Valves versus transistors

The results of a comparison among three different amplifiers

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What follows is the result of a series of listening tests commissioned by the Acoustical Manufacturing Company ("Quad"). The intention of the tests was to investigate claims that valve amplifiers sound better than transistor amplifiers.

IN recent years a cult has arisen in which the members worship valve amplifiers, claiming that amplifiers employing transistors are incapable of achieving the same high standard of sound quality that is obtainable from amplifiers using valves. The reasons for the claimed superiority of valved designs are never set out in detail, nor is there any attempt to prove the claims, but instead they appear to be based on the bottomless argument that *absolute* contradiction of their claims is not possible, so by a process of accelerated inference a remote possibility becomes converted to an absolute certainty. It is to be expected that a valve amplifier costing, say £1000, will have a better performance than a transistorised model costing £100, but it appears to the writer that the claims go beyond this and that it is being suggested that all present designs of transistorised amplifiers include some ingredient 'X' that, being beyond any possible measurement, automatically ensures that it is impossible to duplicate the performance of a valve amplifier with any unit employing transistors.

The discussion that follows describes one attempt at the professional level to discover whether there is in fact any basic difference in the performance of a group of valve and transistor amplifiers, all of them recognised as being at the top of their class at the time they were in production. Ingredient 'X' being, by definition, impossible to measure, any attempt at assessing the performance of the amplifiers by objective techniques would have been unconvincing and was therefore discarded, leaving listening tests as the only alternative likely to be acceptable to members of the cult. However it was decided that if listening tests did reveal any significant difference in the sound quality, then the subjective judgement would be followed by a determined attempt to segregate the cause of the observed quality differences by objective means. Listening test techniques that are completely free from any criticism are not easy to arrange. There is a IEC Publication No. 543 covering the ground in a rather vague manner and a more recent IEC document 29B/WG5 providing a more detailed discussion of the subject. This is more specific in its suggestions and will presumably appear as a British Standard in due course. Where this document was applicable to the tests described, it was followed as far as possible.

In designing a listening test it appears reasonable to try to ensure that all the other elements in the reproducing system are at least an order better in performance than the element being submitted to a subjective judgement, although this is manifestly difficult to ensure when the components being judged are amplifiers of the highest class. If it is assumed that the non-linear distortions are at least a rough guide to the sound quality that can be obtained, then it is impossible to ensure that the recordings and loudspeakers that must be employed in any subjective assessment have a performance that is at all comparable to that of the best current amplifiers. Broadly speaking the situation is as follows.

There are power amplifiers on the market having distortions that are at least 90dB below their rated power output. The best current loudspeaker designs have distortions around 40dB down, professional tape recordings are perhaps 30 to 40 dB down, while the best current disc recordings have distortions that are no better than 25 dB below maximum output. Amplifiers have the additional advantage of having a large amount of headroom allowing the amplifier to be worked well below its overload point without compromising the system signal-to-noise ratio. In consequence the working distortions are much lower than are indicated by a quotation of the distortion content at full power output.

It is not the purpose of the present contribution to discuss all the distortions that exist in a reproducer system, but, assessed on the basis of the amplitude dependent components, it is reasonable to suggest that the best amplifiers have distortion products that are at least 40 to 50 dB lower than in the other elements in a hi-fi sound system. Thus it is a major weakness of a subjective assessment that the programme material and the equipment that must be used for the evaluation has a performance that is far far worse than the amplifiers being evaluated.

The amplifiers employed for the listening tests were all the products of one manufacturer, Acoustical Manufacturing Co. Ltd, (Quad in other words), who commissioned the tests. It seems likely in any case that most people would agree that their amplifiers have been in the top class for very many years, right back to the time when valved types were the only models available. In addition, using the products of one manufacturer seems essential if comparison with other manufacturers' products and design skills is to be avoided. Quad II amplifiers were the valve model used and the performance was compared with that of the type 303, their first transistor design, and with their model 405, the present current dumping transistor design.

Choosing the programme material for a listening comparison is a very difficult problem when the products being judged are 'state-of-the-art' amplifiers. About forty programme samples on 15 i.p.s. tape were available from four of the best-known studios in the country, with some additional material from several other sources. All were original recordings or first generation copies of original recordings made on machines of the highest professional standard. These samples had been provided as the best examples of current recording practice in the particular studio, but these samples were further distilled by careful listening comparisons until we were left with four selections that were considered to be outstanding in respect of frequency response, low distortion and acoustic clarity. The examples of programme finally used consisted of a concert orchestra, a light orchestral section, a group of male singers and finally a 'pop' group, all thought to be broadly representative of the type of music played at home by the average enthusiast.

The tapes were replayed on a Studer A80 recorder, the signal output being applied directly to the three amplifiers through resistive potentiometers to achieve the same output voltage from each of the power amplifiers. Preamplifiers were not necessary and were not used. A double-beam 'scope was installed to monitor the output signal from the amplifier to ensure that over-

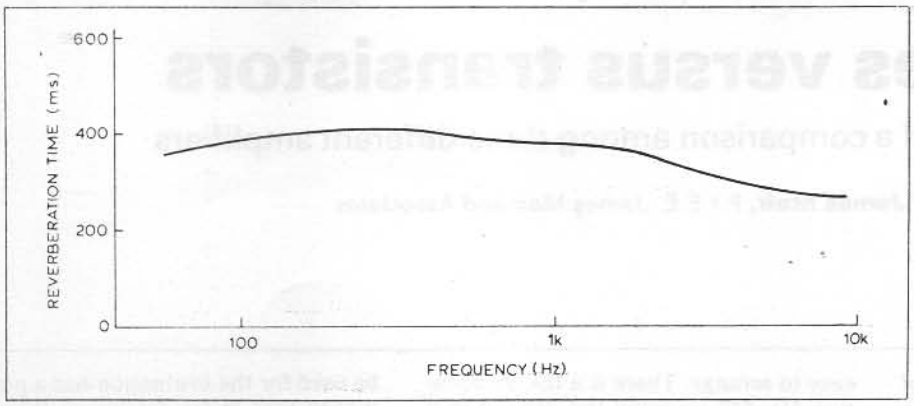

Fig. 1. *Listening room reverberation time response.*

loading did not appear even on instantaneous peaks of very short duration.

Yamaha Type NS 1000 loudspeakers were employed, the choice being that of one of the cult members as a condition of his participation in the tests.

The cult members that were invited to take part in the tests accepted but subsequently withdrew from the listening group, but by that time considerable effort had been devoted to determining the effect of the speaker impedence on the frequency response of each of the amplifiers and by then there was inadequate time available to investigate the performance of any substitute speaker system.

The output from the amplifiers being compared was switched to the loudspeakers by relays with gold-plated contacts to avoid any suggestion that contact-resistance or rectifying-action at the contacts was in any way responsible for the findings. These relays were operated through a switching system that allowed a randomised selection of any pair of amplifiers to be connected to the loudspeakers. At the same time the switching system operated a series of lamps that indicated the number of the particular test to the listening panel. Separate A and B lamps were employed to indicate which of the two amplifiers being compared was connected to the loudspeaker, although the panel had no means of knowing the types of amplifier in use in any particular comparison; all the technical equipment was operated in an adjacent room. In a large number of the comparisons the same amplifier was used in both the 'A' and 'B' positions.

The listening panel were all well known and experienced listeners. They were seated in two rows at a distance of approximately 4.0 metres from the two loudspeakers, but they were free to interchange seating positions as often as they wished. The test was conducted in a typically-furnished lounge having the measured reverberation time/frequency relation shown in Fig. 1 and an ambient noise level around 22dBA in the absence of the panel, rising to 28 dBA at the quietest moments when the panel in a form suitable for statistical training run before judging commenced, the loudness level was adjusted to that thought reasonable by the panel, the level being continuously monitored by the double-beam crt across the speaker line to ensure that this level was maintained through the series of tests.

It is probably impossible to assemble a reproducing system that is absolutely beyond all criticism but the system used had a 'state-of-the-art' performance that was far beyond the facilities of any ordinary enthusiast.

Each item in the musical programme was presented to the panel as two 30s repeats, separated by an interval of one or two seconds during which the amplifiers were switched. This was followed by an interval of about 15-20s before the second piece of music was presented in the same general format.

Obtaining the opinion of a listening panel in a form suitable for statistical analysis requires some careful consideration, for it is not as simple as might appear at first thought. When three identical amplifiers are compared, then if a sufficiently large number of opinions are taken, each amplifier will get one-third of the votes in much the same way as an unbiassed penny will come up heads on 50% of the throws, but only if there are a large number of attempts. Thus a large number of independent quality judgements are required if the result is to be even moderately conclusive. If a small number of judgements are made, any one of the three amplifiers is likely to find favour by sheer chance, in much the same way as the neutral penny tossed three times will confirm that it is weight-biassed because heads will come up twice as often as tails.

To judge the amplifier performance, each of the four pieces of music was played twenty-four times to a panel of six judges, their opinion on the performance of each pair of amplifiers being given after hearing each of the four pieces on music on each of two amplifiers. After each of the four pieces of music, the panel members were asked to record their opinion on that particular pair if amplifiers in the form:—

1. I prefer A.
2. I prefer B.
3. I have no preference.

If a preference was expressed the panel members were asked to indicate their reasons for that preference. It was thought just possible that an expressed preference might be connected in some way with the particular seating position, so each panel member was also asked to mark his position on a small seating plan on the score sheet.

To avoid listening fatigue there were gaps in the comparison process after twelve judgements had been made, with longer gaps after twenty-four judgements. Lunch was taken in the interval between the first and second groups of twelve judgements, a whole day being devoted to the comparisons. Every possible effort was made to ensure that the test conditions were as free from criticism as could be achieved, but it would be too optimistic to believe that the arrangements were beyond all criticism.

Table 1.

PAIRED COMPARISON TEST RESULTS

Comparison	Quad II/405			Quad II/303			Quad 303/405			Same Amplifier	
	Prefer II	Prefer 405	No. Pref.	Prefer II	Prefer 303	No. Pref.	Prefer 303	Prefer 405	No. Pref.	Preference	No Preference
Listener a	5	4	15	7	6	11	5	6	13	11	13
Listener b	2	2	20	1	3	20	4	3	17	3	21
Listener c	3	6	15	5	3	16	4	1	19	7	17
Listener d	4	9	11	2	4	18	7	4	13	8	16
Listener e	2	3	19	2	2	20	3	1	20	3	21
Listener f	8	7	9	8	10	6	7	4	13	14	10
Group results	24	31	89	25	28	91	30	19	95	46	98