THE GREAT AMPLIFIER DEBATE

1 • Transistor Sound

Is it all due to overload? by Richard Oliver

DURING the last year I have been fascinated to note that others have come to a conclusion that my ears indicated a long time ago—this is, all is not well with some transistor amplifiers. Of course, there have been some stinkers of valve amplifiers too, but why is it all such a great mystery when it comes to transistor models? The case is oft-presented that this is something that seems to be audible but cannot be measured. I doubt it. I suspect that the right measurements, interpreted correctly, would show very clearly why things appear to be wrong. But before making a suggestion for a measurement that might well show up one reason, I ought to make it clear that I am not interested in crossover distortion. The presence of this should be enough to disqualify *any* amplifier from the hi-fi stakes.

Let us look at the specification for an old and respected valve amplifier, the Quad II, designed by Peter Walker of the Acoustical Manufacturing Co. And for the sake of this argument let us drop the 'hi-fi' criterion that anything over 0·1% total distortion is beyond the pale. As pointed out on many occasions, we are unable to get a signal off disc with less than 10% for a lot of the time, yet we don't hear people clamouring about this 'scandal'.

Mr Walker's Quad II is 'rated' at 15W. But look a bit further. First, this is a *minimum* specification, probably with low mains volts. Second, look at the Quad II book. This shows an output/linearity curve that hits 0·1% at 15W, and rises ever more steeply beyond that point. But what's this? 0·5% at 20W? Perhaps 1% at 25 or 30? And this is sine-wave power—what is impulse performance like? Perhaps the Quad II will produce as much as 50W equivalent on a peak, lasting, as music peaks do, for a fraction of a second, and still the distortion probably isn't more than the limits obtainable from the disc.

Now for a transistor 'wonder', rated at 50W. True, that 50W may be at only 0·05%, but I can recall several reviews which have confirmed that the onset of clipping comes just above the manufacturers' rated maximum output. And once clipping starts, the only increase of output you get is due to the increase of area under the waveform as it turns from a sine-wave to a square-wave. In other words, that 50W is near the absolute *maximum* output. Could that amplifier produce double its rated power at a fraction of the distortion from the disc? Could it produce a momentary peak corresponding to a sine-wave level of three or four times its rated output?

The rating of a transistor amplifier tends to be much more a maximum figure than a minimum specification. Perhaps this is why a 15W valve amplifier of respectable parentage can often be wound up to sound as loud as a 50W transistor amplifier. And let us not forget today's loudspeakers, which in the main are far less sensitive than speakers in common use when 15W valve amplifiers were standard. Also, they tend to have a drooping bass response, corrected by a bit of bass lift. That bit of bass lift may well call for four or five times the power needed in the midrange, and at frequencies where the speaker impedance has risen to several times its mid-band value. Under these conditions it is quite possible that the system is electrically incapable of producing its rated power, let alone have several decibels to spare.

This is a simplification, of course. But it is a situation that could be confirmed by making the right measurements and interpreting them properly—there's no mystery about rough sound then. And ironically, the old valve amplifier, given the advantages of a regulated supply or at least a low-impendance semiconductor supply, plus fixed bias instead of cathode self-bias (today costing next to nothing but which would have been hideously expensive when the valve amplifier was designed) would almost certainly be even better than it is, perhaps even meeting the arbitrary 0·1% distortion limit at two or three times its original rated power, which was, in any case, a minimum specification. Here is an obvious field to explore, both in measurement and for cheap simple improvement of old but good valve amps.*

By the way, in their *Old Amps for New* (ricochet) article published in October last, Richard Elen and George Chkiantz 'libel' the Quad amplifier, saying that it has only one feedback loop. I can see either two or three, depending on what you mean by 'feedback loop'. I am sorry they disliked its sound, particularly as they praised Quad transistor amplifiers. I believe that Peter Walker of Quad has demonstrated that one can't hear the difference between his new amplifiers and his old ones.† Perhaps Elen and Chkiantz had a Quad in which someone had substituted for the original KT 66 output valves. For some reason, practically every other valve has a characteristic like a dog's hind leg when compared with the Osram KT series.

But then, their article was described as 'lighthearted'. This was just as well, because they referred to the Mullard 3-3 as having 90–100 dB of feedback. As any valve man will tell you, you could hardly ever get more than 25 or 30 dB with an output transformer in circuit; if you tried, the amplifier just oscillated. Perhaps they forgot that the 3-3 produced only three watts rated output, and was thus suitable for driving only the most sensitive loudspeakers in an age of sensitive speakers. Today's 80 dB-at-1 m-for 1 W jobs make it sound like a fuzz-box—and a quiet fuzz-box too.

In case anyone thinks I'm in the pay of Acoustical, I had better list one of their major sins, as a warning for all the transistor people buying up secondhand valve equipment. The HT return circuit from the radio tuner is completed through the audio cable screens phono-plugged to the Quad 22 preamplifier. If the plug falls out, as it did on me, the tuner chassis and the aerial and downlead become live, as well as the HT current attempting to return through the audio input stage. It is quite a nasty experience if you have hold of the volume control and tuning knob at the same time—and the transistor on the input of the stereo decoder wasn't very keen on the arrangement either. Of course, it was done this way to avoid creating a hum-loop. But, thank you Mr. Walker, I prefer to put up with the hum-loop (I can't hear it) and live less perilously.

Of course, I would have realised the danger had I looked at the specification in the right way. And here's another point from specifications: The Quad 22 is often dismissed as being 'too insensitive and noisy' for modern low-output pickups. The most sensitive pickup input gives full output for a 4 mV signal at a 70 dB signal-to-noise ratio, according to the specification. I've heard of absolute pitch as a virtue of some human beings, but never absolute level, and the truth is that you'd only be able to hear the difference in level between a 4 mV pickup and a 2 mV pickup on an A/B comparison. As to noise, well, that's a minimum spec. and you can do better by selecting valves—you might do better still by feeding the heaters with DC from a cheap semiconductor rectifier, not available when the *22* was designed. In any case, I don't think many of my records show a 70 dB signal-to-noise ratio, despite today's high recording levels (higher than when the set was designed). Also, I may be odd, but I prefer the sound of music to that of the pickup on its rest. When records have quieter backgrounds . . . ah, but that's another story. ●

---

* *Readers willing to tackle circuitry should see 'Improving the Quad II' by Denis Turville (HFN, August 1970), while a commercial conversion is performed by Alec Shackman (see p. 91 last month).*

† *See Mr. Walker's PFB letter on p. 81.*

THE GREAT AMPLIFIER DEBATE

2 • Transistor Sound

Could it be due to low-level random noise? by Ralph West

THE writer has been following with great interest the various views and discussions concerning 'transistor sound', culminating in Martin Collom's plaintive cry 'what has gone wrong with amplifier evaluation?' in the October issue.

There are several causes, and these have varied somewhat in the course of time with better understanding of transistors, negative feedback and better semiconductor components. In the early days it was often mainly crossover trouble. One could see it clearly with a good 'scope and hear it, too, especially at low volume levels. Measured percentage distortion did not become vanishingly small at very low levels as in good valve amplifiers, but tended to be almost constant or, sometimes, actually to rise with reduction of signal level.

The harmonic structure of distortion is a vital factor, as Shorter of BBC Research discovered years ago when evaluating (valve) amplifiers to handle studio signals. Listening tests were made to decide on the maximum permissible distortion level to be written into the specification, but he found that there was no correlation between listening and lab measurements unless the distortion was analysed into its harmonic components and each value multiplied by a factor proportional to the order of the harmonic. Only then could a meaningful figure be quoted. Our ears are more sensitive to high order harmonics—or, put another way, kinks and sharp corners on waveforms that should be smooth and rounded are very noticeable. This, of course, is why any (good or bad) slightly overloaded transistor amplifier sounds worse than a slightly overloaded valve amplifier. It is exactly like the difference between, say, limiting the motion of a loudspeaker cone with a solid metal stop as against a soft rubber buffer.

However, crossover and overloading are not the only things that can produce kinks—unfortunately. A point that no one seems to have raised over the years is noise—but *not* the noise we usually measure via an agreed filter (boosting the higher frequencies) to get good correlation between measurement and audibility. With modern components and circuits this is generally low enough to be inaudible, but it used to be audible with early transistors, which also suffered from additional low frequency noise. The latter was not audible in itself unless gross, in which case one changed the transistor. However, it was added to the signal, arithmetically at least, but algebraically if there was distortion in that stage.

Thirteen years ago I was investigating one of the first reliable transistor amplifiers. Distortion and measured noise were comparable with an equivalent valve amplifier, and audible noise noticeably less. With a good clean signal, at a fairly low listening level, it had however a slight roughness or 'haze' compared with the valve amplifier sound. A 1 Hz pure signal was fed into the pickup terminals and progressively reduced, increasing the oscilloscope gain to fill the screen. At full volume setting the trace was visibly perfect; at −20 dB (1/10) the same; but at −40 dB (1/100) the trace looked as though it had been drawn slowly by someone with a shaky hand. At −60 dB (1/1000), if I remember correctly, it was almost lost in noise. Now the pickup (RIAA) input enjoys a very large bass boost, so the LF noise was being shown up clearly.

This meant that all sounds coming through that amplifier were being shaken, as it were, i.e. arriving a bit early or a bit late. Now, we know our hearing sense is very sensitive to discontinuities or unexpected changes in a sound pattern—we wouldn't be here if our ancestors hadn't been similarly sensitive!

Now, could this be the missing ingredient in our objective measurements? I know transistors are nowadays very much quieter and it would be difficult to repeat that simple thirteen-year-old experiment. However, it is probably like an old car—when one cures the major rattle a lot of smaller ones can be clearly heard.

Looking more closely at the noise from active components, we know that valve noise, assuming space-charge control, *i.e.* well below saturation, is almost pure white noise, and the noise voltage with a noise-free load is proportional to the square-root of the current. One did sometimes encounter flicker noise from oxide coated cathodes, but this was rare and only likely to be troublesome if attempting to run under saturated conditions—which is why noise-diodes always had naked tungsten filaments. Incidentally, the saturation-limited device produces about twenty five times the noise energy of the space-charge limited.

Now our solid-state devices do not enjoy the cushioning effect of a valve space-charge. One's mind turns to electrons playing musical chairs as they wriggle between the silicon or germanium atoms. Moreover, the 'chairs' move about sluggishly (with some time lag) with the changing current. Has anyone published a really detailed account of the character of transistor noise? Has the old LF component or something akin really disappeared from modern transistors and ICs?

Returning to the 'chairs moving about' thought, this means a disturbance to current flow that only occurs when the (signal) current changes. This surely is *modulation noise*, and completes the circle of thought. When comparing a reasonably good transistor amplifier with a similar valve system, both played at a very moderate level so that there is no question of overloading, even momentarily, on peaks, one could describe the difference as like that between a good original recording and a good copy with background noise still inaudible. Hearing the copy first, one might be tempted to say it couldn't be bettered. Then, on changing to the original recording, it *is* better, clearer, smoother, sweeter—less modulation noise in fact. This comparison is most noticeable in the quieter passages, *i.e.* well below overload—in fact at levels giving very low levels of distortion both in the original and in the copy, thus eliminating conventional non-linear distortion as the culprit.

To these noises I would add some 50 Hz (and 100 Hz?) mains hum, though this applies equally of course to both amplifier types. Again, a trace of 50 Hz signal on its own will be inaudible, but will add to the signal just like the random noise. I had proof of this years ago when Dennis Turville, one of my old students, wrote the article in *Hi-Fi News* (August 1970) on 'hotting up' the Quad II valve amplifier. Output power was increased and smoothing improved by replacing the rectifier valve with silicon diodes and putting extra capacitance in the vacated space (plus a bias increase to the output valves as HT volts rose a bit). Although hum was completely inaudible beforehand, on replaying familiar discs and tapes I was struck by an improvement that could only be described as 'sweeter'.

Whilst valve amplifiers almost always had real HT smoothing with passive components—choke and capacitors—most transistor power supplies either have no smoothing beyond the reservoir capacitor, or a stabilised supply. In the former there will be quite a large 100 Hz ripple, and to deal with it one relies on the push-pull balance, decoupling of earlier stages, and NFB. There will also be a little 50 Hz ripple due to slight differences between the rectifier diodes and, in the case of the biphase (two diodes only) circuit, differences between the two halves of the mains transformer secondary. The 50 Hz ripple component, though small, will only be attenuated half as much as the main 100 Hz component. Valve amplifier HT supplies also had a trace (or more!) of 50 Hz ripple for the same reasons.

In the stabilised supply, all the current comes through a large power transistor, not chosen for its low-noise properties! The 'stable' voltage is decided by a zener diode, another active component and therefore producing some noise. Fortunately, this reference voltage can be smoothed by shunting with a capacitor, but again its LF noise will be less reduced.

One last thought: if we use very small currents, though on classical reasoning noise will be even less, will the *effective* noise really be less? If one got down, say, to less than ten electrons per second, one would surely hear each one arrive? Under more realistic conditions, though, would no a 'starvation current' lead to signal roughness something like that due to coarse-grained recording tape run at low tape speeds? ●