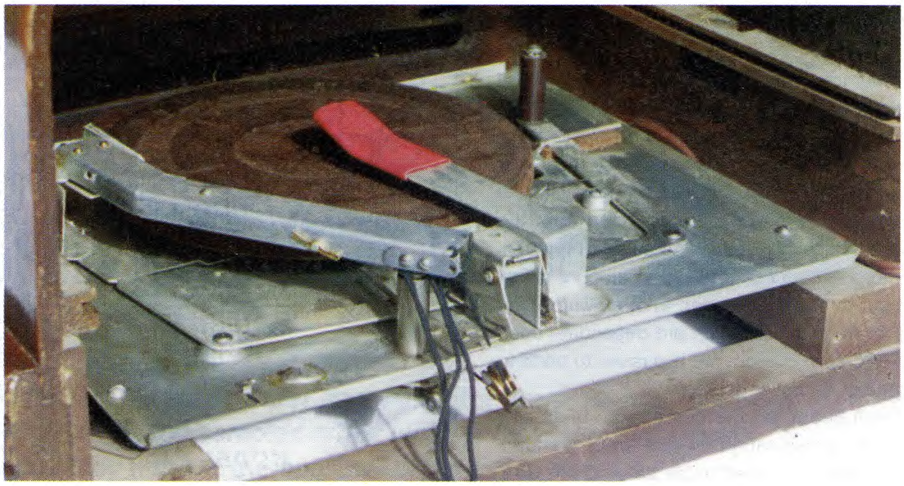


Fig.4: A rear view of an Astor KK tablegram, with the chassis removed. This model used a circuit almost identical to the KM, but with extra complexity for the 'gram' functions.

secondary have a very low resistance, they can be ignored for DC purposes.

The main difference between the Astor circuit and Fig.1(c) is that in the former, the 20nF cap in series with the 25k resistor has been substituted with item 9, a 20nF capacitor, in parallel with item 40, a 2k resistor. The effect of this rearrangement alters the amplitude or the frequency, or both, of the desired bass boost.

Note that in Fig.1(c) the tapped potentiometer is earthed, but so also is the cathode. In effect, the diode load is returned to the valve cathode, which is also the case in the Astor circuit even though the cathode has a 2k cathode bias resistor (item 30) bypassed by the 25uF and 25nF capacitors.

Varying boost frequency

Now let's redraw the circuit in Fig.1(b), this time as Fig.3(b). In place of the variable resistance across the capacitor designated C2 are components (2), (37) and (38), from the Astor circuit. Now this is where the components (2), (37) and (38) can be seen to play their vital role.

Component (9), the 20nF capacitor, is the equivalent of C2 in Fig.1(b) and is shunted by component (2), a 0.1uF capacitor in shunt with 30k resistor (37) and in series with item 38, a 3k resistor.

Now at 60Hz, the reactance of the 0.1uF capacitor is 26.5kΩ. This is in parallel with the 30k resistor, giving a total impedance of 14kΩ (ignoring phase angle), plus the 3kΩ in series giving around 17kΩ. The equivalent figures for 30Hz, 100Hz and 260Hz (middle c) are approximately 22kΩ, 13.5kΩ and 8kΩ respectively.

You can get a fair idea of the effect these different impedances have in parallel with the 20nF capacitor (item 9) from the curves in Fig.1(b). Clearly the higher the frequency, the lower the effective shunt impedance across the boost capacitor, and the lower the bass boost that will occur.

We must remember that all this is achieved using no physical 'tone control'. The tone control is actually there; it's just that there isn't a separate manual control on the cabinet!

Feedback as well

As you may have already realised, the Astor KM goes one step further again. For example component 16, the 100pF capacitor connected from the 6V6-GT plate back to the grid is a form of negative feedback and provides a small degree of treble attenuation. This is mainly to ensure stability at high audio frequencies.

Many sets used a small capacitor from the output valve plate to ground to achieve the same purpose. This could have been omitted in the Astor circuit, but as you can see a modest 3nF capacitor is still used.

Getting back to the use of feedback, we use negative feedback to alter some characteristic of (usually) an audio circuit. Negative feedback can do a multitude of things, but for simple audio applications such as this, it will typically decrease the gain, decrease the distortion and improve the overall frequency response.

As you've probably guessed, the connections shown in Fig.2 from the output transformer secondary and voice coil, back into the bass boost circuit also provide negative voltage feedback, albeit in a rather unorthodox fashion.

So as you can see, those little Astor mantel sets have quite a bit of careful design. Perhaps that is why they were sold in such numbers and so many have endured today. Quite apart from the more desirable cabinet designs, even those with somewhat bland cabinets are sought after by collectors because they work so well.

You may have noticed already from Fig.2 that just to complicate things, the Astor engineers made them a reflex set as well. The model KK radiogram shown in Fig.4 is even more complicated, and a fair little 'bottler'. A mercury switch is tilted via a string, pulley and spring setup when the record is inserted and the door is closed, which then applies the voltage to the gramophone motor. A mechanical guide automatically selects 10" or 12" records (78rpm only) and the pickup arm is automatically swung across to engage the record. A switch in the front, visible when the door is down, selects either the 'radio' or 'gram' function, and in the 'gram' position connects a crystal pickup directly across the volume control.

The audio reflexing is used for both radio and gramophone modes, to increase the gain. With a good crystal pick-up, these devices give quite a reasonable account of themselves — for what was never pretended to be anything other than a utilitarian, budget-priced radiogram!

Just to make things a little more complicated in the KM, one of the bass boost components is switched out in the 'gram' position, thereby varying the boost characteristic from that in the radio position.

Repairing a tapped pot

The Astor sets described above rely entirely upon the proper functioning of the tapped potentiometer. When it fails, the radio will work, but the desirable characteristics will have gone.

To repair one of these pots, remove it completely from the set, remove the back, and carefully spray a tiny amount of contact cleanser — available from electronics stores. This may clean enough 'gunk' off the carbon track and tap connection to restore the pot to reasonable operation.

The next step, if that fails, is to try and scrounge one from a derelict chassis, give it the same treatment and hope that it works. ❖