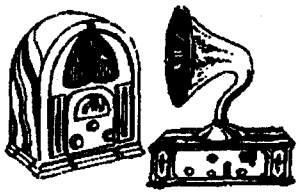
Vintage Radio

by PETER LANKSHEAR



Class 'B' amplification

Class B operation, which combines maximum efficiency and power output with minimum heat dissipation, is practically universal for transistor power amplifiers. It is not, however, a product of the semiconductor age — in fact it was originally developed about 60 years ago, to improve valve amplifier economy.

During the 1920's there came a realisation of the importance of grid bias for valves. Three classes of operating conditions were defined, governed by the amount of bias, and were known simply as classes A, B, and — not altogether surprisingly — class C.

Distortion is lowest and gain is maximum in Class A operation, which is standard for *voltage* amplifiers. The grid is biased so that a constant anode current flows. Power amplifiers can be either single-ended or push-pull, and maximum efficiency is about 40%.

In class B, the negative grid bias is sufficient to just cut off the anode current with no signal. Anode current thus flows only when the grid is driven positive. Initial receiver applications were for 'biased' or 'anode' detectors, and some oscillators. In effect, only half the signal is amplified.

Must be push-pull

Class B audio amplifiers must be push-pull, with the two halves of the signal waveform recombined at the output. This led to some early references to class B audio amplifiers as operating in 'push push'.

Operating conditions can be set anywhere between class A and class B. This intermediate mode is called — naturally — class AB, and became very important for power amplifiers of all types, but especially those using beam tetrodes. A further sub classification was the use of a numerical suffix: a '1' indicating that no grid current was allowed to flow, or a '2' to show that there was grid current during part of the operating cycle.

For class C operation, the anode load is always a tuned circuit. The control grid is biased far beyond cutoff, and anode current flows only at the very peak of the positive component of the grid signal — resulting in a series of pulses which keep the tuned circuit in oscillation. Efficiency is very high, up to 80%. The only, but important, receiver application is that of the local RF oscillator in a superhet.

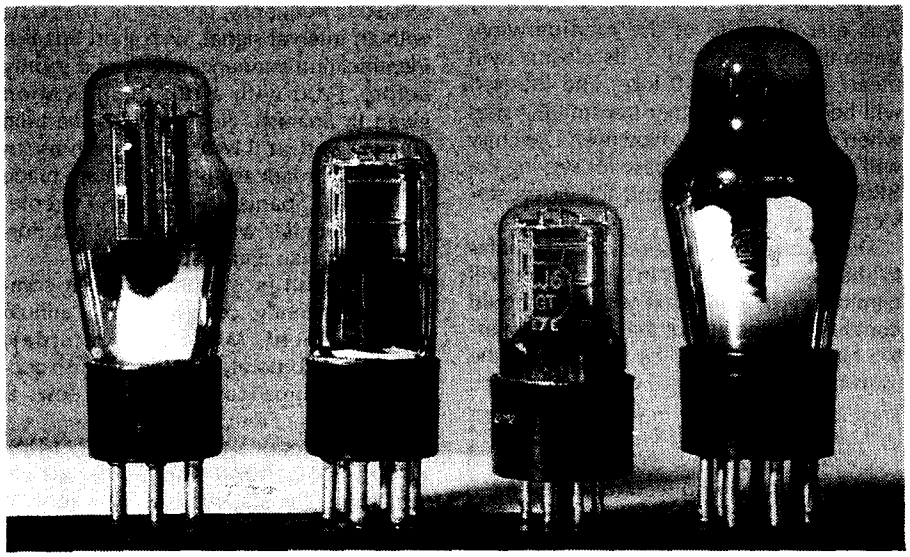
Audio power expensive

During the 1920's, class A was the only recognised type of operation for audio amplifiers. As reasonable outputs could only be achieved with large valves and prohibitive costs in battery consumption, early radios were seriously limited in the audio power that could be produced. Later, the advent of practical mains power supplies and valves such as the the English LS5, the American UX210, UX250, and then the UX245, enabled receivers to produce upwards of a watt of reasonable quality audio power. But battery radio users had to balance output against battery consumption.

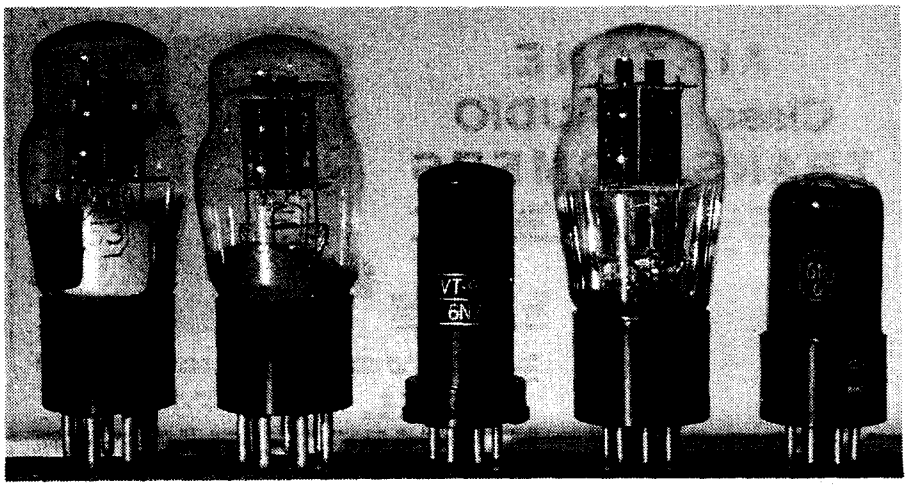
In 1930, British and European output pentodes such as the B443, PM24, 230QT, and PT35 were available, and went some way to solving the efficiency problem. With 150 volts HT at 15mA they were capable of at least half a watt — twice that of the latest American type 231 output triode operating under similar conditions. Although Philips had invented the pentode in 1927, the Americans, for various reasons, delayed its introduction until mid 1931.

New operating mode

Coincident with the release of the first American pentodes (the 47 for mains operation, the 38 for car radios and the 33 for battery sets) were a couple of papers by Loy Barton in the June and July 1931 *Proceedings of the American IRE*, suggesting the obtaining of high audio power from relatively small valves by using class B operation.

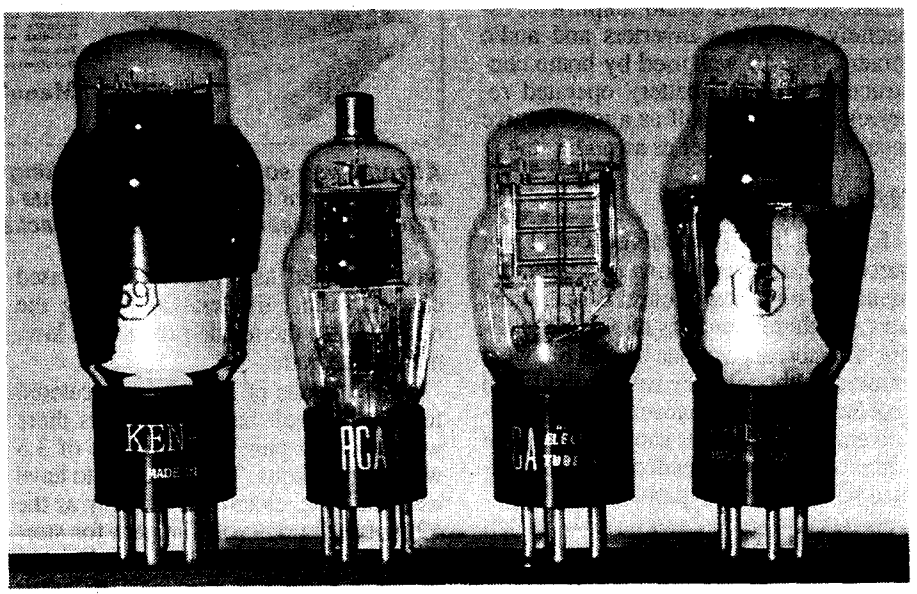


By far the most popular directly-heated class B valves were the 2V double triodes. Shown here from the left are the original 19, a later tubular 19, the octal 1J6GT equivalent and an English version the Cossor 220B or VR32.



Left: All brothers under the shell, the 53, 6A6 and their 6N7 octal variants were the largest and most important of the indirectly-heated class B double triodes. They found many other applications, from oscillators to resistance-coupled amplifiers.

Below: The multi-grid class B valves were the most versatile, but as single valves they lost out to the double triodes in terms of cost. From left to right are shown the triple-grid 59 and 89, then the tetrode 49 and 46.



There are benefits. For a start, the valve anode current is proportional to power output demands and is practically cut off under no-signal conditions. Furthermore, given the nature of speech and music waveforms, the average current is low even for large power outputs.

There are also snags, however — including the necessity for additional valves. To cope with the grid current drawn by the output valves, the driver valve also has to provide power, generally through a step-down ratio transformer. In effect, the driver is an integral part of a class B amplifier.

Different transformers

Class B output transformers operate in a different manner from those intended for class A. The two halves work independently, but must be very closely coupled and the valve characteristics matched to a 5% tolerance. Furthermore, in the transition period — as conduction switches between valves — there can be serious 'crossover' distortion, especially at low volume. Another problem is created by the large variations in anode current, requiring well regulated power supplies.

Although the cheaper option of a single resistance-coupled pentode was available, by early 1932 several American manufacturers, using a pair of the very low powered type 30 general purpose triodes, had produced battery operated receivers producing more than one watt of class B audio power. This dramatically illustrated the significant improvement in efficiency of class B operation. The same valves, operating in class A, would have been struggling to produce 100 milliwatts.

Late in 1932 and into 1933, class B became 'flavour of the season' for mains as well as battery operation. Valves specifically designed for this class of service were developed, and within a year there were at least eight new American releases having class B ratings, outnumbering the range of pentodes available!

Three groups

Except in Britain, high-mu triodes were invariably used for class B operation. The high amplification factor meant that anode current with no signal was nearly at cutoff without negative bias, a considerable advantage with mains powered receivers. Battery powered twin pentodes found considerable favour in Britain and will be described later.

Three different varieties of triode class B valve emerged. Ultimately the most popular were the double triodes. Their advantage was the saving of one valve and socket, and the characteristics of the two halves could be closely matched. Best known were the 2.0 volt filament US type 19 and the similar Philips KDD2 or B240, the Mullard PM2-B and Cossor's 220B and 240B — capable of producing up to two watts. Companions were the 6.3-volt type 79 for car radios, capable of about five watts, and the 2.5-volt mains powered type 53 rated at up to 10 watts.

Valve manufacturers were very fond of repackaging an existing design. To the 53 goes the distinction of having the largest number of derivations, all with 6.3-volt heaters. First there was the 6A6, and then followed the octal metal-enveloped 6N7 and finally the glass variants 6N7G and 6N7GT.

The 19 in octal form was the 1J6G, and a 1.4 volt version was the 1G6G. With an octal base the 79 became the 6Y7G.

New octal variants

There were two new 6.3-volt heater types issued in the octal era. The 6Z7G with a 0.3 ampere heater was intended for storage battery operated sets, but the most unusual were the 6AC5G and 6AC5GT. These were single zero bias high-mu triodes, but were also given class A ratings for operating with a *positive* grid bias and directly coupled to a cathode-follower driver valve. Why such a valve was issued when similar valves

such as the 2B5, 6B5 and 6N6 (complete with built-in driver valves) were already in existence, is a mystery.

The indirectly heated double triodes were used to a limited extent in mains powered receivers. Typical was the AWA Radiola 140, incorporating a type 53 valve driven by a 42. It was soon realised however, that HT current economy was of little importance in mains powered receivers and that because of the extra expense and higher distortion, there was little merit in this line of development.

Double triodes proved quite popular as resistance-coupled audio amplifiers, especially for phase inverters and audio mixers. The 19 was used by home constructors of small battery operated receivers, using one half as a regenerative receiver and the other as an audio stage.

New rectifier

Existing rectifier valves could not meet the stringent power supply demands of high power class B operation. To meet these demands two new rectifiers, the mercury vapour 82 and 83, were created. Although they solved regulation problems, they were never popular in receivers. Their life was short, choke input filters were recommended and they created RF interference problems.

Multi-grid triodes

Concurrently with the 19 there appeared three unique directly heated valves, each with *two grids*. With the grids connected together, these valves were intended as high-mu zero biased class B output triodes. Connecting the outer grid to the anode produced a low-mu driver triode.

Three classes of service were catered for. For 2.0-volt battery receivers there was the 49, a pair being capable of 3.5 watts at 180 volts. The 52 seems to have used the same electrode assembly as the 49, but had a 6.3-volt filament for storage battery operation. Third member was the large 2.5-volt filament type 46, a pair being rated at no less than 20 watts at 400 volts!

Demand for the dual-grid series was limited. Two valves cost more than a twin triode and they were overpowered for most receiver applications. The 46 and 49 were used to a limited extent around 1933/34, but became well known in other ways.

The 46 found favour in PA work and amateur transmitters, for both modulator and RF applications, but the 49 became best known in this part of the world as the valve for the *Hikers' One*, described in the October 1989 Vintage Radio column. In New Zealand, far more type 49 valves were used by young radio enthusiasts for the *Hikers* series of radios than

AIRZONE
Class B. AUDIO
TRANSFORMERS

Airzone announce a range of high quality Audio Transformers, specially designed for operation in Class "B" Amplifiers. The Transformers are housed in a moulded bakelite case, and are available in two types:—

One with 9in. connecting leads for manufacturers' use; and the other with terminals for set builders.

For Battery Receivers an interstage transformer with a ratio of 2.5 to 1 overall is suitable for use with the following range of tubes, specially designed for class "B" amplifiers:

R.C.A., Type 19. Mullard, PM2-B.
R.C.A., Type 49. Philips, B-240.
Cossor, Type 240-B.

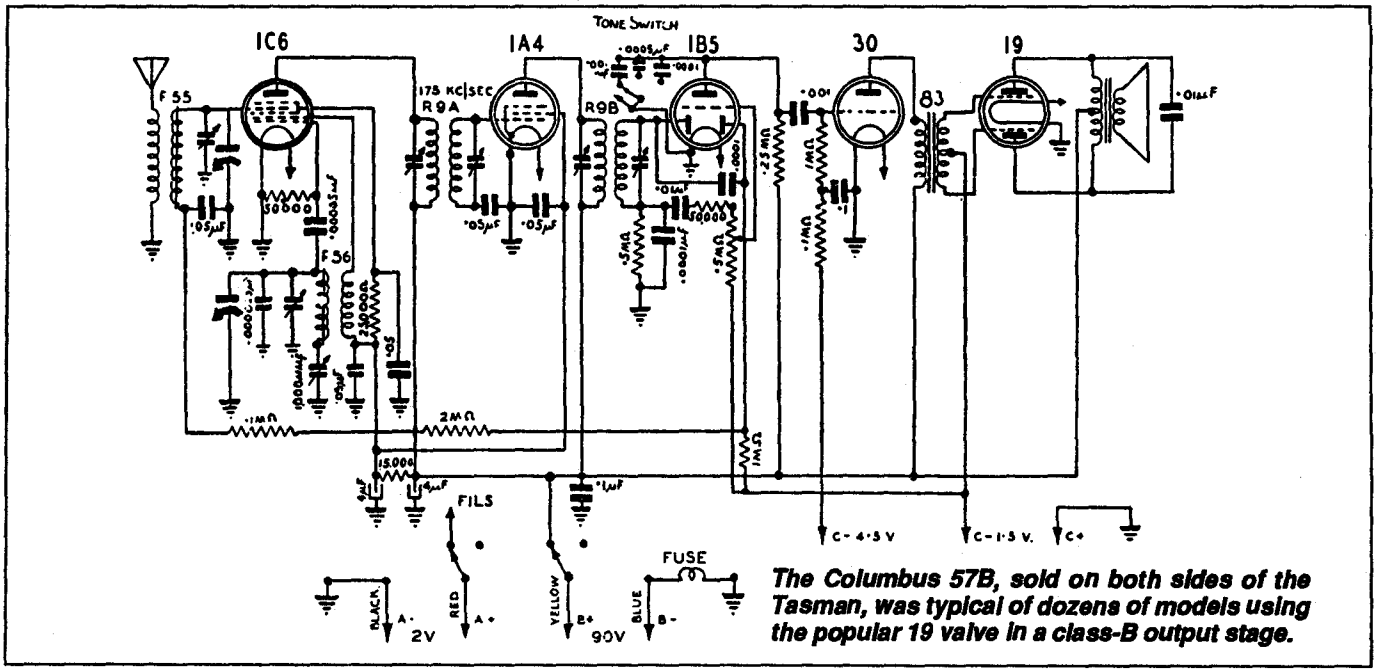
It is essential that the secondary resistance of class "B" interstage transformers shall be of a low value, and in the Airzone Class "B" Transformer the secondary resistance has been reduced to a value of under 300 ohms.

Airzone Transformers are produced on the latest automatic multiple winding machines from highest-grade enamelled wire and best quality insulating materials. All windings are dehydrated and impregnated in the most up-to-date vacuum impregnating equipment in Australia. The completed coil is further sealed in the moulded bakelite case with a special compound, thereby preventing ingress of moisture with consequent breakdown. Eight tests and inspections are applied, including an insulated test at 2000 volts A.C.

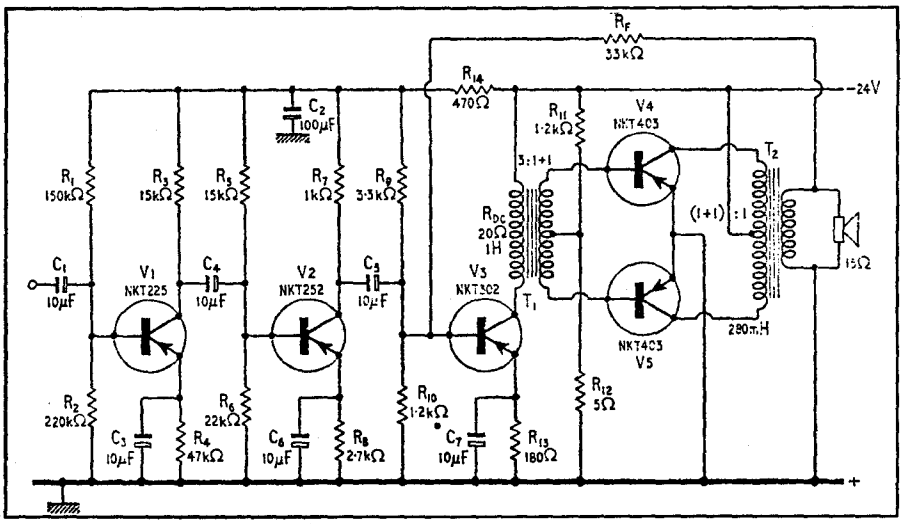
The price is consistent with a first-class product at 17/6 each retail. Manufacturers and dealers ask for trade discounts.

Manufactured by AIRZONE (1931) LTD.,
16 Australia St., Camperdown, Sydney.

Airzone was soon involved in making class-B transformers, as shown by this advertisement from the July 13 issue of Wireless Weekly for 1934. The price of 17/6 each reveals one of the drawbacks of class-B technology — its high cost.



The Columbus 57B, sold on both sides of the Tasman, was typical of dozens of models using the popular 19 valve in a class-B output stage.



Early transistor audio amplifiers were closely based on class-B valve technology, as this diagram reveals. Compare its output stage with that of the 57B receiver.

were ever used for their intended purpose. The only user of the type 52 that I can find was United American Bosch, who used it in a DC mains receiver and two police car radios. It was not listed by RCA.

The third type of American-designed Class B valve was represented by the indirectly heated *triple grid* types 59 and 89, with heaters rated at 2.5 volts and 6.3 volts. This versatile pair could be used in three ways. With the two outer grids connected to the anode, they became low-mu driver triodes. With the two inner grids connected together and the outer grid connected to the anode, they were high-mu class B triodes, a pair of type 89's being capable of 3.5 watts. The 59 had similar applications and ratings to the 46 in class B service, with the advantage of an indirectly heated cathode.

The third, and eventually, major application for the 59 and 89 was as conventional power pentodes. They were both rated at around three watts output, the 59 having characteristics similar to the well-known types 42 and the 2A5. But as class A pentodes, the 59 and the 89 were eventually displaced by the more conventional standard power pentodes.

Quiescent push-pull

America and Australasia generally stayed with simple triodes, the type 19 being very popular for battery receivers. In Britain however, where battery powered receivers were very common, practically every valve company produced a double class B pentode, used with about 12 volts bias and operating in what was called the *quiescent push-pull* mode. They were more sensitive than triodes, and drew little grid current, simplifying driving requirements. Apart from the American 1E7G, which had only class A ratings, the double pentode output valve was unique to Britain. Some QPP valve types were QP22A, QP22B, 240QP, QPT2, QP21, QP230 and QP240.

Because of all its complications and distortion, use of the class B valve audio amplifier soon became confined to battery receivers where its economy was important. But in any event, efficient pentodes eventually became available and after 1940, the class B valve receiver output stage was rarely seen.

Class B today

There are still in operation many AM broadcast transmitters using class B valve modulators — and tamed by plenty of negative feedback and accurately maintained operating conditions, producing kilowatts of high quality audio. In this application, the efficiency of class B operation is of real value. It can be quite intriguing to observe lightly damped current meters in the mains supplies to these transmitters, indicating power demand variations in step with the programme modulation!

With the limited dissipation and risk of thermal runaway of early transistors, class B operation would have needed to be invented had it had not already existed, and it is not surprising that the technology of the first transistor audio amplifiers closely resembled that for class B valves.

With the development of direct coupling and complementary transistor pairs, the application of considerable levels of negative feedback to solid state equipment became practicable — enabling physically small amplifiers to produce high performance and power efficiently. ■