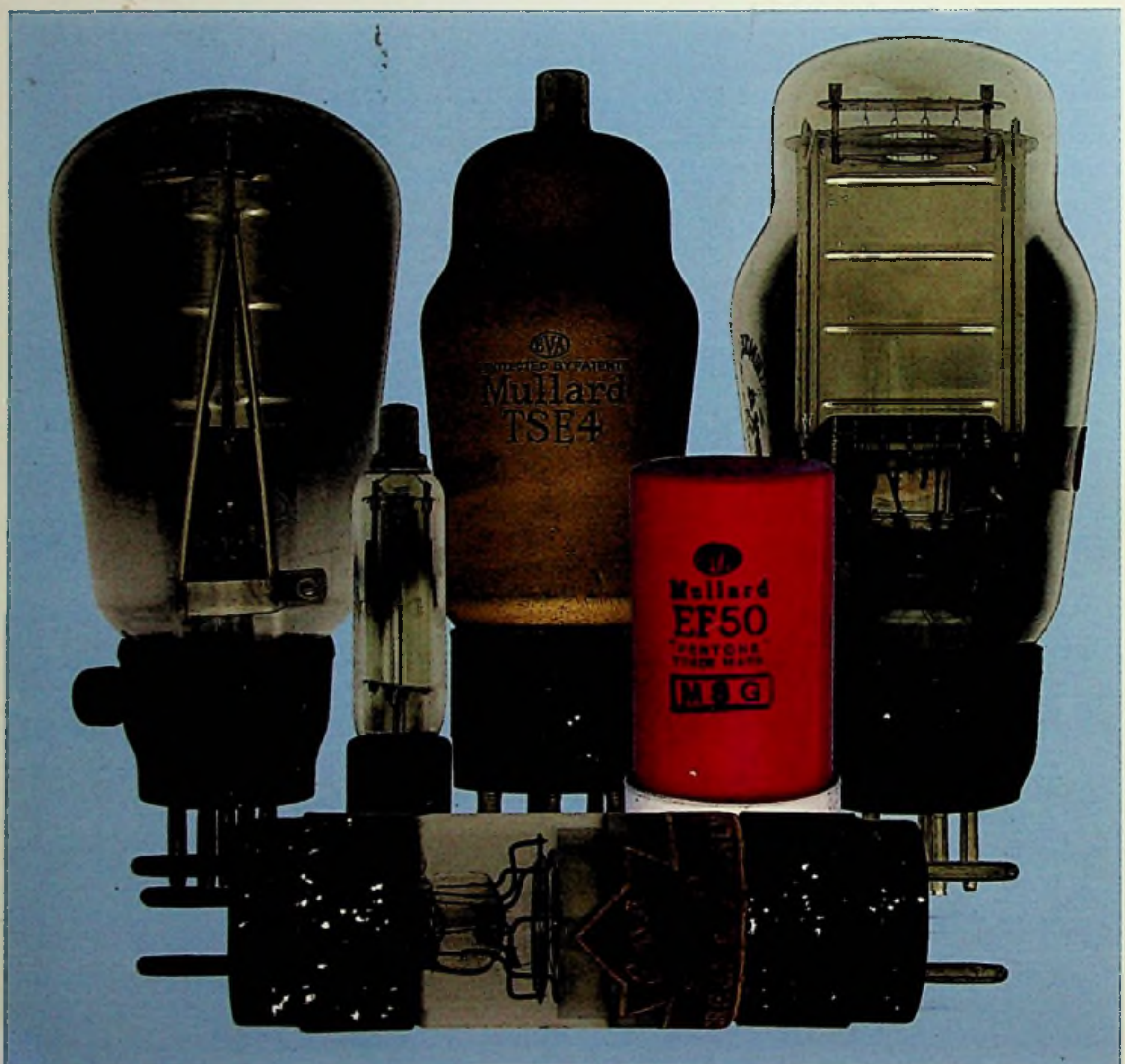
British Radio Valves
The Classic Years: 1926 – 1946

Keith R Thrower



Speedwell

British Radio Valves
The Classic Years: 1926–1946

British Radio Valves
The Classic Years: 1926–1946

Keith R Thrower

Speedwell
4 Mapledene
Caversham
Reading, RG4 7DQ
England

Published by Speedwell, England

ISBN 978-0-9537166-3-0

Contents

Preface

This book is the second to be published in the series *British Radio Valves*. The first of these covered 'The Vintage Years' from 1904 to 1925 during which time all valves were directly heated. From around 1915/16 many of the British valves were derivatives of the French TM (the R valve in Britain) and these all had uncoated tungsten filaments. From 1922 onward there was a rapid conversion to thoriated tungsten filaments which operated at a lower temperature and, consequently, were considerably more efficient. It was only at the end of this 'vintage' period in 1925 that the oxide-coated filament began to emerge, although a small number of Marconi valves had used this type of filament in the 1913 to 1915 period. (Also the US Western Electric Company had consistently used the oxide filament for its repeater valves from 1913 onwards.)

This book covers 'The Classic Years' from 1926 to 1946 during which time the modern valve emerged. The progress made during this period is summarized in Chapter 1. The following ten chapters deal with valves manufactured by the large and medium-sized British companies. Chapter 12 is concerned with the smaller British manufacturers, only four of which survived into the 1930s.

Chapter 13 covers the companies that supplied valves into Britain, including those manufactured by several European companies.

Valves manufactured and supplied from US companies are dealt with in Chapter 14, most of which appeared from 1937 onwards, particularly during the war years from 1939 to 1945.

The final chapter is concerned with the valves used by the British armed services and the Post Office.

Data and base connections for all the valves described in the various chapters can be found in the separate Valve Data Supplement which was too extensive to include in this book. This supplement brings together, for the first time, a comprehensive coverage of practically all the low-power valves available in Britain during the period from 1926 to 1946.

What is hoped will be found useful are the tables in each chapter which list the various ranges of valves, together with their approximate year of introduction.

The book includes photographs of over 1000 valves as well as many other illustrations. Because of the continuing interest in valve hi-hi amplifiers, additional data have been included for the push-pull operation of power valves. However, a word of caution is called for here. It must be appreciated that the characteristics and maximum operating conditions of many of the valve types changed over the years, so it is often not possible to use some of the earlier valve, such as the Marconi-Osram PX4, at the anode voltages shown in the later data for these valves.

It is hoped that the book will be found useful both to the valve collector and those seeking information on specific valves where, for many of the types, information is very difficult to locate.

Abbreviation for titles of Journals

BSTJ	*Bell Systems Technical Journal*
Elec.	*Electronics*
J. App. Sci.	*Journal of Applied Science*
JIEE	*Journal of the Institution of Electrical Engineers*
JNS	*Journal of Nautical Science*
POEEJ	*Post Office Electrical Engineering Journal*
Proc IEE	*Proceedings of the Institution of Electrical Engineers*
Proc IEEE	*Proceedings of the Institute of Electrical and Electronic Engineers*
Proc IRE	*Proceeding of the Institute of Radio Engineers*
P.W.	*Popular Wireless*
Trans AIEE	*Transactions of the American Institute of Electrical Engineers*
W.E.	*Experimental Wireless & Wireless Engineer*
W.T.	*Wireless Trader*
W.W.	*Wireless World*

Acknowledgments & Sources

Acknowledgments

This book has taken five years in its preparation. It would not have been possible to produce this in such an extensive way without considerable help from many people. I would particularly like to thank Philip Taylor for allowing me to photograph many hundreds of his valves, made during several visits to his house over a period of three years. Philip has also been very helpful in providing valve data and checking through much of the text in this book. He also trawled through the stocks held by Gerry Wells and Martin Billington of Billington Export to find many of the more obscure types and I should like to thank both these gentlemen for the loan of valves from their stock

Dr Tom Going has provided much information on valve companies and patents, particularly for many of the European companies. Several of the photographs are also of valves loaned to me by Tom, including some of those of Lissen and Hivac. Tom has also assisted in checking the text. Others who have assisted with photographs are Rod Burman and Bengt Svensson.

I would also like to thank Ludwell Sibley for his assistance with the chapter on US valves and also for commenting on military valves, particularly the US types.

Finally, I must give special thanks to Adri de Keijzer my Dutch friend who compiled a CD ROM containing data for some 1700 CV valves. This task took him nearly two years to complete and included photographing over 7000 pages from the CV Register and re-producing these in a more acceptable form. Information from this CD has been invaluable to me for the chapter on Military and Post Office valves. Adri also kindly arranged two visits to the Philips museum in Eindhoven which helped me with much background information of this company

Sources

Information used in this book had been compiled from many sources, particularly data from the valve manufacturers contained in their various data and applications books. A further valuable source of information has been from the many articles and reviews contained in *Wireless World*.

As the reference sections at the end of the chapters show, I have also drawn on articles published in several of the professional journals published by the IEE (now re-named the IET), the Post Office and the American IEEE.

I have also drawn on information from several books (see Bibliography on page 334). Of special note I should mention the books by Tyne, Stokes and Callick.

Chapter 1
Progress in valve design and development

Summary
From 1925 onwards there was rapid progress in valve design. Amongst the most significant developments was the change from the thoriated filament to oxide-coating, which, in turn, led to the indirectly-heated cathode. Just as important was the addition of a screen grid electrode, which enabled valves to operate as stable high-frequency amplifiers. Also, over the years, valves were made more rugged and the machinery used in their manufacture ensured more precise construction; these, together, ensured both improved performance and greater reliability. The screen grid opened the door to new families of multi-electrode valves such as the pentode, beam tetrode and frequency changers.

Further improvements in construction led to valves of smaller size and reduced electrode spacing, enabling them to operate at increasingly higher frequencies. This chapter provides a brief overview of these developments, but for more detailed information the reader should refer to an earlier book of the author [1].

The getter [2]

All valves up to the early 1920s required a considerable pumping period to reduce the gas pressure to an acceptably low level—typically less than 10^{-5}mm Hg*. Gases were also trapped within the electrodes and the glass envelope. Much of this was removed during manufacture by heating both the electrodes and the bulb during pumping. In spite of this, however, gas continued to be released during the life of the valve and this led to a deterioration of the vacuum.

The problem was overcome by insertion of a getter within the valve. With early valves the getter was a thin strip of magnesium or phosphorus, which was evaporated at the end of the pumping period before the final airtight seal was made. The getter had the desirable property of adsorbing most of the harmful residual gases within the envelope and then continued to act as a 'sponge', mopping up released gases during the life of the valve. A further desirable feature was that the pumping period could then be shortened.

From the valve collector's point of view, the getter is an eyesore because it is liable to cover the internal surface of the glass envelope, obscuring the electrode assembly. The magnesium left a bright silvery deposit and the phosphorus an orange-red deposit.

By the early 1930s, it was found that the most effective getter material was barium which, for best results, was usually mixed with aluminium or magnesium. Barium had the merit of providing an effective cleanup for all the major gases encountered within the valve—oxygen, water vapour, nitrogen, hydrogen, carbon monoxide and carbon dioxide. The barium mixture was held in a small pellet positioned at a suitable place within the enclosed envelope, so that, after being volatised, it would settle on the walls of the envelope rather than the electrode assembly.

Oxide-coated cathode [3]

The majority of early valves produced during the period from 1915 to 1922 had tungsten filaments, which operated at a temperature of about 2500K†. At this temperature the filament glowed bright yellow and for this

* At normal atmospheric temperature and pressure mercury (chemical symbol Hg) will rise to a height of about 760mm in a glass tube sealed at the top and from which the air above has been removed. So a gas pressure of 10^{-5}mm Hg represents a pressure reduction of 76 million to 1.

† For those readers more used to centigrade degrees, add 273° to the Kelvin figure, i.e. 2500K ≡ 2773°C.

reason the valves were known as bright emitters. Tungsten had the advantage of being quite robust and not easily damaged by gases of low pressure within the bulb. There were, however, several disadvantages:

- Because of the high temperature, the tungsten gradually evaporated and filament failure occurred after about 1000 hours operation.
- The filament required a considerable amount of heating power—typically three watts for a small receiver valve such at the type R.
- There was an appreciable movement of the filament as it expanded with heating and this meant that the grid could not be positioned close to the filament, which limited the amplification that the valve could provide.

Nevertheless, the tungsten filament continued to be used for high-power transmitter valves during the whole period covered by this book because the electrostatic forces present due to high values of anode potentials did not damage it.

Pure tungsten is inclined to brittleness and for this reason a small quantity of thorium oxide was added to make it ductile. Whilst experimenting with filaments of this type, Irving Langmuir, a brilliant engineering scientist working for the American General Electric Company, discovered that, when suitably heat-treated, the thorium oxide within the tungsten could break down to form a monatomic layer of pure thorium on the surface of the tungsten. Under this condition the filament was found to provide a similar electron emission to that of a bright emitter but at the lower temperature of about 1875K where it glowed dull yellow [4]. Although this discovery was made in 1914 it was several years before these thoriated valves (known as dull emitters) were produced commercially. The first British valve of this type was the Marconi-Osram LT1 which appeared in 1921, this being a forerunner of the commercial DER. Very soon the dull emitter valves superseded the bright emitter types for almost all receiver valves.

The principal merit of the thoriated filament was the lower filament consumption—typically one tenth that of the bright emitter. The main disadvantage was that residual gas molecules within the envelope could destroy the emission. Fortunately, however, the problem was minimized by use of the getter.

The thoriated tungsten filaments eventually gave way to the oxide-coated filament for all low power valves, but continued to be used for several years for many medium power types and the tungsten filament remained in use for high-power transmitting valves. The oxide-coated filament was the invention of the German physicist, Arthur Wehnelt, in 1904 [5]. He coated platinum wire with various oxide combinations such as barium, calcium and strontium and found that there was profuse emission at quite low temperatures. Various early valves, such as those designed by Henry Round of the Marconi Company, used this type of filament, but the high temperature tungsten type proved to be more robust at the time. Eventually manufacturing and reliability problems were overcome and the oxide-coated filament came into general use from the mid- to late-1920s, and was then used for almost all types of low- to medium-power valves. The first British types were in the Cossor Wuncell range of 1924. These were not successful but, late in 1925, the Mullard Company, by now closely aligned with Philips of Holland, introduced its type PM4, the first of the long-running PM series of valves.

The oxide-coated filament operated at a temperature of about 1100K, which meant that its power dissipation was even lower than that of the thoriated tungsten type. At first the filaments were made from platinum wire coated with barium oxide by a messy azide process. Before long the platinum was replaced by nickel or a nickel alloy, primarily because of the high cost of platinum. Also it was found that improved emission resulted from a mixture of both barium oxide and strontium oxide in approximately equal proportions.

Indirectly heated cathode [6]

Up until 1927 all British valves had directly heated filamentary cathodes. With the advent of the oxide coating, and with the increasing electrification of homes, it became desirable to power the cathode from the a.c. mains, via a suitable step-down transformer to provide the low voltage. The principal problem was hum modulation of the electron current. One interim solution was to operate the filament at a very low voltage such as 0.8 volts, with a proportional increase in filament current. The Marconi-Osram Company produced a range of valves of this type, known as the Point 8 Series. This was not a satisfactory solution, particularly for the valves used in the early stages of a receiver, particularly the detector, because the hum modulation could not be reduced to a sufficiently low level.

The solution came with an indirectly heated cathode consisting of a nickel sleeve, coated with the oxides of barium and strontium, and heated by an insulated wire inserted inside the sleeve. Typically the wire was made from either tungsten or a tungsten-molybdenum alloy. Various coating materials were tried for the heater, as it became known, but the most satisfactory proved to be alumina, which was usually mixed with a small quantity of beryllia. Early heaters were just V-shaped, but these did not provide an adequate cancellation of the alternating electromagnetic field. A more satisfactory solution was to wind the wire into a reverse helix or reverse double helix.

The first British valves to have indirectly heated cathodes were the Marconi-Osram types KL1 and KH1. At first these were not very satisfactory and the Metrovick Company (the manufacturer of Cosmos valves) produced improved types; these valves were based on a slip-coating technique, invented by Ernest Yeoman Robinson [7]. The first two types to be produced by the Company, both in 1927, were the AC/G and AC/R. The mutual conductance of the AC/R had the remarkably high value of 4mA/V, a figure that was not exceeded by other manufacturers for several years.

Screen grid tetrode [8]

It had long been recognized that the triode valve was unsuitable as a tuned r.f. amplifier at frequencies much above a few hundred kilohertz. This was due to the high interelectrode capacitance between the anode and grid electrodes, the problem being compounded by the additional capacitance of the connecting wires. To minimize this problem some valves, such as the Marconi-Osram types Q and V24 brought the anode and grid connections out to metal caps mounted diametrically opposite on the glass envelope. Although this helped it was not a complete solution; furthermore the valves were comparatively expensive to manufacture.

The solution came with the addition of a second grid, located between the control grid and anode electrodes, connected via a low impedance path to the common supply rail (or, more accurately, to the cathode). This grid provided an electrostatic screen, thereby reducing very considerably the interelectrode capacitance between the control grid and anode; it became known as the screen grid.

The first British screen grid valve, the MOV type S625, was designed by Henry Round and became available towards the end of 1927. The valve was unusual in that it had connections at both ends, which required a special mounting frame. Because of this it was not popular with set manufacturers and was soon superseded by types having a conventional British 4-pin base with a top terminal for the anode connection. Amongst the first of these improved types was the Mullard PM12.

The screen grid valve provided a major improvement in receiver design. It was now possible to incorporate one or more stages of r.f. amplification, which significantly improved the receiver's sensitivity and selectivity. A limitation of the valve was a kink in the anode characteristic, which occurred when the anode voltage was less than that of the screen grid. This kink had a negative resistance characteristic and could give rise to instability. In practice it was not a serious problem for r.f. amplifiers because the output signal at the anode was not usually very high, so it was possible to ensure that the anode voltage never dipped below that of the screen grid. It did mean, however, that the screen grid valve could not be used in the audio output stage where a high signal swing was required at the anode for efficient power amplification.

The kink in the anode characteristic was caused by a phenomenon known as secondary emission. The electrons from the cathode were accelerated to a high velocity by the screen grid. As these struck the anode they dislodged electrons from the metal. Providing the anode potential was higher than that of the screen grid they were collected again by the anode. If the screen grid voltage was higher than that of the anode, however, the electrons were collected by this grid, resulting in a fall of anode current as the anode voltage was increased.

Output pentode [9]

The problem was quickly solved by inserting another grid between the screen grid and anode and connecting this to a point of low potential. Initially this was done by an internal connection to the filament (although for some valves it was connected to the control grid). This three-grid valve was called a pentode and the additional electrode the suppressor grid.

The pentode was invented by the two Dutch engineers Gilles Holst and Bernard Tellegen who worked for the Philips Company. It was originally designed for use in the output stage of radio receivers or audio amplifiers. The first of these valves, the B443, was manufactured by Philips in September 1927 and used in their 2502 battery-operated set.

By the middle of 1928, Mullard, which by then was wholly owned by Philips, was offering two output pentodes—the PM22, which had a 2-volt filament, and the PM24 with a 4-volt filament. These valves both had 4-pin bases with a side terminal for connection to the screen grid. The Mullard and Philips name for this class of valve was 'pentone', which they continued to use for several years alongside the more usual name of pentode.

Beam tetrode [10]

An alternative to the output pentode was the beam tetrode. The valve had characteristics similar to that of the pentode but was more linear, which meant it produced less distortion.

The beam tetrode was invented by the two EMI engineers, Cabot S Bull and Sidney Rodda who made a patent application in 1933 [11]. The first valve of this type to appear was the Marconi N40 which was announced early in 1935, although only about 1000 were produced. MOV, which was half owned by EMI, did not believe the valve could be manufactured economically and the design was passed to RCA under an exchange agreement between the two companies. RCA redesigned the valve to simplify its construction and the outcome was the 6L6 which appeared on the US market in 1936 [12]. The KT66, introduced by MOV in the following year, was an improvement on this.

A further improvement, also introduced on the 6L6, and one that was carried over to many later r.f. tetrodes and pentodes, was to align the wires of the screen grid with that of the control grid. By so doing, the screen grid current was reduced. This not only lowered the overall power consumption of the valve but also reduced one component of noise produced within the valve, known as partition noise. (The aligned grid, or 'shadow' grid, would appear to have been a Philips invention dating back to about 1931.)

An alternative to the beam tetrode was the critical-distance tetrode of the Hivac Company, an invention of J H Owen Harries in 1935 [13]. He showed that if the spacing between the anode and screen was increased, there was a critical separation of about 3cm where there was no kink in the anode characteristic. Hivac continued to use this type of valve until the Company changed its emphasis to miniature valves in the post World War 2 period.

Variable-mu and RF pentodes [14]

A serious problem with early r.f. amplifiers, particularly when the screen grid valve was introduced, was cross-modulation. Cross modulation is when the intelligence carried by a high-level unwanted signal, off tune from a wanted weaker signal but within the pass band of the receiver tuned circuits, becomes transferred to the carrier frequency of the wanted signal. The result is that two signals are heard simultaneously. It is caused by non-linearity in the r.f. amplifier or the demodulator and cannot be removed by subsequent filtering.

An answer to the problem came with a new type of screen grid valve whose gain varied very considerably over a wide range of control grid voltage. The valve was the invention of S Ballantine and H A Snow of the Boonton Research Corporation and was announced in December 1930 [15] and was known as a variable-mu tetrode. It was shown that the new valve reduced cross modulation by a factor of 500 over a conventional screen grid valve for an input signal of 200mV.

With an ordinary screen grid valve the wires that form the control grid have a uniform spacing. When a voltage is applied to the grid a more-or-less uniform electric field is set up between the grid and cathode.

Because of this a variation of grid voltage only results in a gain variation of about two to one. With the variable-mu valve the spacing of the grid wires is non-uniform, varying from coarse to fine along it length. This has the effect that the gain of the valve is high for small values of negative grid bias and low for high values of grid bias, with an overall variation of at least 100 to 1.

Apart from the improvement in cross modulation, the variable-mu valve provided a simple means for controlling the gain of a receiver—merely by varying the grid bias of the r.f. amplifier valves (or in the case of the superheterodyne receiver, the i.f. amplifier and frequency changer valves).

The first British variable-mu valve was the Marconi-Osram VMS4 that appeared in 1931. Valves of this type were very quickly designed into new receivers and gave a further improvement in overall performance.

Although the pentode first appeared in 1927 it was a few years before types were produced for use in r.f. amplifiers. The first of these was the Cossor MS/PenA that was announced in May 1930. This did not find much application and was the sole example until 1933 when Mullard announced the SP4 and VP4, the latter having a variable-mu characteristic.

Frequency changers [16,17]

Frequency changing is a fundamental requirement for superheterodyne receivers, where the incoming signal is converted to a fixed, intermediate frequency. At this intermediate frequency (i.f.) the signal is then amplified within a bandwidth that suits the signal requirements, after which it is demodulated and passed to the audio amplifier.

The process of frequency changing requires a local oscillator, whose frequency tracks that of the incoming signal with a fixed offset equal to the i.f., and a mixer which combines the input signal (f_s) and local oscillator frequency (f_o), to produces sum and difference frequencies at is output ($f_o + f_s$ and $f_o - f_s$). The output from the mixer is then passed to the i.f. amplifier, which is usually tuned to the difference frequency. (For example, suppose the input signal is 1 MHz and the i.f. is 470 kHz, then the local oscillator frequency will be 1.470 MHz; and if the input is changed to 1.2 MHz, then the local oscillator will be tuned to 1.670 MHz.)

Early superheterodyne receivers used the bi-grid valve such as the Cossor 41MDG or the Mullard PM1DG for frequency conversion, these both being introduced in 1931. With this valve, the r.f. input signal was usually applied to the inner grid and the heterodyne frequency generated by feedback from the anode to the outer grid. Sometimes a separate triode oscillator was used, the output being fed to the outer grid. An alternative to the bi-grid was a tetrode or pentode, either using a separate triode oscillator or as an autodyne type of self-oscillating mixer.

From 1933 onwards several multi-electrode valves became available that could carry out the dual function of local oscillator and mixer and were far more effective than the bi-grid: these were known as frequency changers. Basically there were three types:

- The heptode (known as the pentagrid in the US) and the octode.
- The triode pentode.
- The triode hexode and triode heptode.

The heptode first appeared on the American market in 1933, where it was known as the pentagrid because it had five grids, one of these being used as an anode for the oscillator circuit. Initially there were two types, both introduced by RCA: the 2A7, which had a 2.5-volt heater, and the 6A7 with a 6.3-volt heater. The first British heptode was the Ferranti VHT4 which appeared late in 1933. This valve was similar to the 6A7 except that it had a 4-volt, 1-amp heater. A variation of the heptode was the octode, which had the addition of a suppressor grid.

The first British triode pentode was the Mazda AC/TP, which was announced early in 1934. With this valve the triode was used as an oscillator and the pentode as a mixer.

The triode hexode was developed by Karl Steimel of the German AEG-Telefunken Company. The first two Telefunken-Valvo triode hexodes to be released were the ACH1 (with a 4-volt heater) and the BCH1 (with a 24-volt heater), both of which were in production by mid-1934. The Lissen Company produced the first British triode hexodes late in 1934. There were two types: the FC2, a battery valve with a 2-volt filament, and the indirectly heated ACFC, which had a 4-volt heater.

A variation of the triode hexode was the triode heptode, which, like the octode, had the addition of a suppressor grid.

Tuning indicators [18]

A tuning indicator is a device that gives a visual indication of the signal strength. An early type of tuning indicator was announced by STC in 1933 and was given the name 'Tunograph'. In effect it was a small cathode-ray tube, where the electron current from the cathode was focused into a narrow beam and passed through a hole in the anode to a fluorescent screen. A pair of plates was used to deflect the spot and this deflection depended upon the signal strength.

In 1934 the GEC Company produced a neon tuning indicator which they called a 'Tuneon'. Cossor also produced similar neon tuning indicators about the same time.

In 1935, an improved form of cathode-ray tuning indicator was introduced in America by the RCA Company. This, the 6E5G, had a sharp cut-off triode within the valve, and the focused beam formed a fan-shaped shadow on a fluorescent screen at the top of the envelope. With a very weak signal the width of the shadow was wide, and this narrowed as the signal strength increased. This type of tuning indicator became known as a 'magic-eye'. The first British magic-eye was the Mullard TV4, introduced in the autumn of 1936.

Thyratron [19]

The thyratron is a gas-filled triode, which behaves as a switch, and was an invention of A P Hull of the US General Electric Company in 1928. With the thyratron, if the anode voltage is slowly increased from zero, then, at first, the anode current increases in a similar way to a high-vacuum triode and may be controlled by a negative potential on the grid. At some critical voltage, which depends on the grid potential, the gas becomes ionized and a discharge takes place between the anode and cathode. At the same time, the grid becomes surrounded by a sheath of positive gas ions, which prevents it from having any more control of the anode current. The only way the discharge can be stopped is by reducing the anode voltage to a suitably low level—typically 10 to 20 volts, depending on the gas used. Early thyratrons were filled with mercury vapour and later types used argon or helium

The thyratron found many applications in industrial process control, but an important use was in scanning circuits of pre-WW2 cathode-ray oscilloscopes and the frame and line time bases of television receivers developed for the new high-definition service that commenced in 1936.

Structural and performance improvements

The construction of the early bright emitter valves, such as the type R, was based very much on the manufacturing methods of incandescent lamps: they had spherical bulbs and the lead-out wires from the electrode assembly came out though a glass stem with a pinch seal. Thick wire rods supported the grid and anode electrodes, whilst the filament was a straight tungsten wire, usually spring-tensioned at one end to allow for expansion when it became hot. This type of construction was adequate for the low gain valves and insensitive receivers in use at the time but, with the introduction of the dull emitter and the screen grid, the gain of the valves increased and it became possible to design more sensitive receivers having stable r.f. amplifiers. With these new types of valves the cylindrical anode and helical grid of the earlier types gave way to a box construction and the filament became an inverted V-shape, rather like a hairpin. The electrodes were also made more rigid, with the filament supported along its length and a mica bridge inserted at top and bottom of the overall assembly. All this helped to reduce any minute movement of the electrodes caused by shock or vibration, thus minimizing microphony effects.

As additional electrodes were added it became necessary to increase the number of pins in the base but, for many years, apart from incremental improvements, the basic design remained unchanged. One innovation of the M-O Valve Company was to adopt an outer metal casing above the glass base, which formed the anode—a construction copied from that used on many of their transmitting valves but this proved unsuccessful because the manufacturing costs were too high. (Other metal envelope valves, such as those introduced in America in 1935 and having octal bases, were far more successful and continued in manufacture into the 1960s.)

By the mid-1930s commercial radio services began to operate in the h.f. and v.h.f. bands of 3–30 MHz and 30–300 MHz and experiments were already being made in frequencies above this in the u.h.f. band. Another important milestone was the opening of high definition television in 1936 from Alexandra Palace: this operated at a carrier frequency of 45 MHz and required a bandwidth of around 3 MHz. The existing types of valve were not capable of operating at frequencies much above 30 MHz and new a new type of construction was required to minimize the transit time of the electron path from the cathode to the anode, and to reduce the inductance of the internal connecting leads from the valve pins to the electrodes. In America, the first valves capable of working at these higher frequencies were the 'acorn' range, consisting of a triode, a pentode and a variable-mu pentode. These tiny valves were introduced in 1933; they had considerably reduced electrode spacing and very short connections to wire pins that were sealed through the glass envelope.

A further innovation, made by MOV in 1933 with their Catkin valves, was to eliminate the pinch seal. Further improvements were made by RCA and, later, the Dutch Philips Company, where the electrode assembly was mounted close to a glass base through which the connecting pins passed. Apart from the Catkins, which were not commercially viable, the first two valves to be introduced in Europe using this 'pinchless' type of construction were the EE50, in 1938, and the EF50, a year later. Both these valves were designed for use in television receivers, but the EF50, together with improved variants, was used in huge quantities during WW2 in allied radar equipment. As with the earlier acorn valves, the electrode spacing was reduced to minimize transit time.

Radar requirements during the war years provided an enormous incentive to produce valves for operation in the v.h.f., u.h.f. and microwave bands. For frequencies up to around 300 MHz the types of valves already described were just about adequate but for higher frequencies entirely new types were required. Of particular note were the disc-seal valves, normally used as grounded-grid amplifiers or oscillators. These were designed by the STC Company and first appeared in 1941. Further types were manufactured by Mullard and MOV. Conventional valves were not capable of operation at microwave frequencies and for these bands (above 3 GHz) magnetrons and klystrons were used as high-power oscillators in radar equipment. Neither of these two classes of valve is dealt with in this book.

More details of the higher frequency valves can be found in Chapter 15.

Valve bases

Most of the early receiver valves used the standard British 4-pin base (B4) and this was adequate for the triodes and rectifiers (although for half-wave rectifiers one of the pins was often removed). The B4 base continued in almost sole use until 1927 when the tetrode and indirectly heated valves appeared. For the screened-grid valves a top terminal was added for connection to the anode and for the indirectly heated triodes an additional pin was added to the base, located roughly at the centre, and provided a connection for the cathode lead. For output pentodes the screen grid connection was made to a side terminal and the suppressor grid was internally connected to the filament or cathode sleeve.

By 1933 the r.f. pentode and other multi-electrode valves began to appear and this necessitated a further increase of pins to seven and several of the valves with 5-pin bases and side-terminal were provided with an alternative of a 7-pin base. A 9-pin base appeared in 1934 for some valves such as triode pentodes and QPP double pentodes but these were not widely used.

The British 4-, 5-, 7- and 9-pin bases were never used on American valves. Instead they had there own bases. The 4-pin UX type had two larger diameter pins for the filament connections. The 5-pin base had pins of equal diameter, whereas the 6- and 7-pin bases also had two pins of larger diameter. Most of the US receiver valves imported into the UK in the 1920 and 1930s used these bases. However there was a major shift after 1935 when the international octal base was introduced and this type was soon adopted by most of the British valve companies, starting with MOV. Mazda, however, was an exception with their variant of the octal base.

Two other bases that appeared on the US market in the late 1930s were the 8-pin Loctal and 7-pin B7G. In the UK the Loctal base became known as the B8B and was used on the Brimar 1.4-volt 1L-series and the 6.3-volt 7-series of valves. The B7G, although used during the WW2 years on some of the British-made US valves, was not used on British valves until 1947, with the one exception of the Mullard EB91double diode of 1946.

One other base of special note is the 9-pin B9G which was introduced by the Philips Company for their EE50 and EF50 television valves. The nine pins were sealed through a glass base and the internal glass stem dispensed with, allowing the electrode assembly to be mounted close to the base.

Various other types of base were introduced for miniature valves, such as those used for hearing aids, and special larger types were adopted for many of the higher-power valves. For further details see the Valve Data Supplement.

REFERENCES

1. Thrower, Keith R, *History of the British Radio Valve to 1940* (MMA International Ltd., 1994, ISBN 0-952-0684-0-0). Now out of print.
2. Ibid, p. 96
3. Ibid, pp. 89–92.
4. Ibid, pp. 35–7.
5. Wehnelt, A, German patent DE 157,845, Klasse 21g, app. 15 January 1904, Iss. 13 January 1905.
6. Thrower, op. cit., pp. 45–49.
7. Robinson, E Y, British Patent GB 278,787, App. 7 July 1926, iss. 7 October 1927.
8. Thrower, op. cit., pp. 55–9.
9. British Patent GB 287,958, App. 24 December 1926, Iss. 26 March 1928.
10. Thrower, op. cit., pp. 62–3.
11. Bull, C S and Rodda, S, British Patent GB 423,932, app. 2 August 1933, iss. 2 February 1935.
12. Schade, O H, 'Beam Power Tubes', *Proc. IRE*, **26**, No. 2, February 1938, pp. 137–81.
13. Harries, J H O, 'A New Power Output Valve' *W.W.*, **34**, 2 August 1935, pp.105–6.
14. Thrower, op. cit., pp. 63–6.
15. Ballantine S, & Snow, H A, 'Reduction of Distortion and Cross-Talk in Radio Receivers by means of Variable-mu Tetrodes, *Proc. IRE*, **18**, No. 12, December 1930, pp. 2102–27.
16. Thrower, op. cit., pp. 66–8.
17. Witts, Alfred T, *The Superheterodyne Receiver*, 5th Edition (Sir Isaac Pitman & Sons Ltd, 1942).
18. Thrower, op. cit., pp. 69–71.
19. Hull, A W, 'Gas-Filled Thermionic Tubes, *Trans, AIEE*, **47**, No. 3, July 1928, pp. 753-63.

Year	Valve Development	Examples of new valve types	Notes & related developments
1925/26	Oxide-coated filament	Mullard PM Series Cossor Point One and Stentor range	Original work of Wehnelt in 1903. Cossor 'Wuncell' range of 1924
1926	Screen grid tetrode		Patented by H J Round and the Marconi Company. Parallel work by Hull & Williams of GE
1926	Pentode		Patented by Holst and Tellegen of the Dutch Philips Company
1927	Indirectly heated cathode	Marconi-Osram KL1 and KH1 Cosmos AC/G and AC/R	Slip-coated cathode patent of E Yeoman Robinson and Cosmos Company
1927	Commercial screened grid tetrode	Marconi-Osram S625, RCA UX222	
1927	Philips output pentode	Philips B443	
1928	First British output pentodes	Mullard PM22 and PM24	
1928	Thyratron		Invented by Hull of Western Electric
1929	Indirectly heated screened grid valve	Mullard S4V	
1930	Indirectly heated output pentode	Mazda AC/Pen	
1930	First r.f. pentode	Cossor MS/PenA (not commercially successful)	
1930	Variable-mu tetrode	Arcturus 551 (later 35/51)	Developed by Ballantine and Snow of Boonton Research Corporation
1931	British variable-mu tetrode	Marconi-Osram VMS4 Mullard MM4V	
1932	Hexode mixer	Telefunken RENS1234 in 1933	Developed by Steimel of Telefunken
1933	Pentagrid converter (frequency changer)	RCA 2A7 & 6A7 Ferranti VHT4	Developed by RCA
1933	Beam tetrode	Marconi N40 in 1935 RCA 6L6 in 1936 MOV KT66 in 1937	Patented by Bull & Rodda of EMI
1933	Metal Valves	Marconi-Osram Catkins US metal valves by RCA in 1935 Philips and Telefunken valves in 1938	
1934	Acorn valve	RCA triode 955, 954 pentode and 956 VM pentode in 1935	
1934	Triode pentode frequency changer	Mazda AC/TP	
1934	Triode hexode frequency changer	Telefunken ACH1 & BCH1 Lissen FC2 & ACFC	Developed by Steimel of Telefunken
1935	Critical Distance Tetrode	Hivac AC/Y, AC/Z, Y220, Z220, etc.	Patented by J H Owen Harries
1935	Miniature valves	Hivac 'X' Series	
1935	'Magic Eye' cathode-ray tuning indicator	RCA 6E5	
1938	Valves dispensing with the pinch seal. All leads sealed through glass button base	US Loctal, Telefunken metal valves and Philips/Mullard EE50 (and EF50 in 1939)	
1941	Disc-seal triode	S25A (CV16)	Developed at STC during WW2

Table showing principal low-power valve developments in the period 1926 to 1941.

Chapter 2

Associated Electrical Industries Ltd. (AEI)

(Trade names: BTH, Cosmos, Ediswan, Mazda)

Associated Electrical Industries Ltd. (AEI) was formed in 1928 by the merger of British Thomson Houston Ltd (BTH), the Edison Swan Electric Company Ltd (Edison Swan) and Metropolitan Vickers Ltd (Metrovick).

British Thomson-Houston Ltd. commenced R-valve production in 1916. All the valves were manufactured by the Mazda Lamp Works at Rugby. Initially the company used the brand name BTH, but later valves used the brand name MAZDA (the mythical goddess of light). After the AEI merger, the company ceased manufacture of radio valves and concentrated on special devices, such as thyratrons and magnetrons.

Metropolitan Vickers Co. Ltd. commenced R-valve production a year later than BTH. For the first few years, production was concentrated at their Trafford Park plant in Manchester. It was here that the SHORT PATH series of valves was developed, which was introduced in 1925. The special feature of these was the reduced spacing between the filament and grid electrodes, which improved the mutual conductance. Several years earlier, in 1917, Metrovick acquired a lamp factory at Brimsdown, not far from the Edison Swan Ponders End plant. A German company had owned the factory, but it was sequestrated by the British Government under special war powers. The factory was re-named the Cosmos Lamp Works; valve manufacture was transferred to this plant by 1925 and within two years the factory was in high volume production. The Metrovick valves used the brand name COSMOS. These were marketed by Metro-Vick Supplies Ltd., but this company ceased trading soon after the AEI merger in 1928. Following the merger, the Metrovick valve manufacturing facilities at Brimsdown were taken over by Edison Swan.

Edison Swan Electric Co. Ltd. was an important manufacturer of valves during World War I. After the war, the company extended its range of bright emitter types and introduced its first dull emitter, the ARDE, in 1923. The company also manufactured valves for Marconi's up until the formation of the Marconi-Osram Valve Co. Ltd. in 1919. Prior to the AEI merger, the valves were manufactured at Ponders End with the brand name EDISWAN. (Some valves up to 1923 were marked ROYAL EDISWAN.) In 1929, the year after the AEI merger, the Cosmos Lamps works at Brimsdown was transferred to Edison Swan to work in conjunction with their factory a mile down the River Lea at Ponders End. From this time the BTH brand name MAZDA was used, although the EDISWAN name was retained for high power and industrial valves—also for valves sold into some overseas territories. In 1940, a 'shadow factory' was built at Baldock as an insurance against enemy bombing, but this was closed in 1946. From this time the main production of radio valves was at Sunderland, where a reserve factory had been built three years earlier. By 1955, this new facility was producing some 12 million MAZDA radio valves per year and employing a staff of about 1000.

Thorn took over Brimar in 1957 and soon after acquired AEI. Subsequently a new company, Thorn-AEI Radio Valves & Tubes, was formed which then became Thorn Radio Valves & Tubes. Production of valves at Brimsdown ceased in 1968 and at Sunderland in 1976.

The late Brian Munt, who was Editor of the Company's publications from 1960 to 1972, wrote an excellent article on the early history of Ediswan and Mazda [1].

BTH VALVES

DULL EMITTER TRIODES

B3, B4, B5, B6 and B7 have all been dealt with in Volume 1[‡].

B4H was also dealt with in Volume 1; however, although it was first announced in 1924, it not released until January 1927. It was a general-purpose type for use as an r.f. amplifier, detector or first a.f. amplifier and had a 6-volt, 0.25-amp filament. It was intended to be used with the B4 output valve.

B5H was also released in January 1927. This was a high impedance dull emitter for use as an r.f. amplifier, and having a 2.8-volt, 60mA filament. It was intended to complement the B5 (detector) and B6 (a.f. amplifier/output). Although the filaments for all three of these types were rated at 2.8 volts they normally were used either with a four-volt accumulator, in conjunction with a filament rheostat, or with dry cells.

B8 was a very high impedance type for use in resistance-capacitance-coupled (RCC) audio amplifiers, thus eliminating the need for an expensive intervalve step-up transformer. It had a 6-volt, 0.12-amp filament and was released in March 1927.

B11 and B12 were both output valves and released in 1927. The B11 had a 6-volt, 0.5-amp filament, whereas the B12, a so-called 'super-power' valve, had a 7.5-volt, 1.25-amp filament.

COATED FILAMENT TRIODES

The first three BTH oxide-coated filament valves were released in July 1927. In October a further three appeared and these used nickel wire for the filament instead of the more usual tungsten. All six were of the two-volt class.

B21, B22 and B23. The B21 was a medium impedance type for use as an r.f. amplifier or detector, the B22 was a general-purpose type and the B23 a low impedance type intended for power amplifying.

B210H, B210L and B215P. The B210H had very high impedance and could be used either as an r.f. or RCC audio amplifier. The B210L was intended as a detector and the B215P was a low impedance output valve. It must be assumed that these were intended to supersede the earlier three.

Unified Range. This range of 16 types were released in 1928 with the BTH label but were later re-issued as Mazda (see Table 2.1 below).

Type	Filament		Application
	Volts	Amps	
GP210	2.0	0.10	General purpose
GP407	4.0	0.07	General purpose
GP607	6.0	0.07	General purpose
HF210	2.0	0.10	RF amplification
HF407	4.0	0.07	RF amplification
HF607	6.0	0.07	RF amplification
LF215	2.0	0.15	AF amplification
LF407	4.0	0.07	AF amplification
LF607	6.0	0.07	AF amplification
RC210	2.0	0.10	RC amplification
RC407	4.0	0.07	RC amplification
RC607	6.0	0.07	RC amplification
P227	2.0	0.27	Power amplification
P415	4.0	0.15	Power amplification
P615	6.0	0.15	Power amplification
PX650	6.0	0.50	Power amplification

Table 2.1:
BTH nickel filament triodes released in 1928 and then re-issued as Mazda.

‡ See reference 13 on page 334.

DOUBLE TRIODE, BTS.215

At the 1928 Olympia Radio Show BTH exhibited a one-valve receiver, the type VR2 Form C/A (see Figure 2.1). The valve used in this was a double triode having a 4-pin base, with the filament pins common to both triodes, but with the addition of two terminals on the side of the base for connections to anode 1 and grid 2. The receiver was a two-stage set with the valve acting as a detector-a.f. amplifier combination. A photograph of the valve can be seen in Figure 2.2, together with a view showing the internal electrode construction with the a.f. amplifier triode mounted above the detector. The valve was re-issued in 1929 as TS.215 under the BTH Mazda trade name. Figure 2.3 shows a typical receiver circuit using the valve.

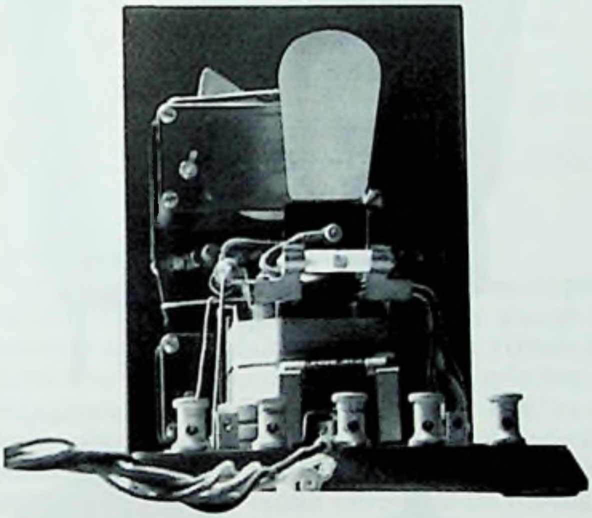


Figure 2.1:
BTH receiver type VR2 with BTS.215 double triode.

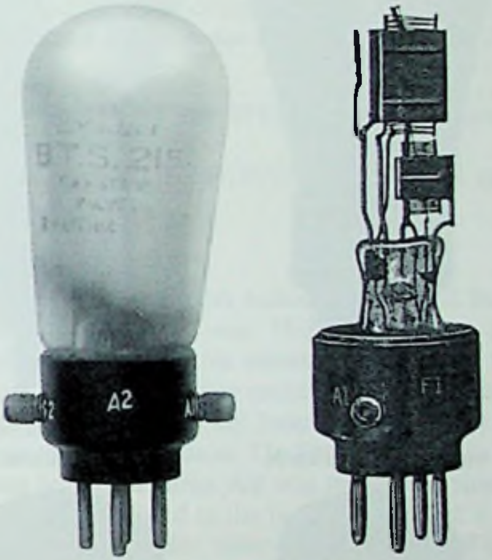


Figure 2.2:
BTS.215 double triode (Ediswan label).

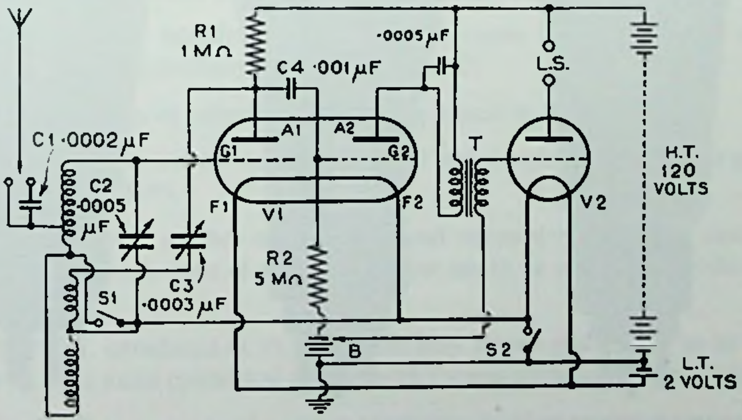
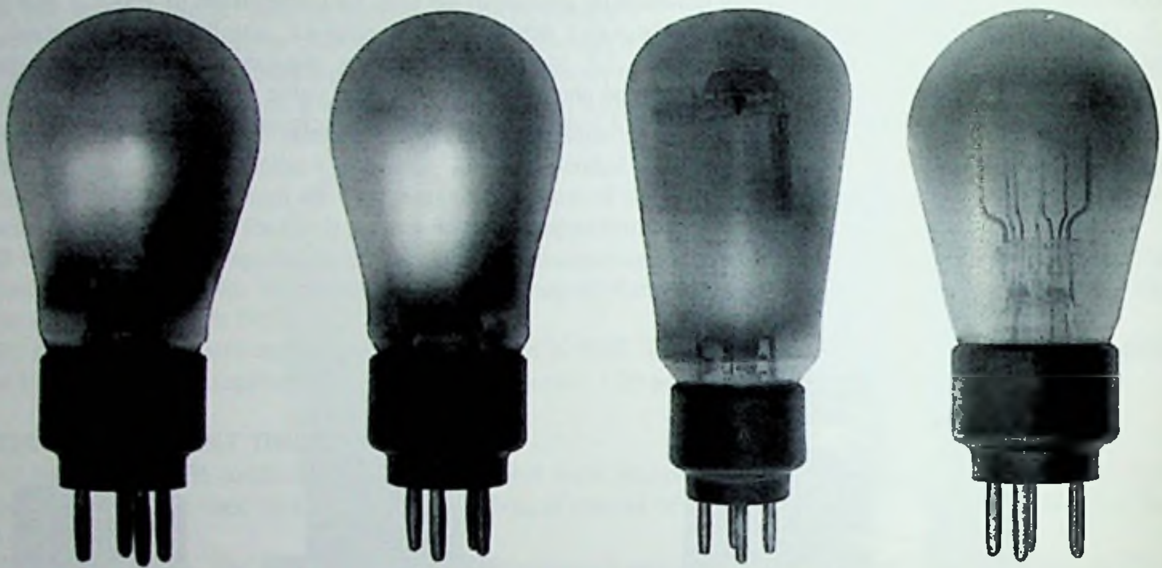


Figure 2.3: Three-stage receiver employing the TS215 valve. (V2 could be either LF215 or P227.)

SCREENED GRID VALVES

BTH introduced its first screened grid valve at the 1927 Olympia Radio Show. Very little is known of this, but it had a 1-volt, 0.1-amp filament, which was most unusual. It does not appear to have been used in any commercial applications. (A photograph of the valve can be seen in the November 1927 issue of the *Wireless Engineer*, page 650.)

Soon afterwards, there was the SG.207 which had a 2-volt, 0.07-amp filament. There was also a BS215 tetrode which came with a 4-pin base and top terminal and also with a special 5-pin base. As with the BTS.215 these were both re-issued in 1929 under the BTH Mazda trade name.

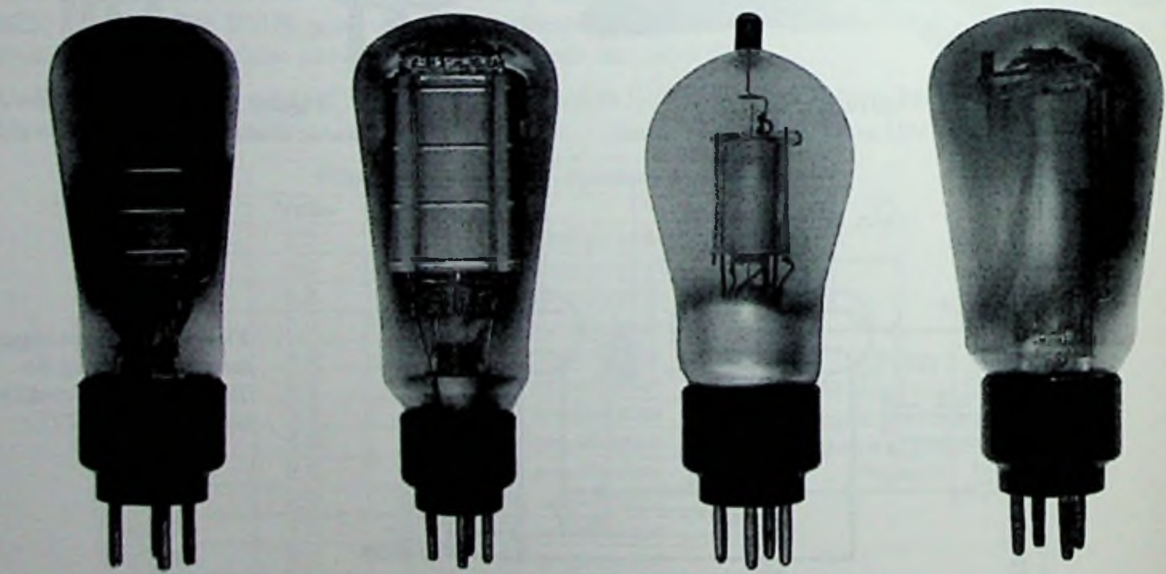


B8: RCC high-impedance triode.

B11: 6-volt, 0.5-amp output triode.

B12: 7.5-volt, 1.25-amp 'super power' triode.

B23: 2-volt. 0.2-amp output triode.



GP607: general-purpose triode with a 6-volt filament.

PX650: 6-volt, 0.5-amp output triode.

S.G.207 screen grid tetrode of 1928.

RH1*: half-wave rectifier.

Figure 2.4: Some examples of BTH valves.

*The RH1 rectifier had a 7.5-volt, 1.25-amp thoriated filament and was intended for battery eliminators. It was re-issued under the Mazda trade name as U65/550.

COSMOS VALVES

DIRECTLY HEATED TRIODES

By 1925 Cosmos was using the term 'Short Path' to indicate that its new valves had enhanced performance due to the closeness of the grid electrode to the cathode, made possible by the introduction of the dull emitter filament. From this time onwards the type numbers for all the directly heated triodes were prefixed with the letters SP. All the types had either two- or six-volt filaments, unlike most other manufacturers who also had four-volt types. A coloured spot was painted on the valves to indicate their circuit function: blue for RCC amplifier, green for general-purpose, red for power output, and two red spots for super power output. The range consisted of the following types:

***2-volt filaments**:* SP16/B, SP16/G, SP16/R, SP18/B, SP18/G, SP18/R and SP18/RR (a higher power version of the SP18/R, with two red spots).
***6-volt filaments**:* SP50/B, SP50/R, SP55/B, SP55/R; SP60/B, SP610/B, SP610/G and SP610/RR (see Figure 2.6).

INDIRECTLY HEATED VALVES

Metrovick was one of the first British companies to produce valves with indirectly heated cathodes and from the start they used the patented 'slip-coating' process for insulating the heater wire. This technique was the invention of the Metrovick engineer Ernest Yeoman Robinson and involved the successive coating of the heater wire with thin layers of an insulating refractory material. The coated heater could then fit snugly into the cathode sleeve and the whole assembly could be reduced in diameter to only 1mm. This resulted in a highly efficient cathode with excellent thermal conduction from the heater element. The first two valves to be produced were the AC/G and AC/R, both with 4-volt, 1-amp heaters, a rating that was to become almost universal for indirectly heated valves until the 6.3-volt heater was introduced in the late 1930s (Figure 2.5).

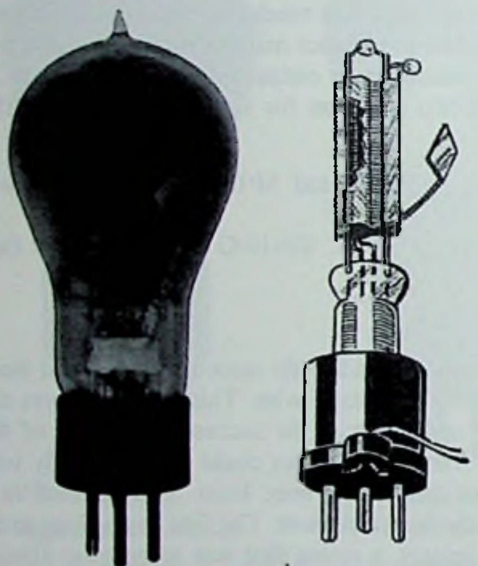
Altogether there were six types, comprising two general-purpose triodes, three output triodes and one screen grid tetrode. They all had a special 5-pin base—three of these pins occupied the normal positions of anode, control grid and filament (except that this pin was connected to the cathode), and there were two further, shorter pins, which were connected to the heater:

> The AC/G was introduced at the 1927 Olympia Radio Exhibition and was a general-purpose triode, although normally used as a detector [2].
>
> The AC/P1 was an output triode, which appeared in 1928.
>
> The AC/P2 was similar to the AC/P1 but had a higher output power and was intended for public address amplifiers.
>
> The AC/R was another output triode and released at the same time as the AC/G. It had the remarkably high slope of 4 mA/V, a figure not to be exceeded by other manufacturers for several years.
>
> The AC/S, introduced in 1929, was the only screen grid tetrode to be produced by Metrovick. It had a large metal cylindrical top cap with a screw terminal for the anode connection.
>
> The AC/X was a general-purpose triode but its characteristics were considerably inferior to the AC/G.

In Figure 2.5 can be seen a diagram of the cathode assembly and, at the base, there is a Bakelite adapter which slips over the three long pins but makes connections to the two short heater pins: this enables the heater to be brought out on two flying leads. The valve could then be plugged into a standard 4-pin base and used as a replacement in battery receivers with the minimum of re-wiring.

The AC/R can be seen in Figure 2.5 and three further examples of these valves in Figure 2.6, including the AC/S r.f. tetrode.

Following the formation of AEI, several of these valves were re-labelled with the Mazda trade name and the base changed to the standard four-pin, B4 type with a side terminal for the cathode connection, although in some instances the earlier Cosmos C5 base can be found. Brief details of these type changes are shown in Table 2.2.



Cosmos adapter for B4 base.

Cosmos type	Mazda type	Class
AC/G	AC/HL	Detector triode
AC/P1	AC/P1	Output triode
AC/S	AC/SG	RF tetrode
AC/R	AC/P	Output triode

Figure 2.5: (Left) AC/R output triode of 1927. (Middle) cathode assembly of Cosmos AC valves. (Far right) base adapter to enable the valve to plug into a standard 4-pin base.

Table 2.2: Cosmos valves and the new Mazda type designations of 1929.

DIRECTLY HEATED RECTIFIERS

Altogether Metrovick produced four mains rectifiers: three half-wave and one full-wave. Two of these, SP41/U and SP42/U, were introduced in 1927 and the other two, SP43/U and SP45/U, in late 1928 or early 1929. The first three of these were originally directly heated but these were converted to indirectly heated cathodes at the time of the changeover to Mazda when their type designations were also changed. The fourth type, the SP45/U, was discontinued (see Table 2.3).

Cosmos type	Mazda type	Class
SP41/U	U30/250	Half-wave
SP42/U	UU60/250	Full-wave
SP43/U	U75/300	Half-wave
SP45/U	Discontinued	Half-wave

Table 2.3: Cosmos and Mazda type designations for rectifiers.

SP610/RR:
6-volt output triode.

AC/P1:
output triode.

AC/X:
general-purpose triode.

AC/S:
r.f. tetrode.

Figure 2.6: Various Cosmos valves of 1928/29.
(All, except the SP610/RR, have the special Cosmos 5-pin base, C5.)

EDISWAN VALVES

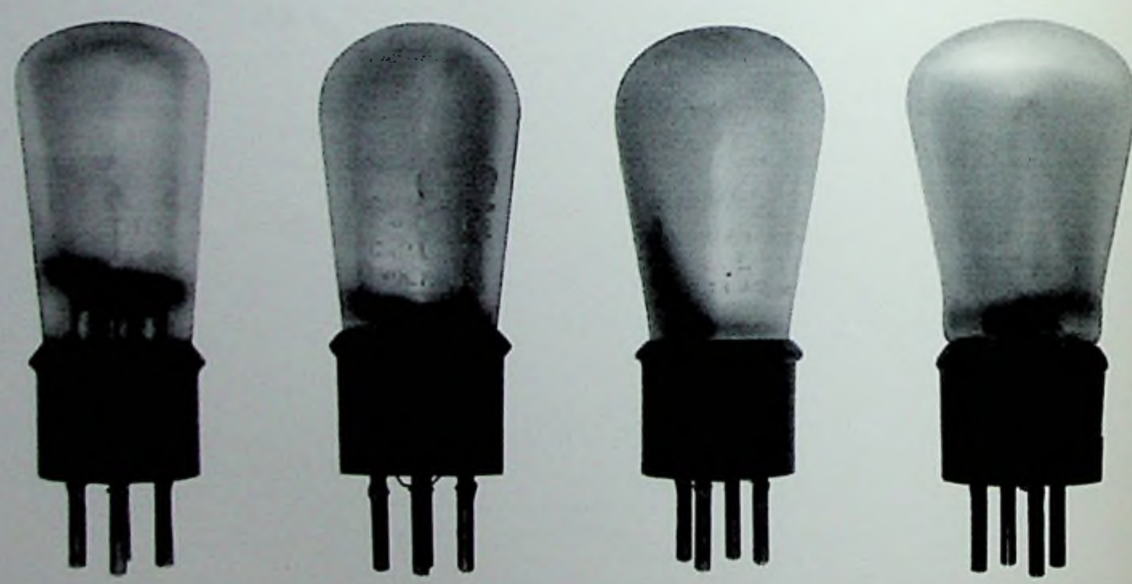
DULL EMITTER TRIODES

D.R.2, G.P.2, R.C.2 and G.P.4 (see Figure 2.7). These four valves were introduced over the period 1926 to 1927. The first three have 2-volt, 0.1-amp filaments and the last of these a 4-volt, 0.15-amp filament.
The D.R.2 was specially designed as a detector, but could also be used as an a.f. amplifier.
The G.P.2 was designed for use as both an r.f. and a.f. amplifier.
The R.C.2 was a very high impedance valve intended for use in RCC a.f. amplifiers.
The G.P.4 was a general-purpose valve specially designed for low microphony. It was recommended for use as an r.f. amplifier, detector or a.f. amplifier.
P.V.2. The original version of this output valve appeared in 1924 and had a 6-volt bright emitter filament. It was re-issued in late 1926 or early 1927 with a 2-volt, 0.15-amp thoriated filament and then in the following year with a coated filament having the same rating. It was designed as a companion to the G.P.2 and D.R.2.
P.V.4 was an output valve having a 4-volt, 0.35-amp filament, giving a higher output than the P.V.2. Its companions were the G.P.4 or the earlier bright emitter types, A.R. and R.

(For types P.V.5, P.V.6 and P.V.8 see Volume 1.)

COATED FILAMENT TRIODES

P.V.2. As was mentioned above, this output valve was re-issued initially with a thoriated tungsten filament. In its new, improved form the valve had a lower impedance and slightly higher mutual conductance, making it more suitable for loudspeaker use. Also its filament was changed to an inverted 'V' shape and both the anode and grid were flattened. (Photographs of the P.V.2 and P.V.4 can be seen in Figure 2.7.)



D.R.2: detector or a.f. triode. (The G.P.2 looks similar.)
R.C.2: RCC triode (blue line).
P.V.2: output triode. (Oxide-coated filament.)
P.V.4: (DE) output triode.

Figure 2.7 Examples of Ediswan dull emitter triodes.

E.S.220 was a double triode of very unusual design, as can be seen from the diagrams in Figure 2.8 and in Figure 2.9. The valve has a six-pin base with the electrode assembly supported in the usual way above the glass stem. This assembly has an outer anode, P_2, which surrounds the grid, G_2. The anode of the second valve, P_1, consists of an inner vertical rod which is surrounded by its grid, G_1. There is a common filament consisting of two vertical wires, rated at 2-volt, 0.075-amp.

The valve was produced for a one-valve receiver designed by A H Midgley [3], the circuit of which is shown in the right-hand side of Figure 2.8. This can be seen to consist of an anode-bend detector followed by a resistance-capacitance coupled audio amplifier. Tuning is by the capacitor C_1 in conjunction with the lower coil of the transformer. The upper coil, in conjunction with the capacitor C_2, provides reaction. The receiver was claimed to give excellent headphone reception of many foreign stations and loudspeaker reception up to twenty miles from a main station.

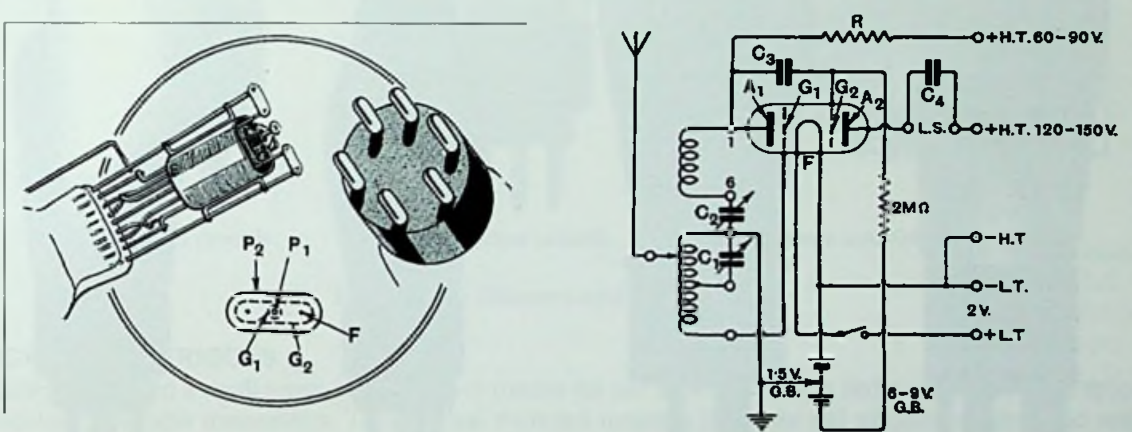


Figure 2.8: (Left) the Ediswan-Midgley E.S.220 double triode. (Right) circuit of the Ediswan receiver.

Unified Range. This range of two-volt, four-volt and six-volt valves with coated filaments was issued in 1928. Brief details are given in Table 2.4.

Type	Filament		Application
	Volts	Amps	
HF210	2.0	0.10	RF amplifier & detector
HF410	4.0	0.10	RF amplifier & detector
HF607	6.0	0.07	RF amplifier & detector
HF610	6.0	0.10	RF amplifier & detector
LF210	2.0	0.10	AF amplification
LF410	4.0	0.10	AF amplification
LF410A	4.0	0.10	AF amplification & output
LF610	6.0	0.10	AF amplification
PV215	2.0	0.15	Output
PV225	2.0	0.25	Output
PV410	4.0	0.10	Output
PV425	4.0	0.25	Output
PV610	6.0	0.10	Output
PV625	6.0	0.25	Output
PV625A	6.0	0.25	Output (m/c loudspeaker)
PV625X	6.0	0.25	Output (m/c loudspeaker)
RC210	2.0	0.10	RC amplification
RC410	4.0	0.10	RC amplification
RC610	6.0	0.10	RC amplification

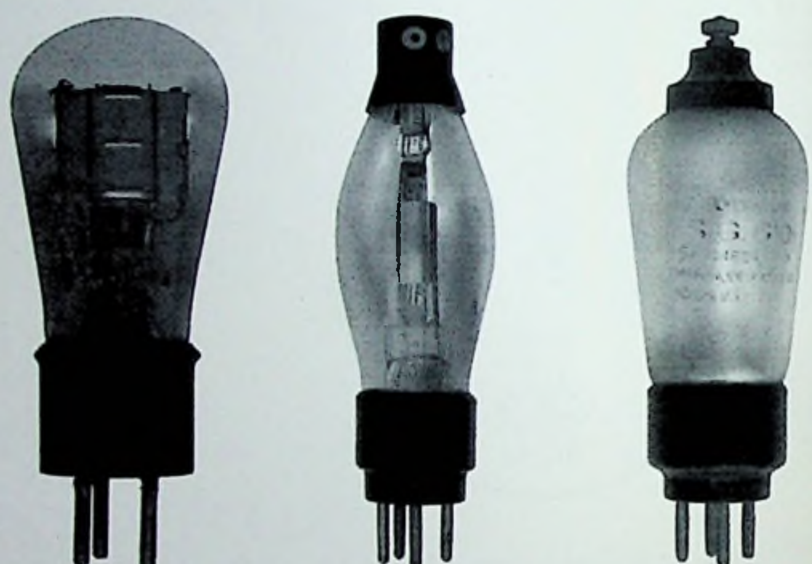
Table 2.4: The Cosmos coated filament valves in the unified 2V, 4V and 6V ranges.

INDIRECTLY HEATED TRIODES

Ediswan produced just four indirectly heated triodes, all of which appeared in 1928. They had 4-pin bases and a moulded Bakelite cap which carried two metal contacts for connection to the heater (see Figure 2.10). The heaters were rated at four volts, one amp. The two base pins which would normally be used for the heater were internally strapped together and connected to the cathode. The reason for this arrangement was to make it easy to substitute the valves into existing battery-operated receivers without the need to re-wire the valveholders. It would then be a simple matter to connect the top terminals to the heater winding of a mains transformer.

ES220:
detector and output.

Figure 2.9: Double triode.



HF410:
r.f or detector triode.

M41LF:
Indirectly heated a.f. triode.

S.G.610:
r.f. tetrode

Figure 2.10: Various later valves.

The MI 41 was the first to be released. This was a low impedance valve, probably most suited for use as a detector or a.f. amplifier. This was soon followed by the MI 41HF, MI 41LF and MI 41RC. The last two letters indicate the class of valve: r.f amplifier, a.f. amplifier and RCC amplifier. It is probable that the original MI 41 and the MI 41HF were the same valve, but in the absence of adequate data it is not possible to be certain about this. Production ceased after the AEI merger.

SCREENED GRID & PENTODE VALVES

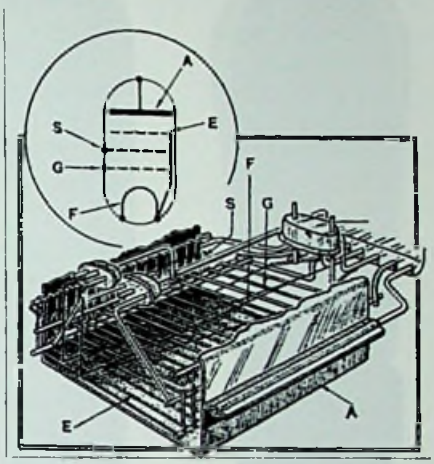
Ediswan introduced a family of three screened grid tetrodes at the 1928 Olympia Radio Exhibition. They all had 4-pin bases and a top terminal for connection to the anode.

These three valves were the 2-volt S.G.215, the 4-volt S.G.410 and the 6-volt S.G.610 (see Figure 2.10). There would also the B.T.S.215, which was probably made by BTH and can be seen in Figure 2.2, but with an Ediswan label. It was re-named TS.215 by Mazda.

Towards the end of 1928 two output pentodes were released. One, the 5E225, had a 2-volt inverted 'V'-shaped filament and the other, the 5E415, a 4-volt 'M'-shaped filament (see Figure 2.11). The valves had a 4-pin base and a side terminal for connection to the screen grid. The suppressor grid was internally connected to one end of the filament. Both types were soon discontinued.

5E225 output pentode.

5E415 output pentode.



Electrode assembly of the 5E415.

Figure 2.11: Ediswan output pentodes of 1928.

HIGH POWER TRIODES

Ediswan produced a small range of high-power triodes for use in public address audio amplifiers or as speech modulators in radio transmitters. They all had thoriated tungsten filaments and graphite anodes. The range consisted of the following types:

ES.60, which had two filaments connected in parallel operating at six volts, four amps, and a maximum anode dissipation 60 watts. The valve had a graphite anode, carbonised thoriated filament and was enclosed in a hard glass bulb. It had an the large 4-pin L4 base. The rated value of anode dissipation was 60 watts, which should never be exceeded.

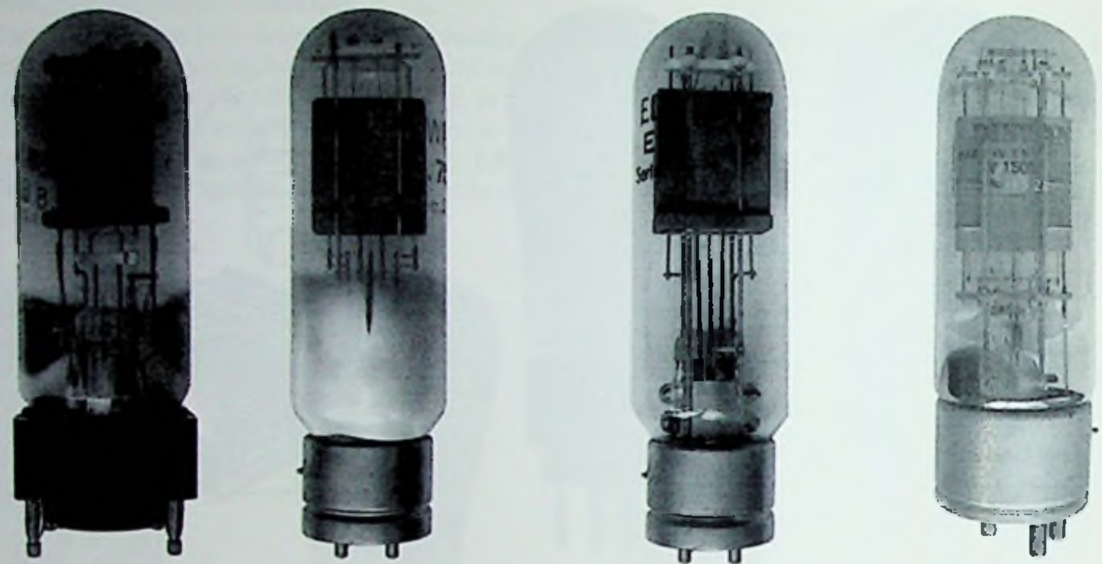
ES.75 was released in 1930. It had a filament rating of ten volts, 3.25 amps and a maximum anode dissipation of 75 watts. When used in single-ended power amplifiers it could deliver an output of 15 watts. The filament current was later increased to 4.2 amps. Like the ES60 the valve had a graphite anode, carbonised thoriated filament and was enclosed in a hard glass bulb. The maximum anode dissipation was 75 watts.

ES.75H was similar to the ES.75 but had a higher slope. The filament rating was ten volts, 4.2 amps. Both the ES.75 and ES.75H were fitted with the large American 4–pin base (British B4F base).

ES.100 was released in 1936. It had a 6-volt, 3-amp filament and a maximum anode dissipation of 100 watts. The valve could deliver an output power of 30 watts. The ES.100 was an equivalent of the Mullard MZ1-100; it was fitted with the L4 base. It construction was similar to that of the ES75.

V1505 was a very high-power valve having a 14-volt, 6.5-amp filament and a slope of 7mA/V. Apart from use in large public address amplifiers it was also used in transmitting equipment. In the late 1950s it appeared with a GEC label and was shown to deliver an output power of 450 watts in Class AB1 push-pull or up to 1100 watts in Class AB2 push-pull.

Some examples of these valves can be seen in Figure 2.12.



ES60: power triode having a 60-watt anode rating.

ES.75: power triode having a 75 watt anode rating.

ES75H: higher slope version of the ES75.

V1505 power triode with 300 watt anode rating.

Figure 2.12: Various directly heated power triodes.
(Note the three different types of base: L4, B4F & USL4b.)

MERCURY VAPOUR RELAY TYPE MR/AC.1

This was a thyratron valve designed for use in the timebases of oscilloscopes and early television receivers (before the introduction of the EMI 405-line system). A helium-filled type HE/AC.1 was also available where a higher speed timebase was required. A photograph of the MR/AC1 can be seen in Figure 2.13. (The HE/AC.1 is similar.)

The MR/AC.1 was superseded by the Mazda T11 and the HE/AC.1 by the T31.

MERCURY VAPOUR RECTIFIERS

Ediswan produced a range of high-power, half-wave, mercury vapour rectifiers for use with public address amplifiers and radio transmitters. The MU.1 (Figure 2.14) was rated at 1.5kV and a rectified current of 250mA. The MU.2 was a lower power valve which, initially, had a 4kV rating and was more suited for the e.h.t. supply of oscilloscopes. Later, the filament current of the MU.2 was increased from one amp to 3.1 amps and its peak inverse anode voltage increased to 12.5kV, allowing the valve to be used for the e.h.t. supply of television receivers. If either of these valves were to be used at full operating current it was essential to include a thermal delay switch to allow the cathode to reach its operating temperature before the anode voltage was applied.

The higher power rectifiers were the ESU.75, ESU.150 and ESU.300. The ESU.75 had been developed specially for use in conjunction with the ES.75 and ES.75H power triodes and was fitted with a large Edison screw base. It had a 2-volt, 8-amp filament, maximum inverse voltage of 3kV and a peak current of 900mA. The ESU.150 had a 4-volt, 10-amp filament and could deliver a peak current of 1.8 amps. It also had a large Edison screw base. The ESU.300 had a 4-volt, 16-amp filament and a peak current rating of 3.5 amps. It was fitted with the 'Goliath' valve cap. The maximum inverse anode voltages for the ESU.150 and ESU.300 were 5kV and 7kV respectively.

Figure 2.13: Ediswan MR/AC.1 mercury vapour relay (thyratron).

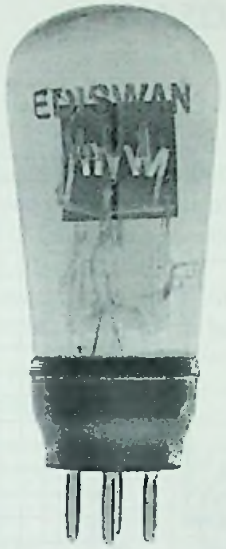


Figure 2.14: MU1 mercury vapour rectifier.

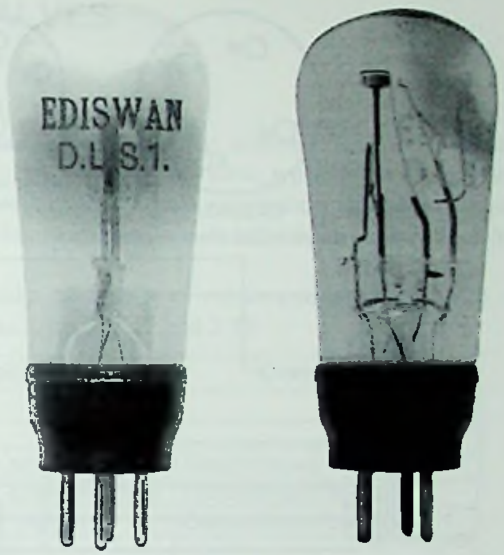


Figure 2.15: Ediswan vacuum thermal delay switches. (Left) DLS.1 and (Right) DLS.10 with its later B4 base.

VACUUM THERMAL DELAY SWITCHES

Ediswan produced two thermal delay switches for use in h.t. power supplies: these were the DLS.1 and DLS.10 (see Figures 2.15 and 2.16). They were vacuum types and designed to overcome the shortcomings of bi-metallic strip delay switches. Both had a small filament mounted vertically on a glass stem adjacent to a thin strip of thermostatic metal, which terminated in a springy contact wire. On application of a current to the filament the metal strip was heated by radiation and curved away from the filament. The contact wires then pressed firmly against a contact ring. On switching off the contact was broken after a few seconds. The switch-on time could be varied up to about one minute for the DLS.1 or five minutes for the DLS.10 by inserting a series resistor in the filament circuit. Table 2.5 shows the ratings and dimensions of the two devices.

Ratings & dimensions	DLS.1	DLS.10 (earlier)	DLS.10 (later)
Filament voltage	3–6	3–6	4
Filament current (amps)	0.6	2.1	1.4
Maximum peak current (low voltage rating)		6.0 amps at 250V	
Maximum peak current (high voltage rating)	200mA at 2kV		
Time delay	Up to 1 min.	Up to 5 min.	
Maximum overall length (mm)	120	140	116
Maximum overall diameter (mm)	35	48	45
Base	B4	US4 (UX)	US4 or B4

Table 2.5: Ratings and dimensions of the Ediswan Vacuum Thermal Delay Switches.

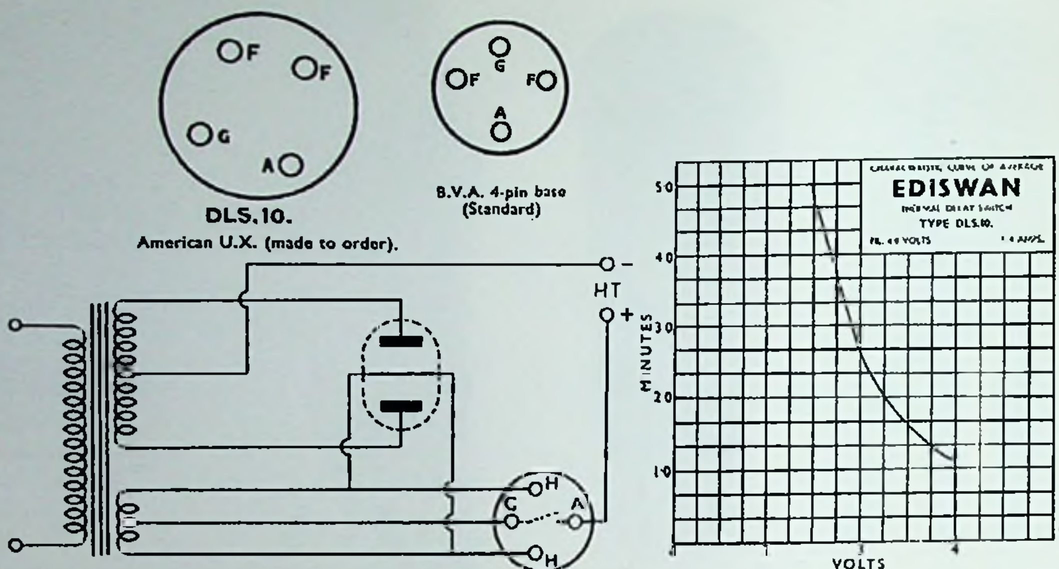


Figure 2.16: Base connections and typical circuit for the DLS1 and DLS10, together with characteristic curve for later version of DLS10.

MAZDA VALVES

EARLY TYPES OF 1928 & 1929

The first valves to be released in 1928 under the new Mazda label were the sixteen BTH triodes shown in Table 2.1 on page 12. These had 2-, 4-, and 6-volt filaments and were of four basic types: general-purpose, r.f. amplifiers, a.f. amplifiers and power output. One of the 6-volt output valves was of the super-power class and designed for use with the newly introduced moving-coil loudspeakers, which required a higher drive power because of their lower acoustic efficiency.

In September of the following year Mazda introduced a new range of valves consisting of the 25 types shown in Table 2.6, some examples of which can be seen in Figures 2.17 and 2.18

Type	Filament		Application	Comments
	Volts	Amps		
2-Volt Range				
H.210	2.0	0.10	RF or RCC amplifier triode	Discontinued by 1932
HL.210	2.0	0.10	RF or RCC amplifier triode	Discontinued by 1934
L.210	2.0	0.10	AF amplifier triode	Discontinued by 1932
P.220	2.0	0.20	Output triode	
P.240	2.0	0.40	Output triode (SP)	Discontinued by 1933
RC.207	2.0	0.07	RCC triode	
230 Pen	2.0	0.30	Output pentode	Discontinued by 1930
215 SG	2.0	0.15	RF tetrode	Was BTH type BS.215 Discontinued by 1930
4-Volt Range				
425 Pen	4.0	0.25	Output pentode	Discontinued by 1930
P.425	4.0	0.25	Output triode (SP)	
6-Volt Range				
H.607	6.0	0.07	RF or RCC amplifier triode	Discontinued by 1930
HL.607	6.0	0.07	General purpose triode	Discontinued by 1930
P.625A	6.0	0.25	Output triode (SP)	Discontinued by 1932
P.625B	6.0	0.25	Output triode (SP)	Discontinued by 1932
P.650	6.0	0.50	Output triode (SP)	Discontinued by 1934
PX.650	6.0	0.50	Output triode (SP)	
AC Range				
AC/HL	4.0	1.0	RF or detector triode	Was Cosmos AC/G
AC/P	4.0	1.0	Output triode (SP)	Was Cosmos AC/R
AC/P1	4.0	1.0	Output triode (SP)	Was Cosmos AC/P1
AC/SG	4.0	1.0	RF tetrode	Was Cosmos AC/S
Special Super Power				
PP3/425 (was B12)	7.5	1.25	Output triode (SP)	Discontinued by 1933
Rectifiers				
UU60/250	4.0	2.0	Full-wave	Was Cosmos SP42/U Discontinued by 1934
U65/550	7.5	1.25	Half-wave	Discontinued by 1933
U30/250	4.0	1.0	Half-wave	Was Cosmos SP41/U Discontinued by 1930
U75/300	4.0	2.0	Half-wave	Was Cosmos SP43/U Discontinued by 1930

Table 2.6: Mazda valves introduced in September 1929.
(Note: SP = Super Power.)

215SG:
2-volt r.f. tetrode.

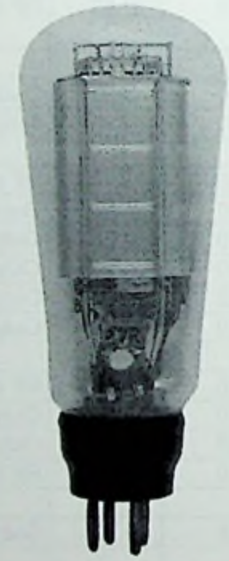
HL210: 2-volt
general-purpose triode.

P220: 2-volt
output triode.

P425: 4-volt
output triode.

425Pen: 4-volt
output pentode.

HL610: 6-volt
general-purpose triode.



P650: 6-volt
output triode.

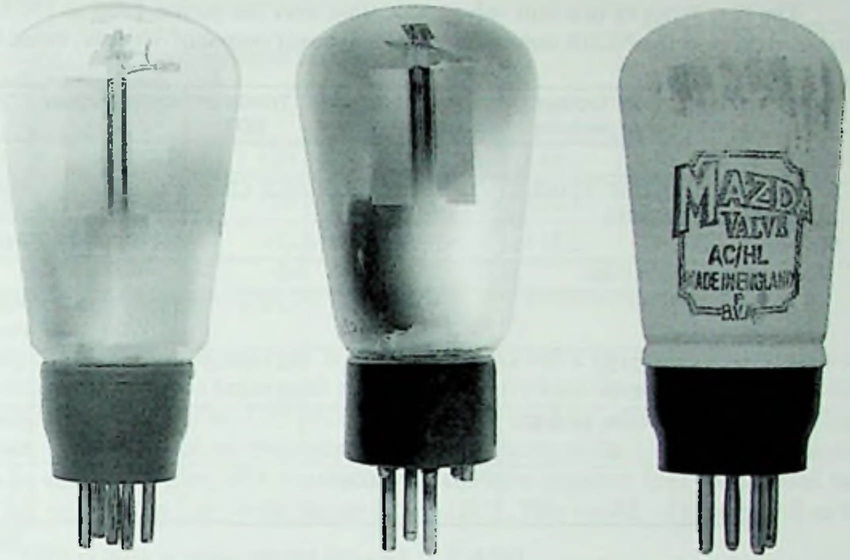
PX650: 6-volt
SP output triode.

Figure 2.17: Typical examples of early Mazda valves of 1929.

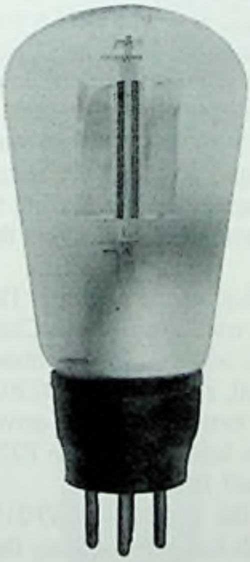
Notes:

1. The 215SG was later re-classified as the SG215.
2. Although not visible in the photograph, the 425Pen has a side terminal for the screen connection. It later became the Pen425.

AC/SG: 4-volt r.f. tetrode. Early example with a top screw terminal.



Three examples of the AC/HL 4-volt detector or a.f. triode. At the left is an early version with the anode opened exposing the control grid. At the centre the valve has a similar electrode structure but note the Cosmos C5 base. At the right is a later metallised version.



AC/P and AC/P1: 4-volt output triodes.

Later version of the AC/P.

PP3/425: 7-5 volt directly heated 3W output triode.

U65/550: half-wave rectifier rated at 550V, 65mA.

Figure 2.18: Early Mazda valves for a.c. operation of 1929.

2-VOLT BATTERY VALVES: 1930–1937

The majority of the battery valves shown in Table 2.6 were either discontinued by 1930 or were only available for replacement purposes. The only type that continued in current production into the mid- to late-1930s was the P220 output triode.

The new types of two-volt valves appearing over the period 1930 to 1937 are shown in Table 2.7. The first of these was the P220A output triode with a power output of 350mW, twice that of the P220.

Year	RF tetrode or pentode	Freq. Changer	Diode	Triode or DDT	Output triode	Output pentode
1930					P220A	
1931	S215A, S215B, SG215			HL2, L2		Pen220 (B4 base), Pen220A (B4 base), Pen230, Pen425 (4V)
1932	S215VM			H2		
1933				L2/DD	P215, PD220, PD220A	Pen220 (B5 base), Pen220A (B5 base)
1934	SP215, VP215	TP22		HL21/DD, L21/DD		QP240 (B9 base)
1936	SP210, VP210					Pen231 QP230 (B7 base)
1937		TP23	DD207			

Table 2.7: Two-volt battery valves of 1930 to 1937.

An entirely new range was introduced in 1931 consisting of three r.f. tetrodes, two triodes and four output pentodes. The r.f. tetrodes were S215A, with a slope of 1.1mA/V, the S215B with a higher slope of 1.7mA/V and the SG215 with a slope of 1.1mA/V (basically the same as the earlier 215SG). The S215A was an improvement on the SG215: it had lower internal capacitance, a higher anode resistance and a metallised coating. The triodes were the general-purpose HL2, which was mainly used as a detector, and the low-impedance L2, which was intended as an a.f. amplifier or a power-grid detector. The output pentodes were the 0.5-watt Pen220, which was particularly suitable for portable receivers, the one-watt Pen200A, the 0.35-watt Pen230 and the short-lived, four-volt Pen425 (previously the 425Pen) with an output power of 0.8 watts. Initially both the Pen220 and Pen220A had 4-pin bases with a side terminal for the screen connection, but 5-pin versions of these were introduced in 1933. The Pen425 also had a 4-pin base and side terminal, but the Pen230 only had a 5-pin base.

The only new types in 1932 were S215VM variable-mu r.f. tetrode and the high-mu, H2 triode. The following year saw the L2/DD double diode triode, the low consumption P215 output triode and the two Class B double triodes, PD220 and PD220A. The PD220 was designed to operate with a low grid bias of about –1 volt and so would be driven into grid current on positive half cycles of the signal, whereas the PD220A required a higher grid bias of –6 volts and so would not normally be driven into grid current. A typical driver valve for the PD220 was the L2 with transformer coupling to the two grids, but for higher power the P220 was preferred as the driver. Examples of the 1930 to 1933 valves are shown in Figures 2.19 and 2.20.

The first battery r.f. pentodes appeared in 1934: these were the SP215 and the variable-mu VP215. There was also the first battery triode pentode frequency changer, the TP22, which had a 9-pin base; this valve was only suitable for operation on the medium and long wave bands for frequencies up to 2MHz. For best performance on these wavebands it was recommended that the oscillator output should be injected into the filament leads via a suitable transformer. Injection in the suppressor grid was also possible at the expense of a lower conversion gain. There were two double diode triodes, the medium impedance HL21/DD and the low impedance L21/DD. Finally there was the QP240 double output pentode for QPP operation. This had a 9-pin base and the two sections of the valve were distinguished by the letters 'A' and 'B' stamped opposite pins 2 and 7. Although the valves were matched before despatch it was recommended that the screen voltages should be adjusted according to the values shown in Table 2.8. To enable this to be done the valves were further marked with a code letter on the base.

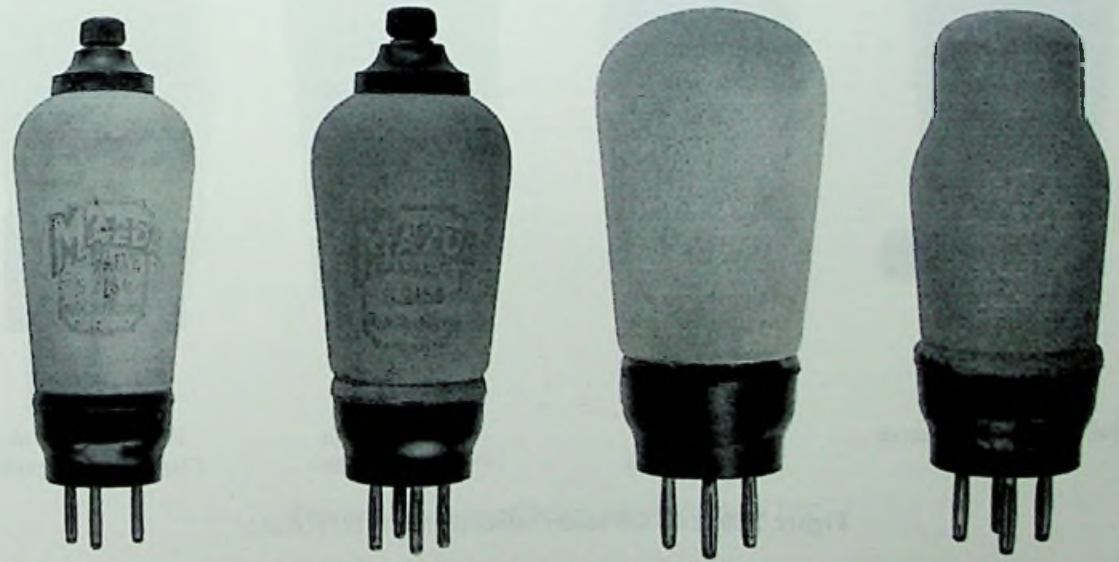
Anode voltage	Grid bias	Screen voltages for code letters					Anode to anode load	Quiescent anode current
		P	Q	R	S	T	(ohms)	mA
150	–11.5	112.5	121.5	130.5	139.5	148.5	15,000	4.0
135	–10.5	103.5	111.0	118.5	126.0	133.5	16,000	3.3
120	–9.0	91.5	97.5	103.5	109.5	115.0	17,000	3.0

Table 2.8: Recommended screen voltages for the Mazda QP.240 QPP double output pentode.

An improved QPP type, the QP.230, was released in 1936. With this valve the two screen grids were internally connected, which enabled a B7 base to be used in place of the B9 base fitted to the QP.240. Also each section was better matched than the earlier QP240, eliminating the need to adjust the screen voltage between one valve and another; instead the screen grids were connected directly to the h.t. supply. It was also recommended that self bias be used by means of a resistor in the common negative lead. The actual bias required depended upon the h.t. voltage but was –9.6V for an h.t. of 120V. This would, of course, fall as the h.t. battery became discharged.

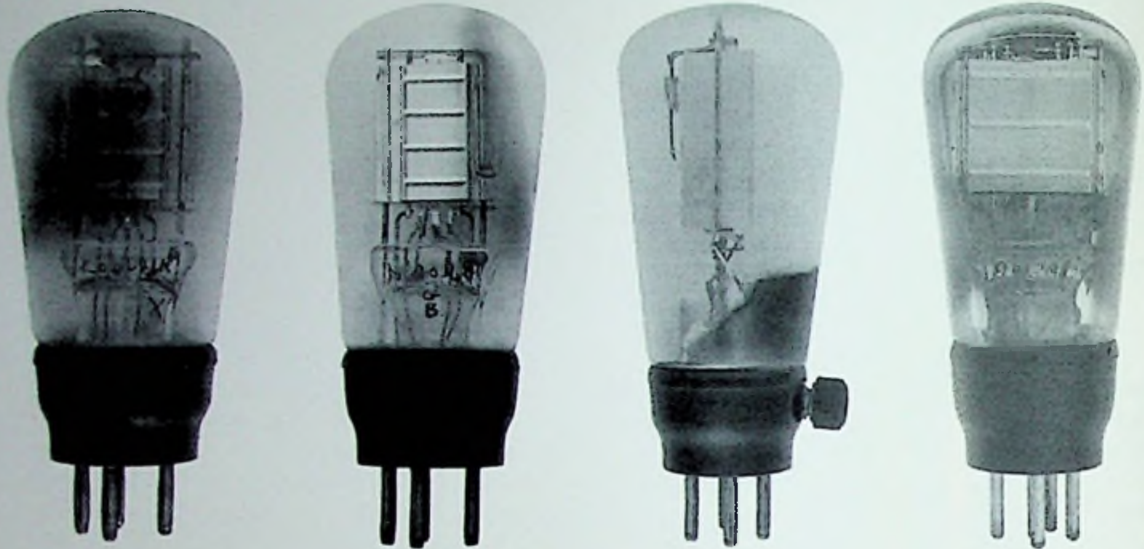
Also released in 1936 were the SP210 and VP210 r.f. pentodes, with 0.1-amp filaments, which replaced the SP215 and VP225. Apart from their lower filament current both valves also consumed considerably less anode and screen currents, making them particularly suitable for us in portable radios.

Another two-volt type to be released in 1936 was the Pen231 output pentode. This had a slope of 3.6mA/V as against only 1.5mA/V for the earlier Pen230, thereby requiring considerably less grid drive. It also provided a slightly higher output power.



S215A: r.f. tetrode. | S215B: r.f. tetrode. | HL2: general-purpose triode. | HL2: (later version).

Figure 2.19: Two-volt battery valves of 1930 to 1933.

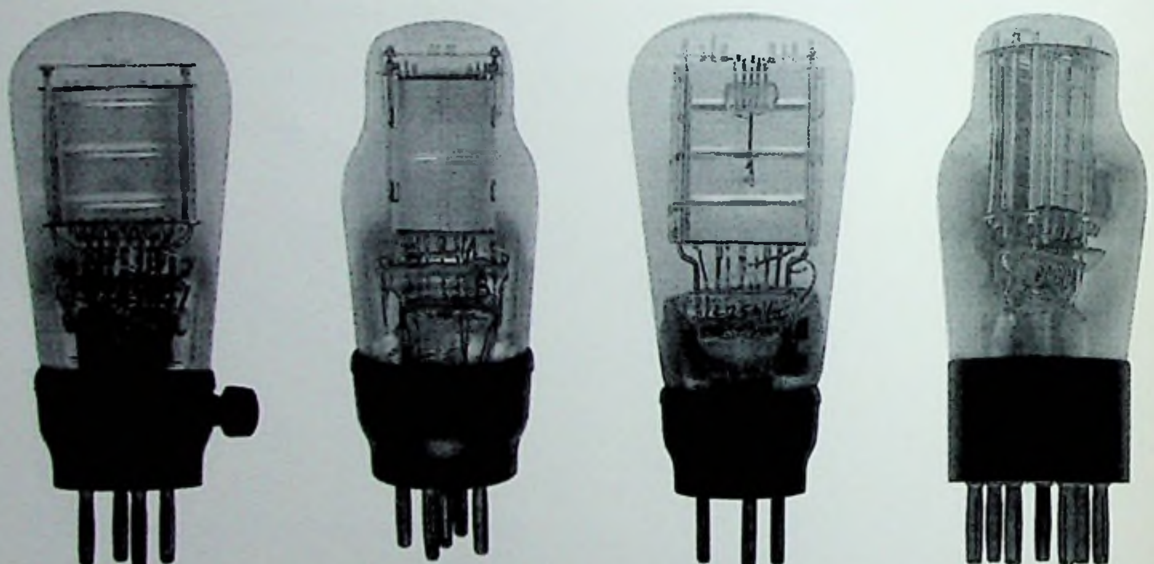


L2:
detector or a.f. triode.

P220A: 350mW
output triode.

Pen220: output pentode
(early 4-pin version).

Pen220:
(5-pin version).



Pen220A: output pentode
(4-pin version).

Pen220A:
(5-pin version).

Pen425: 4-volt
output pentode.

PD220 &PD220A:
Class B double triodes.

Figure 2.20: Two-volt battery valves of 1930 to 1933 (cont.).

In 1937 there was an improved triode pentode frequency changer, the TP23. This was designed for use at frequencies up to 20 MHz and for this suppressor grid injection was used by an internal connection of the suppressor grid to the grid of the triode oscillator. This allowed a 7-pin base to be used.

The only other valve to appear during this year was the DD207 double diode which had a 0.075 amp filament. Examples of these later valves can be seen in Figure 2.21.

SP215: r.f. pentode.
(VP215 is similar.)

SP210: r.f. pentode.
(VP210 is similar.)

TP22: triode pentode
with 9-pin base.

TP23: triode pentode
with 7-pin base.

DD/207:
double diode.

L21/DD:
double diode triode.

Pen231:
output pentode.

QP230: QPP double
output pentode.

Figure 2.21: Two-volt battery valves of 1934 to 1937.

THE MAZDA OCTAL BASE OF 1938

Whereas all other major valve companies eventually decided on the new US octal base (the IO), Mazda went entirely alone with an octal base of its own design. The pin spacing on this was different from the IO and the central spigot had a larger diameter, as can be seen from Figure 2.22. Mazda's stated reason for adopting this base was that a larger spigot would provide space for the exhaust tube, thereby allowing the electrode leads to be shortened. Another difference, although not a reason for adopting a different base, was for the filament or heater connections to be made to pins 1 and 8 and for the pins normally connected to the cathode, screen and metallising to be employed as guard pins by being located in alternate positions in the base. The pins located between these guard pins could then be connected to the 'hot' electrodes to reduce the capacitance between them.

This new base was called the Mazda Octal and was fitted to valves from 1938 and continued into the post-WW2 years for some of its new valves and, of course, for those of late-1930s design that had continued into post-war production. These were, however, supplemented by new types with the IO base. Needless to say the MO base caused much confusion and frustration, particularly if the wrong base had been wired into a chassis, which was a common occurrence because of its superficial similarity to the international octal types.

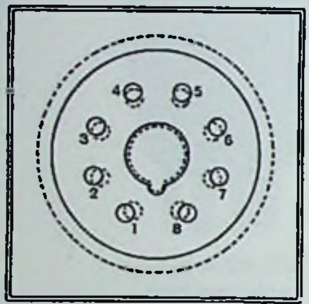


Figure 2.22 The Mazda octal base of 1938. The IO outline is shown dotted. Note the different pin spacing and different spigot diameters. The MO base is also smaller in diameter.

2- & 1.4-VOLT BATTERY VALVES WITH THE MO BASE (Table 2.9)

2-volt range

In this range there were three r.f. pentodes. Two of these, the SP22 and VP22, had identical characteristics to the SP210 and VP210 respectively except for the inter-electrode capacities. Also the bulbs were smaller in diameter and length. The third, the VP23, was an economy type for use in portable receivers, having a filament consumption of 0.05-amps. As was usual practice, the letters VP denoted variable-mu, r.f. pentodes.

Range	Year	RF pentode	Frequency changer	Triode or double diode triode	Output pentode
2-volt	1938	SP22, VP22 VP23	TP25	HL22, HL23, HL22/DD HL23/DD, L22/DD	Pen24, Pen25
	1939		TP26		QP25
1.4-volt	1939	SP141	FC141	H141D	Pen141

Table 2.9: Two- and 1.4-volt battery valves with the Mazda octal base.

There were two frequency changers, TP25 and TP26, both triode pentodes. The TP25 was intended for all-wave receivers; consequently the oscillator grid and suppressor grid of the pentode were joined internally, as was normal practice for this type of valve. It was also classed as an economy type, making it particularly suitable for portable receivers, but its conversion conductance was only 0.26mA/V. The TP26, released in 1939, was also classed as an economy type but had a higher conversion conductance of 0.55mA/V. It was designed for long and medium wave receivers only, so the suppressor grid of the pentode section was internally connected to the filament, as with the TP22. It was recommended that when used with the VP23 as an i.f. amplifier, half of the a.g.c. bias applied to the VP23 should be applied to the TP26.

There were five triodes. The HL22 was a general-purpose type suitable for use as an oscillator, detector or a.f. amplifier. The HL23 was similar to the HL22 but had a lower filament consumption of 0.05 amps and was designed for use in portable receivers. The HL22/DD and HL23/DD were both double diode triode versions of the HL22 and HL23. Finally the L22/DD was another double diode triode; the characteristics of this were similar to the L21/DD but the filament current was 0.1 amps rather than 0.15 amps.

SP22: r.f. pentode.

VP23: 'Economy' variable-mu r.f. pentode.

TP25 and TP26: triode pentodes.

HL22: general-purpose triode.

HL23/DD: double diode triode.

L22/DD: double diode triode.

Pen24: output pentode.

Pen25: 'Economy' output pentode.

Figure 2.23 Two-volt battery valves with Mazda octal bases of 1938 to 1939.

Two output pentodes were released in 1938. The first of these, the Pen24, had a similar sensitivity to the Pen231 but its output power from a 120-volt h.t. supply was increased from 370mW to 440mW. It was recommended that the grid bias should be obtained by means of a common resistor in the h.t. negative line and suitably by-passed. Because of its high sensitivity, the valve could be used immediately following the diode detector stage. The second type was the Pen25, which had lower filament consumption and was particularly recommended for use in portable receivers. Like the Pen24 it also had a high sensitivity and required a similar grid bias arrangement; it was capable of 400mW output from a 120-volt h.t. supply. Examples of these 1938 to 1939 valves can be seen in Figure 2.23

A third two-volt type released in 1939 was the QP25 double pentode for QPP operation. It had a lower filament consumption than the QP230 and a higher output power. It was particularly suitable for battery portable receivers, where an output power from a 90-volt supply was 450mW (see Figure 2.24).

Typical Operation				
HT voltage	90	108	120	130
Anode voltage	83.5	100	110	120
Screen voltage	83.5	100	110	120
Grid bias voltage	6.1	7.7	8.65	9.75
Total anode current (mA)	3.2	3.85	4.25	4.65
Total screen current (mA)	0.6	0.72	0.80	0.87
Anode-to-anode load (ohms)	17k	17k	16k	15.5k
Power output (watts)	0.45	0.75	0.95	1.2
Input swing (r.m.s.)	4.3	5.45	6.1	6.9

Figure 2.24
QP25 double output pentode and typical operating conditions.

1.4-volt range

Mazda released a range of four, low-power battery valves at the Olympia Radio Exhibition in August 1939. The range had 1.4-volt filaments and consisted of the following types: an r.f. pentode, SP141, a heptode frequency changer, FC141, a single diode triode, H141D, and an output pentode, Pen141. Shown at the left of Figure 2.25 is the H141D where, in this example, the metallising is coloured green; at the right is the output pentode, Pen141.

The only known use of these 1.4-volt valves by the author was in the Decca potable model MLDJ of 1939.

H141D: 1.4-volt single diode triode.

Pen141: 1.4-volt output pentode.

Figure 2.25: Two examples of the Mazda 1.4-volt range of 1939.

4-VOLT AC RANGES WITH B4, B5, B7 & B9 BASES

Several of the earlier a.c types from the late 1920s continued in production for several years, notably the AC/SG, AC/HL, AC/P and AC/P1. With redesign, the characteristics of these were significantly improved, as can be seen from the brief data shown in Table 2.10, which shows the changes that occurred over the period 1929 to 1933. For the two triodes the improvements were in reduced anode impedance and increased mutual conductance. (The lower anode impedance for the AC/P1 meant it was capable of delivering more output power.) For the screened tetrode, AC/SG, the main improvement was in increased anode impedance, which meant less loading on the tuned circuit.

Type	1929		1933	
	r_a	g_m	r_a	g_m
AC/HL	13.5	2.6	11.7	3.0
AC/P1	2.0	2.5	1.45	3.7
AC/SG	600.0	2.0	895.0	1.9

Table 2.10: Improved valve characteristics from 1929 to 1933.

Mazda launched a new range of indirectly heated valves and rectifiers in 1930 (see Table 2.11). Apart from some of the rectifiers, and the output triodes, all the valves had 4-volt indirectly heated cathodes.

Amongst the first of these valves was the AC/Pen. This was the first British output pentode having an indirectly heated cathode. It was released in May 1930 and had a mutual conductance of 2.5mA/V [4]. A diagram of its electrode assembly can be seen in Figure 2.26. Initially it had a 5-pin base, with a side terminal for connection to the screen grid, but this was changed to the 7-pin base in 1933. The AC/Pen received high praise from the *Wireless World* magazine in November 1930 when the winning apparatus from its readers' votes were reviewed [5].

Year	RF tetrode or pentode	Freq. changer	Diode	Triode or DDT	Output* triode	Output pentode	Tuning indic.	Rectifier
1930						AC/Pen (B5)		U60/500, U120/500, UU2, UU120/350
1931	AC/S2				PP5/400			UU30/250, UU120/500
1932	AC/S1VM, AC/SGVM		AC/DD	AC/2HL	PP3/250			
1933	AC/S2Pen			AC/HLDD, AC/HLDDD		AC/Pen (B7), AC2/Pen		
1934	AC/VP1	AC/TP	V914			AC2/Pen.DD		UU3
1936	AC/SP1, AC/VP2	AC/TH1			PA20 (2v)	AC3/Pen		UU4, UU5
1937					PA40	AC4/Pen	AC/ME	
1938						AC5/Pen, AC5/Pen.DD		
1939				V312				

*The four output triodes are directly heated

Table 2.11: Four-volt a.c. ranges and rectifiers of 1930 to 1939.

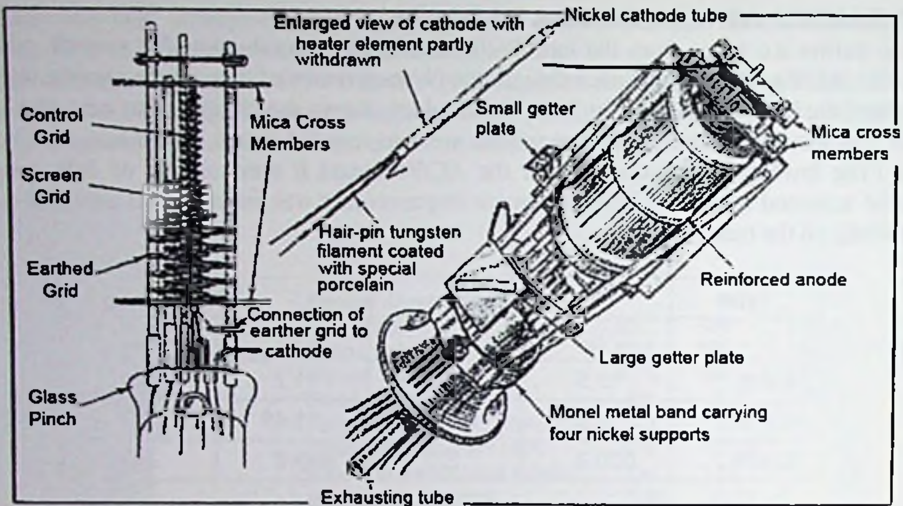


Figure 2.26: Electrode assembly of Mazda AC/Pen (1930).

There were also four new rectifiers. The half-wave U60/500 and U120/500 were both rated at 500V r.m.s. with rectified currents of 60mA and 120mA respectively. The UU120/350 was full-wave, rated at 350V, 120mA. Finally, the UU2, another full-wave type, was rated at 250V, 60mA

It has been previously mentioned that the AC/SG was derived from the earlier Cosmos AC/S and initially had a large metal top terminal for the anode connection (see Figure 2.18), but this was soon changed to a Bakelite insulated screw. The AC/S2 r.f. tetrode was released in 1931 and had a considerably higher mutual conductance than the AC/SG, which meant that a stage gain of about 400 could be achieved, so, to avoid overloading on strong signals, it was recommended that a volume control should be used in the aerial circuit (a problem that would be overcome when the variable-mu valves became available).

Another new type to appear in 1931 was the PP5/400 output triode which had a directly heated 4-volt, 2-amp filament and could deliver an output power of a little under six watts. There were also two new full-wave rectifiers: the UU30/250, rated at 250V, 30mA, and the higher current UU120/350, rated at 350V, 120mA.

There were five new valves in the following year. The AC/S1VM and AC/SGVM were both variable-mu r.f. tetrodes. These initially had slopes of 0.6mA/V and 1.4mA/V respectively but, with later improvements the slopes were increased to 1.1mA/V and 2mA/V. Automatic gain control was introduced by most set manufacturers from around 1933 so, before then, volume control was achieved by varying the negative grid bias of the variable-mu valves. For the AC/S1VM a gain variation of about 400:1 could be achieved by a grid bias change from –2V to –35V.

The AC/DD was the first double diode to appear on the UK market. It was probably requested by the Murphy Radio Company for use in its new superheterodyne receiver, the 8-valve A8, which was released at the Olympia Radio Exhibition in August 1932. This receiver had quite an advanced design for its time (see Figure 2.27). It had an r.f. amplifier, followed by a screen-grid mixer and a separate triode oscillator; there then followed two stages of i.f. amplification and a push-pull diode detector to balance out the carrier frequency component of the signal. The d.c. component of the rectified carrier was applied as an a.g.c. voltage to the grids of the r.f. and i.f. amplifier valves, all three of which had variable-mu characteristics. The detector was then followed by a volume control, a tetrode audio amplifier stage and a pentode output stage. This basic receiver design set an example for types to follow in subsequent years, with the only significant change being a dedicated frequency changer valve incorporating both the mixer and local oscillator functions. The AC/DD was actually a UU2 full-wave rectifier with a metallised bulb.

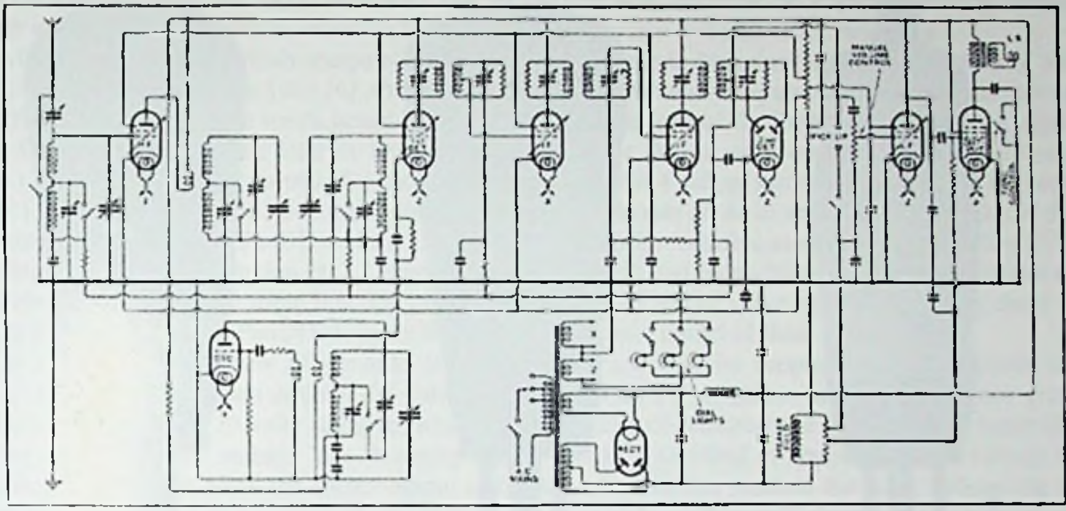
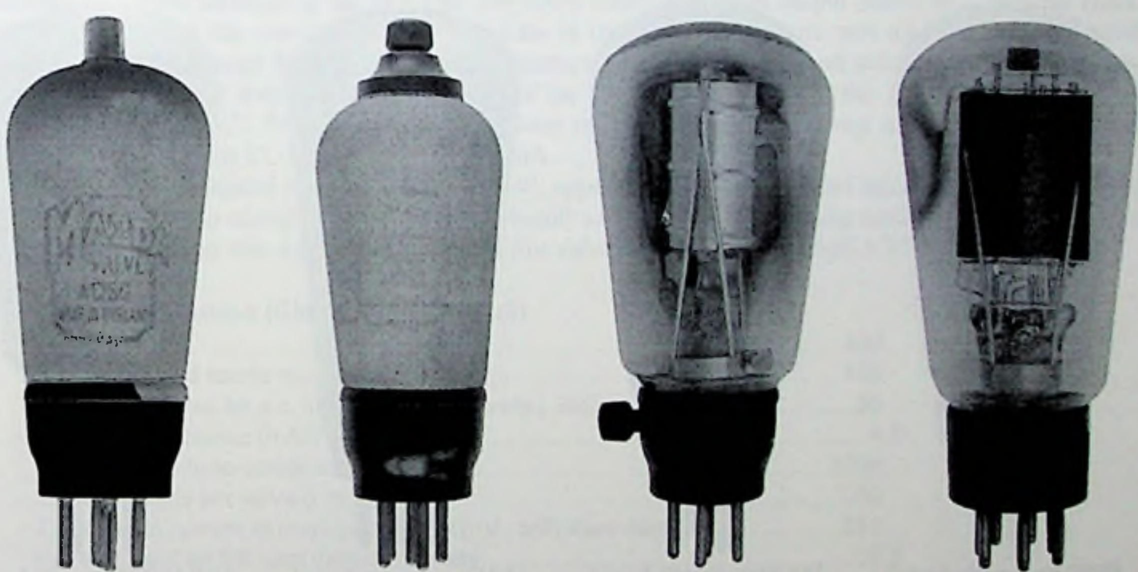


Figure 2.27: The Murphy A8 superheterodyne receiver of 1932 (note the double diode detector). The valve line-up is r.f. amplifier (VMS4), mixer, i.f. amplifiers and a.f. amplifier (AC/S1VM), oscillator (AC/HL), detector and a.g.c. (AC/DD), output (AC/Pen) and rectifier (Philips 1807).



AC/SG: r.f. tetrode. 1930s version.

AC/S2: r.f. tetrode.

AC/Pen: output pentode of 1930 with 5-pin base.

AC/Pen: output pentode of 1933 with 7-pin base.

Figure 2.28: Four-volt a.c. valves of 1930 to 1932.

The other two valves of 1932 were the AC/2HL, a low impedance detector or a.f. triode with a slope of 6.5A/V and the PP3/250 directly heated output triode. Initially this had a power output of 2.5 watts, but the power was later increased to 4.2 watts and the anode voltage increased from 250V to 300V.

ACSG/VM: variable-mu r.f. tetrode (later version).

AC/DD: double diode (basically a UU2 rectifier).

AC2/HL: detector or a.f. triode.

PP3/250: directly heated output triode.

PP5/400: directly heated output triode.

UU2: indirectly heated full-wave rectifier.

UU120/350: directly heated full-wave rectifier.

Figure 2.29: Four-volt a.c. valves of 1930 to 1932 (cont.).

Figures 2.28 and 2.29 show representative examples of Mazda a.c. valves available during the three-year period from 1930 to 1932. Also included is the 1933, 7-pin version of the AC/Pen.

The first r.f. pentode, AC/S2Pen, appeared in 1933, along with a double diode triode, AC/HL.DD, and a triple diode triode, AC/HL.DDD. There was a new output pentode, the AC2/Pen, which had a high slope of 8mA/V; in receivers employing a.g.c. it was possible to obtain sufficient output power by feeding the

AC2/Pen directly from the diode detector. The AC/S2Pen was intended as a self-oscillating frequency changer in early superheterodyne receivers but was also suitable as a detector or a.f. amplifier.

Mazda was the first British company to produce triode pentode frequency changers, the first of which, the AC/TP, appeared early in 1934 [6]. Prior to this time the only other frequency changer available was the pentagrid of US design. (The triode hexode, designed by Karl Steimel of the Telefunken Company, appeared on the German market a little later in 1934, although the basic design work on this had started some time earlier.) The AC/TP was not suitable for short wave use. Other 1934 valves were the variable-mu r.f. pentode, AC/VP1, available with both 5-pin and 7-pin bases, the V914 double diode to replace the AC/DD, the double diode output pentode, AC2/PenDD and the UU3 full-wave rectifier, which was similar to the earlier UU2 but had a higher heater consumption of 2.2 amps. The AC/2PenDD had identical pentode characteristics to the AC/2Pen and combined the triple function of detector, a.g.c. and output valve in one bulb; later, there was a 6.3-volt version of this, the PenDD61, made for Philco for use in a model of their 'Peoples Set'.

In 1936 there was a new r.f. pentode, the AC/SP1, for use in noise suppression and automatic tuning circuits. In noise suppression circuits the valve was used as an a.f. amplifier and the suppressor grid was initially biassed at 15 to 20 volts negative, which had the effect of reducing the gain to zero—typically this could be the a.g.c. delay voltage. The incoming carrier was then rectified to apply a positive voltage to the suppressor grid, so that when the carrier output of the last i.f. amplifier reached the delay voltage the initial bias on the suppressor grid was neutralised and the valve operated at full amplification.

Another new valve of 1936 was the AC/VP2 variable-mu r.f. pentode with identical characteristics to the AC/VP1 but having the control grid taken to the top cap rather than the anode. A valve of special interest was the PA20. This was another directly heated output triode but it had a 2-volt filament and, otherwise, the characteristics were identical to the PP3/250. The valve could deliver an output power of 2.75 watts from a 250-volt supply, but this was increased to 4.2 watts in the late 1930s. There was also the AC/TH1, triode hexode frequency changer having a conversion conductance of 0.75mA/V and suitable for use in all-wave receivers. A valve that does not appear in most of the Mazda publications is the AC3/Pen output pentode having a slope of 9mA/V. Finally there were two new indirectly heated, full-wave rectifiers—the UU4 rated at 350V, 120mA and the UU5, rated at 500V, 120mA.

A new directly heated output triode, the PA40, appeared in 1937. This was intended for public address amplifiers where a pair operating in Class AB push-pull was capable of producing around 40 watts output (see Table 2.12). There was also a post-war version of this valve which was designated V503.

Typical operation (Class AB push-pull)

Anode voltage	400	450
Total quiescent anode current (mA)	100	110
Approx. grid bias for a.c. filament heating (volts). Individually adjusted	85	96.5
Mutual conductance (mA/V)	4.5	4.5
Optimum anode-to-anode load (ohms)	3700	4000
Input grid volts per valve (r.m.s.)	60	68
Total anode current at maximum output (mA, with fixed bias)	210	230
Power output for 5% total distortion (watts)	33.5	41

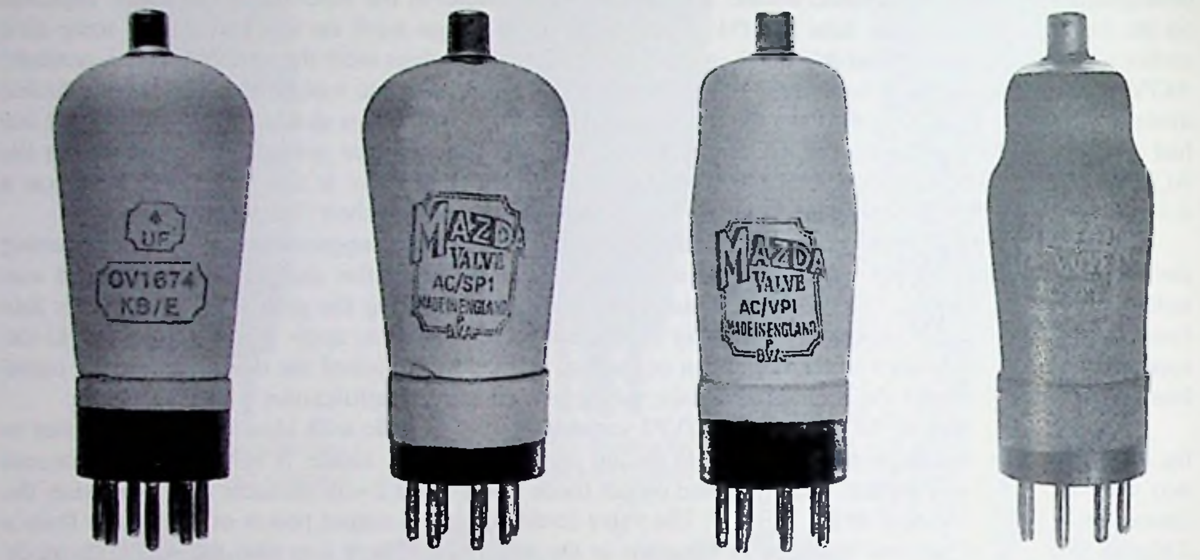
Table 2.12: Typical operating conditions for PA40 triodes in Class AB push-pull and fixed bias.

Another 1937 valve was the AC4/Pen beam tetrode with an output power of 6.9 watts from a 250-volt supply and a slope of 11mA/V. There was also the first of the Mazda cathode-ray tuning indicators, the AC/ME.

In 1938 there were two new beam tetrodes, the AC5/Pen and the AC5/PenDD, the latter having the addition of two diodes. The sensitivity of these was similar to the earlier AC2/Pen and AC2/PenDD but they were capable of a greater output power.

The last valve in this group of a.c. types with 4-, 5-, 7- and 9-pin bases was the V312, a low-noise triode for microphone amplifiers and similar types of applications. There was also a V339 (CV3767) high-mu triode but the author has been unable to determine when this valve first appeared.

Examples of these four-volt a.c. valves from the period 1933 to 1939 are shown in Figures 2.30 to 2.32.

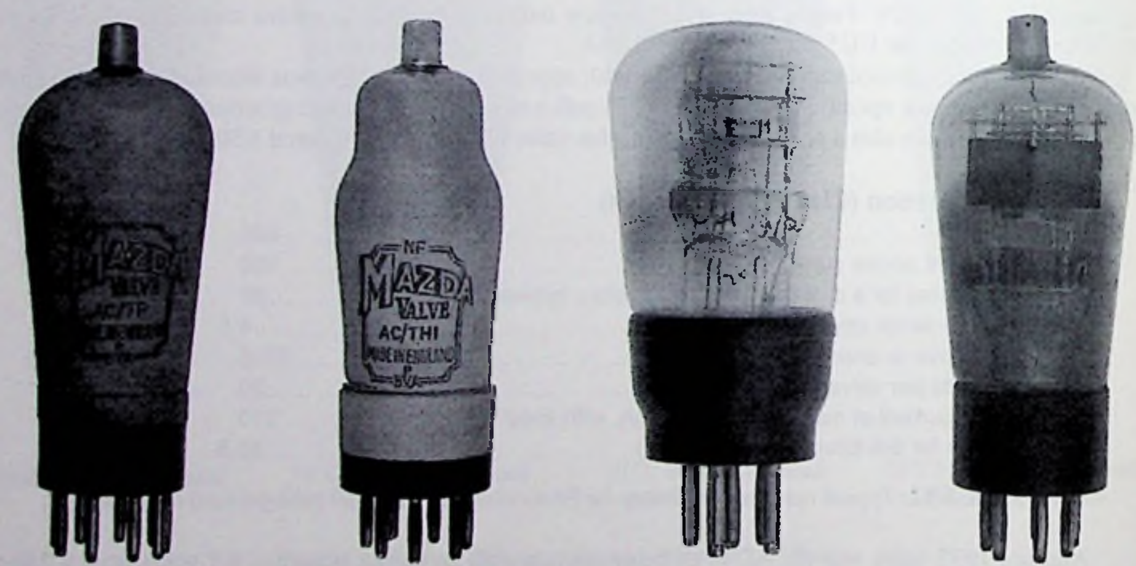


ACS2/Pen (CV1674): pentode frequency changer.

AC/SP1: noise suppression pentode.

AC/VP1: variable-mu r.f. pentode (anode top cap).

AC/VP2: variable-mu r.f. pentode (grid top cap).



AC/TP: triode pentode frequency changer.

AC/TH1: triode heptode frequency changer.

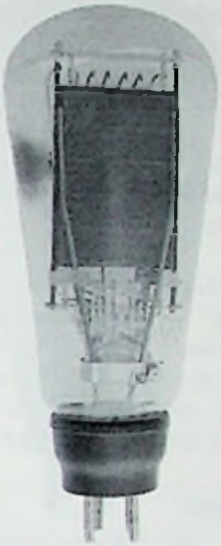
V914: double diode. (Replaced AC/DD in 1934.)

AC/HLDD: double diode triode.

Figure 2.30: Four-volt a.c. valves of 1933 to 1939 with 5-, 7- and 9-pin bases.

AC/HLDDD:
triple diode triode.

PA20:
2-volt output triode.



V503: 4-volt output triode,
equivalent to PA40.

AC2/Pen & AC5/Pen:
output pentodes.

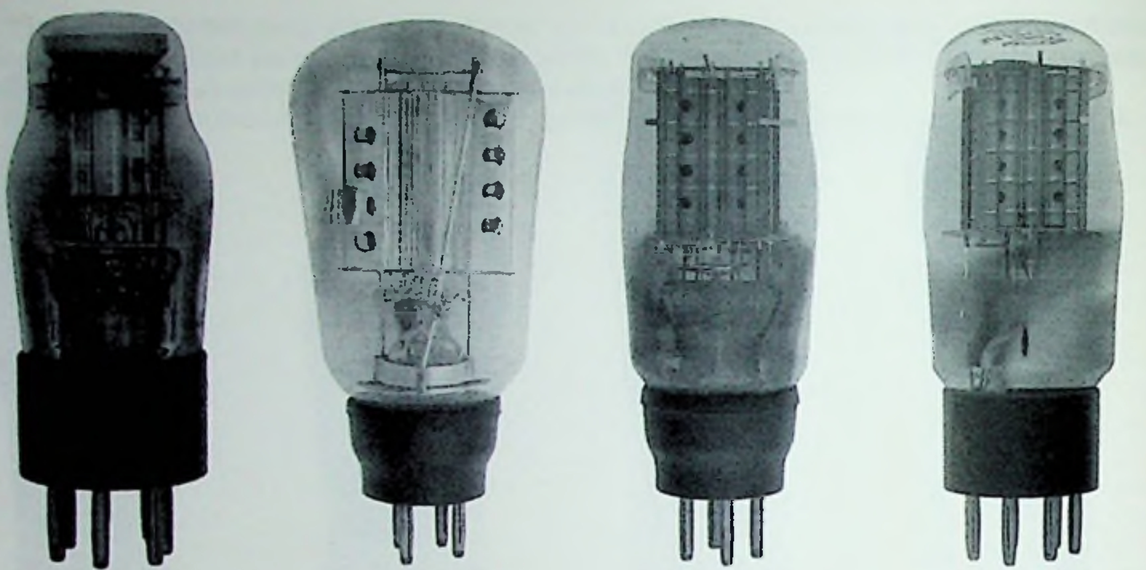
AC2/PenDD: double diode
output beam tetrode*.

AC4/Pen:
output beam tetrode.

AC5/PenDD: double diode
output beam tetrode.

V312: low noise a.f. triode
for microphone amplifiers.

Figure 2.31: Four-volt a.c. valves of 1933 to 1939 with 4-, 5-, 7- and 9-pin bases.
(*There was also a PenDD61, identical to the AC2PenDD but with a 6.3-volt heater and made for Philco.)



AC/ME: cathode-ray tuning indicator. UU3: full-wave rectifier (250V, 60mA). UU4 & UU5: full-wave rectifiers. UD41: indirectly heated voltage doubler rectifier.

Figure 2.32: Four-volt a.c. valves of 1933 to 1939 with 5- and 7-pin bases (cont.).

4-VOLT AC RANGE WITH MO BASE

The Mazda octal base described earlier was used on almost all the new Mazda valves from 1938 onwards and several of these had similar characteristics to earlier types with 5- or 7-pin bases. They were, however, usually smaller and had improved inter-electrode capacitance. Table 2.13 lists the 4-volt types that were produced for equipment other than those specifically made for television use.

Year	RF pentode	Frequency changer	Double diode	Triode or DDT	Output beam tetrode	Tuning indic.	Rect.
1938	SP41, VP41	AC/TH1A, (see TH41)	DD41	HL41, HL41/DD	Pen45		UU6, UU7
1939		TH41, (as AC/TH1)		HL42/DD	Pen44, Pen45/DD	ME41	UU8

Table 2.13: Four-volt a.c. valves with Mazda octal bases of 1938 to 1941.

There were two r.f. pentodes: the SP41 and the variable-mu VP41. (There was also a WW2 version of the SP41 with a 6.3-volt heater which, in post-war years, was designated SP61. Both of these are described in greater detail in the later section of this chapter that deals with v.h.f. and television valves.) The VP41 was used quite extensively as an i.f. amplifier in radio receivers and was also used in the sound channel of television sets. It had a very high signal handling capability and could accept signals with a peak carrier level up to ten volts.

The only frequency changer was the TH41 of 1939, a triode hexode whose electrical characteristics were identical to the AC/TH1, except for the internal capacitances. It was also smaller in length and diameter. Mazda also listed an AC/TH1A, but this was an early type designation for the TH41 and was used with a few pre-war receivers (e.g. the McMichael 808 Bijou mains portable of 1938).

There was just one double diode, the DD41, where each diode had its own separate cathode and fully screened from each other. This independence of the two diodes increased the flexibility in the circuit design.

There was one triode, the general-purpose HL41, which could be used as an oscillator or a.f. amplifier. There were also two double diode triodes: the HL41/DD, released in 1938, and the HL42/DD in 1939. The HL41DD was a medium impedance triode with D_2 used for detection and D_1 for a.g.c. If D_1 was not used it was connected to the common cathode.

The HL42/DD had a variable-mu characteristic and was particularly suitable for all-wave receivers where it was desired to improve inadequate a.g.c. characteristics. For this purpose a portion of the a.g.c. voltage was applied to the grid and an extra gain control of 9 to 1 was obtained for a bias variation from −1.25V to −20V.

The first beam tetrode with the Mazda octal base was the Pen45 followed, in 1939, by the Pen45/DD. These two valves had identical electrical characteristics to their 7-pin counterparts, the AC5/Pen and AC5/PenDD, except for their internal capacitances. They were also smaller in length and diameter. The Pen44 also became available in 1939. This was described as a high power type and was capable of providing an output of 20 watts when used in push-pull from a 270-volt h.t. supply, or nine watts in single-ended operation. It was stated that the valve should always be self-biassed (see Table 2.14).

Typical operation	Push-pull	Single-ended			
Anode voltage	260	240		260	
Screen voltage	270	250		270	
Negative grid bias	11.1	10.0		11.1	
Anode current per valve (mA)	70.0	64.0		70.0	
Screen current per valve (mA)	12.0	11.0		12.0	
Power output (watts)	20	6.9	7.85	8.0	9.25
Anode load (ohms)		3000	2650	3000	2650
Anode-to-anode load (ohms)	4000				
Input swing volts per valve (r.m.s.)	7.5	5.3	6.1	5.65	6.7
Anode current at full output (mA)	83.0	67.0	70.0	73.0	76.0
Input swing for 50mW output (r.m.s.)		0.39	0.41	0.38	0.40
Input swing for 250mW output (r.m.s.)		0.88	0.92	0.86	0.90
3rd harmonic distortion at full power (%)	4	5	7	5	7

Table 2.14: Typical operational conditions for Pen44 beam tetrode with self bias.

The only tuning indicator was the ME41 which had similar characteristics to the AC/ME. It was stated that the grid of the valve should be controlled from the detector circuit and not the a.g.c. diode, to enable visual tuning to be obtained below the delay point.

Finally there were three full-wave rectifiers, all rated at 350V r.m.s. The UU6 had a rectified output current of 90mA, the UU7 of 120mA and the UU8 of 250mA.

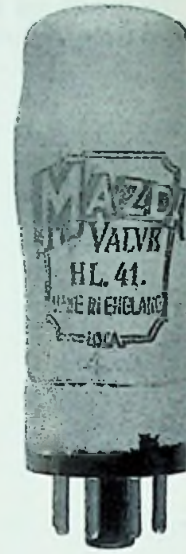
Typical of the receivers using these valves was the Murphy A90, released in February 1940, where the line-up was TH41, VP41, HL41/DD, Pen 45 and UU6.

Representative examples of the four-volt a.c. valves with the Mazda octal base can be seen in Figures 2.33 and 2.34.

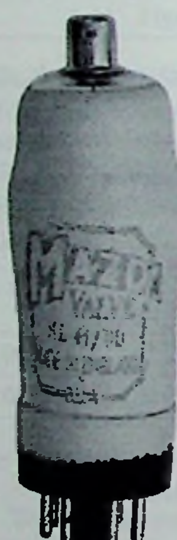
VP41: variable-mu r.f. pentode.

TH41: triode hexode frequency changer.

DD41: double diode with separate cathodes.



HL41: general-purpose triode.



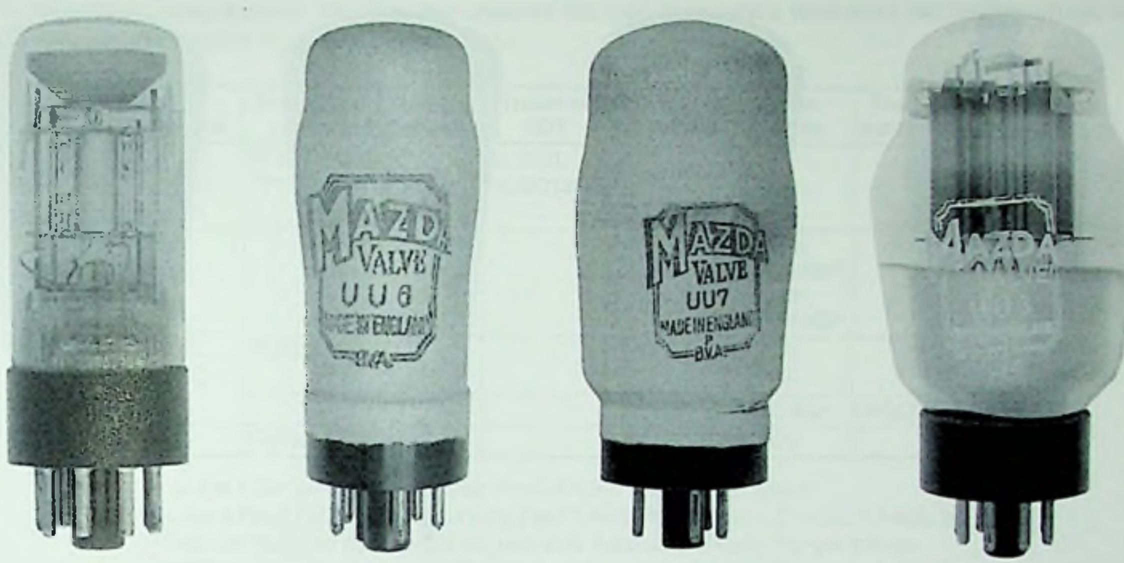
HL41/DD: double diode triode.

Pen45: 4.5W output beam tetrode.

Pen45/DD: double diode and output beam tetrode.

Pen44: output beam tetrode (20W in push-pull).

Figure 2.33: Four-volt a.c. valves with Mazda octal bases of 1938 to 1939.



ME41: cathode-ray tuning indicator.

UU6: full-wave rectifier (350V, 90mA).

UU7: full-wave rectifier (350V, 120mA).

UU8: full-wave rectifier (350V, 250mA).

Figure 2.34: Four-volt a.c. valves with Mazda octal bases of 1938 to 1939 (cont.).

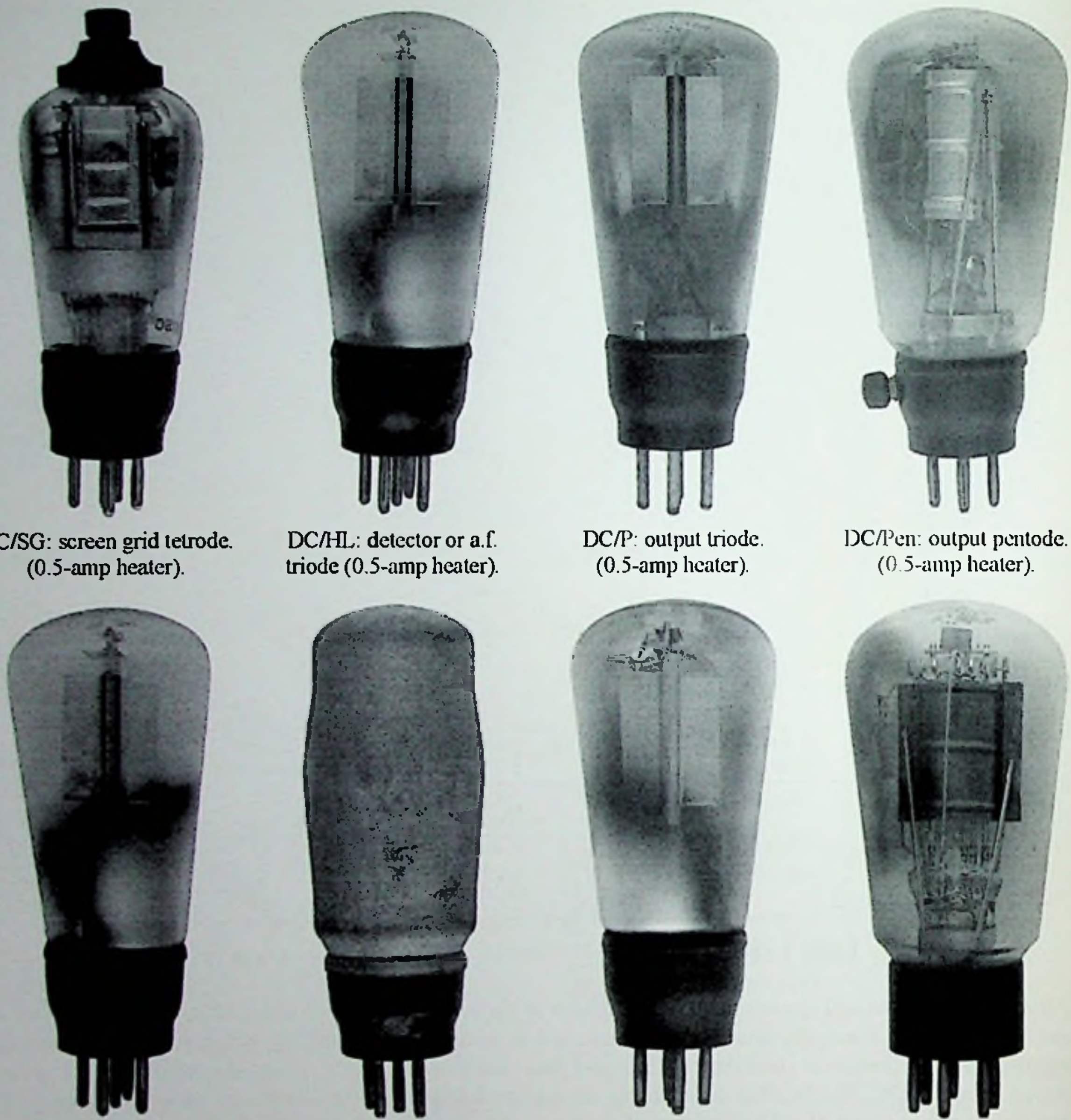
DC RANGE OF 1931 TO 1933 (Table 2.15)

Year	RF tetrode or pentode	Triode or DDT	Output triode	Output pentode
1931	DC/SG	DC/HL, DC/3HL	DC/P, DC/2P	DC/Pen, DC/2Pen (5- & 7-pin)
1932	DC/2SG DC/2SGVM			
1933		DC/2HLDD		

Table 2.15: DC valves of 1931 to 1933 with 0.1-amp and 0.5-amp heaters.

All these d.c. valves had characteristics very similar to their a.c. equivalents, the principal difference being in the heater ratings. Since the heaters were connected in series, with a dropping resistor from the d.c. mains supply, it was necessary to limit their current and thus save on total power consumption. The first types to be issued were the DC/HL, DC/Pen and DC/SG, soon to be followed by the DC/P. All these appeared in 1931 and had heater currents of 0.5A (half that of their a.c. equivalents). Later in 1931 these were followed by the DC/3HL, DC/2P and DC/2Pen with 0.1-amp heaters of either 25 volts or 30 volts. The two screened grid tetrodes, DC/2SG and DC/2SGVM, were released in the following year, both having 20-volt, 0.1-amp heaters.

A further 0.1-amp type, the DC/2HL/DD double diode triode, was introduced in 1933. Examples of these valves can be seen in Figure 2.35.



DC/SG: screen grid tetrode. (0.5-amp heater).

DC/HL: detector or a.f. triode (0.5-amp heater).

DC/P: output triode. (0.5-amp heater).

DC/Pen: output pentode. (0.5-amp heater).

DC3/HL: detector or a.f. triode (0.1-amp heater).

DC3/HL: later, metallised version.

DC2/P: output triode (0.1-amp heater).

DC2/Pen: output pentode (0.1-amp heater, 7-pin).

Figure 2.35: DC mains valves of 1931 to 1933.

AC/DC RANGES OF 1934 TO 1938

This range, introduced in 1934, replaced the earlier d.c. ranges and included two groups of valves (see Table 2.16). One of these had 13-volt 0.2-amp heaters and could be used on a.c./d.c. supplies with series connection of the heaters, or in car radios. Others of the 13-volt types, however, had higher current heaters and were, therefore, only suitable for car radio use. The second group had varying heater voltages ranging from 6 to 45 volts, all with 0.2-amp heaters. The first two digits of the type designation represents the heater voltage and the third the heater current (e.g. 1320 = 13V, 0.2A).

Year	RF pentode	Frequency changer	Double diode	Triode or DDT	Output triode	Output pentode	Tuning indicator	Rectifier
1934	SP1320, VP1320, VP1321	TP2620 (B9), TP1340*	DD620	HL1320, HL/DD1320				U4020
1935					PP3521	Pen3520, Pen/DD4020†, Pen1340*, Pen/DD1360*		
1936	SP2220, VP1322	TH2320						
1937						Pen/DD4021	ME920	
1938		TH2321				Pen3820		

*TP1340 and Pen1340 have 0.4-amp heater. Pen/DD1360 has 0.6-amp heater.
†There was also a Pen/DD2530 identical to the Pen/DD4020 but having a 25-volt, 0.3-amp heater. This was made for Philco so that it could be used with American 0.3-amp big-pin valves.

Table 2.16: 13-volt and 0.2-amp a.c./d.c. range of 1934 to 1938 with 5-, 7- and 9-pin bases.

The first pentodes for use on a.c./d.c. mains supplies were introduced in 1934. These were the SP1320, VP1320 and VP1321. Neither of the first two of these found much application. Two new types appeared in 1936. These were the VP1322 and SP2220. The first of these was identical to the VP1321 except that the top cap connection was for the control grid rather than the anode. Apart from its heater rating the SP2220 was identical to the AC/SP1.

There were four frequency changers. The first of these, the TP2620 triode pentode, had a 9-pin base and similar characteristics to the AC/TP, except that it was normally operated at a lower anode voltage. The second was the TP1340, which was identical to the TP2620 but had a 0.4-amp heater and was intended only for car radios because its high heater current would preclude its use for series operation with the other a.c./d.c. types of valves. The third was the TH2320, a triode heptode with identical characteristics to the AC/TH1. Finally, there was the TH2321 which was introduced in 1938; this was another triode heptode but more suited for use in all-wave receivers than the earlier TH2320.

There was just one double diode, the DD620, which had a common cathode. There was also just one triode and one double diode triode, the HL1320 and HL/DD1320. The HL1320 was a medium-mu triode that could be used as a detector or a.f. amplifier.

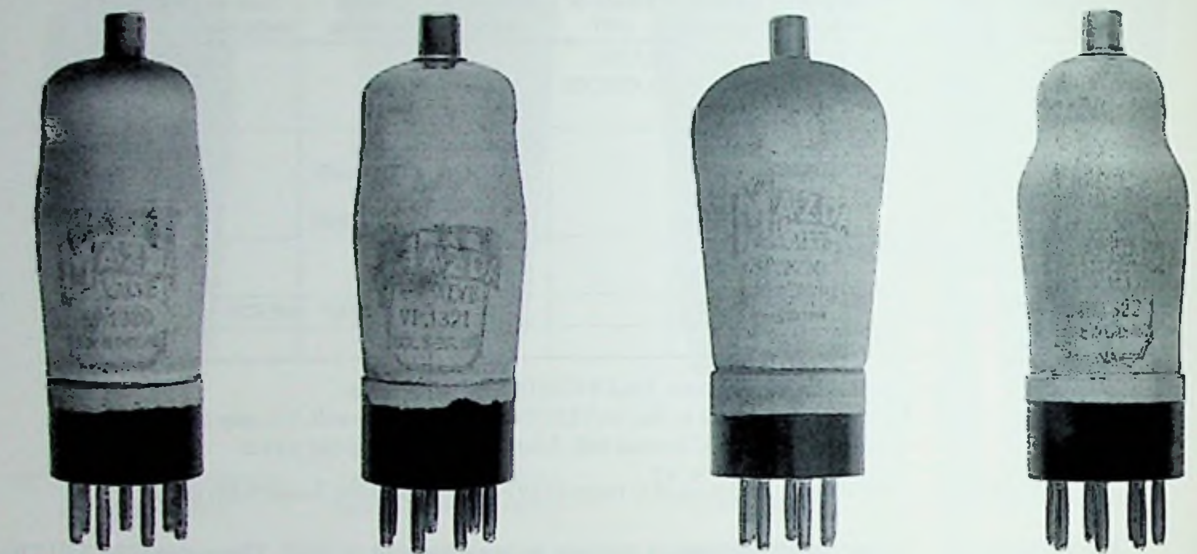
The PP3521 was an output triode capable of delivering a power of 2.3 watts in single-ended operation or six watts in push-pull.

Altogether there were six output pentodes and beam tetrodes, three of which incorporated double diodes. The Pen3520 and the double diode type, Pen/DD4020, were released in 1935. The first of these had sufficient sensitivity to operate directly from a diode detector, such as the DD620, and was capable of an output power of three watts from a 200-volt supply. The Pen/DD4020 had a higher maximum dissipation and could deliver 3.9 watts from a 240-volt supply. Also released in 1935 were the Pen1340 and Pen/DD1360, both intended for car radio use. The two beam tetrodes, Pen/DD4021 and Pen3820 appeared in 1937/38. The Pen3820 was designed for use in the output stage of receivers where the double diode section of the Pen/DD4021 was not required. They could both deliver an output of 3.75 watts from a 160-volt supply.

The ME920 was a cathode-ray tuning indicator having a 9-volt heater. Finally there was the U4020, a half-wave rectifier rated at 230V, 120mA.

Examples of these 0.2-amp valves can be seen in Figures 2.36 and 2.37.

One of the receivers using these valves is the Pye SE/U, released in 1935. This a.c./d.c. superhet has two VP1321 valves, one used as an r.f. amplifier, the TP2620 triode pentode and the Pen/DD4020 double diode output pentode.

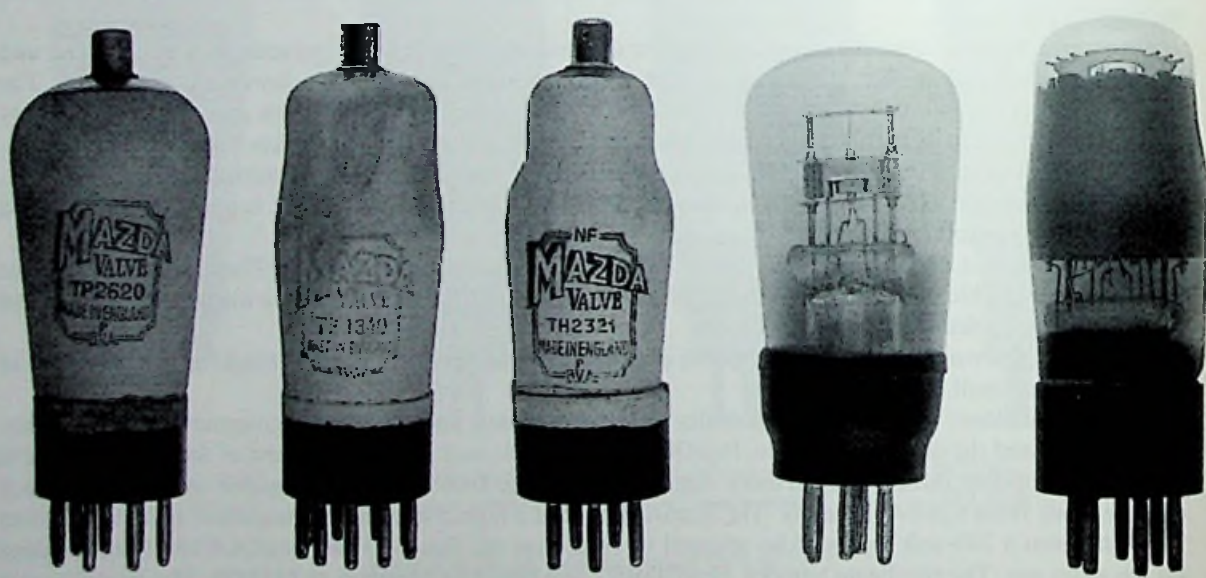


SP1320: 13-volt r.f. pentode.

VP1320 and VP1321: 13-volt VM r.f pentodes.

SP2220: 22-volt r.f. pentode.

VP1322: 13-volt VM r.f. pentode.



TP2620: 26-volt triode pentode.

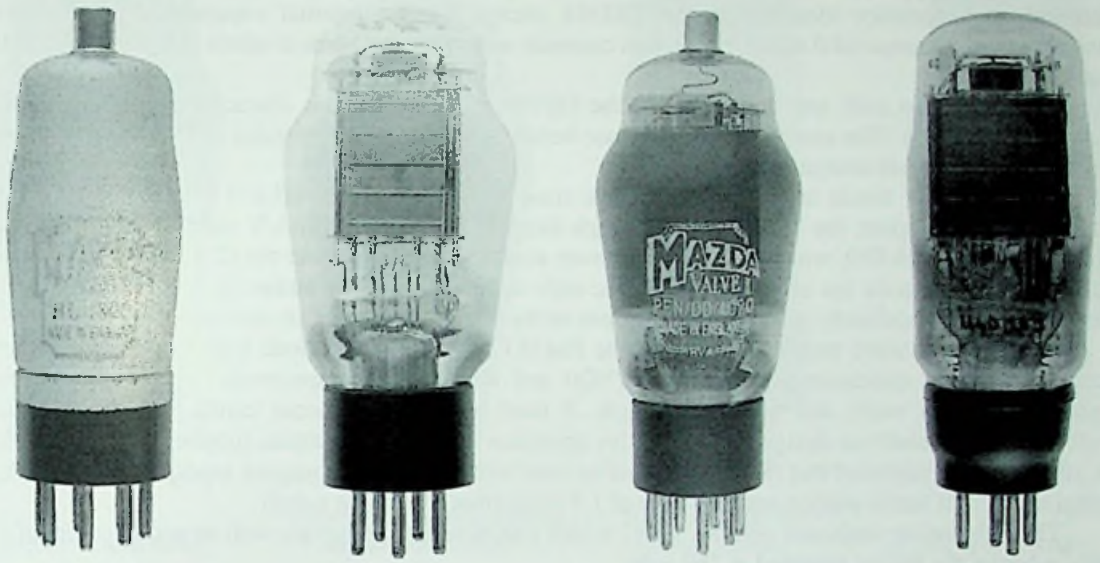
TP1340: 13-volt triode pentode.

TH2320 & TH2321: 23-volt triode heptodes.

DD620: 6-volt double diode.

Pen1340: output pentode. (AC3/Pen looks similar.)

Figure 2.36: AC/DC range of 1934 to 1938.



HL1320: 13-volt triode, detector or a.f. amplifier. PP3521: 35-volt output triode. Pen/DD4020: 40-volt duo diode output pentode. U4020: 40-volt half-wave rectifier.

Figure 2.37: AC/DC range of 1934 to 1938 (cont.).

For car radios a typical valve line-up would be: TP1340 (frequency changer), VP1321 or VP1322 (i.f. amplifier), HL/DD1320 (detector, a.g.c. and a.f. amplifier) and Pen1340 (power output). Alternatively, the Pen/DD1360 could be used for detector, a.g.c. and power output, dispensing with the HL/DD1320.

0.2-AMP AC/DC RANGE WITH MO BASE

As with the battery and a.c. valves, the a.c./d.c. range with the Mazda octal base was released in 1938 (see Table 2.17). The first two digits of the type designation indicate the heater voltage but the third digit does not indicate the heater current, unlike the earlier a.c./d.c. types.

Year	RF pentode	Frequency changer	Double diode	Triode or DDT	Output pentode	Tuning indicator	Rectifier
1938	VP133		DD101	HL133 HL133/DD	Pen383 Pen353/DD	ME91	U403
1939		TH233					
1940	SP181			HL134/DD			
1946					Pen384		U201*

*The U201 has an international octal base.

Table 2.17: 0.2-amp a.c./d.c. range with Mazda octal bases of 1938 to 1946.

There were two r.f. pentodes: the SP181 for use in the r.f. stage of short wave receivers and the variable-mu VP133. According to the Mazda data manual, the VP133 was specially designed for receivers employing the loudspeaker field winding for h.t. smoothing. Under these conditions the screen voltage would not rise above 175 volts with an average mains tapping. Initially, it was also recommended that in superheterodyne receivers it be used with the TH2321 converter and that the a.g.c. bias should be between one half and two thirds of the bias applied to the TH2321. However, the TH233 triode heptode was released in 1939. This had electrical characteristics identical to the TH2321 except for the internal capacitances, both having a conversion conductance of 0.65mA/V. As was common with other MO-based valves the length and diameter was smaller.

There was also only one double diode, the DD101. This had similar characteristics to the DD41 and identical dimensions. The complete independence between the two diode systems of the valve increased the flexibility in the circuit design.

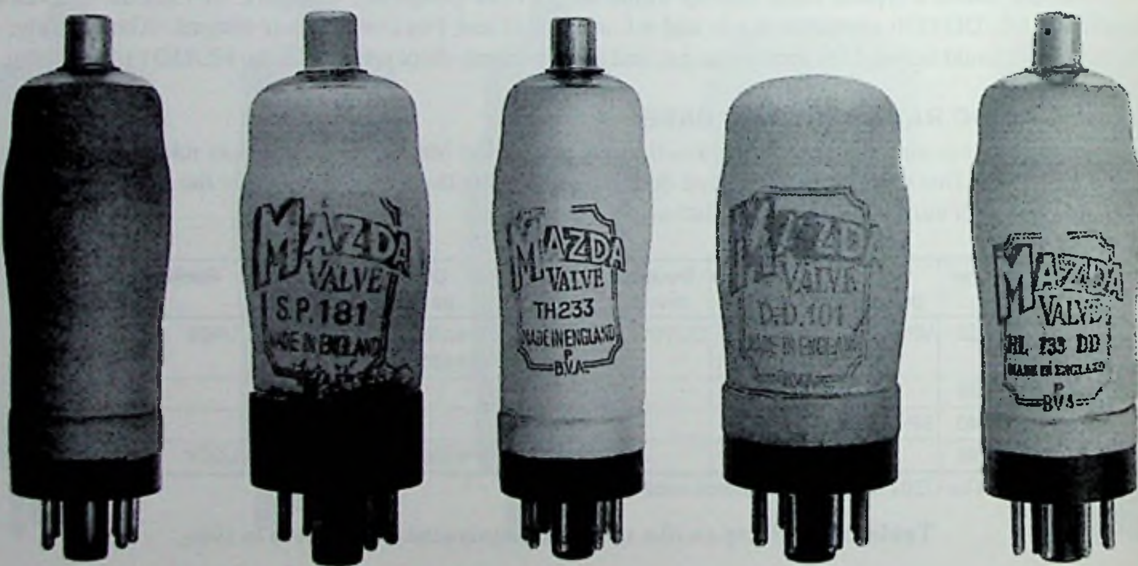
There was one triode and two double diode triodes. These were the HL133 a.f. triode and its double diode triode counterpart, the HL133/DD (although this had a slope of 2.5mA/V rather than 3.4mA/V). The third type, the HL134/DD, was an oddity. It had very similar characteristics to the HL133/DD and, although it was shown in a Mazda list of August 1939, the only data found by the author is in the AVO Valve Data Manual. Another peculiarity is that the connections to the two diode anodes are reversed.

Initially there were two beam tetrodes, the Pen383 and the double diode type Pen 453/DD. They had identical electrical characteristics to the Pen3820 and Pen/DD4021 respectively, except for the internal capacitances. They were also smaller in length. A third type, another beam tetrode, the Pen384, became available in 1946 and was designed specially for operation from 110-volt mains supplies. Because of the low h.t. supply it was intended that the valve should be used with a permanent magnet loudspeaker rather than the energized type. It had a modest output power of 1.9 watts from a 110-volt supply.

The only tuning indicator was the ME91 which was designed to operate with an anode potential of 175 volts, whereas the ME41 operated at 250 volts.

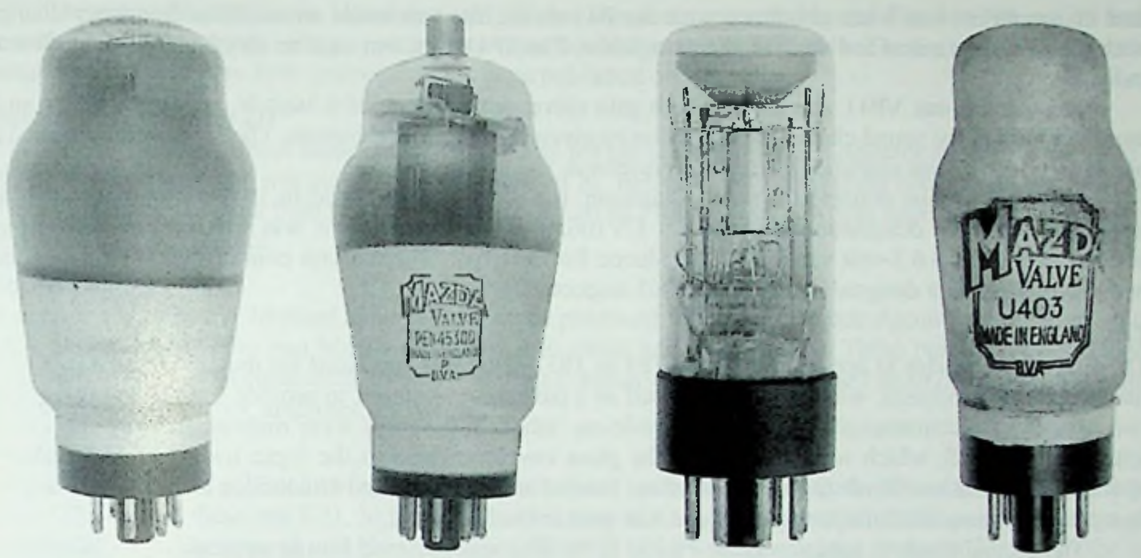
The U403 half-wave rectifier was released in 1938 and was rated at 230V, 120mA. The U201, released in 1946, had the international octal base and was rated at 250V, 90mA.

Examples of these a.c./d.c. valves with 0.2-amp heaters and fitted with the Mazda octal base can be seen in Figures 2.38 and 2.39.



VP133: variable-mu r.f. pentode. SP181: r.f. pentode for short waves. TH233: triode heptode. DD101: double diode. HL133/DD: double diode triode.

Figure 2.38: Mazda 0.2-amp a.c./d.c. valves with the Mazda octal base of 1938 to 1946.



Pen383: output beam tetrode. | Pen453/DD: double diode output beam tetrode. | ME91: cathode-ray tuning indicator. | U403: half-wave rectifier.

Figure 2.39: Mazda 0.2-amp a.c./d.c. valves with the Mazda octal base of 1938 to 1946 (cont.).

TELEVISION & VHF TYPES (Table 2.18)

This section deals with the valves specially designed for use in high definition television receivers, oscilloscopes, v.h.f. equipment and some industrial applications. The first of these appeared in 1936, making them available for the new 405-line television service which commenced during that year. The bulk of the types, however, were released during the following two years, so that Mazda valves could then be used in all stages of the receivers.

Year	RF pentode	Diode	Triode	Op triode	O/p pentode	Rectifier	Thyratron
1936							T11, T21
1937	AC/SP3	D1		AC/P4		U21*, UD41	T31
1938	SP41, VP41, SP42		P41		AC6/Pen		T32
1939	A41		A40			U22 (MO)	T41
1940					Pen46		
1941	SP41 (6.3V)		P41 (6.3V)				
PW	SP61, SP62		P61				

U21 has a B4 base

Table 2.18: Television and u.h.f. valves of 1936 to 1941.

RF amplifiers

The first of these was the AC/SP3 which was released in 1937. It was designed for use in the r.f., i.f. and video amplifier stages of television receivers. For these applications a high working slope was required, but its performance was limited because its 7-pin base inevitably meant relatively long lead-out wires from the electrode assembly.

It was superseded in 1938 by the SP41, VP41 and SP42, all of which had the new Mazda octal base and with shorter leads to the electrodes. The SP41 had a slope of 8.5mA/V and was intended for use as both r.f.

and i.f. amplifiers but, when combined with the P41 triode, the pair made an excellent frequency changer, with the SP41 as a mixer and the P41 as an oscillator. The SP41 was also used as an r.f. amplifier in all-wave radio receivers.

The variable-mu VP41 was another high gain valve, with a slope of 6.5mA/V, and was used as an i.f. amplifier both in the sound channel of television receivers and in radio receivers. The SP42 was dedicated for use as the video output amplifier in television receivers.

With the wartime demand for radar equipment, the SP41 was produced in 1941 with a 6.3-volt heater and given the RAF designation VR65 (later CV1065). Apart from this, it was identical to the four-volt version. Similarly, a 6.3-volt version was produced for the SP42. The 6.3-volt commercial versions of these two valves were later designated SP61 and SP62 respectively.

Triodes

The first of the triodes to appear was the AC/P4 in 1937. This was produced for use in output stages of the line and frame timebases, where a pair was used as a paraphase amplifier to provide a push-pull drive to the two anodes of electrostatically deflected cathode-ray tubes. The valves were distinguished by the grading letters Q, R and S, which were marked on the glass envelope close to the 5-pin base. Grade R indicated average amplification. Grade Q was on the lower limit of amplification and Grade S on the higher. When used in a paraphase amplifier, the lower limit type was used in the first stage.

The second triode to appear was the P41 in 1938. This was designed for use as an oscillator in television or v.h.f. radio receivers, where the SP41 was the mixer valve (see Figure 2.40). A version with a 6.3-volt heater was introduced in 1941 to complement the 6.3-volt version of the SP41.

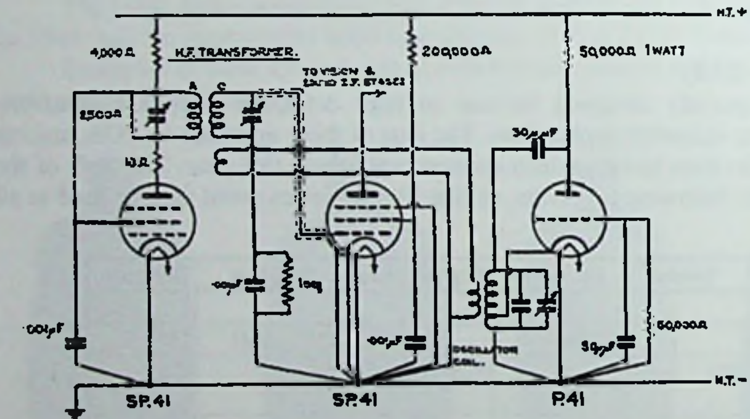


Figure 2.40: SP41 and P41 as a frequency changer.

The circuit is for use with a receiver, comprising r.f. amplifier, mixer and local oscillator, operating at a vision i.f. of 13 MHz and a sound i.f. of 9.5 MHz. With the oscillator operating at 32MHz layout is quite critical and lead lengths were to be kept to a minimum. The 0.001μF capacitor from the screen grid of the first SP41 must be connected directly to the cathode tag of the valveholder.

Beam tetrodes

There were two beam tetrodes, both designed for use in the output stages of timebases for magnetically deflected cathode-ray tubes. To withstand the high anode voltages required for this type of circuit the valves had an anode rating of 3kV; for this reason the anodes were brought out to top caps.

The first of these two valves was the AC6/Pen of 1938, which had a 7-pin base. The second, the Pen46, appeared in 1940; this had similar electrical characteristics to the AC6/Pen, but had a Mazda octal base.

Thyratrons

Many of the early television receivers and oscilloscopes used thyratrons in their timebases. The earliest Mazda types were the T11 and T21. They both appeared in 1936 and were meant to replace the two Ediswan types, MR/AC1 and HE/AC1 described earlier (see page 22). The T11 was mercury filled and its operating frequency limited to 5 kHz. The T21 was helium filled and was capable of operating up to 15 kHz.

The argon filled T31 was introduced in 1937, but this was superseded by the T41 in 1940, which had a considerably higher anode voltage rating. Both types could operate up to 15 kHz. There was also a T32 with a metallised bulb but very little information has been published on this valve.

Detector diode type D1

The D1 was the first British diode designed specially for use as a vision signal detector and was introduced in 1937. The self capacity was reduced to a minimum by use of small dimensions and of short pins sealed directly through the glass bulb. The Mullard type EA50 of Philips design, which appeared a year later, was very similar in appearance.

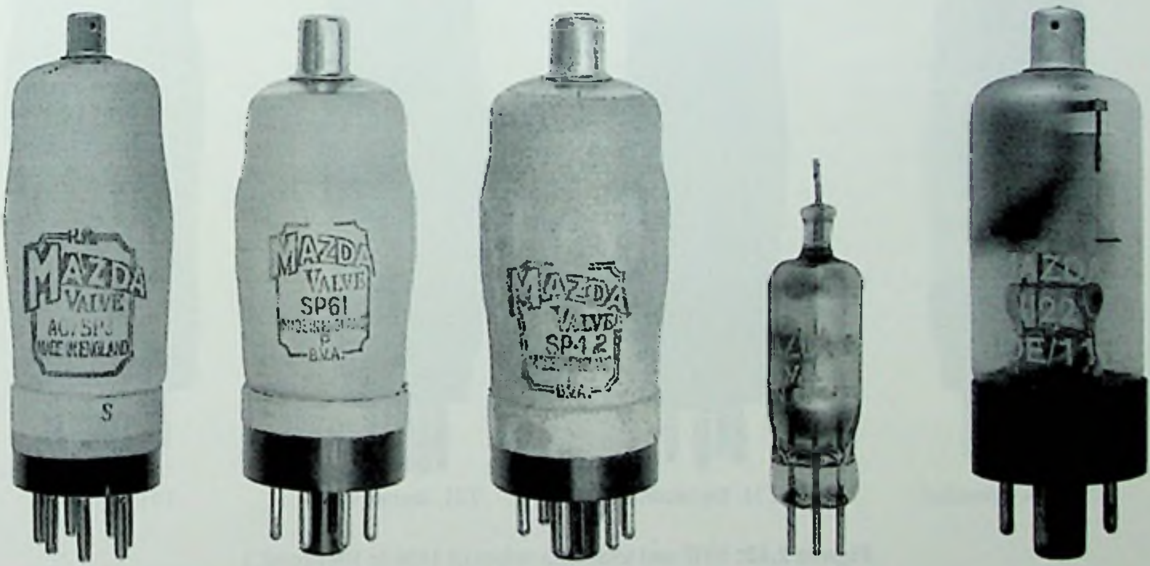
Acorn valves

In common with MOV, Mullard and Philips, Mazda produced triode and pentode Acorn valves, based on the RCA design. There were two Mazda types: the A40 triode and A41 pentode. These both had 4-volt heaters and could operate at frequencies in the v.h.f. and u.h.f. bands. The triode was used as an oscillator or detector, and the pentode as an r.f. amplifier.

Rectifiers

In 1937 Mazda released two high vacuum rectifiers, each having indirectly heated cathodes and 4-pin bases. The first of these, the U21, had a peak anode rating of 12.5kV which required the anode to be brought out to a top cap. The second was the UD41 (see Figure 2.32), a voltage doubler designed for use in the h.t. supplies of television timebases for electrostatically deflected cathode-ray tubes. For such circuits, the T31 thyratron and AC/P4 power pentode were recommended. The U22 rectifier was released in 1939; this had a Mazda octal base and was, otherwise, identical to the U21.

Examples of these v.h.f. and television types can be seen in Figures 2.41 and 2.42.



AC/SP3: r.f. or i.f. pentode. | SP61: r.f. or i.f. pentode. | SP42: video output pentode. | D1: television detector diode. | U22: 12.5kV e.h.t. rectifier.

Figure 2.41: VHF and television valves of 1936 to 1941.

P41:
oscillator triode.

AC/P4: line timebase
output triode.

AC6/Pen: line timebase
output beam tetrode.

Pen46: line timebase
output beam tetrode.

U21: e.h.t. rectifier.

T11: thyratron.

T31: thyratron..

T41: thyratron.

Figure 2.42: VHF and television valves of 1936 to 1941 (cont.).

REFERENCES

1. Munt, Brian E. 'The early history of Ediswan and Mazda', *Supplement to the BVWS Bulletin*. No. 2, December 1991, pp. 7-12.
2. 'The New Cosmos A.C. Valve', *W.W.*, **22**, 23 November 1927, pp. 713-4.
3. Editorial in *W.E.*, **4**, November 1927, pp. 650-1.
4. 'The first indirectly heated pentode', *W.W.*, **26**, 28 May 1930, pp. 552-4.
5. *WW*, **27**, 12 November 1930, pp. 550-1.
6. 'The Triode Pentode', *W.W.*, **35**, 23 March 1935, pp. 20.

Chapter 3
A C Cossor Ltd.

A C Cossor Ltd. started as a family business in about 1890, operating from small London premises in Farringdon Road, Clerkenwell. The founder, Alfred Charles Cossor, learned the trade of glass blowing from his father, who had also established a small business in Clerkenwell. During the early years Cossor manufactured scientific glassware, including Crookes tubes and x-ray tubes. Other products were a range of electric lamps, including various small items for use in medical instruments. In 1902 the company made the first British examples of Braun cathode-ray tubes. With the invention by Fleming of the diode detector in 1904, it was natural that he should ask Cossor to manufacture some of these devices. In 1909, A C Cossor was formed as a private company [1]. This led to a considerable growth in business which, by 1918, necessitated the move to larger premises in Highbury, known as the 'Aberdeen Works'. These new premises became the centre of the Cossor valve making business.

Although not widely known, the M-O Valve Company held a substantial shareholding in Cossor, which it purchased from the GEC Company on 30 April 1927 for the sum of £94,766.8s. Following the purchase, an MOV director was appointed to the Cossor Board, which meant that regular reports of Cossor activities were available to MOV.

Towards the end of 1927, Cossor signed a licence agreement with MOV for use of its valve patents. Cossor became a public company in 1938, a year after the death of its managing director, W R Bullimore—a man who played an important part in the growth of the company.

At the Radiolympia Exhibition in 1927 Cossor introduced the first of its successful range of kit sets known as the 'Melody Maker'. Each kit was accompanied by a full-size plan of the baseboard showing the exact position of each component, together with constructional details. The venture was very successful and led to a massive increase in sales of Cossor valves. With the initial Melody Maker all the components had to be purchased separately, only the valves being Cossor types. Owing to the enormous demand there was a shortage in supply of the components, so, in 1928, Cossor began supplying complete kits of parts. It was also necessary to acquire additional premises for the production of the coils, transformers, etc.

By the early 1930s Cossor was manufacturing cathode-ray tubes in production quantities for use in oscilloscopes and for other display applications, such as ionospheric research, which, in turn, led to the production of tubes for the high definition television service from 1936 onwards.

The work on CRTs, hard valve timebases and other associated circuits led to Cossor's wartime activities in radar and IFF equipment. Key players here were Leslie Bedford and O S Puckle.

After 1945, Cossor reorganised its valve business and formed a new subsidiary company, Electronic Tubes Ltd. EMI acquired a controlling interest in this company in 1949.

BATTERY & MAINS VALVES OF 1926 TO 1928 (Table 3.1)

Range	Year	RF tetrode	Triode	Output triode	Output pentode	Rectifier
2-volt	1926		Point One Plain top, Point One Red top, (210D), (210H)	Stentor Two Green top		
	1927	SG210, SG220	(210) Det & LF, (210) HF, (210) HF & Det, (210) RC	(215P) Stentor Two, (220P) Stentor Two		
	1928	210SG, 220SG	(210) LF	230P	230	
4-volt	1927	SG410	(410H), (410) HF & Det, (410) LF, (410) RC	(410P) Stentor Four		
	1928	410SG	(410) HF		415	
6-volt	1927	SG610	(610) HF, (610) HF & Det, (610) LF, (610) RC	(610 P) Stentor Six		
	1928	610SG		610FP		
AC	1927		M41HF, M41LF, M41RC, M61HF, M61LF	M41P, M41SP		
	1928					BU6, SU6

Note: Where brackets have been inserted in front of the type designation, this is to indicate the alternative designation. For example the two-volt HF valve was listed as 210HF even though the 210 was not shown on the label of these early valves.

Table 3.1: Cossor Ranges of 1926 to 1928.

Point One and Stentor battery ranges

Cossor's first attempt at valves with oxide-coated filaments was the 'Wuncell' range of 1924–25. This range was not very successful because the coating technique of was far from perfect. However, in July 1926, Cossor announced three new valves with coated filaments which became known as the Point One and Stentor range. The first two of these were the 'Point One Red Top' for r.f. amplification or resistance capacitor coupled amplifiers and the 'Point One Plain Top' for detection or a.f. amplification. The third was known as the 'Stentor Two Green Top' and was a power valve (see Figure 3.1). These three valves had two-volt filaments, although they were actually specified as 1.8-volts. The Stentor Two had a current rating of 0.15 amps, whilst the two Point One types were rated at 0.1 amps.

By early 1927 the r.f. amplifier had become known as the 210H and the red top was replaced with a red paper band. Similarly the detector became the 210D with a black paper band, and the Stentor Two became the (215P) with a green paper band, replaced later in 1927 by the (220P) with a 0.2-amp filament. At about the same time the four-volt Stentor Four (410P) and six-volt Stentor Six (610P) were released. None of these, nor many of subsequent ones in the range, had the type designations (indicated here in brackets) anywhere on the valve. These type designations, however, can be deduced from the markings on the labels, as will be explained shortly.

By mid-1927 Cossor had released a full range of two-, four- and six-volt valves for all the stages of a receiver: HF, detector, LF and output. They continued with the helmet-shaped anode, but the six-volt range required a longer filament than the four- and two-volt types and this was achieved by the electrode structure shown in Figure 3.2.

In order to provide some mystique for the coated filament Cossor coined the name 'Kalenised Filament', although the author has never discovered the derivation of this name, but it was claimed to be very robust.

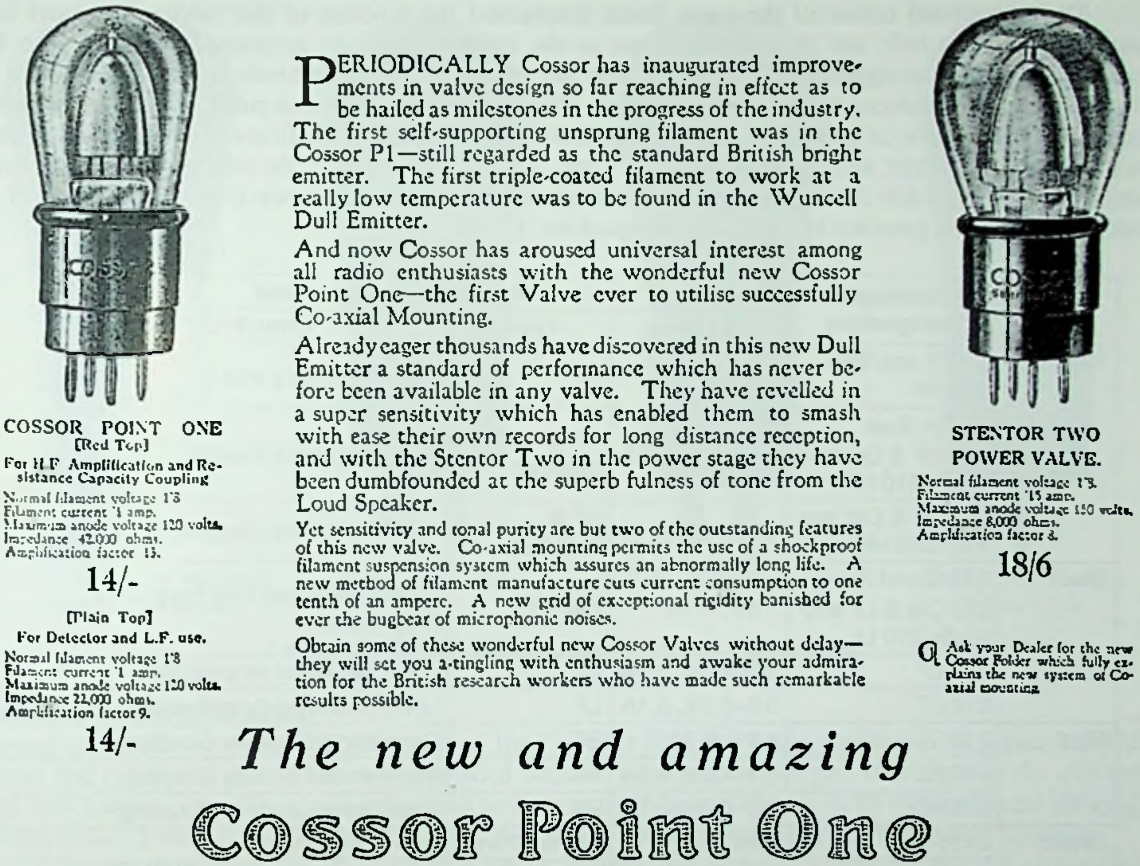


Figure 3.1: Cossor October 1926 advert for the Point One and Stentor valves.

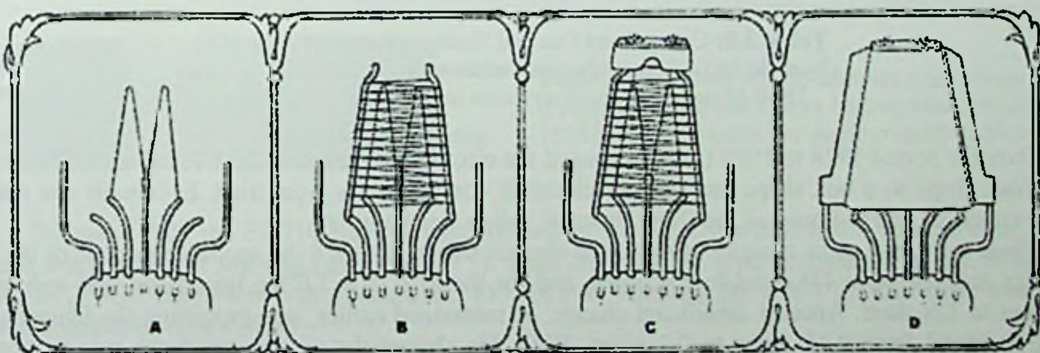


Figure 3.2: Electrode structure of the six-volt Point One Series. (A) shows the double inverted V-shaped filament, (B) the grid winding, (C) the seonite insulator with spring tensioning for the two arms of the filament, and (D) the final anode assembly.

The background colour of the paper bands determined the function of the valves. The band fully encircled the glass bulb and was adhered close to the Bakelite base. As mentioned earlier, with a few exceptions, the type designations of the valves were not printed on the paper bands or anywhere else on the valve but could be deduced from the printed details. The designations, shown in published lists, consisted of three numbers and one or two letters. The first number indicated the nominal filament voltage and the other two the filament current: so 210 meant 2-volts, 0.1amp. Abbreviated details of the writing on the paper bands are summarized in Table 3.2 together with the catalogue designations to the types. (Note: the wording of the circuit function was preceded by 'Specially Designed for'.)

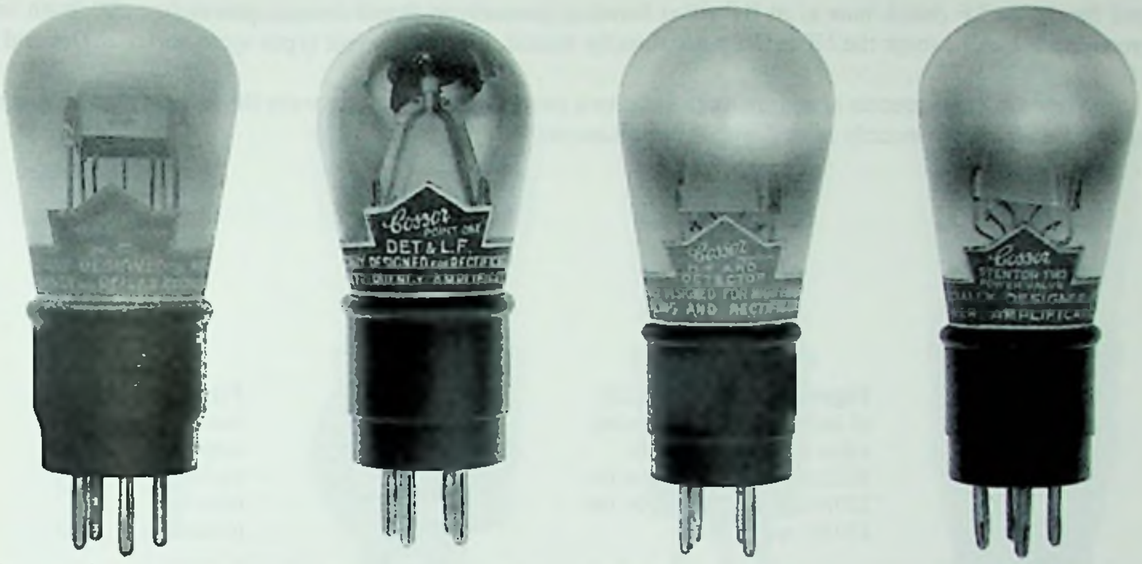
Band colour	Catalogue designation	Markings on paper band		
		Filament	Type	Circuit function
Red	210 H and then 210 HF	1.8V, 0.1A	HF	High Frequency and Reflex Coupling
	410 H, then 410 HF & Det and finally 410 HF	3.6–4.0V, 0.1A	HF & Detector	High Frequency Coupling & Rectification
	610 HF & Det and then 610 HF	5.6–6.0V, 0.1A	HF & Detector	High Frequency Coupling & Rectification
Black	210 D and then 210 Det & LF and finally 210 LF	1.8V, 0.1A	Det & LF	Rectification and Low Frequency Amplification
	410 LF	3.6–4.0V, 0.1A	LF	Low Frequency Amplification
	610 LF	5.6–6.0V, 0.1A	LF	Low Frequency Amplification
Blue	210 RC	1.8V, 0.1A	RC	Resistance Capacity Coupling
	410 RC	3.6–4.0V, 0.1A	RC	Resistance Capacity Coupling
	610 RC	5.6–6.0V, 0.1A	RC	Resistance Capacity Coupling
Green	215 P	1.8V, 0.15A	Stentor Two	Power Amplification
	220 P	1.8V, 0.2A	Stentor Two	Power Amplification
	410 P	3.6–4.0V, 0.1A	Stentor Four	Power Amplification
	610 P	5.5–6.0V, 0.1A	Stentor Six	Super Power Valve

Table 3.2: Cossor Point One and Stentor valves of 1926 to 1927.
(Note the two different filament current ratings for the Stentor Two.
The 0.15-amp rating was very soon increased up to 0.2-amps.)

Over the period 1928 to 1929 Cossor changed the electrode structure of the HF, LF and RC valves from the helmet shape to a box shape and various electrode configurations were tried. Eventually the range was further enhanced and re-issued as the 'New Process' valves (see page 62).

There were also some changes to the valve characteristics. By 1928 the anode impedance of the 210HF had been reduced from 44k ohms to 25k ohms, and for the 210Det & LF the impedance was reduced from 22k ohms to 12k ohms. Another significant change, as mentioned earlier, was increasing the filament current of the Stentor 2 from 0.15 amps to 0.2 amps. With this change the anode impedance was reduced from 8k ohms to 5k ohms and the slope increased from 0.8mA/V to 1mA/V.

Some examples of the Point One and Stentor range can be seen in Figure 3.3. (Note: the early valves in the series had an abrupt step in the base, as can be seen with the three valves that have the helmet-shaped anodes. On later valves, e.g. H.F. in Figure 3.3, the step was changed to have rounded edges.)



H.F. (2-volt). Later version with box-shaped anode. | Det & L.F. (2-volt). | H.F. & Detector (4-volt). | Stentor Two (2-volt). Output triode.

Figure 3.3: Point One and Stentor valves of 1927 to 1928.

Early screened grid types

Cossor exhibited two screened grid valves at the Olympia National Radio Exhibition in September 1927. These had cylindrical glass bulbs with mounded Bakelite caps at each end provided respectively with three and two contact pins. The construction was similar to the Marconi-Osram S625 that had been released a month earlier. Unlike the S625, however, the valves had coated filaments rather than thoriated filaments.

The two types were the SG210 with a 2-volt filament (see Figure 3.4) and the SG610 with a 6-volt filament. Both had red paper labels. The SG210 was specified as the r.f. amplifier in the first Cossor melody maker receiver. It was also the first two-volt screened grid valve to be manufactured in Britain.

Figure 3.4: Cossor SG210 screened grid valve of 1927. (Specified for the first Cossor Melody Maker receiver of 1928 but superseded by the single-ended SG220.)

By early 1928 the SG210 had been superseded by the SG220 which had a conventional four-pin base and screw terminal top cap (see Figure 3.5). Later in 1928 the type designation of the SG220 was changed to 220SG and a four-volt version, the 410SG, was released. By mid-1927 the range was further extended with the six-volt 610SG.

Early a.c. types

The first range of a.c. triodes was released in 1927. The valves had a standard 4-pin base but there were two top terminals for connections to the heater (see Figure 3.6). The author has identified seven types in this range and these must have been made in very small quantities because they never appeared in any commercial receivers. Of these, five had 4-volt, 1-amp heaters and the other two had 6-volt, 1-amp heaters. All the type designations were preceded by either M41 or M61. Considering first the 4-volt types, there was an HF & Det (red band), an LF (black band), an RC (blue band), a power type P and a super power type SP (both with green labels). All except the HF & Det were directly heated. The two 6-volt types were an HF & Det and an LF.

The only new types to appear in 1928 were two power rectifiers: these were the full-wave BU6 and the half-wave SU6, both directly heated with 6-volt filaments.

Figure 3.5: Cossor SG220 of early 1928, a single-ended valve that superseded the SG210. This soon became the 220SG, to be followed by the 410SG and 610SG.

Figure 3.6: Early Cossor mains valve, type M41P output pentode, with two top terminals for connections to the heater. (Courtesy Rod Burman.)

Early battery output pentodes

The first two Cossor output pentodes were the two-volt type 230 and the four-volt type 415, both of which were introduced in 1928. By the following year these two had been re-classified respectively as 230PT and 415PT.

NEW PROCESS BATTERY VALVES OF 1929 & 1930

Cossor announced their 'New Process' range of valves in September 1929, with a diamond-shaped paper label. The claims made were: New Construction, New Process and New Filament [2]. Many of these had the same type designations as the earlier Point One and Stentor types, except that the full designation was now printed on the label. Apart from an improved filament with higher emission, Cossor had also dispensed with the helmet-shaped anode and gone to box-shaped electrode assemblies because this type of assembly was cheaper to manufacture and was able to provide improved support for the filament. The battery types available in 1929 are listed in Table 3.3.

Range	RF tetrode	Triode	Output triode	Output pentode
2-volt	220SG	210HF, 210RC, 210LF	220P, 230XP	230PT (B4 base)
4-volt	410SG	410HF, 410LF, 410RC	415XP	415PT
6-volt	610SG	610HF, 610LF, 610RC, 680HF	610P, 610XP, 625P	

Table 3.3: New Process battery valves of 1929.

In addition to the types covered in Table 3.1, repeated here because of their improved construction, there were four new output triodes: 230XP, 415XP, 610XP and 625XP. Also the two earlier output pentodes—types 230 and 415—had been re-classified as 230PT and 415PT respectively.

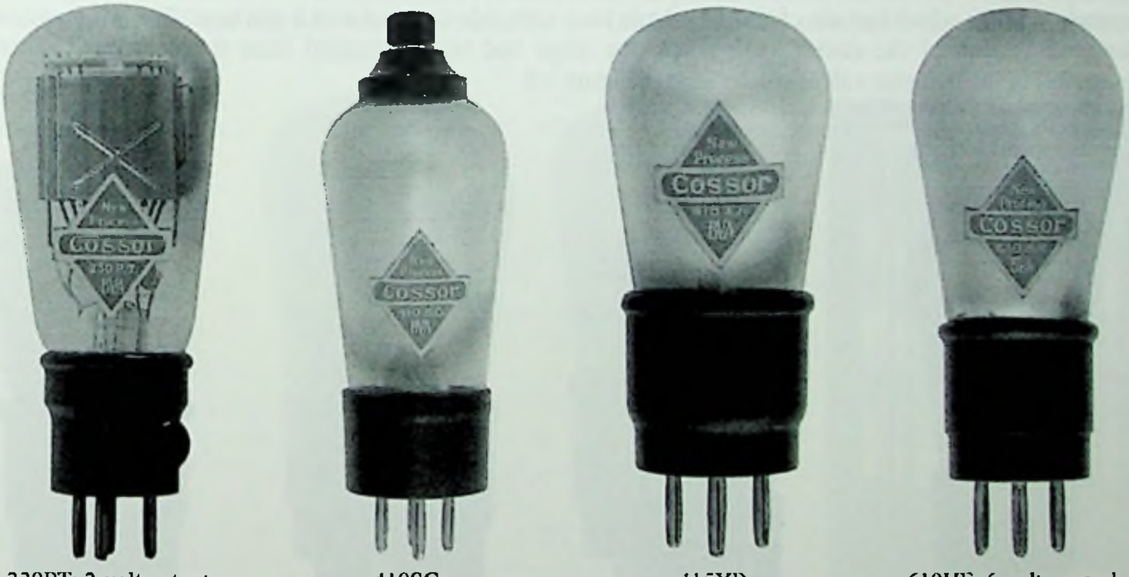
Some examples of these valves can be seen in Figure 3.7.

220SG: 2-volt r.f. tetrode.

210HF: 2-volt general-purpose triode.

210LF: 2-volt a.f. amplifier triode.

220P: 2-volt output triode.



230PT: 2-volt output pentode (4-pin version).

410SG: 4-volt r.f. tetrode.

415XP: 4-volt output triode.

610HF: 6-volt general-purpose triode.

Figure 3.7: 'New Process' battery valves of 1929.

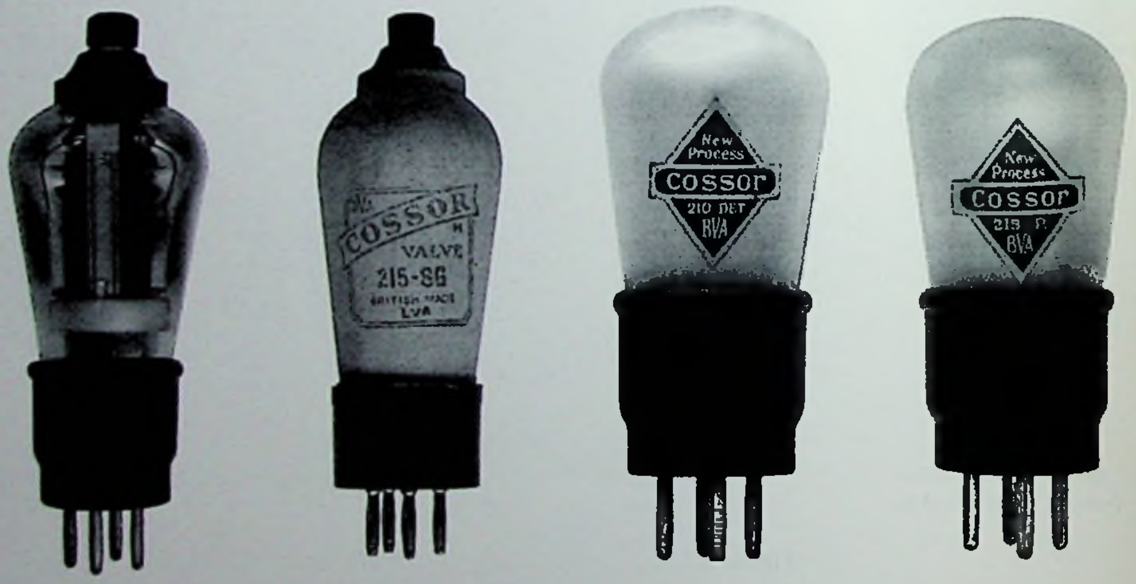
BATTERY RANGE: 1930–1940

By 1930 Cossor had dispensed with most of the earlier types of battery valves and was expanding their New Process ranges. Table 3.4 lists the types released during the 1930s.

Year	RF tetrode or pentode	Frequency changer	Diode	Triode or DDT	Output triode	Output pentode or tetrode
1930	215SG			210Det	215P, 425XP	615PT (B4, B5)
1931	220VSG	210DG		210HL	220PA	230HPT (B4)
1932						220HPT (B4), 220PT (B4), 410PT
1933	220VS				220B, 240B	220HPT, 220PT, 230PT (all B5)
1934	210SPT (B4, B7) 210VPT (B4, B7)	210PG	220DD			
1935						
1936		210SPG				
1937						220OT, 240QP
1938	210VPA, 220IPT	210PGA, 220TH		210DDT		206PT (deaf aid)
1940s						

Table 3.4: Battery ranges of 1930 to 1940.

In 1930 Cossor introduced a new two-volt screen grid valve, the 215SG, which replaced the earlier 220SG in some applications, where, for example, two r.f. stages were used. With this valve the filament current was reduced from 0.2 amps to 0.15 amps and the anode resistance increased from 200k ohm to 300k ohm. The higher slope 220SG, however, continued in use into the 1930s. There was also a new detector triode, the 210Det. Two other new types were the four-volt output triode, 425XP, and the six-volt output pentode, 615PT, which had the choice of a 4-pin base with side terminal or a 5-pin base. There was also a re-designed version of the earlier 215P where the slope had been increased from 0.8mA/V to 2.25mA/V. Examples of the two-volt valves can be seen in Figure 3.8.



215SG: r.f. tetrode which replaced the 220SG. Clear version at left and metallised version at right.

210Det: detector triode.

215P: output triode.

Figure 3.8: Two-volt battery valves of 1930.

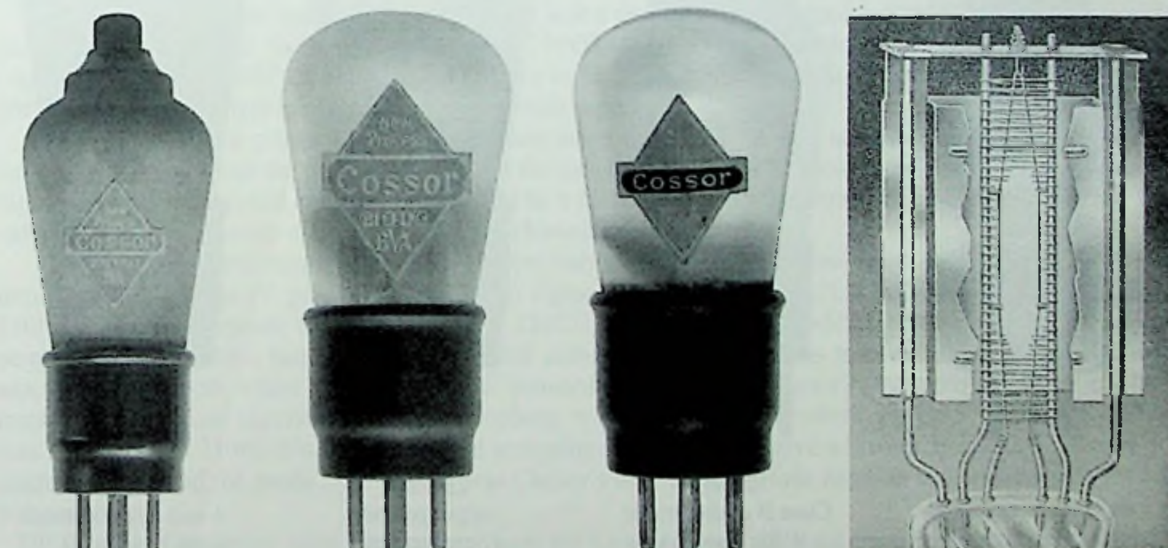
The year 1931 saw the introduction of five new two-volt valves. These were the 220VSG variable-mu r.f. tetrode, the 210DG bi-grid, for use as a frequency changer in superheterodyne receivers, the 210HL triode for use as an r.f. amplifier or a detector, the 220PA output triode and the 230HPT output pentode. The 210HL, like the 210Det, featured a new filament construction which had seven-point suspension to eliminate microphony problems, as shown at the extreme right in Figure 3.9. There was also a mica bridge at the top of the electrode assembly which both added to the strength and provided excellent insulation between the electrodes.

The bi-grid 210DG should not be confused with a screen grid valve, where the outer grid acts as an electrostatic screen to reduce the capacitance between the anode and inner grid. The bi-grid valve could be used in several ways but the r.f. signal was usually applied to the inner grid and the output from a separate oscillator valve applied to the outer grid. It could also be used as a self-oscillating mixer, but either way it was not very efficient and was soon superseded, first by a screen grid valve, and then by frequency changer valves such as the heptode or triode hexode.

The 210HL soon became the most popular battery valve for use as a detector. It was particularly suited as a leaky grid detector with transformer coupling to a low-power output triode or pentode. The 210Det, however, was specially designed for receivers where the detector was expected to handle a fairly large signal before overload. It was also suitable as an a.f. amplifier.

The 220PA could produce about the same output power as the earlier type 220P (around 180mW from a 150-volt h.t. supply) but was considerably more sensitive, with a slope of 4mA/V as against only 2mA/V for the 220P.

Two new output pentodes were introduced in 1932: these were the 220HPT, described as an economy pentode and intended as a replacement for the 230HPT; the second was the short-lived four-volt, 410PT which replaced the earlier 415PT and provided twice the output power. Initially the 220HPT had a 4-pin base with a side terminal but this was soon superseded by a 5-pin base, as also were the bases of the 220PT and 230HPT.



220VSG: variable-mu r.f. tetrode.

210DG: bi-grid used mainly as a frequency changer.

210HL: detector triode. The diagram at the right shows the seven-point filament suspension and mica support bridge at the top of the assembly.

Figure 3.9: Two-volt battery valves of 1931.

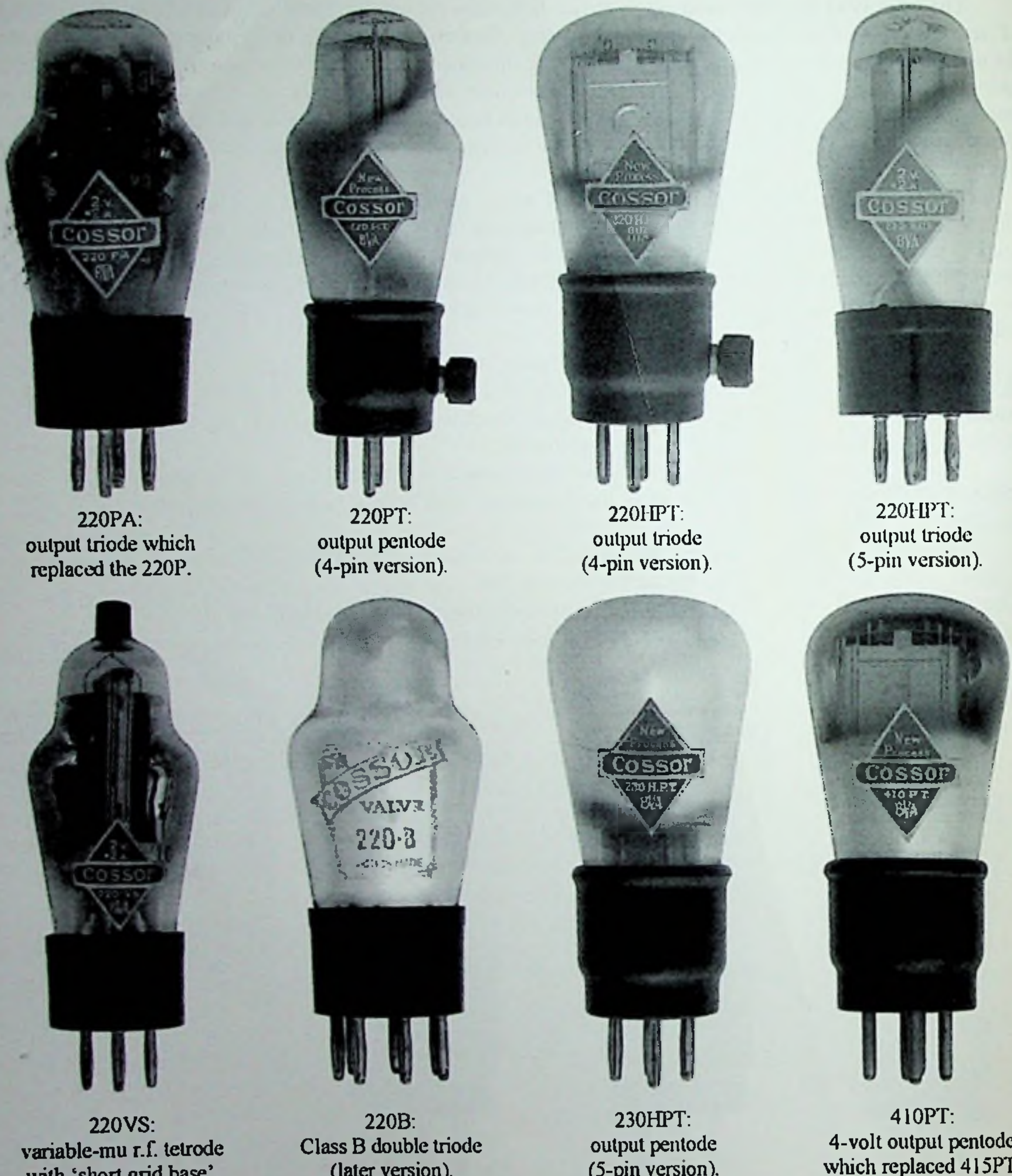


Figure 3.10: Two- and four-volt battery valves of 1931 to 1933.

The following year saw a new variable-mu screen grid tetrode, the 220VS. This was described as a short grid base type requiring only a 9-volt grid bias battery, whereas the earlier 220VSG had a longer grid base and required an 18-volt grid bias battery in order to provide an adequate range of volume control.

Also in 1933 there were two Class B double triodes. These were the 220B and the higher power type 240B. Because of its lower filament current the 220B became the preferred choice in most battery receivers. Both valves were intended to be operated at zero grid bias. Table 3.5 shows the anode current and optimum load resistance for the two types. The recommended driver valve for the 220B was the 215P although the 210LF could also be used. For the higher power 240B the driver valve could be the 215P, 220P or 220PA. The output power for the two valves with a 120-volt supply was quoted at 1.25 watts for the 220B and two watts for the 240B.

Examples of the 1931 to 1933 battery valves can be seen in Figures 3.9 and 3.10.

Anode Voltage	Static anode current (mA)		Average anode current (mA)		Optimum load (ohms)	
	220B without driver	240B without driver	220B with 215P driver	240B with 215P driver	anode to anode	
					220B	240B
90	3.0	4.3	6.0	7.0	20,000	10,000
120	6.0	8.5	7.5	11.0	12,000	8,000

Table 3.5: Anode current and optimum load for the Cossor 220B and 240B Class B double triodes.

In 1934 Cossor, in common with most other British manufacturers, introduced valves specifically for superheterodyne receivers. The new types consisted of a straight r.f. pentode, 210SPT, a variable-mu r.f. pentode, 210VPT, a heptode frequency changer, 210PG, and an indirectly heated double diode, 220DD. The 210PG had a conversion conductance of 0.45mA/V; it was later re-classified as 210SPG. The r.f. pentodes were produced with a choice of 4- or 7-pin bases; the 4-pin version had the suppressor grid joined internally to one of the filament pins, whereas the 7-pin version had a separate pin for this electrode. The indirectly heated cathode of the 220DD made possible delayed a.g.c. by provision of cathode bias via a potential divider from the h.t. supply.

There were no new battery types until 1937 when an output beam tetrode, 220OT, and a QPP double pentode, 240QP, made their appearance. The 220OT had the same anode current, grid bias and base connections as the 220HPT, enabling either valve to be interchanged without any alteration to the receiver; both valves had an output of 500mW from a 150-volt supply.

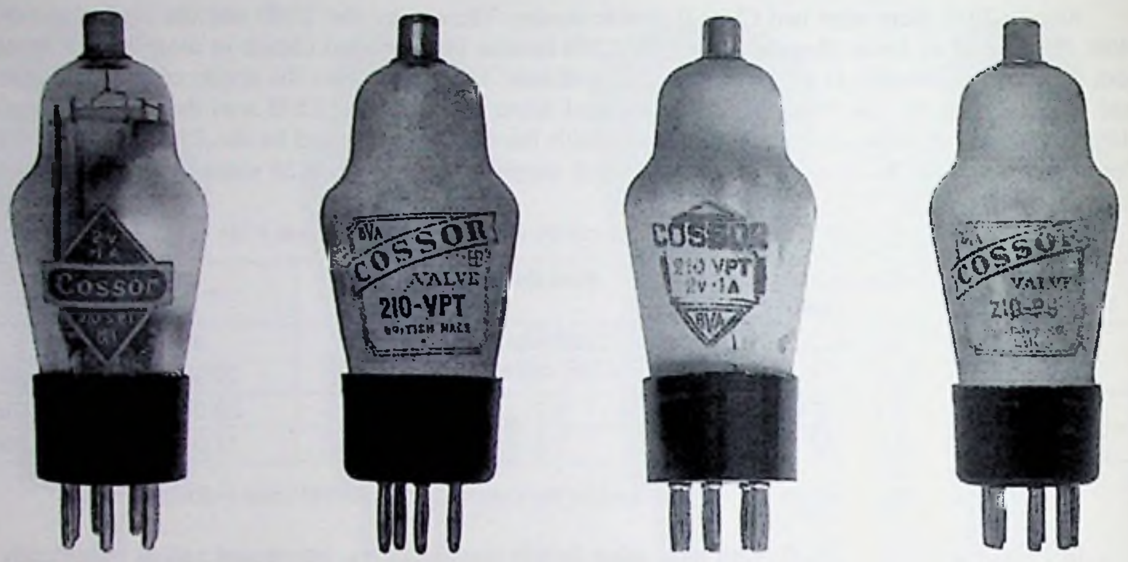
As was common practice at the time, when using the 240QP it was necessary to incorporate a tone correction circuit across the primary winding of the output transformer to prevent the rise in its impedance at high frequencies. A typical circuit for this would be a 20k ohm resistor in series with a 5000pF capacitor. The valve had an output power of 1.25 watts from a 150-volt supply.

To complete these ranges of two-volt battery valves there were five new types in 1938. These were an improved variable-mu r.f. pentode, 210VPA (to replace the earlier 210VPT), a heptode frequency changer, 210PGA, a triode heptode frequency changer, 220TH, a double diode triode, 210DDT, and an unusual r.f pentode, 220IPT, which had an indirectly heated cathode. The 220IPT was mentioned in a *Wireless World* article in April 1938, where it was said to be 'primarily for use as a detector in portable receivers in which trouble is sometimes experienced from microphony when filament-type valves are used' [3]. The 210PGA was similar to the 210PG but had a modified screening arrangement to give a lower capacitance between the modulator grid and the anode. The 220TH was Cossor's only battery triode heptode and was suitable for all-wave receivers.

Typical of receivers using these valves were the Cossor 35 and 37 three-band battery superhets, where the line-up was 220TH, 210VPT, 210DDT and 220OT.

Cossor produced one other two-volt battery valve, the 206PT output pentode. This was of small size and designed for deaf aid use. It had a 60mA filament and both anode and screen were intended to work at 35 volts. The connections to the electrodes were wire ended.

Various examples of the 1934 to 1939 battery valves can be seen in Figures 3.11 and 3.12.

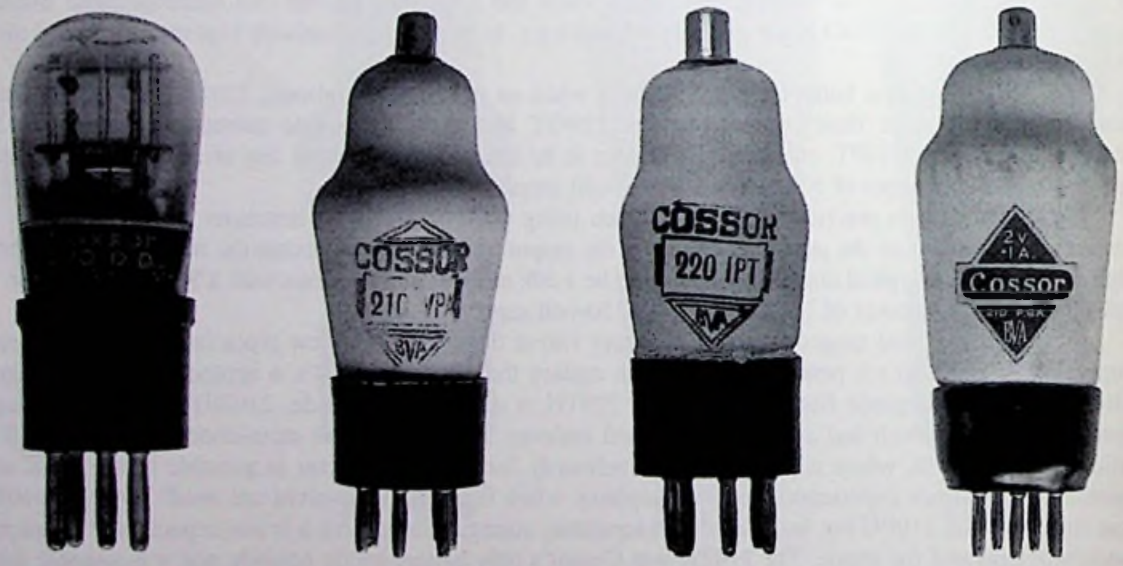


210SPT: r.f. pentode of 1934 and never superseded.

210VPT: variable-mu r.f. pentode. (4-pin-version).

210VPT: variable-mu r.f. pentode. (7-pin version).

210PG: heptode frequency changer which became 210SPG in 1936 and 210PGA in 1938.



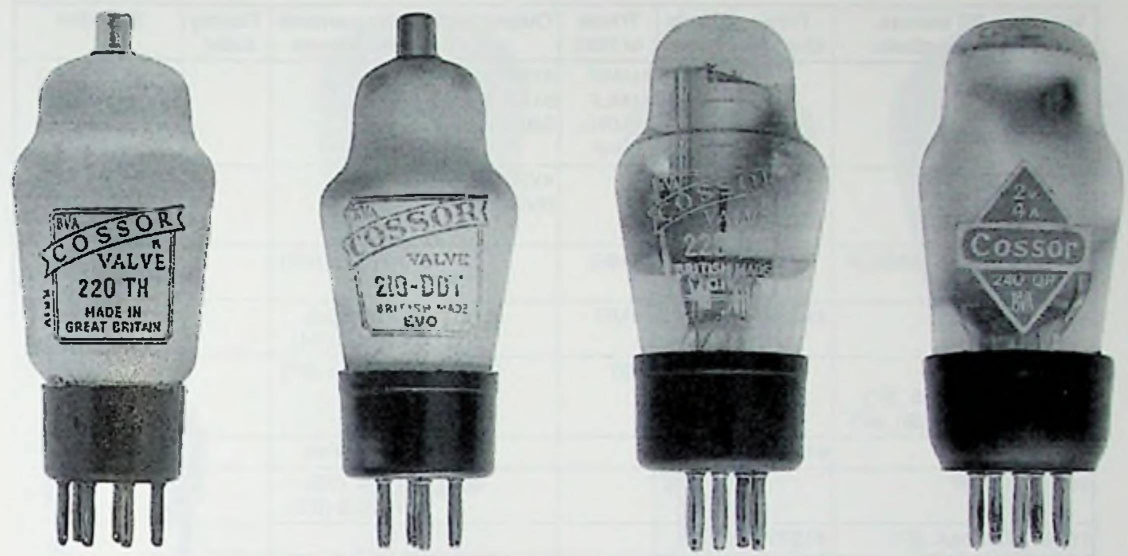
220DD: indirectly heated double diode.

210VPA: variable-mu r.f. pentode.

220IPT: indirectly heated pentode detector.

210PGA: heptode frequency changer.

Figure 3.11: Two-volt battery valves of 1934.



220TH: triode heptode frequency changer. | 210DDT: double diode triode. | 220OT: output beam tetrode. | 240QP: QPP double output pentode.

Figure 3.12: Two-volt battery valves of 1934 to 1938.

AC RANGES: 1929–1941 WITH B4, B5 & B7 BASES

In 1929 Cossor released a new range of indirectly heated valves (see Table 3.6). These were the 41 Series and consisted of a screened r.f. tetrode, the MSG41, three low power triodes, 41MHF (for r.f or detector use), 41MLF (for the first a.f. stage) and the 41MRC (for detector or resistance coupled a.f. amplifiers). There were two output triodes, the 41MP and the higher power 41MXP. There was also a range of directly heated output triodes having six-volt filaments. In ascending order of output power these were the one-watt 680P, the 2.5-watt 680XP, the 600T and the ten-watt 64XP; the filament currents for these power triodes ranged from 0.8 amps for the first two, one amp for the 600T and four amps for the 64XP. Another new triode was the six-volt directly heated 680HF which was an a.f. amplifier presumably intended to drive a high power output stage.

In 1929 there were also three new directly heated rectifiers. Of these two were full-wave, the 412BU and 612BU, which both had 250-volt anode ratings, and the half-wave 660SU with a 1kV, 150mA anode rating and presumably intended for use in public address amplifiers with output valves such as the 64XP.

Finally, amongst these early a.c. types there were several new releases in 1930. These consisted of an r.f. tetrode, the 41MSG, to replace the MSG41, and three directly heated output triodes: the 2.8-watt 4XP with a 4-volt, 0.6-amp filament (later uprated to one amp), the five-watt 620T, and the 11-watt 660T.

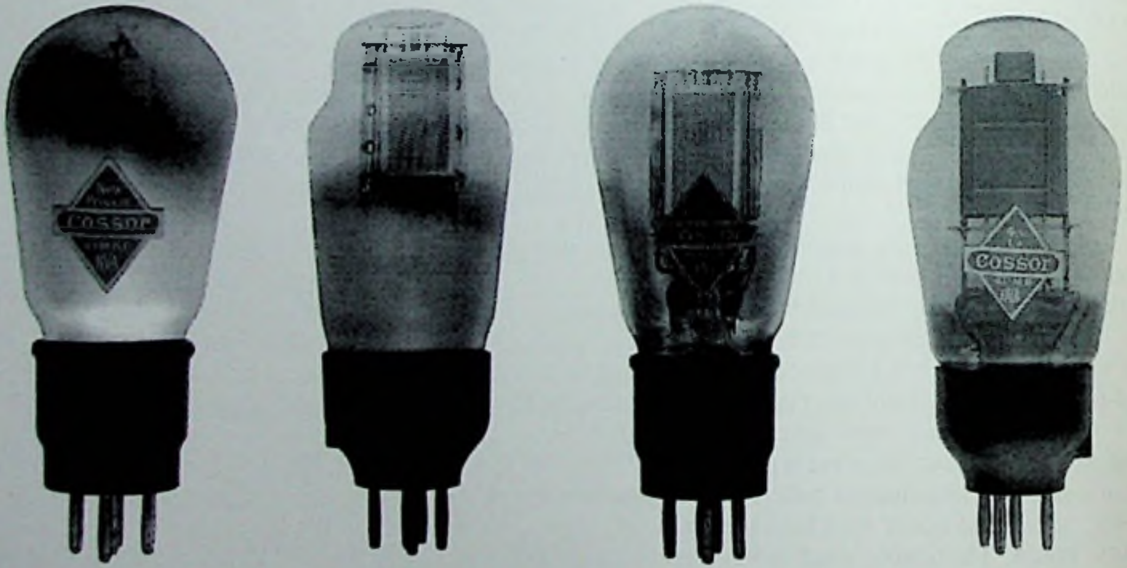
In addition, there were several new directly heated rectifiers consisting of two half-wave types, 44SU and 412SU, and four full-wave types, 408BU, 506BU, 624BU and 825BU. The 44SU had a rating of 200V, 20mA and was intended for battery eliminators. The 408BU was also a low current type with a rating of 250V, 30mA and would have been used in small mains receivers, whereas the 506BU had a higher rating of 250V, 60mA. The 624BU, rated at 500V, 60mA, was very soon discontinued. Finally the 825BU had a rating of 500V, 120mA and would have been intended for medium power amplifiers.

Examples of the 1929 and 1930 a.c. valves can be seen in Figures 3.13 and 3.14.

Year	RF tetrode or pentode	Freq. changer	Diode	Triode or DDT	Output triode	O/p pentode or tetrode	Tuning indic.	Rectifier
1929	MSG41			41MHF, 41MLF, 41MRC, 680HF	41MP, 41MXP, 64XP, 600T, 680P, 680XP			412BU, 612BU, 660SU
1930	41MSG				4XP, 620T, 660T			44SU, 408BU, 412SU, 506BU, 624BU, 825BU
1931	MSG/HA, MSG/LA, MS/PenA			41MHL		MP/Pen (B5)		442BU, 460BU
1932	MVSG	41MDG		41MH		PT41 (B4), PT41B (B4)		
1933	DD/Pen, MS/Pen (B5, B7), MVS/Pen (B5, B7)			DDT		MP/Pen (B7)		
1934		41MPG	DD4			42MP/Pen		
1935						PT41 (B5), PT41B (B5)		
1936	MS/PenA (B7)	41STH						
1937	MS/PenB, MVS/PenB					42OT, 42OT/DD		4/100BU, 43IU, 44IU, 225DU
1938		4THA			2XP		41ME	
1939								45IU
1940					2P, 41FP*	PT10*		

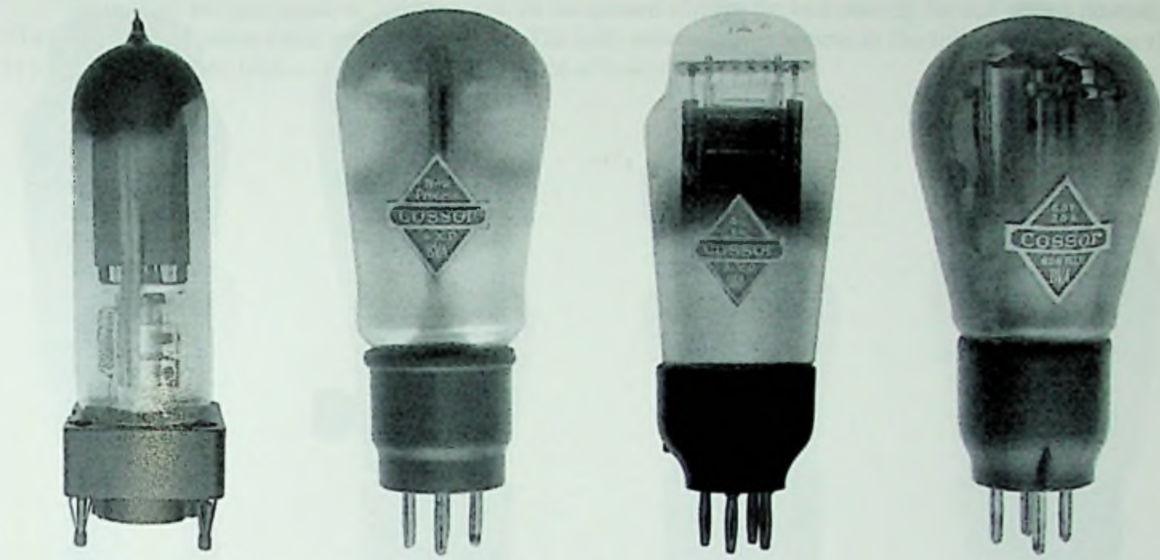
*Approx. date only

Table 3.6: AC ranges of 1929 to 1940 with British bases.



41MHF: r.f. or detector triode. 41MLF: a.f. triode. 41MXP: output triode (early version. 41MP is similar.) 41MP: output triode (later version).

Figure 3.13: AC mains valves of 1929 and 1930.



660T:
11-watt directly heated output triode with L4 bases.

4XP: directly heated 3-watt output triode (early version).

4XP: directly heated 3-watt output triode (later version).

624BU: full-wave directly heated rectifier.

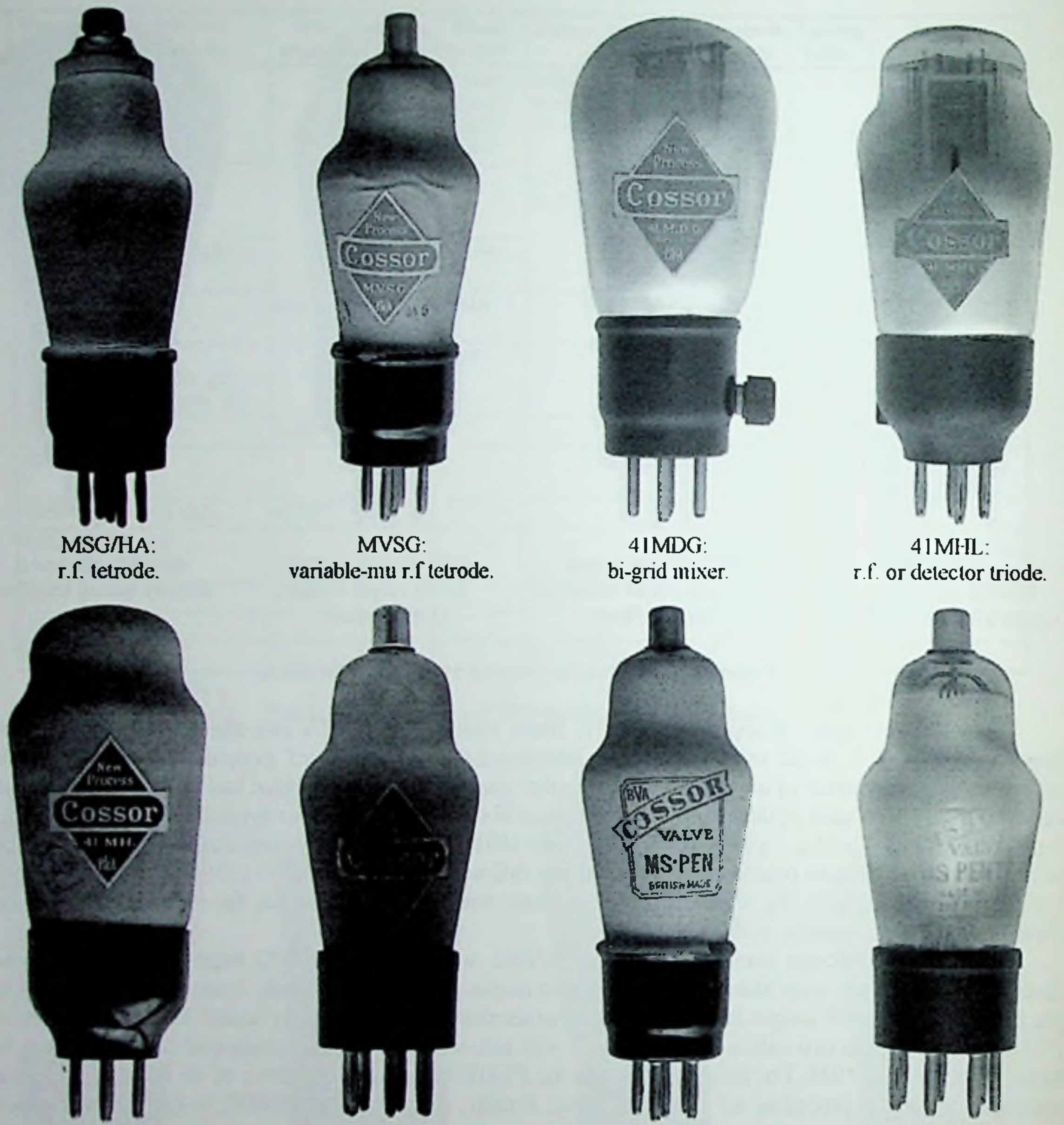
Figure 3.14: AC mains valves of 1929 and 1930 (cont.).

Two new r.f. tetrodes appeared in 1931; these were the MSG/HA and the higher gain but lower impedance MSG/LA. At the same time Cossor introduced the first British r.f. pentode, the MS/PenA, which was two years in advance of any similar type by other manufacturers. This valve had an anode impedance of only 90k ohm but in spite of this it continued to appear in Cossor valve lists for several years and even had the 5-pin base replaced with a 7-pin type in 1936. Other 1931 types were a low-impedance, high-slope detector triode, 41MHL, an output pentode, MP/Pen, and two full-wave rectifiers, 442BU (350V, 120mA) and 460BU (500V, 120mA). Initially, the MP/Pen had a 5-pin base with a side terminal for the screen connection but a 7-pin base became available in 1933.

The first variable-mu screen grid tetrode, MVSG, was released in 1932 together with an improved detector, 41MH. There were also two directly heated output pentodes with 4-volt, 1-amp filaments: these were the PT41, rated at 2.6W output and with similar characteristics to the indirectly heated MP/Pen, and the 3.6W PT41B. Initially these two valves had 4-pin bases with side terminals for the screen grid connection, but 5-pin bases were fitted in 1935. For full output power the PT41B required a grid drive of 40 volts peak making it necessary to have a preceding a.f. amplifier valve. Finally, there was the 41MDG bi-grid valve which was intended as a mixer in superheterodyne receivers.

In 1933 there were two new r.f pentodes. The first of these, the MS/Pen, was an alternative to the earlier MS/PenA and, although it had a lower slope, it had a far higher anode impedance of 800k ohm. The second was the variable-mu MVS/Pen. Both of these valves had the option of a 5-pin or 7-pin base. There was also the DD/Pen, with similar characteristics to the MS/Pen, but which incorporated two diodes. The suppressor grid of this valve was internally connected to the cathode and this electrode was common to both diodes and the pentode.

Examples of the 1931 to 1933 valves can be seen in Figure 3.15, and 3.16.



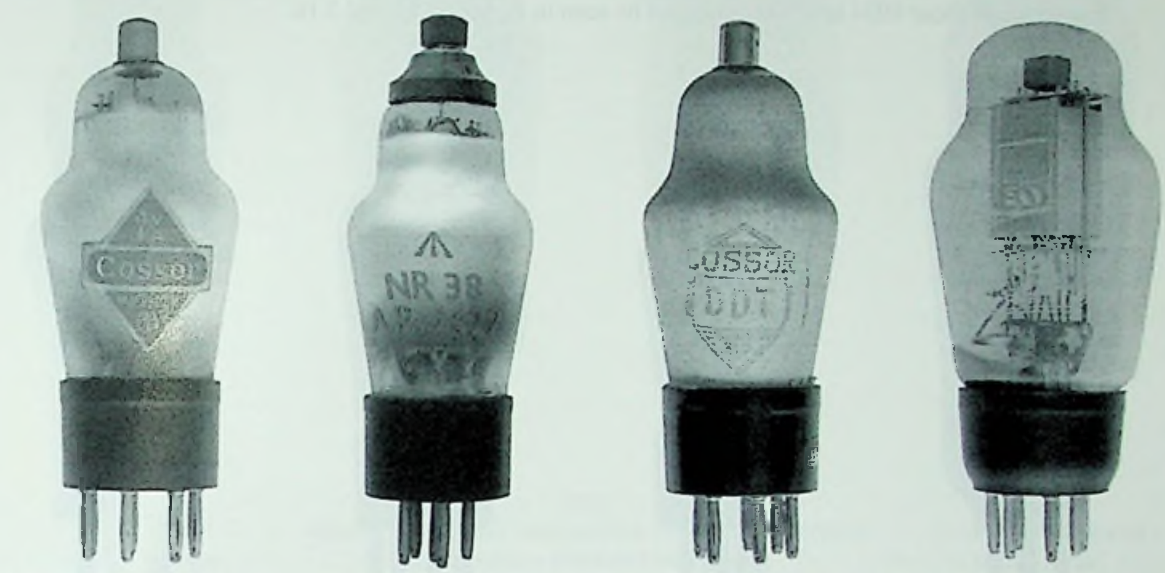
MSG/HA: r.f. tetrode. MVSG: variable-mu r.f tetrode. 41MDG: bi-grid mixer. 41MHL: r.f. or detector triode.

41MH: detector triode. DD/Pen: double diode a.f. pentode. MS/Pen: r.f. pentode (5-pin version). MS/PenT: = MS/Pen (7-pin version).

Figure 3.15: AC mains valves of 1931 to 1933.

Cossor's first indirectly heated frequency changer valve, the 41MPG heptode, appeared in the spring of 1934 along with a new indirectly heated output pentode, the 42MP/Pen, which had a slope of 7mA/V. Because if its high sensitivity it was possible to feed this valve directly from a detector, and for this purpose Cossor introduced the double diode DD4. Thus for a low cost superheterodyne receiver, such as the Cossor model 535, a typical valve line-up would be 41MPG, MVS/Pen, DD4, 42MP/Pen and 442BU.

There were no new types in 1935, except, as mentioned earlier, the two directly heated output pentodes, PT41 and PT41B, were fitted with 5-pin bases. The only new valve to appear in the following year was the 41STH triode hexode with a conversion conductance of 0.6mA/V.



MVS/Pen: variable-mu r.f. pentode (7-pin version).

NR38 = MVS/Pen (5-pin version).

DDT: double diode triode.

MP/Pen: output pentode. (7-pin version).

Figure 3.16: AC mains valves of 1931 to 1933 (cont.).

Up until the mid-1930s it was usual practice to bring the anode connection of r.f. pentodes out to the top cap but, thereafter, this was changed to the control grid. This change was first made with the MS/PenB and MVS/PenB of 1937 which were, otherwise, identical to the earlier MS/Pen and MVS/Pen. The same year saw Cossor's first beam tetrodes, the 42OT, together with its double diode version, the 42OT/DD; this latter valve was for use in low-cost receivers to avoid the need for a triode audio amplifier stage. Finally there were three new full-wave rectifiers: of these the 43IU and 44IU were both indirectly heated, and the third was a high power, directly-heated type, 4/100BU, which was rated at 500V, 200mA, for applications in public address amplifiers and television receivers. (In 1939 this was superseded by the indirectly heated 45IU.) Finally there was the 225DU, a voltage doubler rectifier which had two separate 2-volt, 0.5-amp filaments. This valve could also be used as a full-wave rectifier with the filaments connected either in series or parallel.

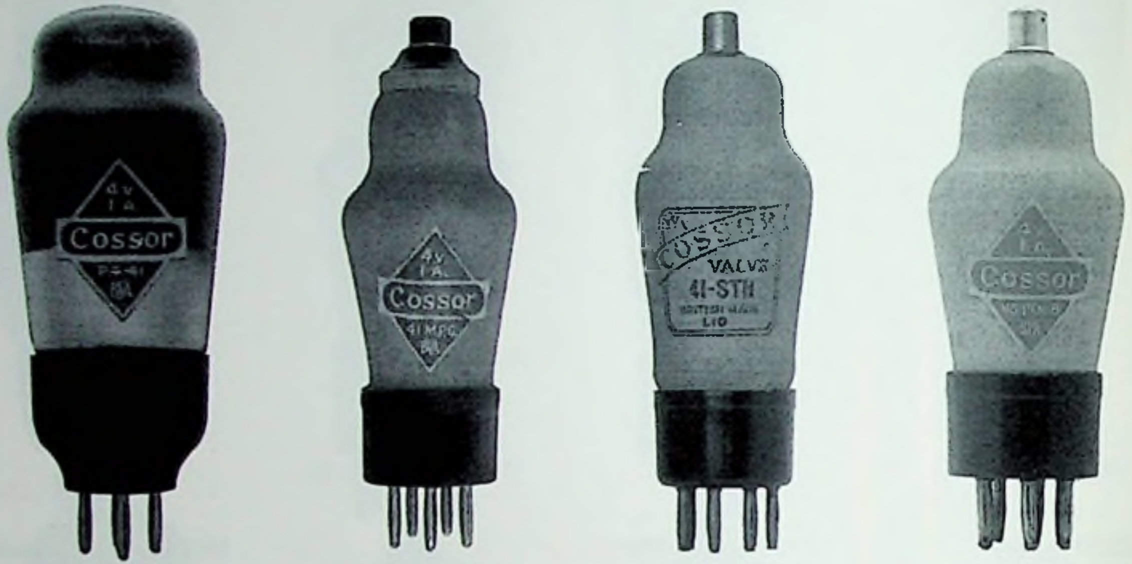
In the following year there was a new triode hexode frequency changer, the 4THA, which replaced the earlier 41STH and had a higher conversion conductance of 0.85mA/V. There was also a two-volt directly heated output triode, 2XP and the 41ME tuning indicator. Apart from its lower filament voltage the 2XP was identical to the earlier 4XP. The intention was that the 4XP should be used in push-pull amplifiers where mains hum produced from the filament would be cancelled out; the 2XP, with its lower filament voltage, was more suitable in single-ended audio amplifiers where the hum contribution would be less. Furthermore, the hum could be reduced by the use of a potentiometer connected to each end of the filament and with the slider connected to the common h.t. negative line. (Such a potentiometer was known as a 'hum-dinger'.)

There was one new full-wave rectifier, which was introduced in 1939. This, the indirectly heated 45IU, was rated at 500V, 250mA and was suitable for high-power audio amplifiers.

Around 1940/41 Cossor released three new power valves: the two-volt 2P (a lower power alternative to the 2XP and not requiring a Post Office licence because its anode dissipation was less then ten watts), the indirectly heated 41FP triode and the PT10 pentode with an output power of 4.2 watts.

A valve released in the post-WW2 period was the 4SH, a hexode mixer which doesn't appear in the usual Cossor data sheets. It was probably produced solely for military purposes and was given the Service designation CV1126.

Examples of these 1934 to 1941 valves can be seen in Figures 3.17 and 3.18.

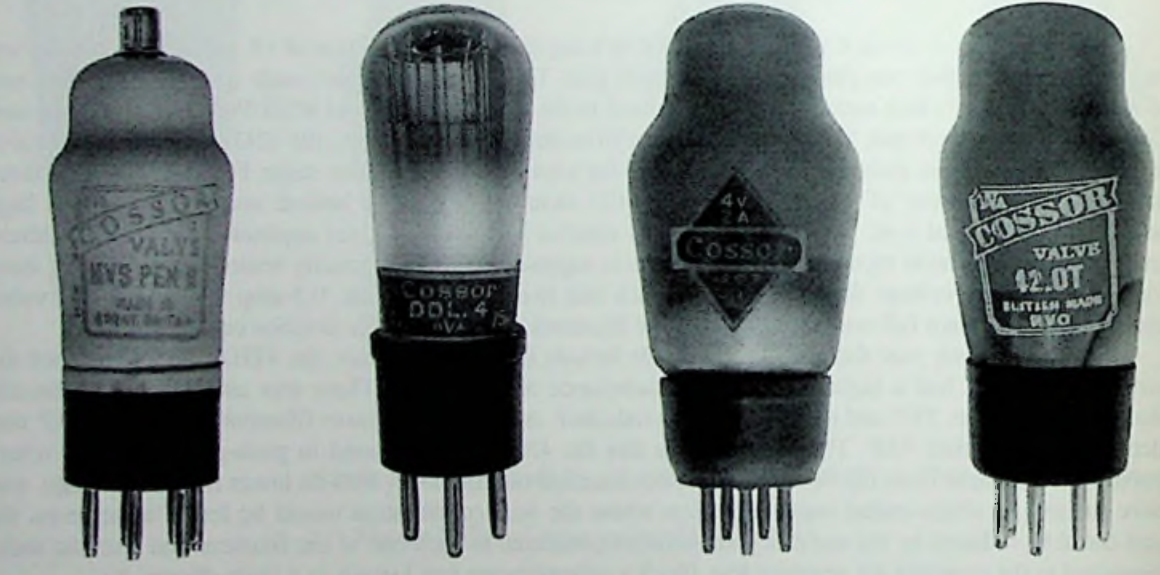


PT41: output triode. (5-pin version of 1935).

41MPG: heptode frequency changer.

41STH: triode hexode frequency changer.

MS/PenB: r.f. pentode with grid top cap.



MVS/PenB: variable-mu r.f. pentode. (Later version supplied by Mullard.)

DDL4: double diode triode.

42OT: output beam tetrode. (Early version at left and later version at right.)

Figure 3.17: AC valves of 1934 to 1937.

4THA:
triode hexode
frequency changer.

43IU:
indirectly heated full-wave rectifier rated at 350V, 120mA.
(Early version at left and later version
at right supplied by Mazda.)

2P:
2-watt directly heated
output triode.

225DU:
voltage doubler rectifier
with two, 2-volt filaments.

45IU: indirectly heated
full-wave rectifier
rated at 500V, 250mA.

41FP:
a.f. or low-power output
triode (soon discontinued).

4SH = CV1126
hexode mixer (post-WW2).

Figure 3.18: AC valves of 1938 to 1941 (cont.).

DC & AC/DC RANGES OF 1933–1940

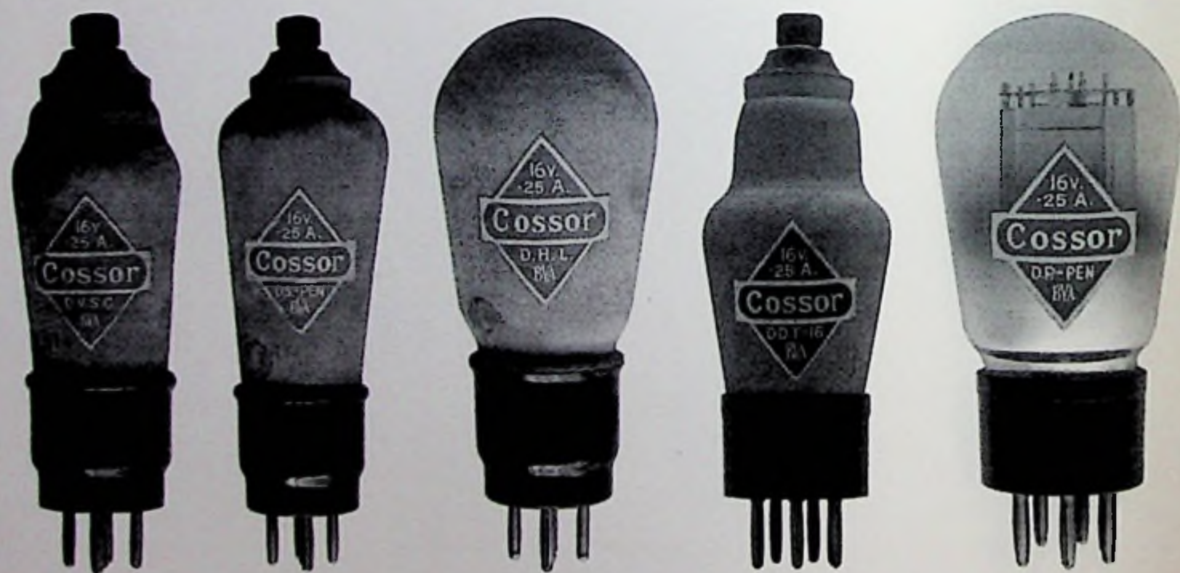
These valves can be conveniently broken down into the three ranges shown on Table 3.7.

Range	Year	RF tetrode or pentode	Freq. changer	Triode or DDT	Output triode	O/p pentode or tetrode	Rectifier
16-volt, 0.25-amps	1933	DS/Pen, DVSG, DVS/Pen		DDT16, DHL	DP	DP/Pen (B5), DP/Pen (B7)	
13/40-volts, 0.2-amps	1934	13SPA	13PGA	13DHA		40PPA	40SUA
	1935	13VPA					
20/30/40-volts 0.2-amps	1936		202MPG	202DDT	402P	402Pen	
	1937		202STH			402OT	
	1938	202SPB, 202VP, 202VPB	203THA			402Pen/A	
	1940		302THA				OM1

Table 3.7: DC and a.c./d.c. ranges of 1933 to 1940.

0.25-amp d.c. range of 1933

This range had 16-volt 0.25-amp heaters and consisted of the following types: DVSG (variable-mu screened grid tetrode), DS/Pen (r.f. pentode), DVS/Pen (variable-mu r.f. pentode), DDT16 (double diode triode), DHL (detector triode), DP (output triode) and DP/Pen (output pentode). There were no further types in subsequent years because the range was quickly superseded by a 0.2-amp range for a.c./d.c. mains operation. A selection of these d.c. valves can be seen in Figure 3.19.



DVSG: variable-mu r.f. tetrode.

DS/Pen: r.f. pentode.

DHL: detector or a.f. triode.

DDT16: double diode triode.

DP/Pen: output pentode (7-pin version).

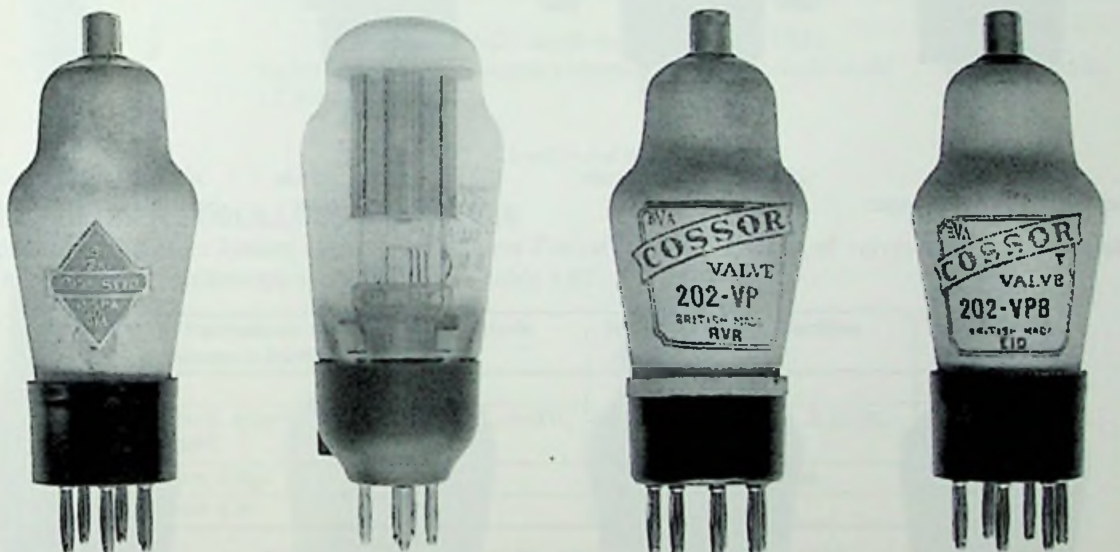
Figure 3.19: 16-volt d.c. range of 1933.

0.2-amp a.c./d.c. ranges

This first of these two ranges was introduced in 1934 and consisted of a mixture of 13-volt and 40-volt types. This was expanded into a further range a couple of years later with 20-, 30- and 40-volt types. The initial valves of 1934 consisted of 13SPA (r.f. pentode), 13PGA (heptode frequency changer), 13DHA (double diode triode), 40PPA (output pentode) and 40SUA (half-wave rectifier). When used in a typical superhet, having four valves plus a rectifier, the total series voltage would amount to 119V, leaving the remainder to be dropped by a suitable ballast resistor or barretter. A variable-mu pentode, 13VPA, was added in the following year.

The second 0.2-amp range included the 202SPB r.f. pentode, the 202VP variable-mu r.f. pentode (with the anode connected to the top cap), the 202VPB (as 202VP but with the control grid connected to the top cap), the 202MPG heptode frequency changer, the 202 STH triode hexode frequency changer, and the 202DDT double diode triode. An 'odd-ball' was the 203THA, a triode hexode having a 20-volt, 0.3-amp heater, which didn't fit in this range and was superseded in 1938 by the 302THA which had a 30-volt, 0.2-amp heater. One other 30-volt valve was the half-wave rectifier, OM1, which had an octal base. Finally there were four 40-volt types: these were an output triode, 402P, an output pentode, 402Pen, a higher power version of this, the 402PenA, and an output beam tetrode, 402OT.

Example of these 0.2-amp a.c./d.c. valves can be seen in Figures 3.20 and 3.21.



13SPA: r.f. pentode. | 40SUA: half-wave rectifier. | 202VP: variable-mu r.f. pentode (anode to top cap). | 202VPB: variable-mu r.f. pentode (control grid to top cap).

Figure 3.20: AC/DC 0.2-amp ranges of 1934 to 1940.

6.3-VOLT AC RANGE WITH OCTAL BASES

In 1940 Cossor released a small range of 6.3 volt valves, all of which were equivalents to the Mullard E-series. Initially the range comprised the OM5 general-purpose pentode, OM6 variable-mu r.f. pentode, OM8 octode frequency changer, OM4 double diode triode, OM10 triode hexode frequency changer and the OM9 output pentode. There was no 6.3-volt rectifier. In later years the OM5 was superseded by the OM5B and later still there was the OM5C which was particularly suitable for d.c amplifiers. Many of the Cossor valves were of Mullard manufacture and examples of the range can be seen in Figure 3.22.

The Mullard equivalents are as follow:

OM1 = CY31	OM3 = EB34	OM4 = EBC33	OM5 = EF36	OM5A/B = EF37A
OM6 = EF39	OM7 = EF39	OM8 = EK32	OM9 = EL32	OM10 = ECH33

202MPG: heptode frequency changer.

202STH: triode hexode frequency changer.

203THA: triode hexode with 0.3-amp heater

302THA: 0.2-amp triode hexode. Replaced 203THA.

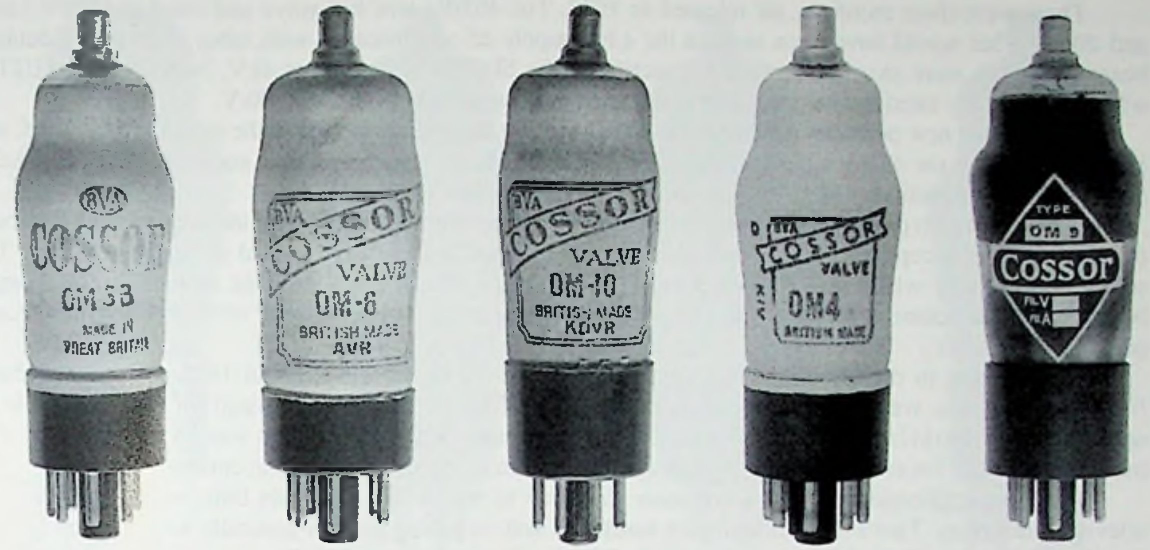
202DDT: double diode triode.

402OT: 2.5-watt output beam tetrode.

402/PenA: 3-watt output pentode.

OM1: 30-volt half-wave rectifier.

Figure 3.21: AC/DC 0.2-amp ranges of 1934 to 1940 (cont.).



OM5, OM5A and OM5B: general purpose pentodes.

OM6: variable-mu r.f. pentode.

OM10: triode hexode frequency changer.

OM4: double diode triode.

OM9: output pentode.

Figure 3.22: 6.3-volt octal range of 1940.

TELEVISION AND OSCILLOSCOPE VALVES

In common with other leading valve manufacturers Cossor launched a range of valves specifically intended for television and oscilloscope applications (see Table 3.8).

Year	Pentode or pentode + triode	Diode	Triode	RF power pentode	Rectifier	Thyratron
1935						GDT4
1937	41MTS, 42SPT, 41MPT	DDL4	41MTA, 41MTL, 41MTB	42MPT 42PTB	405BU, SU2130, SU2150	GDT4B, GDT4C
1938	4TPB, 4TSA				SU2150A	
1939	4TSP, 4TP					

Table 3.8: Television and thyratron valves of 1935 to 1939.

With the exception of an early thyratron, the first of these valves were launched in 1937. Considering first the pentodes: the 41MTS had the anode split into two sections for use as a sync separator, the line pulses being taken from one anode and the frame pulses from the other; the 41MPT was intended as an r.f. amplifier, but its gain was limited because its slope was only 4.8mA/V; the 42SPT was mainly intended as a video amplifier and had a high slope of 11mA/V. There were two r.f. power pentodes: the 42MPT, with the anode connected to the top cap, and 42PTB, with the grid connected to the top cap; these both had the same characteristics and a slope of 8mA/V. The 42PTB was soon discontinued in favour of the 42MPT.

Turning now to the diodes and triodes. There was one double diode, the DDL4 which was used as a detector or in d.c. restoration circuits, but was also used frequently in radio receivers in place of the earlier DD4. There were two triodes specifically intended for timebase applications: the 41MTA and 41MTB. The first of these was used as a discharge valve and a pair of 41MTB valves was used as a push-pull amplifier in the output stage. Another triode was the 41MTL, which was intended as a v.h.f. oscillator.

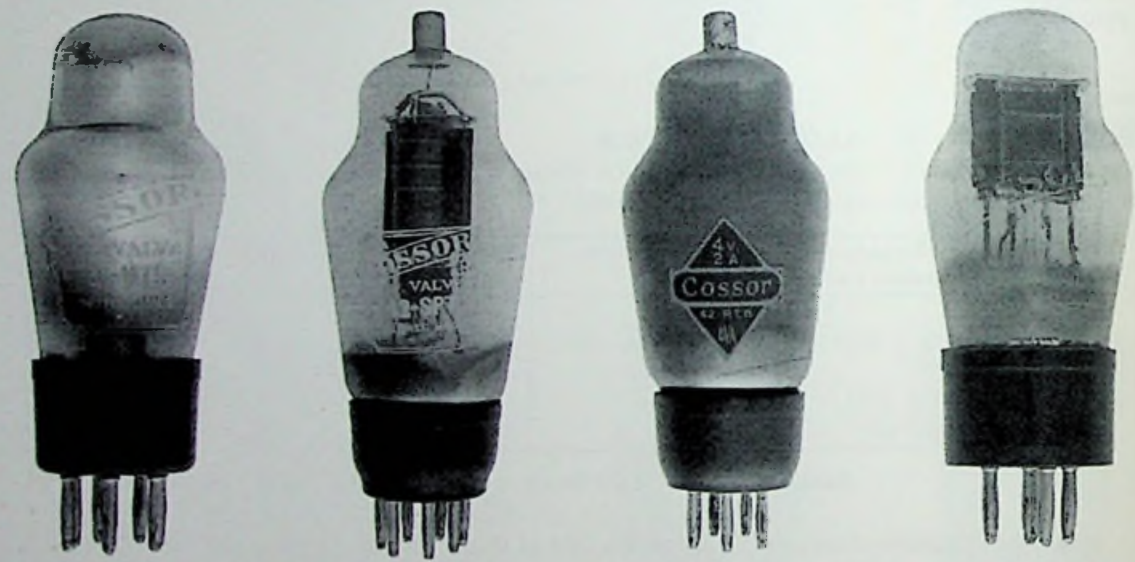
There were three rectifiers, all released in 1937. The 405BU was full-wave and rated at 1500V r.m.s. and 20mA. This would have been used in the e.h.t. supply of oscilloscopes with tubes such as the double-beam 09. There were two half-wave e.h.t. rectifiers: the SU2130 was rated at 4kV, 2mA and the SU2150 which was initially rated at 5kV r.m.s., 2mA but soon re-designed to operate up to 8kV.

In 1938 two new pentodes appeared: the 4TPB, having the grid connected to the top cap, was for r.f. and i.f. amplifiers and the 4TSA which was another split anode type for use as a sync separator. There was also another half-wave rectifier, the SU2150A, which was rated at 5kV r.m.s., 10mA.

Only two new types appeared in the following year: these were the 4TSP with identical characteristics to the earlier 4TPB except that the top cap connection was made to the anode instead of the control grid. The second was the 4TP which was a triode pentode combination, although not intended as a frequency changer but for use in timebase circuits where the pentode section acted as a discharge valve and the triode as a paraphase amplifier.

Turning now to the thyratrons: the first of these, the GDT4, appeared about 1935 and was mercury-filled. In 1937 this was replaced by an improved type, GDT4B, which was argon-filled and capable of operation up to 100kHz in timebase circuits. Finally there was the GDT4C, which was also argon-filled, and intended primarily for switching a.c. supplies up to 350V r.m.s. at a maximum mean current of 200mA.

Timebase applications of thyratrons soon gave way to hard-valve timebases both in oscilloscopes and television receivers. Two excellent books on timebases and switching circuits generally were written by O S Puckle and D A Levell, both of whom had worked for the Cossor Company [4,5].



41MTS: split-anode pentode for sync. separator. | 42SPT: r.f. power pentode. | 42PTB: r.f. pentode. | 41MTA: triode for timebases.

Figure 3.23: Television valves of 1937.

Before leaving this section mention should be made of two small diodes that appeared in 1941 and 1943 listings and are believed to have been similar the Mullard EA50. These were the 4-volt, 0.2-amp D4 and the 6.3-volt, 0.15-amp D6. They do not, however, seem to have gone into production, although it is possible that some of the original prototypes may have survived.

Examples of these television valves and thyratron can be seen in Figures 3.23 to 3.25.

41MTL:
triode for timebases.

41MPT:
pentode for i.f. amplifiers.


42MPT:
pentode for i.f. amplifiers.

CV829 (4TPB):
r.f. pentode.

4TSA: split-anode pentode
for sync. separator.

4TP: triode and pentode
for timebases.

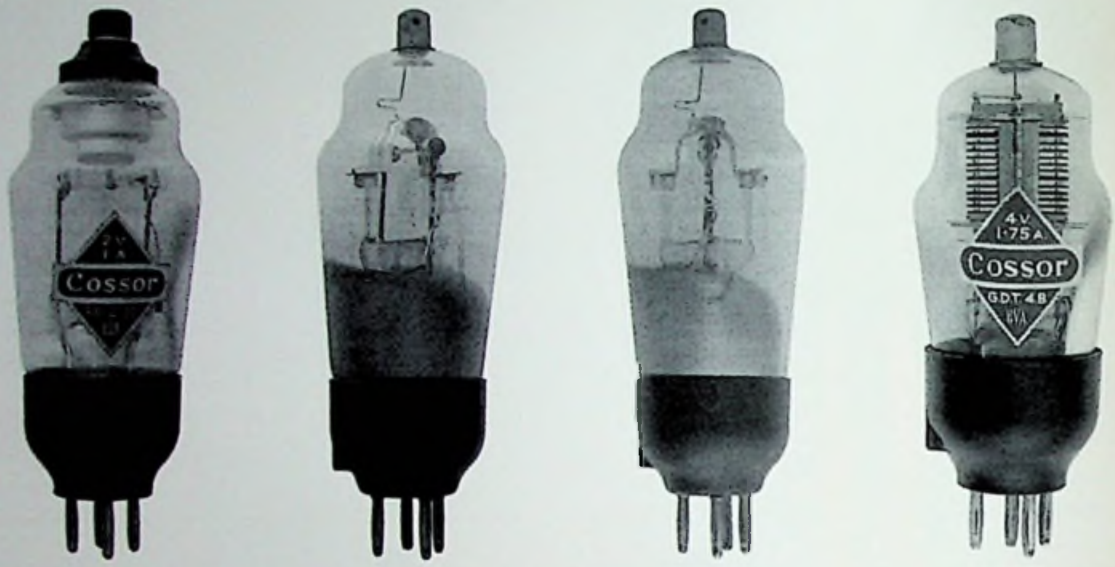

4TSP:
r.f. pentode.


405BU: full-wave rectifier
for oscilloscopes.

Table 3.24: Television and oscilloscope valves of 1937 to 1939.

US RANGES

Sometime, possibly in 1939, Cossor acquired the US range of Philco valves which were then sold under the Cossor label. These ranges were given in the manufacturers' listing included in the May 1940 issue of *Wireless World* [6]. US valves are dealt with in Chapter 14 so they will not be covered here, but the Cossor types are all listed in the Valve Data supplement. Briefly, however, they fell into seven categories: a 1.4-volt battery range with US bases, a 1.4-volt battery range with octal bases a 2-volt battery range with US bases, a 2.5-volt a.c. range with US bases, a 6.3-volt a.c. range with US bases, a 6.3-volt a.c. range with octal bases (or 5-volt for most of the rectifiers) and a 0.3-amp a.c./d.c. range with US bases.



SU2130: 4kV half-wave rectifier. SU2150: 8kV half-wave rectifier. SU2150A: 5kV half-wave rectifier. GDT4B: argon-filled thyratron.

Figure 3.25: Television and oscilloscope valves of 1937 to 1939 (cont.).

REFERENCES

1. *A Brief History of Cossor*, published by Cossor Ltd, London.
2. Advert. in *W.W.*, **24**, 11 September 1929, p. A11.
3. 'New Cossor battery valve', *W.W.*, **42**, 7 April 1938, p. 321.
4. Puckle, O S, *Time Bases* (Chapman & Hall, London, 1943).
5. Levell, D A, *Pulse and Time-base Generators* (Sir Isaac Pitman, London, 1958).
6. 'Cossor Valves', *W.W.*, **46**, April 1940, Advertisement, pp. 14-17.

Chapter 4
Ferranti Ltd.

The company was established in 1892 by Sebastian Ziani de Ferranti and the present name was adopted when it was incorporated in 1905. Ferranti was to become a manufacturer of a broad range of electrical goods: one of its specialist areas was transformers. In the early 1930s the company commenced manufacture of radio receivers and in 1933 entered the valve business. Design and manufacture of the valves was at a plant in Hollinwood, Lancashire. In later years, plants were also opened at Moston, Gem Mill (near Oldham), Edinburgh and Dundee. One of the earliest valves manufactured by the company was a heptode frequency changer—the first of this class of valves to be introduced into Britain.

The company was not a major manufacturer of valves during the pre-war period from 1933 to 1939 but increased its range from 1939 onwards. Initially, these later types were of US origin, followed by the Mullard E-Series. Ferranti, however, did not manufacture most of these later valves.

Table 4.1 summarizes the ranges produced during the 1930s but it has been difficult to determine the exact date when many of these appeared on the market.

Range	Year	RF tetrode or pentode	Frequency changer	Diode	Triode or DDT	Output triode	O/p pentode or DDP	Tuning indicator	Rectifier
2-volt	1933	S2, VS2, SPT2, VPT2			L2	HP2			
	1934		VHT2		H2D	LP2			
	1935		VHT2A				PT2		
	Not known				HL2		QPT2		
4-volt	1933	SPT4, VPT4	VHT4		D4, H4D, L4	P4, LP4			R4, R4A, R4B, R5
	1934						PT4, PT4D		
	1935								
	1936	SPT4A, VPT4B							
	1937								GR4 (MV), ER4 (e.h.t.)
	Not known							FT4, VFT4 VFT6 (6.3V)	R41, R42, R43, R52 (5V)
AC/DC 0.3-amp & 13-volt car battery	1934	SPTS, VPTS	VHTS	SD (4V)	HSD		PTA (0.6A), PTS, PTSD		RS
	1935						PTA (0.3A), PTAD (0.6A)		RA
	1936				DS				
							PTSA		
AC/DC 0.2-amp	1935	VPTA	VHTA		DA, HAD		PTZ (40V)		RZ (20V)
	1936	SPTA		ZD (7V)					

Table 4.1: Ferranti valves of the period 1933 to 1939.

2-VOLT BATTERY VALVES

The first battery valves of 1933 and were r.f tetrodes, S2 and VS2; two r.f pentodes, SPT2 and VPT2; an a.f. or output triode, L2, and a two-watt Class B double output triode, HP2. Both the VS2 and VPT2 were variable-mu types.

There were three new types in 1934. These were the VHT2 heptode frequency changer, the H2D double diode triode and the LP2 output triode.

New valves to appear in 1935 were the VHT2A, a replacement for the VHT2, and the HL2 general purpose triode.

Two other battery valves, where the issue date is uncertain, are and the PT2 output pentode and the QPP double pentode which was capable of delivering an output of 1.5 watts from a 150-volt supply.

The Ferranti Lancastria six-valve portable receiver of 1934/1935 used the VS2 as an r.f. amplifier, the VHT2 as a frequency changer, another VS2 as the i.f. amplifier, the H2D double diode triode as detector, a.g.c. diode, and first a.f. amplifier, the L2 as output driver and the HP2 for push-pull output.

4-VOLT AC RANGE

This range of valves was also released in 1933 and consisted of two r.f. pentodes, a frequency changer, three triodes, two output triodes, a half-wave rectifier and three full-wave rectifiers. The two r.f. pentodes were the SPT4 and the variable-mu VPT4. The frequency changer was the VHT4 heptode which was similar to the RCA type 6A7 except that it had a 4-volt, 1-amp heater and a B7 base [1]. The triodes were the D4 detector, the low impedance L4, which could be used as an a.f. amplifier or as a low power output valve, and the H4D double diode triode. The two output triodes were the P4 and the LP4. The three rectifiers were the R4, rated at 350V, 120mA, the R4A which was rated at 500V, 120mA and the R5 which was similar to the MOV type U5. There was also the half-wave R4B, rated at 400V, 65mA but the author has not been able to find when this was released.

The first output pentodes appeared in 1934. These were the PT4 and the double diode type PT4D. Both were capable of an output of 2.5 watts, later increased to 3.5 watts.

The two earlier r.f pentodes were superseded by the SPT4A and the variable-mu VPT4A in 1936, both having improved characteristics.

There were several later rectifiers, including four full-wave types, a full-wave mercury vapour rectifier and a half-wave e.h.t. rectifier. The four full-wave rectifiers were the R41, rated at 325V, 125mA, the R42, rated at 350V, 120mA, the R43, rated at 500V, 250mA, and the R52, with a 5-volt, 2-amp heater. This last rectifier in the group was equivalent to the 5Z4G and having similar characteristics to the R42. The full-wave mercury vapour rectifier was the GR4, rated at 350V, 250mA. Finally, the ER4 was a half-wave, e.h.t. rectifier and rated at 5kV, 3mA.

Ferranti also produced the FT4 and VFT4 tuning indicators both having 8-pin IO bases. There was also the VFT6 with a 6.3-volt heater and otherwise identical to the VFT4.

0.3-AMP RANGE

The 0.3-amp range was introduced in 1934, a year after the four-volt a.c. range. The 13-volt types, all of which could be used in car radios, consisted of the SPTS r.f. pentode, the VPTS variable-mu r.f. pentode, the VHTS heptode, which had identical characteristics to the VHT4, the HSD double diode triode, the PTA output pentode (which initially had a 0.6-amp heater but was soon reduced to 0.3 amps) and the RS half-wave rectifier. Initially this rectifier was shown to have a 20-volt heater but this was later revised to 13 volts. The other types were the SD, a four-volt double diode, and two 26-volt output pentodes: the PTS and the double diode version, PTSD. Both of these pentodes had identical characteristics to the four-volt output pentodes PT4 and PT4D respectively. A 13-volt output pentode appeared in 1935. This, the PTA, had a 0.6-amp heater but an improved version with a 0.3-amp heater was introduced in the following year together with a 13-volt, 0.3-amp full-wave rectifier, type RA.

Finally in 1936 there was the 13-volt detector or a.f. triode, type DS.

0.2-AMP RANGE

This range was introduced in 1935 and superseded the 0.3-amp range in a.c./d.c. applications. The initial types were the VPTA variable-mu r.f pentode, the VHTA heptode, the DA detector or a.f. triode, the HAD double diode triode, the PTZ output pentode and the RZ half-wave rectifier. A straight r.f pentode, SPTA, appeared in 1936, together with a double diode, ZD.

Examples of the Ferranti valves of the period 1933 to 1937 can be seen in Figures 4.1 and 4.2.

S2: r.f. tetrode.

VPT2: r.f. pentode.

L2: a.f. or output triode.

HL2: general-purpose triode.

VHT4:
heptode frequency changer.

VHT4: heptode of Mullard manufacture.

P4: output triode.
This was soon withdrawn.

LP4:
output triode.

Figure 4.1: Ferranti valves of 1933 to 1939.

H4D: double diode triode.

VFT4: tuning indicator.

R4: full-wave rectifier.

R5: full-wave rectifier.

SPTS: 13-volt, 0.3amp r.f. pentode.

VHTA: 13-volt, 0.2 amp heptode frequency changer.

ZD: 7-volt, 0.2-amp double diode.

Figure 4.2: Ferranti valves of 1933 to 1939 (cont.).

REFERENCES

1. Ferranti advertisement in *W.W.*, **36**, 22 December 1933, p. A1.
2. Hall. Albert, *The True Road to Radio*, 3rd edition. Book published by the Ferranti Company in the early 1930s before manufacturing their own valves. It provides a very good introduction to radio design at that time.

Chapter 5
High Vacuum Valve Company Ltd. (Hivac)

The High Vacuum Valve Company was formed in 1932 and continued in operation during the whole of the period covered by this book. During this time the company produced approximately 75 different types of valves, including several specials, together with a range of miniature types. From the late 1940s the company concentrated solely on the miniature types. Although these later valves are outside the scope of this volume, they are covered briefly on page 93. All valves were produced from premises in Clerkenwell, London and carried the trade name Hivac. There was a close association between Hivac and a small company called Harries Thermionics Ltd, which was owned by J H Owen Harries, a brilliant engineer who was responsible for many of the innovative designs adopted by the Hivac Company.

Initially seven two-volt battery types were released around June 1933 [1] and the range was expanded to eleven types during the next few months. The first four-volt a.c. types were released in 1934 followed by a 0.3-amp a.c./d.c. range in 1936 (see Table 5.1).

Range	Year	RF tetrode or pentode	Freq. chan.	Diode	Triode or DDT	Output triode	Output tetrode or pentode	Specials	Rectifier
2-volt standard	1933	SG210, VS210			D210, H210, L210	B220, P220, PP220, PX230	Y220, Z220 (pentodes B4/5)		
	1934	SG215, SG220, VS215, HP215 & VP215 (B4/5)			DDT220	B230	QP240	DB240	
	1935		TP230			P215	Y220, Z220 (tetrodes B4/5)	J240	
	1936	SG220SW			D210SW, DDT13	PX230SW			
	1937				DDT215				
	1938	VP215b, VP215c					Y230		
2-volt miniature	1935	XSG XSGSW			XD, XL	XP	XY		
AC	1934	AC/SH, AC/SL, AC/VH, AC/VS, AC/HP & AC/VP (B5/7)		AC/DD (B5/7)	AC/DDT, AC/HL	AC/L	AC/Y, AC/Z (pentodes B5/7)		UU120/350, UU120/500
	1935						AC/Y, AC/Z (tetrodes B5/7)		UU60/250
	1936					PX41*	AC/ZDD, AC/YY, FY*		MR1*
	1937					PX5*	AC/Q, AC/Qa	AC/TZ	HVU1
	1938	AC/VPb					AC/TZ		
0.3-amp AC/DC	1936	VP13			HL13, DDT13		Y13, Z26	All-Stage	U26
	1937							A15	

* Directly heated

Table 5.1: Hivac valves of 1933 to 1938.

2-VOLT STANDARD SERIES (Figures 5.1 & 5.2)

RF tetrodes & pentodes

The first of these to be released were the two tetrodes SG210 and the variable-mu VS210. In the following year these were superseded by the SG215, SG220 and VS215, all of which had slightly improved characteristics, although taking higher filament currents. 1934 also saw the introduction of two r.f. pentodes: the HP215 and the variable-mu VP215. Initially the VP215 had a 4-pin base, but a 7-pin base was fitted about a year later. In 1938 the VP215b (with the control grid taken to the top cap) and the VP215c (with the anode taken to the top cap) were released, which were improved versions of the earlier VP215.

Frequency changer

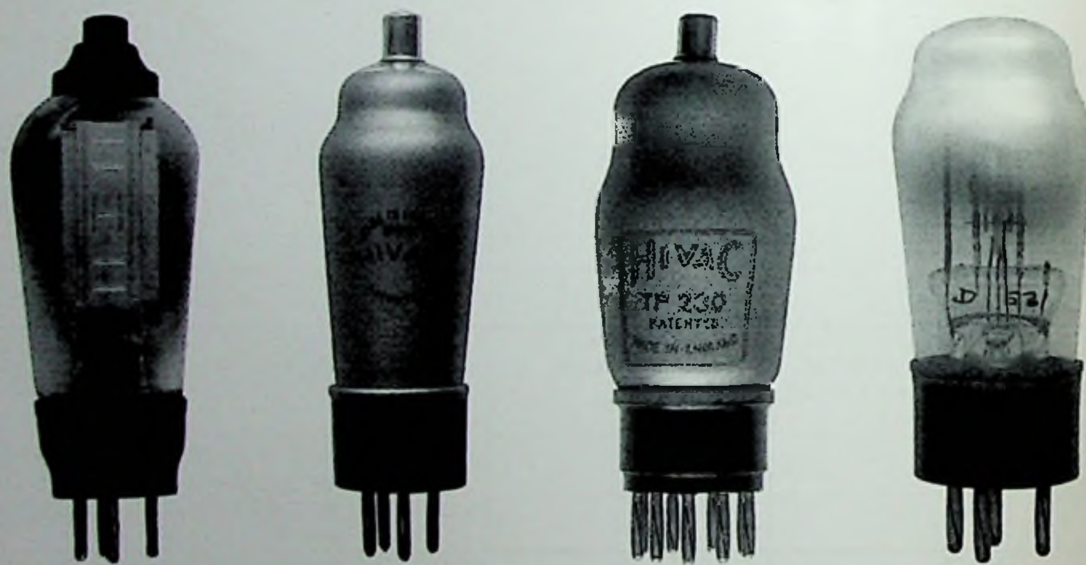
The only frequency changer to be produced by Hivac was the TP220 triode pentode which was introduced in 1935. It's difficult to understand why there were no mains types: one can only guess that it was not considered to be economically viable for a company the size of Hivac.

Triodes

The first seven triodes were released in 1933. The H210 had a medium-mu and was intended for use as an r.f. amplifier in neutralised receivers. The D210 was intended as a detector and the L210 as an a.f. amplifier. The four output types were the P220, the 'super power' PP220, the 'super-super power' PX230 and the Class B double triode, B220.

The first double diode triode, type DDT220, was released in 1934, together with a new Class B double triode, B230, to replace the B220. The only new triode to appear in 1935 was the P215, which was similar to the P220 but had lower filament consumption.

Apart from some special short wave types, to be described shortly, the only other valve in this class was the double diode triode, DDT215, which became available in 1937 and replaced the DDT220.



SG215: r.f. tetrode (SG220 is similar).

VP215: variable-mu r.f. pentode.

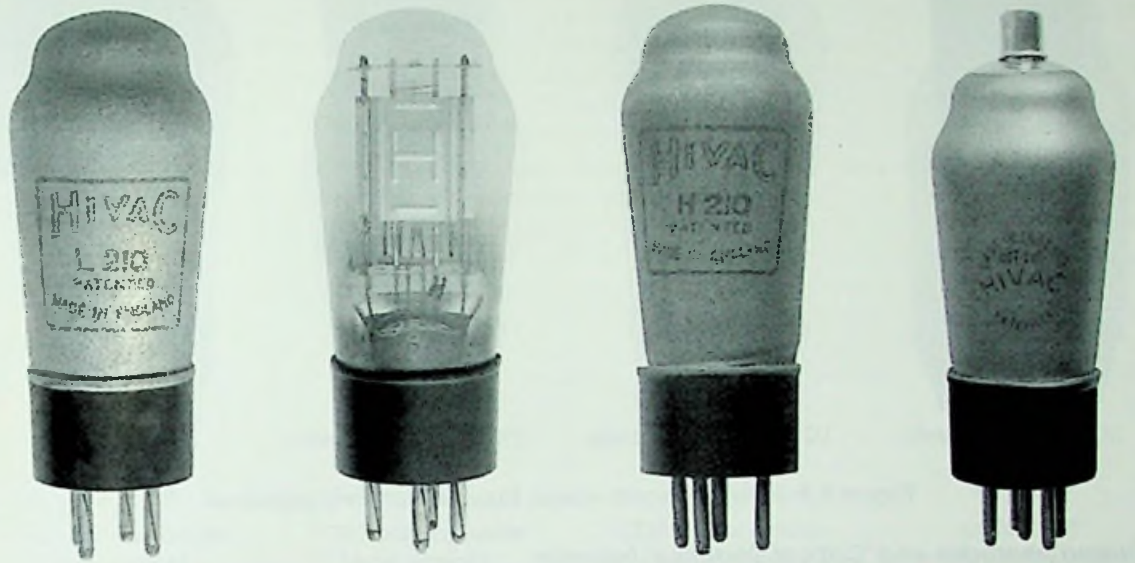
TP230: triode pentode frequency changer.

D210: detector triode.

Figure 5.1: Hivac two-volt valves.

Short wave valves

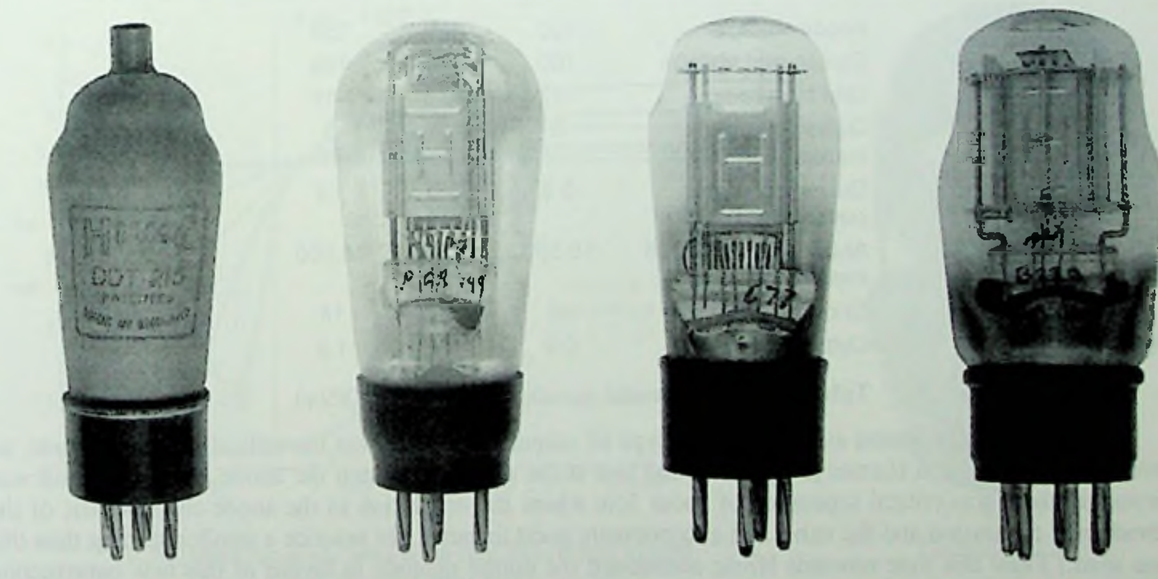
In 1936 Hivac produced special versions of its standard two-volt valves for use by radio amateurs in short wave equipment. These were the SG220SW r.f. tetrode, the D210SW detector triode and the PX230SW power triode. They differed from the standard types in having the control grids brought out to a top cap and the use of a low-loss 'Frequentite' ceramic base [2]. There was also a ceramic base version of the B230 Class B triode (see Figure 5.3). The PX230SW was particularly suitable as a master oscillator, an r.f. power amplifier or in frequency doubler circuits in short wave transmitters.



L210:
a.f. triode.

H210: general-purpose triode.
(Plain and metallised versions.)

DDT220: double diode
triode (0.2-amp version).



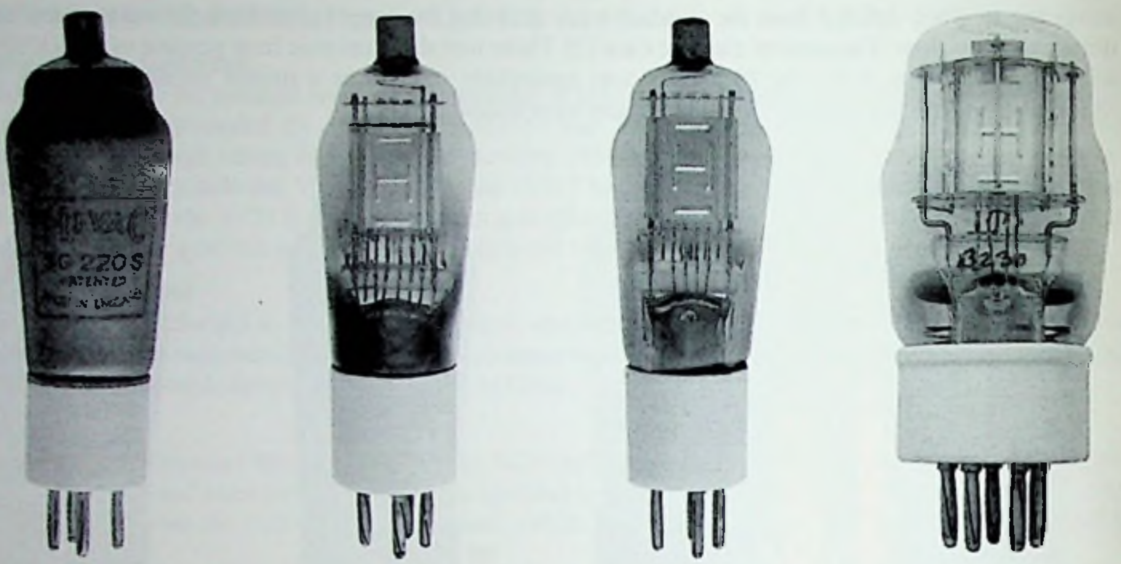
DDT215: double diode
triode (later 0.15A version).

P220:
output triode.

PX230: 'super power'
output triode.

B230:
Class B output triode.

Figure 5.2: Hivac two-volt triodes.



SG220SW: r.f. tetrode. D210SW: detector triode. PX230SW: power triode. B230: double triode.

Figure 5.3: Hivac valves with ceramic bases for short wave applications.

Output pentodes and 'Critical Distance' tetrodes

The first two output pentodes were the Y220 and the higher power Z220 which were both introduced in 1933. In the following year Hivac introduced its only QQP double pentode, the QP240. The recommended operating conditions for this valve are given in Table 5.2. Figure 5.4 shows examples of various output pentodes.

Anode voltage	100	125	150
Screen grid voltage	100	125	150
Grid bias voltage	–12	–15	–18
Quiescent anode current (ma) total	3	5	8
Quiescent screen current (ma) total	0.6	1.0	1.2
Anode to anode load impedance (ohms)	18,500	16,500	14,500
Grid swing r.m.s.	11	12.8	14
Output power (W)	0.9	1.2	1.6

Table 5.2: Recommended operating conditions for QP240.

In 1935 Hivac released an entirely new type of output valve; this was the critical distance tetrode, an invention of J H Owen Harries [3, 4]. He found that if the spacing between the anode and screen grid was increased, there was critical separation of about 3cm where the usual kink in the anode characteristic of the tetrode was eliminated and the valve had exceptionally good linearity. (In practice a smaller spacing than this was used.) From this time onwards Hivac abandoned the output pentode in favour of this new construction (except for the miniature type XP of 1935 and all other miniature types produced after World War 2).

Figure 5.5 shows a set of anode characteristics given by Harries showing the effect of varying the anode to cathode spacing. Also shown is the electrode structure of the a.c. type AC/Y.

The first step was to modify the Y220 and Z220. Although a higher output power did not result, the distortion was lower. The screen current was also reduced, giving greater efficiency. Figure 5.6 shows the critical distance version of the Z220.

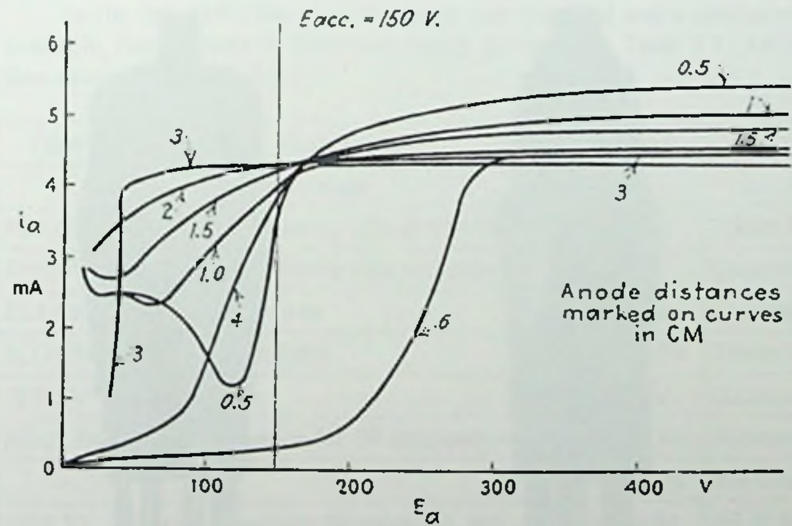
Y220: output pentode (4-pin version).

Y220: output pentode (5-pin version).

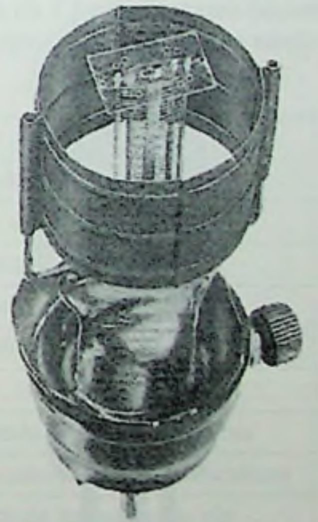
Z220: output pentode (5-pin version).

QP240: QPP double output pentode.

Figure 5.4: Hivac 2-volt output pentodes.



V_a/I_a curves for anode spacing varying from 0.5cm to 6cm with an optimum at 3cm.



Electrodes of AC/Y.

Figure 5.5: Effect on anode characteristics of varying the anode to cathode spacing; also shown is the electrode structure of the AC/Y critical distance tetrode.

The only other two-volt output tetrode was the Y230 which was introduced in 1938 but was little used. It does not appear to have any advantage over the Y220: it consumed a higher filament current and gave a slightly lower power output. The slope of the valve was not quoted but because the grid bias was only –3 volts it probably had a higher slope then the Y220, making it a more sensitive option.

Specials/multiples

Apart from their more conventional valves, Hivac also introduced a few 'specials. The first of these was a combination of a triode driver and a pair of output triodes for Class B operation. This valve, the DB240, made its appearance in 1934 [5]. It was recommended that the driver section should be coupled to the Class B stage by a 1.5:1 step-down transformer, the secondary of which should have a resistance not exceeding 400 ohms. Similarly the primary resistance of the output transformer should not exceed 400 ohms. The Class B stage was operated with positive grid excitation which would mean that the centre-tap of the driver transformer would be returned directly to the common zero-volt rail. A slighter later variant of this valve was the DB230 which had a lower filament consumption of 0.3 amps (see Figure 5.6).

The second type to appear was the J240 which was designed for use in a receiver that figured in 1935 Jubilee issues of the *Popular Wireless* magazine [6] and known as the 'Silver King'. This valve combined an r.f. pentode, a detector triode and an a.f. triode. It would only appear to have been produced for the amateur constructor because it was never listed in Hivac catalogues. The valve is metallised and has a 9-pin base. The top connection is to the pentode screen grid. The unusual feature of the Silver King was that it combined two receivers in the one cabinet which shared a common aerial and batteries. Each receiver had its own set of controls which were mounted on opposite panels of the cabinet. One receiver operated on the long and medium wave bands; this used the pentode section of the J240 and two additional triodes: one as a detector and the other for driving a high impedance loudspeaker. The second receiver covered two short wave bands (in fact at the time these were known as short wave and ultra short wave), and this used the two remaining triodes sections of the J240 for driving a pair of headphones—one as a detector and the other as an a.f. amplifier. A photograph of the J240 can be seen in Figure 5.6.

Z220: critical distance output tetrode (5-pin version).

DB230: combined triode driver and Class B output triodes

J240: combined r.f pentode, detector triode and a.f. amplifier triode.

Figure 5.6: Hivac 2-volt multiple valves and the Z220 critical distance tetrode.

2-volt miniature range

The first of the Hivac miniature valves were released in March 1935 [7]. Initially there were just three types, these being a screened grid tetrode, XSG, a detector triode, XD and an a.f. triode, XL. Later in the year the range was completed by adding an output triode, XP, and an output pentode, XY. There was also an XHH double triode but no information has been found for this (see Figure 5.7).

This miniature range was intended for use in portable equipment such as hearing aids and police radios. The first four of these valves required a filament current of only 0.066 amps and the output pentode had a higher consumption of 0.14 amps. For short wave work all types could be supplied with the low-loss 'Frequentite' ceramic base. The overall dimensions of the valves are shown in Table 5.3.

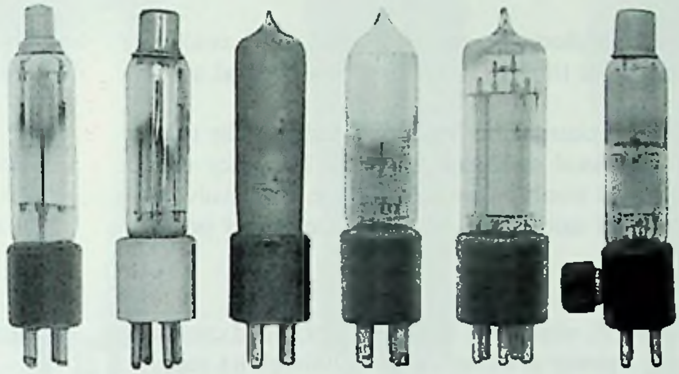


Figure 5.7: Hivac miniature 2-volt valves. Left to right—XSG r.f. tetrode; XSGSW (short wave version of XSG), XD detector triode, XP output triode, XP output pentode and XHH double triode.

Valve type	Length (mm) (excluding pins)	Diameter (mm)
XSG	70	16
XD	65	16
XL	65	16
XP	65	16
XY	63	20

Table 5.3: dimensions of Hivac miniature 2-volt range of 1935.

In the late 1940s the two-volt range was extended and a similar range with 1.5-volt filaments became available. Brief details of these two ranges are given in Table 5.4. All these new types were a little smaller than those shown in Table 5.3.

Type	Description	Type	Description
1.5-volt range		2-volt range	
XD1.5V	AF triode for hearing aids and receivers	XD2.0V	Triode for a.f. amplifier or detector
XH1.5V	AF triode for hearing aids and detector	XH2.0V	General purpose triode
XL1.5V	AF or output triode	XL2.0V	General purpose triode
XLO1.5V	Triode for oscillator	XLO2.0V	Triode for oscillator
XP1.5V	Output triode	XP2.0V	Output triode
XSG1.5V	Screened tetrode for GP applications	XSG2.0V	Screened tetrode for GP applications
—		XVS2.0V	VM screened tetrode for GP applications
XW1.5V	RF or AF pentode for receivers, etc.	XW2.0V	RF or AF pentode for receivers, etc.
XY1.5V	Output pentode for GP applications	XY2.0V	Output pentode for GP applications

Table 5.4: the Hivac 2- and 1.5-volt range of post-WW2 miniature valves.

4-VOLT AC RANGE

RF tetrodes and pentodes

The first a.c. valves in this class were released in 1934, about a year later than the battery valves. In all, there were four tetrodes: AC/SH, AC/SL, AC/VH and AC/VS. The last two of these were variable-mu. There were also two pentodes: the AC/HP and the variable-mu AC/VP, both of which were available with 5- or 7-pin bases. All these tetrodes and pentodes could be used as r.f. or i.f. amplifiers, but the straight types were also suitable as detectors.

The only other valve in this class was the AC/VPb, another variable-mu pentode, which was released in 1938 and had a higher slope than the earlier AC/VP.

Diodes and triodes

Also in 1934 Hivac released the AC/DD double diode, the AC/HL triode, which could be used as a detector and a.f. amplifier, and the AC/DDT double diode triode. (The AC/DD initially had a 5-pin base but this was later superseded by a 7-pin base.)

Hivac never produced an a.c. frequency changer but recommended that the r.f. tetrodes or pentodes could be used as mixers, and a triode as a local oscillator. By 1934 frequency changer valves became available from several other manufacturers, so it would be unlikely that the Hivac valves would be used in the manner suggested because of the extra cost of using two valves and the poorer performance from such a combination.

Output triodes

Hivac's first a.c. triode was the low power AC/L which was released in 1934 and could be used a detector or transformer-coupled output valve delivering a power of 675mW from a 200-volt h.t. supply.

There were also two higher power triodes, both directly heated. These were the PX41, which gave a maximum output of 2.5 watts, and the PX5 with an output capability of 5.75 watts. The first of these became available in 1936 and the PX5 in 1937. In order to minimize hum it was necessary to either use a centre-tapped filament winding on the mains transformer or a 20-ohm centre-tapped resistance connected across the winding.

Output tetrodes and pentodes

As with the battery valves, the first two multi-grid output valves to appear were the AC/Y and AC/Z, both released in 1934 as pentodes and then re-issued in the following year as critical distance tetrodes. Although both types could provide an output power of three watts the AC/Z was far more sensitive, with a slope of 8mA/V, compared with 3.5mA/V for the AC/Y. Three more tetrodes became available in 1936: these were the five-watt AC/YY, the double diode AC/ZDD and a directly heated FY. The tetrode section of the AC/ZDD was identical to that of the AC/Z and both gave an output power of 6.5 watts. The type FY was probably intended as an equivalent to the PT4 (MOV), PT41 (Cossor) and PM24M (Mullard), although it had a higher slope than all three of these valves.

The final two Hivac output tetrodes were the AC/Q and AC/Qa. These were both high power types with identical characteristics and capable of an output of 11.5 watts. The only differences between the two were that the AC/Qa had an 8-pin international octal base and the heater was rated at 6.3-volts instead of the usual 4-volts; these were both released in 1937. The AC/Qa was equivalent to the US type 6L6.

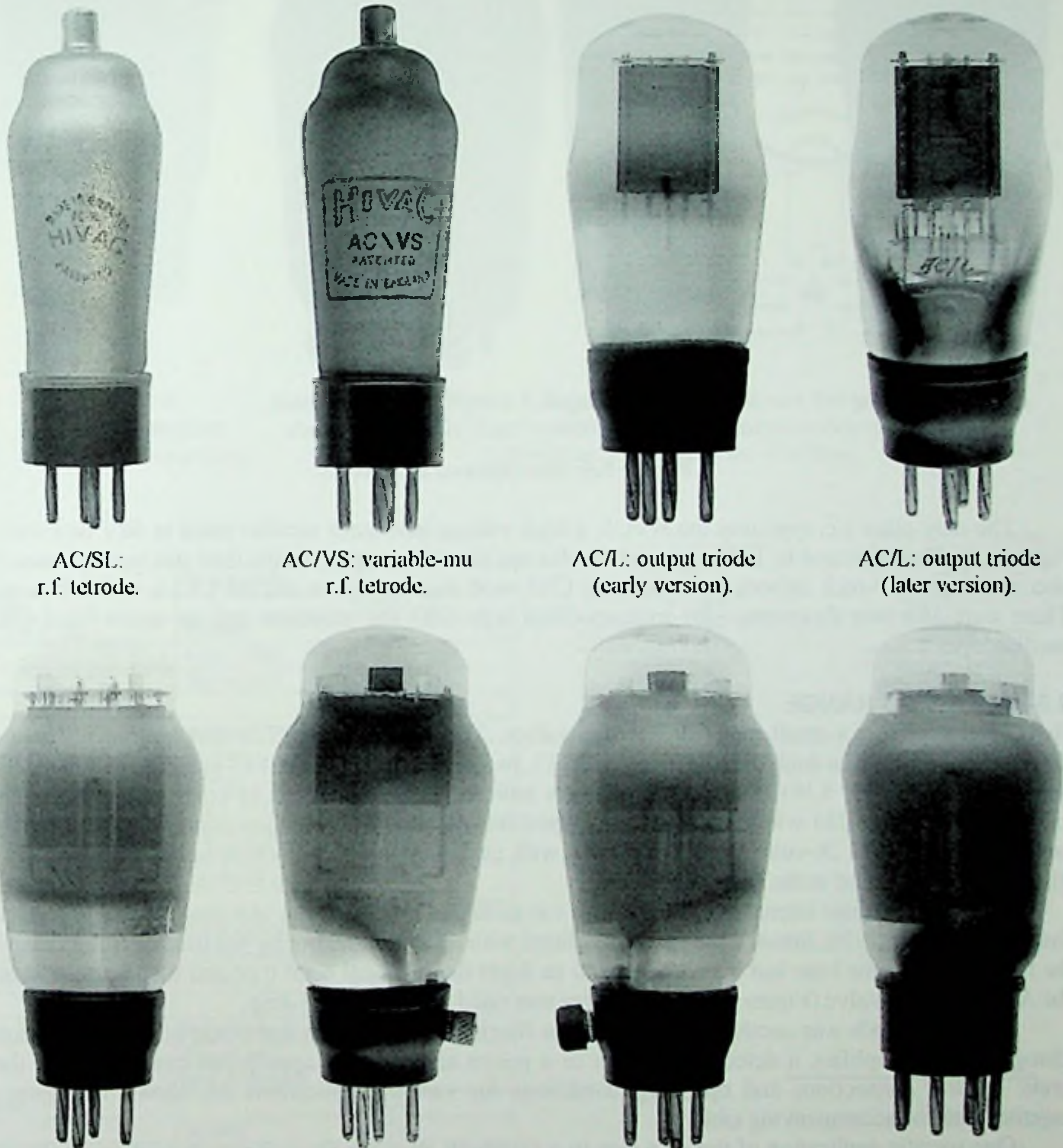
There was also one special type, the AC/TZ, which incorporated a triode and output tetrode and was used in the line timebase of early Pye television receivers such as Model 817. In a typical circuit the triode was used as blocking oscillator and the tetrode as a driver for the line deflection coils.

Rectifiers and thyratrons

The first two rectifiers were full-wave types and were released 1934. These were UU120/350 and UU120/500 where the numbers indicate the d.c. rectified current and r.m.s. voltage ratings respectively. In the following year the UU60/250 became available. All three of these had indirectly heated cathodes.

The only mercury-vapour type was the half-wave MR1, capable of an output current of 250mA. In order to ensure long life it was necessary to connect a thermal delay switch in series with the filament to switch the h.t. supply on after a period of no less than 30 seconds. Also the h.t. must be switched off before or at the same time as the filament supply.

A selection of these a.c. valves can be seen in Figures 5.8 and 5.9.



AC/SL: r.f. tetrode.

AC/VS: variable-mu r.f. tetrode.

AC/L: output triode (early version).

AC/L: output triode (later version).

PX41: directly heated output triode.

AC/Y: output tetrode (5-pin version).

AC/Z: output tetrode (5-pin version).

AC/Z: output tetrode (7-pin version).

Figure 5.8: Hivac 4-volt a.c. valves.

FY: directly heated output tetrode.

AC/QA: 6.3-volt output tetrode with octal base.

AC/TZ: driver triode and output tetrode.

HVU1: 6kV e.h.t. rectifier.

Figure 5.9: Miscellaneous a.c. valves.

The only other a.c. type was the HVU1, a high voltage half-wave rectifier rated at 6kV and 3mA (see Figure 5.9). This appeared in 1938 and intended for use in oscilloscopes. At the time this was released Hivac also announced a 3-inch cathode ray tube, type CR3, with a green screen and the CR3A with a blue screen. There were also two thyratrons—the mercury-filled type GR1 for television and an argon-filled GR2 for oscilloscopes.

0.3-AMP AC/DC RANGE

Hivac produced just a small range of a.c./d.c. valves. There was the VP13, a variable-mu r.f. pentode, a detector triode, HL13, a double diode triode, DDT13, two output tetrodes, the Y13 and Z26, and the U26 half-wave rectifier (Figure 5.10). As the type numbers indicate, these either had 13-volt or 26-volt heaters, the exception being the U26 which had a centre-tapped heater, allowing operation from either 13-volts (when used in car radios) or 26-volts. All these valves, with the exception of the VP13, became available in 1936 (the VP13 was released in the following year).

However, the most interesting of the Hivac valves in this range was the 'All-Stage' valve [8] which was first announced in 1936. Initially the valve was fitted with a 9-pin base, but by the time of full production in the following year the base had been changed to an 8-pin international octal type and then became known as the A15 All Stage Valve (Figure 5.11). The heater was rated at 15-volts, 0.3-amp.

The A15, which was another design of Owen Harries, had five grids and could be used as a frequency changer, an r.f. amplifier, a detector-amplifier or a power amplifier, by appropriate connections of the five grids. Typical connections and operating conditions for various applications are shown in Figure 5.12, together with the accompanying table.

One specific application of the A15 was in a Gambrell all-wave receiver which used six of the valves, plus a UU120/350 rectifier. The various functions performed were r.f. amplifier, mixer, separate oscillator, i.f. amplifier, detector-amplifier, and power output. Figure 5.12 shows various connections for the A15: (a) triode, (b) and (c) screened voltage amplifier and (d) critical distance output tetrode. These are supplemented by the connections shown in the table at the left of the figure.

Figure 5.10:
U26 half-wave rectifier
for a.c./d.c. mains operation.

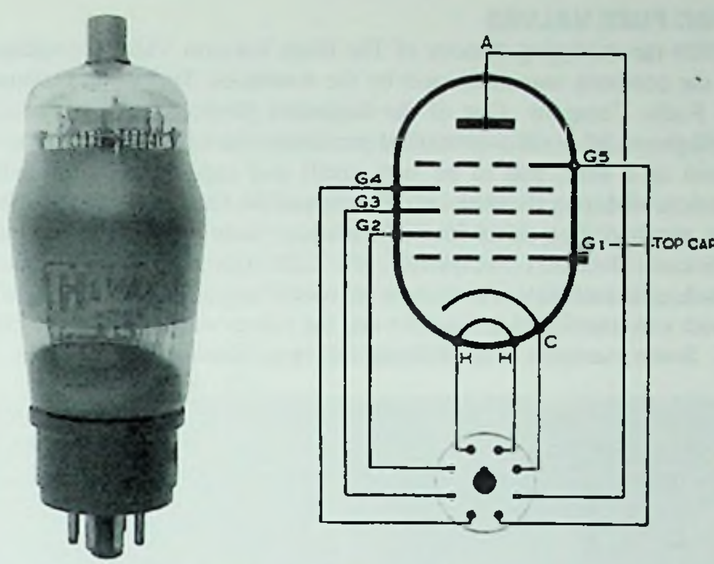


Figure 5.11: A15 all-stage valve with five grids. The diagram at the right shows the base connections viewed from underside of the octal base.

RF amplifier		
Anode		250v
G2, G4 & G5	Screen	60v
G3	A.g.c. Grid	
G1	Signal grid	–3v
		Gm = 2ma/v
Frequency changer		
Anode	Screen	250v
G5	Screen	90v
G4	A.g.c. Grid	
G3	Signal grid	–6v
G2	Oscillator anode	90v
G1	Oscillator grid	
		Gc = 0.48ma/v
Detector-amplifier		
Anode	Diode anode	
G2 & G5	Screen	40v
G4		–11v
G3	Signal anode	130v
G1	Signal grid	–4v
Class A output		
Anode		400v
G5	Screen	150v
G4	Screen	0v
G2 & G3	Screen	250v
G	Signal grid	–14v
		Po = 5.3w

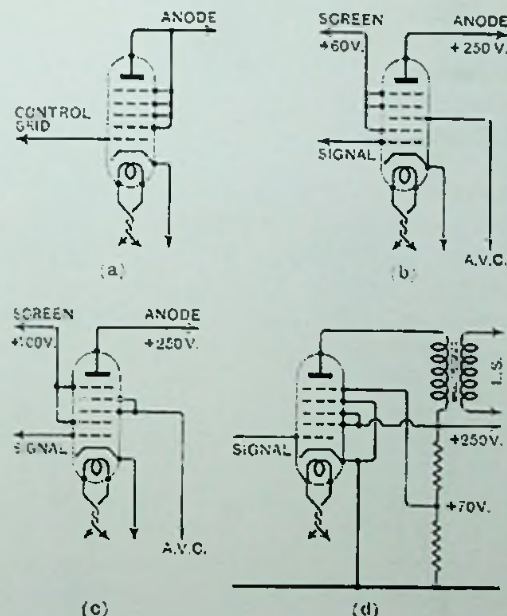


Figure 5.12: Various connections possible with the A15 all-Stage valve. Typical operating conditions are shown in table for several applications.

HIVAC FUZE VALVES

In 1939 the managing director of The High Vacuum Valve Company was tragically killed in a car accident and the company was taken over by the Automatic Telephone Company Ltd. which had close links with the Pye Radio Company. One of the important projects that the Pye Company became involved in was the development of a radio-controlled proximity device for fitting into artillery shells. The proximity device, known as a fuze, had to be very small and capable of withstanding the enormous gravitational forces experienced during the initial acceleration of the shell from the gun; for this, miniature, high-reliability valves were required. Pye asked Hivac to produce these valves and samples were made, although they were not sufficiently robust. Consequently, the GEC Company also became involved but, even they, with their considerable technical resources, were unable to produce valves of sufficient reliability. Eventually the whole project was transferred to the USA and the valves were finally produced by Sylvania. (See also page 313.)

Some examples of these Hivac valves are shown on Figure 5.13.

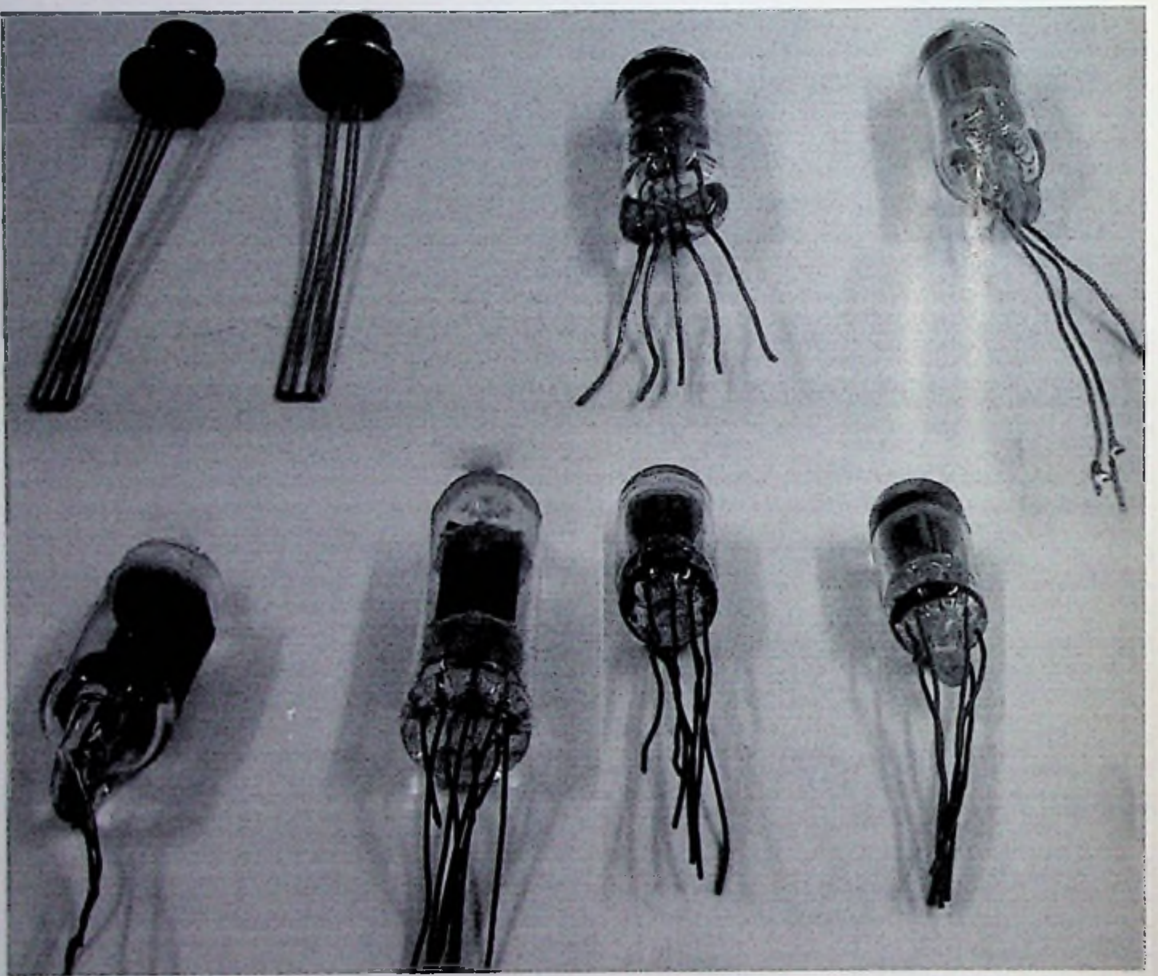


Figure 5.13: A selection of Hivac sub-miniature fuze valves.

REFERENCES

1. 'Hivac valves', *W.W.*, **32**, 30 June 1933, p. 469.
2. 'Hivac short-wave valves', *W.W.*, **38**, 15 May 1936, p. 488.
   See also advert on the front page of the *T&R Bulletin*, **11**, May 1936.
3. Harries, J H O, 'The anode to accelerating electrode space in thermionic valves', *W.E.*, **13**, April 1936, pp. 190-9.
4. Harries, J H O, 'A new power output valve', *W.W.*, **37**, 2 August 1935, pp. 105-6.
5. 'New apparatus reviewed: Hivac DB240 class B valve', *W.W.*, **34**, 23 March 1934, p. 209.
6. Roberts, J H T, 'Jubilee The dawn of a new era in reception', *P.W.*, 6 April 1935, pp. 91, 92, & 127-130. Kelsey, G T, 'Two-Channel Reception', pp. 93-4 & 96. Rogers, K D, 'Silver King, The Set of the Century', pp. 97-104, 107-8 & 110.
   Also 'Touring Europe on the Silver King', 20 April 1935, pp. 167-8 & 182.
7. 'Hivac midget valves', *W.W.*, **36**, 22 March 1935, p. 289.
8. Harries, J H O, 'An All-stage Valve', *W.W.*, **39**, 20 November 1936, p. 559.
   See also *W.E.*, **13**, October 1936, pp. 527-8.

Chapter 6
Lissen Ltd.

Lissen Ltd (LISSEN) was founded in 1923 by Thomas Noah Cole. Initially the company manufactured radio components and supplied complete kits for home construction of radio receivers. The company was purchased by Ever Ready in 1928 and entered the valve business in the autumn of the following year. Some of the valves offered for sale in 1929 may have been redundant stocks from BTH and Edison Swan, but the company manufactured modest quantities of valves during the period 1929 to 1936, principally for use in its kit sets. The registered offices and works were in Isleworth, Middlesex.

Located at the top of the valves was a manufacturing code which indicated the week and year of manufacture: 261, for example, meant the 26th week of 1931.

BATTERY RANGES

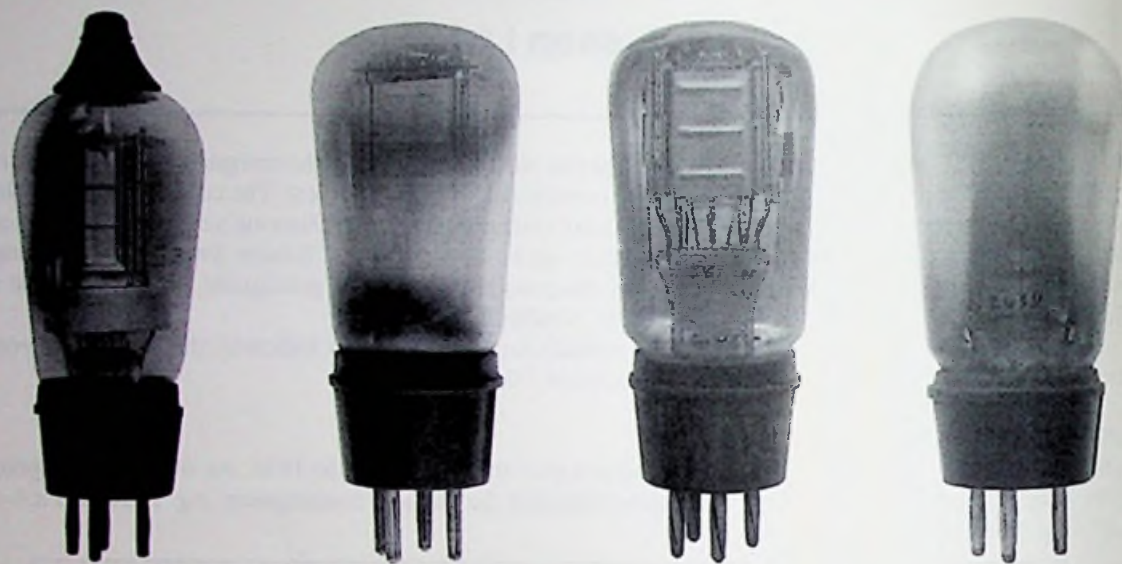
Table 6.1 lists the ranges of battery valves produced over the period 1929 to 1936. As was common practice at the time, the numerals in the type designation indicated the filament consumption, e.g. P625 had a 6-volt, 0.25-amp filament.

Year	RF tetrode or pentode	Freq. changer	Triode or diode triode	Output triode	Output pentode
1929	SG215		H210, HL210, L210	P220, PX240	PT225 (B4), PT240 (B4)
1930	SG410		H410, H610, HLD410, HLD610, L410, L610	P410, P425, P610, P625, P625A	PT625 (B4)
1931			H2, HL2, L2	LP2, P220A, P240A	PT220A, PT425 (B4)
1932	SG2V				PT225 (B5), PT240 (B5), PT425 (B5), PT611, PT625 (B5)
1933	AVC2		L2/D	B2, BB240	PT2A (B4)
1934	SP2, SP2V	FC2		BB220A, BB240A	PT250, QP240
1936					PT2A (B5)

Table 6.1: Lissen battery valves of 1929 to 1936.

The first types to appear in 1929 consisted of an r.f. tetrode, the SG215, three amplifying triodes, two output triodes and two output pentodes. The three triodes were the high impedance H210, the medium impedance HL210 and the low impedance L210. All three were suitable as detectors or a.f. amplifiers. The H210 could be RC coupled to a second stage of a.f. amplification but the other two would normally be transformer coupled. The two output triodes were the low power, 150mW, P220 and the higher power, 800mW, PX240. The two output pentodes were the PT225, which was rated at 300mW output, and the PT240, rated at 800mW. They were both fitted initially with 4-pin bases but 5-pin versions became available in 1932.

Four- and six-volt valves appeared in 1930. The r.f. tetrode was the SG410; the four-volt triodes were the H410, HLD410 and L410. Similarly, the six-volt triodes were the H610, HL610 and L610. There were five output triodes: the P410, P415, P610, P625 and P625A. The last two of these would normally be used in a.c. receivers or amplifiers rather than with batteries. There was only one output pentode. This was the six-volt PT625 which was supplied initially with a 4-pin base and a side terminal for connection to the screen grid. A 5-pin version became available in 1932. It was recommended for use in all-mains receivers where an output power of one watt could be obtained from a 200-volt h.t. supply.

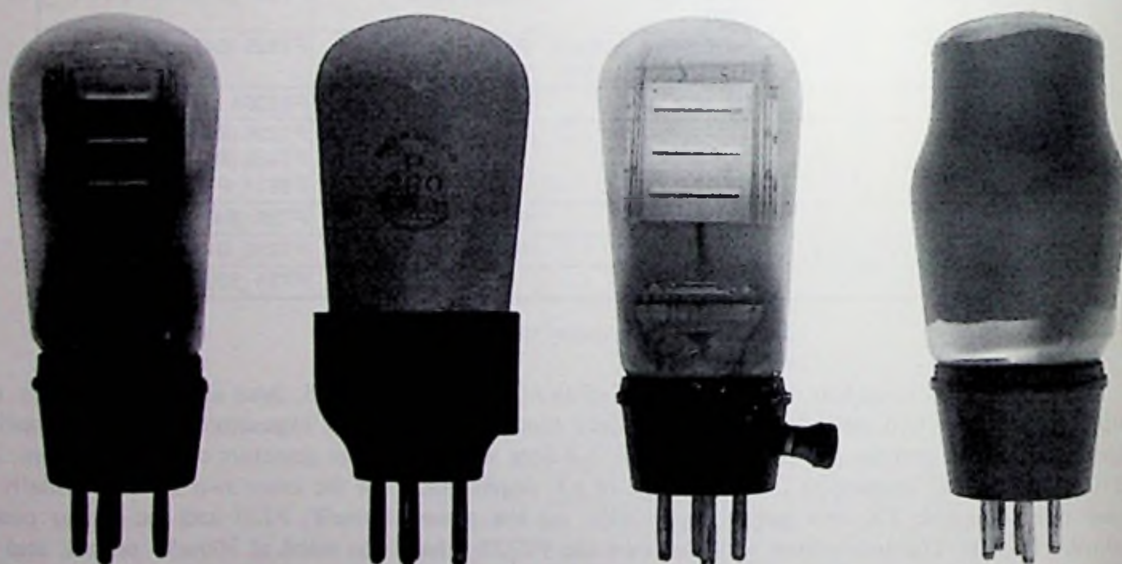


SG215: r.f. tetrode.

H210: high-impedance detector or RCC triode.

L210: low-impedance a.f. triode.

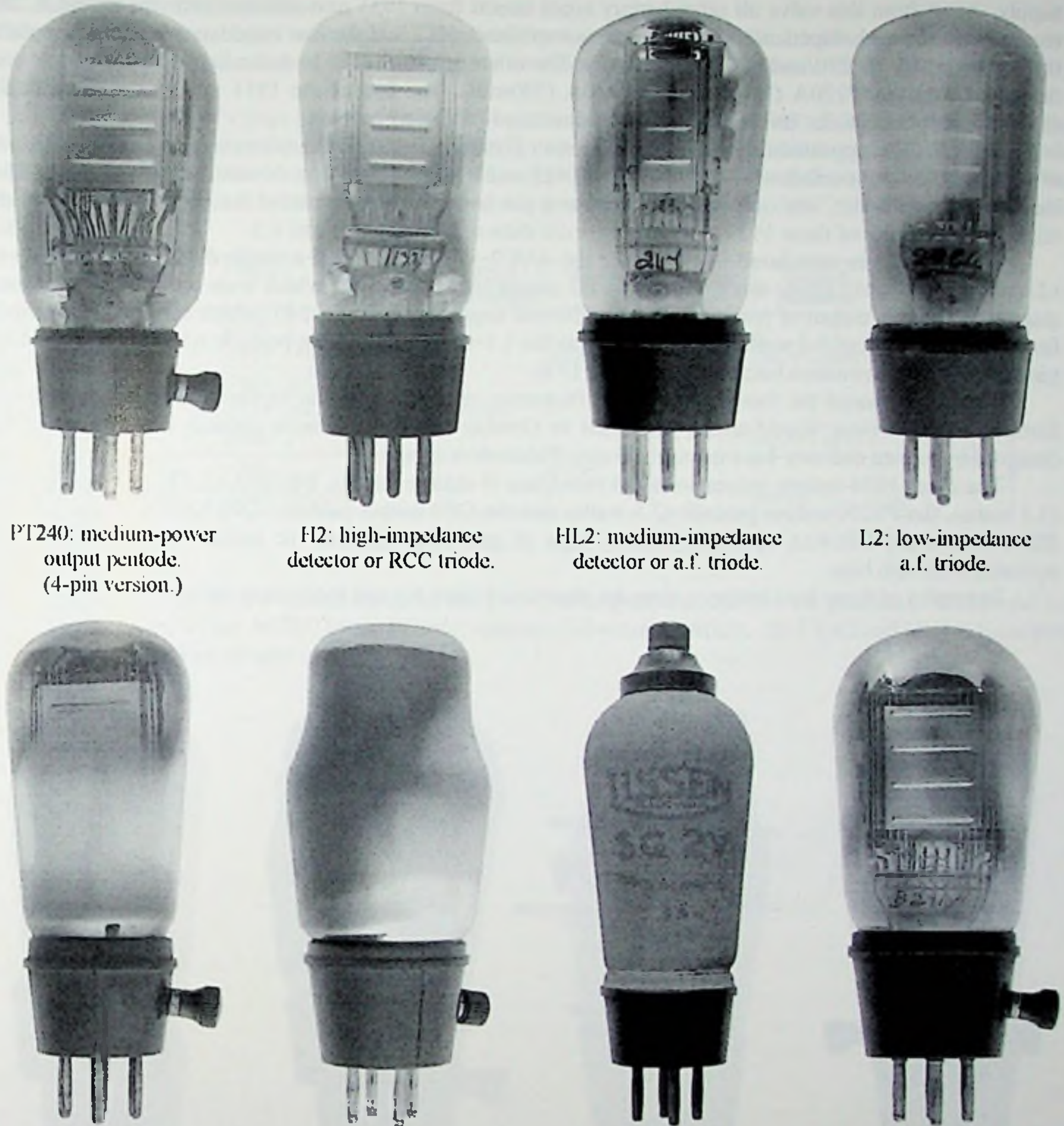
PX240: 'super power' output triode.



P220: low-power output triode. (Clear and metallised versions.)

PT225: low-power output pentode. (4-pin and 5-pin versions.)

Figure 6.1: Lissen battery valves of 1929 to 1932.



PT240: medium-power output pentode. (4-pin version.)

H2: high-impedance detector or RCC triode.

HL2: medium-impedance detector or a.f. triode.

L2: low-impedance a.f. triode.

PT425: 'super-power' output pentode. (Early and later versions, both 4-pins.)

SG2V: r.f. tetrode. (Replaced SG215.)

PT2A: output pentode.

Figure 6.2: Lissen battery valves of 1929 to 1932 and the PT2A of 1933.

A four-volt output pentode, the PT425, became available in 1931. This also had a 4-pin base with side terminal; as with all the earlier battery pentodes, a 5-pin version appeared in 1932. Initially, this valve was rated at 650mW from a 150-volt supply but it was upgraded in the following year to 900mW from a 200-volt supply. Apart from this valve all other battery types issued from 1931 onwards had two-volt filaments. The triodes were the high impedance H2, the medium impedance HL2 and the low impedance L2, which replaced the earlier H210, HL210 and L210 respectively. The other output triodes in ascending order of power were the LP2 (200mW), P220A (350mW) and P240A (550mW). The last of the 1931 valves was the PT220A (550mW) output pentode. This was only supplied with a 4-pin base.

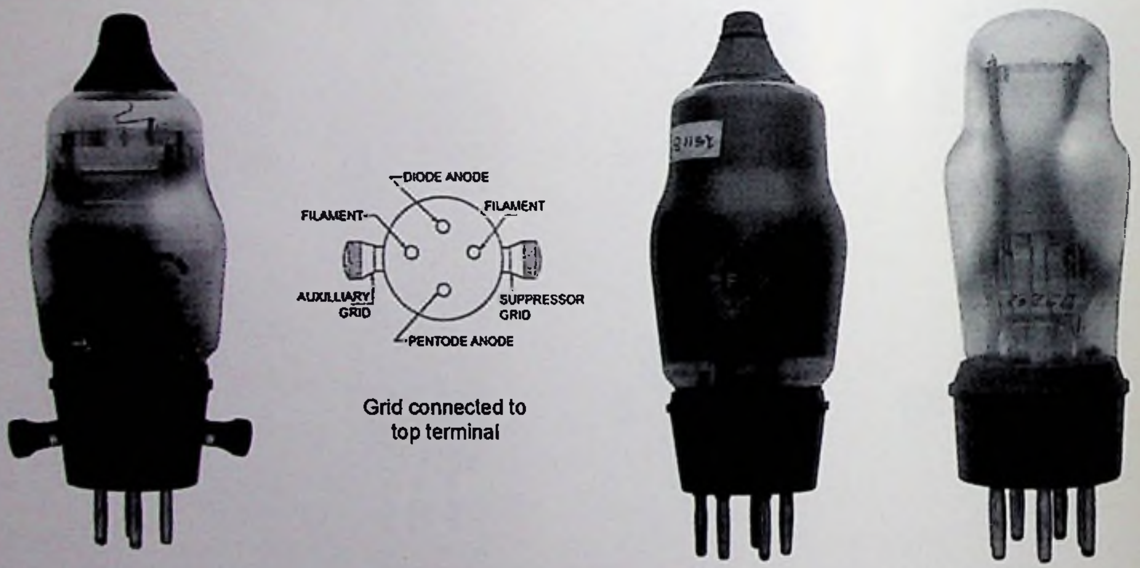
In 1932 there appeared the SG2V, variable-mu r.f. tetrode. Most of the other valves were 5-pin versions of the earlier output pentodes: PT225, PT240, PT425 and PT625. There was, however, a new pentode. This, the low-power PT611, was only supplied with a 4-pin base and was intended for series operation in d.c. receivers. Examples of these 1929 to 1932 valves are shown in Figures 6.1 and 6.2.

The new valves introduced in 1933 were the AVC2, which combined a single diode and a variable-mu r.f. pentode, the L2/D single diode triode, the B2 output triode, a pair of which were required for a Class B stage to deliver an output of two watts from a 150-volt supply, and the BB240, which combined two triodes for a Class B output of 3.2 watts. Finally there was the 1.1-watt PT2A output pentode which initially had a 4-pin base but a 5-pin version became available in 1936.

Lissen introduced the first triode hexode frequency changer to appear in the UK. This, the FC2, was featured in a *Wireless World* article published in October 1934[1]. It is most unlikely that the valve was designed by Lissen and may have been based on a Telefunken design.

The other 1934 battery valves were the two Class B double triodes, BB220A (2.5 watts) and BB240A (3.5 watts), the PT250 output pentode (2.5 watts) and the QPP output pentode, QP240 (1.5 watts). Both the BB220A and the BB240A operated with –3 volts of grid bias, whereas the earlier B2 and BB240 were operated with zero bias.

Examples of these later battery valves are shown in Figure 6.3 and the bottom right of Figure 6.2.



AVC2: single diode and variable-mu pentode.

Base connections for AVC2. (Note the two side terminals.)

FC2: triode hexode frequency changer.

BB220A: 2.5-watt Class B double triode.

Figure 6.3: Lissen battery valves of 1933 and 1934.

---

[1] Shelton, E E, 'New Frequency-Changer: The Triode Hexode', *W.W.*, 35, 5 October 1934, pp. 283–4.

AC RANGE OF 1930–1935

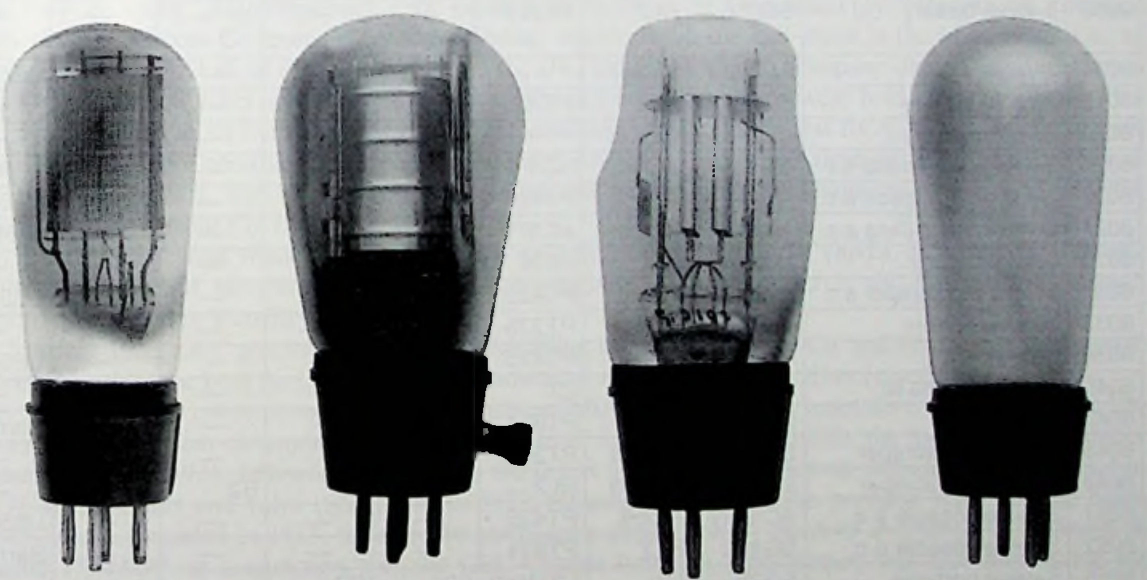
This range of valves is listed in Table 6.2. The first two types were the U650, a half-wave rectifier intended for battery eliminators, and the UU41, a full-wave rectifier rated at 300V, 80mA. They were both directly heated.

The next batch of valves appeared in 1932. There were two r.f. tetrodes, the AC/SG and the variable-mu AC/SGV. There were also the AC/HL detector triode, the AC/P output triode and the AC/PT output pentode with a 5-pin base and side terminal (a 7-pin version appeared in 1935). In the following year there was the AC/AVC, which combined a single diode with an r.f. pentode. This, like the AVC2 battery valve, had two side terminals.

Range	Year	RF tetrode or pentode	Freq. changer	Triode	Output triode	Output pentode	Rectifier
AC	1930						U650, UU41
	1932	AC/SG, AC/SGV		AC/HL	AC/P	AC/PT (B5)	
	1933	AC/AVC					
	1934	AC/SP, AC/SPV	AC/FC				UU42, UU43
	1935					AC/PT (B7)	
AC/DC 0.25-amps	1932			HL16			
	1933	SGV16				PT16	U16

Table 6.2: Lissen a.c. and a.c./d.c. valves.

The final group of new valves appeared in 1934. This consisted of the two r.f. pentodes, AC/SP and the variable-mu AC/SPV, the AC/FC triode hexode, and two full-wave rectifiers, the UU42 and UU43. Examples of these a.c. valves can be seen in Figure 6.4.



AC/HL: detector triode.

AC/PT: output pentode (5-pin version).

UU41: full-wave rectifier.

U650: half-wave rectifier for battery eliminators.

Figure 6.4: Lissen a.c. valves.

AC/DC VALVES

Lissen produced just one range of a.c./d.c. valves during the two year period 1932 to 1933. These had 16-volt, 0.25-amp heaters. There was a variable-mu r.f. tetrode, SGV16, the HL16 detector triode, the PT16 output pentode and the U16 half-wave rectifier.

LISSEN RECEIVERS AND BATTERY ELIMINATORS

Shown in Table 6.3 is a list of all the radio receivers and battery eliminators produced by Lissen in the period up to end of 1933, all employing Lissen valves. In later years the receivers used mostly Ever Ready valves of Mullard manufacture.

No	Description	Valve 1	Valve 2	Valve3	Valve 4	Valve 5	Valve 6	Valve 7	Valve 8
734	Eliminator	—	—	—	—	—	—	—	U650
735	Eliminator	—	—	—	—	—	—	—	U650
736	Eliminator	—	—	—	—	—	—	—	U650
737	Eliminator	—	—	—	—	—	—	—	U650
818	2-valve battery	HL2	P220	—	—	—	—	—	—
8001	2-valve a.c.	AC/HL	PT425	—	—	—	—	—	U650
8005	2-valve battery	HL2	PT225	—	—	—	—	—	—
8006	3-valve band-pass a.c.	AC/SG	AC/HL	PT425	—	—	—	—	U650
8007	2-valve a.c.	AC/HL	PT425	—	—	—	—	—	U650
8008	3-valve band-pass a.c.	AC/SG	AC/HL	PT425	—	—	—	—	U650
8010	3-valve band-pass a.c.	AC/SG	AC/HL	AC/PT	—	—	—	—	UU41
8011	3-valve band-pass a.c.	AC/SG	AC/HL	AC/PT	—	—	—	—	UU41
8012	2-valve d.c.	HL2	PT611	—	—	—	—	—	—
8013	3-valve battery Skyscraper	SG215	HL2	PT225	—	—	—	—	—
8014	2-valve a.c.	AC/HL	PT245	—	—	—	—	—	U650
8019	3-valve battery	SG215	HL2	PT225	—	—	—	—	—
8020	2-valve battery	HL2	PT225	—	—	—	—	—	—
8023	3-valve band-pass a.c.	AC/SG	AC/HL	AC/PT	—	—	—	—	UU41
8026	3-valve band-pass a.c.	AC/SG	AC/HL	PT425	—	—	—	—	U650
8027	3-valve band-pass a.c.	AC/SG	AC/HL	AC/PT	—	—	—	—	UU41
8030	3valve battery	HL2	HL2	P220	—	—	—	—	—
8031	3valve Skyscraper a.c.	AC/SGV	AC/HL	PT425	—	—	—	—	U650
8033	3-valve battery	SG215	HL2	PT225	—	—	—	—	—
8039	3-valve a.c.	AC/SGV	AC/HL	PT425	—	—	—	—	U650
8040	4-valve Zalma kit	SG2V	L2	L2	PX240	—	—	—	—
8043	3-valve d.c.	SG410	HL2	PT611	—	—	—	—	Barretter
8045	4-valve Skyscraper	SG2V	SG215	PT2A	PT2A	—	—	—	—
8048	7-valve Skyscraper	SG215	SG215	HL2	AVC2	L2	B2	B2	—
8051	3-valve console a.c.	AC/SGV	AC/HL	PT425 ·	—	—	—	—	U650
8052	3-valve console d.c.	SG410	HL2	PT611	—	—	—	—	Barretter
8055	5-valve portable	SG2V	L2	L2 (Met)	B2	B2	—	—	—
8066	6-valve a.c. superhet	AC/SG	AC/HL	AC/SG	AC/AVC	AC/PT	—	—	UU41

Table 6.3: Lissen valves used in Lissen receivers.

Chapter 7
M-O Valve Company Ltd.
(Trade names: Marconi, Osram, M.W.T., GEC)

In 1919, the Marconi Company and GEC decided to set up a joint company for valve design and manufacture that could benefit from their pooled know-how and valve patents. The company was incorporated on 20 October of that year and originally called Marconi-Osram Valve Co. Ltd., but the name was changed in the following year to M-O Valve Co. Ltd. (MOV). Production of the valves was at the Osram-Robertson lamp works in Brook Green, Hammersmith, west London.

Following its formation, the company grew rapidly to become one of the foremost valve manufacturers in the UK, with production concentrated at the Hammersmith plant. Until late in 1925, the valves bore the MARCONI brand name but, after this time, valves marketed by GEC used the brand name OSRAM, whilst those marketed by Marconiphone (see below) continued with the MARCONI brand name. Apart from receiving valves, the company also manufactured a wide range of transmitting valves, and these often bore the Marconi's W.T. Co. label. Throughout this book, all receiving valves manufactured by this company, whether bearing the Marconi or Osram labels, will be referred to as Marconi-Osram or MOV valves.

In 1922, the Marconi Company set up a 'Marconiphone Department' at their Chelmsford plant for the design, manufacture and sale of broadcast receivers. This led, in December 1923, to the formation of a subsidiary company, Marconiphone, with production facilities at Dagenham [1]. Because of financial problems, the Marconi Company sold Marconiphone, together with the half-share in the M-O Valve Co., to the Gramophone Co. Ltd. at the end of 1929. In the UK, the Gramophone Company owned the well-known 'His Master's Voice' label and, at the time, about fifty percent of its shares were held by RCA-Victor. This link with RCA led to an exchange of technical information between MOV and RCA, to the benefit of both companies. A further consolidation took place in 1931 when a new holding company, Electric and Musical Industries Ltd. (EMI), was created which combined the activities of the Gramophone Co. Ltd. and the Columbia Graphophone Co. Ltd.

During the Second World War, the company became a major supplier of valves, including magnetrons, to the British armed services; the basic research required was carried out at the GEC Hurst research laboratories located in Wembley, Middlesex.

In July 1956, GEC purchased the EMI shareholding in the M-O. Valve Co. and became its sole owner. Valves from this time bore the GEC label. The production of most receiving valves ceased in 1958.

Throughout its entire period in the valve business MOV was always an innovative company. In the UK it was first with a four-electrode space-charge tetrode (F.E.1 and F.E.2 in 1920), the thoriated, dull emitter filament (L.T.1 in 1921, followed soon after by the D.E.R.), the indirectly heated cathode (KH1 and KL1 in 1927), the screened grid valve (S625, also in 1927, although patented in the previous year) and the beam power tetrode (patented in 1933, followed by small-scale production of the N40 in 1935). As is shown in Chapter 15, MOV, in conjunction with the GEC Central Research Laboratories, was also responsible for major developments in both low- and high-power valves during the Second World War.

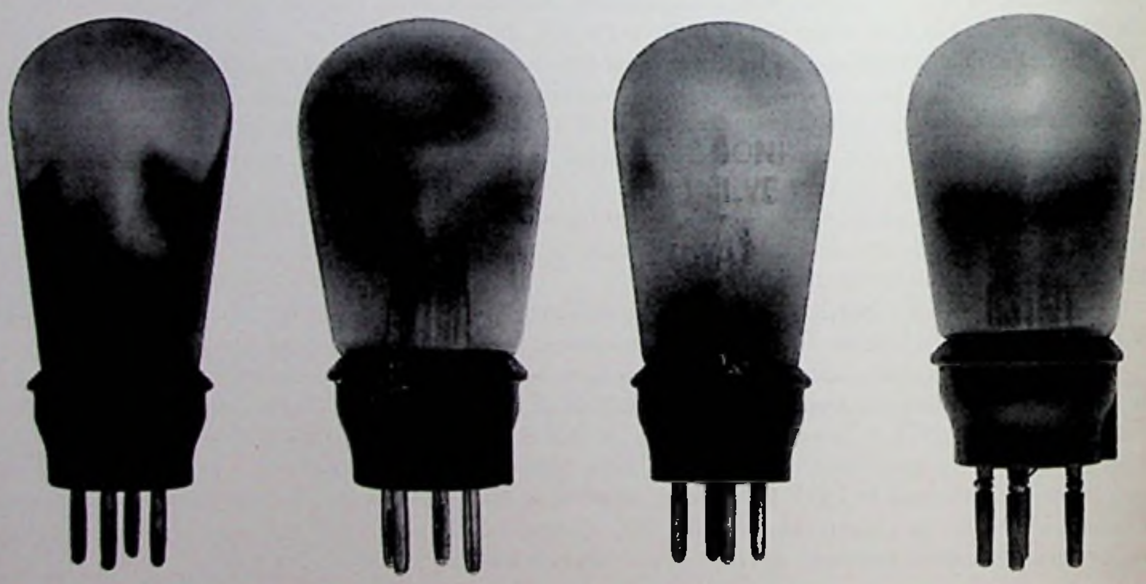
THE PERIOD 1926 TO 1929

During the first year of this period, the valves in use were principally the dull emitter types of the previous few years such as the D.E.2 and L.S.5. The only new types to be introduced in 1926 were the half-wave and full-wave rectifiers, U4 and U5.

Several new ranges, however, were introduced over the next three years. These are shown in Table 7.1 below. The first three of these ranges consisted of a unified series of 2-, 4- and 6-volt dull emitter valves. The D.E.H. range was intended as detectors or RCC amplifiers; the D.E.L. range was detectors or transformer-coupled audio amplifiers and the D.E.P. range was output valves. The D.E.H. types could also be used in neutralised r.f. amplifiers. Initially many of these valves had thoriated tungsten filaments but MOV introduced the oxide-coated filament in late 1927 and the valves were subsequently re-designed with this filament. Figure 7.1 shows examples of the valves. Not part of the unified range was a general-purpose triode type LS5B which had a 5.25-volt filament (An example of this valve made for the Post office and with the BC4 base can be seen in Figure 15.18 on page 316.).

Range	Year	RF tetrode	RF, detector or AF triode	Output triode	Output pentode
2-volt, D.E.	1927/28		D.E.H.210, D.E.L.210	D.E.P.215, D.E.P.240	
4-volt, D.E.	1927/28		D.E.H.410, D.E.L.410	D.E.P.410	
6-volt, D.E.	1927/28	S625	D.E.H.610, D.E.H.612, D.E.L.610, D.E.L.612, LS5B	D.E.P.610	
2-volt, oxide	1928/29	S215	HL210, H210, L210	P215, P240	PT235, PT240
4-volt, oxide	1928/29	S410	HL410, H410, L410	P410, P425	PT425
6-volt, oxide	1928/29	S610	HL610, H610, L610	P610, P625, P625A	PT625
AC, 3.5-volt	1927		KH1	KL1	
AC, DH	1928/29	S.8	D.8, H.8, HL.8	P.8	

Table 7.1: Marconi-Osram valves of 1927 to 1929.



DEL210:
2-volt detector or a.f. triode.

DEL610:
6-volt detector or a.f. triode.

DEP410:
4-volt output triode.

DEP610:
6-volt output triode.

Figure 7.1: Examples of the DE Series of 1927–1928.
(Electrodes obscured by heavy magnesium getter.)

The first screened grid valve to be produced in the UK was the S625. This had been patented by H J Round of the Marconi Company in May 1926 and became available around mid-1927 [2.3]. The design was rather unusual (see Figure 7.2). It had a V-shaped filament, surrounded in a conventional way by the control grid, with the three connecting wires being taken out to one end of the valve. Beyond the control grid was a frame structure consisting of a metal gauze attached to the end of a shallow nickel cylinder, 5mm deep and 28mm in diameter, which formed the screen grid. The anode was a metal disc 25mm in diameter contained within the frame. The connections to the screen grid and anode were brought out to two pins at the other end of the valve. It had a 6-volt thoriated tungsten filament, a grid-to-anode capacitance about 200 times less than a triode valve and a high value of anode resistance, making it eminently suitable as an r.f. amplifier.

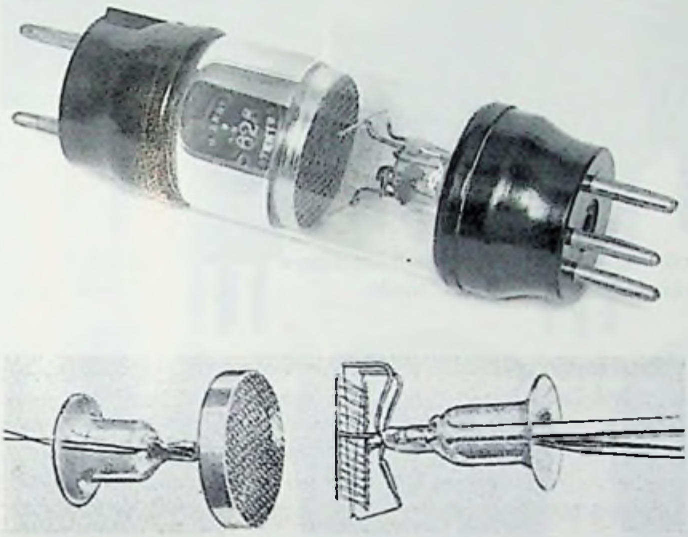


Figure 7.2: S625 screened grid tetrode of 1927. Note the use of two caps—one with three pins (at the right) for the control grid and filament connections and the other (at the left) for connections to the screen grid and anode.

The diagram below shows the electrode construction with a V-shaped filament surrounded by a flattened control grid. The screen grid is the shallow frame with a wire mesh at one end and the anode a disc within the frame.

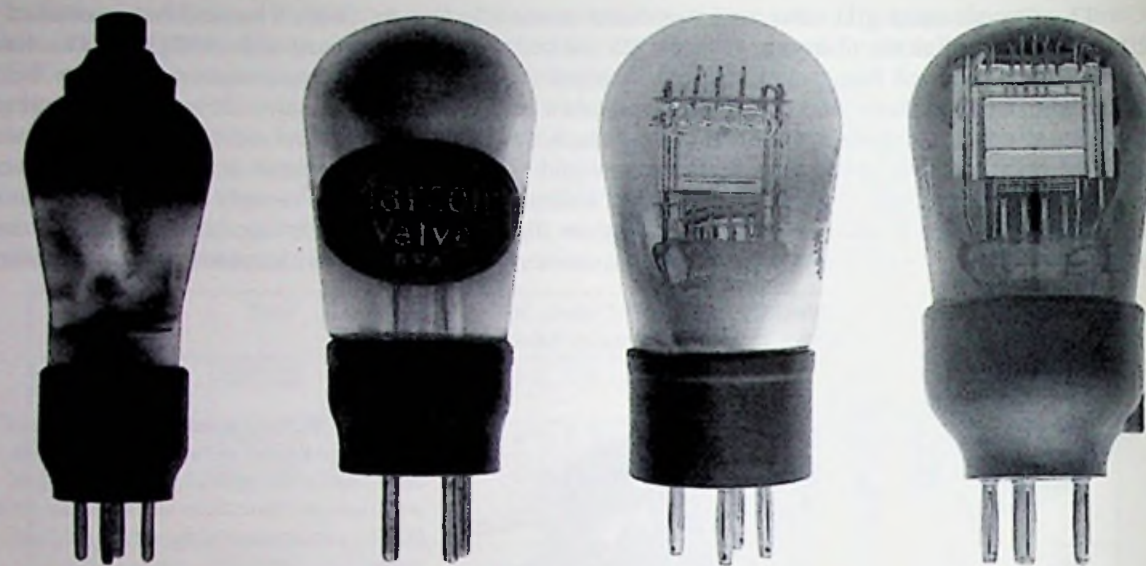
The D.E. Series was soon superseded by a new series of unified 2-, 4- and 6-volt valves that included r.f. tetrodes and output pentodes in each of the three voltage ranges. A significant change with the tetrodes was the use of single end cap and a top terminal for connection to the anode. This change was made because the double-ended S625 had proved unpopular with set makers. The output pentodes had four-pin bases with a side terminal for connection to the screen grid; the suppressor grid was internally connected to the filament, as was common practice with most other valve manufacturers.

The triodes consisted of the H210, H410 and H610 which were high impedance types recommended for RC coupled amplifiers; there were the HL210, HL410 and HL610 which were medium-impedance, general-purpose types; finally there were the L210, L410 and L610 which were low-impedance types best suited as transformer-coupled a.f. amplifiers.

There were several output triodes. In the two-volt range there was the low-power P215, which was superseded by the higher power P240 rated at 400mW output, but was still available for replacement purposes throughout the 1930s; the two four-volt types were the P410 and the higher-power P425; the three six-volt types were the P610, P625 and P625A. The latter two of these were suitable for a.c. operation on their filaments. Whereas the P625 had an anode rating of 250 volts the P625A had a reduced rating of 200 volts.

There were four output pentodes: the PT235, PT240, PT425 and the PT625. Of these, the highest power valve was the PT625 which was capable of two watts from a 250-volt supply.

Representative examples of the valves in the series can be seen in Figure 7.3.

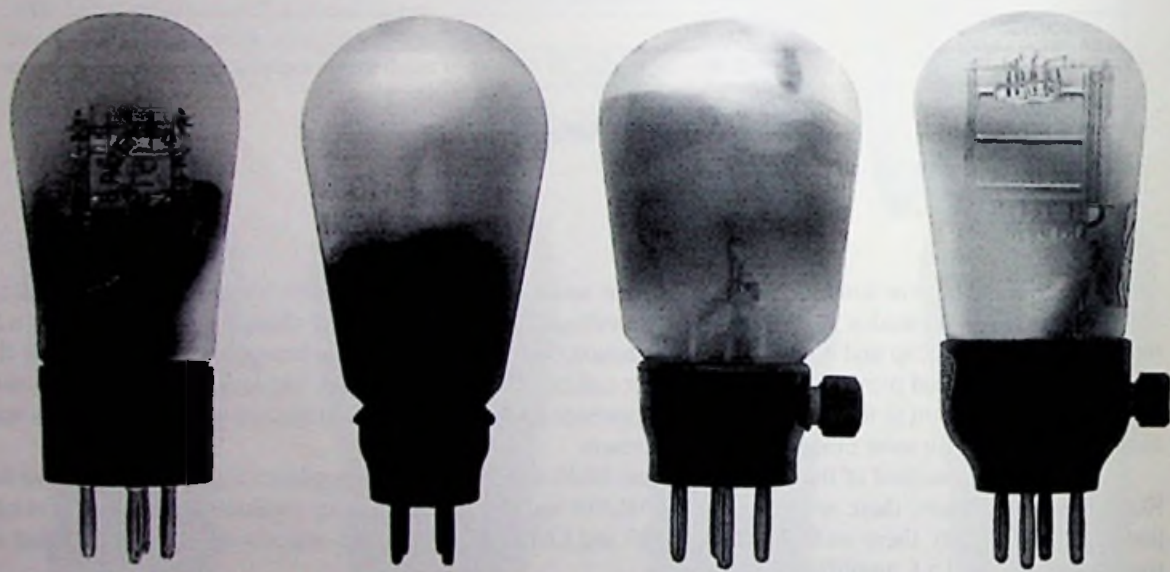


S215, S410 and S610: r.f. tetrodes.

HL210: 2-volt general-purpose triode.

H410: 4-volt high-impedance RCC triode.

HL610: 6-volt general-purpose triode.



L410: 4-volt a.f. triode.

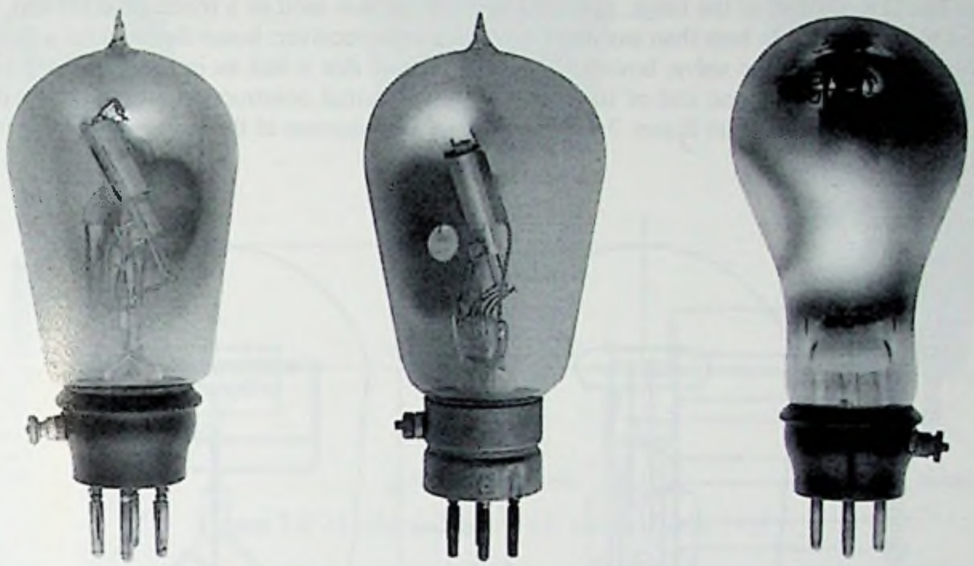
P625 & P625A: 6-volt output triodes.

PT235: 2-volt output pentode.

PT425: 4-volt output pentode.

Figure 7.3: Unified two-, four- and six-volt valves of 1928 to 1929.

MOV was the first company in the UK to manufacture valves with indirectly heated cathodes. The first two types were the general-purpose triode, KH1, and the output triode, KL1, both of which became available early in 1927 [4,5]. These had a tungsten heater with 'air' spacing to the cathode, resulting in a slow warm-up time. Outwardly, the two valves appeared very similar (see Figure 7.4); they had a four-pin base with side terminal for connection to the cathode and the electrode assembly was tilted to aid with heat radiation. As it turned out the valves proved difficult to manufacture—possibly because of poor oxide coating; as a result, some of the valves marked KL1, for instance, were actually manufactured by Metrovic at their Cosmos works (see Figure 7.4).



KH1: general-purpose triode (with bakelite base).

KL1 output triode (with metal-shell base).

KL1 by Cosmos (actually an AC/R).

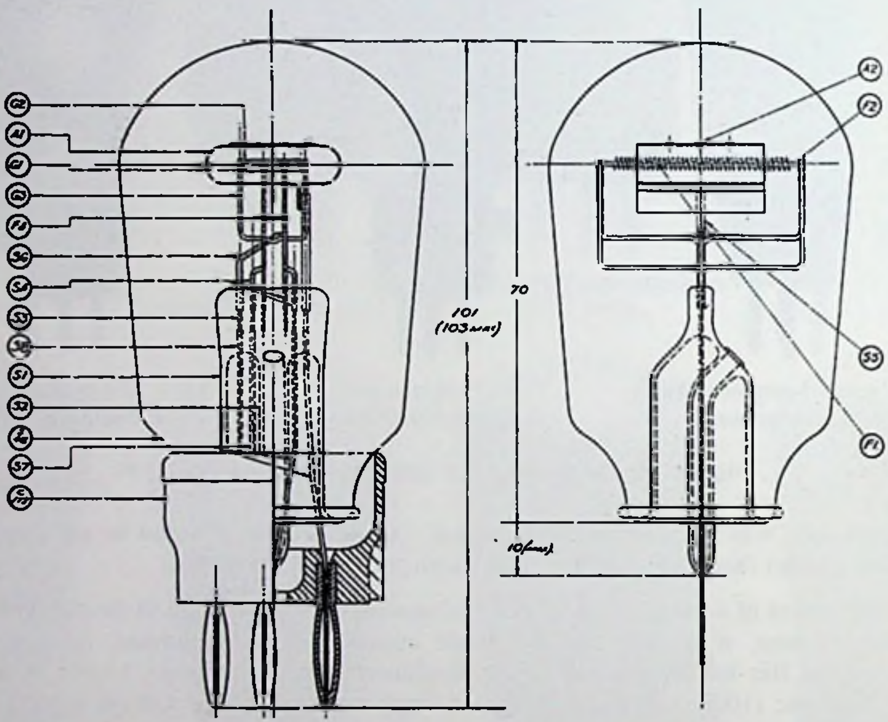
Figure 7.4: The KL1 and KH1 indirectly heated triodes of 1927.

One might ask 'Why have an indirectly heated cathode? Surely it would be possible to operate the filament from a.c. rather than d.c.?' There are three main problems to overcome:

1. The anode current of a triode depends upon the anode-to-cathode voltage. If the filament is fed from an alternating voltage, it is clear that the anode current will be modulated, resulting in hum. The components of this modulation will be the fundamental mains frequency (50Hz in the UK) and its second harmonic (100Hz). If the transformer supplying the filament voltage is centre tapped, or a potentiometer is connected across the supply, it is possible to cancel the fundamental component and to reduce the second harmonic component by a factor of four [6]. This technique was common practice for output triodes and continues today in modern hi-fi valve amplifiers.
2. The alternating electric field at the filament will be capacitively coupled to the grid and the resulting voltage induced at the grid will be amplified at the anode. This problem can be reduced by using a very low filament voltage, the necessary heating power being produced by operating the filament at a correspondingly higher current, although this is not necessary for output triodes.
3. The alternating current in the filament will create a magnetic field that tends to deflect the electron current flowing from the filament to the anode. Maximum deflection will occur at the positive and negative peaks of the current, both of which will cause a slight fall in the anode current. As a result, hum modulation will occur at twice the mains frequency. This problem can be reduced very significantly by forming the filament into a V or W shape, both which tend to cancel the magnetic field.

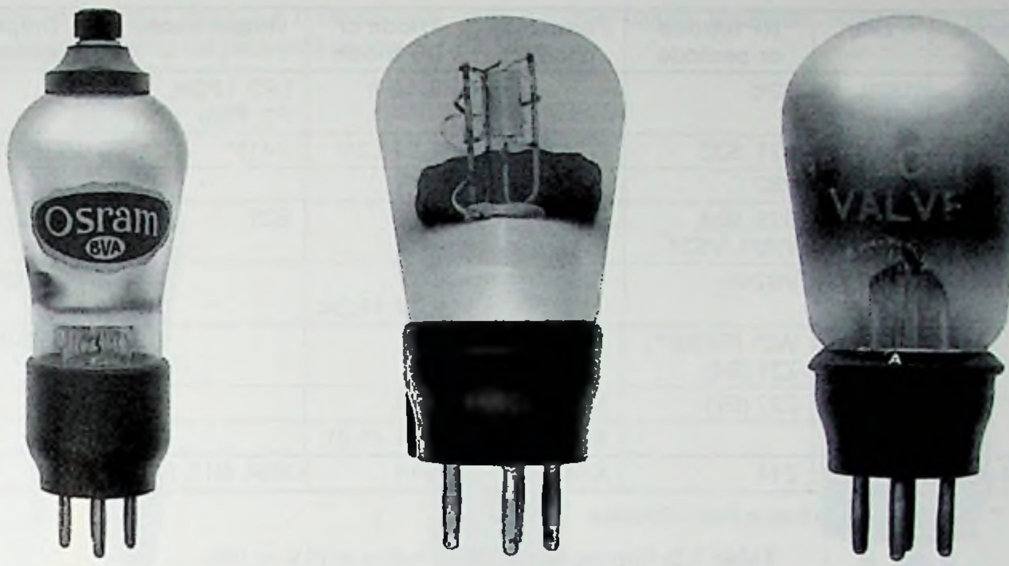
It is also possible that the instantaneous heating and cooling of the filament, as the current alternates between zero and maximum (at twice the mains frequency), could also influence the anode current. In practice, provided the filament is fairly thick, this problem is of minor importance.

MOV produced a range of valves where the filament was directly heated by the a.c. supply. The range, known as the Point-8 series (see bottom row in Table 7.1), was introduced in 1928. They had oxide-coated filaments, operating at 0.8 volts, 0.8 amps, with the exception of the type D.8 that required a current of 1.6 amps. The D.8, the last of the range, appeared in 1929. (It was used as a triode detector and, because of this, it was more sensitive to hum than any other valve in a radio receiver; hence the need for a thicker, higher current filament. Study of the valve, however, appears to show that it had an indirectly heated cathode that was internally connected to one end of the filament.) The internal construction of the valves is shown in Figure 7.5 and some examples in Figure 7.6. Following the introduction of the indirectly heated cathode, this range soon became obsolete.



A1	Anode	Nickel	S1	Seal	Glass tubing
A2	Getter	Magnesium	S2	Stem	Glass tubing
C172	Base	Bakelite	S3	Pinch wires	Red platinum
F1	Filament	Silicated tungsten	S4	Filament support	Nickel
F2	Filament end	Nickel	S5	Anode support	Manganese nickel
F3	Filament end	Nickel	S6	Grid support	Nickel
F4	Cross wires	Nickel	S7	Anode & filament lead wires	Copper
G1	Grid	Molybdenum wire			
G2	Damping wire	Nickel	S8	Grid lead wire	Copper
G3	Grid cross	Nickel	S4G	Bulb	Glass

Figure 7.5: General construction of the of Point 8 valves H, HL and P.



S.8: r.f. tetrode. D.8: detector triode. P.8: output triode.

Figure 7.6: The Point-8 range of a.c. valves of 1928–1929.

BATTERY VALVES OF 1930–1940

The various ranges that were introduced during this ten-year period are shown in Table 7.2. By 1930 the earlier four- and six-volt ranges were becoming obsolete and new two-volt types issued.

The H2 was a general-purpose triode used mainly as a detector or a.f. amplifier and replaced the earlier H210. It was the preferred detector when there was no preceding r.f. amplifier because of its high sensitivity. The HL2 was also a general-purpose triode but was of lower impedance. Like the HL210, which it eventually replaced, it was used as a detector or a.f. amplifier. Both the LP2 and P2 were output triodes, as was the P415, although this had a 4-volt filament. The LP2 was a low-power valve more suited for use in portable receivers, whereas the P2 was classed as a 'Super Power' valve.

Five of the 1930/31 valves were only sold with the Marconi label. These were the S2/c, HL2/c, LP2/c (all three sourced from Cossor), the L2/b and the P2/b (both sourced from Mazda).

The two screened grid tetrodes, S21 and S22, were very similar, except that the S22 had a higher slope, and both replaced the earlier S215. It was recommended that the S21 should be used when there was more than one stage of r.f. amplification.

The BG4 and DG2 were both bi-grid tetrodes for use as a combined oscillator and first mixer in early superheterodyne receivers. They had very similar characteristics, the principal difference being the filament voltage. When used as a frequency changer the inner grid was connected via the secondary winding of the oscillator coil back to the positive end of the filament. The valves were fitted with 5-pin bases the centre pin of which was connected to the inner grid.

The only other valve to appear in 1931 was the PT2 output pentode which replaced the earlier PT215 and PT240. With this valve there was a choice of 4-pin base, with a side terminal for connection to the screen grid, or a 5-pin base. It could provide an output of 450mW from a 150-volt supply.

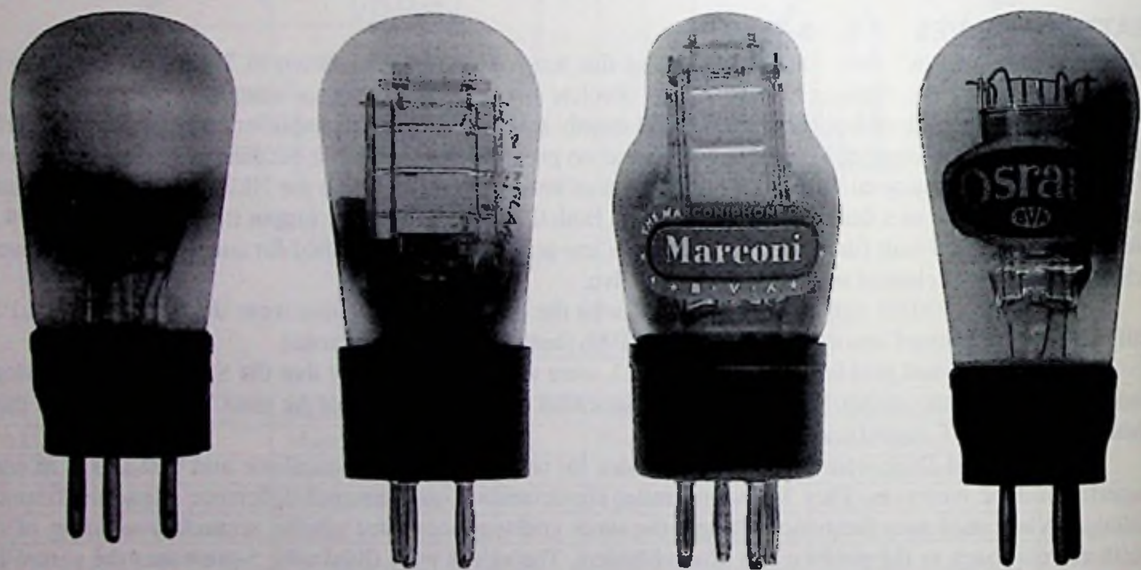
The only new valve to be introduced in 1932 was the VS2. This was Marconi-Osram's first variable-mu r.f. tetrode.

A selection of the valves available from 1930 to 1932 can be seen in Figures 7.7 and 7.8.

Range	Year	RF tetrode or pentode	Frequency changer	Triode or DD triode	Output triode	Output pentode
2-volt	1930	S2/c		H2, L2/b	LP2, LP2/c, P2, P2/b	
	1931	S21, S22	BG4*, DG2	HL2, HL2/c	P415*	PT2 (B4&B5)
	1932	VS2				
	1933	S23, S24, VP21, VS24		L21	B21	
	1934	VS24/k	X21	HD21, HD22, HL2/k		PT2/k, QP21
	1937	W21 (B4&B7), Z21 (B4)	X22			KT2, KT21
	1938	Z22 (B7)	X23	HD23		
	1939/40		X24	HD24, HL21		KT24
1.4-volt	1940	Z14	X14	HD14	N14, N15, N16	

* The BG4 and P415 were four-volt valves

Table 7.2: Marconi-Osram battery valves of 1930 to 1940. (Excluding the miniature types for use with hearing aids, which are described later in this chapter under Special Types.)



H2: detector or a.f. triode.

LP2: output triode (early version).

LP2: output triode (later version).

P2: output triode.

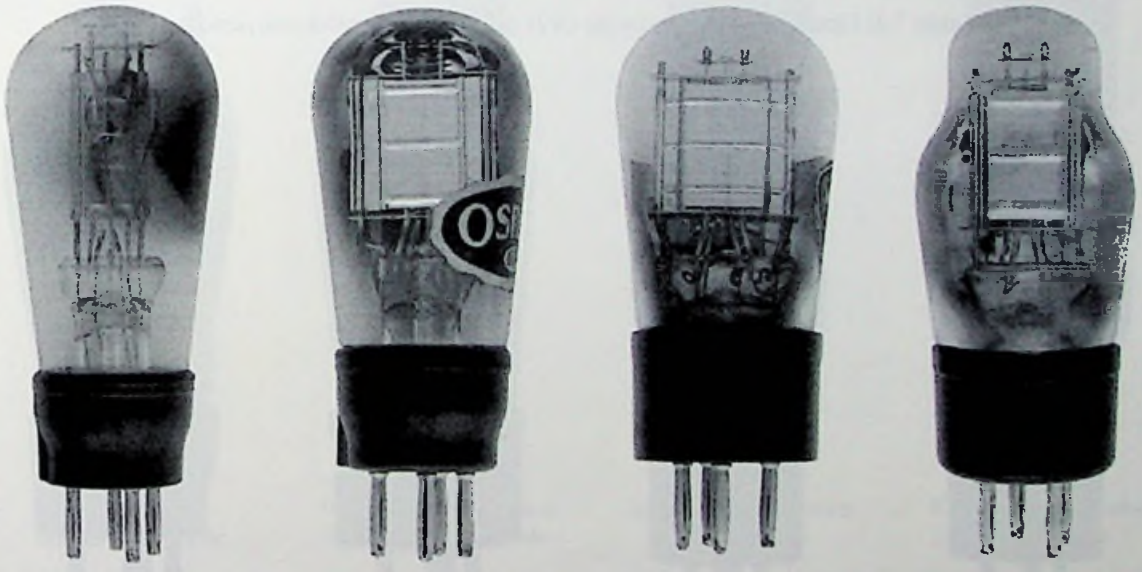
Figure 7.7: Two-volt battery valves of 1930.

There were several new additions during 1933 and 1934. These included the S23 and S24 r.f. tetrodes to replace the S21 and S22, a new variable-mu tetrode, the VS24, to replace the VS2, and a variable-mu pentode, VP21. The HL2 detector triode and the P2 output triode continued in use throughout the 1930s, but a Class B double triode, B21, together with a driver triode, L21, were added in 1933. In a typical receiver the L21 would be coupled to the B21 by a 1.3:1 transformer, with a centre-tapped secondary winding to provide the necessary phase-splitting for push-pull operation.

S21 and S22:
r.f. tetrodes.

VS2:
variable-mu r.f. tetrode.

DG2:
bi-grid frequency changer.



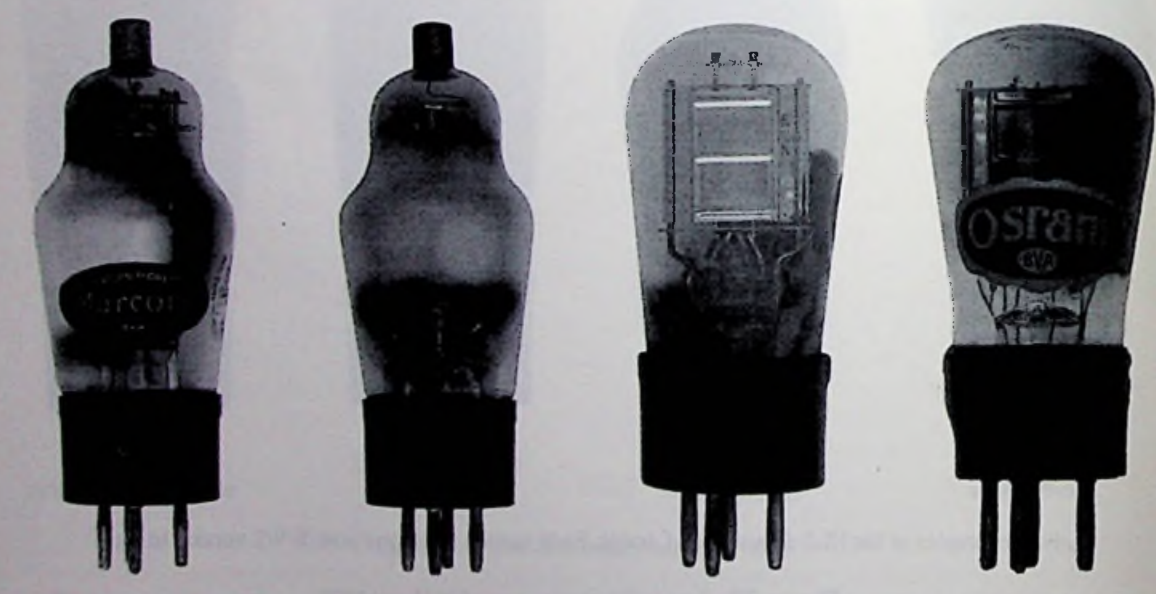
Four examples of the HL2 detector or a.f. triode. Early version at left and post-WW2 version at right.

Figure 7.8: Two-volt battery valves of 1931 and 1932.

The bi-grid tetrode mixers, BG4 and DG2, were superseded in 1934 by the X21 heptode frequency changer. Two double diode triodes also became available: these were the HD21 and HD22, although the first of these appears to have been used only by the Marconi Company. For use in portable receivers there were slimmed down versions of the VS24, HL2 and PT2 (VS24/k, HL2/k and PT2/k); these were based on the Catkin construction described later in this chapter. The other new valve was the QP21 double pentode for QPP operation. This valve was supplied in three groups, each with a code letter marked on top of the bulb to indicate the recommended screen voltage for a fixed grid bias or, alternatively, the recommended grid bias for a fixed screen voltage. A typical driver valve for this was the HL2 used a leaky grid detector and then transformer coupled to the QP21. Operating conditions for the valve are shown in Table 7.3 and typical examples of the 1933–1934 valves in Figures 7.9 and 7.10.

Anode voltage	150			120		
	Code letter			Code letter		
	V	W	X	V	W	X
Screen voltage (fixed grid bias)	140	146	150	90	105	111.5
	Grid bias –9v			Grid bias –6v		
Grid bias (fixed screen voltage)	–9.8	–9.5	–8.8	–7.8	–7.6	–7.1
	Screen voltage 150			Screen voltage 120		
Average quiescent anode current (mA)	3.5			2.8		
Average quiescent screen current (mA)	0.9			0.7		
Optimum load resistance (anode to anode)	25,000 ohms			35,000 ohms		
Average full load anode current (mA)	12.5			8.0		
Average full load screen current (mA)	6.0			3.0		
Output power (Watts)	1.2					

Table 7.3: Operating conditions for the QP21 quiescent push-pull double pentode.

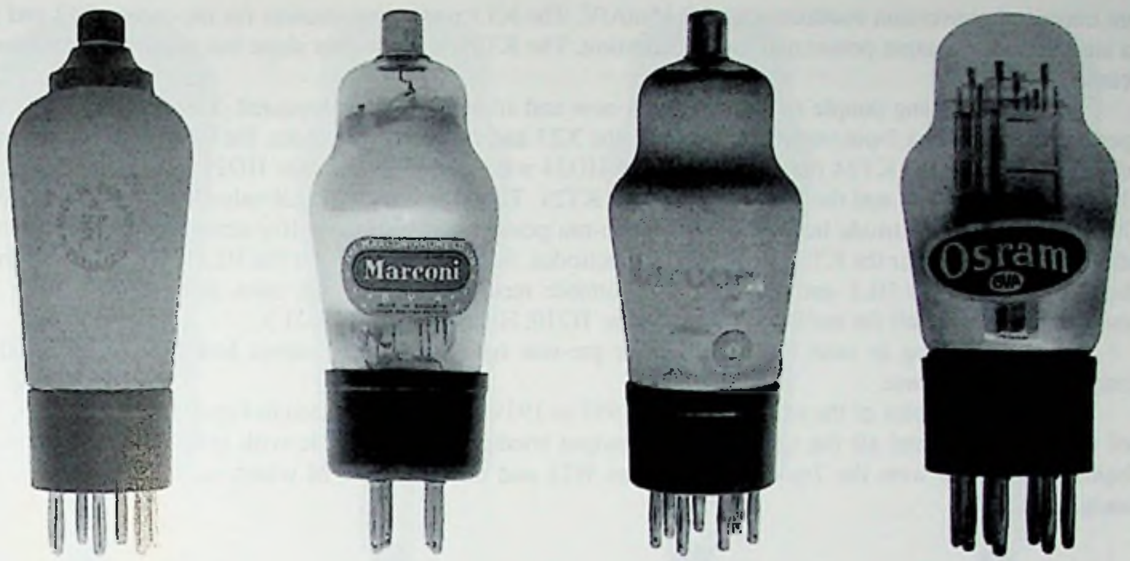


S23 and S24: r.f. tetrodes (plain bulb version).

VS24: r.f. tetrode (plain bulb version).

Two version of the L21 a.f. driver for the B21 Class B double output triode.

Figure 7.9: Two-volt battery valves of 1933.



VP21:
variable-mu r.f. pentode.

X21: heptode frequency changer.
(Plain and metallised versions.)

B21:
Class B output triode.

HD22:
double diode triode.

VS24/k: Marconi Catkin
variable-mu r.f. tetrode.

HL2/k: Marconi Catkin
detector triode.

PT2/k: Marconi Catkin
output pentode.

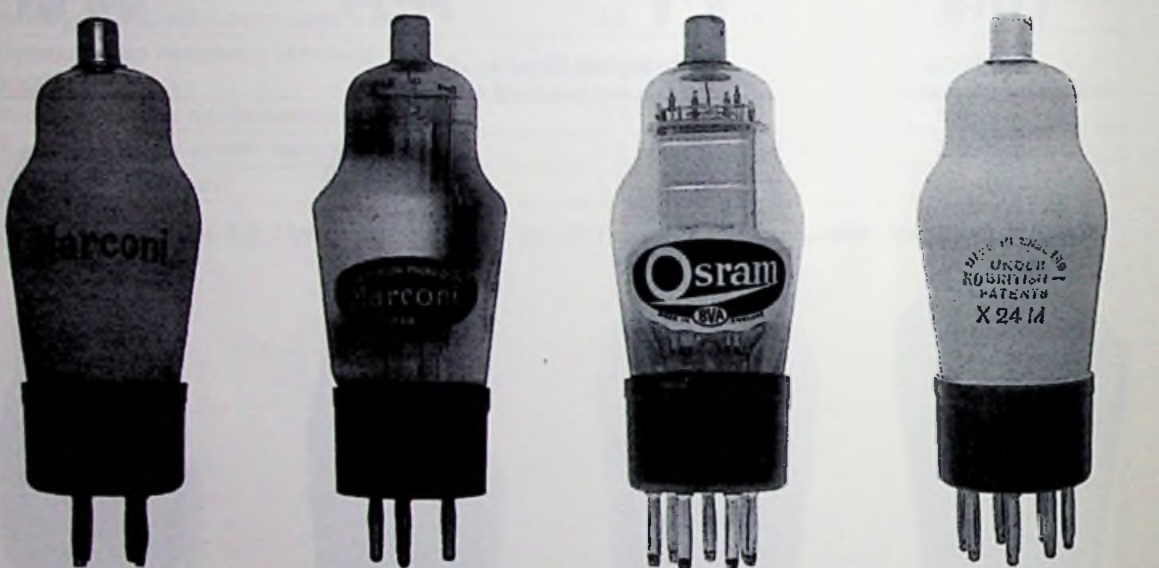
Figure 7.10: Two-volt battery valves of 1933–1934.

In 1937, an entirely new range of two-volt battery valves was released. This consisted of an r.f. pentode, Z21; a variable-mu r.f. pentode, W21; a heptode frequency changer, X22, and output tetrodes KT2 and the steep-sloped KT21. The W21 had a choice of 4-pin or 7-pin base, whereas the Z21 was only provided with a 4-pin base; both types were available with metallised or plain bulb. The X22 replaced the earlier X21 and had an improved conversion conductance of 0.35mA/V. The KT2 was a replacement for the earlier PT2 and gave a slightly higher output power and lower distortion. The KT21 had a higher slope but required more filament current.

In the following couple of years several new and improved types appeared. These were the Z22, r.f. pentode which was a 7-pin version of the Z21, the X23 and X24 triode hexodes, the HD23 and HD24 double diode triodes and the KT24 output tetrode. The HD24 was soon to replace the HD21, HD22 and HD23, the X24 replaced the X23 and the KT24 replaced the KT21. Thus, by 1939 a typical valve line-up consisted of the X22 heptode or X24 triode hexode, Z22 variable-mu pentode, HL2 detector (for straight sets), HD24 double diode triode and either the KT2 or KT24 output tetrodes. Shown in the table is the HL21, which was a smaller bulb version of the HL2 and intended for portable receivers, but it was soon discontinued. (The HL2 eventually replaced all the earlier detector triodes: H210, HL210, H2 and HL21.)

It is interesting to note that none of the pre-war two-volt battery valves had the newly introduced international octal base.

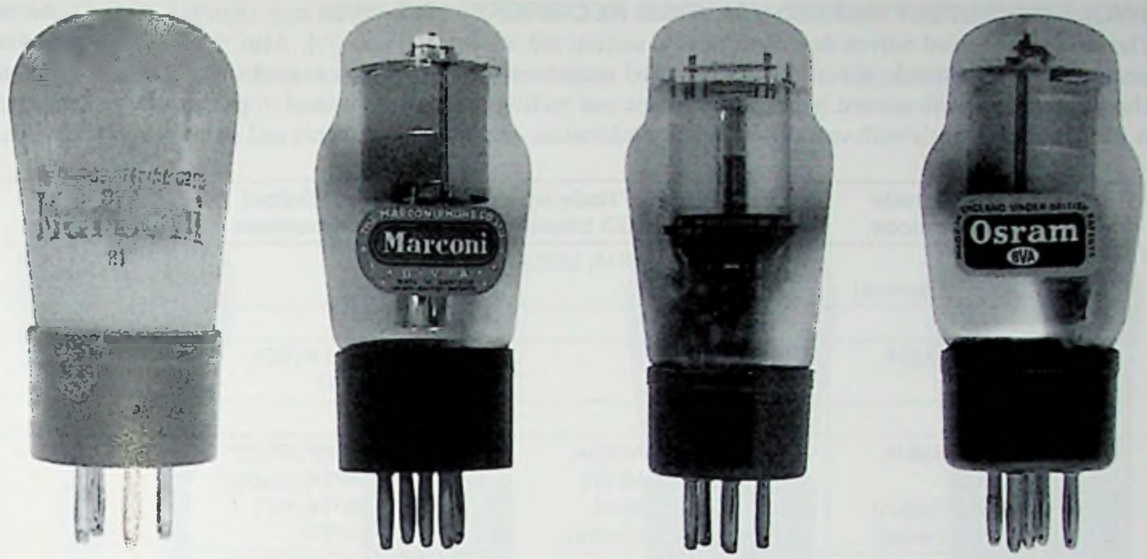
Typical examples of the valves from the 1937 to 1939 period can be seen in Figures 7.11 and 7.12. Most of the r.f. valves, and all the triodes, except output triodes, were available with either plain or metallised bulbs. Exceptions were the 7-pin version of the W21 and the Z22, both of which were only available with metallised bulbs.



W21: variable-mu r.f. pentode (4-pin version). Z21: r.f. pentode (Z22 has 7-pins). X24: triode hexode frequency changer. X24M: metallised version of the X24.

Figure 7.11: Two-volt battery valves of 1937 to 1939.

In the spring of 1940, MOV announced a range of 1.4-volt battery valves for operation from 'all-dry' batteries [7]. This range comprised an r.f. pentode, Z14; a heptode frequency changer, X14; a single diode triode, detector and a.f. amplifier, the HD14; and two output pentodes, types N14 and N15 (later superseded by the N16). All the valves had straight, tubular, plain bulbs and octal bases. They had identical characteristics to the US types 1N5G, 1A7G, 1H5G, 1C5G and 35QG respectively. The N15 and its replacement, N16, both had centre-tapped filaments for operation on either 1.4- or 2.8-volt supplies. Apart from its tapped filament, the N15 was identical to the N14; the N16, however, had a higher slope. Examples of the valves are shown in the lower portion of Figure 7.12.

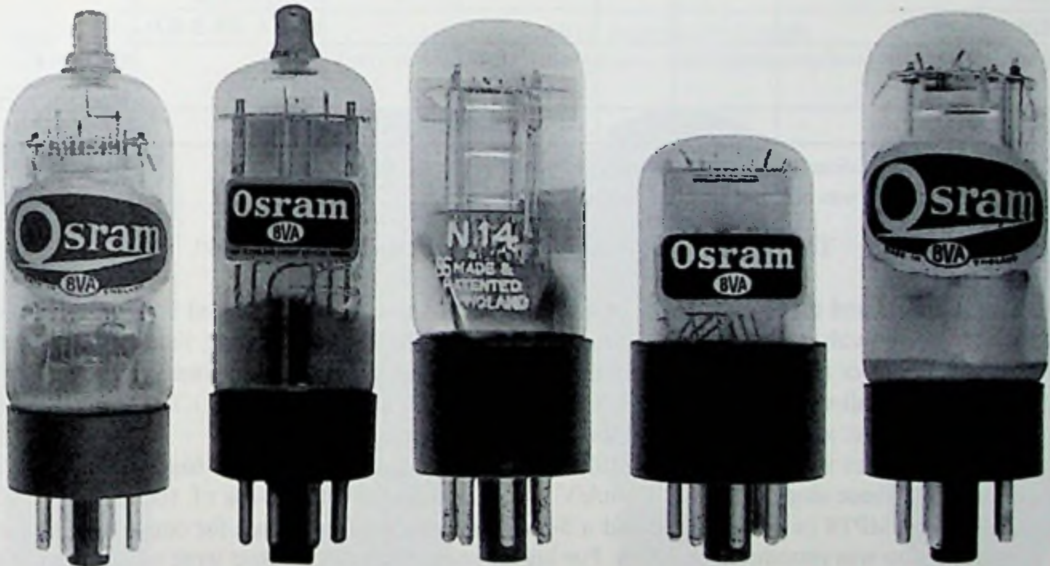


HL21: triode (small bulb version of the HL2).

KT2: output beam tetrode.

KT21: high-slope output beam tetrode.

KT24: output beam tetrode.



1.4-volt battery range of 1940. From left to right: X14 heptode frequency changer, HD14 single diode triode, N14, N15 and N16 output pentodes. (The N15 and N16 have centre-tapped filaments for 1.4-volt or 2.8-volt operation.)

Figure 7.12: Two- and 1.4-volt battery valves of 1937 to 1940.

4-VOLT INDIRECTLY HEATED VALVES & RECTIFIERS: 1929–1933

The indirectly heated valves described in this section are shown in Table 7.4. Also shown in the table, and marked with an asterisk, are six directly heated output valves; these are covered in a later section of this chapter, together with several high-power triodes and rectifiers which were used in public address amplifiers. A further section deals with valves intended for television, scientific instruments and industrial applications.

Year	RF tetrode or pentode	Freq. Changer	Diode	Triode or DD triode	Output triode	Output pentode	Rectifier
1929	MS4, MS4/c (Marconi)			MH4, MHL4	ML4, PX4*, LS6A*		U8 (1928), U9
1930							U10
1931	MS4B, VMS4					MPT4 (B5), PT4*	U12, U14
1932							
1933	MSP4, VMP4, VMS4B, MS4B (Catkin), VMS4 (Catkin)			MHD4, MH41 MH4 (Catkin)		PT16*, PT25* MPT4 (Catkin), MPT4 (B7) MPT41	MU12, MU14
1934	VMP4/k (Catkin)	MX40				PT25H*	
1935	VMP4G, WD40	X41	D41			N40, DN41, N41	
1936	W42	X42		DH42, H42		N42	U18
1937						KT41, KT42	
1938						MKT4 (B5 & B7)	
1939						KT44	MU12/14 U12/14, U20
1940					ML6 (6V)	KT45	U18/20, U19/23

* These six valves are directly heated and covered in a later section of this chapter.
N40, a Marconi valve, was made only in pre-production quantities.

Table 7.4: Marconi-Osram four-volt, a.c. valves of 1929 to 1940.

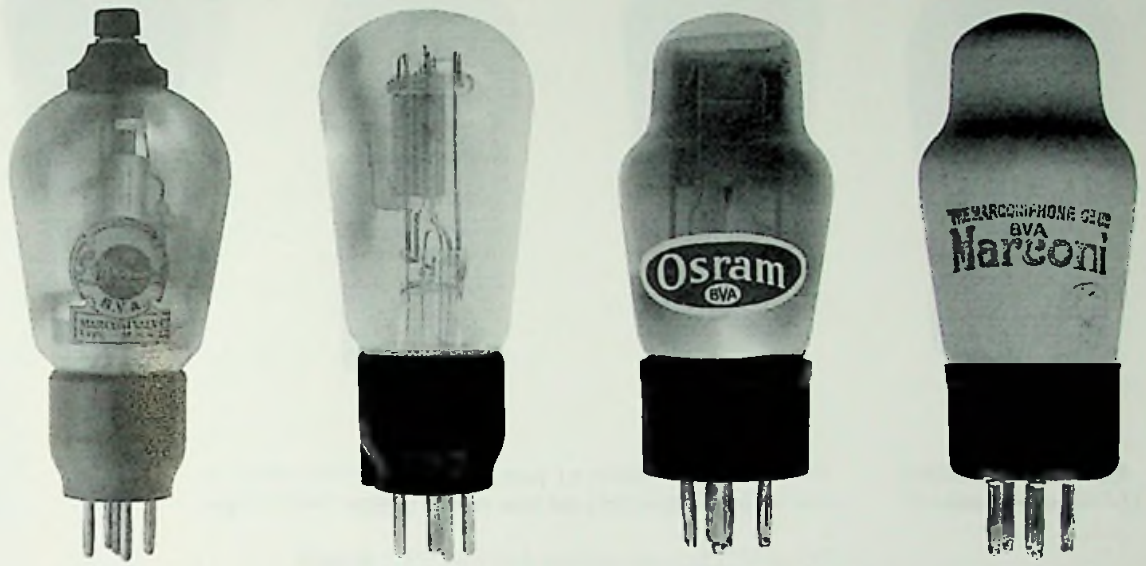
The KH1, KL1 and the Point-8 range of directly heated valves was superseded by a new range of four-volt indirectly heated valves in 1929. This range consisted of the MS4 r.f. tetrode, the MH4 detector triode, the MHL4 a.f. amplifier triode, the ML4 low-power output triode and the U9 full-wave rectifier. (There had also been an earlier full-wave rectifier, the U8, which was rated at 500V, 120mA.) The U9 was replaced in 1930 by the U10. (Note: all rectifiers, except the MU types, were directly heated.)

Several new types were introduced in 1931. The MS4B r.f. tetrode, with its higher slope of 3.2mA/V, replaced the MS4 whose slope was only 1.1mA/V. There was also a variable-mu r.f. tetrode, the VMS4, and an output pentode, MPT4 (which initially had a 5-pin base with a side terminal for connection to the screen grid; a 7-pin version was introduced in 1933). For higher current operation, there were two new rectifiers: the U12 (350V, 120mA) and the U14 (500V, 120mA). In 1939, the type designations of these two rectifiers were merged to become the U12/14.

Apart from the Catkin valves described on pages 123–5, several new types were introduced in 1933. The r.f pentodes were the MSP4 and the variable-mu VMP4. There was just one r.f. tetrode: the variable-mu VMS4B, which required a relatively small range of grid bias variation for full control of the mutual conductance and less than half that required for the VMS4. There were two triodes: the high-slope MH41, for use as a detector or a.f. amplifier, and the MHD4 which combined two diodes. The only new output pentode was the 8-watt MPT41 with a slope of 5.5mA/V. There were also two indirectly heated full-wave rectifiers:

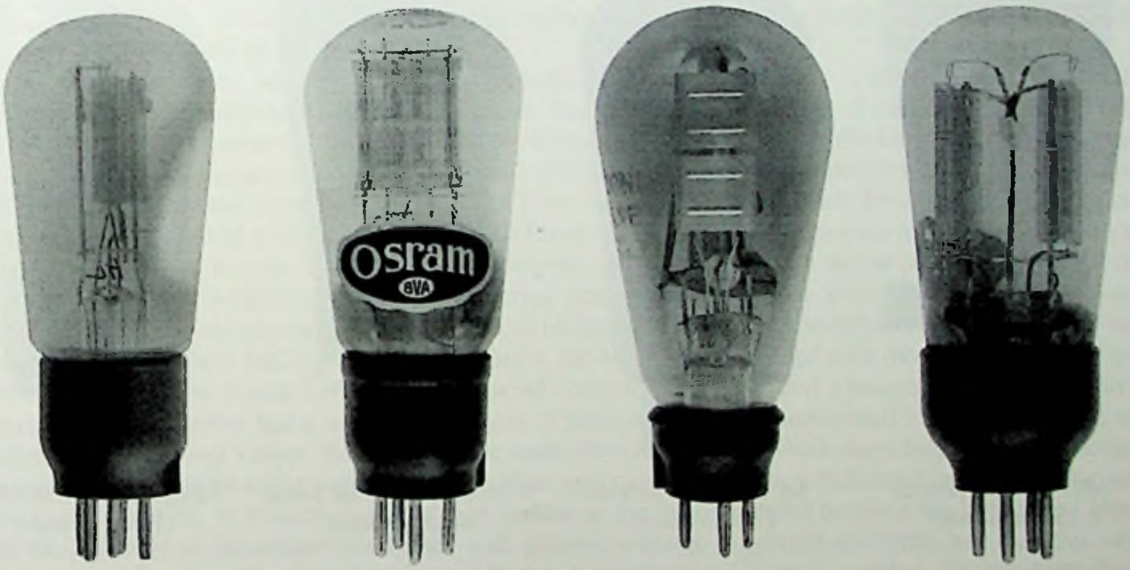
the MU12 (350, 120mA), and the MU14 (500, 120mA). In addition, the earlier MPT4 now became available with a 7-pin base.

Examples of both early and later versions of these valves can be seen in Figures 7.13 to 7.15.



Marconi MS4/c: r.f. tetrode.

MH4: detector or a.f. triode. Early version (left), later version (centre) and metallised version (right).



MHL4: medium impedance triode.

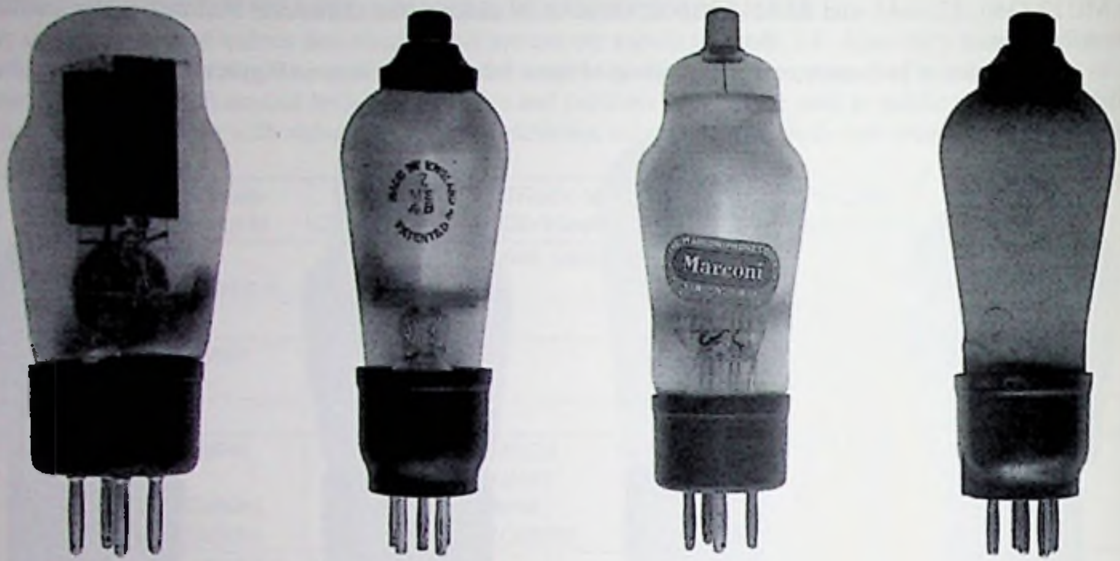
ML4: low impedance a.f. or output triode.

U8: full-wave rectifier of 1928 (500V, 120mA)*.

U10: full-wave rectifier (250V, 60mA).

*U8 has 7.5V, 2.4A filament.

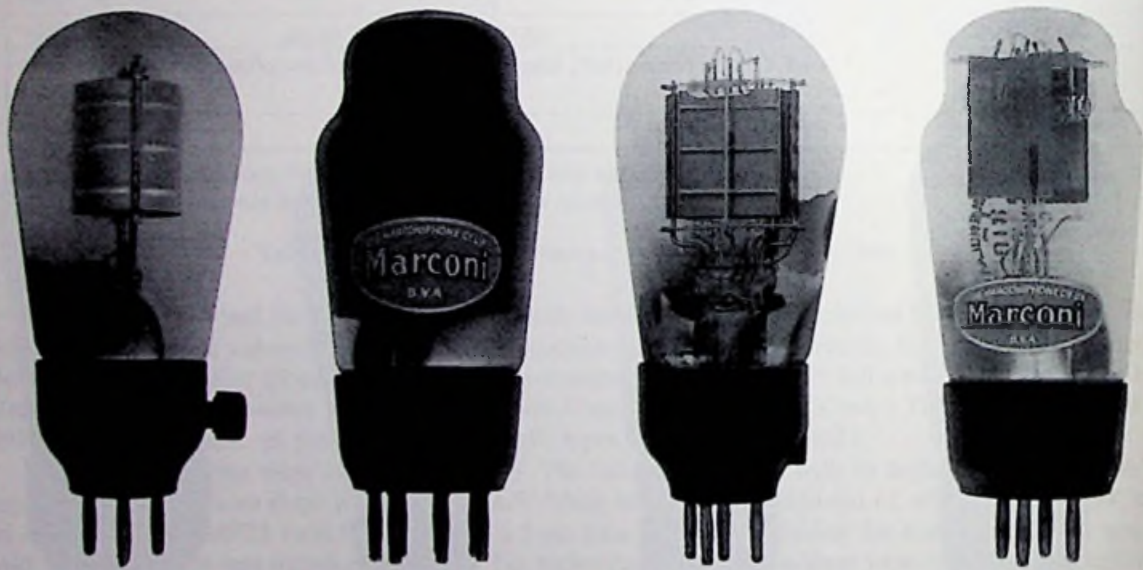
Figure 7.13: Four-volt a.c. valves of 1928 to 1930.



U10: full-wave rectifier (later version).

MS4B: r.f. pentode. Early version (left) and later version (right).

VMP4: variable-mu r.f. pentode (MSP4 is similar).



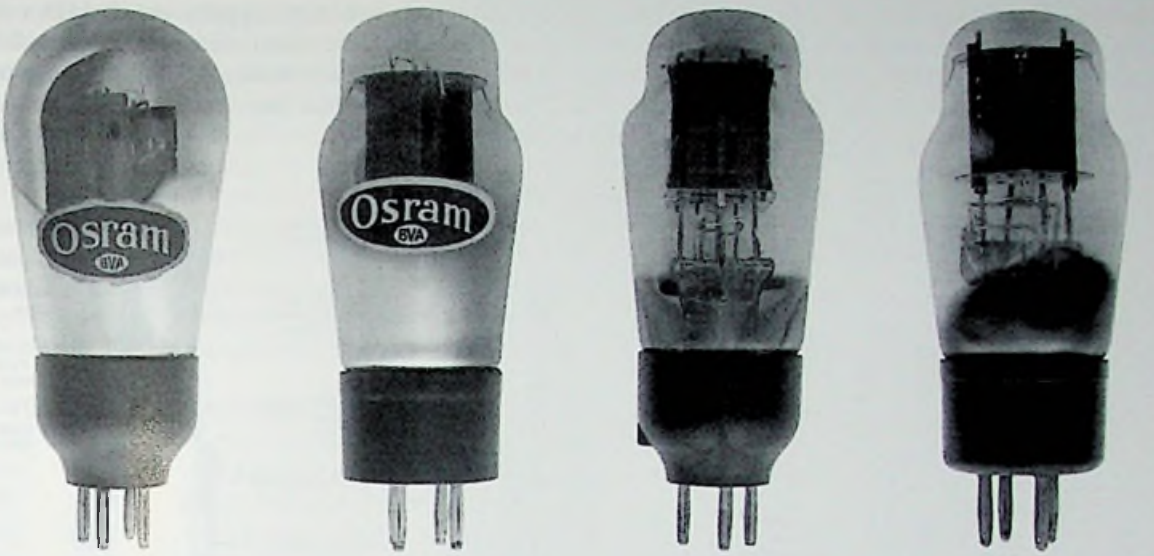
MPT4: output pentode (5-pin version).

MPT4: output pentode (7-pin version).

PT4: directly heated 2-watt output pentode.

U12: full-wave rectifier (325V, 120mA).

Figure 7.14: Four-volt a.c. valves of 1930 to 1933.



U14: full-wave rectifier (500V, 120mA). Early version (left) and later version (right).

MU12: IH, full-wave rectifier (350V, 120mA).

MU14: IH, full-wave rectifier (500V, 120mA).

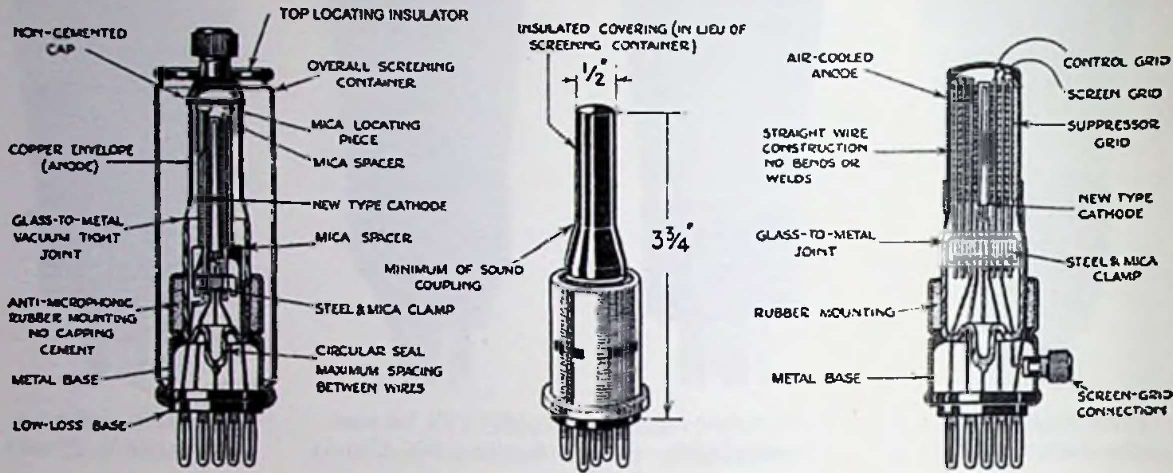
Figure 7.15: Four-volt rectifier valves of 1931 to 1932.

The Catkin valve

In May 1933, MOV announced a range of low-power radio valves which were a major departure in design from current practice. These valves had a metal envelope, which formed the anode, and dispensed with the glass stem and pinch seal [8,9].

For several years, MOV had been manufacturing transmitter valves with water-cooled anodes, designated CAT (an abbreviation for Cooled Anode Transmitting). The largest of these at the time was the CAT14, which had an anode dissipation of 120kW. (Four of these were used in the Droitwich, 150kW, long-wave transmitter that opened service on 7 October 1934. The new range of low-power radio valves was called Catkin, a name that was registered in December 1932. Initially four types were introduced, all having the same type designations as existing glass valves and fitted with 5-pin bases: these were a screened grid tetrode, MS4B, a variable-mu tetrode, VMS4, a general-purpose triode, MH4, and an output pentode, MPT4. In the following year, three additional valves in the series were introduced: these were VMP4/k, a variable-mu pentode, the W30, a variable-mu pentode with a 13-volt heater, and the N30, an output pentode with a 13-volt heater. All three of these had 7-pin bases; in addition, the MPT4 was provided with the alternative of a 7-pin base. The diagrams in Figure 7.16 show the general construction and various versions of the Catkin valve. The outside of the valves had a metal screen made of plain brass or cadmium-plated brass, but this was not always fitted; with later valves, the screens were made from aluminium, which was cheaper to manufacture. The main outer envelope of the valves consisted of an upper copper portion, which constituted the anode, and a lower glass portion. A vacuum-tight seal was formed at the overlap region between the copper and glass; first, the thin edge of the copper was coated with potassium borate to prevent oxidation, and then this edge and the end of the glass tube were raised to red heat in a gas flame and brought together. The resulting glass-to-metal seal was then annealed in an oven. The good ductility of the thin copper ensured a vacuum-tight seal in spite of the wide difference of temperature coefficient between the copper and glass.

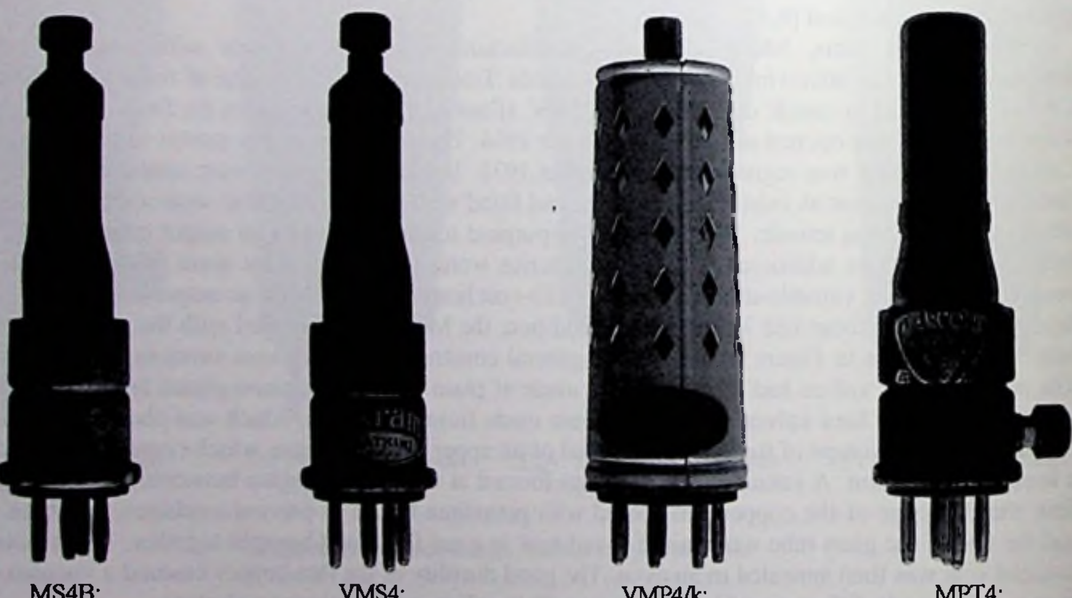
Instead of an internal glass stem and pinch, the connecting leads of the Catkin valve were brought through a circular glass foot with a central exhaust tube, and these wires were sealed into the glass. Above the foot, the connecting wires were welded to the metal electrode supports and these supports were held in a steel clamp with mica insulators. Accurately machined mica insulators were fitted during assembly of the electrodes to the supports, which both helped to improve the rigidity of the electrodes and ensured the correct spacing between them. The electrode assembly and foot were then pushed into the glass portion of the envelope and the two glass parts were moulded together under heat.



Screen-grid | Triode | Pentode

Uniformity of characteristics, generous cooling, and reduction of base losses are the essential advantages afforded in this revolutionary valve design. There is a screening cover to the screen grid valve, but this is optional with the triode.

Figure 7.16: Construction of the Catkin valve.



MS4B: r.f. tetrode. | VMS4: variable-mu r.f. tetrode. | VMP4/k: variable-mu r.f. pentode. | MPT4: output pentode (5-pin).

Figure 7.17: Various four-volt Catkin valves of 1933 to 1934.

The Catkin valves went into pilot production at the MOV Hammersmith plant in May 1932. Unfortunately, there were serious leakage problems with the copper-to-glass seal, which affected nearly half the manufactured items. The problem was never fully solved and market release was delayed for a year. It was hoped that the Catkin would supersede the more fragile all-glass valves. In practice, their manufacturing costs were higher than those of conventional valves and they were withdrawn within a couple of years. Various examples of the valves are shown in Figure 7.17.

In 1934, MOV released three battery valves with 2-volt filaments, which were of similar internal construction to the Catkin, except they had internal anodes and all-glass envelopes; these were a variable-mu tetrode (VS24/k), a general-purpose triode (HL2/k) and an output pentode (PT2/k). Except for their bases, all these valves were physically smaller than their conventional equivalents. Examples of these can be seen in Figure 7.10. (During World War 2, the HL2/k and VS24/k were produced as glass-pinch versions with small envelopes. These were given the Service numbers CV1050 and CV3803 respectively.)

4-VOLT INDIRECTLY HEATED VALVES & RECTIFIERS: 1934–1940

Although the Catkin valve continued in use for a couple more years, it soon became clear that this approach to valve construction was never going to be economically viable. Consequently, all further new types reverted to previous manufacturing techniques but with improvements in cathode emission, strengthening the electrodes supports and reduction of spacing between the electrodes where this gave better performance.

In 1934, MOV introduced its first mains-operated frequency changer, the MX40 heptode, and the high-slope output pentode, type N41. The biggest surprise, however, was an entirely new design of output valve, which was given the type designation, N40.

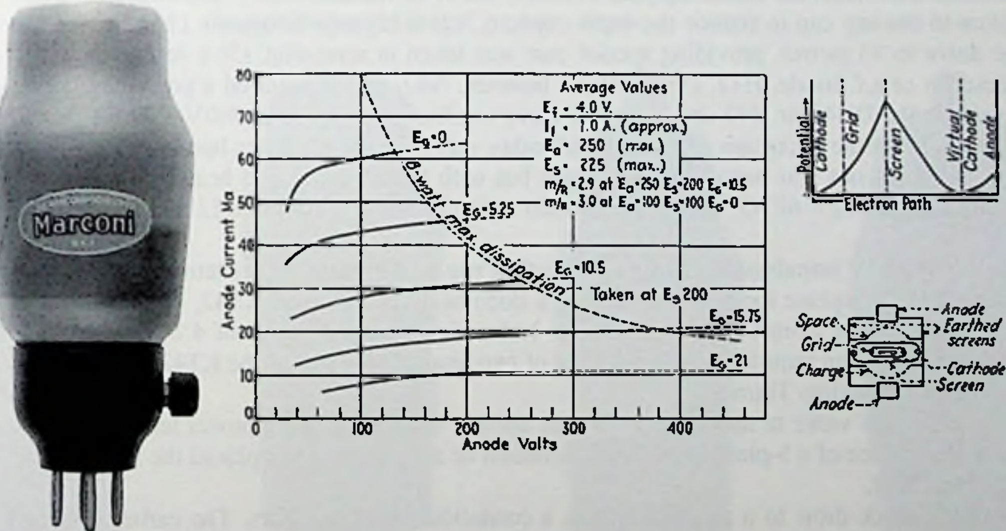


Figure 7.18: The Marconi N40 beam tetrode of 1935. The valve has a 5-pin base with side terminal for connection to the screen grid. The centre diagram shows the valve's anode characteristics. The top diagram at the right shows the potential distribution within the valve and the bottom diagram shows the electrode distribution.

The N40 was the first beam power tetrode and the story of its development is of historical significance. At this time, MOV was part owned by EMI and the head of Research Department at EMI, Isaac Shoenberg, was anxious to find a way round the Philips pentode patent. The outcome of this was a beam tetrode power valve designed by the two EMI engineers, Cabot S Bull and Sidney Rodda [10]. A prototype of the valve was demonstrated by the Marconi Company at the Physical and Optical Societies Exhibition at the Royal College of Science, London, as reported in the February 1935 issue of the US journal *Electronics* [11]. The review showed a diagram of the electrode structure and the potential distribution from the cathode to the anode. In an interview that the author had with the late George Jessop who was responsible for the manufacture of the valve, he said: 'You needed three pairs of hands to assemble it'. It would appear that about 1000 were manufactured and these were offered for sale by Marconiphone in 1935 and continued to be listed into the mid-1940s. Its design was passed by EMI to RCA under an exchange agreement between the two companies and it was re-designed to produce the famous 6L6 beam power valve which appeared on the US market in 1936 [12]. Figure 7.18 shows a photograph of the N40 together with its characteristic curves, electrode structure and potential distribution within the valve.

Most of the new valves released in 1934 used the newly introduced dome top to the glass bulb of the valve (known in the US as the ST style). This narrower top to the glass, combined with the shoulder below it, provided a means to support the electrode structure and helped improve rigidity and reduce microphonic effects. This change was later made to some of the earlier types that were still being produced for current or replacement applications, such as the S23, VS24, MH4, MHD4, MHL4 and the MPT4.

In 1935, there was a new range of valves providing a full complement for a superheterodyne receiver. The range comprised: (1) the VMP4G variable-mu pentode to replace the VMP4, (2) the WD40 double diode and variable-mu pentode with a 9-pin base, (3) the X41 triode hexode for use in all-wave receivers (with a typical range of 2000–10 metres or, in carefully designed receivers, down to 5 metres—60MHz), (4) the D41 double diode, for detection and a.g.c. and capable of direct connection to the high-slope N41 output pentode, (5) finally there was the DN41double diode output pentode where the pentode section was identical to the N41. (A ceramic base version of the X41, designated X41C, was introduced in 1938 for use in television receivers.)

Valves released in the following year were: (1) the W42 variable-mu r.f. pentode, which had the control grid taken to the top cap to reduce the input capacity, (2) a heptode frequency changer, X42, which could operate down to 15 metres, providing special care was taken in screening, (3) a double diode triode, DH42, (4) a detector or a.f. triode, H42, (5) an output pentode, N42, which required a preceding triode amplifying valve such as the DH42 or H42 and (6) a full-wave rectifier, U18, rated at 500V, 250mA (later replaced by the U18/20). With the exception of the N42, all other valves in the 42 series had low consumption, 0.6-amp heaters. The 42 Series was based on US designs but with British bases and heater ratings. For example the N42 = 6F6G and H42 = 6F5G. The rectifiers used with this range were the U12 and U14: there never was a U42.

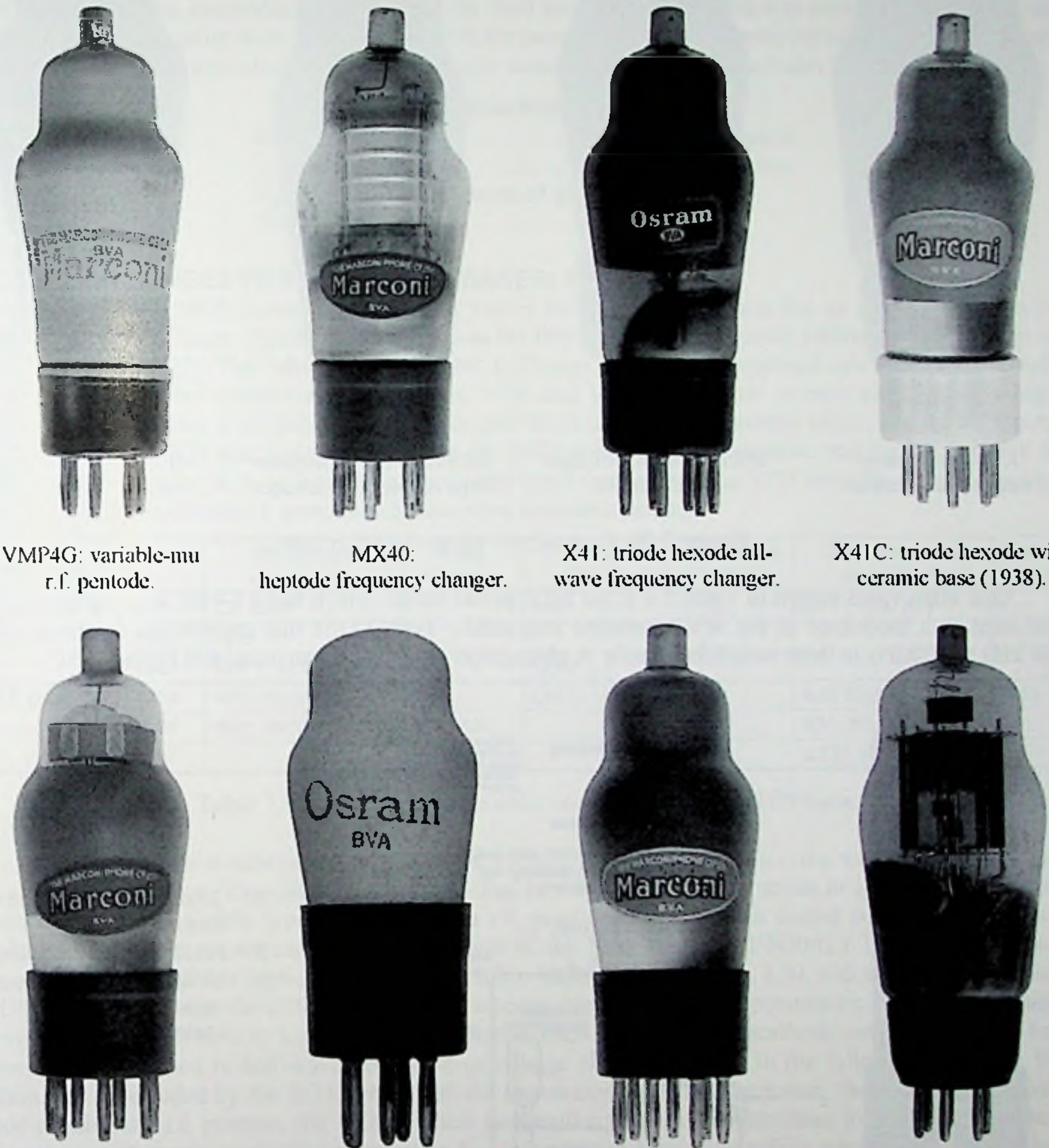
In 1937, MOV introduced their first production run of the beam power tetrode. The four-volt versions were the KT41, to replace the N41 and having a slope of 10.5mAV, and KT42, a replacement for the N42, with a lower slope of 2.5mAV. The KT41 also had a higher output power of 4.2 watts compared with 3.2 watts for the KT42, but required a heater current of two amps, twice that of the KT42. (The letters KT were an abbreviation for Kinkless Tetrode.)

The only new valve to appear in 1938 was another high-slope beam power tetrode, the 8-watt MKT4, which had the choice of a 5-pin base with side terminal or a 7-pin base; it replaced the MPT4—and, later, both the KT42 and N42.

At the decade drew to a close there was a consolidation of rectifiers. The earlier U12 and U14 were reissued as a U12/14 and the MU12 and MU14 became the MU12/14. A new full-wave rectifier, the U20, appeared in 1939; this was rated at 850V, 125mA. It had a 4-volt, 3.75-amp filament but this, together with the U18, was later combined to produce the U18/20; when operated at 500V the anode current could be increased to 250mA.

There were also two new beam power tetrodes. These were the KT44 and KT45 which appeared in 1939/40; these had identical characteristics and were combined to become KT44/45. (This appears to be a Marconi valve and was on their current list in the 1950s and used mainly in television receivers.)

There were also three other four-volt valves, not listed in Table 7.4: these were a v.h.f. pentode, KTZ41, and two single diodes, D42 and D43. These valves were intended mainly for television use and are dealt with later in this chapter. Examples of these 1934 to 1940 valves are shown in Figures 7.19 and 7.20.



VMP4G: variable-mu r.f. pentode.

MX40: heptode frequency changer.

X41: triode hexode all-wave frequency changer.

X41C: triode hexode with ceramic base (1938).

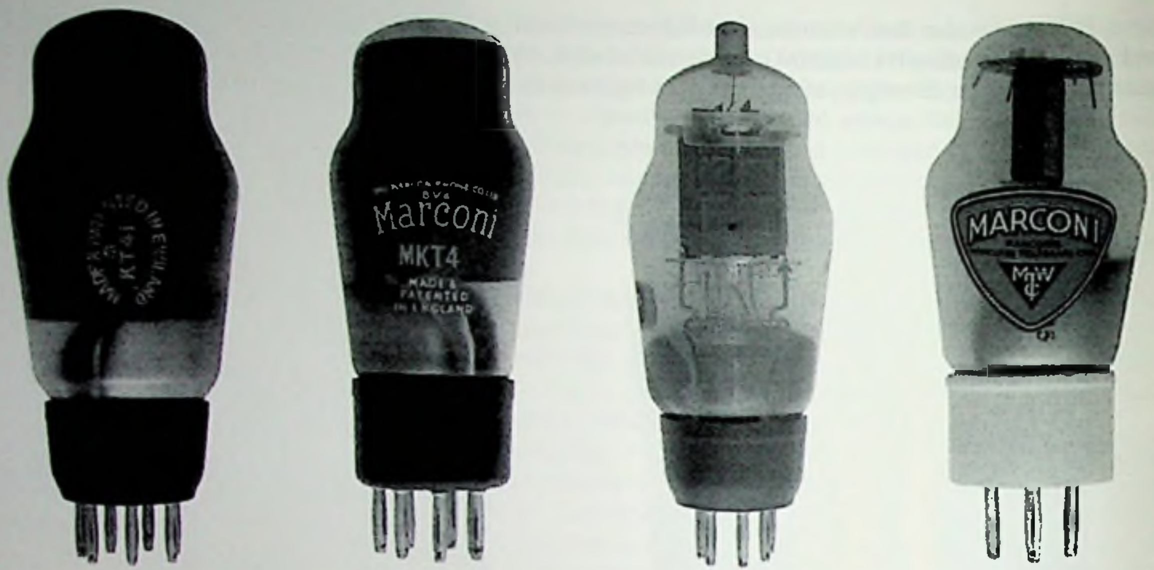
W42: variable-mu r.f. pentode.

D41: double diode for detector and a.g.c.

DH42: double diode triode.

DN41: double diode output pentode.

Figure 7.19: Four-volt a.c. valves of 1934 to 1936.



KT41: high-slope output beam tetrode.

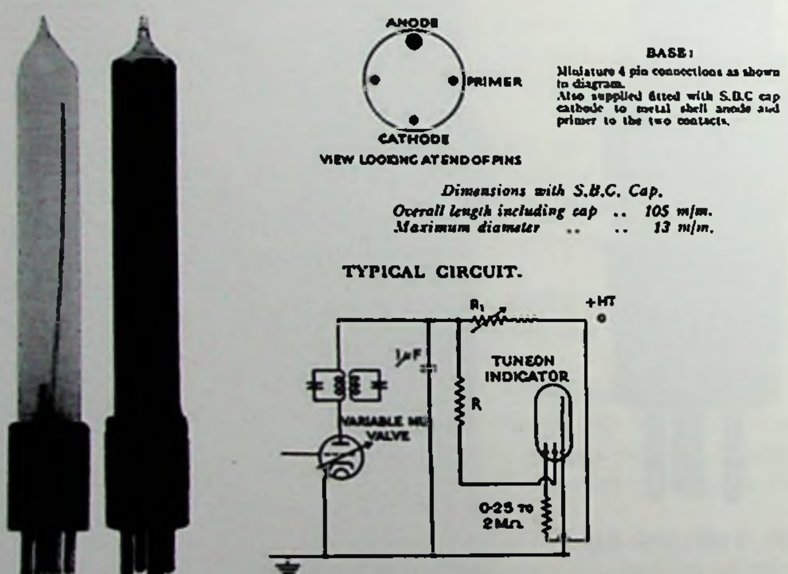
MKT4: low-slope output beam tetrode.

KT44 and KT45: medium slope output beam tetrodes.

ML6 = CV1105: output triode (6V heater).

Figure 7.20: Four-volt a.c. valves of 1937 to 1940.

One other valve shown in Table 7.4 is the ML6 power triode, which had a 6-volt, 0.7-amp heater. This was used as a modulator in the WW2 airborne transmitter, Type T1154 that covered the frequency range 200 kHz to 10 MHz in three switchable bands. A photograph of the valve can be seen in Figure 7.20.



Circuit values

R_1 = 20 kΩ to 80 kΩ depending on the h.t. voltage

R = 10 kΩ to 60 kΩ depending on the range of current variation given by the controlled valve.

Figure 7.21: GEC 'Tuneon' Indicator with suggested circuit and base connections. The glass of the tube on the left is clear whereas that on the right is blackened except for a vertical column of small windows, which progressively glow as the receiver is tuned in to the radio station.

Tuneon

In 1934, two years before the introduction of the cathode ray tuning indicator in the UK, GEC produced a neon tuning indicator, which they called the Tuneon (see Figure 7.21.) The Tuneon consisted of a neon-filled tube containing three electrodes, two short and the third long, and was intended to provide a visual indication of the correct tuning point in an a.g.c. receiver. On the passage of a small current through the tube, a luminous glow appeared on the long electrode. When correctly tuned the glow had a maximum length.

Characteristics

Striking voltage..165 approx.
Cover voltage...180 approx.
Current at commencement of glow...........0.15mA
Normal current...1.4mA

DC & AC/DC RANGES WITH B5, B7 & B9 BASES: 1931–1937

During this period, MOV issued two ranges of valves intended for use from d.c. or a.c/d.c. supplies (see Table 7.5). The d.c. range, introduced in 1931, was the first of these, with further additions over the next two years (see Figure 7.22). The valves all had 16-volt, 0.25-amp heaters and comprised two straight r.f. tetrodes, the DS and DSB; two variable-mu r.f. tetrodes, VDS and VDSB (the latter in each case having a higher slope); the DH detector or a.f. triode; the DHD double diode triode; the DL output triode, and the DPT output pentode. All the valves had 5-pin bases, except the DHD, which had a 7-pin base and the DPT, which was available with a choice of 5- or 7-pin base. Two other types that appeared in 1933 were the DSP1 r.f. pentode and the VDP1 variable-mu r.f. pentode but these were soon discontinued.

Range	Year	RF tetrode or pentode	Freq. changer	Triode or DD triode	Output triode	Output tetrode or pentode	Rect.
DC 0.25A	1931	DS, DSB		DH	DL	DPT (B5 & B7)	
	1932	VDS					
	1933	DSP1, VDSB, VDP1		DHD			
AC/DC 0.3A	1934	W30 (Catkin)	X30	DH30, H30, L30		N30 (Catkin), N30/G	U30
	1935	W31, WD30	X31, X32			N31, N34 (0.45A)	
	1937					KT30, KT31	

Table 7.5: Universal d.c. and a.c/d.c. ranges with B5, B7 and B9 bases.

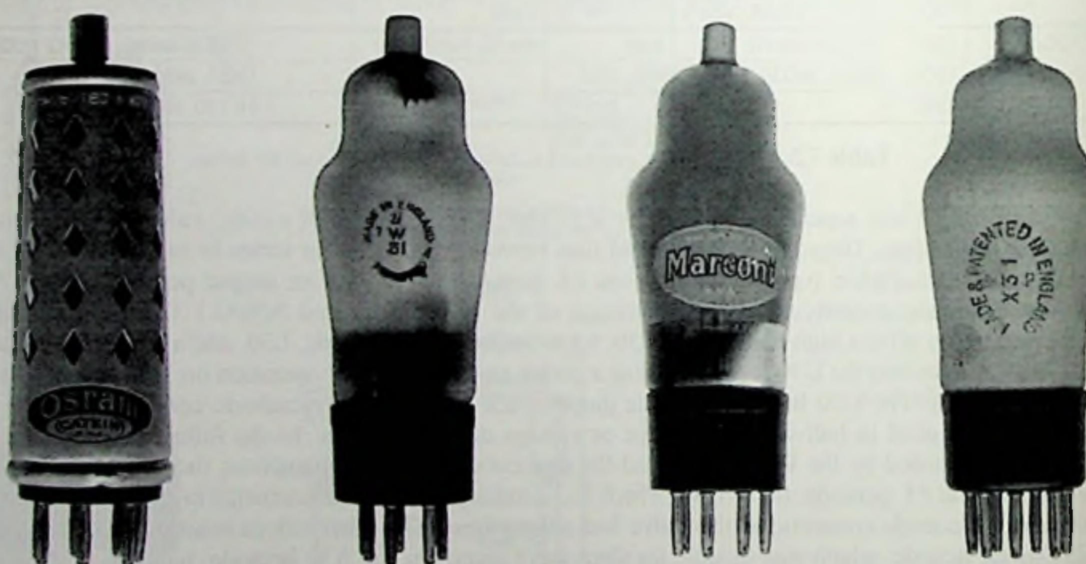
The d.c. range was superseded in 1934 by a 13-volt, 0.3-amp range of a.c/d.c. valves, which was also intended for car radios. The valve heaters could thus be connected either in series or in parallel. The initial range included two Catkin types: a variable-mu r.f. pentode, W30, and an output pentode, N30. (As an alternative there was a conventional, glass version of the N30, designated N30/G.) There was a heptode frequency changer, X30; a high-gain triode, H30; a low impedance a.f. triode, L30, and a double diode triode, DH30; finally, there was the U30 rectifier having a centre-tapped heater for operation on 13 volts, 0.6 amps or 26 volts, 0.3 amps. The U30 had two separate diodes, each with their own cathode connection at the base, allowing it to be used in half-wave, full-wave or voltage doubler circuits. In the following year, the W30 Catkin was superseded by the W31, which had the conventional glass construction; there was also a double diode variable-mu r.f. pentode, the WD30, which had similar pentode characteristics to the W31; because of its number of electrode connections, this valve had a 9-pin base. The other valves released in that year were the X31 triode hexode, which was suitable for short wave receivers, the X32 heptode, which was identical to the X30 except that it was constructed to minimize modulation hum, and the N31 output pentode which had a high slope and was capable, therefore, of operating directly from the diode detector in the WD30. To complete the 0.3-amp range two beam power valves were released in 1937: the KT30 which was the tetrode replacement for the N30 or N30/G, and the KT31 which replaced the N31. Both the N31 and KT31, like the

U30, had centre-tapped heaters for operation on 13 volts, 0.6 amps or 26 volts, 0.3 amps. Finally, there was the N34, a high-slope output pentode with a 13-volt, 0.45-amp heater.

Examples of these a.c./d.c. valves are shown in Figures 7.23 and 7.24, and an N31 circuit in Figure 7.25.

DSB: r.f. tetrode. DH: detector or a.f. triode. DL: output triode. DPT: output pentode.

Figure 7.22: 0.25-amp d.c. mains range of 1931 to 1933.



W30: Catkin variable-mu r.f. pentode. W31: variable-mu r.f. pentode. X30: heptode frequency changer. X31: triode hexode frequency changer.

Figure 7.23: 0.3-amp Universal range of valves for a.c./d.c. receivers and car radios (1934 to 1937).

H30:
high mu triode.

DH30: double diode triode
(early version).

DH30: double diode triode
(later version).

L30:
low impedance a.f. triode.

N30:
Catkin output pentode.

N31: output pentode with
centre-tapped heater.

N34: output pentode with
13V, 0.45A heater.

U30: twin diode rectifier
with separate cathodes and
centre-tapped heater.

Figure 7.24: 0.3-amp Universal range of valves for ac/d.c. receivers and car radios (1934 to 1937).

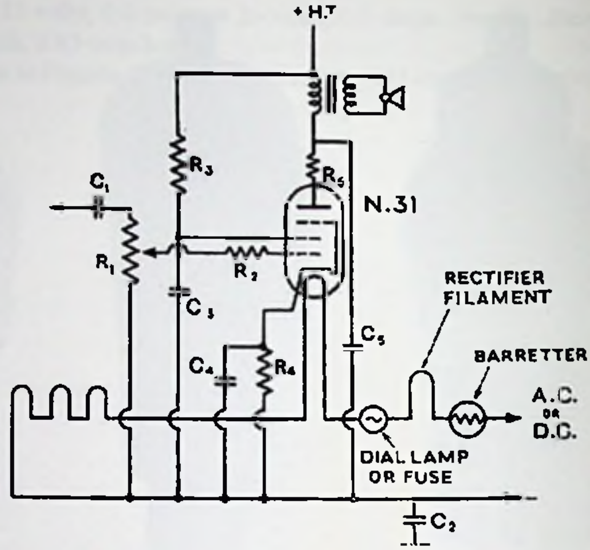


Figure 7.25: Typical circuit of the N31 in an a.c/d.c. receiver. Because of its high slope (10 mA/V), it was possible to connect C_1 directly to the output of the detector portion of the D41 double diode. (The D41 has a 4V, 0.3A heater which could be series connected in a.c/d.c. sets.)

Notes

- W31 was supplied only with a metallised bulb.
- X30 and X32 are very similar. The X32, however, was constructed to minimize modulation hum when used on a.c/d.c. receivers designed for maximum low frequency response. Both were supplied only with metallised bulbs.
- X31was suitable for short wave receivers. It was supplied only with a metallised bulb.
- WD30 was only available with a metallised bulb and has a 9-pin base. The pentode section was used as an i.f. amplifier.
- DH30 was available with plain or metallised bulb.
- H30 is a high-mu triode designed for low microphony and low residual hum response. It was available with plain or metallised bulb.
- L30 is a low impedance triode for use in a.f. amplifiers. Unlike the H30, it did not have a top cap for the grid connection and was available only with a clear bulb.
- N30/G is a glass version of the earlier N30 Catkin. A grid stopper resistor is recommended as a precaution against parasitic oscillation.

THE 'INTERNATIONAL' RANGE WITH INDIRECTLY HEATED CATHODES

A new range of Marconi-Osram valves was announced in an April 1937 issue of *Wireless World* [13]. These valves had the US type of octal base with a central keyed spigot (see top section of Table7.6). Those released in 1937 all had 6.3-volt heaters (except for the rectifiers, which had 5-volt directly heated filamentary cathodes) and most required a heater current of 0.3 amps. The majority of the valves in the range were direct equivalents of US types.

All those with 0.3 amp heaters could be connected in series for operation from a.c/d.c. mains supplies, with the exception of the Y63 tuning indicator which required an anode potential of 250 volts for satisfactory operation. The valves initially available in 1937 were the X63 heptode frequency changer, the X64 hexode mixer for use with short wave sets and requiring a separate oscillator for frequency changing, the W63 variable-mu r.f. pentode, the Z63 straight r.f. pentode, the D63 double diode with separate cathodes, the DH63 double diode triode, the H63[1] high mu triode with the grid taken to a top cap to reduce its input capacitance, the KT63 beam power tetrode, the KT66 beam power tetrode with aligned grids to reduce screen current, the Y63 tuning indicator and the U50 full-wave rectifier having a 5-volt filament. Types to appear later in 1937 were the KTZ63 straight r.f. tetrode and the X65 triode hexode frequency changer for use in all-wave sets. There was also a Marconi tuning indicator, type TI65, which was similar to the Y63 except that it had a coaxial display. Examples of the valves are shown in Figures 7.26 and 7.27.

Range	Year	RF tetrode or pentode	Frequency changer	Diode	Triode or DDT	Output pentode	Tuning Indicator	Rect.
6.3-volt, octal Universal	1937	W63, Z63, KTZ63	X63, X64, X65	D63	DH63, H63	KT63, KT66	TI65 Y63	U50
	1938	KTW63			L63		Y64	U52
	1939	KTW61, KTW61M	X63M		DH63M, DL63,	KT61, KT61M	Y61, Y62	U134*
	1940s	KTW62, Z66 KTZ63/6J7G	X61M,		B65			
26-volt octal	1937					KT32		U31
	1938/39 1940					KT33, KT33C, KT35		
AC/DC, 0.17A 'Uniwatt'	1939 & early 1940s	KTW73M, KTW74M, KTZ73M	X71M, X73M, X75		DH73M, DH74M DL74M	KT72, KT74, KT73 (0.4A)	Y73	U70*, U71, U74
AC/DC, 0.16A	Mid-1940s	W76	X76M		DH74 DH76	KT71, KT76		U76

*U70 has 0.8A heater and the U134 a 13-volt, 1.5-amp heater.

Table 7.6: The International range of a.c. and a.c/d.c. valves.

Four further types were introduced in 1938: the KTW63 variable-mu r.f. tetrode (which was a replacement for the W63), the L63 a.f. triode, the Y64 tuning indicator (requiring an anode potential of 180 volts, which enabled it to be used in a.c/d.c. sets) and the U52 full wave rectifier with 5-volt filament. Further types to be issued in 1939 were the KTW61 variable-mu r.f. tetrode, the DL63 double diode, medium-mu triode and the KT61 beam power valve having a slope of 10.5mA/V. There were also tubular versions of the Y63 and Y64 tuning indicators, which were designated Y61 and Y62 respectively. Finally, there was the U134, a double bi-phase rectifier having two separate cathodes and a heater rating of 13 volts, 1.5 amps. Also in 1939, MOV added the letter M at the end of the type designation for valves with a metallised bulb, e.g. DH63M.

Several new types appeared in the 1940s. These were the KTW62 variable-mu r.f. tetrode (identical to the KTW61, both types being CV1100); the Z66 r.f. pentode, which later replaced the v.h.f. type Z62 (see page 156); the KTZ63/6J7G, an r.f. pentode, not to be confused with the KTZ63 tetrode: this was directly equivalent to the 6J7G and had the same base connections, whereas the KTZ63 had its suppressor plates internally connected to the cathode and pin 5 had no connection, although, apart from this, it was equivalent to the 6J7G. There was also a new frequency changer, the X61M triode hexode, suitable for use up to 60MHz. Another new type was the B65 double triode, equivalent to the 6SN7GT. A selection of the valves is shown in Figure 7.28.

Of all these valves the one type to survive into modern times is the KT66 which is still much favoured by 'audiophiles' for use in high quality amplifiers. It was a re-design of the US type 6L6, which was the first beam power tube to appear on the market (except for the N40 described earlier in the chapter). The KT66 is still being manufactured in Russia, the Czech Republic and China.

[1] * Some later valves marked H63 are actually 6J7G pentodes with the suppressor grid omitted and the screen connected to the anode. This was done by way of economy, rather than manufacture small quantities of the H63.

Z63: r.f. pentode (later version).

KTZ63: r.f. kinkless tetrode.

Early version of the X63 & X64 heptode frequency changer.

X63: heptode frequency changer (later version).

X65: 'all-wave' triode-hexode frequency changer (later version).

DH63: double diode triode (early version).

DH63: double diode triode (later version).

DH63M: double diode triode (metallised) of 1946.

Figure 7.26: 6.3-volt a.c. valves with octal bases of 1937. (The M version of the DH63 appeared in 1946.)

D63: double diode with independent cathodes.

KT66 output beam tetrode. An early version is shown at the left.

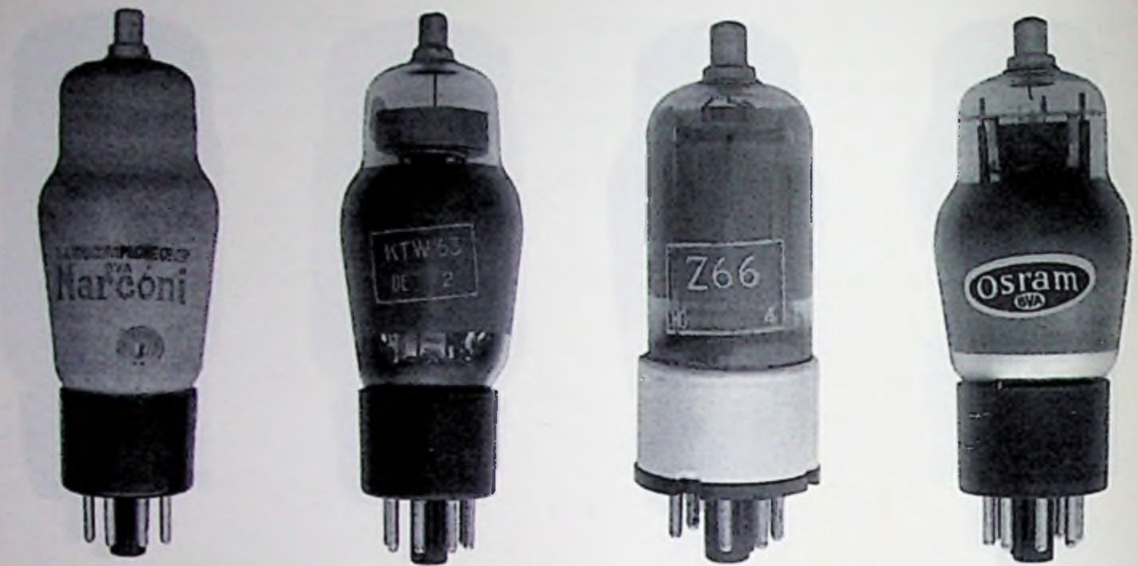
H63: detector or a.f. triode.

TI65: Marconi tuning indicator (coaxial display).

Y63: tuning indicator.

U50: full-wave rectifier (350V, 120mA).

Figure 7.27: 6.3-volt a.c. valves with octal bases of 1937 (cont.).
(The U50 rectifier has a 5-volt, directly heated filament. The TI65 was used as an alternative to the Y63 in the Marconiphone 858 four-band receiver of 1938).

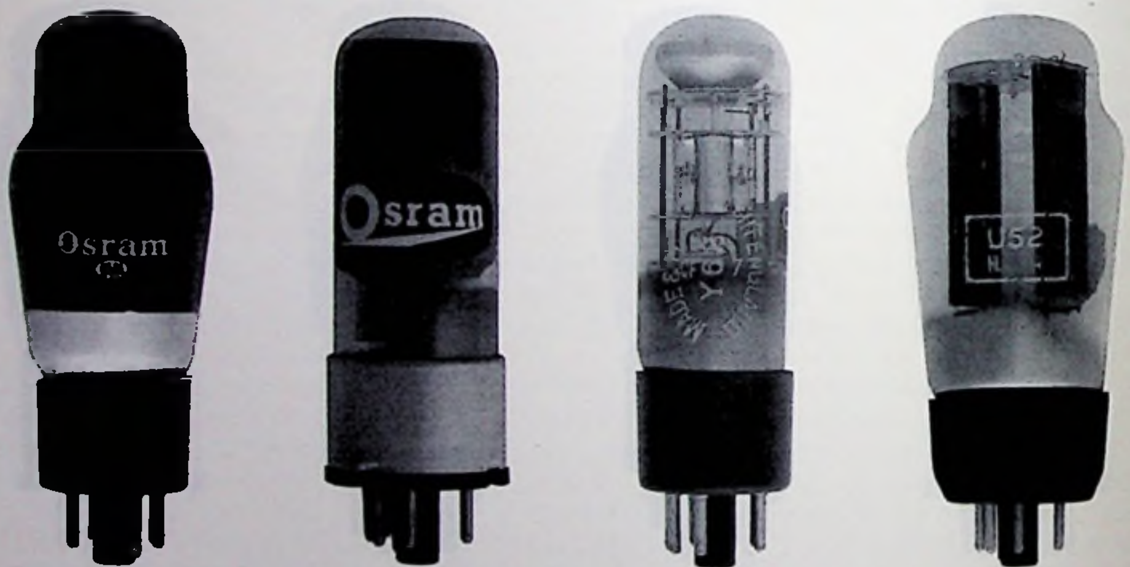


KTW61M: variable-mu kinkless tetrode.

KTW63 & KTW62: variable-mu kinkless tetrodes.

Z66: r.f. pentode.

DL63: medium-mu double diode triode.



L63: low impedance general-purpose triode (early version at left and later version at right).

Y62: tuning indicator (tubular version of Y64)

U52: full wave directly heated rectifier (500V, 50mA).

Figure 7.28: 6.3-volt a.c. valves with octal bases of 1938 to 1940.

Notes

- Several of these valves were re-designed into tubular bulbs in the mid-to-late 1940s.
- The Z62 has a high-slope making it suitable for use in television vision amplifiers and other v.h.f. equipment. It was replaced by the Z66. Supplied with plain bulb only.
- The KTW61 and KTW62 are identical, the latter number being dropped. (Also M version of KTW61.)
- The KTZ63 and KTZ63/6J7G are virtually identical except for the suppressor grid connection required for the latter type. The earlier type Z63 pentode was also interchangeable with the 6J7G. All were supplied with plain bulbs only. The KTZ63/6J7G was often bought in from Brimar.
- The X61M (metallised bulb) and X62 (plain bulb, TV type) were triode hexodes with identical dimensions to the X63. The X62 (triode hexode) and X64 (hexode mixer) were soon discontinued.
- The D63 and DH63 were available with plain or metallised bulbs. Most of the other types were supplied with plain bulbs only.

Table 7.7 is a summary of various operating conditions for the KT66. Shown in the table is its use as a single-ended amplifier, both in the tetrode and triode connection; as a push-pull amplifier operating in Class AB1 and with auto bias, connected first in the tetrode mode and then the triode mode; finally, it is shown in the tetrode mode with fixed bias and operating in Class AB1.

With triode connection, the output power is reduced by about 50%, but the distortion is somewhat lower, particularly the unpleasant odd order harmonics. Furthermore, the triode connection is more tolerant to variations in output load that inevitably occurs over the frequency range of the loudspeaker system. For these reasons, the famous Williamson amplifier, published in *Wireless World* in April and May 1947, and revised slightly in August 1949, used KT66s in the triode mode [14]. This amplifier gave an output power of 15 watts, with total harmonic distortion less then 0.5%

In later years, it became more usual to connect the KT66 in the ultra-linear mode, where the screen grids were connected to taps on the output transformer. This was found to give distortion lower than that of the triode connection and almost as tolerant to load variations. As an extra bonus, it could deliver twice the output power (30 watts with auto bias and 50 watts with direct bias). The optimum screen tap was found to be around 43% from the h.t. end of the transformer. In spite of these well-documented advantages there is still a hard core of 'audiophiles' who swear by Class A, single-ended triode amplifiers and who will not be budged from their conviction that they sound better. It may be that the high level of second harmonic distortion in these amplifiers is found to have a pleasing effect, even though this is not how the original music sounded.

26V AC/DC octal range: 1937-40

All the valves described so far in this section, apart from the two rectifiers, had 6.3-volt heaters and most were rated at 0.3-amp, allowing them to be used either in parallel for a.c. only sets or in series for a.c/d.c. sets. There was, however, a small number of valves with 26-volt, 0.3-amp heaters. The first of these appeared in 1937/38 and were the KT32 and KT33 beam tetrodes and U31 half-wave rectifier. The KT32 was designed for a working h.t. of between 110 and 135 volts, whereas the KT33 was for operation with an h.t. between 200 and 250 volts. In 1939, there appeared the KT33C, which was very similar to the KT33 except for a centre-tapped heater, allowing for operation at either 26 volts or 12 to 13 volts, making it also suitable for use in car radios.

The KT33C could also be used in push-pull amplifiers where a pair could deliver an output power of about 15 watts from a 200-volt supply or 7.5 watts from a 150-volt supply.

There was also a KT35 that appeared around 1940. This, like the KT33, also had a centre-tapped heater allowing series operation at 26 volts, 0.3 amps or parallel operation at 13 volts, 0.6 amps.

Examples of these 26-volt valves are shown in Figure 7.29.

OPERATING CONDITIONS

Single valve	Tetrode connected	Triode connected		
Anode & screen voltage	250	400	250	volts
Bias voltage	–15	–38	–19	volts
Anode current	85	63	60	mA
Screen current	6.3	—	—	mA
Signal input	15	38	19	pk. volts
Bias resistor	180	600	315	ohms
Anode load resistance	2200	4500	2750	ohms
Distortion	9	7	6	%
Power Output	7.25	5.8	2.2	watts

Two valves in push-pull, tetrode connected, auto bias

	450V supply	250V supply	
Anode voltage (full load)	390	250	volts
Screen voltage (full load)	275	250	volts
Bias voltage	–22.5	–17.5	volts
Anode current (full load)	125	165	mA
Screen current (full load)	18	20	mA
Bias resistor	500	200	ohms
Signal input (grid to grid)	70	36	volts
Load resistance (anode to anode)	8000	4000	ohms
Distortion	6	4	%
Power output	30	17	watts

Two valves in push-pull, triode connected, auto bias

	450V supply	250V supply	
Anode & screen voltage	400	250	volts
Bias voltage	–38	–20	volts
Anode current	125	110	mA
Signal input (grid to grid)	80	40	volts
Bias resistor (per valve)	600	360	ohms
Load resistance (anode to anode)	4000	2500	ohms
Distortion	3.5	2	%
Power output	14.5	4.5	watts

Two valves in push-pull, tetrode connected, fixed bias
(data per pair of valves)

	No signal	Full signal	
Anode voltage	510	475	volts
Screen voltage (stabilized)	395	380	volts
Bias voltage	–40	–40	volts
Anode current	80	175	mA
Screen current	3	19	mA
Anode dissipation (per valve)	21	17	watts
Screen dissipation (per valve)	0.6	3.5	watts
Signal input (grid to grid)	—	80	volts
Load resistance (anode to anode)	5000	5000	ohms
Distortion	—	5	%
Power output	—	50	watts

Table 7.7: Data for KT66 beam power valve.

KT32: output beam tetrode. | KT33C: output beam tetrode. | KT35: output beam tetrode. | U31: half-wave rectifier (250V, 120mA).

Figure 7.29: 26-volt a.c./d.c. valves of 1937 to 1940.

'Uniwatt' Range

In 1939, MOV launched their 'Uniwatt' Range (see Table 7.6 on page 133), which had the following principal features:

1. Low heater power—the majority of the valves had a heater consumption of only one watt and operated at a current ranging from 0.6 to 0.7 amps.
2. Suitable for a heater supply variation from 5.4 to 7.5 volts (except where stated below).
3. Small size.
4. Fitted with the international octal valve base.

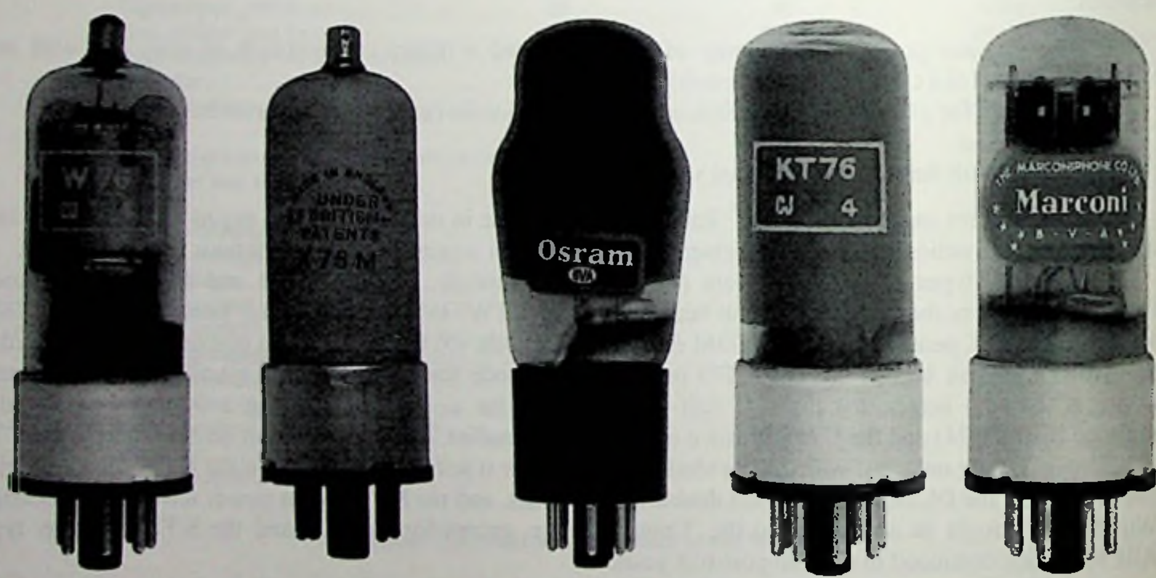
These features made the 'Uniwatt' Range suitable for use in universal a.c/d.c. mains receivers with low consumption, car radios, and battery receivers having a six-volt accumulator and a vibrator h.t. supply.

The initial types to be issued were (1) the X73M heptode, (2) the X71M and X75 triode hexode frequency changers (both having 15-volt heaters), (3) the KTW73M variable-mu r.f. pentode and KTZ73M short grid-base r.f. pentode, (4) the DH73M double diode triode, (5) the KT72 beam power tetrode for a.c/d.c. sets (with a 15-volt heater) and the KT73 beam power tetrode for car radios and 6-volt accumulator sets, having a 0.4-amp heater, (6) the U71 half-wave rectifier for a.c/d.c. sets, having a 30-volt heater (later replaced by the U74) and the U70 full-wave rectifier for car radios, having a 0.8-amp heater, and (7) the Y73 'magic-eye' tuning indicator with double shadow angle. Later types to be added were the KTW74M variable-mu r.f. tetrode, the DL74M and DH74M double diode triodes, and the KT74 beam power tetrode. The Second World War brought an abrupt end to the 'Uniwatt' range, except for the U70 and the KTZ73 (Army type ARP38) which continued in use into post-war years.

A further range appeared in the mid-to-late 1940s that had 0.16-amp heaters. These valves, shown in the bottom row of Table 7.6, comprised the W76 variable-mu r.f. pentode (having similar characteristic to the KTW74M); the X76 triode hexode frequency changer; the DH76 double diode triode, having identical characteristics to the DH74M; the KT71 and KT76 beam power tetrodes and the U76 half-wave rectifier. All these later types in the 76 Series were for a.c./d.c. operation and had heater voltages ranging from 13 to 48 volts. Examples of the 0.17 amp and 0.16 amp ranges can be seen in Figures 7.30 and 7.31.

KTZ73M: variable-mu r.f. pentode. | KT74: output beam tetrode. | U70: half-wave rectifier (0.8A heater). | U74: half-wave rectifier (30V, 0.17A heater).

Figure 7.30: Examples of 0.17 amp Uniwatt range of 1939.



W76: variable-mu r.f. pentode. | X76M: triode hexode frequency changer. | KT71: high-slope output beam tetrode. | KT76: low-slope output beam tetrode. | U76: half-wave rectifier.

Figure 7.31: Examples of the 0.16 amp Uniwatt range of 1940 and later.

The following notes relate to replacement of the earlier 0.17 amp Series with the later 0.16 amp, 76 Series:

Earlier type	Later type	Probable effect in apparatus	Modifications required
DH73M	DH76	None	Heater voltage, increase bias resistor
DL74M	DH76	Probably none	Increase bias resistor
KT72, KT74	KT76	None	None
KTW73M	W76	None	Heater voltage, connect suppressor
KTW74M	W76	None	Connect suppressor
U71	U76	None	None
X71M	X76M	Probably none	None
X73M	X76M	Probably none	Heater voltage

Barretters

For the d.c. and a.c/d.c. valves shown in Table 7.5 and 7.6 there was a range of barretters (current regulators) which were connected in series with the heaters to enable their connection to the d.c. or a.c. mains supply. The barretter was always connected to the 'live' end of the supply, followed by the rectifier, whereas the detector valve (in TRF receivers) or the frequency changer valve (in superhets) were connected at the chassis or neutral end of the supply.

Details of the Marconi-Osram barretters are shown in Table 7.8 (see also Figures 7.32 and 7.33). There are four different current ratings and each type provides regulation for a specified voltage range: for example the 304 might be used with the D41, X31, N31, W31 and U30 (a total of 82 volts for the heaters, giving a regulation range of 177 to 247 volts). Dial lamps would each add a further 6.5 volts to these figures. It should be noted that the 171 was for use with the 'Uniwatt' 0.17-amp range of valves and the 161 for the later 0.16-amp range.

Type	Current (amps)	Voltage range	Base
161	0.16	100–200	ES
171	0.17	100–200	ES
201	0.20	80–200	Ct8
202	0.20	120–200	B4
251	0.25	100–180	B4
301	0.30	138–221	ES
302	0.30	112–195	ES
303	0.30	86–129	ES
304	0.30	95–165	ES
305	0.30	40–90	ES
306	0.30	40–90	IO

Table 7.8: Marconi-Osram barretters (current regulators).

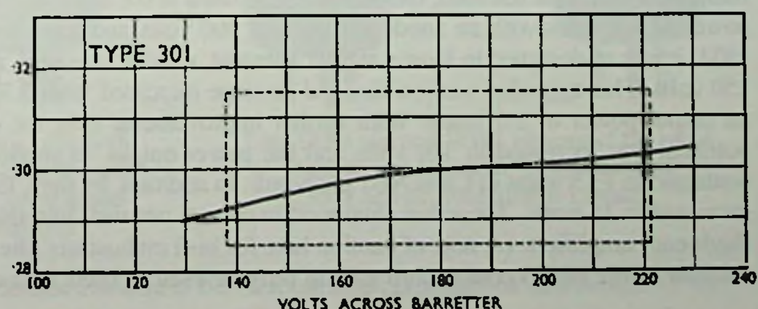
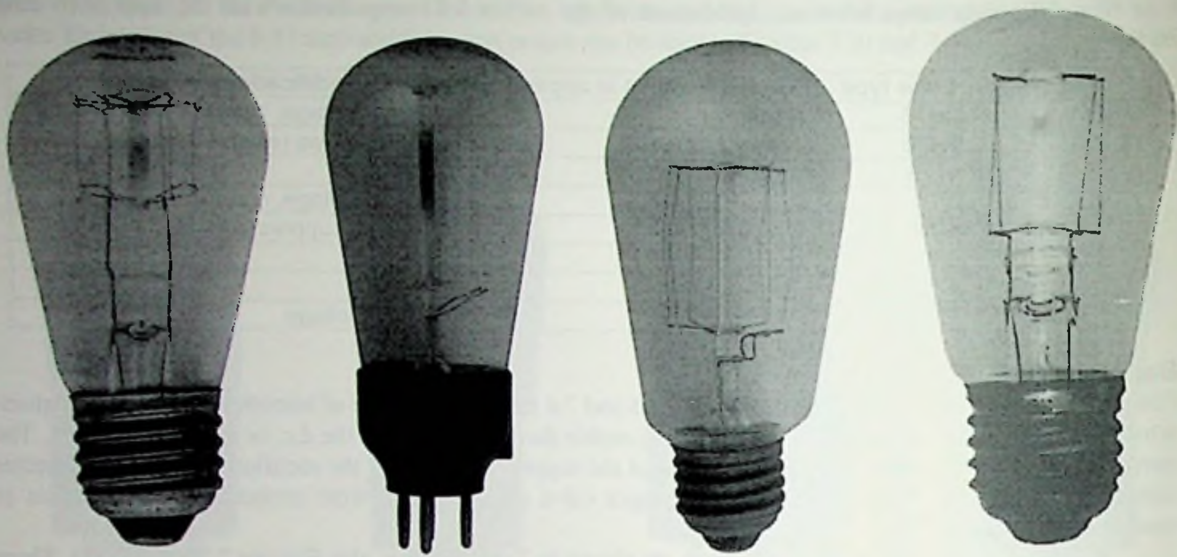


Figure 7.32: Characteristic curve of a typical barretter where the nominal current is 0.3 amps.



161: 0.16 amp, 100–200V. 251: 0.25 amp, 100–180V 301: 0.3 amp, 138–221V 305: 0.3 amp, 40–90V.

Figure 7.33: Examples of Osram and GEC barretters.

DIRECTLY HEATED POWER TRIODES & RECTIFIERS

Almost all of the power triodes produced by the MOV Company had directly heated filaments. Apart from their obvious use in audio amplifiers, they were also used extensively as modulators in radio transmitters. (Included in this section are the rectifiers used with these triodes.)

Important note: It is usual practice to operate the filament of power triodes from an a.c. source, with the bias resistor taken to a centre-tap on the filament winding. If a d.c. source is used for the filament supply, the grid bias should be **decreased** by an amount approximately equal to one-half of the rated filament voltage, and be referred to the negative filament terminal, instead of the mid-point as in a.c. operation.

LS6A: The LS6A (see Figure 7.34) appeared in 1929 and was a higher power version of the earlier type LS5A. It had a 6-volt, 2-amp thoriated tungsten filament (later superseded by an oxide-coated filament) and was capable of an output power of five watts when operated at an anode potential of 400 volts. It was fitted with a molybdenum anode to allow for the heat dissipation under maximum power conditions.

***PX4*:** The PX4 also appeared in 1929 but, unlike the initial version of the LS6A, it had an oxide-coated 4-volt filament. When first released, the filament was rated at 0.6 amps and the valve was only capable of an output power of 1.1 watts with an anode potential of 200 volts and a maximum anode dissipation of ten watts. By 1931, it was re-designed to have a stouter filament, rated at one amp, and the anode potential was increased to 250 volts. This upgraded version also had its slope increased from 3.3mA/V to 6mA/V and could now deliver an output power of 2.5 watts. With further improvements over the succeeding years, the maximum anode potential was increased to 300 volts and the power output, in single-ended operation, was increased to 4.5 watts and to 13.5 watts in Class AB1 push-pull. In addition, by then, the maximum anode dissipation had been increased to 15 watts. The valve continued in current use well into the 1950s and is still found today in some 'high-end' amplifiers. (A note of caution here for hi-fi enthusiasts: **the earlier versions of the PX4 are vastly inferior to the later versions and should only be used at their lower rated operating conditions.)**

Figure 7.35 shows four examples of the valve ranging from 1929 to post-WW2; an early leaflet can be seen in Figure 7.36 and Table 7.9 is a summary of its principal characteristics. A typical circuit of a push-pull amplifier employing the PX4 is shown in Figure 7.37.

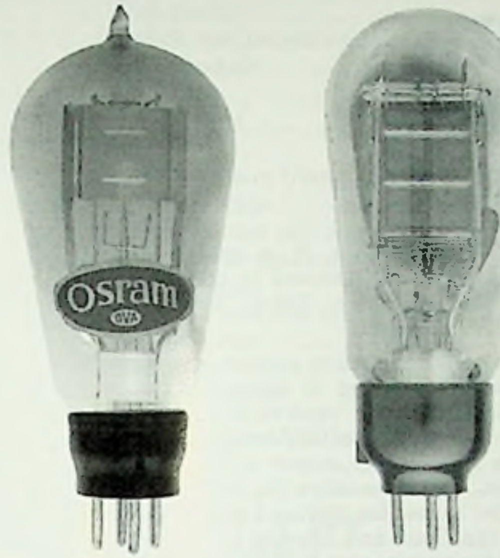
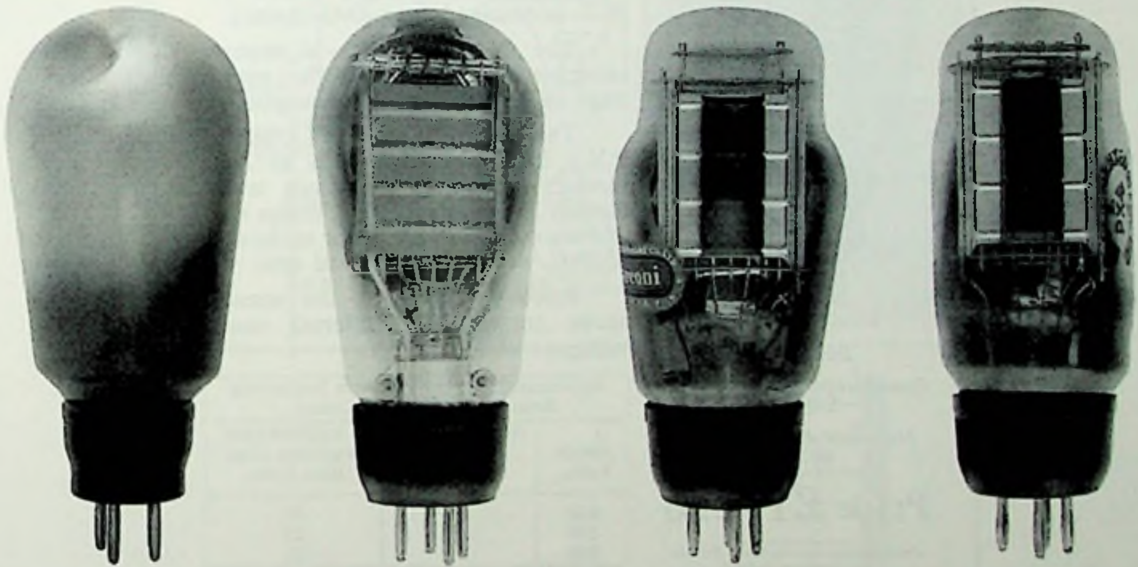


Figure 7.34: LS6A output triode with larger power handling than the earlier LS5A. It was fitted with a molybdenum anode, which ran red hot when dissipating maximum power. The maximum anode potential was 400V.

An early version of the valve, which had a thoriated tungsten filament and a top seal, is shown at the left and a later version, with an oxide-coated filament, at the right.



Early valve of 1929 with 4-volt, 0.6-amp filament and 10-watt anode dissipation.

Mid-1930s valve with 4-volt, 1-amp filament and 12.5-watt anode dissipation.

Late-1930s and post-WW2 versions of the valve where the anode voltage was increased to 300V and its dissipation to 15 watts.

Figure 7.35: PX4 output triode that became available in 1929 and continued in production until the mid-1950s.

Osram Valves

Type P.X.4.

The OSRAM P.X.4 is a type which is setting a new standard in the conception of a Power Valve for moderate H.T. voltages.

This valve is designed to operate at up to 200 anode volts and to dissipate with safety a D.C. power equivalent to 10 watts. It is capable of delivering a considerable A.C. Power output to the Loudspeaker, and is therefore the ideal Output Valve to use for driving Loud-speakers of the Cone and Moving Coil type, where for circuit reasons, the High Tension supply is restricted to 200 volts (such for example where the H.T. is obtained from D.C. mains).

The OSRAM P.X.4 is strongly recommended for use in the output stage of electric or radio-gramophones.

The filament of the OSRAM P.X.4 may be heated from an A.C. through a suitable step-down trans-former, in the case of A.C. mains sets, or from a 4 volt accumulator in the case of D.C. or battery operated sets.

Below is tabulated the average anode currents for different anode voltages :—

Dimensions :

Overall length (including pins) 145 *m/m.*

Maximum diameter of bulb 60 *m/m.*

Price £1:2:6

Price applies only in Great Britain and Northern Ireland.

Approximate Operating Data Neglecting Resistance of Output Circuit.		
Anode Volts.	Average Anode Current m.a.	* Approximate Negative Grid Bias Volts.
200	50	33
150	37	23
100	25	13

* The figures given above are approximate only, and it will be found that individual valves may vary from these. It is recommended that the negative grid bias be adjusted for each valve, so as to obtain the required anode current.

Figure 7.36: An early leaflet for the PX4 output triode. In its original form the heater current was 0.6 amps.

Single valve Class A				
Anode voltage	300	250	200	volts
Anode current	50	60	30	mA
Bias resistor	1000	600	1000	ohms
Anode load resistance	3500	2500	3500	ohms
Power output	4.5	3.2	1.6	watts
Distortion	4	4	5	%
Signal input	49	36	30	peak volts
Two valves in Class AB1 push-pull				
Anode voltage	300	250		volts
Anode current (per pair)	100	116		mA
Bias resistor (per valve)	1000	650		ohms
Bias voltage	–50	–38		approx. volts
Anode-anode load resistance	4000	3000		ohms
Power output	13.5	9		watts
Distortion	2.5	2		%
Input signal	110	80		peak volts

Table 7.9: Operating conditions for later versions the PX4 power triode.

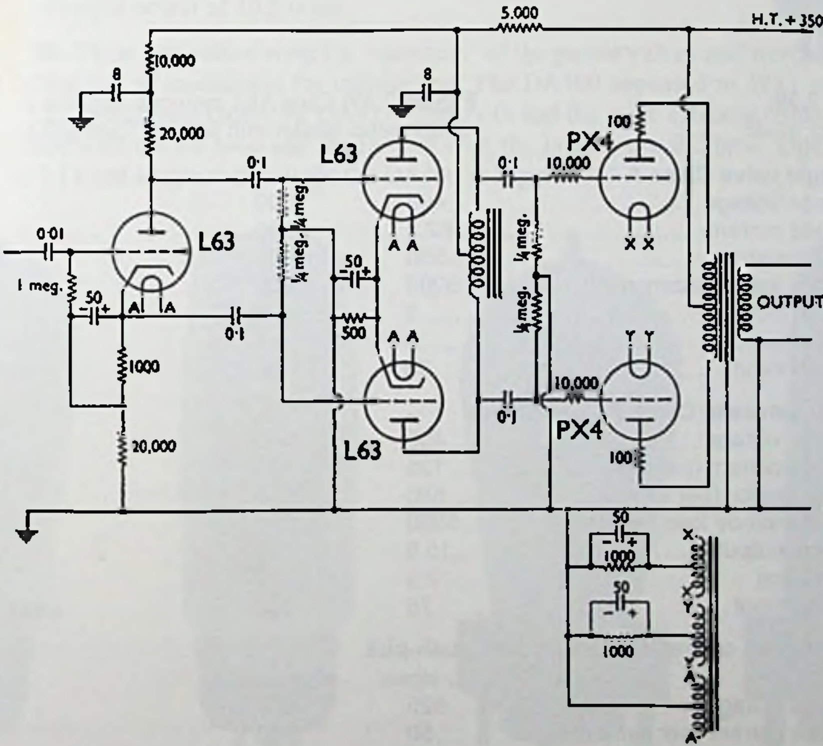


Figure 7.37: Class AB1 push-pull amplifier using PX4 power triodes.

In the circuit of Figure 7.37, it should be noted that three filament windings are required: one for each output valve and one for the remaining three triodes. Note also that to achieve the required high drive voltage for the grids of the PX4s the anode loads of the two driver valves are derived from the centre-tapped inductor.

PX25: The PX25 appeared in 1932 and was intended to provide a higher output power than the PX4. An early version of the valve is shown in Figure 7.38, the operating conditions in Table 7.10 and a typical circuit in Figure 7.39. At the time of writing both the PX4 and PX25 are available from KR in the Czech Republic.

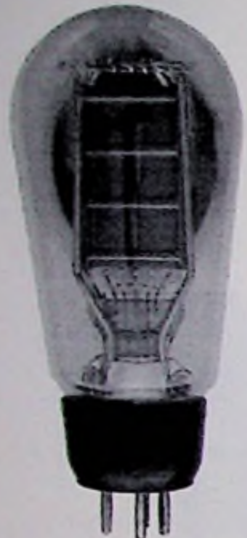


Figure 7.38: PX25 power triode.

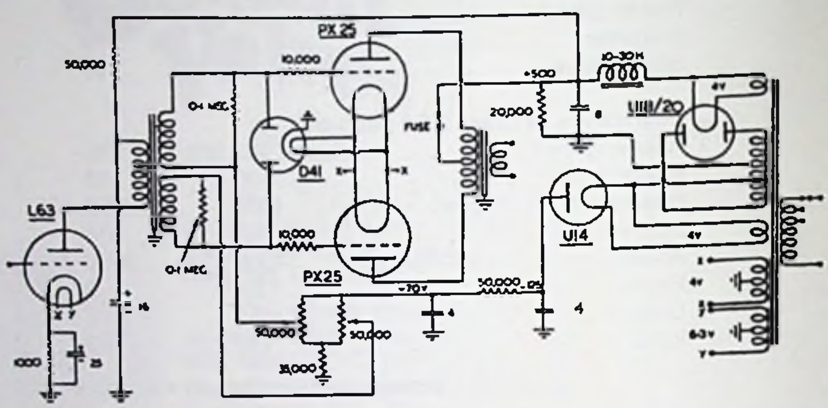


Figure 7.39: Class AB1 push-pull amplifier using PX25 power triodes with separate fixed grid bias.

Single valve Class A			
Anode voltage	400	500	volts
Anode current	62.5	50	mA
Bias resistor	550	1000	ohms
Anode load resistance	3200	5500	ohms
Power output	6	8.5	watts
Distortion	6	7	%
Signal input	33	50	peak volts
Two valves in Class AB1 push-pull			
Anode voltage	400	500	volts
Anode current (per pair)	125	100	mA
Bias resistor (per valve)	600	1000	ohms
Anode-anode load resistance	5000	10,000	ohms
Power output	15.5	20	watts
Distortion	2.5	2	%
Signal input	76	102	peak volts
Fixed bias operation—Class AB1 push-pull			
	No signal	*Max. output*	
Anode voltage	525	500	volts
Anode current (per pair)	50	165	mA
Bias voltage	–54	–54	approx. volts
Anode-anode load resistance	—	3400	ohms
Power output	—	26	watts
Distortion	—	4	%

Table 7.10: Operating conditions for the PX25 power triode.

For the circuit shown in Figure 7.39, in order to prevent the 'trigger' effect caused by an excessive positive voltage being applied to the PX25 grids, a D41 diode is shunted across the intervalve transformer and bias unit, providing a low impedance path to earth. It is essential not to omit this valve. (It would be more usual these days to fit a pair of silicon power diodes in place of the D41.)

PX25A and DA30: The PX25A appeared in 1934. It was a variant of the PX25 and was of identical appearance. It was superseded by the DA30, which appeared in the following year (see Figure 7.40). A pair of DA30s could provide an output power of 44 watts when operated in Class AB1 conditions with fixed grid bias. Under Class A conditions, it was strongly recommended that automatic grid bias be used.

DA41: The DA41 was a high power triode that made its appearance in 1939. It was specifically designed for Class B push-pull operation where an output power of 175 watts was obtainable. The valve was fitted with the American medium 4-pin bayonet base (USM4b) and had a 7.5-volt, 2.5-amp thoriated tungsten filament. It was designed to operate at zero grid bias, so effecting a considerable saving by avoiding the need for a separate grid bias supply. Because of the high drive voltage and current required a typical driver stage would consist of a pair of triode-connected KT61 valves in push-pull, cathode-coupled to the output stage by a 'bridged-transformer' arrangement.

DA60: This valve, the first of the DA series, appeared in 1929. It had a 6-volt, 4-amp thoriated tungsten filament and was fitted with the 4-pin L4 base (see Figure 7.41). In spite of its high filament consumption, it could only deliver an output power of 10.5 watts.

DA100 and DA250: These two valves were the 'monsters' of the power valves and were used in both high-power audio amplifiers and as modulators for transmitters. The DA100 appeared in 1933 and the DA250 in 1938 (see Figures 7.42, which also shows the DA41). They both had the more efficient oxide-coated filament. The DA100 was fitted with the L4 base and the DA250 with the large 4-pin BC base. Operating conditions are shown in Table 7.11 and a typical circuit for the DA100 in Figure 7.43.

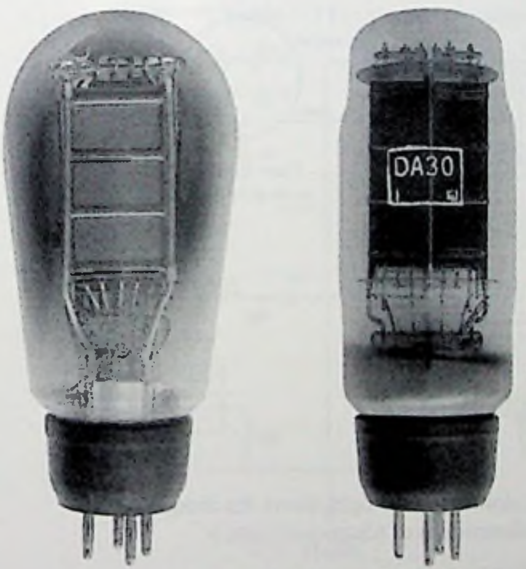


Figure 7.40: DA30: output triode providing 44 watts in Class AB1. (Early version at left and later version at right.)

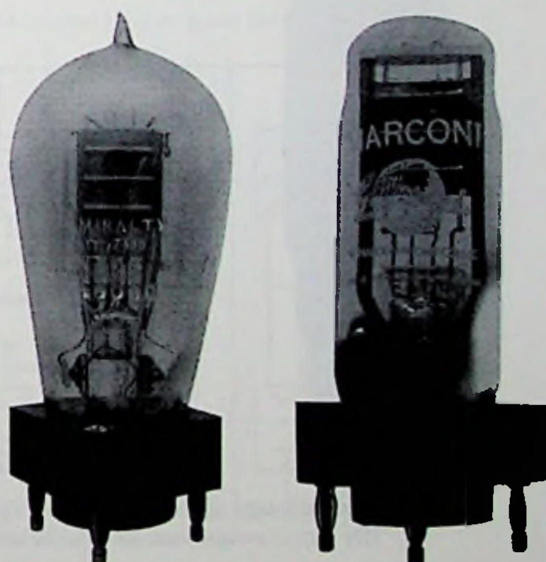
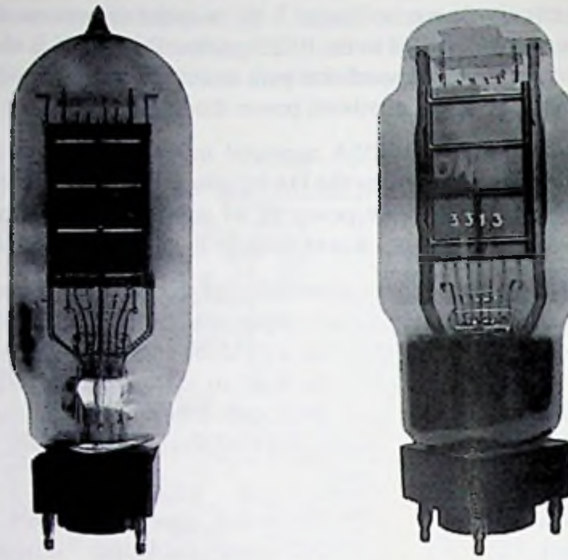
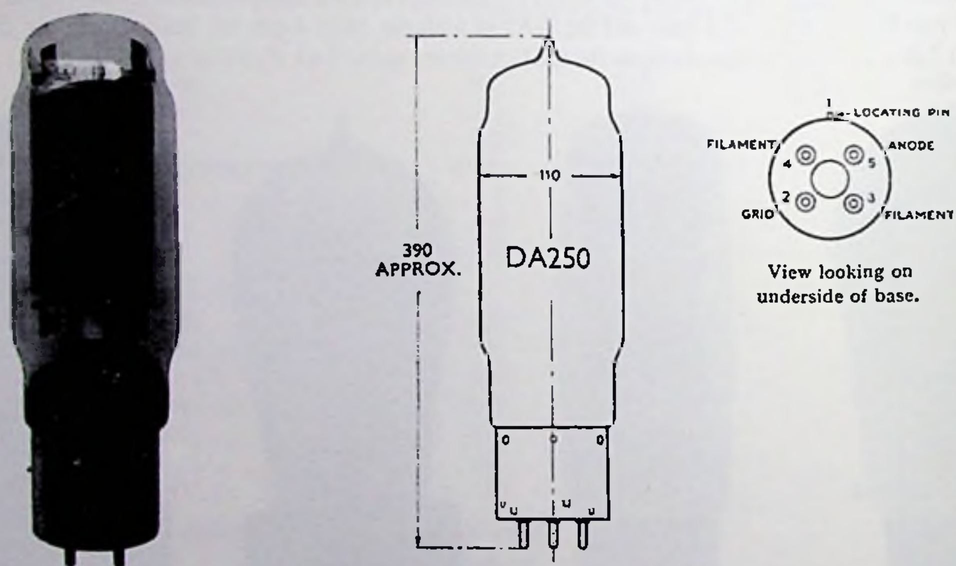


Figure 7.41: DA60: 10.5-watt output triode. (Early version at left and later version at right.)

DA41: Output triode for Class B operation giving 175 watts.



DA100: high-power output triode providing 125 watts in Class AB1 or 200 watts in Class AB2. (Early version at left and later version at right.)



DA250 high-power output triode or modulator. The outline drawing at the right shows the dimensions. (By way of comparison, the DA100 has typical dimensions of 65mm x 192mm.)

Figure 7.42: DA41, DA100 and DA250 high power output triodes.

DA100 in push-pull	Class AB1		Class AB2		
Anode voltage (max. signal)	1000	1250*	1000	1250*	volts
Anode current (per pair, no signal)	100	100	100	100	mA
Anode current (per pair, max. signal)	330	300	300	365	mA
Anode dissipation (no signal)	55	70	55	55	watts
Anode dissipation (max. signal)	53	100	50	80	watts
Grid bias voltage	–200	–225	–200	–225	volts
Signal input (grid-to-grid)	400	450	500	560	peak-peak volts
Grid current	—	—	–15	20	mA
Anode-anode load resistance	4000	8000	8000	8000	ohms
Power output	125	175	200	300	watts
Distortion	4	5	6	6	%

*1250V conditions from 1951 data

DA250	Class A	Class AB1 push-pull	Class AB2 push-pull	
Anode voltage	2500	2500	2500	volts
Anode current (per pair, no signal)	100	100	100	mA
Anode current (per pair, max. signal)	—	360	500	mA
Anode dissipation (no signal)	—	135	135	watts
Anode dissipation (max. signal)	—	250	190	watts
Grid bias voltage	–126	–130/160	–130/160	volts
Cathode bias resistor	1260	—	—	ohms
Signal input	—	130/160	130/160	peak volts
Grid current	—	—	20	mA
Anode-anode load resistance	17,500	12,000	12,000	ohms
Power output	90	400	800	watts
Distortion	—	up to 5	up to 6	%

Table 7.11: Operating conditions for DA100 and DA250 power triodes.

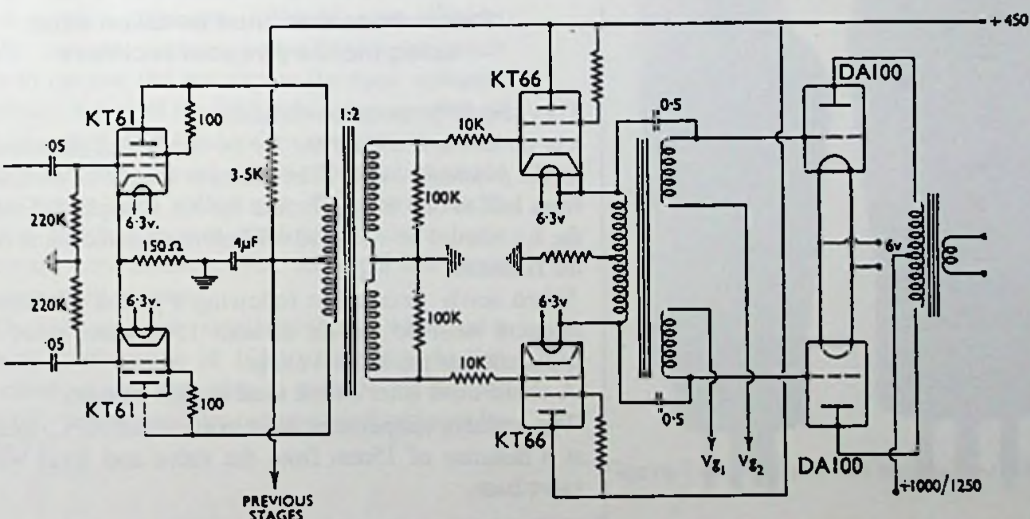


Figure 7.43: 200-300 watt amplifier using DA100 power triodes operating in Class AB2. (The earthing resistor for the centre-tap of the KT66 transformer should be of such a value that, together with the d.c. resistance of the transformer, it will be 600Ω per valve. All screen resistors are 100Ω.)

As can be seen from Table 7.11 the DA100 and DA250 required very high h.t. voltages, which were potentially lethal. Amplifiers built using them were, inevitably, expensive and requited several transformers, both for interstage and for the final output stage. They became obsolete when the KT88 beam power valve appeared in the late 1950s. It was then possible to construct a 400-watt amplifier using ten KT88s in parallel push-pull (i.e. 5 + 5). Furthermore, with this arrangement, no interstage transformers were required which, apart from saving cost and weight, now made it possible to apply overall negative feedback to reduce harmonic distortion [15].

Rectifiers

Both high vacuum and mercury vapour rectifiers were used with the power triodes. These rectifiers had to supply a high rectified current and were capable of operating at high voltage. The mercury vapour types were all half-wave and had 4-volt directly heated filaments: these will be described first.

GU1 and GU5: The first two mercury vapour types to appear were the GU1 (1930) and the GU5 (1936). They had 3-amp filaments and could supply a rectified current of 250mA. Under normal operating conditions, the bulb has a blue glow due to ionization of the mercury vapour. By virtue of the gas, the impedance of the rectifier is very low and the voltage drop across the valve is only 15 volts while the discharge is maintained. Two of the rectifiers could be used to provide full-wave rectification with a current up to 500mA. The GU1 was suitable for r.m.s anode voltages up to a maximum of 1000 and the GU5 up to 1500 volts. Because of its higher operating voltage, the GU5 had its anode brought out to a top cap.

GU50: The GU50 (1940) was a replacement for the GU5 and could operate with an input voltage up to a maximum of 1750 volts r.m.s. with a rectified current of 250mA. Its forward voltage drop was only 12 volts.

Figure 7.44 shows examples of the GU1 and GU50 and the precautions that must be taken when using mercury vapour rectifiers. A typical circuit using the GU50 is shown in Figure 7.45.

Figure 7.44: GU1 (left) and GU50 (right) mercury vapour rectifiers.

Precautions that must be taken when using mercury vapour rectifiers

They should be mounted vertically.
On no account should the HT be applied at the same time as the filament voltage. The filament should be switched on from half to one minute before the h.t. is applied. Similarly, the h.t. should be switched off before or at the same time as the filament.
When newly installed or following a period of disuse, the filament must be run for at least 15 minutes prior to the application of the anode voltage.
A choke input filter circuit must always be used.
The ambient temperature must not exceed 35°C, measured at a distance of 15mm from the valve and level with the valve base.

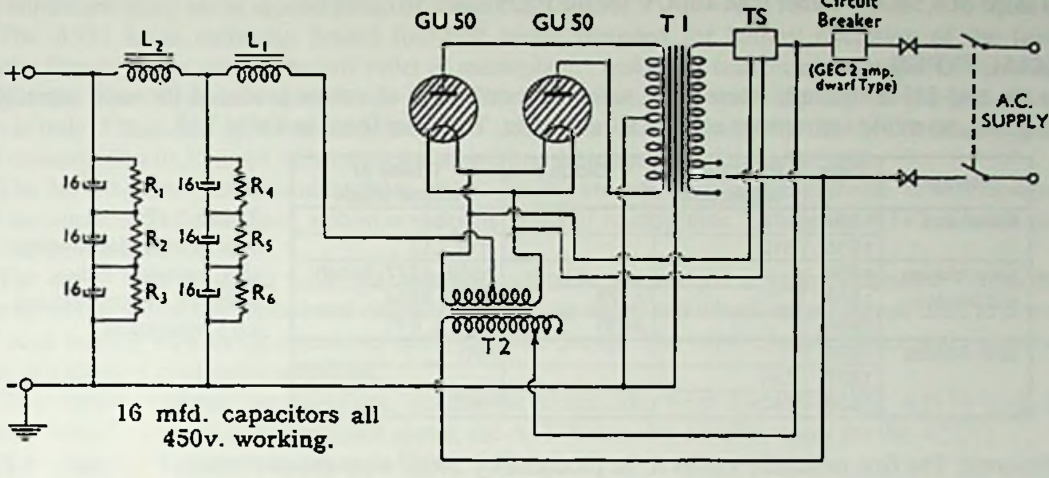


Figure 7.45: A typical circuit diagram of a high-voltage power supply using a pair of GU50 mercury vapour rectifiers.

In the circuit above all resistors are 50k ohm, the two chokes are 10 henries, the filament transformer four volts at six amps and TS is a time delay switch.

U19 and U23: These was the only high-vacuum rectifiers capable of operating with the large power valves such as the DA100 and DA250 (see Figure 7.46). They both had oxide-coated filaments rated at 4-volts, 3.3-amps. Although less efficient than the mercury vapour types they were much simpler to use and did not require the same stringent precautions. A pair of the U19 valves was capable of giving an output of 500mA when used in a bi-phase half-wave circuit and were suitable for applied anode voltages up to 2500 volts r.m.s. When used under maximum rectified current conditions a choke input filter circuit was recommended, having a minimum inductance of 10 henries.

The U23 was very similar to the U19 but had a maximum anode rating of 1750 volts r.m.s. At this lower rating, it was only able to provide the h.t. for the DA100. It was soon discontinued and replaced by the U19.

Figure 7.46: U19 and U23 high voltage rectifiers.

DIRECTLY HEATED OUTPUT PENTODES

In Table 7.4 there is shown several 4-volt directly heated output pentodes that were part of the early a.c. range. The first of these types to appear was the PT4, in 1931, which had a modest output power of two watts (see Figure 7.14 on page 122). This was followed in 1933 by the PT16, with output power of 6.3 watts and the PT25 with the higher power of ten watts. The PT25H was released a year later and had the same output power as the PT25, which it subsequently replaced, but operated with 400 volts on the screen rather than 200 volts; it had a slope of 6.5mA/V rather than 4mA/V for the PT25.

SPECIAL TYPES

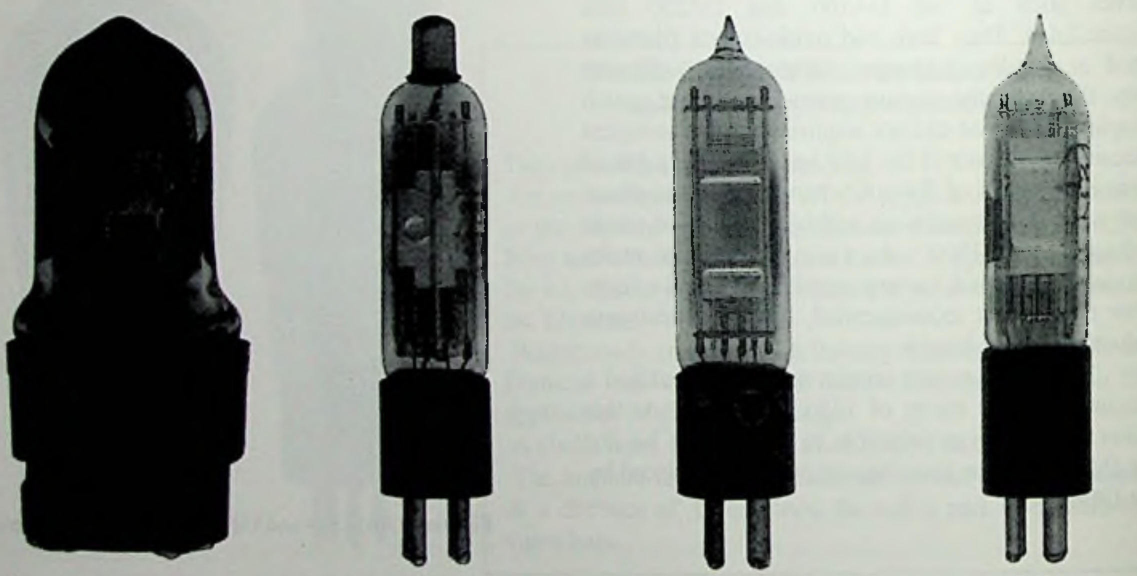
From the mid-1930s onwards, there were several special types of valves produced for such applications as hearing aids, scientific instruments and u.h.f. equipment. These are listed in Table 7.12.

Range	Year	RF tetrode or pentode	Diode	Triode or output triode
Miniatures	1934			H11, L11
	1938	S12		H12, L12
Misc. diodes and triodes	1936			A537, A577, MH40
	1938		A373	A802, A964
	1939		A800	A1178, ET1
UHF Acorns	1936			HA1
	1937	ZA1		
	1939	ZA2		HA2

Table 7.12: Special types for hearing aids, miniature radios, scientific instruments and u.h.f. equipment.

Miniatures: The first miniature valves to be produced by MOV were the two triodes H11 and L11 [16] (see Figure 7.47). They had a rated filament consumption of 0.1 amps at one volt and could be connected either in series to a two-volt accumulator or in parallel to a single dry cell. They were fitted with the Ct4, side contact base. Because of their small size, they were particularly applicable to miniature equipment, such as police radios and hearing aids. The H11 was of medium impedance (30kΩ) and the L11 low impedance (12.5kΩ).

A further range of miniatures was introduced in 1938 (see also Figure 7.47). This consisted of an r.f. tetrode, S12, a general-purpose triode, H12, and an output triode, L12. These valves had a filament rating of two volts, 0.06 amps and were intended primarily for use in hearing aids or 'pocket-size' amplifiers. They were fitted with the miniature 4-pin Sm4 base and the S12 had a top cap for the anode connection.



H11 & L11: 1-volt triodes for hearing aids and miniature radios.

S12: 2-volt r.f. tetrode.

H12: 2-volt a.f. triode.

L12: 2-volt output triode.

Figure 7.47: One- and two-volt miniature valves of 1934 and 1938.

Misc. diodes and triodes:

These valves are listed in the second group of Table 7.12.

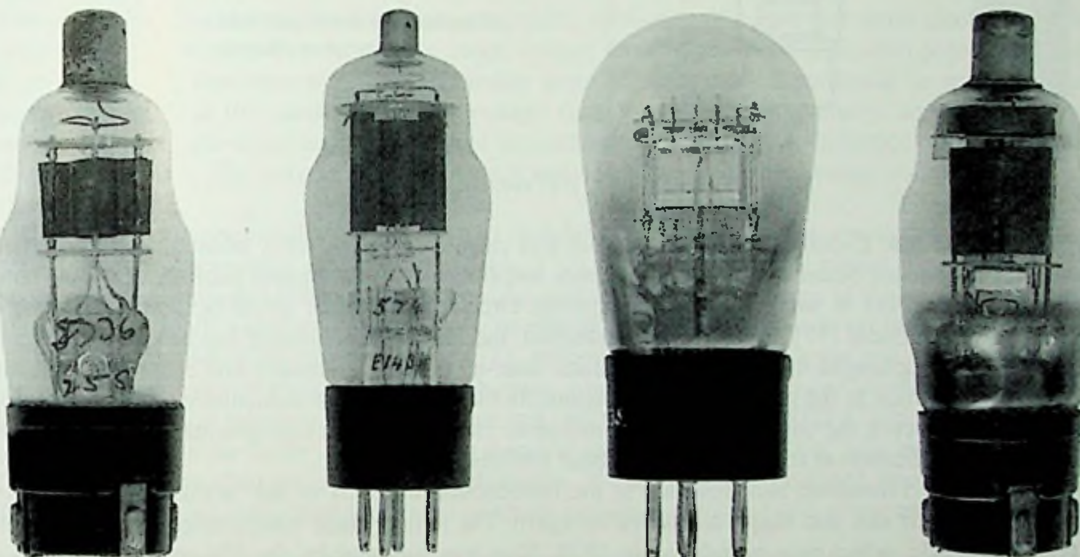
The A537 is an indirectly heated four-volt triode intended for battery operation of the heater. A particular feature of the valve is its low order of microphony, making it suitable as an amplifier for condenser microphones. The valve has a side contact base with four connections and a top cap for the grid. Its overall length is only 77mm and its diameter 51mm. The valve was later replaced by the A1178 which had lower heater consumption (0.25 amps rather than 0.4 amps) and which provided a higher gain.

The MH40 is another low-microphony triode having an indirectly heated cathode. It was designed for use as an amplifier for condenser, ribbon or velocity types of microphone. Unlike the A537, it has a standard 5-pin, B5 base and no top cap.

The A577 was designed with characteristics suitable for use in a valve voltmeter. Typically, the voltmeter would utilize the anode bend characteristics of the valve and a backing off circuit used to provide an initial zero reading on a meter connected in the cathode circuit. The valve characteristics make it unsuitable for use as a conventional audio amplifier.

Two valves designed as amplifiers, mainly for photocells, were the A802 and A1178 both having indirectly heated cathodes. (As mentioned above, the A1178 was also a replacement for the A537.)

A selection of the valves is shown in Figure 7.48.



A537: triode for microphone amplifier. | A577: triode for valve voltmeter. | A964: triode for photocell amplifier. | A1178: low-noise a.f. triode.

Figure 7.48: Triodes for miscellaneous applications.

The ET1 is an electrometer triode specially designed to have a very high input resistance. Typical applications were the measurement of ionization currents, hydrogen-ion concentrations and the study of piezo-electric effects. In order to ensure the very high input resistance required for these applications the control grid electrode is connected to a terminal mounted at the end of a special high resistance glass stem. Internal and external guard rings and an electrostatic shield round the electrode system are connected to a pin at the base of the valve and may be connected to the negative end of the filament or given any desired negative potential. Figure 7.49 shows a photograph and an outline drawing of the valve, together with its base and top cap connections.

Finally, in this group of miscellaneous valves there is the A373, a diode designed for use as a rectifier for an r.f. voltmeter. It has a SES screw type of base and a top cap for its anode connection. There was also the A800 absorber diode.

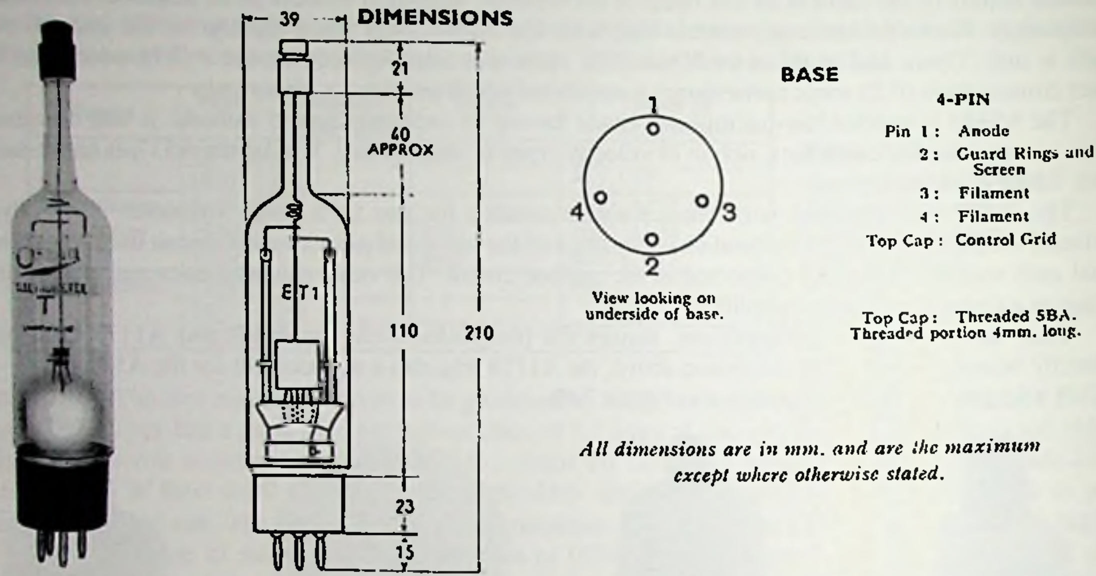


Figure 7.49: ET1 electrometer triode.

UHF Acorn valves: Experimental research work was carried out at the RCA laboratories during the early 1930s to investigate the behaviour of radio frequency amplifier valves. In a paper published by B J Thompson and G M Rose in 1933 it was shown that improved circuit performance could be achieved if the valve dimensions were reduced [17]. With a linear reduction, the mutual conductance and other valve parameters remained almost unchanged but the lead inductance, inter-electrode capacitance and electron transit time all fell in direct proportion to the reduction of dimensions. In fact, such a linear reduction was not practicable; the paper showed, however, the construction of sub-miniature valves, which in experimental circuits were capable of providing amplification at frequencies up to about 400MHz.

The work of Thompson and Rose led to the introduction by RCA of the 'acorn' series of valves, so named because their size and shape resembled an acorn. The first of these valves to go into production was the type 955 triode, which was introduced in 1934. This was followed by the 954 pentode in 1935 and a variable-mu pentode, the type 956, in 1936 (see Figure 7.50). The first two of these, the 954 and 955, were described in detail by Bernard Salzberg and D G Burnside in 1935 [18]. They both had indirectly heated cathodes operating at 6.3 volts, 0.15 amps. The diameter of the heater-cathode assembly was comparable with that of a common household pin and the overall length was less than half. The capacitance between the control grid and anode for both the triode and pentode was about half that of conventional valves and all other internal capacitances were also significantly reduced.

Before long, acorn valves, based on the RCA design, were introduced in Britain by Mazda, Marconi-Osram and Mullard (of Philips design and manufacture). Initially, all the British acorn valves had 4-volt heaters, but 6.3-volt versions were introduced in 1939.

The Technical Staff of MOV gave several circuit applications for acorn valves in 1938 [19]. These circuits, which operated in the range 50 to 300MHz, included low-power oscillators, a super-regenerative receiver and a frequency changer. Of the three types of valves mentioned above MOV only produced the triode and straight pentode. The first of these to appear was the HA1 triode (in 1936), to be followed a year later by the ZA1 pentode, both having 4-volt heaters. The 6.3-volt versions, HA2 and ZA2, were introduced in 1939. These were direct copies of the 955 and 954 respectively.

Figure 7.50: RCA Acorn valves. Left 954 pentode; centre 955 triode; right 956 variable-mu pentode. The MOV type HA2 is a direct equivalent of the 955 and the ZA2 a direct equivalent of the 954. (Approx. actual size.)

THYRATRONS

Thyratrons are gas-filled relays that have three electrodes, consisting of a grid, or control electrode, an anode and a cathode. For the valve to switch on the anode voltage must be above the ionization potential of the gas. If the grid voltage is then increased from an initially large negative value a point will be reached when the valve switches on and the anode-to-cathode voltage then falls to a value usually between 10-15 volts, depending upon the type of gas used. Variation of the grid potential then has no influence on the magnitude of the discharge current. The valve can only be switched off by reducing the anode voltage below the gas ionization potential.

Thyratrons were produced both for industrial switching applications and as a switch in timebase circuits of oscilloscopes and television receivers (see Table 7.13). In timebases, a CR circuit is used to provide an approximately linear sweep voltage and the thyratron provides a rapid discharge of the capacitor; this results in the required sawtooth waveform for successive sweeps of the trace on a cathode-ray tube.

The first of the MOV thyratrons was the GT1, introduced in 1931, where the gas was mercury vapour. This had a relatively slow switching time, which made it unsuitable for television timebases. In 1936, when the first high-definition television receivers appeared, MOV produced the GT1A and GT1B, which were argon filled and had a far faster switching time than the earlier GT1. The GT1C was added to the range in 1937 and replaced the other three in many applications. It was, however, designed primarily as a relay for handling relatively large currents and its use in timebase circuits was limited to a maximum speed of 8 kHz.

Range	Year	RF tetrode or pentode	Freq. Chang.	Diodes	Triode or output triode	Output pentode	Thyratrons	Rect.
Thyratrons	1931						GT1	
	1936						GT1A, GT1B	
	1937						GT1C	
Television valves	1936	MSP41		D42		N43		U16, U17
	1938	KTZ41	X41C	A748				
	1939	Z62	X62	D43	BL62, BL63	KT44		U27
	1940s					KT36, KT45		

Table 7.13: Thyratrons and television valves.

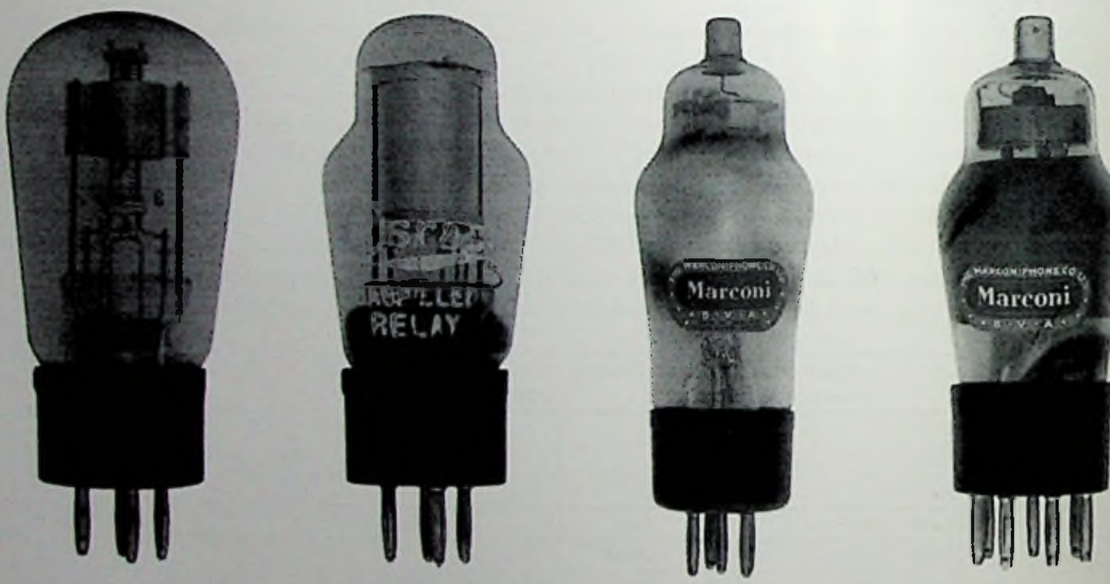
TELEVISION TYPES

MOV launched a range of valves in 1936 for use in television receivers. Apart from the GT1A and GT1B thyratrons mentioned above, there was an r.f. pentode, MSP41; a single diode of low impedance, the D42; a video output pentode, N43, and two high-voltage rectifiers, U16 and U17. The MSP41 only had a slope of 3.2mA/V, rather low for use in the wideband amplifiers required for high-definition television signals; it was similar to the earlier MSP4 but operated at the higher screen potential of 240 volts and a negative grid bias of four volts. The N43 is similar to the N41 but has a top-grid connection and very low grid-anode capacitance. When first released in 1936 the U16 had a 2-volt, 0.25-amp filament but two years later the filament current was increased to 1 amp and the rectified current increased from 2mA to 5mA.

The MSP41 was soon discontinued in favour of the MSP4 and a new r.f valve, the KTZ41 tetrode, appeared in 1938 that had a slope of 12mA/V. There was also a ceramic base version of the X41 triode hexode, which was used in several superhet receivers such as the HMV 904. A valve not found in the usual listings is the A748, a double diode version of the D42 and used in the GEC television BT3701 of 1938.

In the following year there were several octal types: these were (1) an r.f. pentode, Z62, (2) a triode hexode frequency changer, X62, (3) the single diode, D43, (4) a double triode, BL62, intended for the output stage of timebases (later replaced by the BL63 and used in the R1155 Services communications receiver as a 'visual meter switching valve') and (4) the U134 rectifier having two independent diodes, each rated at 350V, 100mA. In addition, there were the two Marconi beam power tetrodes, KT44 and KT45, which had 7-pin bases and top cap anodes. These had identical characteristics and could be used for audio output or in line timebases; apart from their heater rating they had similar characteristics to the KT66.

A typical valve line-up for a 1939 model television (Marconiphone 707 [20]), which also had three broadcast bands, is as follows: MSP4, X41C, 3 x KTZ41, MHD4, KT41, MS4B, 3 x KTZ63, 2 x KT63, D42, U17, U52. By this time, hard valves had replaced thyratrons in the line and frame timebases (KTZ63 and KT63). Examples of the thyratrons and television types can be seen in Figures 7.51 and 7.52.



GT1 & GT1A: mercury- and argon-filled thyratrons.   GT1C: argon-filled thyratron.   MSP41: r.f. or i.f. pentode.   KTZ41: r.f. tetrode.

Figure 7.51: Thyratrons and television r.f valves.

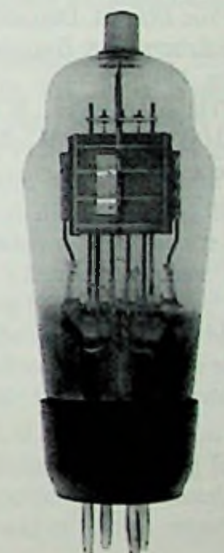
D42:
television diode.

VR102 = BL63: double triode
originally designed for timebases.

VT107 = N43:
video output pentode.

U16: half-wave e.h.t. rectifier
(5kV, 2mA—later 5mA).

U17: half-wave e.h.t. rectifier
(2.5kV, 30mA).



U27: half-wave e.h.t. rectifier
(5kV, 50mA).

Figure 7.52: Various valves for television use.

REFERENCES

1. Baker, W J, *A History of the Marconi Company* (Metheun & Co. Ltd., 1970, ISBN 0-416-17050-1), p. 194.
2. Willans, P W, 'Screened valves. A new Development', *W.W.*, **21**, 27 July 1927, pp. 107-10.
3. Round, H J, British patent GB275,335, app. 5 May 1926, iss. 5 August 1927.
4. 'Filamentless valves for A. C. supply', *W.W.*, **20**, 26 January 1927, pp. 115-6.
5. Henderson, F C, 'The KL1 valve', *W.W.*, **21**, 20 July 1927, pp. 83-5.
6. Parker, P, *Electronics* (Edward Arnold, 1960), Section 28.1, pp. 101-4.
7. 'All-dry valves', *W.W.*, **46**, May 1944, pp. 136-8.
8. 'The Catkin valve', *W.W.*, **32**, 12 May 1933, pp. 340-1 and 19 May 1933, p. 365.
9. 'The Catkin in the making', *W.W.*, **33**, 3 November 1933, pp. 358-60.
10. Bull, C S and Rodda, S, British patent GB423,932, app. 2 August 1933, iss. 2 February 1935.
11. 'A new output tetrode', *Elec.*, **8**, February 1935, p. 65.
12. Burnap, R S, 'New developments in Audio Power Tubes', *RCA Review*, **1**, No. 1, July 1936, pp. 101-8. Also Schade, O H, 'Beam power tubes', *Proc IRE*, **26**, No. 2, February 1938, pp. 137-81.
13. 'New series of Marconi valves', *W.W.*, **40**, 23 April 1937, p. 402.
14. Williamson, D T N, 'Design for a high-quality amplifier, *W.W.*, **53**, April 1947, pp. 118-21. Also May 1947, pp. 161-3.
    'High-quality amplifier new version', *W.W.*, **55**, August 1949, pp 282-7.
15. Woodville, G R, '400-watt audio amplifier', *W.W.*, **63**, November 1957, pp. 543-6.
16. 'New midget valves', *W.W.*, **34**, 6 April 1934, p. 240.
17. Thomson, B J & Rose, G M, 'Vacuum tubes of small dimensions for use at extremely high frequencies', *Proc IRE*, **21**, December 1933, pp. 1707-21.
18. Salzberg, B & Burnside, E G, 'Recent developments in miniature tubes', *Proc IRE*, **23**, October 1935, pp. 1142-57.
19. 'The acorn valve', *W.W.*, **43**, 7 July 1938, pp. 2-4.
20. 'HMV Model 904', *W.W.*, **43**, 1 September 1938, pp. 218-30. (Gives circuit diagram of the television receiver.)

Chapter 8
Mullard Radio Valve Company Ltd.

Following its formation in 1920, Mullard initially manufactured various versions of the R-valve, together with a range of transmitting diodes and triodes. For a short while, manufacture continued at the old Z Electric Lamp plant at Southfields, whilst a new facility was being prepared at Claybrooke Road, Hammersmith. With the greater demand for radio valves, larger premises were required and the company moved to Balham in late 1922. In later years, factories were opened at Mitcham in Surrey and at Blackburn in Lancashire.

In 1921 the Marconi Company sued Mullard for infringement of two Marconi-held patents. The first was that of H J Round for 'a vacuum tube containing a hot filament, a grid formed as a closed cylinder completely enclosing the filament, and a third electrode in the form of a cylinder surrounding the grid ...' The second was that of that of Péri and Biguit based on the construction of the French TM-valve (known as the R-valve in the UK). The case went on until April 1924 and, during this time, the Mullard Company successfully fought the case first in the Chancery Division, then in the Court of Appeal and finally in the House of Lords. There is little doubt that the case cost the fledgling Mullard Company a considerable amount of money in legal fees.

All the Mullard valves up to this time were based on those of other companies and they desperately required an injection of technical know-how and capital. Consequently, in 1924, half the company shares were bought by the Dutch company, N V Philips Gloeilampenfabrieken. Three years later, Philips acquired the remaining shares of Mullard to meet further demands for capital. With the Philips take-over all future valve design was carried out in Holland and Mullard effectively became a UK manufacturer of Philips valves [1]. The first of the new valves, introduced in 1925, was the PM series with directly heated filaments. (PM was meant to stand for Philips-Mullard and, although briefly used, it was quickly dropped by the Mullard Company which wanted the general public to believe that Mullard was solely a British company. Mullard even went so far as to invent the name **P**ure **M**usic to disguise the original meaning of PM.)

Three non-manufacturing companies to whom Mullard sold valves were the Electron Co., which used the brand name SIX-SIXTY, Ever Ready and S-T (owned by Scott-Taggart). Mullard bought all the shares of the Electron Co. in 1928 and changed the name to the Six-Sixty Radio Co. Ltd.; the company was sold to Ever Ready in 1935. In 1938, Mullard purchased the valve interests of E K Cole Ltd., better known as EKCO.

Mullard quickly became established as the major valve manufacturer in Britain, accounting for about 40% of the total production by the late 1930s. (In post-World War 2 years, this percentage increased, and by 1954, they were producing about 60% of the UK output, although much of this was of Philips manufacture.) Valve production ceased around 1989/90.

BATTERY VALVES: 1926–1931 (Table 8.1)

Soon after its acquisition by Philips, Mullard introduced the PM ranges of valves. The first of these was the four-volt output triode, PM4, which became available from September 1925. The construction was typical of most valves of that period, although amongst the earliest to have an oxide-coated filament. In its original form the electrode assembly was of a flattened box shape, mounted horizontally, and the filament was of an 'N' shape and rated at 3.8 volts, 0.1 amps.

By mid- to late-1926 there were 2-, 4- and 6-volt ranges of triodes. RF tetrodes were added in 1927 and output pentodes in 1928. The first two-volt triode was the general-purpose PM1, soon to be replaced by the

PM1HF and PM1LF. The PM1 was of medium impedance and used mainly as a detector or a.f. amplifier with RC coupling to the output stage. The PM1LF was of low impedance and designed for use as a detector or a.f. amplifier where transformer coupling was to be used. Finally, in 1926, there was the PM2 output triode capable of a modest power of around 150mW. There was also the 1.5-volt PM0 but this did not go into general production.

Range	Year	RF tetrode	RF amplifier, detector or a.f. triode	Output triode	Output pentode
2-volt	1926		PM1, PM1HF, PMILF	PM2	
	1927	PM12	PM1A	PM252	
	1928		PM2DX		PM22 (4-pin)
	1929				PM22 (5-pin)
	1930			PM2A	
	1931	PM1DG	PMIHL	PM202	
4-volt	1926		PM3	DP425, PM4 (1925)	
	1927	PM14	PM3A	PM254	
	1928		PM4DX (PM4D)		PM24* (4-pin)
	1929				PM24* (5-pin), PM24A*
	1930				
	1931	PM4DG	PM3D		
6-volt	1926		PM5	PM6	
	1927	PM16	PM5A, PM5B, PM5X	PM256*	
	1928		PM6D		
	1929				PM26 (4- & 5-pin)
	1930		PM5D	PM256A*	

*PM24, PM24A, PM256, PM256A were also used with an a.c. filament supply.

Table 8.1: Battery ranges 1926 to 1931.

The four-volt triodes of 1926 were the general-purpose PM3 and the very short-lived DP425. Also included here is the PM4 output triode of late-1925 which continued in production for a few more years. The PM3 initially had a 0.1-amp filament but its current was reduced to 0.075 amps in the following year. Also in 1926, there were two six-volt triodes: the general-purpose PM5 and the PM6 output valve.

The three tetrodes to appear in 1927 were the two-volt PM12, the four-volt PM14 and the six-volt PM16. Other two-volt valves were the high impedance PM1A for RCC amplification and the 'super power' PM252, which initially had a 0.3-amp filament but, with subsequent improvements, its filament rating was increased to 0.4-amps and its output power increased to 320mW. The equivalent RCC triodes in the four- and six-volt ranges were the PM3A and PM5A, and the 'super power' triodes were the PM254 and PM256 respectively. An improved version of the PM254 was introduced in 1929 where the filament current was reduced from 0.25 amps to 0.18 amps. The PM256 was also gradually improved over the succeeding years and was then capable of an output power of one watt with an anode supply of 250 volts. Two other six-volt triodes to appear in 1927 were the high impedance PM5B and the low impedance PM5X which was used as a detector or a.f. amplifier: initially the PM5X had a 0.1-amp filament was this was soon reduced to 0.075 amps.

The Philips Company had significant R&D facilities in their Eindhoven laboratories and was foremost in the development of the oxide-coated filament. Initially, the filaments were coated with barium oxide using a rather messy azide process. Eventually it was found that a combination of barium and strontium oxides provided a considerable improvement in both the emission and the efficiency. The azide process was then dispensed with in favour of various deposition techniques such as dragging or spraying [2].

The Philips Company was also the inventors of the pentode. Credit for this goes to the two Dutch engineers, Gilles Holst and Bernard Tellegen, who made a Dutch patent application in December 1926, but, because of an oversight, it was allowed to lapse. Patents were taken out in several other countries, however, including Britain, France and Germany [3].

The pentode was originally designed for use in the output stage of radio receivers and audio amplifiers. The first of these, the B443, was manufactured by the Philips Company in 1927 and used in their 2502 battery-operated receiver [4]. (Many pentode valves, both Mullard and Philips, used the trade name 'Pentone'.)

By the middle of 1928 Mullard was offering two output pentodes—the two-volt PM22 and the four-volt PM24 (this being identical to the B443). Initially, these both had 4-pin bases with a side terminal for connection to the auxiliary grid, but 5-pin versions became available in 1929. In 1928, Mullard also introduced new medium impedance triodes in the three voltage ranges, all intended for use as detectors or a.f. amplifiers; these were the PM2DX, PM4DX and PM6D. Initially, the PM2DX had a 0.2-amp filament but this was reduced to 0.1 amps with an improved version of 1931. The PM4DX was originally known as the PM4D but the X was added shortly after its release.

The only new types to appear in 1929 were the four-volt output pentode, PM24A, and the six-volt output pentode, PM26. The PM24A, like the PM24, could also be used on an a.c. supply and was capable of an output power of one watt, twice that of the PM24. The PM26, like the PM22 and PM24, was fitted initially with a 4-pin base and side terminal, but a 5-pin version became available later in the year.

In the following year the PM2A replaced the earlier PM2 output triode and the PM5D replaced the PM6D detector triode in the six-volt range. The only other new type was the PM256A output triode which appears to be a downgraded version of the PM256, with very similar characteristics but a lower slope of 2.6mA/V rather than the 3.25mA/V of the PM256.

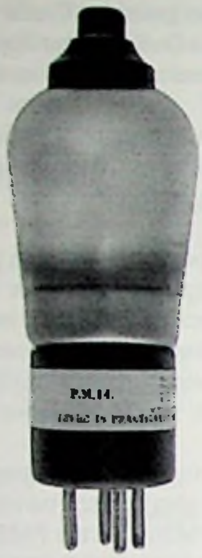
By 1931 there was a revived interest in the superheterodyne receiver but there was no suitable valve that could be used as a combined first mixer and local oscillator. For this reason, the four-electrode valve of the early 1920s was resurrected. In its earlier form the inner grid was a 'space-charge' grid biased with a positive potential for reducing the space charge of the electrons surrounding the cathode, thereby enabling the anode to be operated at a very low potential. In its new form, however, the signal was applied to the inner grid and the outer grid formed part of the oscillator circuit. (In an alternative arrangement the connections to the two grids were reversed.) The difference (intermediate) frequency was then extracted from the anode using a suitably tuned transformer. Mullard, in common with many other valve manufacturers, produced four-electrode valves for this purpose. The one most commonly met was the PM1DG with a two-volt filament, which appeared in 1931. This valve had a conventional 4-pin base and a side terminal for connection to the inner grid. There was also a four-volt version, the PM4DG, and the sample in the author's collection has a continental 5-pin base. Apart from their use as a self-oscillating first detector, the valves could also be used as a mixer—with a separate oscillator—or as an a.f. amplifier.

The only other valves to appear in 1931 were the PM1HL, a medium impedance general-purpose triode, the PM202 output triode (both with four-volt filaments), and the four-volt PM3D which was a low-impedance a.f. triode.

By the early-1930s the four- and six-volt ranges of battery valves had become obsolete. There were several reasons for this. Perhaps the most important was that improvements in valve performance now meant that the two-volt valves could provide sufficient gain and output power to meet all the requirements necessary for radio receivers of that time. Secondly, the two-volt valves only required a single-cell accumulator, saving both weight and cost.

Figures 8.1, 8.2 and 8.3 show representative examples of the PM series of valves issued in the period 1926 to 1931. Many of the types not shown had almost identical external appearances to those in the photographs and, in almost all cases, the internal electrode structure is obscured by the heavy silvery magnesium getter.

PM12: 2-volt r.f tetrode (metallised version).



PM14: 4-volt r.f. tetrode (plain bulb only).

PM16: 6-volt r.f. tetrode (plain bulb only).

PM1HF: 2-volt medium impedance r.f. or detector triode.

PM1LF: 2-volt detector or a.f. triode.

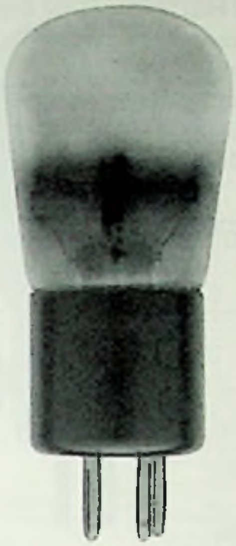
PM1A: 2-volt high impedance RCC triode.

PM2DX: 2-volt detector or general-purpose triode.

PM3: 4-volt detector or a.f. triode.

Figure 8.1: Examples of PM Series valves 1926 to 1928.

PM4D: 4-volt detector or a.f. triode. (Soon became PM4DX.)



PM4DX: 4-volt detector or a.f. triode. (Initially PM4D.)

PM5A: 6-volt high impedance RCC triode.

PM5X: 6-volt detector or a.f. triode (metallised version).

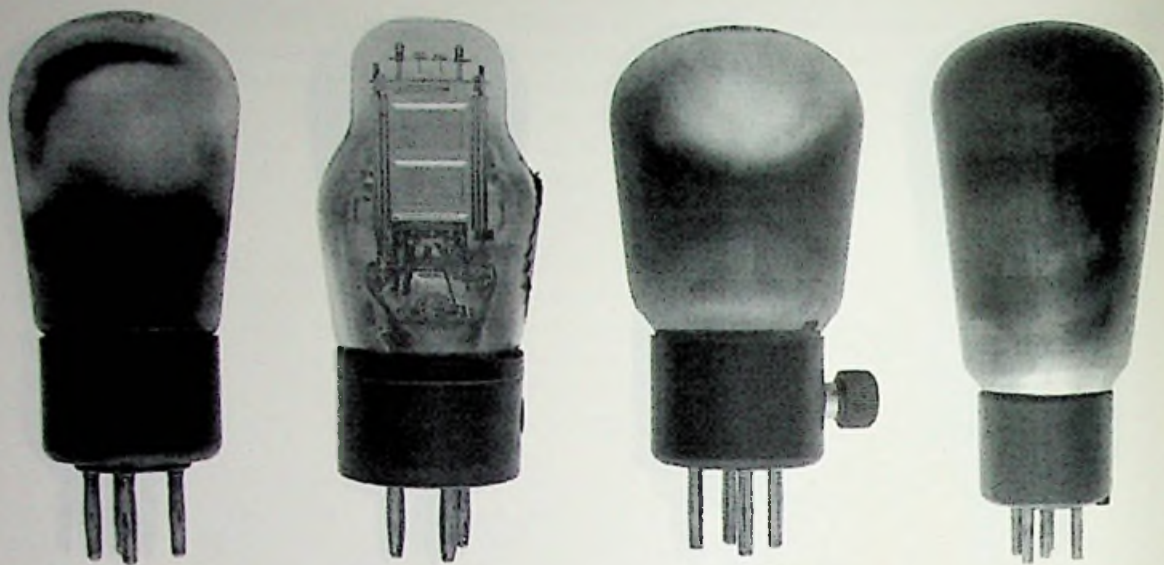
PM252: 2-volt output triode.

PM254: 4-volt output triode.

PM256: 6-volt output triode.

PM22: 2-volt output pentode (4-pin version).

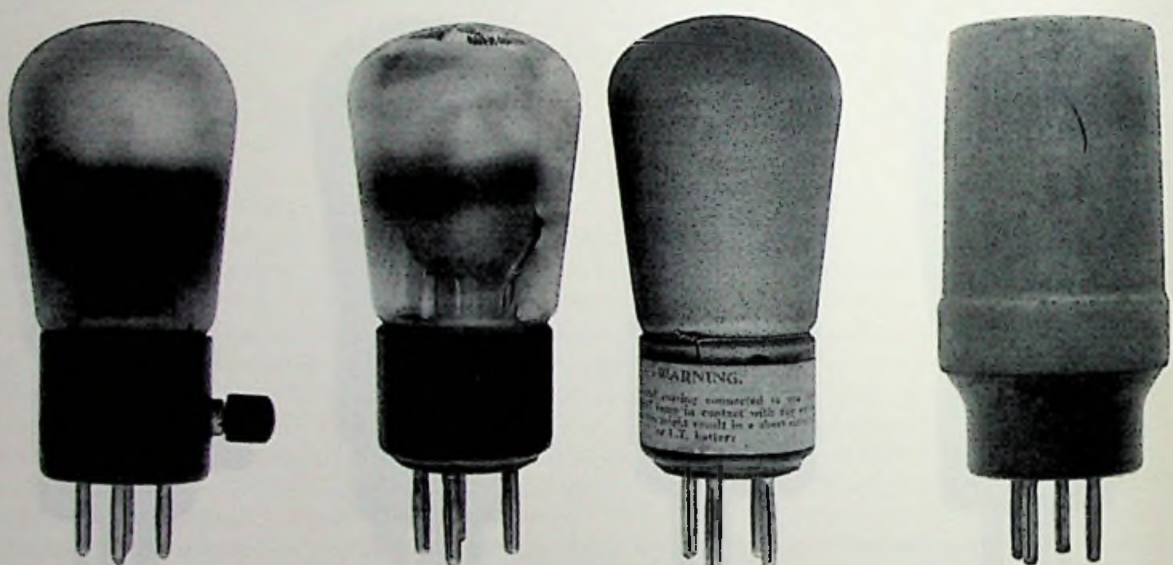
Figure 8.2: Examples of PM Series valves 1926 to 1928 (cont.).



PM2A: 2-volt output triode.
Early version (left) and later, MOV version (right).

PM24: 4-volt output pentode
(4-pin version).

PM24: 4-volt output
pentode (5-pin version).



PM1DG: 2-volt four electrode
bi-grid with 4-pin base and
side terminal for inner grid.

PM1HL:
general-purpose triode. Plain version at
left and metallised version at right.

PM3D: 4-volt detector or
a.f. triode enclosed in
metal screening can.

Figure 8.3: Examples of PM Series valves, 1928 to 1931.

2-VOLT BATTERY RANGES WITH BRITISH BASES: 1932–1939 (Table 8.2)

During the first two years of this period the valves continued to be prefixed exclusively with the letters PM but this nomenclature was gradually phased out over subsequent years. The earlier PM12 was superseded by the PM12A, which had a higher slope, and there was the PM12V, a variable-mu tetrode, but this was replaced by the higher-performance PM12M in 1933 (which was later also a replacement for the PM12A). Also the PM22 output pentode was superseded by the PM22A which initially had a 0.2-amp filament but this was reduced a few years later to 0.15 amps.

Year	RF tetrode or pentode	Frequency changer	Diode, triode or DD triode	Class B double triode	Output pentode or double pentode
1932	PM12A, PM12V				PM22A (B4 & B5)
1933	PM12M			PM2B	
1934	SP2, VP2		TDD2, TDD2A	PM2BA	PM22C
1935		FC2	PM2DL		QP22A
1936			2D2*		PM22D
1937	VP2B (hexode)	FC2A			
1938			PM2HL		QP22B
1939/40		TH2			

*2D2 is indirectly heated

Table 8.2: Two-volt battery valves with British bases: 1932 to 1939.

Another valve to appear in 1933 was the PM2B. This was a Class B double triode requiring no grid bias and capable of an output power of 1.25 watts. In the following year the PM2BA was introduced; this was similar to the PM2B but required a grid bias of –4.5 volts. The use of negative bias increased its sensitivity and provided improved fidelity at low output levels. The PM2BA also had a slightly higher output of 1.45 watts.

The first battery r.f. pentodes came in 1934. These were the SP2 and the variable-mu VP2, both types continuing in production for many years. There was also two double diode triodes—the TDD2 and TDD2A. The TDD2 had an anode impedance of 12,000 ohms, whereas the TDD2A had the higher impedance of 25,000 ohms. With both valves the triode portion was used as an a.f. amplifier preceding a Class A output stage but the TDD2, with its lower impedance, was also suitable as a Class B driver. All four of these valves were supplied only with metallised bulbs. Finally there was a new output pentode, the PM22C, capable of delivering 1.45 watts.

In 1935, Mullard released the octode frequency changer, FC2 and the PM2DL triode which was used either as a transformer-coupled driver for the two Class B valves, or as an a.f. amplifier. There was also a QPP double output pentode, QP22A. As was common practice at the time, the QPP valves were graded to ensure accurate matching of their characteristics by appropriate adjustment of the auxiliary grid voltage. First it was necessary to identify the two pentode sections of the valve. For this the letter 'A' was printed on the side of the base in line with pin 2 and the letter 'B' on the side of the base in line with pin 7. Pins 1, 2, and 3 were the connections for assembly 'A' and 7, 8, and 9 for assembly 'B'. (These corresponded, respectively, to grid 1, the anode and grid 2.) The letters 'P', 'Q', 'R', 'S' and 'T' were used to denote the five grades and these were etched on each side of the assembly-identifying letters. Assuming a 135-volt h.t supply was used and grid bias of 10.5 volts, then the appropriate voltages for the auxiliary grids, g_2, were as indicated below:

P 103.5V	Q 111.0V	R 118.5V
S 126.0V	T 133.5V	

PM12A:
r.f. tetrode.

PM12V:
variable-mu r.f. tetrode.

PM12M: variable-mu r.f.
tetrode, replacing PM12V.

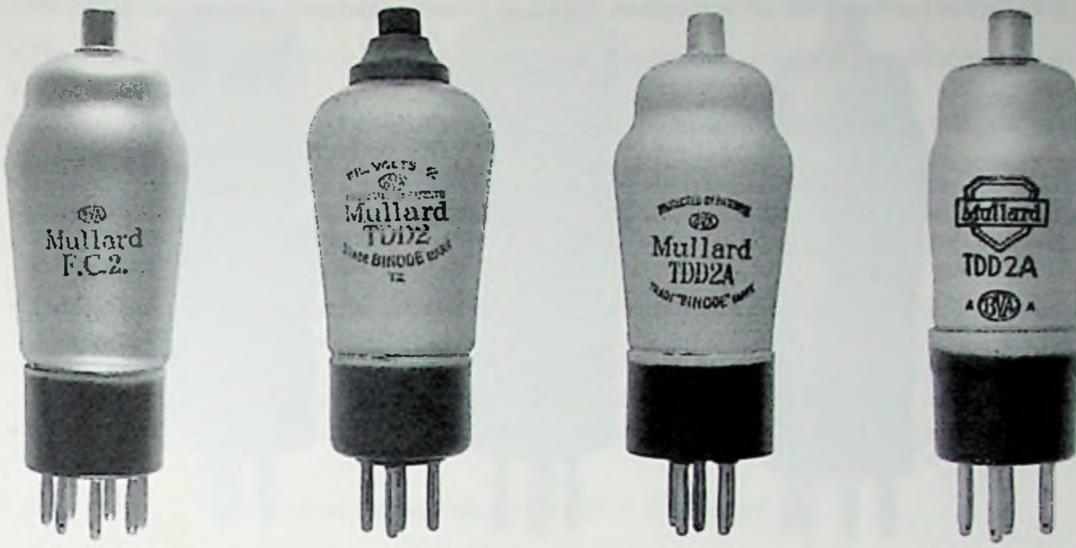
PM22A: output pentode.
(Later 5-pin version.)

PM2B and PM2BA:
Class B triodes.

SP2 r.f. pentode: early version (left) and later, Mazda
version (right). (The variable-mu VP2 is similar.)

VP2B: hexode for use as a
mixer or r.f. amplifier.

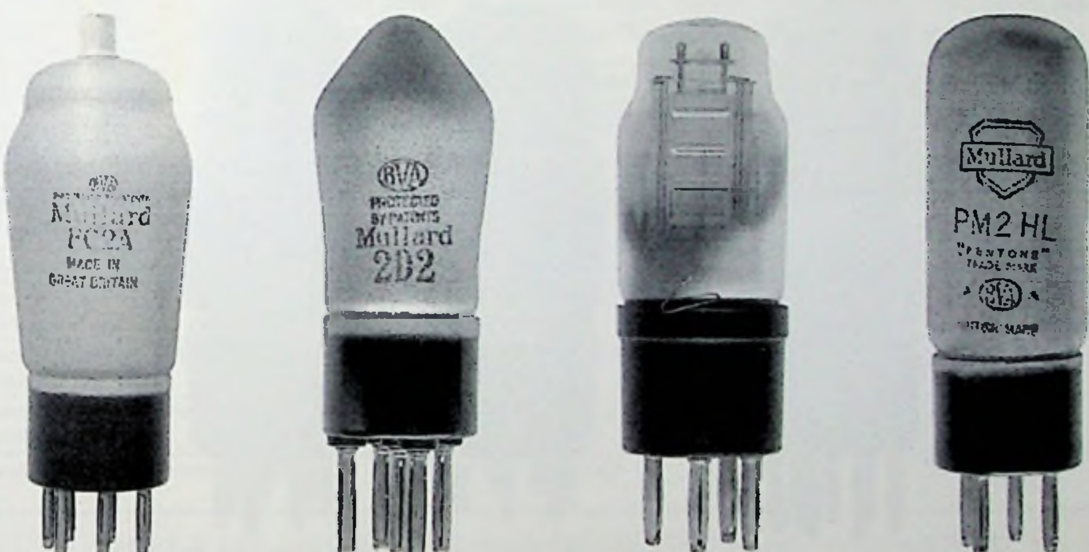
Figure 8.4: Two-volt battery valves, 1932 to 1939.



FC2: octode frequency changer.

TDD2: double diode and low-impedance triode.

Two versions of the TDD2A double diode and medium-impedance triode.

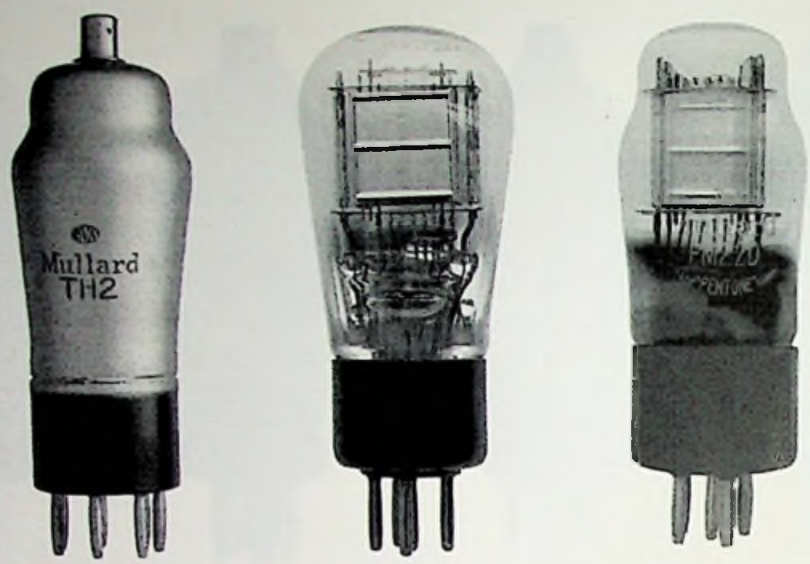


FC2A: 'all-wave' octode frequency changer.

2D2: indirectly heated double diode.

PM2HL: medium impedance triode. Early version with plain bulb (left)—actually the MOV HL2k). Later, metallised version (right).

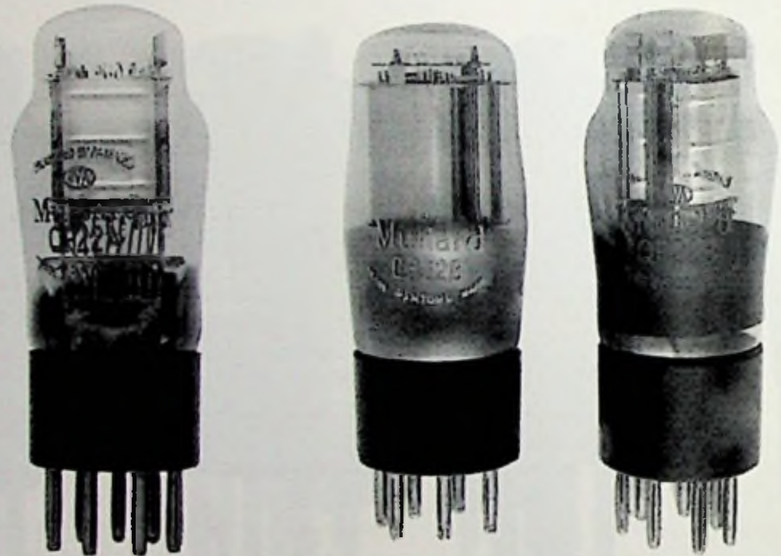
Figure 8.5: Two-volt battery valves, 1932 to 1939 (cont.).



TH2: triode hexode frequency changer.

PM22C: 2-volt output pentode.

PM22D: 2-volt output pentode.



QP22A: QPP output pentode with 9-pin base.

QP22B: two examples of the later version of the QPP output pentode. That at the left is of Mazda manufacture.

Figure 8.6: Examples of Mullard two-volt battery valves 1932 to 1939 (cont.).

The valves issued in the remaining years of the 1930s, as shown in the last four rows of Table 8.2, were:

- The double diode, 2D2, which had an indirectly heated cathode to simplify the application of a.g.c.
- The output pentode, PM22D.
- A variable-mu r.f. hexode, VP2B, which could be used as a pentode by strapping g_2 and g_3 and earthing g_4, or as a mixer by strapping g_2 and g_4.
- The FC2A octode frequency changer, which had a higher conversion conductance than the earlier FC2 and was suitable for short wave operation.
- A general-purpose triode, PM2HL, which eventually became a replacement for the PM1A, PM1HF, PM1HL, PM2DL and PM2DX.
- The QP22B, which replaced the earlier QP22A and did not require special grading for the auxiliary grids of the two pentodes sections because they were far better matched. However, whereas the QP22A had a 9-pin base, the QP22B had a 7-pin base because the two screen grids were now internally strapped, so, for replacement purposes, it was necessary to change the valveholder.
- Finally, there was the TH2 triode hexode frequency changer with a conversion conductance of 0.43mA/V.

Examples of these later valves can be seen in Figures 8.4, 8.5 and 8.6.

1.4V, 1.5V & 2V BATTERY RANGES WITH Sm4, Ct & IO BASES (Table 8.3)

During the period 1936 to 1946 there were several battery ranges designed for use in miniature and portable equipment. The first of these appeared in 1936 and was intended for hearing aids or portable audio amplifiers. These were the DA1 high-impedance triode and the two output triodes DA2 and DA3; two years later the DAS1 tetrode was added to the range. These all had two-volt filaments and the miniature Sm4 base.

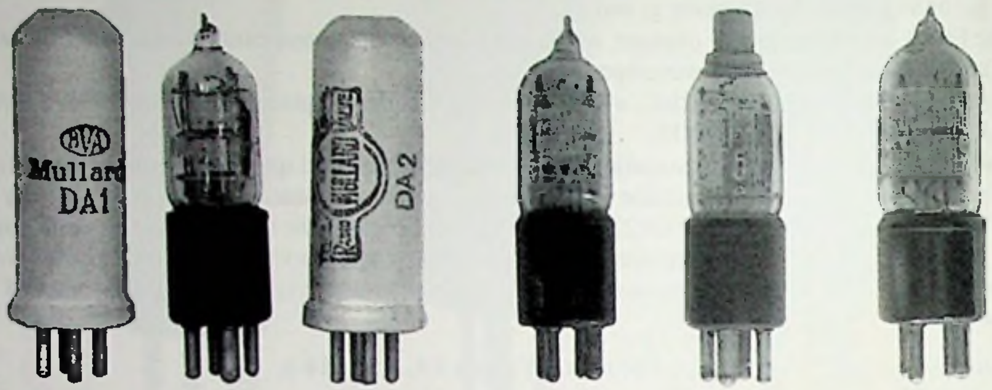
Range	Year	RF tetrode or pentode	Frequency changer	Diode, triode or DD triode	Output triode or double triode	Output pentode or duo pentode
2-volt midgets for hearing aids	1936			DA1	DA2, DA3	
	1938	DAS1				
1.5-volt midgets for hearing aids	1939	DF51 DBS1		DB1, DB3, DC51	DD51	DL51
1.4-volt Ct	1939	DF1	DK1	DAC1		DL1, DL2
1.4-volt, IO, US types	1939/40	1N5GT	1A7GT	IH5GT		3Q5GT, 1C5GT
Standard British (equiv.) types	PW	DF33	DK32	DAC32		DL33, DL35
Non-standard British types	PW	DF31, DF32		DAC31, DBC31		DL31
2-volt, IO types	1946	KF35	KCF32, KK32	KBC32		KL35, KLL32

Table 8.3: 1.4V, 1.5V and 2V battery ranges with Sm4, Ct and IO bases: 1936 to post WW2.

A further range of miniature valves appeared in 1939. These all had 1.5-volt filaments and, like the earlier types, had the Sm4 base. In this range there was the DF51 pentode, DBS1 tetrode, the high impedance triode, DB1, a low impedance triode, DB3, another high impedance triode, DC51, an output triode DD51and an output pentode DL51. The DF51, DC51 and DD51 were intended for use in hearing aids. Examples of two- and 1.5-volt valves are shown Figure 8.7.

Also in 1939, Mullard launched a range of 1.4-volt valves with the continental Ct8 base having eight side contacts (also known as the P-base). This range comprised the DF1 variable-mu r.f. pentode, the DK1 heptode frequency changer, the DAC1 single diode triode and the two output pentodes, DL1 and DL2. The valves all had 50mA filaments, except for the higher power output pentode, DL2, which had a 100mA filament. Examples of these 1.4-volt valves are shown in Figure 8.8.

One receiver that used these was the Philips 229B All-Dry Portable superhet of 1940, where the valves used were the DK1, DF1, DAC32 and DL35.



2-volt triodes: DA1 (left & centre); DA2 (right). The metal can versions were non-standard.

DA3: 2-volt output triode.

DF51: 1.5-volt tetrode.

DC51: 1.5-volt a.f. triode.

Figure 8.7: All these midget valves were designed primarily for use in hearing aids but they were also used in miniature amplifiers. (Note the special versions of the DA1 and DA2 mounted within screened cans.)

DF1: r.f. pentode.

DK1: heptode.

DAC1: single diode triode.

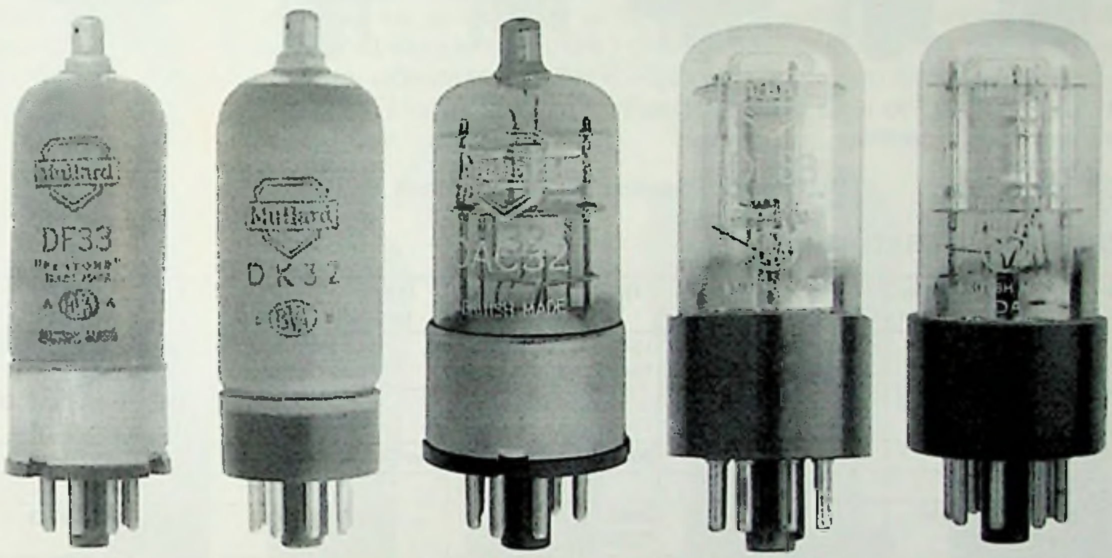
DL1: output pentode.

Figure 8.8: Examples of 1.4 volt battery valves of 1939 with continental Ct8 bases.

In 1939 Mullard marketed a range of US valves which were originally named the Amerty Series (Amerty was an abbreviation for **Amer**ican **Ty**pe). These valves had both the international octal (IO) base and the US4-US7 bases (usually, although inaccurately, known in Britain as UX bases). These will not be discussed in any detail here but many of the US types available in the UK are discussed in Chapter 14. Mention will be made, however, of the series of 1.4 volt, 50mA valves with the octal base because Mullard produced equivalent types in the post-war period, as also did MOV. These valves are listed in Table 8.3 and consist of the following types (Mullard equivalents shown in brackets): 1N5GT (DF33) variable-mu r.f. pentode, 1A7GT (DK32) heptode, 1H5GT (DAC32) single diode triode, and the two output pentodes 1C5GT (DL35) and 3Q5GT (DL33). The 3Q5GT had a centre-tapped filament, which meant it could be operated either on 2.8 volts or 1.4 volts; in the parallel operation (1.4 volts) it could produce a slightly higher output power, but, of course, its filament current was doubled to 100mA. Examples of these valves are shown in Figure 8.9.

The Mullard versions of the valves were used in several post-WW2 potable radios such as the Pye 75B and the McMichael 463. These both used the DK32, DF33, DAC32 and DL35.

There were also several non-standard types in the range, but these were primarily Philips products, although they have been listed in Mullard publications. These are the DF31 pentode, DF32 variable-mu pentode, DAC31 single diode triode, DBC31 double diode triode and DL31 output pentode.



DF33: r.f. pentode. DK32: heptode. DAC32: single diode triode. DL33: output pentode. DL35: output pentode.

Figure 8.9: Examples of the 1.4 volt range with IO bases.

The last of the battery ranges to be released during this period was the K Series which appeared in 1946. This was a two-volt range with octal bases and comprised the KF35 variable-mu r.f. pentode, KCF30 triode pentode frequency changer, the KK32 octode frequency changer, KBC32 double diode triode, KL35 output pentode and the KLL32 double output pentode. Of these the KCF30 was soon discontinued. The KL35 could deliver an output of 310mW, with self-bias, or 340mW with fixed bias but for this required an h.t. of 135 volts. The KLL32, on the other hand, being a double pentode, could deliver 1.2 watts in push-pull with an h.t. of 135 volts, or 0.45 watts at the lower h.t. of 90 volts. Examples of the K series are shown in Figure 8.10.

The K Series was superseded by the 1.4-volt, B7G-based, D90 Series in the late 1940s and this was the last of the Mullard ranges of battery receiver valves. (A radio using these was the Peto Scott BP31, released in June 1947.)

KF35: variable-mu r.f. pentode. KCF30: triode pentode. KK32: octode. KBC32: double diode triode. KL35: output pentode. KLL32: double output pentode.

Figure 8.10: Examples of the battery two-volt 'K' series.

4-VOLT AC VALVES (Table 8.4)

Range	Year	RF tetrode or pentode	Freq. Changer	Diode	Triode or DDT	Output triode	Output pentode	Tuning indic.	Rectifier
British bases	1929	S4V (B4 & B5)			154V, 164V, 354V	104V			DU2 (1928, DU10 (1928)
	1930	S4VA, S4VB							DU1, DU3, DU4, DU5, DW1, DW2, DW8,
	1931	MM4V			904V	054V	Pen4V		DW3, DW4
	1932	VM4V							
	1933	SD4, SP4*, VP4*			244V, TDD4				IW2, IW2A, IW3
	1934	VP4A	FC4, TP4	2D4, 2D4A			Pen4VA*		IW4
	1935	SP4B, VP4B			484V, 994V		Pen4VB (= PenA4)		
	1936		TH4						DW4/350, IW4/350
	1937		TH4A	2D4B		TT4	Pen4DD, Pen428, PenA4, PenB4		
	1938		TH4B						
	1939					TT4A			DW4/500, FW4/500, IW4/500
	1940s						AL60		FW4/800, AX50
Ct 8 base	1936	SP4C						TV4	
	1938							TV4A	AZ1, AZ2, AZ3
	1939								AZ50

* The SP4, VP4 and Pen4VA have 5- or 7-pin bases.

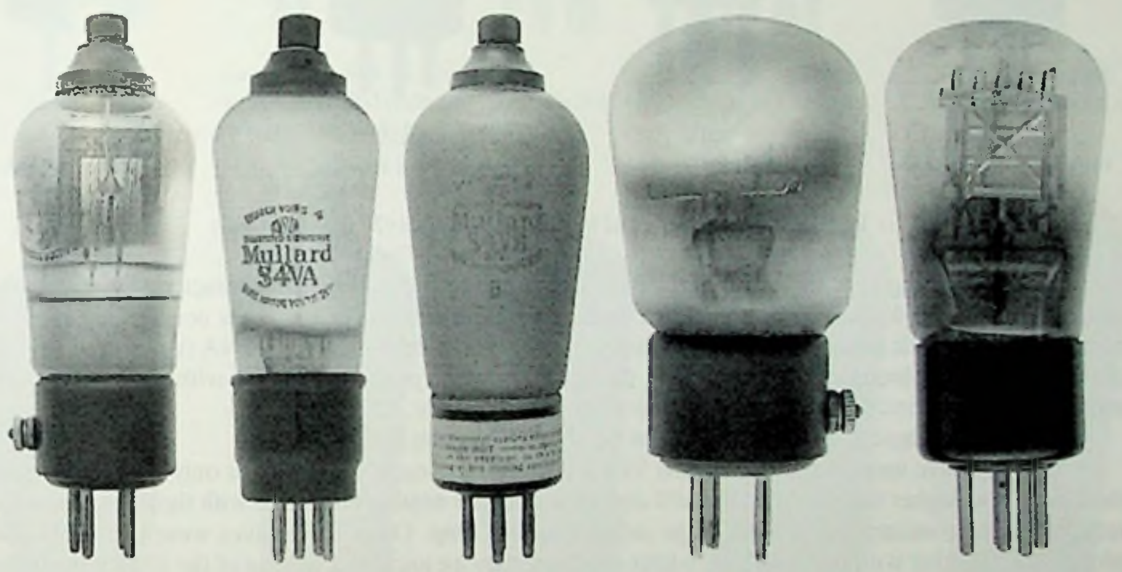
Table 8.4: Four-volt a.c. valves with British and side contact bases, 1929 to WW2.

The first indirectly heated valves for a.c. operation were introduced in 1929. However, the DU2 full-wave rectifier and the DU10 half-wave rectifier appeared a year earlier; both were directly heated and intended for battery eliminators. The 1929 valves consisted of the S4V r.f. tetrode, the 154V low impedance triode with a 4-pin base and side terminal for the cathode connection, the 164V and 354V general-purpose triodes with 5-pin bases, and the 104V output triode, which also had a 5-pin base. There was also a 152T output triode with a 4-pin base and side terminal but this was soon withdrawn.

The S4V was initially fitted with a 4-pin base and side terminal for the cathode connection but this was very soon replaced by a 5-pin base; it had a slope of only 1.1mA/V but in the following year there were two new r.f. tetrodes with higher slopes: the S4VA (2mA/V) and the S4VB (2.5mA/V). Also in 1930, there were several new rectifiers. The half-wave types were the DU1, rated at 250V, 30mA and the DU4 (500V, 60mA). The full-wave types were the DW1 (250V, 30mA), DW2 (250V, 60mA) and the DW8 (425V, 60mA). Although the release date is not clear, there were two other rectifiers around this time: the DU3 (500V, 30mA) and the DU5 (300V, 75mA), both half-wave types. One suspects that many of these rectifiers were very similar and were selected for their voltage and current ratings. All the DU and DW types were directly heated.

Mullard's first variable-mu r.f. tetrode, the MM4V, appeared late in 1931. Other 1931 types were the high impedance triode, 904V, for use as a detector or RCC audio amplifier, the 054V output triode, the Pen4V output pentode and two full-wave rectifiers, DW3 (350V, 120mA) and the DW4 (500V, 120mA). In the following year the MM4V was replaced by the VM4V, which had very similar characteristics.

Examples of these 1929 to 1932 valves are shown in Figure 8.11 and 8.12.

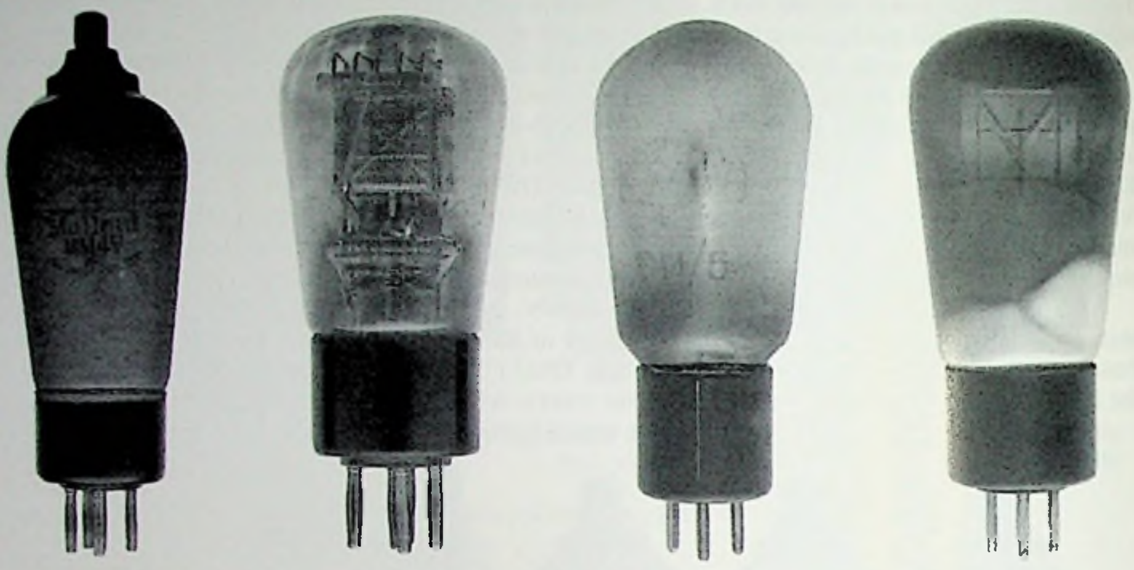


S4V: r.f. tetrode (early 4-pin version with side terminal). | S4VA: r.f. tetrode. (Cossor supply.) | S4VB: r.f. tetrode. | 154V: a.f. triode with 4-pin base and side terminal. | 354: detector or general-purpose triode.

Figure 8.11: Examples of Mullard a.c. valves of 1929 to 1932.

New types of 1933 were a single diode tetrode, SD4, intended as a detector and a.f. amplifier, the SP4 r.f. pentode, which was also used as a first detector or frequency changer in early superhet receivers, the VP4 variable-mu r.f. pentode, the 244V general-purpose triode, which was also used as a 'power grid' detector and capable of handling peak inputs up to four volts, and the TDD4 double diode triode. There were also three indirectly heated full-wave rectifiers: the IW2 and IW2A, both rated at 250V, 60mA and the IW3 rated at

350V, 120mA. (The IW2A had twice the heater current of the IW2.) The SP4 and VP4 were both supplied with either a 5-pin or 7-pin base; with the 5-pin versions the suppressor grid was internally connected to the cathode, but with the 7-pin versions it was taken out to pin 3. The 5-pin version of the SP4 was a replacement for the S4V, S4VA and S4VB.



MM4V: variable-mu r.f. tetrode. 904V: detector triode. DU5: half-wave rectifier. DW3: full wave rectifier.

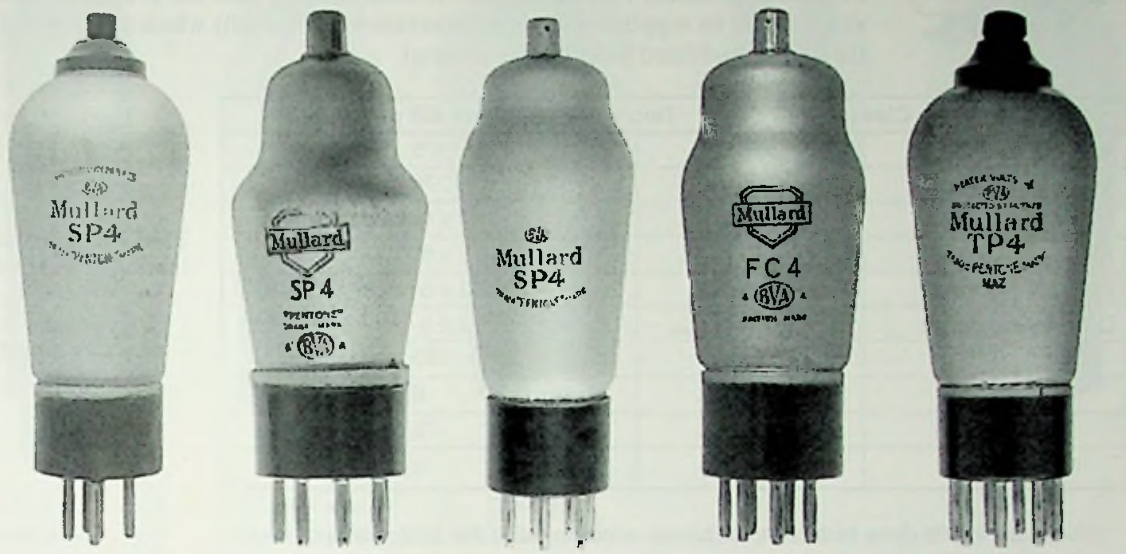
Figure 8.12: Examples of Mullard a.c. valves 1929 to 1932 (cont.).

In the following year there was the VP4A variable-mu r.f. pentode with characteristics slightly better than those of the VP4; this was also supplied with either 5-pin or 7-pin bases. Other new types were the FC4 octode and TP4 triode pentode frequency changers, two double diodes, 2D4 and 2D4A (the former having one of the diode anodes brought out to a top cap), the Pen4VA output pentode (supplied with 5-pin or 7-pin bases) and the IW4, an indirectly heated full-wave rectifier, rated at 500V, 120mA.

Examples of these 1933 and 1934 valves are shown in Figure 8.13.

In 1935, there appeared the SP4B and VP4B with grid top caps. These valves only had 7-pin bases and their slope was higher than those of the SP4 and VP4. Another notable difference with these two valves was a reduced heater consumption of 0.65 amps rather than one amp. Other new valves were the 484V detector triode (this, together with the 244V, were later superseded by an improved version of the 354V), the high gain 994V triode and the Pen4VB output pentode with a slope of 10mA/V, making it suitable for connection directly to the output of a diode detector. (Note: the 164V, 244V, 354V and 904V initially had 1-amp heaters but by 1935 the heater current had been reduced to 0.65 amps.

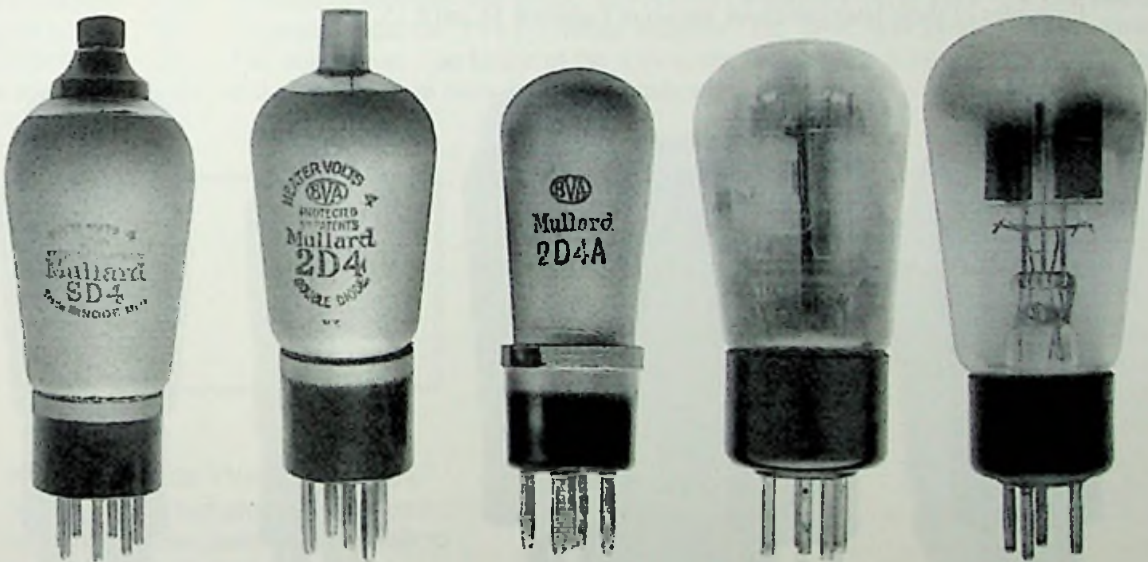
Mullard's first triode hexode frequency changer, the TH4, appeared in 1936. Over the next two years there was first the TH4A and then the TH4B, which replaced both the earlier types. Also in 1936 there was a consolidation of rectifiers with the DW4/350 replacing the DW3 and the IW4/350 replacing the IW2, IW2A and IW3. Apart from the TH4B, other valves to appear in 1937 were the 2D4B with a 7-pin base (the earlier 2D4 and 2D4A had a 5-pin base), the TT4 output triode with an indirectly heated cathode and capable of an output of 500mW, the Pen4DD double diode output pentode with a slope of 9.5mA/V, enabling the pentode section to be driven directly from one of the diodes, the PenA4 having a 7-pin base and a direct replacement for the earlier Pen4VB. and the high-slope PenB4 with a 7-pin base. Finally there was the Pen428, a high-power output pentode for use in single-ended or push-pull amplifiers (see Table 8.5.)



Three versions of the SP4 r.f. pentode.
At left, the 5-pin version. Centre and right are 7-pin versions.
(The centre valve was made by Cossor.)

FC4: octode frequency changer.

TP4: triode pentode frequency changer.



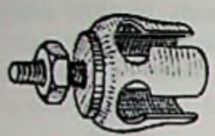
SD4: single diode tetrode, detector & a.f. amplifier.

(Left) 2D4 double diode with top cap anode for d". (Right) 2D4A which replaced the 2D4.

244V: detector or general-purpose triode.

IW2A: full-wave rectifier.

Figure 8.13: Four-volt a.c. valves of 1933 to 1934.
(Note: both the SD4 and the TP4 are early versions with top terminals.)



In the early 1930s there was a changeover from a top terminal to a metal thimble. Mullard announced early in 1935 that this new top cap was about to be fitted to the SP2 and VP2 battery r.f. pentodes, but in order to allow their use in existing sets each valve would be supplied with an adapter (shown at the left) which was pressed over the top cap and fitted with a screw terminal.

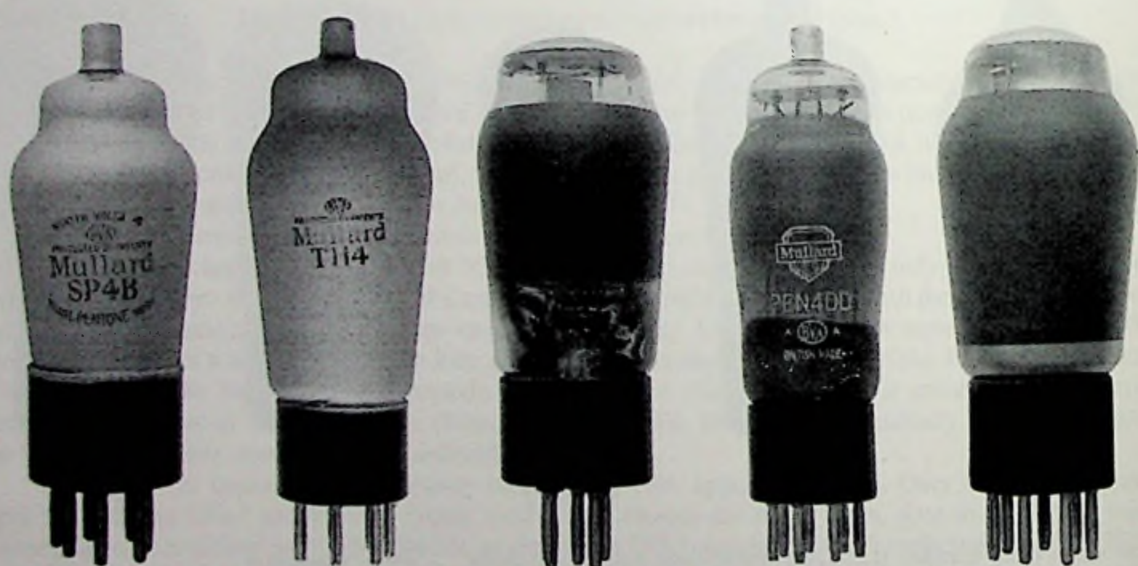
Single valve Class A			Two valves in Class AB push-pull			
V_a	250	V	V_a	250	375	V
V_{g2}	250	V	V_{g2}	275	275	V
R_k	150	Ω	$I_{a\,(o)}$	2 x 52	2 x 48	mA
R_a	3.3	kΩ	$I_{a\,(max)}$	2 x 66	2 x 62	mA
P_{out}	8.0	W	$I_{g2\,(o)}$	2 x 4	2 x 5	mA
D_{tot}	10.0	%	$I_{g2\,(max)}$		2 x 9	mA
			R_k†	120	165	Ω
			$R_{a\text{-}a}$	4.5	6.5	kΩ
			P_{out}	19.0	28.0	W
			D_{tot}	6.0	3.0	%

Table 8.5: Operating conditions for Pen 428 output pentode.

† Common cathode resistor

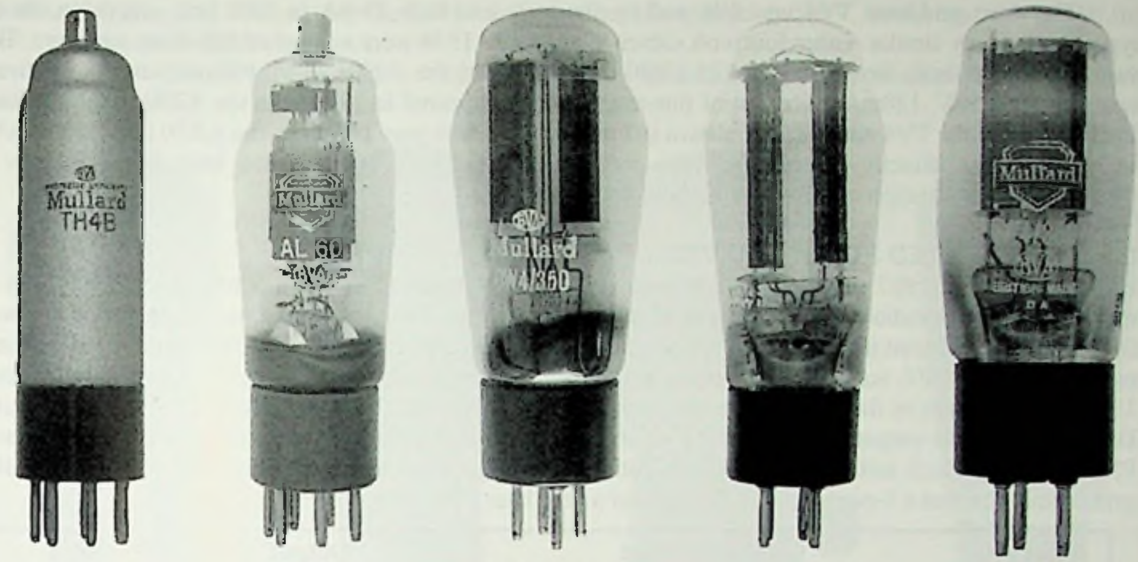
As the 1930s drew to a close there was another indirectly heated output triode, the TT4A. This was very similar to the TT4 but had a higher slope. There was also a further consolidation of rectifiers. The DW4/500 replaced the DW4, the IW4/500 replaced the IW4 and there was a new directly heated type, the full-wave FW4/500, rated at 500V, 250mA. Finally there was the AL60 output pentode which had a top cap anode connection, a pair of which produced an output power of 14.5 watts in Class AB1 push-pull.

Examples of these later valves are shown in Figures 8.14 and 8.15.



SP4B: r.f. tetrode. TH4: triode hexode frequency changer. TT4: indirectly heated output triode. Pen4DD: double diode output pentode. Pen A4: output pentode.

Figure 8.14: Four-volt a.c. valves of 1935 to 1939.

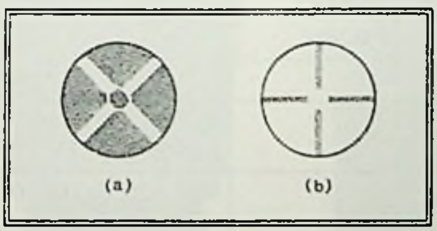


TH4B: triode hexode frequency changer.	AL60: 8-watt output pentode.	DW4/350: full-wave rectifier.	FW4/500: full-wave rectifier.	IW4/350: full-wave rectifier.

Figure 8.15: Four-volt a.c. valves of 1935 to 1939 (cont.).

4-volt valves with side contact bases

Mullard produced a small range of four-volt side contact valves over the period 1936 to 1939. The first two of these were the SP4C r.f. pentode and the TV4 [5] tuning indicator. The SP4C was identical to the SP4B except for the base and its dimensions. The image of the TV4 is shown in Figure 8.16 and differs from the more normal fan-shaped shadow found on many later tuning indicators.



With no signal the TV4 shows a green cross on a dark background (a). When a signal appears the illumination spreads to produce a dark cross on a green background (b).

Figure 8.16: Diagram showing images produced by the TV4 tuning indicator.

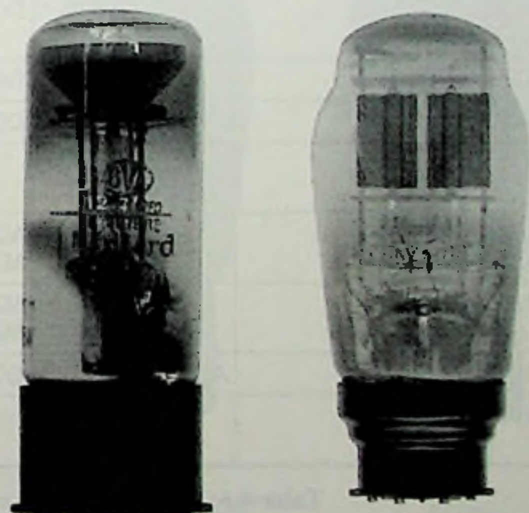


Figure 8.17: (Left) TV4 tuning indicator, (right) AZ3 full-wave rectifier.

The short grid-base TV4 was followed by the long grid-base TV4A in 1938 but, otherwise, the two types looked very similar. Other four-volt valves to appear in 1938 were a range of full-wave rectifiers. There were the two directly heated types AZ1 (300V, 100mA) and the AZ2 (500V, 160mA), and the indirectly heated AZ3 (350V, 120mA). The last of this range, which appeared in 1939, was the AZ50 (500V, 250mA). Photographs of the TV4 and AZ3 are shown in Figure 8.17. There was, however, the AX50 (500V, 250mA), a mercury vapour, directly heated, full-wave rectifier of the 1940s, but this was later superseded by the FW4/500. (A photograph of this valve is shown in Figure 8.21.)

DIRECTLY HEATED POWER VALVES & RECTIFIERS

During the period 1927 to 1938 Mullard produced a comprehensive range of power triodes, pentodes and rectifiers for use in radio receivers and public address amplifiers. These covered a wide range of output power from less than one watt up to several tens of watts and are listed in Table 8.6. The first of the triodes were an extension to the DFA series (an abbreviation for **D**ull **F**ilament **A**mplifier), a range that was introduced in 1924. The last three in this range were the output triode, DFA7, which could deliver one watt, the a.f. triode DFA8, and another output triode, DFA9, with an output power of 840mW. About the same time there was the PM24 pentode which had a 500mW output; initially this had a 4-pin base with side terminal for the auxiliary grid connection, but a 5-pin base was fitted about a year later.

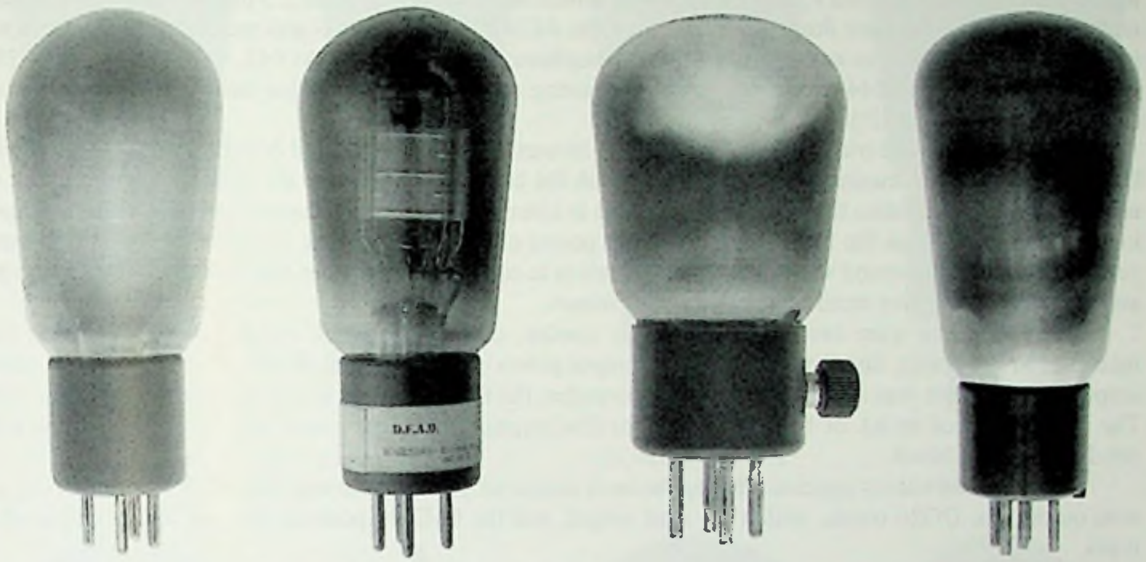
Date	Output triodes			Output pentodes	Rectifiers
	< 2 watts	2-5 watts	> 5 watts		
1927	DFA7, DFA8				
1928	DFA9			PM24 (4-pin)	
1929		DO20		PM24 (5-pin) PM24A	DW15, DW30
1930	AC064, AC104	AC044, AC084, AC084N	AC054, DO25, DO60	PM24B	DU15
1931			DO24, DO75	PM24C, PM24D	DW6
1932			DO10	PM24M	
1933			DO26		
1934					RZ1-75, RZ1-150, RZ1-250
1935			MZ05-60, MZ1-75		RG1-125, RG1-250
1936			MZ1-100, MZ2-250		RG2-500
1937		AC042	DO30	PM24E	
1938					RG1-240, RG1-240A AX50 (PW)

Table 8.6: Directly heated a.c. output triodes, pentodes and rectifiers.

In 1929, there appeared the DO20 triode, which was claimed to deliver a power of three watts, but two years later this was amended to four watts and, at the same time, the filament current was reduced from 1.3 amps to 1.1 amps. Also in 1929, there was the PM24A pentode, with an output of 1.5 watts (later increased to

2.5 watts). Other 1929 valves were the DW15 full-wave rectifier, rated at 500V, 60mA and the DW30 full-wave rectifier, rated at 500V, 120mA.

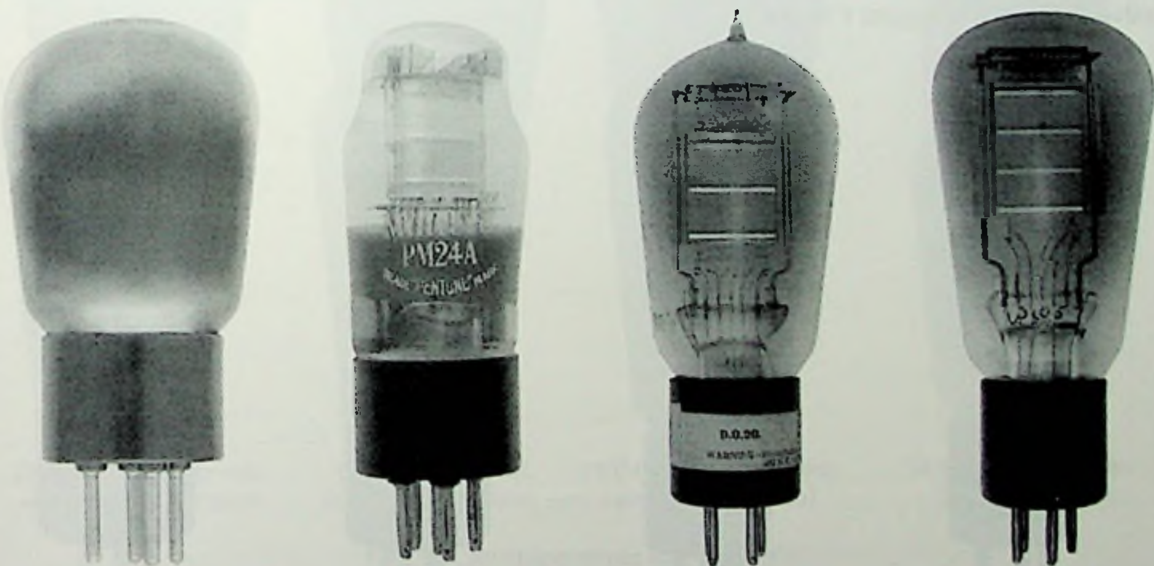
Examples of these 1927 to 1929 valves are shown in Figure 8.18. (Two versions of the DW30 can be seen in Figure 8.19.)



DFA7:
1-watt output triode.

DFA9:
840mW output triode.

PM24: 500mW output pentode
(4-pin version at left and 5-pin version at right).



PM24A: 1.5-watt output pentode.
Early version at left and later, 2.5-watt version at right.

DO20: 3-watt triode
(early pip-top version).

DO20:
later 4-watt version.

Figure 8.18: Directly heated output triodes and pentodes of 1927 to 1929.

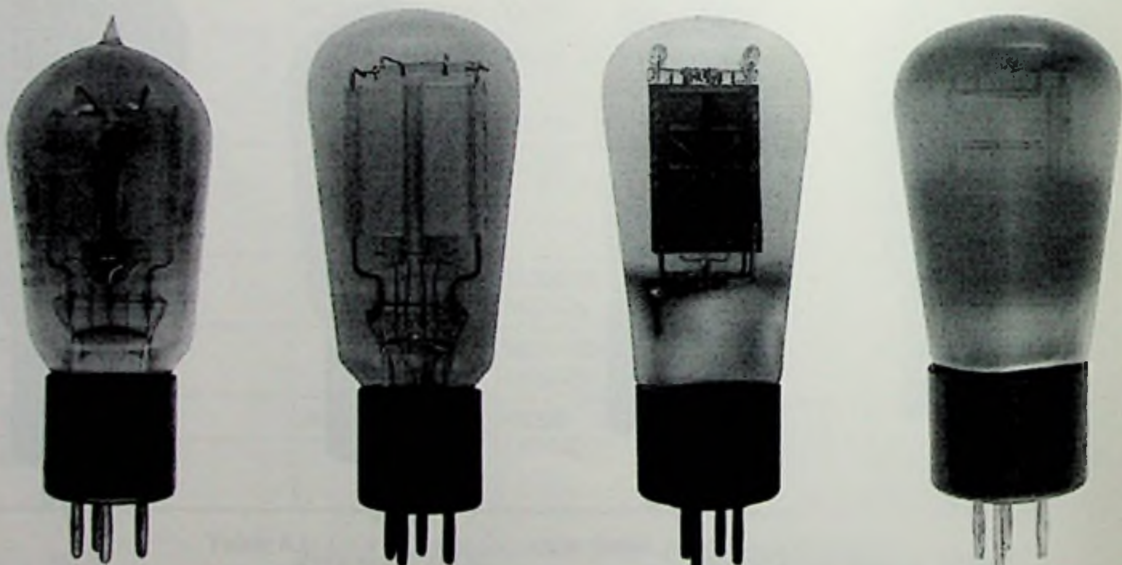
Several new triodes appeared in the following year. The lower power types were the AC064 (620mW) and the AC104 (400mW). In the medium power range there was the AC044, which initially had an output of one watt but was later increased first to 2.7 watts and eventually to 3.5 watts; there was also the AC084, which had a slope of 1.1mA/V, and the AC084N which had a higher slope of 2.5 mA/V. These two, together with the AC042, were later dropped in favour of the AC044. All these low- and medium-power valves were intended mainly for use in radio receivers or gramophone amplifiers. (The AC042, which appeared in 1937, was identical to the AC044 except for its filament rating of 2-volt, 2-amps rather than 4-volt, 1-amp and was similar to the Cossor 2XP.)

The highest power triode to be released in 1930 was the DO60 that could deliver an output of ten watts. Unlike all the earlier triodes, which had the British B4 base, the DO60 had the 4-pin, L4 base, which was necessary to accommodate the larger bulb size and to cater for the filament requirement of 6-volts, 4-amps. A lower power triode was the DO25 with an output power of five watts, which was increased to seven watts a year later with an improved version. Two other valves to appear in 1930 were the three-watt PM24B pentode and the DU15 half-wave rectifier, rated at 500V, 60mA.

In 1931, there were two new high-power triodes: the DO24, which could deliver five watts (later increased to 7.1 watts), and the DO75 with an output power of 18 watts and intended for large public address amplifier use. There was also two new output pentodes: the PM24C (eight watts) and the PM24D (ten watts). The DO75 required an h.t. of 1000 volts and, for this purpose, there was a new full-wave rectifier, the DW6, rated at 1000V, 120mA.

Three further valves appeared during the next couple of years. There was the DO10 triode, having a six watt output, the DO26 triode, with a 7.5 watt output, and the PM24M pentode with the lower output of 2.8 watts.

With gradual rationalization over the years the PM24 was replaced by the PM24A (although the 4-pin version of the PM24 required a change to a 5-pin base); also the PM24B and PM24C were replaced by the PM24M, although, in both cases, it was necessary to re-design the circuit. Examples of the 1930 to 1933 valves are shown in Figures 8.19 to 8.21.

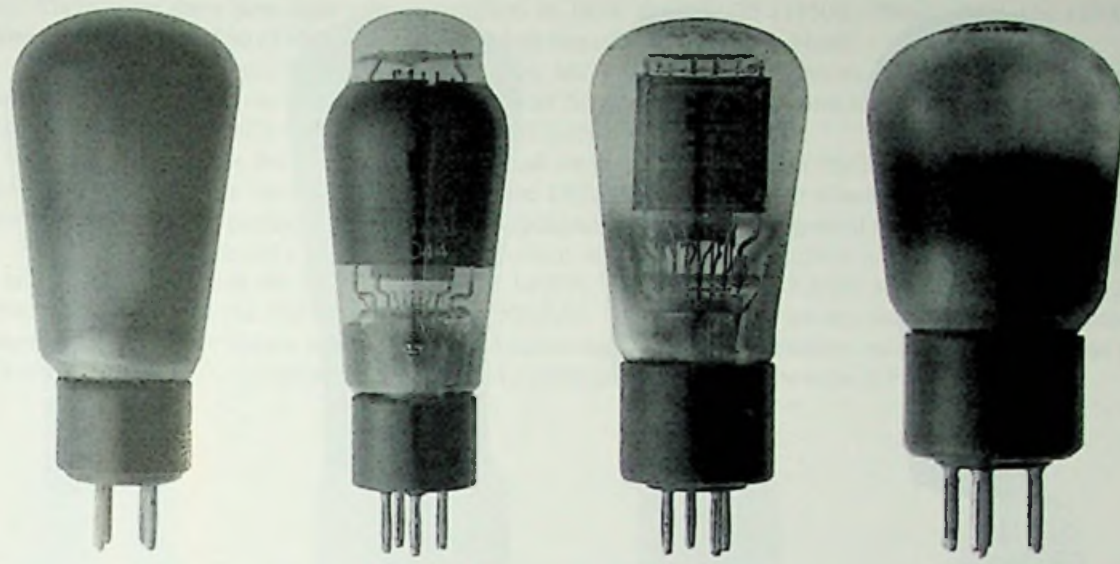


DW15: full-wave rectifier. 500V, 60mA (early version).

DW30: full-wave rectifier rated at 500V, 120mA. Early thoriated version at left and oxide version at right.

AC064: 620mW triode.

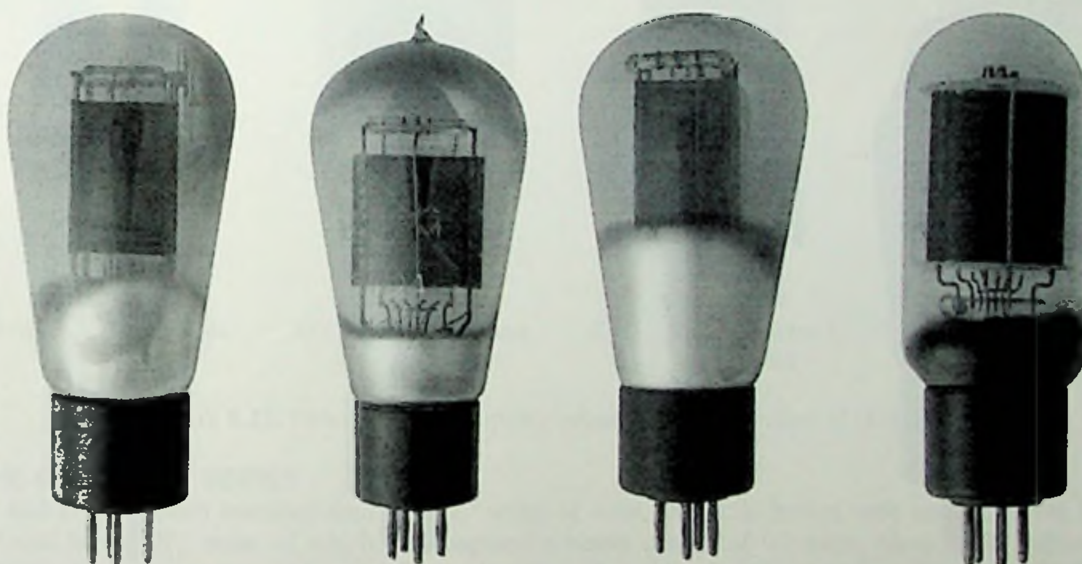
Figure 8.19: Directly heated triodes and rectifiers of 1929 to 1930.



AC044: early 1-watt version at left and later, 3.5-watt version at right.

AC084 & AC084N 4-watt triode.

AC104: 400mW triode.



DO23: output triode with very fine grid wire pitch

DO24: 5-watt triode (early pip-top version).

DO24: 5-watt triode (early version with 'S' bulb).

DO24: 7.1-watt triode (later version).

Figure 8.20: Output triodes of 1930 to 1931. (No data has been found for the DO23.)

DO25: 5-watt triode (later increased to 7 watts).

DO26: 7.5-watt triode.

PM24B: 3-watt pentode.

PM24D: 10-watt pentode.

PM24M: 2.8-watt pentode.

PM24E: 10-watt pentode (later version).

AC042: 3.5-watt triode of 1937.

AX50: mercury vapour rectifier (Philips make).

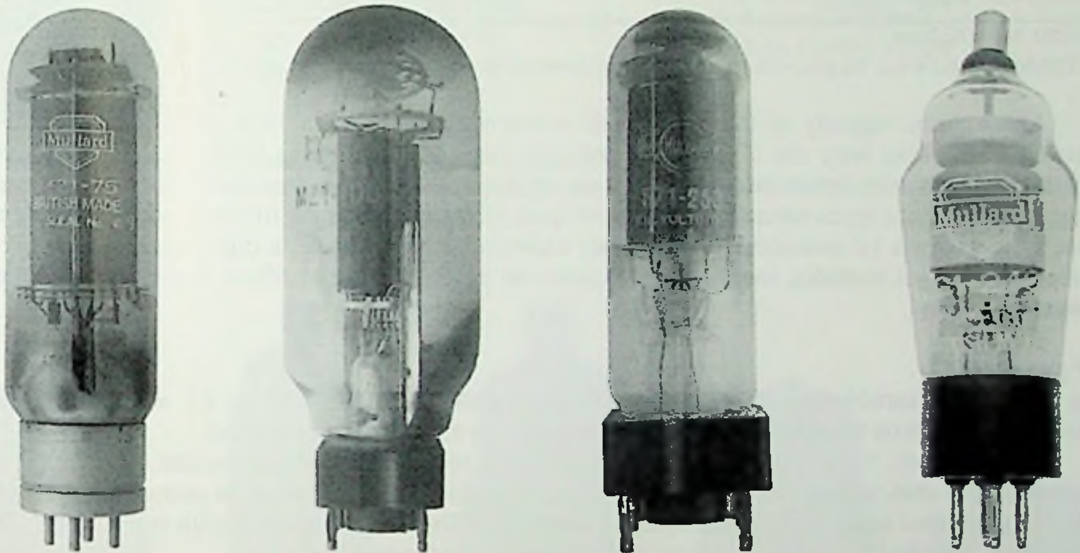
Figure 8.21: Directly heated output triodes and pentodes. The first five of these appeared in the period 1930 to 1933 and the remaining three from 1937 to the 1940s.

There were three new high-voltage rectifiers in 1934: the RZ1-75 (1150V, 70mA), RZ1-150 (1000V, 150mA) and the RZ1-250 (1500V, 500mA). The last two of these had the L4 base.

In the following year Mullard introduced the MZ series of output triodes for use in public address amplifiers [6]. The first two of these were the 10-watt MZ05-60 and the 20-watt MZ1-75. Types to appear in 1936 were the 30-watt MZ1-100 and the 75-watt MZ2-250.

In 1937, there was the eleven-watt DO30 and the short-lived 6.6-watt PM24E output pentode. There were also other types in the DO series, such as the DO23 (Figure 8.20) for which no data has been found; presumably these were produced for specialized applications rather than for general use.

Mullard also produced a small range of half-wave, mercury vapour rectifiers which appeared in the mid- to late-1930s. There was the RG1-125 (rated at 1400V, 250mA) with an Edison screw base; the RG1-240 (1500V, 500mA) and the RG1-240A (1670V, 500mA), these latter two having standard 4-pin, B4 bases. Examples of these are shown in Figures 8.22. Another mercury vapour rectifier, mentioned earlier, was the full-wave AX50 which appeared in the 1940s and a photograph of this can be seen in Figure 8.21.



MZ1-75: 20-watt triode with BC4 base. | MZ1-100: 30-watt triode with L4 base. | RZ1-250: 1500V, 500mA half-wave rectifier. | RG1-240A: 1670V, 500mA mercury vapour rectifier.

Figure 8.22: Directly heated high-power output triodes and rectifiers of 1934 to 1938.

THE 6.3-VOLT 'E' SERIES

In mid-1938 Mullard launched their Red 'E' series of octal, indirectly heated, side contact valves having 6.3-volt heaters [7], many of which only required a heater current of 0.2 amps. Most of the valves were suitable for a.c., a.c./d.c. and car radio applications. As with all receiver valves following the Philips acquisition of Mullard in the mid-1920s, they were designed in Holland and this range appeared on the Dutch market in 1936. The special features of the valves were their small size, low heater consumption—resulting from a short cathode—good heat radiation and mechanical rigidity. The small dimensions meant closer spacing of the electrodes which reduced the electron transit time, making the valves particularly suitable for use at higher frequencies. Starting in 1940, many of the existing valves, together with new types, were fitted with the international octal base and the number 3 was added to the alphanumeric type designation (e.g. EF6 became EF36). Table 8.7 lists the types that were available on the British market over the period 1937 to 1946.

Range	Year	RF tetrode or pentode	Frequency changer	Diode	Triode or DDT	Output pentode	Tuning Indicator	Rectifier
6.3V side contact base	1937						TV6 = EM1	EZ2
	1938	EF5, EF6, EF8, EF9	ECH2, EH2, EK2, EK3	EB4, EAB1	EBC3	EBL1, EL2, EL3, EL5, EL6	EM1, EM3	EZ1, EZ3
	1939	EBF2, EF2	ECH3			Pen 650 = EL50, EL51	EFM1, EM4	
6.3V octal base	1939		TH62					AZ31, AZ32
	1940	EF36, EF38, EF39	ECH33, EK32		EBC33	EBL31, EL32, EL33, EL36		
	1941		ECH35	EB34				
	WW2				ECC31	EL35	EM31	EZ35
	1946	EF37		EB91*	EBC33, ECC32, ECC33, ECC34			
	PW	EBF32			EC31, ECC35	EL31, EL37	EM34, EM35	

*EB91 has B7G base.

Table 8.7: 6.3V a.c. ranges with side contact and international octal bases (AZ31 and AZ32 have 4-volt filaments).

Although the majority of the side contact valves were launched in 1938 two types appeared in the previous year: these were the TV6 tuning indicator (later re-classified as EM1) and the EZ2 full-wave rectifier. Except for its heater rating the TV6 was identical to the earlier four-volt type TV4. The complete range of side contact types released between 1937 and 1939 is shown in the first three rows of Table 8.7. Of these there were six r.f. pentodes, five frequency changers, a double diode, a triple diode, one double diode triode, seven output pentodes, four tuning indicators and three full-wave rectifiers. These groups will now be considered in turn.

RF pentodes

The EF5 had a variable-mu characteristic and was suitable both as an i.f. or r.f. amplifier in all-wave receivers. The EF6 on the other hand was better suited as an a.f. amplifier or detector.

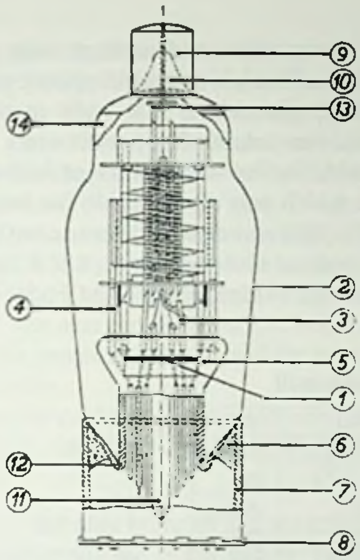
The low-noise, variable-mu EF8 had four grids, the additional grid being located between the control grid and screen grid, with the wires of g_2 and g_3 exactly aligned with each other. In normal use the additional grid was connected to the cathode and caused a bunching of the electrons on their path to the anode. This had the effect of reducing the screen grid current, thereby reducing the partition noise.

The variable-mu EF9 differed from the EF5 in that instead of having a fixed screen voltage it was connected to the h.t. line via a series resistor so that its voltage varied as the a.g.c. bias was applied. Without any a.g.c. voltage the screen potential was adjusted to about 100 volts, but as the control voltage increased the screen current fell and hence the voltage across the screen series resistor also fell, resulting in an increase in the screen voltage; this was claimed to reduce cross modulation. Finally there was the EBF2, a double diode r.f. pentode. Figure 8.23 shows a typical example of the r.f. pentodes and an internal view of the EF9.

Frequency changers (Figure 8.24)

Initially, the frequency changers consisted of the ECH2 triode heptode, the EH2 heptode and the octodes EK2 and EK3. In 1939 the ECH2 was superseded by the ECH3 which was particularly suitable for short wave use where its frequency drift was less than 1 kHz at 15m (20MHz) for a mains voltage variation of 10%. The EH2 was intended as a mixer for frequencies up to about 60MHz (5m) and required a separate triode oscillator such as the EBC3. The EK2 octode had an internal capacitor between the first and fourth grids to compensate for an apparent negative capacitance produced by electronic coupling; this enabled the valve to be used on short waves. The EK3 was described as a four-channel octode: the electrons from the cathode were formed into four bunches—two of these served the oscillator section of the valve and two the mixer section, thereby separating the two sections, with the advantage of ensuring improved oscillator stability on short waves.

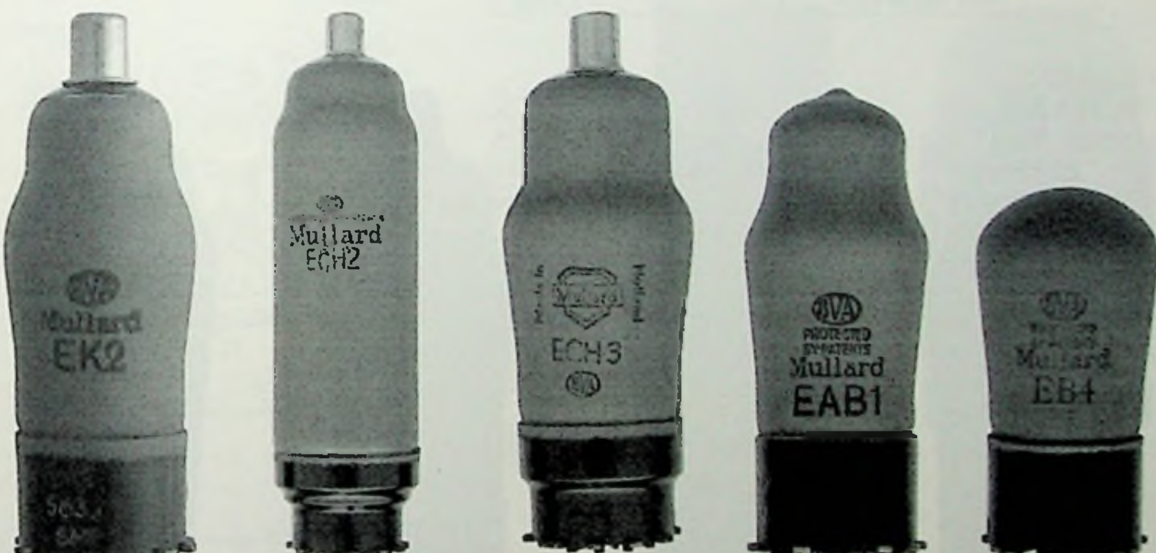
EF6 general-purpose pentode. The EF5, EF8 and EF9 look similar.



Internal view of the EF9 variable-mu r.f. pentode with sliding screen grid voltage operation.

1. Getter plate
2. Bulb
3. Cathode leading-in wire
4. Support rod for electrode assembly
5. Pinch
6. Cement securing the base to the bulb
7. 'Philite' base
8. Base contact
9. Top cap for grid connection
10. Sealed aperture in bulb for grid connecting lead
11. Pumping tube
12. Fused joint between bulb and pinch
13. Grid connecting lead
14. Metallic coating of bulb

Figure 8.23: 'E' series r.f. pentodes of 1938.



EK2: octode. ECH2: triode heptode. ECH3: triode hexode. EAB1: triple diode. EB4: double diode.

Figure 8.24: 'E' Series frequency changers and diodes.

Diode and diode-triode combinations

Valves having diode and diode triode combinations were the EB4 double diode, the EAB1 triple diode, and the EBC3 double diode triode (see Figures 8.24 and 8.25).

Output pentodes (Figure 8.25)

The EL2, with its 0.2-amp heater, was aimed at car radios and could provide an output power of 3.3 watts from a 250-volt supply. The EL3 had a high slope of 9mA/V, so could operate without a triode driver stage; it had an output power of 4.5 watts in single-ended operation or nine watts in push-pull. The EL5 also had a high slope: in push-pull operation it could deliver an output of power 19 watts. The EL6 had an even higher slope of 14.5mA/V making it particularly suitable for low-cost, three- or four-valve superhet receivers. The EBL1 was a double diode, high-slope pentode which was also suitable for low-cost receivers. Finally there was the EL50 (which started off as the Pen650). This was designed for use with high-power audio amplifiers and could deliver 55 watts in Class AB1 push-pull, as shown in Table 8.8. A further application of the EL50 was as a line output pentode in television receivers. (There was also an EL51, a high-power pentode, which does not appear in the usual Mullard listings.)

Two valves in Class AB1 push-pull

Anode voltage	600	volts
Anode current (no signal)	2 x 25	mA
Anode current (max signal)	2 x 73	mA
Screen voltage	300	volts
Screen current (no signal)	2 x 2.2	mA
Screen current (max signal)	2 x 11	mA
Bias voltage	–25	volts
Anode-anode load resistor	10k	ohms
Power output	55	watts
Distortion	1.3	%
Input signal ($g_1 - g_1$) r.m.s.	36	volts

Table 8.8: Operating conditions for EL50 output pentode in Class AB1 push-pull, fixed bias.

EBC3: double diode triode.

EBL1: double diode output pentode.

EL2: output pentode for car radios.

Pen 650 = EL50: high-power output pentode.

Figure 8.25: 'E' series double diode triode and output pentodes of 1938 to 1939.

Tuning indicators

The EM1 (previously TV6), apart from its heater rating, was identical to the four-volt TV4 shown in Figure 8.17. There was also the long grid-base EM3 but this found few applications. A particularly versatile tuning indicator was the dual-sensitivity EM4. The dual sensitivity feature enabled both weak and strong signals to be tuned in with equal ease. Outwardly the EM4 was very similar to both the EM1 and EM3 except that the indication at the top was two fan-shaped shadows in the fluorescent screen operated by separate triodes within the valve, one having high gain and the other low gain. Diagrams of the valve are shown in Figure 8.26.

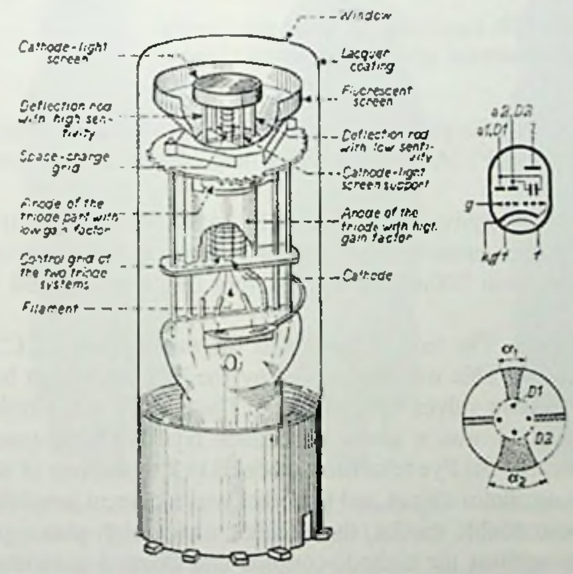
The only other tuning indicator was an unusual type because it incorporated a variable-mu, sliding screen a.f. pentode. This, the EFM1 (see Figure 8.26), also had two fan-shaped shadows but it did not have the dual-sensitivity feature of the EM4. The pentode section was driven via a volume control from the diode detector and its control grid was also fed by the a.g.c. bias voltage. The grid of the tuning indicator section was internally connected to the common cathode, and the ray control electrode was internally connected to the screen grid of the pentode section.

A typical low-cost superhet could be constructed using a frequency changer such as the ECH2 or ECH3, the double diode pentode, EBF2, the EFM1 and one of the high-slope output pentodes, EL5 or EL6.

Rectifiers

The three rectifiers, EZ1, EZ2 and EZ3 were all full-wave types. The first two of these had 0.4-amp heaters, making them particularly suitable for use in car radios. The EZ1 was rated at 250V, 60mA and the EZ2 at 350V, 60mA (Figure 8.27). The EZ3 was designed for higher current applications and could be used up to 400V at 100mA.

Although not strictly part of the 'E' series, the 4-volt directly heated AZ types, shown in Table 8.4, were frequently included in Mullard lists of the series.



Diagrammatic view of the EM4 showing also the shadows formed by the high-gain and low-gain triode sections.

EM4 (the EM1 and EM3 appear very similar).

EFM1 a.f. pentode and tuning indicator.

Figure 8.26: 'E' series tuning indicators of 1938 to 1939 having the 8-contact Ct8 (P-type) base.

Philips types not listed by Mullard were the EBF2, C/EM2 (tuning indicator), EEP1 (secondary emission valve), ELL1 (double output pentode) and EZ4 (full-wave rectifier).

'E' series with International Octal bases

The octal-based valves are listed in the bottom section of Table 8.7. The first of these appeared in 1939 and all the early types, together with a few of the later ones, were merely re-based versions of the side contact types (see Table 8.9 below).

Figure 8.27:
EZ2 full-wave rectifier.

Description	IO base	Ct8 base
General-purpose pentode	EF36	EF6
Low-noise r.f. pentode	EF38	EF8
Variable-mu r.f. pentode	EF39	EF9
Double diode and r.f. pentode	EBF32	EBF2
Triode hexode frequency changer	TH62 = ECH33	ECH3
Octode frequency changer	EK32	EK2
Double diode	EB34	EB4
Double diode and output pentode	EBL31	EBL1
Output pentode	EL32	EL2
Output pentode	EL33	EL3
Output pentode	EL35	EL5
Output pentode	EL36	EL6
Tuning indicator	EM31	EM1
Tuning indicator	EM34	EM4

Table 8.9: Equivalent 'E' series valves with the international octal and side contact bases.

In 1946 the EF36 was superseded by the EF37, a low-noise pentode designed for use in the early stages of audio amplifiers. This, in turn, was superseded by the EF37A in 1950 which had an anti-microphonic construction.

The TH62 appeared in 1939 and this was the IO-based equivalent of the ECH3. In the following year it was re-classified as the ECH33. The ECH35 was a later improvement on this valve: it had identical characteristics except for increased heater consumption from 200mA to 300mA (but this was reduced to 225mA in the early 1950s).

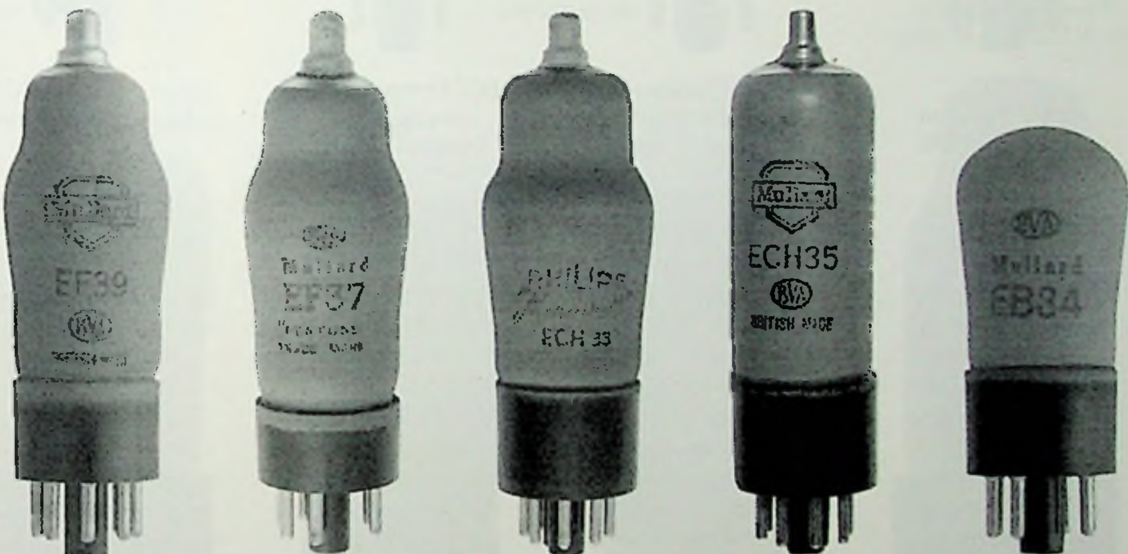
Several types of double triode appeared in the 1940s. The first of these was the medium-mu ECC31 which had a single cathode serving the two triode sections. This was superseded by the ECC32, which had separate cathodes but, otherwise, the characteristics of the two valves were identical. The ECC33 was similar to the ECC32 but had a slightly higher gain. The ECC34 was a lower impedance type with an anode resistance of 5.2k ohm and was used in the frame timebase of the Pye television model B16T where one of the triodes generated the sawtooth waveform in a blocking-oscillator circuit and the other was a current amplifier for energizing the frame deflector coil. The last of these double triodes, the ECC35, was a high-gain type, particularly suitable for use in audio amplifier circuits such as the cathode-coupled and floating paraphase phase splitters. The double triodes were also used in multivibrator circuits for instrumentation equipment. There was also one single triode, the EC31. This was a low gain type with a maximum anode dissipation of five watts. It could, therefore, be used as a low-power output valve or as a driver for a high-power output stage.

Two output pentodes, which were particularly suited for use in push-pull amplifiers, were the EL36 (together with the earlier EL6) and the post-war type EL37. Table 8.10 gives typical operating conditions for these valves. However, an entirely different version of the EL36 appeared in the late 1950s, intended for television use in line timebases and these valves are not interchangeable with the earlier version.

Two valves Class AB1 push-pull	**EL6/EL36**	**EL37**		
Anode voltage (max. signal)	250	250	325	volts
Anode current (no signal)	2 x 45	2 x 59	2 x 77	mA
Anode current (max. signal)	2 x 53	2 x 68	2 x 90	mA
Screen voltage	250	250	325	volts
Screen current (no signal)	2 x 5.1	2 x 7.5	2 x 9.8	mA
Screen current (max. signal)	2 x 8.5	2 x 18	2 x 30	mA
Common cathode resistance	90	130	130	ohms
Signal input (grid-to-grid) r.m.s.	14.5	29	43	volts
Anode-anode load resistance	5000	4000	4000	ohms
Power output	14.5	20	35	watts
Distortion	2.2	2.25	4.4	%

Table 8.10: Operating conditions for EL6/EL36 and EL37 in Class AB1 push-pull (auto bias).

The EL6/EL36 had a maximum anode rating of 250V and provided a single-ended output power of eight watts, increasing to 14.5 watts when operated in Class AB1 push-pull. The comparable figures for the EL37, which had a maximum anode rating of 400V, were 11.5 watts and 35 watts respectively. The EL37 replaced both the EL35 and EL36 but was, itself, superseded by the EL34 in 1955 [8]. (The EL34 is of special interest to hi-fi enthusiasts because it is used frequently in modern valve amplifiers where it can provide 34 watts of output with auto bias and 54 watts in fixed bias operation.)



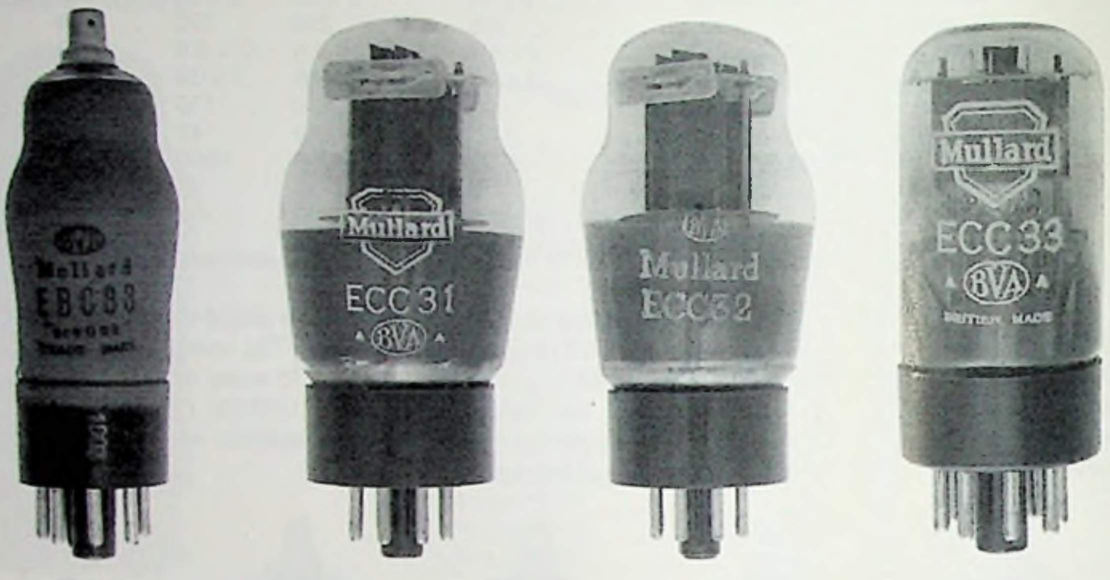
EF39: variable-mu r.f. pentode. (EF36 and EF38 look similar.) | EF37: a.f. pentode. (Superseded EF36.) | Philips version of ECH33 triode hexode frequency changer. | ECH35: triode hexode frequency changer. (Later version.) | EB34: double diode (separate cathodes).

Figure 8.28: 'E' Series with international octal base.

There was only one new rectifier: this was the full-wave EZ35 which was rated at 325V, 70mA making it suitable for most radio receiver applications. However, for medium power amplifiers using the EL37, for example, a higher current rectifier was required, such as the 5U4G. There were also two 4-volt, directly heated full-wave rectifiers with the IO base—the AZ31 (300V, 100mA) and AZ32 (300V, 160mA). They have been included in Table 8.7 although not strictly E Series valves.

One other valve of special note was the double diode type EB91. This was a very early example of a B7G-based valve, three of which were used in the Pye television model B16T of 1946.

Examples of the 'E' series valves having the international octal base are shown in Figures 8.28 to 8.31.

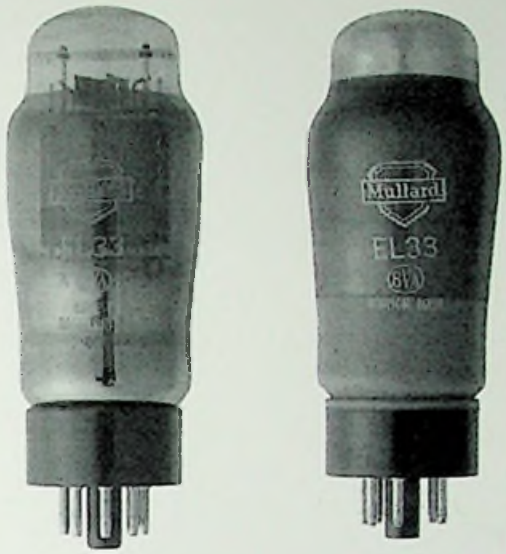


EBC33: double diode and medium-mu triode. | ECC31: medium-mu double triode (with common cathode). | ECC32: medium-mu double triode (replaced ECC31. | Early version of ECC33 medium-mu double triode.

Later version of ECC33 with larger base. | ECC34: low-mu double triode. | Early version of ECC35 high-mu double triode. | Later version of ECC35 (CV569) with larger base.

Figure 8.29: 'E' Series with international octal base (cont.).

CV1052 (EL32): 3.6-watt low-slope, output pentode.



Two versions of EL33 4-watt, output pentode.

EL31: high-power output pentode for push-pull operation (replaced EL50).

Two versions of the EL37 high-power output pentode. (Replaced both the EL35 and EL36.)

EM31: cathode-ray tuning indicator.

EM35: cathode-ray tuning indicator.

Figure 8.30: 'E' Series with international octal base (cont.).

There were three tuning indicators: the EM34, shown in Figure 8.31, the short-lived EM35 (which was similar to the 6U5G and Y63) and the EM31, which was identical to the EM1 except for the base. These latter two can be seen in Figure 8.30.

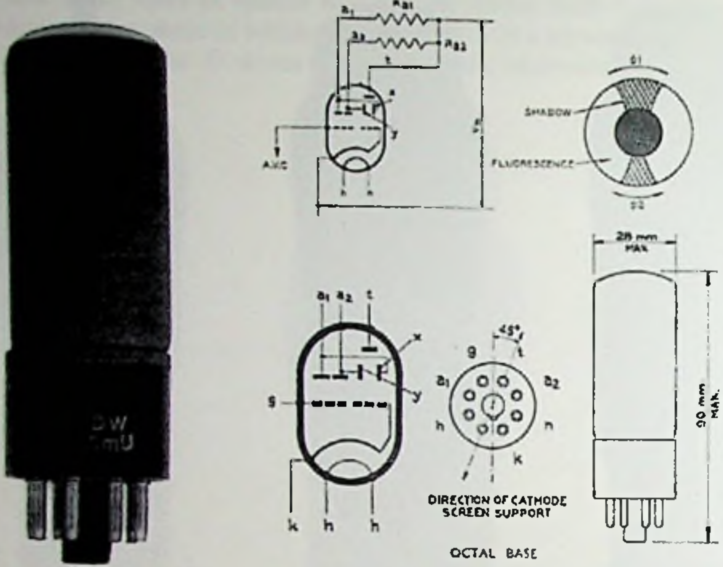


Figure 8.31: EM34 cathode-ray tuning indicator.

DC & AC/DC RANGES 1929 TO 1940 (Table 8.10)

Directly Heated types

The first of the ranges were directly heated valves that could have readily been used in battery receivers. There were just three types, as shown in the first line of Table 8.10. They all have a filament current of 0.1 amps, which is the current in the positive end of the filament under working conditions. However, the current in the negative end is higher and exceeding that in the positive end by the emission current of the valve.

The current passing to the filament of the PM4DX detector triode, which immediately precedes the PM25 output pentode, is, therefore, 0.1 amp plus the anode and auxiliary grid currents of the PM25. Consequently its filament must be shunted by a resistor to avoid this excess current flowing through it.

Similarly the PM13 r.f. tetrode must also be shunted to avoid the excess current from both the PM25 and PM4DX valves.

The wiring for the filaments would then consist of a 0.1 amp barretter connected to the positive side of the mains, followed by the PM25, the PM4DX (shunted by a suitable resistor) and the PM13 (also shunted by a resistor), with the final connection of the PM13 to the negative side of the d.c. mains. It should be noted that negative grid bias was also required for the PM25. The voltage at the negative end of the valve's filament would be + 8 volts, which would mean that if the grid return of the PM25 went to the h.t. negative line there would only be eight volts of negative grid bias and this would be insufficient for optimum operation of the valve. The actual bias, of course, depends on the operating conditions of the PM25 but would be 18 volts for an anode-to-filament voltage of 150V. It would then be necessary to make up the extra bias of ten volts by an additional resistor inserted in series with the negative lead of the PM25 filament to the positive end of the PM4DX filament.

Indirectly Heated types

It should be clear from this description that the use of directly heated valves for use with d.c. mains supplies was not very satisfactory. Fortunately this problem was overcome a few years later when indirectly heated valves became available, first on d.c. mains supplies and then for a.c./d.c. supplies. The indirectly heated d.c. valves were introduced in 1932. All had 20-volt, 0.18-amp heaters, except for the TDD25 which had a 25-volt heater. The initial valves were the SG20 screen grid tetrode, MM20 variable-mu tetrode, HL20 detector triode and Pen20 output pentode. The r.f. pentodes, SP20 and the variable-mu VP20, appeared in 1933 together with the TDD25 double diode triode. There was also the SD20 single diode tetrode.

Range	Year	RF tetrode or pentode	Frequency changer	Diode	Triode or DDT	Output pentode	Tuning Indicator	Rectifier
DC, DH	1929	PM13			PM4DX	PM25		
DC 20V, 0.18A series, IH B5/B7 base	1932	MM20, SG20			HL20,	Pen20		
	1933	SP20, VP20			H20, TDD25			
	1934	SD20						
AC/DC, 0.2A, series, Ct base	1934	SP13, VP13A	FC13	2D13, 2D13A	HL13, TDD13	Pen26		UR1, UR2
	1935							UR3
AC/DC, 0.2A, series B5/B7 base	1935	SP13C, VP13C	FC13C		HL13C, TDD13C	Pen13C, Pen36C		UR1C, UR3C
	1936		TH13C, TH21C	2D13C				
	1939		TH30C			Pen40DD		CY1C
AC/DC, 0.2A new series, Ct base	1938					CBL1, CL4, CL6	EM1, EM3, EM4	CY2
	1939	EF9	ECH3, EK2					CY1
AC/DC, 0.2A, IO base	1940	EF39	ECH33, CCH35		EBC33	CBL31, CL33		CY31, CY32

Table 8.10: DC and a.c./d.c. ranges of 1929 to 1940.

The d.c. ranges were superseded in 1934 by the first of the a.c./d.c. ranges. The valves in the series had 0.2-amp heaters, and most of these operated at 13 volts. All the bases were side contact 'P' or 'V' types. (P-base = 8 contacts, V-base = 5 contacts.) The range consisted of the SP13 r.f. pentode, VP13 variable-mu r.f. pentode, FC13 octode, 2D13 double diode with one anode taken to a top cap, 2D13A double diode without a top cap, HL13 triode, TDD13 double diode triode, Pen26 output pentode, UR1 half-wave rectifier and the UR2 full-wave rectifier having separate cathodes (re-classified as UR3). The two double diodes were the only ones in the range having the 5-contact V-base. The Pen26 had a 24-volt heater and the UR2/UR3 a 30-volt heater. The full-wave UR2/UR3 could be connected in three ways: both diodes wired in parallel to provide a maximum rectified current of 120mA, as a normal full-wave rectifier with the two cathodes strapped, or as a voltage doubler.

A further 0.2-amp range was introduced in 1935 but with British 5-pin or 7-pin bases. Most of these had the same type designations as the side contact range except for the addition of the letter 'C' at the end, although their characteristics of the two r.f. pentodes differed. Those with 13-volt heaters could be used in car radios where, of course, the heaters would be connected in parallel and are recognized by the number 13 in their type designation (e.g. SP13C). The 13-volt types in both the side contact range and British base range were as follows:

Base	RF pentode	VM pentode	Octode	Triode hexode	Double diode	Triode	DD triode	Output pentode
Side contact	SP13	VP13	FC13		2D13	HL13	TDD13	
British	SP13C*	VP13C*	FC13C	TH13C	2D13C	HL13C	TDD13C	Pen13C

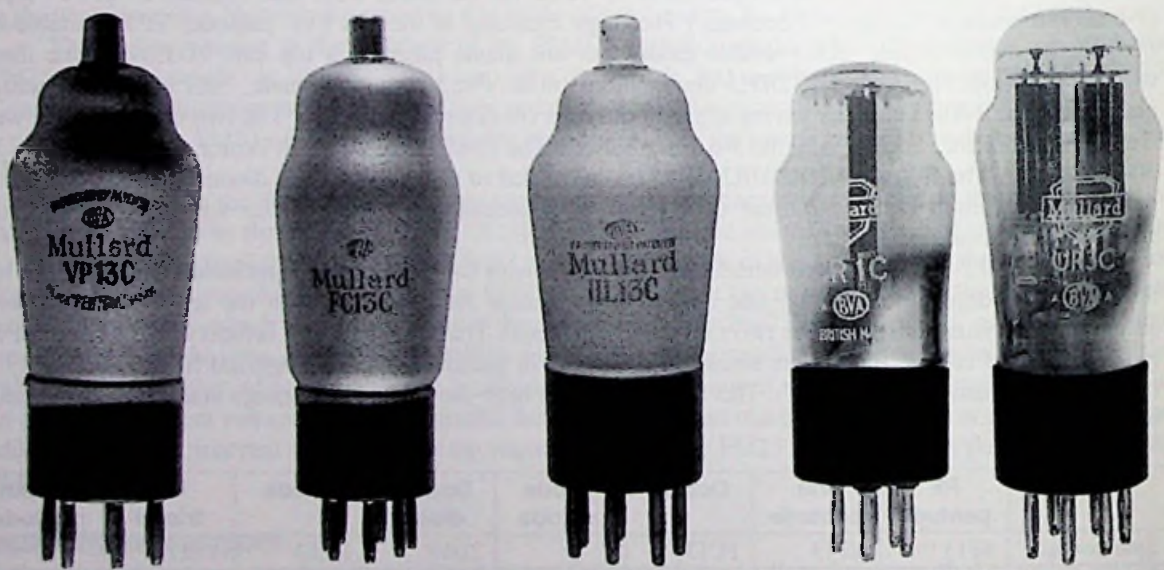
*These two valves have different characteristics to the side contact types and so are not interchangeable.

Two 13-volt types that did not appear in the side contact range were the TH13C triode hexode and the Pen13C output pentode. Non-13 volt equivalents in the British-base range were the two pairs of rectifiers

UR1/UR1C and UR3/UR3C. Two other valves, which appeared in 1939, were the TH30C triode hexode with a 29-volt heater and the Pen40DD double diode output pentode with a 44-volt heater.

Examples of the valves with the side contact and British bases are shown in Figures 8.32 and 8.33.

Figure 8.32: 0.2-amp side contact range of 1934. SP13 r.f. pentode, 2D13 double diode with one anode taken to the top cap, 2D13A double diode, HL13 detector or a.f. triode and Pen26 output pentode.



VP13C: variable-mu r.f. pentode. FC13C: octode frequency changer. HL13C: double diode triode. UR1C & UR3C: half-wave rectifiers.

Figure 8.33: 0.2-amp range with British B5 and B7 bases of 1935 to 1936.

The 'C' Series

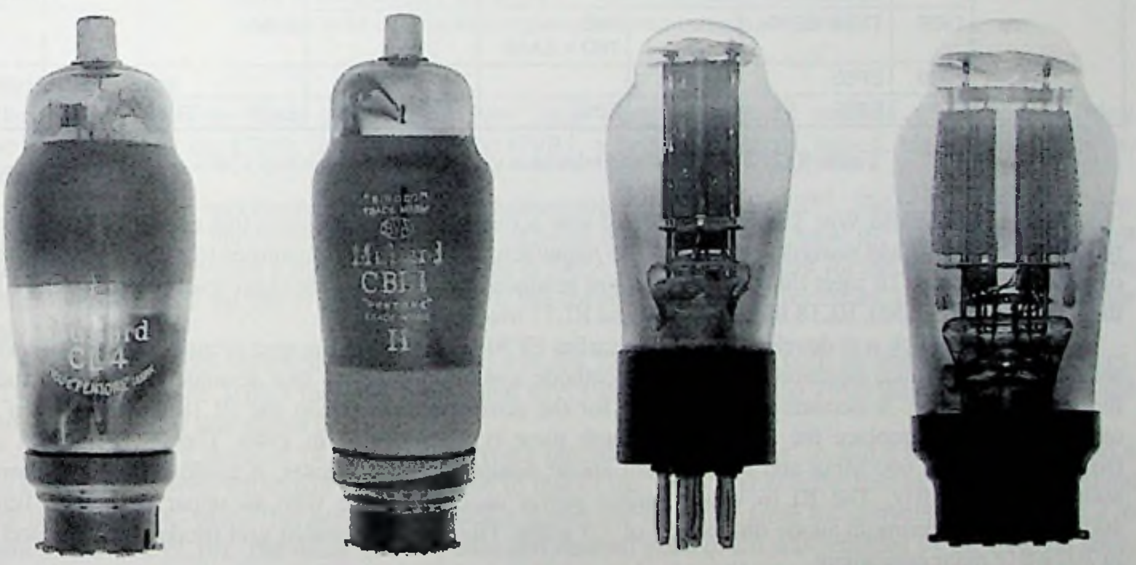
In 1938, Mullard introduced the 'C' series of 0.2-amp output pentode and rectifier valves fitted with the side contact P-base (see Figure 8.34). Types with the international octal base were introduced in the following year. Apart from their heater ratings these 'C' series valves had identical characteristics to the companion 'E' series types. Several of the 0.2-amp 'E' series valves were also used for series operation in a.c./d.c. receivers as is shown in Tables 8.10 and 8.11.

Base	RF pentode	Frequency Changer	DD triode	Output pentode	Tuning indicator	Half-wave rectifier	Full-wave rectifier
Side contact	EF9	ECH3, EK2		CBL1, CL4, CL6	EM1, EM4	CY1	CY2
Int. Octal	EF39	ECH33, CCH35, EK32	EBC33	CBL31, CL33	EM34	CY31	CY32

Table 8.11: 0.2-amp 'C' and 'E' series valves for a.c./d.c. operation.

A typical valve line-up for an all-wave receiver such as the Mullard MUS221 was:

CCH35	Frequency changer
EF39	IF amplifier
EBC33	Detector, a.g.c. and audio amplifier
CL33	Output
CY31	Rectifier



CL4: output pentode.

CBL1: double diode output pentode.

CY1C: half-wave rectifier with B4 base.

CY2: multiple rectifier with two separate diodes.

Figure 8.34: 0.2-amp 'C' Series valves of 1938 to 1940.

It should be noted that the Philips range was more extensive than that offered by Mullard and included the CB2 double diode, CBC1 double diode triode, CC2 triode, CF3 variable-mu pentode, CF7 pentode, CH2 hexode, CK1 octode, the C/EM2 tuning indicator, and the CL1 and CL2 output pentodes.

Many of the other 0.2-amp 'E' series valves were also suitable for a.c./d.c. operation but this was rarely necessary. The EM1, EM4 and EM34 were only suitable for high h.t. voltages because at lower voltages the brilliance of the fluorescent screen was reduced—for 110-volt supplies, it was necessary to use the CY2 or CY32 as a voltage double rectifier.

VHF, UHF & TELEVISION VALVES (Table 8.12)

The first valves for v.h.f. and u.h.f. applications were Philips equivalents of the RCA acorn valves, except that they had four-volt heaters. Both the AP4, pentode and AT4 triode appeared in 1936 which, apart from their heater ratings, were identical to the 954 pentode and 955 triode. The 6.3-volt types, 4672 and 4671 were introduced in 1940.

Range	Year	RF tetrode or pentode	Triode + hexode	Diodes	Triode or output triode	Output pentode	Thyratron	Rect.
UHF 'acorns'	1936	AP4			AT4			
	1940	4672			4671			
VHF & UHF	1940	RL7			RL18			
	1941				RL16, RL37			
	PW	EF54 (= RL7)			EC52 (= RL16), EC53 (= RL18) EC54 (= RL37)			
Television	1936	TSP4					GT4A	HVR1
	1937						GT4H	HVR2, HVR2A
	1938	TSE4, EE50		T4D, T6D = EA50		EL50		
	1939	EF50	6153T†					
	PW	EF55		EB91		EL38	EC50	

Table 812: VHF, UHF and television valves of 1936 to the mid-1940s.

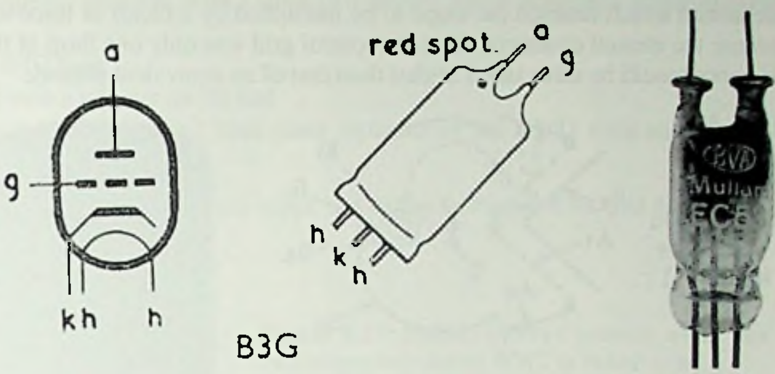
During the World War Two years Mullard was active in producing valves that could replace the acorn types because these had proved very difficult to manufacture in sufficient quantities to meet the requirements of radar production. To meet this demand Mullard produced the RL7 pentode (later re-classified at the EF54), the RL16 triode (EC52), RL18 triode (EC53) and RL37 triode (EC54).

The RL7, which was developed from the earlier EF50 (described in the next section of this chapter), had aligned grids to reduce partition noise and the cathode was brought out to four separate pins, which reduced the lead inductance. It became a replacement for the acorn pentode, whilst the RL18 was used as a local oscillator valve to replace the acorn triode; both these types appeared in 1940. The RL18 had an upper frequency limit of 600 MHz and a maximum anode dissipation of 2.5 watts; it could generate a power of 800mW at 400 MHz. The RL16 was a higher power oscillator valve with an upper frequency limit of 400MHz and a maximum anode dissipation of 7.5 watts. This was a grounded-grid triode amplifier and used in 200 MHz radar equipment.

The RL7, RL16 and RL37 were all mounted on the 9-pin B9G base, whereas the RL18 had its pins brought directly through the glass wall with three at the bottom for the heater and cathode connections, and two at the top for connections to the anode and grid. Figure 8.35 shows views of the post-war EF54 (RL7) and the EC53 (RL18).

† The 6153T, a special combination valve, was used in the frame timebase of the Pye 615 television receiver where the triode worked as a blocking oscillator and the hexode as the output amplifier. It was not a frequency changer.

EF54: v.h.f. pentode with aligned grids to reduce noise.



EC53 oscillator triode which replaced the 955 acorn triode in wartime radar equipment. (Maximum length and diameter 54mm and 16mm.)

Figure 8.35: Mullard v.h.f. and u.h.f. valves, originally produced for wartime radar equipment to replace the acorn pentode and triode.

Television valves

Mullard's first television valves appeared in 1936. These were the TSP4 r.f. pentode, which had a modest slope of 4.73mA/V, the GT4A thyratron and the HVR1, a two-volt, directly heated, high-voltage rectifier, rated at 6kV, 15mA.

The GT4A was superseded by the GT4H helium-filled thyratron in 1937. There were also two new high-voltage rectifiers, both with indirectly heated cathodes and rated at 6kV, 3mA: the HVR2 with a two-volt heater and the HVR2A with a four-volt heater. The HVR2A was a replacement for the HVR1, but both were eventually superseded by the HVR2, although in the former case it was necessary to increase the heater supply to four volts.

Several new types appeared in 1938. There was the TSE4 and EE50, both secondary emission valves, the T4D detector triode, with a four-volt heater, and its 6.3-volt equivalent, the T6D (later to be re-designated EA50), and the EL50 line output pentode.

The TSE4 had a slope of 14.5mA/V. This valve preceded the 'E' series, so had a four-volt heater and a 7-pin base. The 6.3-volt EE50 had a similar slope to that of the TSE4 and was the first of the Mullard valves to use the 9-pin B9G base. This new base marked a significant departure from the conventional types used in Britain at the time [9, 10]. The usual Bakelite base and internal glass pinch was replaced by an all-glass base. Elimination of the stem and pinch resulted in a considerable reduction in length of the internal wires. The pins were sealed into the glass base and arranged uniformly around a central metallic spigot which was keyed in order to facilitate insertion into the valveholder. The spigot was joined to an external metal screen which covered the whole base, with small holes to allow the pins through. Because of the screening provided, it was possible to bring all the connections out to the base, avoiding the need for a top cap. When first produced, the valve had L-shaped pins but these were soon changed to straight pins.

As can be seen from the diagram in Figure 8.36, the EE50 was of unusual construction. Instead of a suppressor grid, there was an auxiliary cathode, K_2, which was biased at about +150V. The materials used inside a valve are usually selected to have low secondary emission, but the auxiliary cathode of the EE50 was produced with a material that had a high secondary emission factor. The primary electrons from the normal cathode, K_1, were directed towards the auxiliary cathode by the two screens, S_1 and S_2. When the electrons struck the auxiliary cathode, secondary electrons were released which were collected by the anode. It was this mechanism which enabled the slope to be multiplied by a factor of three to give an overall value of 14mA/V. Because the mutual conductance at the control grid was only one third of this figure, it followed that the input resistance would be three times higher than that of an equivalent pentode.

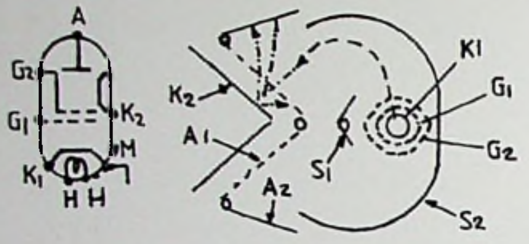


Figure 8.36: The EE50 secondary emission valve. The diagram above shows a plan view of the electrode arrangement and the photographs on the right show two versions of the valve. The prototype version had angled pins, which required the valve to be twisted into the holder, but the straight pins (seen here at the extreme right) soon replaced these because of glass fracture problems.

For television applications, however, secondary emission valves were very soon superseded by high slope pentodes and one of the best known of these was the EF50 [11,12] The story of its development and manufacture is an interesting one and goes back to the mid-1930s when top-secret work was in progress at Bawdsey Manor in Essex on radio direction finding (RDF)—later re-named radar. For this requirement, a valve providing wideband v.h.f. and u.h.f. amplification was required. At the time, Tom Goldup, a senior director in the Mullard Valve Company, was liaising with the British government and was made aware of this requirement. It will be remembered that all the R&D work on valves at that time were carried out by the Philips Company in Eindhoven. Goldup approached Philips asking if they had a valve with the required specification. (Because RDF could not be mentioned at this time one must suspect that he referred to television application.) He was told that a suitable valve was being developed for the Dutch government: samples, therefore, could not be supplied to Mullard. It would appear that the British government approached their Dutch counterpart and valves were then supplied. The valve in question was the EF50, which became available for television use in 1939. At this time all the valves were being produced in Holland.

The EF50, like the earlier EE50, had the B9G base where the nine pins were of chromium-iron sealed into the glass base. As can be seen from the diagram in Figure 8.37 the elimination of the stem and pinch enabled the electrode assembly to be mounted much closer to the base pins, thereby shortening the connections.

The first company to adopt the EF50 was Pye which produced a 45MHz r.f. strip for television use but production was disrupted with the outbreak of war. A more important application, however, was as an i.f. strip in radar equipment, but manufacture of the valve was threatened when Germany was poised to invade Holland. Mullard did not have the capability to manufacture the valve at that time, particularly the base. Consequently, just before the invasion, a truck came from Holland to England with one million of these glass bases and production of the valves in the UK then became possible. Later, huge quantities of the valve were manufactured in America by Sylvania.

Other television valves listed in Table 8.12 are:

- 6153T triode hexode, with an 8-pin side contact base (later replaced by the ECH21with a B8G base),
- the post-war EF55 video frequency pentode, with a slope of 12mA/V and a maximum anode dissipation of ten watts,
- EB91 detector diode with a B7G base,
- EL38 line timebase pentode with a top-cap anode and
- the EC50 thyratron with an 8-pin side contact base (later replaced by the EN31 with an international octal base).

Examples of these, together with some of the earlier types, are shown in Figure 8.38, and 8.39.

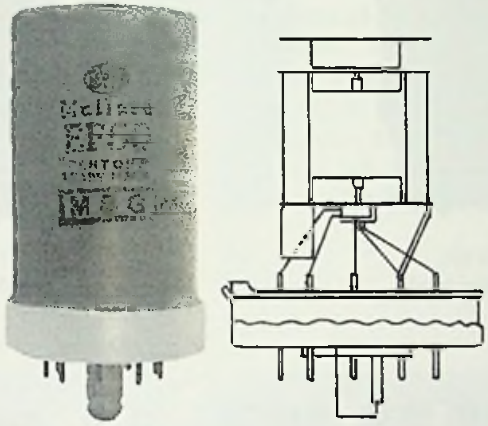
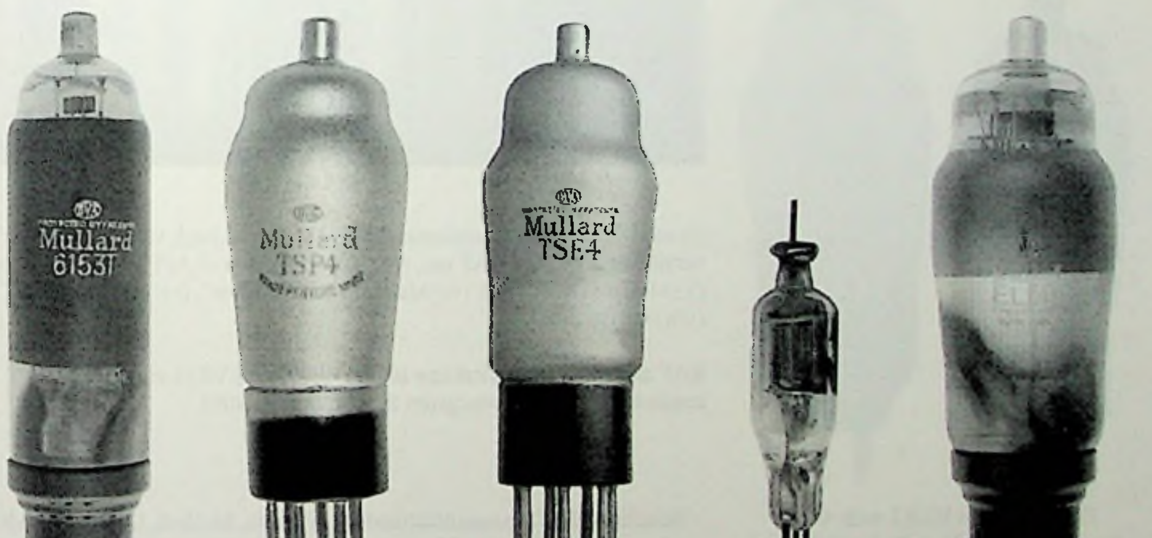


Figure 8.37: Mullard EF50 r.f. pentode, which was used extensively during WW2 in British radar equipment. After the war it was then widely used in television receivers.

The diagram shows a view of the electrode assembly, where it can be seen that by elimination of the stem and pinch the assembly can be mounted closer to the base, thereby shortening the connections to the pins. This improved the valve's v.h.f. performance.



6151T: triode hexode. (Used in timebase of Pye 815 television.)

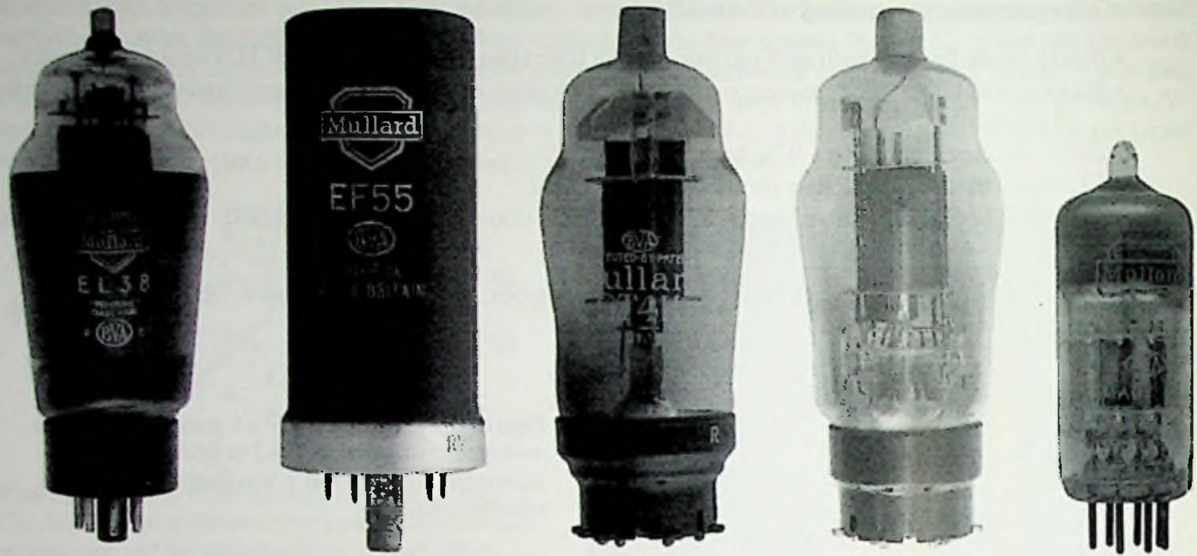
TSP4: r.f. pentode of 1936.

TSE4: secondary emission valve of 1938.

EA50: television diode.

EL50: line output pentode. (Originally the Pen 650.)

Figure 8.38: Various television valves.



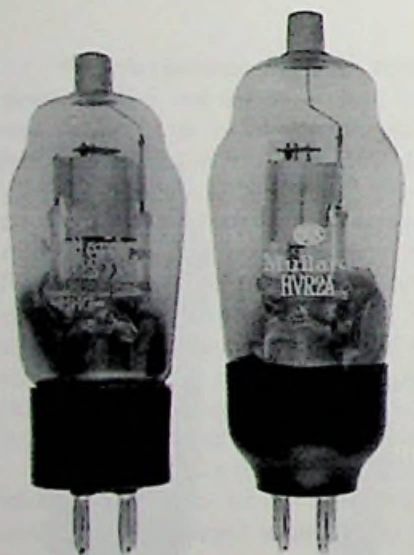
EL38: line output pentode

EF55: video amplifier pentode.

GT4H: gas-filled triode.

EC50: gas-filled triode.

EB91: double diode



EHT rectifiers HVR2 with 4-volt heater and HVR2A with 2-volt heater. Both rated at 6kV, 3mA.

(i) and (ii) Sylvania manufactured VR91 front and back view, (iii) 'silver' version of VR91 for RAF use, (iv) 'silver' version of APP35 for Army use, (v) Mullard EF50 – red, (vi) Mullard EF50 – 'silver', (vii) Cossor 63SPT, (viii) Osram Z90.

RAF and Army classifications for the EF50 were VR91 and APP35 respectively. Later it was given the CV number 1091.

Selection of EF50s manufactured by Sylvania, Mullard, Cossor and MOV.

Figure 8.39: Various television valves and a selection of EF50s. (The EB91 is shown at actual size.)

REFERENCES

1. Thrower, K. *British Radio Valves The Vintage Years: 1904–1924*, See Chapter 7, pp. 72-5.
2. Herrmann, G and Wagener, S. *The Oxide-Coated Cathode* (Chapman & Hall, London, 1951).
3. British patent GB287,958, app. 24 December 1926, iss. 26 March 1928. Also French patent FR629,357 and German patent DE527,499.
4. Stokes, J. *75 Years of Radio Tubes and Valves* (The Vestal Press Ltd., NY, 1982), p. 55.
5. 'Cathode-ray tuning indicator', *W.W.*, **41**, 9 October 1936, p. 380.
6. Advertisement of valves for relay and P.A. equipment, *W.W.*, **40**, 20 March 1936, p. A9.
7. 'New Range of Valves', *W.W.*, **42**, 26 May 1938, pp. 474-5 and 2 June 1938, pp. 489-99.
8. In 1948 Philips produced the EL60 output pentode which had the B9G base. By the following year the valve had undergone some internal re-design to simplify manufacture and was re-issued in The Netherlands with an international octal base and given the new designation, EL34. The EL34 was not released in the UK until 1955.
9. Jonker, J L H and Overbeek, J M W, 'The Application of Secondary Emission in Amplifying Valves', *W.E.*, **15**, March 1938, pp. 150-6.
10. Villier, E S. 'The New Secondary Emission Valve', *W.W.*, **44**, 30 March 1939, pp. 303-4.
11. 'All Glass Valves', *W.W.*, **4**, 6 February 1939, pp. 155-6.
12. Prakke, F, et al. 'A New "All-Glass" Valve Construction', *W.E.*, **16,** May 1939, pp. 224-36.

Chapter 9

Standard Telephones and Cables Ltd.

(Trade names: Micromesh, Standard, STC, Brimar)

In May 1883, the US company, Western Electric, opened up a small office and store in London. From this small beginning, a substantial telephone company developed in Britain. In September 1925, the International Western Electric Company was bought by the International Telephone and Telegraph Company (ITT). Following this purchase, the name of the British company was changed to Standard Telephones and Cables Ltd., a name unchanged until the late 1980s. Initially, STC relied upon Western Electric technology, but with encouragement from their American owners, the company became more independent, developing their own technology. Not surprisingly, a significant early use for valves was in telephone equipment, such as repeater circuits. All the early valves were either supplied by Western Electric or were based upon Western Electric designs. With the development of broadcasting, STC developed valves for use in radio receivers, initially using the brand name STANDARD. During the period 1929 to 1931, the company concentrated on the production of valves for professional equipment, before returning to production for domestic receivers. In 1932, a new brand name, MICROMESH, was introduced with the valves becoming available in the following year but, in 1934, this was replaced by the new brand name, BRIMAR (an abbreviation for **Bri**tish **M**ade **A**merican **R**ange). Valve manufacture was at Footscray in Kent. The Brimar valve and cathode-ray tube division was sold to Thorn Electrical Industries Ltd. in 1957.

STC also produced a very large range of both low- and high-power valves for professional applications such as radio transmitters and telephone equipment. These were almost all of Western Electric design and many of these bore the same type designation as the WE valves but preceded by the number '4'.

MICROMESH AND BRIMAR VALVES WITH BRITISH BASES

As indicated in the previous section, the early STC valves for the domestic market were issued with the Micromesh brand name but after 1934 the name was changed to Brimar. The American ranges appeared in 1937 and, thereafter, almost all the Brimar valves carried the US type designations, although many of these had a suffix letter, usually E, appended at the end.

The early British valves that were marketed between 1933 and 1937 are shown in Table 9.1 and many of these had identical characteristics to US types, differing only in the heater rating and base. In this table all the 1933 valves, together with the 9A3 and 15A2 of 1934, were previously Micromesh types.

2-volt Micromesh range of 1933

This range consisted only of the 5B1, r.f. tetrode, the HLB1 detector or a.f. triode, the PB1 output triode and the PenB1 output pentode.

4-volt a.c. range of 1933 to 1938

The first of these to be released in 1933 were the r.f. tetrode, SGA1, the variable-mu r.f. tetrode, VSGA1, an r.f. pentode, 8A1, and a variable-mu r.f. pentode, 9A1. The triodes consisted of the HLA1, with the remarkably high slope of 8mA/V and a mu of 80, the HLA2 with a slope of 5.5mA/V and the high-impedance 11A2 double diode triode with a mu of 100 and the PA1output triode. There were also two output pentodes, the directly heated PenA1 and the indirectly heated 7A2, which, otherwise, had similar characteristics. To complete the 1933 types there were four indirectly heated full-wave rectifiers: the R1, R2, R3 and 1A7 (with identical characteristics to the R2). The R1 was rated at 250V, 60mA, the R2 at 350V, 120mA and the R3 at 500V, 120mA.

Several of the a.c. valves were described in a *Wireless World* article of August 1932 [1] which referred to the 'extremely small clearances between the electrodes to obtain the improved characteristics'. The output triode, PA1, was also very impressive with a slope of 12mA/V and a mu of 12.6.

Range	Year	RF tetrode or pentode	Frequency changer	Diode	Triode or DDT	Output triode	Output pentode	Rect.
2-volt	1933	5B1			HBL1	PB1	PenB1	
4-volt	1933	SGA1, 8A1 (B5), 9A1 (B5), VSGA1			11A2, HLA1, HLA2	PA1	7A2, PenA1	R1, R2, R3, 1A7
	1934	9A3	15A2					
	1935						7A3	
	1937	8A1 & 9A1 (B7)						
	1938		20A1					
AC/DC 0.2A & 13V car battery	1934	8D2, 9D2	15D1		11D3		7D3	1D5
	1935						7D6, 7D8	
	1936			10D1	4D1	16D1 (0.4A)		
	1938						7D5 (0.35A	
	1939/40		20D2 (0.15A), 15D2 (0.15A)		11D5 (0.15A)		)	

Table 9.1: Micromesh and Brimar 'British' valves.

When first released in 1933 both the 8A1 and 9A1 r.f. pentodes had 5-pin bases but they were additionally fitted with 7-pin bases in 1937. There was a further variable-mu r.f. pentode in 1934. This, the 9A3, was also a Micromesh type and had a 0.65-amp heater rather than the 1-amp rating of the 9A1. However it had a slope of 1.8mA/V, whereas the slope of the 9A1 was 4.25mA/V. The only other 1934 type was the Micromesh 15A2 heptode frequency changer.

There was another output pentode in 1935. This, the 7A3, had a slightly higher power than the earlier 7A2 with an output of 3.75 watts rather than 3.5 watts. It also had a slope of 10mA/V as against only 2.35mA/V for the 7A2, which meant it could operate at a grid bias of only six volts. Its heater consumption was two amps to ensure increased cathode emission.

The last of the four-volt types was the 20A1 triode hexode frequency changer.

AC/DC range

The first types to appear in 1934 all had 0.2-amp heaters. The 8D2 was an r.f. pentode, the 9D2 a variable-mu r.f. pentode, the 15D1 a heptode frequency changer, and the 11D3 a double diode triode (all operating with 13 volts on their heaters). There were also two 40-volt types: the 7D3 output pentode and the 1D5 half-wave rectifier.

Two further output pentodes were added in 1935. There was the 7D6, also with a 40-volt heater, and the 13-volt, 0.65-amp 7D8. This latter type now completed a full compliment for car radios.

In the following year there was the 10D1 double diode, the 4D1 general-purpose triode (both with 13-volt, 0.2-amp heaters) and the 16D1, described as a special double triode; this also had a 13-volt heater, but required a current of 0.4 amps and had a rated output power of 5.2 watts.

The 7D5 output pentode was introduced in 1938. This had a 13-volt, 0.35-amp heater and an output power of 3.5 watts. The last of these types appeared in the late-1930s or in 1940. There were two frequency changers and one double diode triode, all with 13-volt, 0.15-amp heaters. The frequency changers were the

20D2 triode hexode and the 15D2 heptode which, together with the earlier 15D1, had identical characteristics to the four-volt 15A2. The double diode triode was the medium impedance 11D5.

Representative examples of the Micromesh and Brimar valve can be seen in Figure 9.1 to 9.3 and the equivalent US types in Table 9.2.

PenB1:
2-volt output pentode.

9A1: r.f. pentode
(5-pin version).

HBL1: detector triode
(Micromesh only).

HLA1: detector or a.f. triode
(Micromesh only).

HLA2:
detector or a.f. triode.

7A2: output pentode.

PenA1: output pentode.

PA1: output triode.

Figure 9.1: Two-volt and four-volt valves of 1933 and 1934 (all originally Micromesh types).

20A1: triode hexode frequency changer.

PA1: output triode with STC label.

R2: full-wave rectifier (Standard).

R2: full-wave rectifier (Brimar).

Figure 9.2: Four-volt valves of 1933 to 1938.
(Compare the later PA1 shown here with the earlier version in Figure 9.1.)

15D2: 13-volt heptode frequency changer.

9D2: 13-volt variable-mu r.f. pentode.

11D5: 13-volt double diode triode.

7D6: 40-volt output pentode.

Figure 9.3: Brimar a.c./d.c. valves

Brimar valves				US equivalent valves			
Type	V_h	I_h	Base	Type	V_f	I_f	Base
7A2	4.0	1.20	B7	6F6G	6.3	0.70	IO
7A3	4.0	2.00	B7	6AG6G	6.3	1.20	IO
7D3	40.0	0.20	B7	25A6G	25.0	0.30	IO
7D5	13.0	0.35	B7	6F6G	6.3	0.70	IO
7D6	40.0	0.20	B7	6AG6G	6.3	1.20	IO
7D8	13.0	0.65	B7	6AG6G	6.3	1.20	IO
8D2	13.0	0.20	B7	6J7G	6.3	0.30	IO
9D2	13.0	0.20	B7	6K7G	6.3	0.30	IO
20D2	13.0	0.15	B7	6K8G	6.3	0.30	IO

Table 9.2: Brimar valves and their equivalent US types showing differences in heater ratings and bases.

THE STC TUNOGRAPH

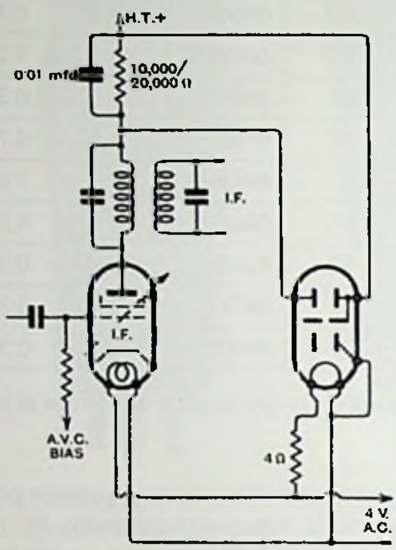
It has been shown that during the 1930s the superheterodyne receiver grew in popularity, both in Britain and abroad. Important features of these receivers were improved selectivity, by the use of double tuned i.f. transformers, and the provision of automatic gain control. The use of a.g.c. tended to flatten the tuning of the receiver, making it difficult to find the setting for maximum signal level. As a result, manufacturers of the more expensive receivers looked for some means of indicating the optimum tuning setting. One type of indicator was a milliammeter which was connected in the anode circuit of the variable-mu i.f. amplifier valve; as the signal level increased, the a.g.c. level became more negative and this, in turn, reduced the current in the valve, resulting in a smaller deflection of the milliammeter needle. Another type of indicator was a small neon tube in which the length of discharge depended upon the applied voltage, the magnitude of which was determined by the a.g.c. voltage.

An interesting new type of tuning indicator was announced by STC in 1933 and given the name 'Tunograph' [2]. This was, in effect, a small cathode-ray tube which plugged into a standard B5 valveholder. Electrons from the hot cathode were focused into a narrow beam and passed through a hole in the anode to hit a fluorescent screen. A pair of plates was used to deflect the spot and this deflection depended upon the a.g.c. voltage. Below is an STC description of the 'Tunograph' provided in a 1936 valve manual:

> The Tunograph has been designed for incorporation into radio sets in order to indicate visually when any particular station is tuned in correctly. By means of the Tunograph it is possible to adjust a set more accurately and easily than by the usual method of tuning by ear.
>
> The Tunograph is actually a miniature cathode ray oscillograph with one pair of deflecting plates mounted in a glass envelope with the leads brought out to a 5-pin valve base. The overall length is not greater than 5½ inches and the maximum diameter is 2 inches. The filament connections are brought out to the usual filament or heater pins, the anode and one deflecting plate to the anode pin, and the second deflecting plate to the grid pin. When a 5-pin base is fitted the shield around the filament is connected to the centre pin which for normal use should be strapped to one of the filament pins. With a 4-pin base the shield is connected to the filament internally.
>
> Instead of viewing the fluorescent spot or line through the end of the bulb, as is usually the case, the screen is carried on a metal plate inclined at an angle to the axis of the cathode ray beam and the spot is viewed through the side of the bulb. The Tunograph is designed to cause the fluorescent spot to fall at one end of the screen when no voltage is applied to the deflecting plates, thus making full use of the total length of screen available.

Figure 9.4 shows a view of the valve, together with a suitable circuit to give a spot on the screen at the top. As the signal level increased the spot moved steadily across the screen to the right.

STC 'Tunograph' of 1933 (4-pin version).



Circuit for light spot to move across screen with increasing signal strength.

SPECIFICATION

Oxide coated cathode, constant current

British 4- or 5-pin base

Length	15.2 cm
Diameter	4.8 cm

Filament current	0.9A
Nominal filament voltage	0.5V
Maximum anode voltage	350V
Minimum anode voltage	10V

Sensitivity: 40V between deflecting plate and anode for full-scale deflection with anode potential of 250V.

Figure 9.4: STC Tunograph of 1933 with typical circuit and specification.

BRIMAR US VALVES

The valves described so far were referred to as 'English types' in the Brimar data sheets. All other valves carried US type designations and were either of US manufacture or direct copies of the US types. These valves began to appear with their US type designations in the Brimar data sheets from the late 1930s although many of them had been available in the US for several years before. Some of them had an additional letter E added to their type numbers, which was often dropped in subsequent years. This letter usually designated a slight variation in characteristics from the US type and was probably of little importance in practice. Data for all the types can be found in the Valve Data Supplement and no attempt will be made in this chapter to describe them in any detail but they have been summarized in the tables that follow.

It was common practice in the UK to refer to the older US 4-, 5-, 6- and 7-pin bases as UX4, UX5, UX6 and UX7 respectively. In this book the bases have been named US4, US5, US6 and US7. All these bases eventually gave way to the International Octal (IO), the 8-pin Loctal and the 7-pin B7G. Other bases, such as the 9-pin B9A, did not come into use in the UK until after 1946 and so fall outside the scope of this book.

Battery 2-volt range with US bases

This range is shown in Table 9.3.

RF pentode	Heptode frequency changer	Triode or double diode triode	Class B double triode	Output pentode or double pentode
15 & 15E (IH), 32E 1A4E & 34E (VM)	1A6, 1C6	30, 30E, 2102 (DDT)	19	2101, 2103 (DP)

Table 9.3: Two-volt range with US bases.
(DP = Double Pentode.)

It should be noted that the two r.f. pentodes 15 and 15E had indirectly heated cathodes even though they were intended for battery receivers.

AC and AC/DC mains ranges with US bases

These ranges are shown in Table 9.4. There was the early a.c. range with 2.5-volt heaters. The later a.c. range had 6.3-volt heaters for the amplifying and power valves, and 5- or 6.3-volt filaments or heaters for the rectifiers. Finally there was a 0.3-amp range for a.c./d.c. series operation. Added to the range shown, however, should be the 0.3-amp types in the 6.3-volt range. An interesting feature of valves, such as the 12A7, was the incorporation of an output pentode and half-wave rectifier in a single envelope, a practice that was never adopted with British valves (see Figure 9.5).

Range	RF tetrode or pentode	Heptode freq. changer	Triode or DDT	Output triode or double triode	Output pentode	Tuning indicator	Rectifier
2.5-volt	24, 24E		27	2A3, 45	2A5, 47, 47E		
6.3-volt	6B7, 6B7E, 6C6, 6D6, 6F7/E/B, 36, 36E, 39/44, 39/44E, 77, 77E, 78, 78E	6A7, 6A7E	37, 75, 76, 85	6A3, 6A6, 6B5, 79	41, 41E, 42, 42E, 71A (5V) 807	6U5, 6G5	5Z3, 80, 83, 84/6Z4
0.3-amp					18, 18E, 43, 43E,12A7(LY), 2151		1D6,12Z3, 25Y5, 25Z5, 25RE, 35RE

Table 9.4: AC and a.c./d.c. ranges with US bases.

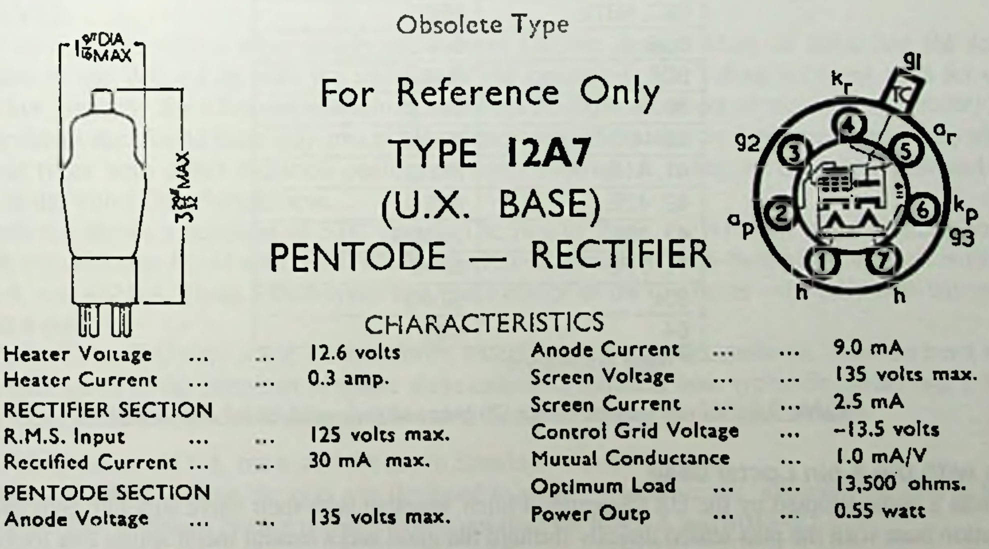


Figure 9.5: Brimar 12A7 Pentode–Rectifier.

Valves with the International Octal base

The international octal base was introduced in America in 1935. These are shown and Table 9.5. Many of the existing valves with the US4, US5, US6 and US7 bases were then fitted with the new octal base; these types are cross-referenced in Table 9.6.

Range	RF tetrode or pentode	Frequency Changer	Diode	Triode or DD triode	Output triode	Output pentode	Rectifier or tuning indicator
1.4-volt	1N5G/GT	1A7EG, 1A7G/GT		1H5G/GT		1A5EG, 1A5G/GT, 1C5EG, 1C5G/GT, 1Q5G/GT, 3Q5G/GT	
6.3-volt	6B8EG, 6B8G/GT, 6B8SG, 6J7G/GT, 6K7EG, 6K7G/GT, 6SG7, 6SH7, 6SJ7, 6SK7, 6U7G	6A8G/GT, 6K8G/GT, 6L7G, 6P8G	6H6G 6H6GT	6B6G, 6C5G, 6F5, 6F5G, 6J5G/GT, 6K5G, 6Q7G/GT, 6R7G, 6SL7GT, 6SN7GT, 6SQ7	6B4G, 6N6G, 6N7G/GT	6AG6G, 6F6EG, 6F6G, 6K6G, 6L6G, 6V6G/GT	5R4GY, 5U4G, 5V4G, 5X4G, 5Y3G, 5Y4G, 5Z4G, 6X5G/GT, 6ZY5G, 6U5G*
0.3-amp						25A6G, 25A7G(LY), 25L6GT, 32L7GT(LY)	25Z4G, 25Z6G
0.15-amp	25B8GT			25SN7GT		12A6, 35L6GT, 50L6GT, 70L7GT(LY), 117P7GT(LY, 0.09A)	35Z4GT
12.6-volt	12C8GT, 12J7GT, 12K7GT, 12SJ7, 12SK7			12Q7GT, 12SQ7, 12SR7		12A6	

*6U5G is a tuning indicator, LY = pentode + rectifier

Table 9.5: Valves with the International Octal (IO) base.

US base	Octal base (IO)
6A3	6B4G
6A6	6N7G/GT
6A7, 6A7E	6A8G/GT
6B5	6N6G
6B7, 6B7E	6B8G
6C6	6J7G
6D6	6U7G
36	6J7G*
39/44	6K7G*
41, 41E	6K6G
42, 42E	6F6G
43, 43E	25A6G
77, 77E	6J7G
80s	5Z4G
84	6Z4

* Near equivalent

Table 9.6: Valves with the earlier US base and their octal-based equivalents.

Valves with the 8-pin Loctal base

Loktal was a name adopted by the US Company, Philco, together with their valve supplier, Sylvania. It has a glass button base with the pins sealed directly through the glass and a central metal spigot that locked into the valveholder. Valves using this base became available from 1939. Other US tube manufacturers very soon produced valves with this 8-pin base which they then named either Loctal, rather than the Philco trade name of Loktal, or simply Lock-In.

The first Brimar valves to use the base appeared in 1939 and the full range is shown in Table 9.7. It should be noted that all the 6.3-volt Loctals were in the 7 Series to distinguish them from the 6.3-volt valves with the earlier US- and IO-based valves.

Range	RF tetrode or pentode	Frequency Changer	Triode or DD triode	Output pentode	Rectifier
1.4-volt	1LN5E, 1LD5	1LA6E	1LH4	1LA4E, 3D6	
6.3-volt	7A7, 7B7, 7C7, 7H7, 7R7	7A8, 7B8, 7S7	7B6, 7C6, 7F7, 7K7, 7N7	7B5E, 7C5	7Y4, 7Z4
1.4-volt B7G	1S5, 1T4	1R5		1S4, 3S4	

Table 9.7: Loctal and B7G valves.

Many of these valves had identical characteristics to those in the IO range (see Table 9.8)

Loctal base	IO base
1LA4E	1A5G
1LA6E	1A7G
1LH5	1H5G
7C5	6V6G
7F7	6SL7GT
7K7	6SL7GT
7N7	6SN7GT

Table 9.8: Loctal-based valves and their IO equivalents.

US valves are covered in Chapter 14 and many of the photographs shown are of Brimar valves.

STC VALVES

The STC or Standard valves were mainly of Western Electric design. Many of these had the same type designations as the WE valves with the addition of the number 4. The valves were not used for domestic receivers but primarily for telecommunications transmitters, radio receivers or repeater equipment. Some of the power valves also found there way into public address amplifiers. A very large number of the valves were high-power types with either radiation cooling or water cooling. A listing of the lower powered types is provided in the Valve Data Supplement.

Figure 9.6 shows a selection of STC valves. The first of these, the 4101-D, has a globular (or 'tennis ball') bulb which is also found with the 4102-D and 4104-D. Similarly the S-bulb of the 4020-A is found with the 4019-A, and 4021-A. These S-bulb types also had a choice of the two bases—the BC4 with bayonet pin or the British 4-pin B4.

Several of the STC valves had various suffix letters in their type designations. This has been shown in the valve data given in the Supplement where these indicated different base types. For some types, however, the suffix letter indicated special features of the valve. Some examples are indicated below:

4033-AF. Identical to 4033-A, but tested for use in Standard Aircraft Radio.

4043-C and 4043-D. For these the grid was designed to reduce grid emission, allowing the grid to be driven more positive to obtain greater undistorted output than the 4043-A and 4043-B.

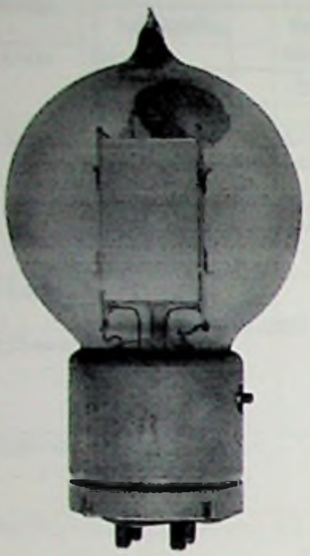
4101-E. Similar to 4101-D but filament designed to reduce sputter noise.

4101-G. Similar to 4101-E except that the anode lead was brought out through the stem to increase the grid-anode insulation.

4102-E, 4102-G, 4104-E and 4104-G. As for 4101-E and 4101-G.

4211-E. Has small chokes (approx. 1μH) inserted in the anode and grid leads to prevent spurious oscillation.

4307-AF. Identical to 4307-A, but tested for use in Standard Aircraft Radio.

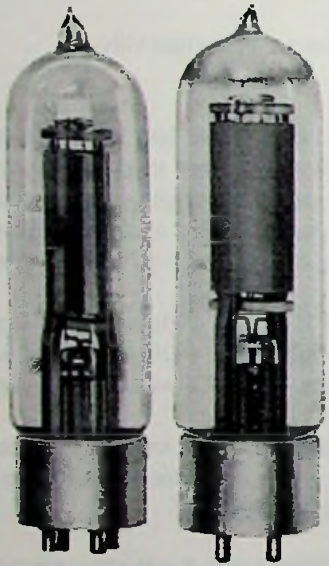


4101-D:
general-purpose triode for telephone repeaters.

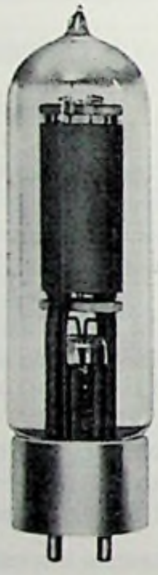
4020-A:
voltage amplifier triode for telephone repeaters.

4033-A: low-power audio output triode or a Class B driver.

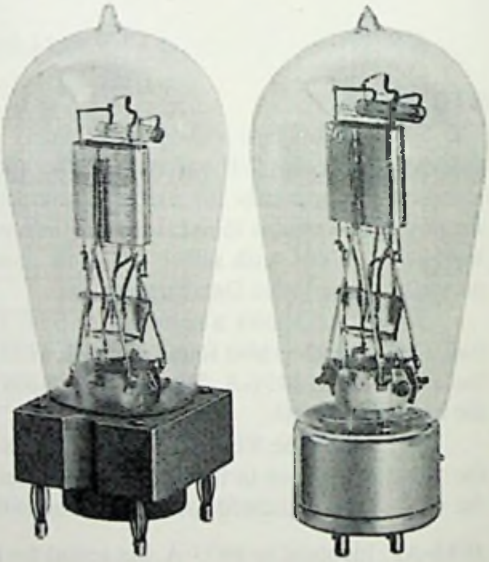
4043-A: r.f. power amplifier triode for Class B operation.



4011-A & 4011-B: power triodes for audio or r.f. applications. 4011-B for lower anode voltage.



4211-D & 4211-E:
a.f. and r.f. power amplifier triodes.



4056-A & 4056-B: r.f. power amplifier triodes for Class B operation.

Figure 9.6: STC repeater and power valves.

REFERENCES

1. 'Standard "Micromesh" A.C. Valves', *W.W.*, **32**, 5 August 1932, pp. 102-3.
2. 'Visual Tuning Indicator', *W.W.*, **33**, 13 October 1933, pp. 307-8.

Chapter 10
The 362 Radio Valve Company Ltd

It was claimed that The 362 Radio Valve Company, together with its associated Companies, was established in 1923, making it one of the oldest valve manufacturing concerns in the UK. For its first ten years it 'supplied Radio Valves on contract to leading set manufacturers and others.' It has not been possible to verify this claim but there is no reason to doubt the substance of it. The author believes that the original manufacturing company was the North London Valve Company Ltd which had premises in Stoke Newington, north London.

The trade name 362 first appeared in 1933 at which time the company began selling valves directly to the public. In May 1937, however, the Company decided to discontinue manufacture of valves for broadcast receivers and to concentrate on transmitting valves, primarily for radio amateurs and the experimenter. This change was not a commercial success and the Company very soon ceased trading.

BATTERY VALVES: 1933 TO 1937

Table 10.1 shows the full range of 2-, 4- and 6-volt battery valves produced by 362. The initial types of 1933 were:

- SG2, SG4 and SG6 r.f. tetrodes
- VS2, VS4 and VS6 variable-mu r.f. tetrodes
- H2, H4 and H6 high impedance detector or a.f. triodes
- HL2, HL4 and HL6 medium impedance detector triodes
- L2, L4 and L6 low impedance a.f. triodes
- LP2, LP4 and LP6 low-power output triodes
- P2, P4 and P6 'super power' output triodes
- BA2 and BX2 Class B double output triodes
- ME2, ME4 and ME6 output pentodes with 5-pin bases
- ME2a, ME4a and ME6a output pentodes with 4-pin bases plus a side terminal for connection to the screen grid.

Range	Year	RF tetrode or pentode	Triode	Output triode	Output pentode
2-volt battery	1933	SG2, VS2	H2, HL2, L2	BA2, BX2, LP2, P2	ME2, ME2a
	1934	VP2			
	1935	VP2c			
	1937			SR2	
4-volt battery	1933	SG4, VS4	H4, HL4, L2	LP4, P4	ME4, ME4a
6-volt battery	1933	SG6, VS6	H6, HL6, L6	LP6, P6	ME6, ME6a

Table 10.1: 362 battery valves of 1933 to 1937.

The BA2 Class B valve had a 0.2-amp filament and provided an output power of 1.5 watts from a 150-volt supply, whereas the BX2 had a 0.4-amp filament and a higher output of three watts.

The only r.f. pentode was the variable-mu VP2 of 1934 with a 4-pin base (a 7-pin version of this, the VP2c, appeared in the following year).

There was also one other output triode: the two-volt SR2 of 1937 with a rated output of two watts from a 200-volt supply.

Figure 10.1 shows a few examples of the two-volt battery valves, including the HL2 which, with several other types, could be supplied in the metal-sheathed 'Toledo' construction. The 'Toledo' types listed were the 2-, 4- and 6-volt versions of the HL, LP, P, SG and VS. This form of construction was claimed to provide greater mechanical strength, uniformity of characteristics, freedom from microphony and perfect screening.

4-VOLT AC VALVES: 1933 TO 1937 (SEE FIGURE 10.2)

Table 10.2 shows the range of 4-volt a.c. valves which were intended primarily for receiver applications. The majority of these appeared in the three years 1933 to 1935. These initial types of 1933 and 1934 included two r.f. tetrodes, two r.f. pentodes, two general-purpose triodes, four output triodes, three output pentodes and two full-wave rectifiers.

Year	RF tetrode or pentode	Frequency changer	Triode or DDT	Output triode	Output pentode	Rectifier
1933	AC/SG4, AC/VS4		AC/H4	AC/L4, AC/P4	AC/PN4 (B5& B7)	
1934	AC/HM4, AC/VP4		AC/HL4	AC/PX4, AC/PX4a*	ACME4 (B5), AC/ME4a* (B4),	RB41*, RB42*
1935		AC/FC4	AC/HL4dd	PX25A*, CLP (6.5V)	AC/ME4b* (B5), AC/ME4c (B7), ME25*, CME (6.5V)	
1936						RB350/80*, RB500/120*
1937	MP4			SR4*		

* Directly heated a.c. valves.

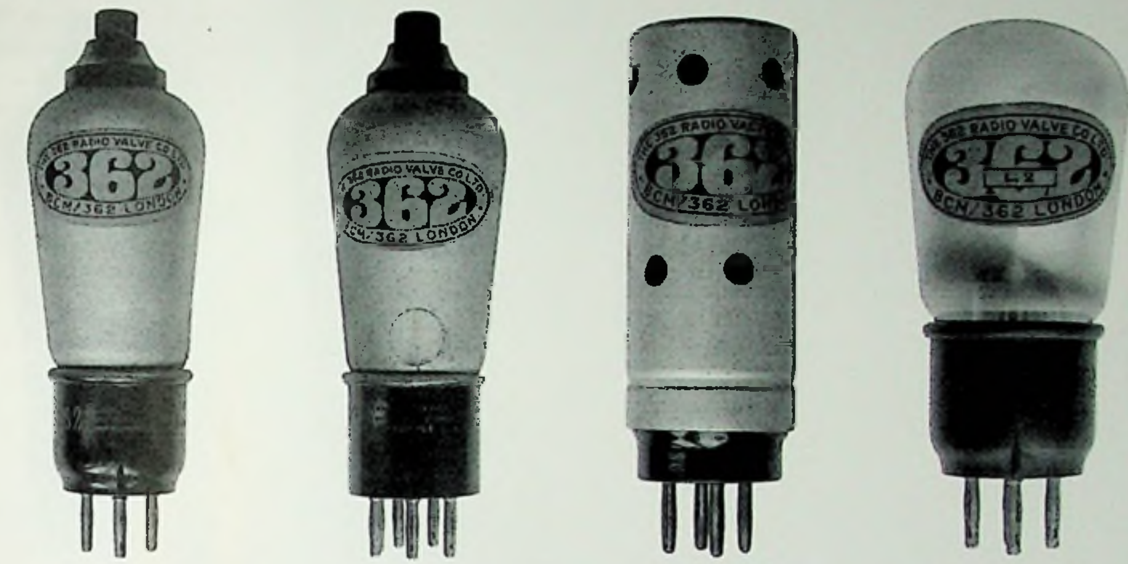
Table 10.2: Four-volt a.c. range of 1933 to 1937.

The 1933 r.f. tetrodes were the AC/SG4 and the variable-mu AC/VS4. The general-purpose triode was the medium impedance AC/H4. The two output triodes were the low-power AC/L4, which could also be used as an a.f. amplifier for driving higher power output triodes or as an oscillator, and the AC/P4. The output pentode was the AC/PN4 which had the choice of a 5- or 7-pin base.

The 1934 r.f. pentodes were the AC/HM4 and the variable-mu AC/VP4. The general-purpose triode was the AC/HL4. The two output triodes were the indirectly heated AC/PX4 and the directly heated AC/PX4a, both having an output power of 2.5 watts. The two output pentodes were the indirectly heated AC/ME4, with a 5-pin base, and the directly heated AC/ME4a with a 4-pin base, both having a side terminal for connection to the screen grid. Finally the two full-wave rectifiers, both directly heated, were the RB41, rated at 300V, 50mA and the RB42, rated at 500V, 100mA.

Two new valves of 1935 for use with superheterodyne receivers were the AC/FC4 heptode and the AC/HL4dd double diode triode. There were two output triodes: the directly heated PX25A with an output power of three watts and the directly heated CLP with a 6.5-volt heater and having an output power of 1.5 watts. There were four output pentodes. These were the directly heated AC/ME4b, the indirectly heated AC/ME4c with a 7-pin base, the directly heated ME25, having an output power of nine watts, and the indirectly heated CME which had a 6.5-volt heater and an output power of 2.5 watts. The AC/ME4, AC/ME4a and AC/ME4c all had very similar characteristics and each had an output power of three watts and a slope of 8mA/V. The AC/ME4c, however, had a lower slope of 3mA/V and a slightly higher output power of 3.5 watts. Both the AC/ME4b and the ME25 had a 5-pin base with side terminal for connection to the screen grid. In 1936 there were two new full-wave, directly-heated rectifiers; these were the RB350/80, which replaced the RB41, and the RB500/120, which replaced the RB42.

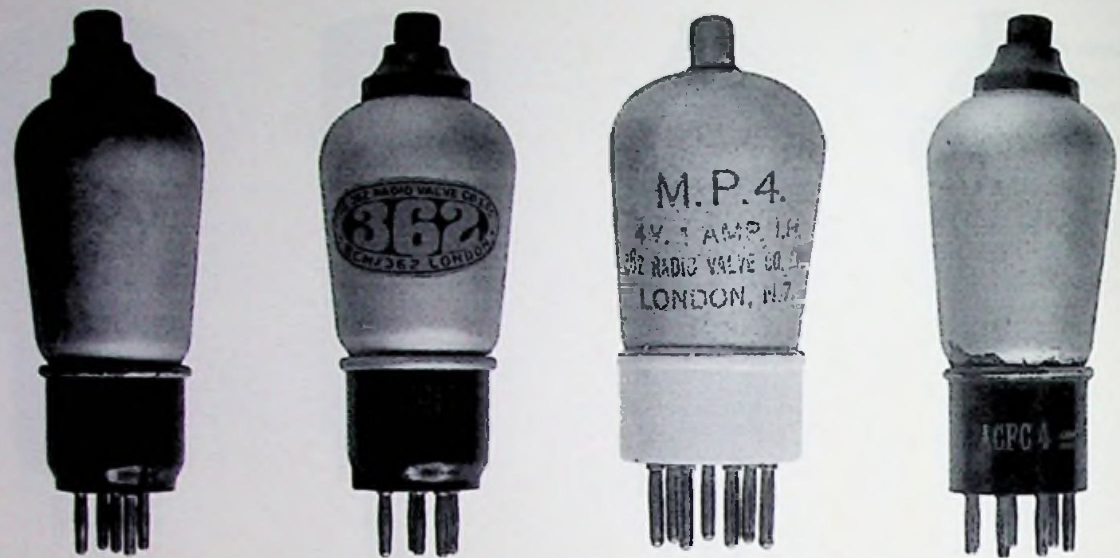
In 1937, the final year of 362 valves, there was the split-anode tetrode, MP4, presumably intended for use in television receivers and also a new power triode, the directly heated SR4.



VS2: r.f. tetrode.	VP2: variable-mu r.f. pentode.	HL2: detector triode shown in the 'Toledo' construction.	L2: a.f. triode.

BA2: Class B double triode.	LP2: low-power output triode.	ME2: output pentode with 5-pin base.	ME2a: output pentode with 4-pin base.

Figure 10.1: Two-volt battery valves.

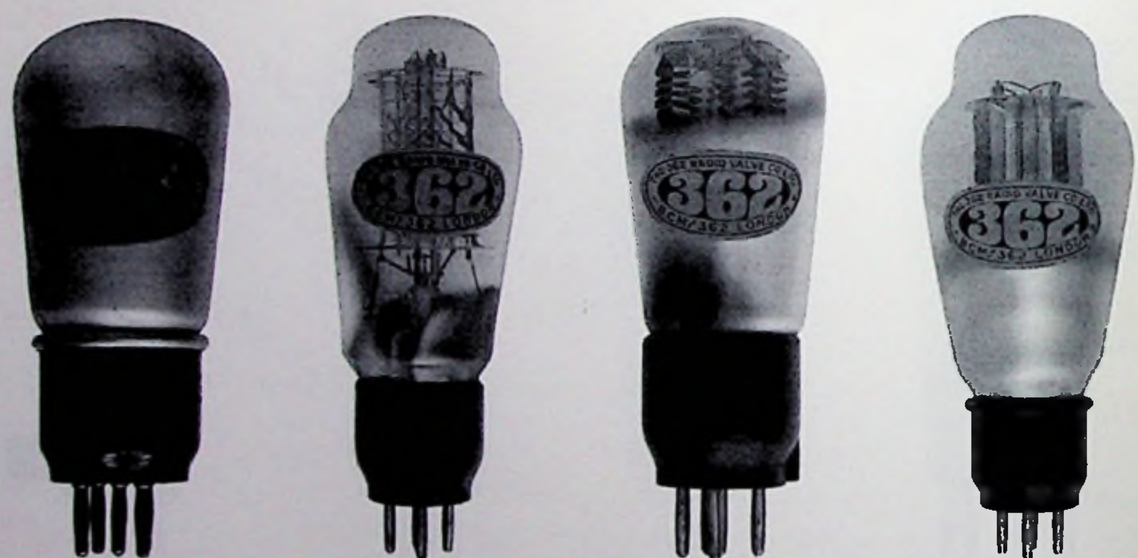


ACSG4:
r.f. tetrode.

ACHM4:
r.f. pentode.

MP4:
split-anode tetrode.

ACFC4:
heptode frequency changer.



ACHL4:
detector or a.f. triode.

ACME4b: directly heated
output pentode (B5 base).

ACPX4: indirectly heated
power triode (B5 base).

ACPX4a: directly heated
power triode (B4 base).

Figure 10.2: Four-volt a.c. valves.

POWER VALVES

362 produced a range or high-power valves intended both for use in public address amplifiers and in radio transmitters. These are listed in Table 10.3 and examples shown in Figure 10.3.

The first of these valves, all appearing in 1935, were seven directly heated triodes, which are shown in the table in ascending levels of output power. These were followed in 1936 and 1937 by a range of r.f. pentodes for use in transmitting equipment. Some details of these two ranges are given immediately following the table.

Year	Audio or RF output triode	Audio or RF output pentode	Rectifier
1935	PX25, PX50, PX60, PX100 PX120, PX200, PX300		RB650/250
1936		RFP15, RFP30, RFP60, RFP120	RB750/150
1937	P625 (Oscillator)	RFP8/14	

Table 10.3: Power valves of 1935 to 1937.

PX25: Suitable for the output stage of very large radiograms, public address amplifiers or small transmitters. Positive grid can drive can be utilized where higher power is required. For audio amplifiers an output power of seven watts can be achieved from a 400V supply. For Class C operation the r.f. output power is 25 watts from a 750V supply.

PX50: Use of the 'Perpendicular Anode' with fins used on this and other high power valves helps reduce excess heating of the anode. For audio amplifiers the output power is 13 watts from a 500V supply. In Class C operation the r.f. output is 28 watts from an 800V supply.

PX60: This is similar the PX50 but has an audio output of 18 watts from a 600V supply. In Class C operation the r.f. output is 37 watts from a 750V supply.

PX100: This valve is of similar design to the PX25, PX50 and PX60 but having a far larger dissipation. It could be used in high-power public address amplifiers, transmitters and small electric furnaces. The audio output is 35 watts from a 1kV supply and in Class C amplifiers the r.f. output is quoted as 37 watts from a 1kV supply, although this output figure appears to be rather low.

PX120: This valve is similar to the PX100 and provides an audio output power of 50 watts from a 1.5kV supply. For Class C operation the r.f. output is 150 watts from a 1.5kV supply.

PX200: This valve has an audio output of 72 watts from a 1.5kV supply, increasing to 84 watts from a 2kV supply. For class C operation the r.f. output is 600 watts from a 3kV supply.

PX300: This was the largest of the power triodes and for Class C operation can provide an r.f. output of 600 watts from a 3kV supply. (It's not obvious why this valve has the same r.f. output as the PX200.)

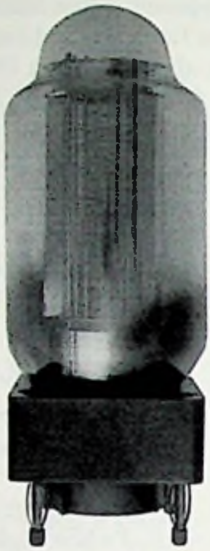
The only other power triode was the P625 of 1937. This only had an output or 1.5 watts but was intended for use as an oscillator.

The r.f. power pentodes appeared in 1936 and were aimed primarily at the amateur radio market. All these 1936 valves were directly heated. In ascending order of power these were the RFP15, RFP30, RFP60 and RFP120, where the numbers 15, 30, etc. refer to the maximum anode dissipation in watts. The last of the power pentodes was the indirectly heated RFP8/14 which was introduced in 1937.

There were only two rectifiers, both directly heated and full-wave. These were the RB650/250, rated at 650V, 250mA, and the RB750/150, rated at 750V, 150mA. These were intended for medium power audio amplifiers or small transmitters.

PX25a:
directly heated 7-watt
power triode.

PX50:
directly heated 13-watt
power triode.



PX60:
directly heated 18-watt
power triode.

RFP15:
directly heated 21-watt r.f.
power pentode.

RFP30:
directly heated 37-watt r.f.
power pentode.

RFP60:
directly heated 70-watt r.f.
power pentode.

P625:
1.5-watt oscillator triode.

RB650/250:
650V, 250mA
full-wave rectifier.

Figure 10.3: Power triodes, pentodes and rectifiers.

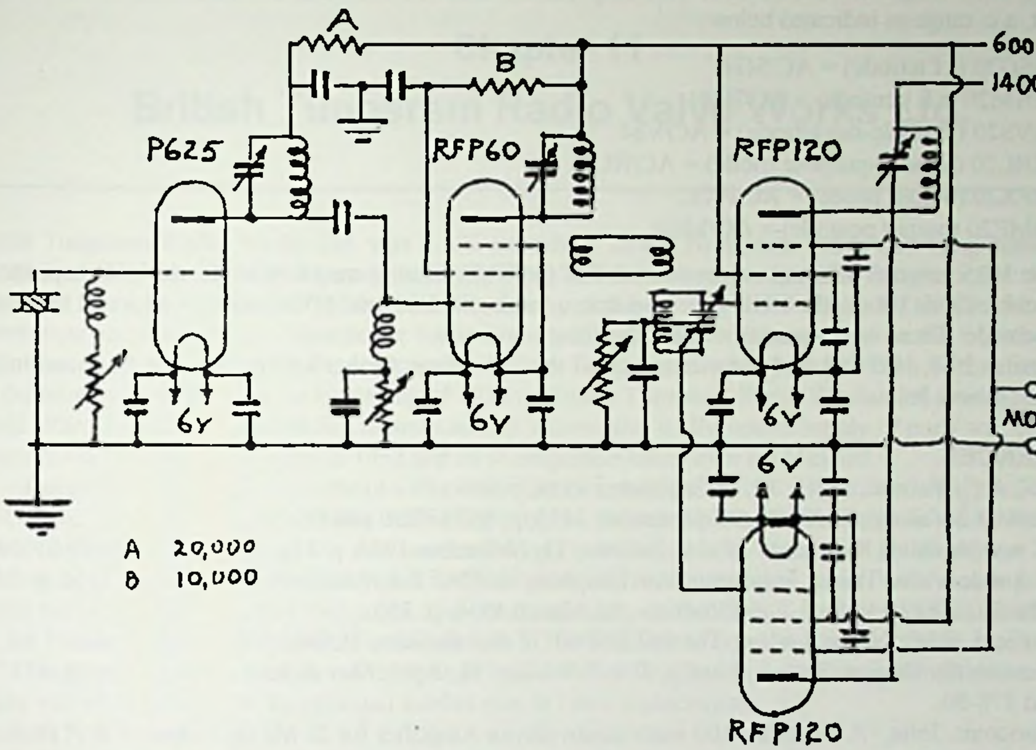


Figure 10.4: A 200-watt telephony transmitter.

TELEPHONY TRANSMITTER

Figure 10.4 shows the circuit of a 200-watt telephony transmitter using 362 valves. In this circuit a P625 is used in the oscillator stage and this is followed by an RFP60 in a frequency doubler stage. At the output there are two RFP120 valves connected in a push-pull frequency doubler stage.

The transmitter is designed to work on both the 14 and 28 MHz bands. It uses suppressor grid modulation.

According to 362 careful adjustment of the grid-leak on the output stage is essential for good results.

AC/DC VALVES

There were two ranges of a.c./d.c. valves (see Table 10.4). The first of these, introduced in 1934, had 0.18-amp heaters and the second, introduced in the following year, had 0.3-amp heaters.

Range	Year	RF tetrode or pentode	Freq. changer	Triode or DDT	Output triode	O/p pentode or tetrode
0.18-amp	1934	MSG20, MVS20, MHM20		MHL20	MPX20	MME20
0.3-amp	1935	UVP	UFC	UHdd, UHL	ULP, UPX	UME

Table 10.4: AC/DC valves of 1934 and 1935.

The 1934 range all had 20-volt, 0.18-amp heaters and had identical characteristics to valves in the four-volt, a.c. range as indicated below:

- MSG20 (r.f tetrode) = AC/SG4
- MHM20 (r.f. pentode) = AC/HM4
- MVS20 (variable-mu tetrode) = AC/VS4
- MHL20 (general-purpose triode) = AC/HL4
- MPX20 (output triode) = AC/PX4,
- MME20 (output pentode) = AC/ME4.

The 1935 range of 0.3-amp valves consisted of the UVP variable-mu r.f. pentode, the UFC heptode, the UHdd double diode triode, the UHL general-purpose triode, the ULP and UVX output triodes and the UME output pentode. There were no rectifiers in either range.

Figures 10.1, 10.2 and 10.3 show examples of the 362 valves; further information may be found in the references shown below.

REFERENCES

1. '362 A.C. Valves', *W.W.*, **35**, 14 September 1934, p. 236.
2. 'New 362 Valves', *W.W.*, **37**, 29 September 1935, p. 567 (PX50 and UFC).
3. 'A new British R.F. pentode', *T & R Bulletin*, **11**, November 1935, p. 138. (RFP 362—later RFP 60).
4. 'A Single-Valve Tri-set Transmitter for Telephony or CW' *T & R Bulletin*, **11**, February 1936, p. 311.
5. 'The 362 RFP15 Valve', *T & R Bulletin*, **11**, March 1936, p. 350.
6. Corfield, B M, 'Valve Review, The 362 RFP60', *T & R Bulletin*, **11**, March 1936, pp. 360-1.
7. 'Transmitter Design' Parts 1, 2 and 3, *T & R Bulletin*, **11**, April, May & June 1936, pp. 390-5, 432-7, and 478-80.
8. Claricoats, John, 'A Push Pull 100 watts mains driven Amplifier for 28 Mc operation', *T & R Bulletin*, **11**, April 1936, pp. 396-7.
9. Claricoats, John, 'The DX2', *T & R Bulletin*, July 1936.
10. 'A British 75 watt Pentode', *Television & Short Wave World*, December 1935, p. 733.
11. 'Keying the Transmitter', *Television & Short Wave World*, April 1936, p. 238.
12. 'Phone Transmitter for the beginner', *Television & Short Wave World*, May 1936, pp. 291, 294.
13. 'A 40 Metre Phone Transmitter', *Television & Short Wave World*, June 1936, p. 362.
14. 'The Doubler Stage', *Television & Short Wave World*, July 1936, p. 415.
15. 'A 50 watt Transmitter', *Television & Short Wave World*, August 1936, p. 471.
16. 'Anode Modulating Pentodes', *Television & Short Wave World*, August 1936, p. 47

Chapter 11

British Tungsram Radio Valve Works Ltd.

British Tungsram Radio Works Ltd. was a UK subsidiary of the Hungarian valve and lamp manufacturer, United Incandescent Co. of Budapest (see Figure 11.1). All the valves produced in Britain before 1938 were assembled from parts exported by the parent company and bore the brand name TUNGSRAM. The first valves were announced at the Manchester Radio Show in October 1929 and appeared on the British market in the following year; at that time the company name was Tungsram Electric Lamp Works (Great Britain) Ltd. but the name was changed at the beginning of 1939 to British Tungsram Radio Works Ltd. During the Second World War Tungsram undertook full manufacture of valves after its European supply of parts was cut off. The company was acquired by Philips in 1952 and its management taken over by Mullard.

Tungsram was a major European valve manufacturer and had a very wide range of types. In the UK most of the valves were fitted initially with the British 4-, 5- and 7-pin bases but later in the 1930s many of the valves had the alternative of the side contact P-base. Valves were also listed with the European 7-pin base (C7) but these types have not been covered in this book in any detail—most of which were also available with British bases. In the late 1930s Tungsram also produced many of the Philips E-Series valves. Initially, these had the P-base but during the 1940s a small number of the octal-based types became available.

Tungsram was not a member of the British Radio Valve Manufacturers' Association (BVA) and did not supply valves to set makers. Its principal market was in valve replacement.

Figure 11.1: Tungsram factory in Budapest c1925.
(Apart from the UK there were also factories in Austria, Czechoslovakia, France, Italy and Poland.)

BATTERY VALVES: 1930 TO 1932

As was previously stated, Tungsram announced their intention of entering the British valve business in 1929 as was reported in the 8 June issue of *Wireless Trader* [1]. A list of types to be released was announced three months later [2]. Table 11.1 shows the 2-, 4- and 6-volt battery types that appeared in the first three years.

Range	Year	RF tetrode	Bi-grid mixer	RF, detector or AF triode	Output triode	Output pentode
2-volt	1930	S210		H210, LG210, R208	P215, SP230	
	1931			L210, PD220	P220	PP230 (B4)
	1932		DG210			
4-volt	1930	S407		G405, G407, G409, G410, H407, R406	L414, P414, P430, P460, SP614	
	1931	S406, S410		HR406, HR410, LD409, LD410	P410, P415	PP415, PP416, PP430, PP431
	1932		DG407, DG407/0			
6-volt	1930			G607, HR607, LG607	P410, P615	
	1931				P610	PP610

Table 11.1: Two-, Four- and six-volt battery valves of 1930 to 1932.

The table shows a comprehensive range of r.f. tetrodes, detector triodes, a.f. triodes, output triodes and output pentodes in all three filament voltage ranges. Table 11.2 shows suggested applications for some of the triodes. Several of these were shown as r.f. amplifiers, but they would need to be used in neutralized stages, a circuit that was rarely adopted by British set makers.

Range	RF	Detector	RCC	AF	Normal Output	S.P. Output
2-volt	H210 R208	H210 LG210 R208	R208	L210	P215	SP230
4-volt	R406 G405	G407 G407	R406	L414 G409	P415 L414	P414
6-volt	HR607 LG607	LG607		G607	P615	SP414

Table 11.2: Applications of various early triode valves in receiver circuits.
(Note: S.P. = Super Power.)

The only new valves to appear in 1932 were the two- and four-volt bi-grids, DG210, DG407 and DG407/0. These valves, in common with similar types by Mullard and Cossor, were intended primarily for use as a mixer in early superhet receivers. The first two of these had 4-pin bases with a side terminal for connection to the inner grid. The DG407/0, however, had the choice of a 4- or 5-pin base and no side terminal.

Of these early valves the P215 was the only one to continue in use into the late 1930s; both the four- and six-volt battery valves were discontinued after 1931.

BATTERY RANGES OF 1933 TO 1938

Table 11.3 shows the battery valves that appeared from 1933 onwards and this is broken down in two groups: the standard range and the lower-current economy range for use with portable receivers. In the standard range there were three new r.f. tetrodes. Of these the S220 had a higher gain than the earlier S210 but required twice the filament current. The other two were the variable-mu SE220, with a slope of 1.2mA/V, and the higher gain SV220 with a slope of 1.8mA/V. There were two triodes: the general-purpose HR210, which would have been used mainly as a detector, and the SP220 output triode with 0.2-amp filament current rather than 0.3 amps of the earlier SP230. Finally there were two new output pentodes: the PP220, with a choice of 4- or 5-pin base, and the CB220 Class B valve. The CB220 could be operated with zero bias but the anode current was then fairly high and it was preferable to use about three volts of negative bias, which resulted in a considerable saving in anode current, although the valve then required a slightly higher input signal at its two grids. Whether worked with or without negative grid bias the valve could deliver and output of 1.4 watts from a 120-volt h.t. supply or two watts from a 150-volt supply. Initially the driver for this was the SP220 until the LP220 was introduced a couple of years later

Range	Year	RF tetrode or pentode	Frequency changer	Triode or DD triode	Output triode	Output pentode
Standard	1933	S220, SE220, SV220	DG210/0	HR210	CB220, SP220	PP220 (B4&B5), PP230 (B5)
	1934	HP210 & HP211 (B4&B7)	MH206			PP280
	1935		VO2*	DDT2, LD210, LP220		PP222 (B4&B5)
	1936	SE211 (B4&B7)		LL2*	CB215*	PP225*
	1937	HP210c, HP210nc, HP211c, SE211c, SS210	VX2*	DDT2B*		
	1938/9	SP2D & VP2D (B4&B7)		HL2*		PP215*
Economy	1936	SP2B*, VP2B*		HR2*		PP2*

All type marked with * were also available with side contact bases.

Table 11.3: Two-volt battery valves of 1932 to 1938.

In 1933 there were also 5-pin versions of the earlier PP230 output pentode and the DG210 bi-grid; this latter valve, re-named DG210/0, had the inner grid connected to the centre pin of the base.

The following year saw the first of the r.f. pentodes; these were the HP210 and the variable-mu HP211, both having 0.12-amp filaments. Two further valves were the MH206 heptode frequency changer, with the rather low conversion conductance of 0.28mA/V, and the PP280 output pentode.

In 1935 the MH206 was superseded by the VO2 octode. There was also the DDT2 double diode triode, the LD210 detector or a.f. triode and the PP222 output pentode. The PP222, like the earlier PP220, had a choice of 4- or 5-pin bases. Finally, there was the LP220 driver triode for the CB220.

In 1936, there appeared the SE211 variable-mu tetrode which was a replacement for the SE220 and had the lower filament current of 0.12 amps. Other new valves were the LL2 triode, the PP225 output pentode and the CB215 Class B triode. The LL2 was intended as a driver for the CB215. It was recommended that the CB215 be operated with zero bias, thereby avoiding the need for a grid bias battery.

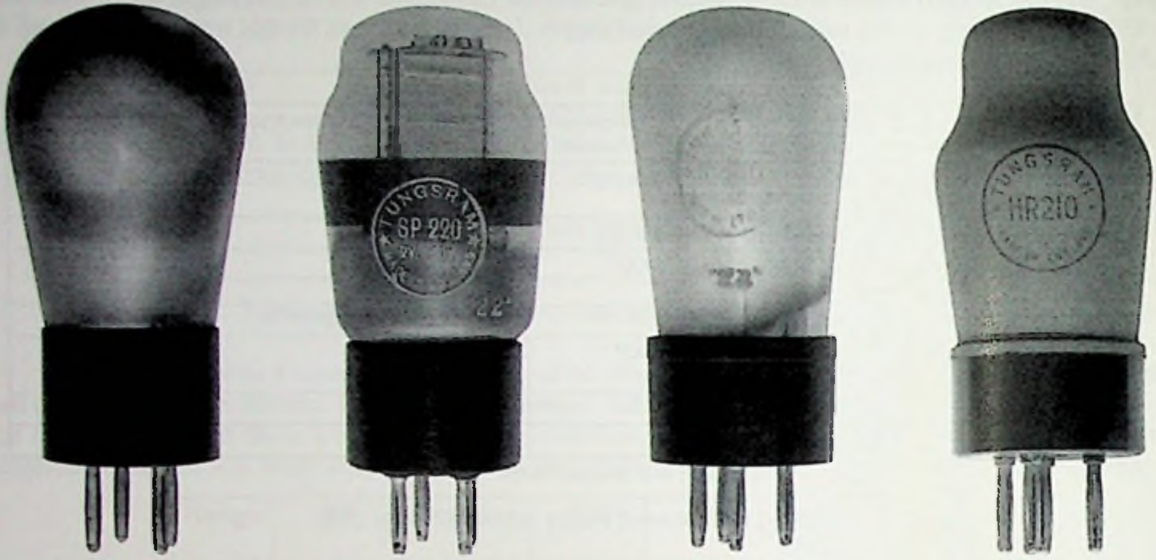
New valves introduced in 1937 were the SS210 r.f. tetrode, to replace the earlier S220, the VX2 hexode mixer and the DDT2B double diode triode, which could be used in economy receivers as a combined detector and triode driver for the CB215. (It should also be noted that some of the earlier valve types were suffixed with the letter 'c' or 'nc', where 'c' indicated a metal cap and 'n' non-microphonic.)

The last of the battery valves to appear in the standard range were the SP2D r.f. pentode, the VP2D variable-mu r.f. pentode, the HL2 triode and the PP215 output pentode. Both the SP2D and the VP2D had a choice of 4- or 7-pin bases and replaced all the earlier r.f. pentodes. The HL2 was a general-purpose triode, which could be used as a detector in t.r.f. receivers or as a local oscillator for the VX2 mixer. This combination of VX2 and HL2 thus became a triode hexode frequency changer for use in all-wave receivers. Finally, the PP215 was a replacement for all the earlier output pentodes.

Economy range

This range of low power-consumption valves was released in 1936 and was intended for portable receivers. It consisted of the SP2B r.f. pentode, the VP2B variable-mu r.f. pentode, the HR2 detector triode, and the PP2 output pentode.

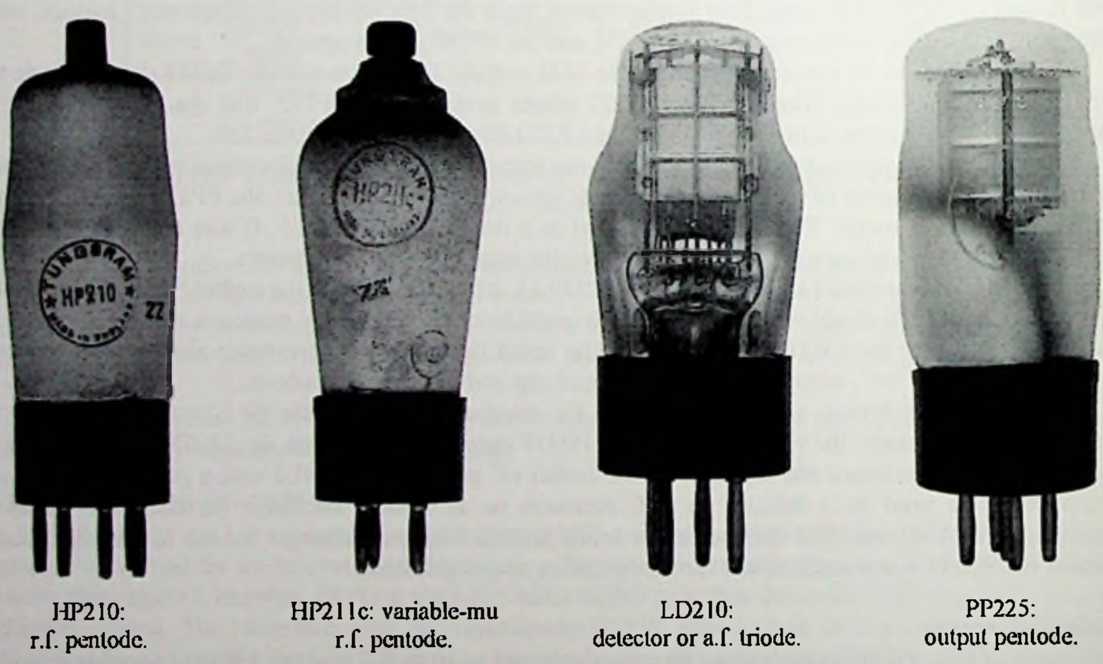
Some example of British-made, Tungsram battery valves can be seen in Figures 11.2 and 11.3, together with a suggested 'all-wave' frequency changer circuit using the VX2 hexode and HL2 triode.



LG210: detector or a.f. triode of 1930.

SP220: output triode.

HR210: general-purpose triode. (Clear version at left and metallised version at right.)



HP210: r.f. pentode.

HP211c: variable-mu r.f. pentode.

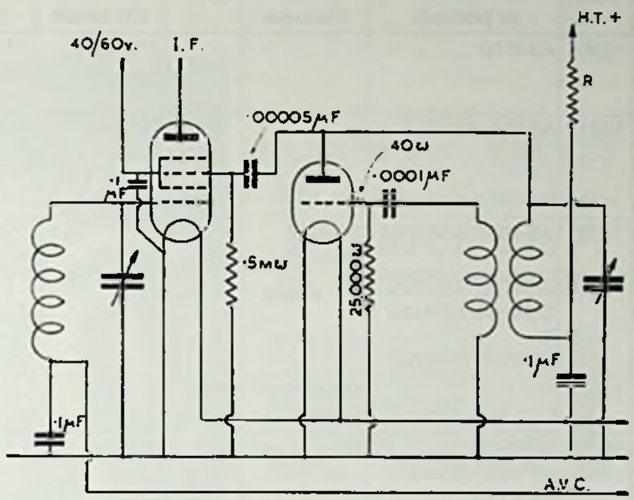
LD210: detector or a.f. triode.

PP225: output pentode.

Figure 11.2: Two-volt battery valves of 1930 to 1938. (Several of these were made by other manufacturers.) (Note: contrary to information provided by Tungsram, the HP211c has a screw terminal rather than a metal cap.)

LL2: driver triode for the CB215.

HL2: oscillator or detector triode.



Frequency changer circuit using VX2 hexode and HL2 as an oscillator.

Figure 11.3: Two-volt battery valves of 1936 to 1938.
(The LL2 is a re-branded Cossor 210LF and the HL2 a re-branded MOV HL2k.)

1-VOLT AC RANGE OF 1930

Tungsram produced a small range of directly heated a.c. valves in 1930. These were all triodes and had 1-volt filaments. There is no evidence of them having been used in the UK. There were two medium impedance types: the G150 and R150, both with 0.5-amp filaments. The only other types were two output valves: the L190 and P190, both having 0.9-amp filaments.

4-VOLT AC VALVES OF 1930 TO 1939

The first of the four-volt a.c. valves appeared in 1930 (see Table 11.4). Most of these were indirectly heated. However, some of the output valves and several of the rectifiers were directly heated. Included in this section are a few valves designed primarily for television. A separate section of this chapter covers the medium-and high-power directly heated output valves, together with the associated rectifiers.

Two types of valve base have been included in the table: the British 5- and 7-pin and the continental side contact. The dates of issue for the valves refer mainly those with British bases, although it has not been possible to date a couple of these. The valves with side contact bases all have the letter 's' at the end of their type designation and the date shown for these has been given the same year as their companion types with British bases; in fact most of them did not appear until later years.

The indirectly heated valves released in 1930, shown on the top row of Table 11.4, were the AS4100 r.f. tetrode with a slope of 1.42mA/V, the AR4100 general-purpose triode, and the AG4100 detector or a.f. triode. The directly heated valves comprised three output triodes, two full-wave and two half-wave rectifiers. The output triodes were the P414, rated at 200mW, the P430, rated at 800mW, and the P460, rated at 1.2 watts. (All three of these were also listed as battery valves in Table 11.1.) The full-wave rectifiers were the PV475 (250V, 50mA) and the PV495 (350V, 70mA). The half-wave types were the V430 (200V, 25mA) and the V495 (400V, 70mA).

Figure 11.4 shows an early Tungsram leaflet for their barium a.c. valves. According to Tungsram the indirectly heated valves have a cathode cylinder coated with a layer of barium metal rather than barium oxide.

Year	RF tetrode or pentode	Freq. Changer	Diode	Triode or DD triode	Output triode	Output pentode	Tuning Indicator	Rectifier
1930	AS4100			AR4100, AG4100	P414†, P430†, P460†			PV475, PV495, V430, V495
1931	AS494, AS495			AR495, AG495, AR4101, AR4120	AL495, AP495, P4100†	PP4100†		PV4100, PV4200
1932	AS4104, AS4105	DG4100 DG4101				APP4100		
1933	AS4120, AS4125, DS4100, HP4100 & HP4105 (B5&B7)					APP4120		APV4200
1934		MH4105/71, MO465	D418, DD465			APP4130, PP4101†		PV4201
1935	HP4101, HP4106 (B5&B7), HP4115	VO4, VO4s	DD4, DD4s	HL4				
1936	APP4G, SP4B, VP4B,	TX4		DDT4, DDT4s, HL4+, HL4G, HL4Gs	P12/250†, P15/250†	APP4B, APP4Bs, APP4C, APP4D, PP4†, PP4s†		APV4, PV4, PV4s V20/7000 (e.h.t.)
1937	SP4, SP4s			LL4		APP4A (B5&B7), APP4As, APP4E, APP4Es, DDPP4B	VME4, ME4s	
1938	HP4101c , VP4 VP4s	TH4A	DD4D			DDPP4M, APP4E*		IVR120/350s RV120/350, RV120/350s, RV120/500, RV120/500s
1939	HP4016 (B5&B7), HP4106c, SP4A	TH4B, VX4s, TP4		LL4C (TV t/b)		APP4G*		

Output triodes and pentodes marked with † are directly heated.

Table 11.4: Four-volt a.c. valves of 1930 to 1939 with British and side contact bases.

In the following year there were two new r.f. tetrodes, the AS494 and AS495. The first of these had a slope of 1.5mA/V, similar to that of the AS4100, but it had a far higher anode resistance and operated at a lower anode current. The AS495, however, was a high gain valve with a slope of 3.4mA/V. There were also four new triodes and three output triodes. Of these the AR495 was a medium impedance, high gain type; the AR4101 was general-purpose valve best suited as a detector; the AR4120 was another medium impedance, high-gain valve which could be used as a detector of a.f. amplifier; the AG495 was suitable either as an a.f. amplifier or as a low-power output valve. The output triodes were the AL495, the higher power AP495, capable of delivering 0.9 watts, and the directly heated P4100, with a 3.5 watt output and equivalent to the Philips E408N. An alternative to the P4100 was the PP4100 directly heated output pentode, equivalent to the Mullard PM24M, with the same output power of 2.8 watts. Finally there were two directly-heated, full-wave rectifiers: the PV4100 (500V, 60mA) and the PV4200 (500V, 120mA).

The first variable-mu r.f. tetrodes appeared in 1932. The AS4104 had a slope of 1mA/V and the AS4105 a slope of 1.2mA/V. Apart from this slight difference the two valves were very similar. There were also the DG4100 and DG4101 bi-grid frequency changers. It has been difficult to determine what the difference is between these two valves. It would appear that they were equivalent to the Philips E441. The only other 1932 valve was the APP4100, three-watt output pentode.

Figure 11.4: An early Tungsram leaflet for the 1930 a.c. valves,

In 1933 there two new r.f. tetrodes, both having a slope of 3mA/V; these were the straight AS4120 and the variable-mu AS4125. The AS4120 could also be used as a detector or a dynatron oscillator. AGC was not used in the UK before 1934 so to control gain it was common practice to connect a volume control in the cathode lead of a variable-mu valve. The recommended value of this for the AS4125 was 25k ohm. Other r.f. valves were the DS4100 single diode tetrode, the HP4100 r.f. pentode and the HP4105 variable-mu r.f. pentode, both having a slope of 3.5mA/V. These two pentodes had a choice of 5- or 7-pin bases. The remaining 1933 valves were the APP4120, 3.4-watt output pentode and the APV4200 indirectly heated full-wave rectifier, rated at 300V, 120mA.

In 1934 there was the MH4105 heptode frequency changer which had a conversion conductance of 0.52mA/V. There was also the MO465 octode with the higher conversion conductance of 0.6mA/V but the exact date when this was introduced has not been found and it could have been a year or two later. For detection and a.g.c. there were the D418 single diode of low capacitance and the DD465 double diode. There were also two new output pentodes, one indirectly heated and other directly heated. The indirectly heated APP4130 had a power output of 2.5 watts as also did the directly heated PP4101. The only other 1934 valve was the PV4201 directly heated, full-wave rectifier which was rated at 600V, 180mA.

There were three further r.f. pentodes in 1935. The HP4101 had identical characteristics to the earlier HP4100, both being equivalent to the Mullard SP4. The HP4106 was, like the earlier HP4105, a long grid-base, variable-mu pentode. The third pentode was the HP4115; this was a short grid-base, variable-mu pentode with a cut-off of about −12 volts. There was an octode frequency changer, the VO4, with a conversion conductance of 0.55mA/V and a double diode, DD4. Finally there was the HL4, a medium-impedance, general-purpose triode.

An interesting r.f power valve was released in 1936. This, the APP4G, was described as a 'special low capacity high slope triple grid valve'. It prime uses were as an amplifier, oscillator or modulator with a maximum anode dissipation of nine watts and a slope of 10mA/V. Unlike most power valves, the suppressor grid was brought out to a separate pin, allowing for suppressor grid modulation. The valve had a 7-pin ceramic base and the control grid was taken to the top cap. Two other r.f. pentodes were the SP4B, which was also suitable as a detector, and the variable-mu VP4B. The triode range consisted of the DDT4 double diode triode, the HL4+ and HL4G. These last two valves had identical characteristics and were of non-microphonic construction. They were intended for use as a detector, oscillator, a.f. amplifier or phase inverter. The only difference between the two was that the HL4+ had a 5-pin base, whereas the HL4G a 7-pin base with the grid taken to the top cap.

Also released during this year there were two directly heated output triodes, four output pentodes, one of which was directly heated, and three rectifiers. The two triodes were the 2.75-watt P12/250 and the 4.2 watt P15/250. The indirectly heated output pentodes were the APP4B, the triple grid APP4C (both having an output of 3.6 watts and a slope of 10mA/V), and the triple grid APP4D with an output of 7.5 watts and a slope of 7mA/V. The directly heated pentode was the 2.8-watt PP4.

The SP4 r.f. pentode appeared in 1937 and this had similar characteristics to the SP4B. Another new valve was the LL4 which was described as a low-impedance power triode. It was intended mainly for use in the driver stage for moderately large Class AB2 or Class B2 amplifiers where the output valves would take grid current. Other applications were as a low-power output valve, a phase inverter and a Class B oscillator. Its companion valve, the LL4C, which appeared a couple of years later, differed from the LL4 by having its anode brought out to a top cap and was intended for time base circuits. Also in 1937 there were three new output pentodes: the APP4A, APP4E and DDPP4B. The APP4A was rather unusual in that the suppressor grid was internally connected to the control grid. This was stated to have 'the advantage that whilst the valve is used in exactly the same manner as a usual pentode, it does not accentuate the high frequencies, hence tone correction can be omitted'. Its power output was three watts and there was a choice of a 5-pin base with a side terminal for the auxiliary grid or a 7-pin base. The second pentode was the triple-grid APP4E, an improved version of the APP4D, which it superseded. It had a slope of 8.5mA/V, enabling it to be used immediately after a diode detector. It could deliver an output of 8.8 watts in single-ended operation and 28.5 watts in Class AB1 push-pull from a 400V supply—in the following year there was a modified version of this valve designated APP4E* which could give five watts output at a considerably lower anode current. The third pentode was the DDPP4B which incorporated a double diode. This was another high-gain valve with a slope of 10mA/V and could deliver an output of 3.6 watts from a 250-volt supply.

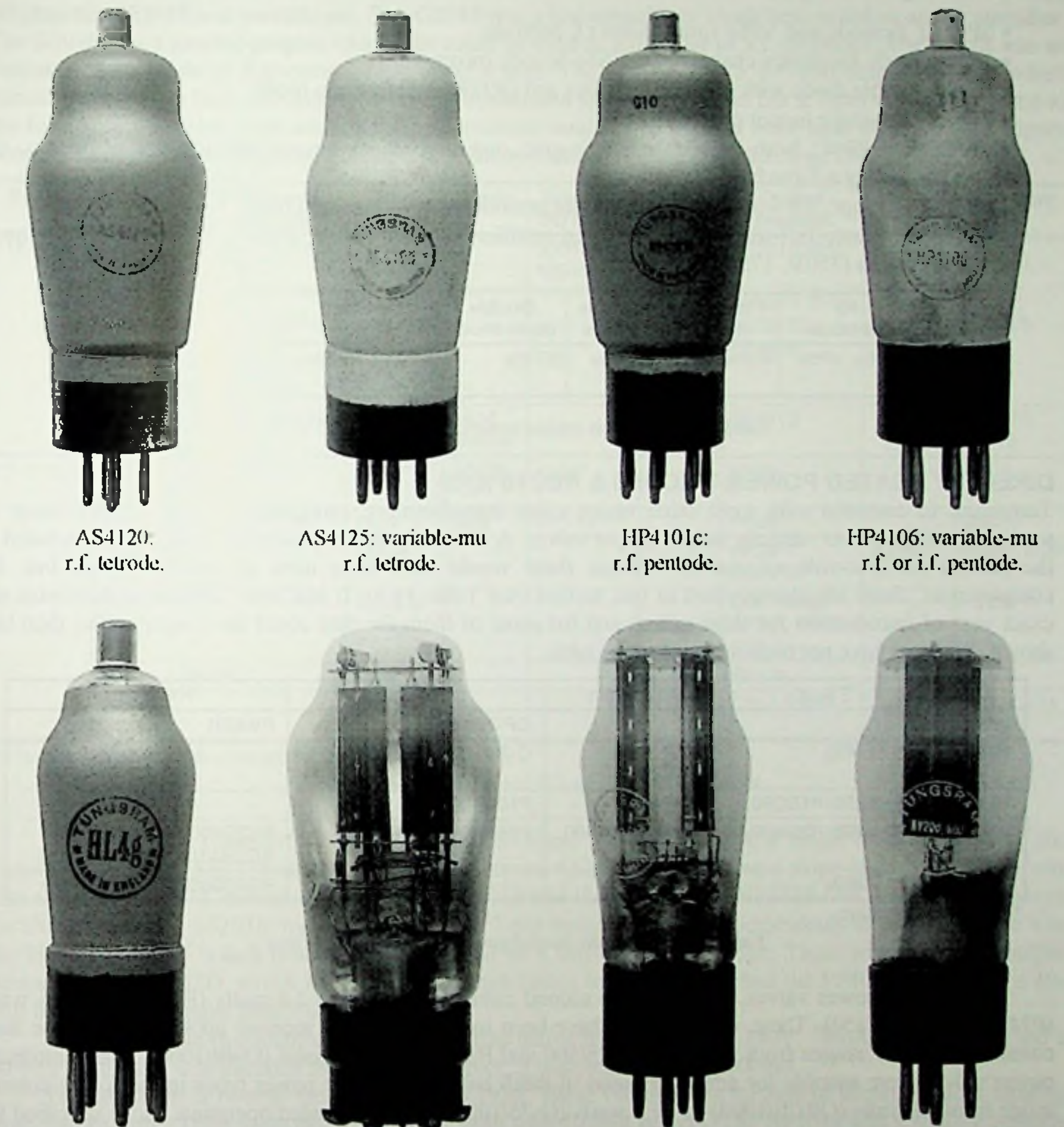
The only other 1937 valves were two magic eye tuning indicators, the VME4 with a 7-pin base and the ME4s with a side contact P-base. These two valves had quite different grid characteristics: the VME4 had a long grid-base requiring –22 volts to close the shadow, whereas the ME4s only required –5 volts. Both valves, in common with the American 6U5, incorporated a space charge grid between the target and cathode which was claimed 'greatly prolongs the life of the fluorescent screen by confining the target current, within close limits, to a smaller value than would flow if the target current were in saturation'. (This extra grid was also adopted by most valve manufacturers for their magic-eye tuning indicators.)

The HP4101c was introduced in 1938 but this appears identical to the earlier HP4101. Other new valves were the VP4 variable-mu r.f. pentode, the TH4A triode heptode, all-wave frequency changer with a conversion conductance of 0.75mA/V, the DD4D double diode, which, unlike the DD4, had two entirely separate diodes in the one envelope, each with their own cathode, and the DDPP4M double diode pentode which was identical to the DDPP4D except for the base connections. There were also three new rectifiers; the IVR120/350s was indirectly heated and had a side contact P-base (there being no 7-pin equivalent); the remaining two, RV120/350 and RV120/500, were directly heated. With these rectifiers the first three numbers indicated the output current and the last three numbers the r.m.s. voltage.

The last of the four-volt a.c. valves appeared in 1939. There was the HP4106c, but this was identical to the HP4106; the TH4B, identical to the TH4A; the VX4s hexode mixer with the side-contact P-base; the

LL4C which have already been mentioned, and the APP4G*, which was identical to the APP4G except that the grid was taken to the top cap rather than the anode.

A small, selection of these four-volt a.c. valves of British manufacture is shown in Figure 11.5.



AS4120: r.f. tetrode.

AS4125: variable-mu r.f. tetrode.

HP4101c: r.f. pentode.

HP4106: variable-mu r.f. or i.f. pentode.

HL4G: low-capacity non-microphonic triode.

IRV/350s: indirectly heated full-wave rectifier.

RV120/350: directly heated full-wave rectifier.

RV200/600: directly heated full-wave rectifier.

Figure 11.5: Selection of Tungsram four-volt a.c. valves of 1933 to 1939.

6.3-VOLT AUTOMOBILE RANGE OF 1936/37

Tungsram produced a range of small valves in 1937 intended for use in motor vehicles with a six-volt battery. This range is shown in Table 11.4 and most of the valves had the continental side contact base. The range consisted of the following types:

- SP6s r.f. pentode and VP6s variable-mu r.f. pentode.
- VO6s octode frequency changer and VX6s hexode mixer.
- DD6ds double diode with separate cathodes and DDT6s double diode triode.
- PP6As high-slope output pentode.
- PP6Bs and PP6C, both high-slope, triple-grid, output pentodes having identical characteristics, the latter having a 7-pin base.
- PP6E high-slope, 8.8 watt, triple-grid, output pentode, also with a 7-pin base.
- There were three full-wave, directly heated rectifiers: PVA6s (350V, 60mA), PVB6s (350V, 100mA) and PVC6s (350V, 175mA).

RF pentode	Frequency changer	Double diode	Double diode triode	Output pentode	Rectifier
SP6s, VP6s	VO6s, VX6s	DD6ds	DDT6s	PP6As, PP6Bs, PP6C, PP6E	PVA6s, PVB6s, PVC6s

Table11.4: 6.3-volt midget automobile range of 1936/37.

DIRECTLY HEATED POWER TRIODES & RECTIFIERS

Tungsram, in common with most other major valve manufacturers, produced a comprehensive range of medium- to high-power, directly heated output valves. A few of the lower power types have been included in the section on four-volt a.c. valves because these would have been used in radio receivers but, for completeness, these are also covered in this section (see Table 11.5). It has been difficult to determine the exact year of introduction for these valves and for some of them the date could have been earlier than that shown. RF types have not been included in the table.

Year	< 5 watts	5–10 watts	>10 watts	Rectifiers
1934			OP-70/1000,	PV4201
1935	O-15/400,	O-40/1000, P25/400	O-75/1000, P60/500*	
1936	P12/250, P15/250	P26/500,	P100/1000	
1937	P24/450, P25/450	P25/500, P27/500, P30/500	P28/500*, P30/500*,	PV75/1000, PV100/2000 RG250/1000, RG250/2000
1938	P15/250s			RG1000/3000, RV200/600

*Push-pull operation

Table 11.5: Directly heated power triodes and rectifiers.

The lowest power valves, shown in the second column, range from 2.8 watts (P12/250) to 4.6 watts (P24/450 and P25/450). These valves would have been more suitable for receiver applications. In the third column the power ranges from five watts (P25/500 and P27/500) to 8.5 watts (O-40/1000). These medium-power valves were suitable for amplifiers used in small halls. The higher power types in the fourth column range from 18 watts (OP-70/1000) to 19.7 watts (O-75/1000) for single-ended operation; those specified for push-pull operation were the P30/500 (40 watts), P28/500 (50 watts) and P60/500 (70 watts). There were also many other types but these were mainly intended for radio transmitters.

The rectifiers fell into two categories: high-vacuum, full-wave (PV and RV types) and the half-wave, mercury vapour (RG types). The numbers that follow the initial two letters indicate the rectified current and r.m.s voltage respectively.

AC/DC VALVES

The a.c./d.c. valves were produced in two current ranges: 0.18-amp and 0.2-amp (see Table 11.6). The 0.18-amp range appeared in 1932 and consisted of three r.f. tetrodes, three triodes and an output pentode. These valves all had 20-volt heaters and 5-pin bases. The S2010N and S2018 were both straight r.f. tetrodes, whereas the SE2018 was variable-mu. The G2018 was a low-impedance triode best suited as an a.f. amplifier. The R2018 was a general-purpose triode that could be used as a detector or a.f. amplifier. The P2018 was an output triode capable of delivering a little under a watt. The PP2018 was a 1.1-watt output pentode, which initially had a 5-pin base with side terminal for connection to the screen grid but a 7-pin version appeared in the following year. One must assume that these valves would have initially been used on d.c. mains supply because there was no accompanying rectifier, but there was a 0.18-amp barretter, type 180R.

Range	Year	RF tetrode or pentode	Freq. Changer	Diode	Triode or DD triode	Output triode	Output pentode	Tuning Indic.	Rectifier
0.18-amp	1932	S2010N, S2018, SE2018			G2018, R2018	P2018	PP2018 (B5)		
	1933	DS2018, SE2118 (B5&B7), SS2018, HP2018 (B5&B7), HP2118 (B5&B7)	DG2018				PP2018 (B7) PP2018D, PP4018		V2018, PV4018
	1934	HP1018, HP1118	MH1118	D418, DD818			PP4118		PV3018, V2118
0.2-amp	1935	HP13*, SP13*, VP13*	VO13*	DD13*	HL13*		PP35		
	1936	SP13B, VP13B	TX21	DD6*	DDT13*		PP36		V30
	1937		VX13s				PP24* DDPP39*	ME6s	PV30*, V20*
	1938		TH29/30				DDPP39M, PP34*, PP37, CL6		PV29*
	1939	VP13K	TX29				PP13s,		
	1940s						CBL1, CL33		CY1, CY31, CY32

*Also available with side contact base

Table 11.6: 0.18-amp and 0.2-amp a.c./d.c. valves.

The range was considerably extended in 1933. There was the DS2018, a single diode r.f. tetrode, the variable-mu tetrode SE2118 and the straight r.f. tetrode, SS2018, both having a slope of 3mA/V. There was also the first of the r.f. pentodes: the straight HP2018 and the variable-mu HP2118. All these valves, except for the DS2018 and SS2018, had a choice of 5- or 7-pin bases. For early superheterodyne receivers there was the bi-grid DG2018 which would have been used as a self-oscillating mixer. There were two new output pentodes: the PP2018D, which had identical characteristics to the PP2018, and the PP4018 which had a 40-volt heater and an output power of 3.4 watts.

There were also two rectifiers. The V2018 was half-wave and rated at 250V, 70mA. The PV4018 had a 40-volt heater and was intended as a voltage doubler: it was rated at 125V, 100mA.

The last of the 0.18-amp range appeared in 1934. These valves had a mixture of heater voltages ranging from four to forty. There were two r.f. pentode, both with 10-volt heaters. The HP1018 was a straight pentode and the HP1018 was variable-mu, both having the continental 7-pin base, C7. There was just one frequency changer, the MH1118 heptode, and this also had a 10-volt heater and a C7 base. There was one single diode, the low-capacitance D418 and a double diode, DD818. The D418 had a 4-volt heater and a 4-pin base (see also Table 11.4), whilst the DD818 had an 8-volt heater and a 5-pin base. There was also a new output pentode, the PP4118, which had similar characteristics to the earlier PP4018; both of these pentodes had the

C7 base. Finally there were two rectifiers. The PV3018 was, like the PV4018, a voltage doubler; it had a 30-volt heater and was rated at 250V, 100mA. The V2118 was almost identical to the earlier V2018 but had a slightly higher current rating of 75mA. Both the PV2018 and PV2118 had the C7 base.

The 0.2-amp range was launched in 1935. Many of the valves had both British and continental side contact bases, as indicated in the table by asterisks. The initial range included three r.f. pentodes: the SP13 was a straight pentode, the VP13 was a variable–mu pentode with a long grid base and the HP13 was another variable-mu valve but this had a short grid base with a cut-off of –10 volts. In addition there was the VO6 octode frequency changer, the DD13 double diode and the PP35 output pentode.

In 1936 there were two new r.f. pentodes: the straight SP13B and the variable-mu VP13B. These differed from those released in the previous year by having their screen grids operating at the same voltage as the anodes—typically 200V. In spite of this both the anode and screen currents were lower than those of the SP13 and VP13 and they also had a higher slope. Another new valve was the TX21 triode hexode which had identical characteristics to the four-volt TX4. Included amongst these 1936 valves is the DD6 double diode although this valve did not appear in the Tungsram lists for a.c./d.c. valves. Other valves were the DDT13 double diode triode, the PP36 output pentode, with its suppressor grid brought out to a separate pin rather than internally connected to the cathode, and the V30 half-wave rectifier, which was rated at 275V, 120mA.

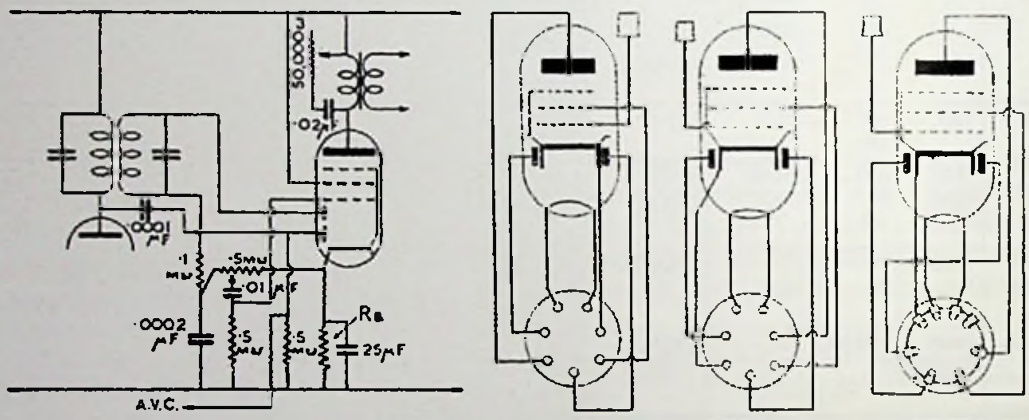


Figure 11.6: At the left is a circuit for the DDPP39 showing detection, a.g.c. and output. The diagrams at the right show the basing for the three versions of the valve.

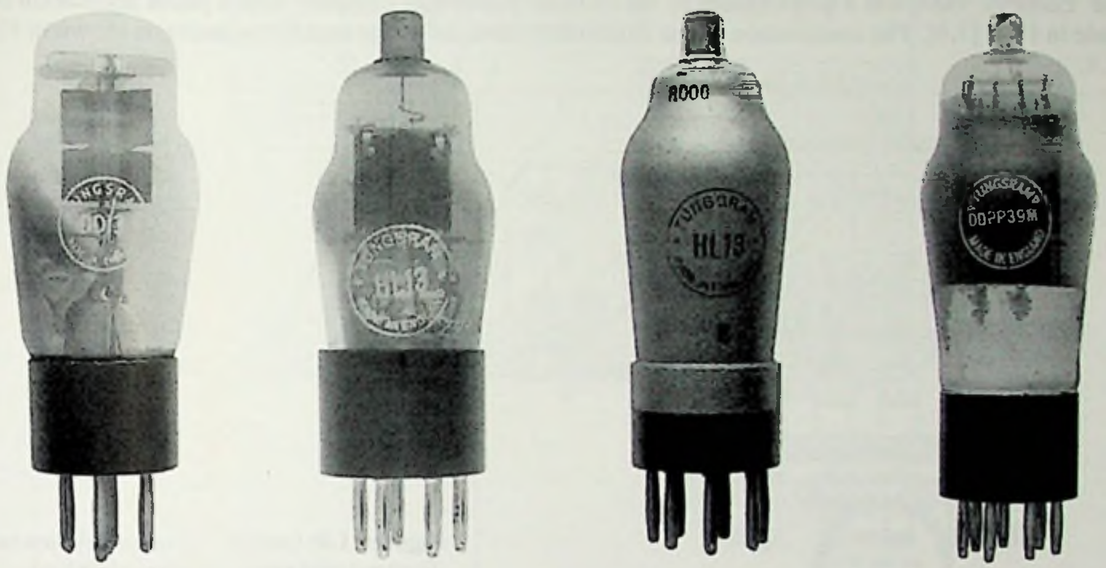
As with the two- and four-volt valves Tungsram produced the VX13s hexode mixer in 1937. Presumably this was meant for use with short wave receivers where the HL13 or HL13s could have been used as a separate oscillator. The other valves introduced at about this time were the PP24 output pentode, the DDPP39 double diode output pentode and the ME6s magic-eye tuning indicator which was a six-volt version of the ME4s. There were also two rectifiers: the PV30 was a voltage doubler rated at 275V, 60mA and the half-wave V20, which was rated at 250V, 80mA.

The TH29 and TH30 triode heptode frequency changers both appeared in 1938. These had identical characteristics and were grouped together in the Tungsram catalogue. They had a conversion conductance of 0.75mA/V. There were also several new output pentodes. The DDPP39M was identical to the DDPP39 except for its base connections (see Figure 11.6). The other output pentode was the PP37, which had a slope of 8.5mA/V and an output of four watts in single-ended or 12 watts in Class AB1 push-pull. The CL6 was a side contact version of this valve. There was also the PV29, a voltage double rectifier, rated at 125V, 120mA.

Three new valves appeared in 1939. The VP13K was a variable-mu r.f. pentode, similar to the earlier VP13 except that the metallising shielding was connected to the cathode rather than being brought out to a separate pin. The TX29 was another triode heptode and had similar characteristics to the TH29/TH30. The third of these valves was the PP13s, a low-power output pentode with a 13-volt heater.

During the 1940s, Tungsram introduced several valve in the C-Series which were identical to the Mullard and Philips types. Initially these had the side-contact P-base but octal-based versions appeared later in the 1940s.

Some example of British made 0-2-amp a.c./d.c. valves are shown in Figure 11.7.



DD13: double diode. | HL13: general-purpose triode (clear glass version). | HL13: general-purpose triode (metallised version). | DDPP39M: double diode output pentode.

Figure 11.7: Examples of Tungsram 0.2-amp a.c./d.c. valves of 1935 to 1938.

E-SERIES VALVES OF THE 1940s

Table 11.7 show the complete range of the E-Series side-contact, octal and 'Footless' valves produced by Tungsram from 1938 to the 1940s.

Range	Year	RF tetrode or pentode	Frequency changer	Diode	Triode or DDT	Output pentode	Tuning Indicator	Rectifier
6.3-volt side contact	1938	EBF2, EF5, EF6, EF8, EF9	ECH2, ECH3, EH2, EK2, EK3	EAB1, EB4	EBC3	EBL1, EL2, EL3, EL5, EL6, ELL1	EFM1, EM1	EZ2, EZ3, EZ4
	1939							
	1940s							AZ1, AZ2, AZ3, AZ4
6.3-volt octal	1940s	EF39	ECH33, ECH35	EB34	EBC33	EBL31, EL33, EL36		EZ33, AZ31, AZ32
'Footless'	1939/ 1940	EBF11, EF11, EF12, EF13, EF14	ECH11	EB11	EBC11	EL11, EL12	EFM11	

Table 11.7: E-Series valves.

The first group of the E-Series valves all had side contact bases and included in this group are the A-Series rectifiers which had 4-volt heaters. The second group all have octal bases and appeared in the 1940s. Philips also manufactured all the valves in both groups and most of them were available from Mullard—one exception being the ELL1 double output pentode for QPP operation.

'Footless' valves

The 'Footless' valve was a development by the German Telefunken Company with a patent application being made in 1936 [3,4]. The construction of the Telefunken valve, as it appeared in the patent, is shown in Figure 11.8.

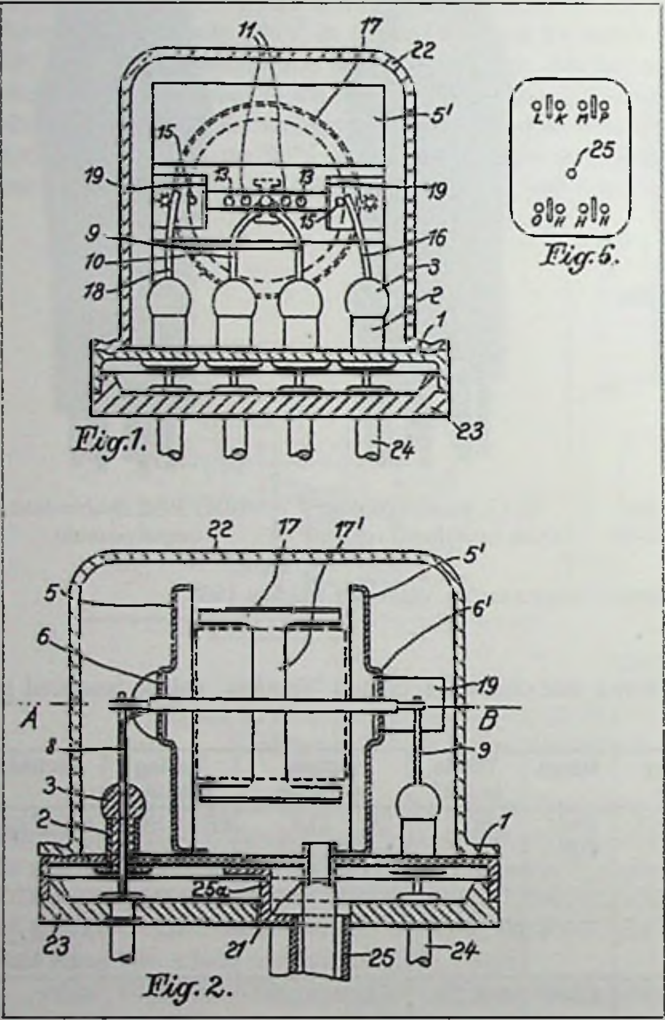


Figure 11.8: Construction of the Telefunken 'Footless' steel valve. Invention of Dr Karl Steimel who took out a patent application in Germany on 2 September 1936 (DE 690,019).

Features of the valve were a metal (steel) envelope, horizontally mounted electrode assembly, internal shielding to minimize unwanted coupling and short leads from the electrodes to the pins. In the diagrams (1) denotes a metal mounting plate to which are welded two rows of metal tubes (2) made of an iron-nickel-cobalt alloy. The lead-out wires pass through the tubes which are hermetically sealed with glass stoppers (3). The wires are then connected to pins (24) in a socket base (23) made of an insulating material. The bulb of the valves is also made of steel (22) which is welded to the base plate. Large numbers of these valves were used by the Germans during the Second World War in military equipment.

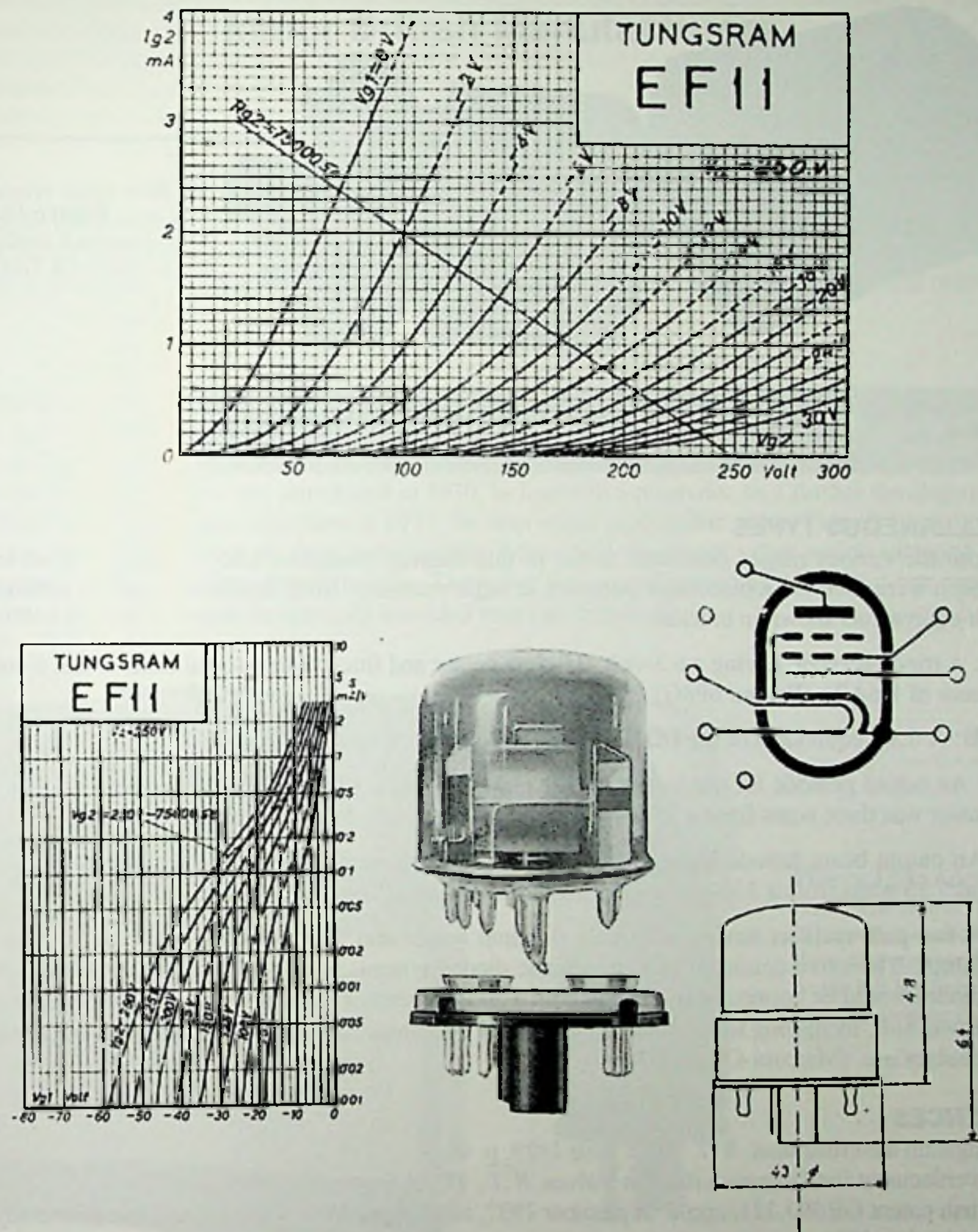


Figure 11.9: Part of the data sheet for the Tungsram EF11 r.f. pentode.
Here one can see the glass construction which was then covered with a black painted copper casing.

Tungsram modified the valve construction and chose to use a glass envelope but to fit a metal cover over this (see Figures 11.9 and 11.10 [5]). As the table shows there was a wide range of valves but no rectifiers. There were five r.f. pentodes.

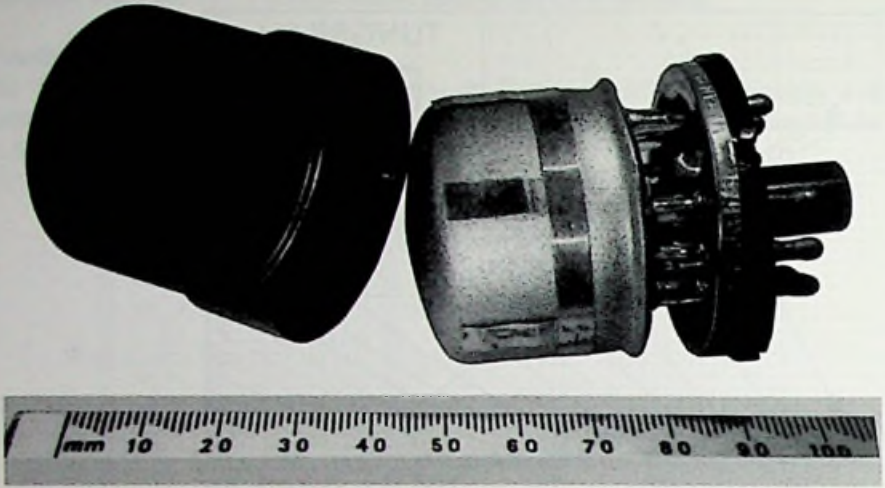


Figure 11.10:
Tungsram footless valve.
(Credit Dr Tom Going.)

MISCELLLANEOUS TYPES

Apart from the various ranges described so far in this chapter, Tungsram also manufactured several other types, which were used for replacement purposes in radio receivers. Brief details of these are outlined below with their equivalents shown in brackets.

6TH8G: A triode heptode having a 6.3-volt, 0.6-amp heater and fitted with an octal base. It had a conversion conductance of 1mA/V. (Brimar 6P8G)

DDPP6B: A 6.3V equivalent of the DDPP4B. (BTH/Philco PenDD61)

PP13A: An output pentode for use in automobile radios having a 13-volt, 0.3-amp heater and 7-pin base. Its output power was three watts from a 250-volt supply. (Brimar 7D8, Marconi-Osram N30)

PP60: An output beam tetrode having a 6.3-volt, 1.27-amp heater and fitted with an octal base. It output power was 7.25 watts from a 250-volt supply. (Marconi-Osram KT66)

PV25: A two-path rectifier having a 25-volt, 0.3-amp heater and fitted with a 7-pin base. It was rated at 250V, 120mA. The valve consisted of two separate diodes systems, each with their own cathode. Normally the two diodes would be connected in parallel with a 50 ohm resistor in each anode circuit when the reservoir capacitor was 8μF, increasing to 75 ohms for 16μF and 175 ohms for 32μF. The valve was not designed for voltage-doubler use. (Marconi-Osram U30)

REFERENCES

1. Tungsram advertisement, *W.T.*, **18**, 8 June 1929, p. 46.
2. Advertisement for Tungsram Barium Valves, *W.T.*, **19**, 14 September 1929, p. A7.
3. British patent GB503,221, app. 1 September 1937, iss. 3 April 1937. Convention Date (Germany) 1 September 1936.
4. 'Steel Valves', *W.W.*, **10**, November 1938, pp. 403-4.
5. 'Revolutionary changes in valve technique. New Tungsram "Footless" valves', *Television and Short Wave World*, June 1939, p. 378.

Chapter 12
Minor British Manufacturers

This chapter deals with the minor British manufacturers. Most of these were only in business for a very short time, partly because they had neither the capital nor the expertise to keep up with the rapid developments in manufacturing techniques and technical developments and partly because they were hounded by the larger companies, accusing them of patent infringements. The companies are covered in alphabetical order by trade name.

ADEY

Adey Radio Ltd (later re-named Adey Portable Radio) was a small radio manufacturing company founded by Horace Adey in 1929 [1]. Their premises were located at 99 Mortimer Street, London W.1, together with a factory in Marylebone which was opened in 1932. The company specialised in portable receivers ranging from a one-valve headphone set, introduced in 1930, to four-valve receivers. In a further development of this set, exhibited at the Olympia exhibition in 1933, the four-valve models had either Class B or pentode output stages. An interesting feature of these sets was the Adey 'Self-Coupling' valve which included an anode choke wound in three sections round its base. The valve was manufactured by Hivac but one assumes that Adey wound the choke round the specially moulded base (see Figure 12.1).

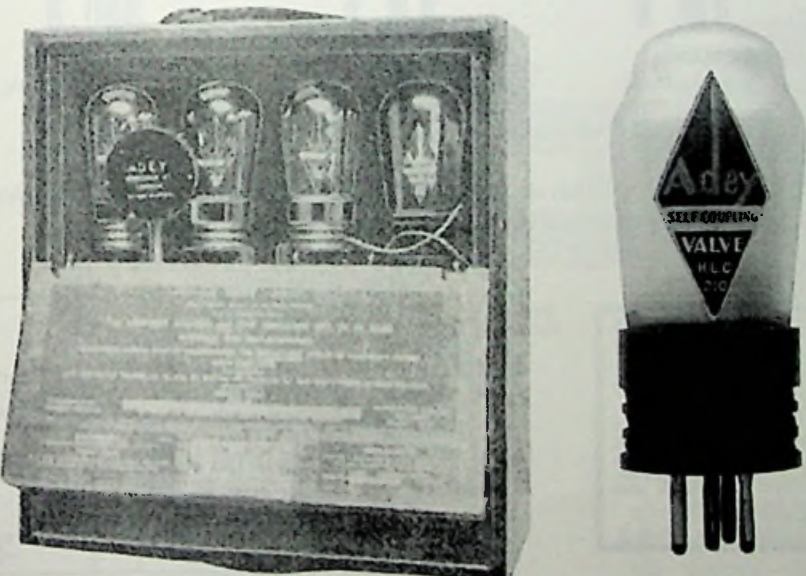
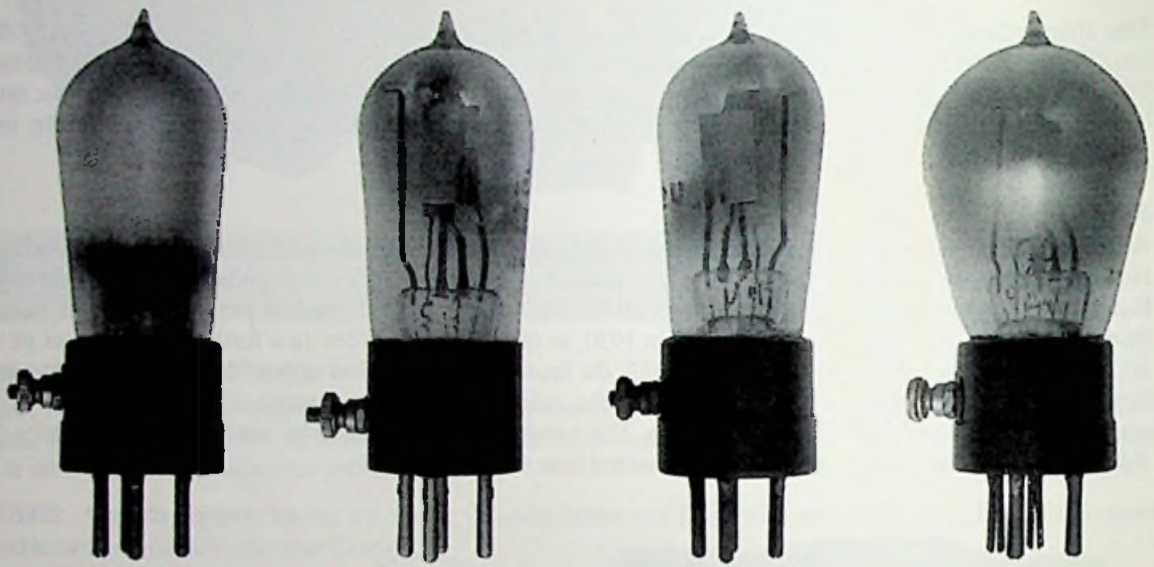


Figure 12.1: Adey H.L.C.210 'Self-Coupling' valve with a choke wound in three sections round the base. At the left is a four-valve portable receiver using the valve.

ANELOY (TWO-GRID)

Aneloy Products began trading in 1926 and was a specialist in four-electrode (bi-grid) valves. Initially it appears to have sold valves by other manufacturers such as Thorpe and Philips. It also carried out valve repairs of both bright- and dull-emitter types (see advertisement in Figure 12.3). The company's works were located in Dulwich, south east London and its main office in Camomile street, EC3.

The first four-electrode valves of Aneloy manufacture appeared in 1927. Typical of these are those shown in Figure 12.2. They usually had a 4-pin base with a side terminal for the inner grid, although some had a special 5-pin base without a side terminal. The inner grid was also known as a space-charge grid.



AP412RC: RCC bi-grid tetrode. | AP412SG: r.f. bi-grid tetrode. | AP412U: detector bi-grid tetrode. | AP425P: output bi-grid tetrode.

Figure 12.2: Aneloy four-electrode valves.

These four-electrode valves were used in Unidyne receivers [2], which attracted interest from home constructors in the mid-1920s. A typical Unidyne circuit is shown in Figure 12.4.

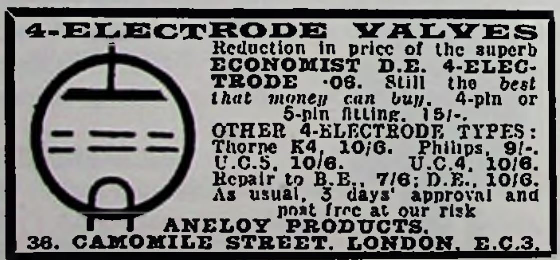


Figure 12.3: Aneloy Products advert.
(*Popular Wireless*, 27 February 1926).

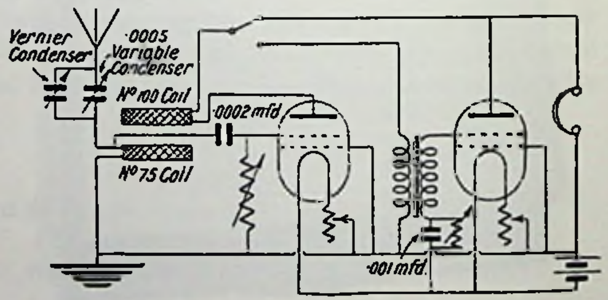


Figure 12.4:
Circuit of the Unidyne receiver.

The Unidyne was the invention of G V Dowding and K D Rogers to eliminate the need for an h.t. battery. In the circuit shown in the figure there are two four-electrode valves each having two grids, known as the inner and outer grid. Its inner grid is biased at a low positive potential by connection to the plus side of the filament battery. The signal is applied to the outer grid and both of these are also returned to the plus side of the filament battery, but through potentiometers which are used to provide bias to these grids. The small potential on the inner grid has the effect of reducing the negative space charge formed by a cloud of electrons that surrounds the filament. Some of the current flows to the inner grid and the remainder passes to the anode. In this circuit two filament rheostats are shown, which was normal practice when bright emitter valves were used. For dull emitter valves a filament rheostat should not be used because the correct operational temperature must be maintained to ensure a constant supply of thorium to the surface of the filament.

Occasionally Unidyne receivers also used a low-voltage supply for the anodes but in the circuit shown the anodes are also returned to the plus side of the filament battery.

The two valves in this circuit act as a cumulative grid detector with reaction and an audio output amplifier. Because there is no h.t. battery the output stage would not be able to deliver sufficient power for a loudspeaker.

A two-valve receiver using Ancloy AP412P and AP412LF valves was featured in a December 1927 issue of *Wireless World* [3].

BERITON

These valves were produced by the Merchant Manufacturers Company Ltd. (later re-named Beriton Ltd) and were first advertised at the end of 1927. British manufacture was claimed for these but the author has been unable to discover who the actual manufacturer was.

Altogether there were twelve triodes in the three filament voltage ranges of 2-, 4- and 6-volts. Each range comprised one each of HF, LF, RC and Power types. All the valves had thoriated tungsten filaments. Figure 12.5 shows an early leaflet advertising two types of the valves in three voltage ranges.

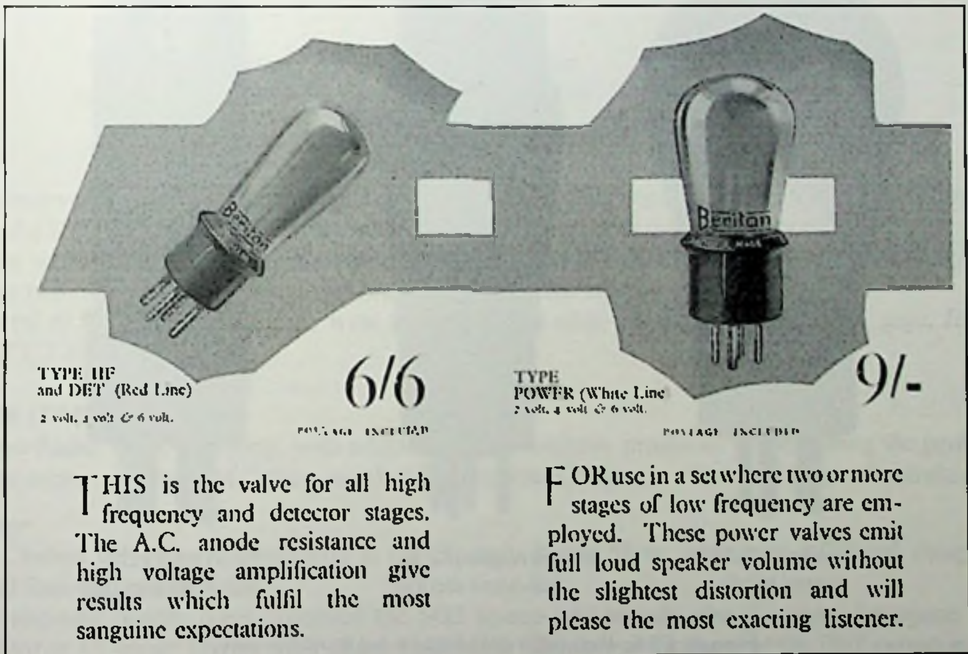


Figure 12.5: Sales leaflet for Beriton valves.

BURNDEPT

Burndept Wireless Ltd. was better known as a manufacturer of radio receivers. However, in 1925, the company announced its intention of manufacturing valves and applied for membership of the Valve Manufacturers' Association (VMA). The early valves produced by the company have been covered in Volume 1, so only the later ones of 1926 and 1927 are dealt with here. Data on all the types, however, can be found in the Valve Data Supplement.

H.L.212 was a general-purpose triode having a 2-volt, 0.12-amp filament.

H.L.425 was also a general-purpose triode but had a 4-volt, 0.25-amp filament. The impedance of these two valves was similar but the H.L.425 had a considerably higher gain.

L.225 was intended for use as an a.f. amplifier. It had a 2-volt, 0.25-amp filament.

These three valves were released in 1926. In the following year Burndept introduced two more triodes: **L.210** was another a.f. type but having a lower filament consumption of 2-volts at 0.1-amp, and the **LL.525**, which was an output valve with a 5-volt, 0.25-amp filament (see Figure 12.6).

The company was one of the first to produce a rectifier for use in battery eliminators. This was the half-wave **U.695** which was announced at the 1926 Olympia Radio show. It had a 6-volt, 0.95-amp filament and its maximum rectified current was 70mA.

Burndept ceased manufacture of valves following its bankruptcy in 1927, after which the company was re-formed and then concentrated on the manufacture of radio equipment.

BRIVARON

The British Valve & Electrical Accessories Manufacturing Co Ltd (Brivaron), which operated from premises at 308 Liverpool Road in north London, manufactured a very small range of rectifier valves in the 1940s. The valves had a very poor record for reliability. Two examples of the valves can be seen in Figure 12.6.

Burndept LL.525: output triode.

Brivaron IRF40: full-wave rectifier.

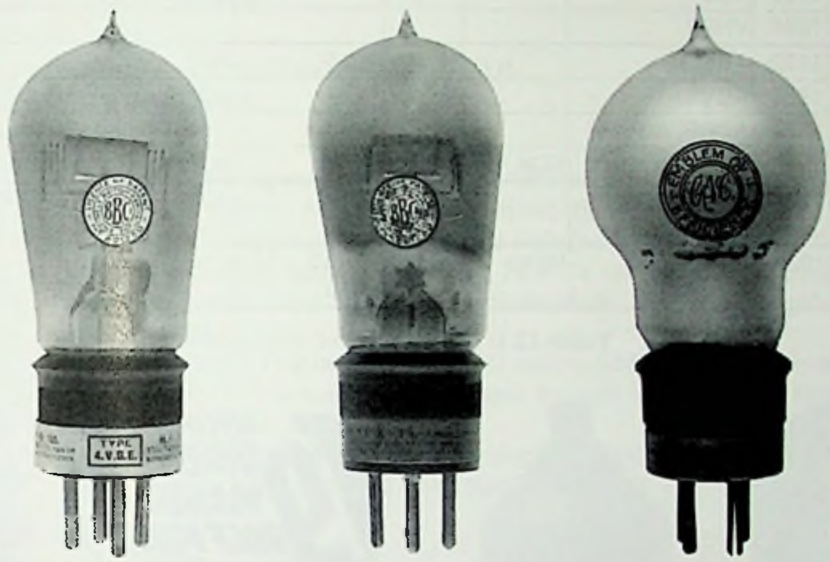
Brivaron 12Z5: full-wave rectifier.

Figure 12.6: Examples of Burndept and Brivaron valves.

CAC

CAC Radio Ltd. entered the valve business in 1925 with the announcement of a general-purpose bright emitter and a two-volt dull-emitter. By 1926 the range had been extended considerably to include two-, four- and six-volt triodes for all stages in a t.r.f. receiver. Figure 12.7 shows typical valves in the range. Note how the anodes are folded over to form an inverted U shape (∩).

Identical valves were also sold by the City Accumulator Company and it is believed that this was another trade name used by CAC. Valves were also sold by Lewis and this company was probably a distributor for CAC.



4VBE: bright emitter general-purpose triode.

2VDE: dull emitter general-purpose triode.

P6: 6-volt output triode.

Figure 12.7: CAC valves of 1926.

The two-volt triodes consisted of the D.E.2 HF and D.E.3 HF, both intended for use as r.f. amplifiers or detectors; the D.E.2 LF and D.E.3 LF, intended as a.f. amplifiers, and the P.2 output triode.

There were two low-consumption types, D.E.06 HF and D.E.06 LF, with 3.8-volt, 0.06-amp filaments. There were two further power valves—the four-volt P.4 and the six-volt P.6.

Several of the type designations were later preceded with the word 'Orpheus', to give, for example Orpheus D.E.3 HF.

CLARION (TABLE 12.1)

The Clarion Radio Valve Company, with a factory in Birmingham, produced valves during the period 1932 to 1936. They were a successor of Octron, another Birmingham Company, which had ceased business in 1931.

1932 Range

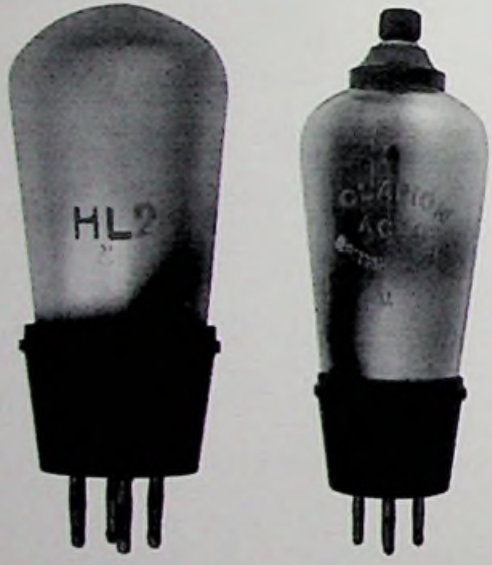
The first Clarion valves were introduced at the Olympia Radio Show in August 1932 and comprised both battery and four-volt mains types.

The two-volt battery types consisted the SG2 screen-grid tetrode, the H2 general-purpose triode, the HL2 detector or a.f. triode (Figure 12.8), the LP2, P2 and PX2 output triodes, and the PN2 output pentode.

The four-volt a.c. types consisted of one screen-grid tetrode, ACSG (Figure 12.8), having a slope of 1.4mA/V, the ACHF detector triode, the ACP directly heated output triode, the UF4 half-wave rectifier, and the UH4 full-wave rectifier.

Range	Year	RF tetrode or pentode	Freq. Changer	Diode	Triode or DD triode	Output triode	Output pentode	Rectifier
2-volt battery	1932	SG2			H2, HL2	LP2, P2, PX2	PN2	
	1933	VS2				B22, B24		
	1934	VHP2						
4-volt a.c. mains	1932	ACSG			ACHF	ACP		UF4, UH4
	1933	ACVS			ACG	ACL	ACPN	
	1934	ACHP, ACVHP						
	1936		FC4	ACD	DDT4	ACPP	ACNDH	UF41
20-volt, 0.18A	1934	ADHP, ADVHP			ADHF	ADG, ADL	ADPN	UDH
13-volt, 0.2A	1936	VHP13	FC13	DD13	DDT13, HF13			

Table 12.1: Clarion valves of 1932 to 1936.



HL2: a.f. or detector triode. ACSG: r.f. tetrode.

Figure 12.8: Clarion valves.

Clarion advertisement from *Wireless World* 28 August 1936.

Figure 12.9

1933 Additions

By 1933 the battery range had been extended to include the VS2 variable-mu r.f. tetrode and the B22 and B24 Class B double output triodes. Both of these Class B valves were designed for operation at zero grid bias. From a 150-volt h.t. supply, the B22 had an output power 1.2 watts and the B24 had a higher output of two watts.

The new four-volt a.c types were the ACVS variable-mu r.f. tetrode, having a slope of 2mA/V, the ACG low-impedance a.f. triode, which could also be used as a low-power output valve, the 500mW ACL output triode and the two-watt ACPN output pentode (see top left hand photograph in Figure 12.10).

1934 to 1936 Additions
The first a.c./d.c. mains valves appeared in 1934. These had 20-volt, 0.18-amp heaters and consisted of:

- an r.f. pentode, ADHP,
- a variable-mu r.f pentode, ADVHP,
- a detector triode, ADHF,
- two output triodes: the 270mW ADG and the 550mW ADL,
- the 2.2-watt ADPN output pentode,
- the UDH half-wave rectifier.

The only two-volt battery type to appear in 1934 was the VHP2 variable-mu r.f. pentode. But there were two, 4-volt a.c. types: a straight r.f. pentode, AC/HP, and the variable-mu AC/VHP.

The last of the Clarion valves to appear were in 1936 and included a range of 13-volt 0.2-amp a.c./d.c. types. The range consisted of a heptode frequency changer, FC13, a variable-mu r.f. pentode, VHP13, a double diode, DD13, a detector triode, HF13 and a double diode triode, DDT13. Strangely there were no output valves or rectifiers in this range.

The four-volt 1936 types were the FC4 heptode, the ACD double diode, the DDT4 double diode triode, the five-watt ACPP output triode, the one-watt ACNDH output pentode and the UF41 full-wave rectifier. Both the ACPP and ACNDH were directly heated.

A Clarion advertisement in late 1936 was offering the valves at a ridiculously low price, presumably in an attempt to clear stocks before the Company closed down (see Figure 12.9).

CLEARTRON

Cleartron Radio Ltd. was a subsidiary of an American concern, the Cleartron Vacuum Tube Company, whose head office was in New York. The British subsidiary company produced valves during the period 1925 to 1929. Following financial problems with the parent company, it was re-named Cleartron (1927) Ltd.

It is claimed that the valves were manufactured in Birmingham, although this may only have been local assembly from parts produced in America. The trade name was C.T.

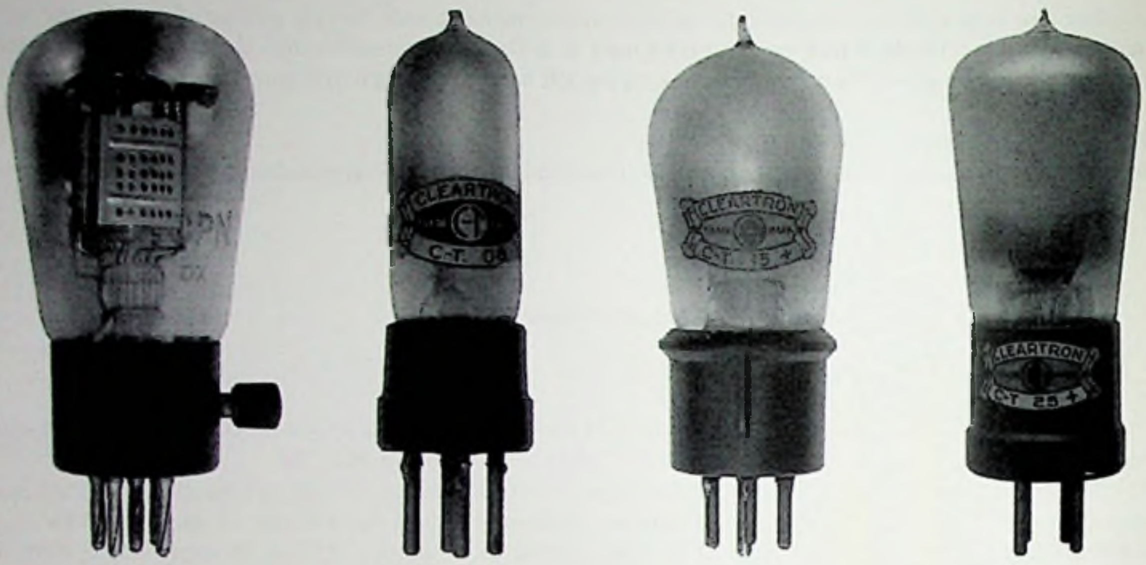
The 1925 types C.T.08, C.T.15, C.T.25 and C.T.25B have been dealt with in Volume 1 and data for these can be found in the Supplement.

Several new triodes were released in 1926. These included the three gas-filled detectors C.T.2.S/S.D, C.T.4.S/S.D and C.T.6.S/S.D for 2-, 4-, and 6-volt batteries respectively. There was also the C.T.08+, a three-volt type intended as a power amplifier. (Note: S/S.D was an abbreviation for Super Sensitive Detector.)

The range was extended further in 1927 with the two-, four- and six-volt power amplifier triodes, C.T.10+, C.T. 15+ and C.T.25+. These new 'Plus' valves were claimed to have 'improved filaments, higher and increased emission and long life'. There were two other triodes: the four-volt general purpose C.T.10 and the very high impedance two-volt C.T.215H, which was intended as an RCC amplifier.

Finally there was just one r.f. tetrode; this was the C.T.215SG (also designated 215 SG) which had a standard 4-pin base with a side terminal for the screen grid connection. No new types were announced in 1928 but a new range having coated filaments were exhibited at the 1929 Olympia Show. Most of these had 0.1-amp filaments, the exception being the super power types which had a higher rating of 0.25-amps. Amongst the types mentioned in the review were the 210 H.F., 410 H.F., 610 H.F., 210 L.F., 410 L.F. and 610 L.F. There was also a C.T.215P output triode (and, possibly, 4- and 6-volt types). The company went out of business about this time so few details of these new types are available.

Figure 12.10 shows a representative selection of Cleartron valves, including two of the later types having a so-called 'Mirilium Cathode', and their only r.f. tetrode, the C.T.215SG.

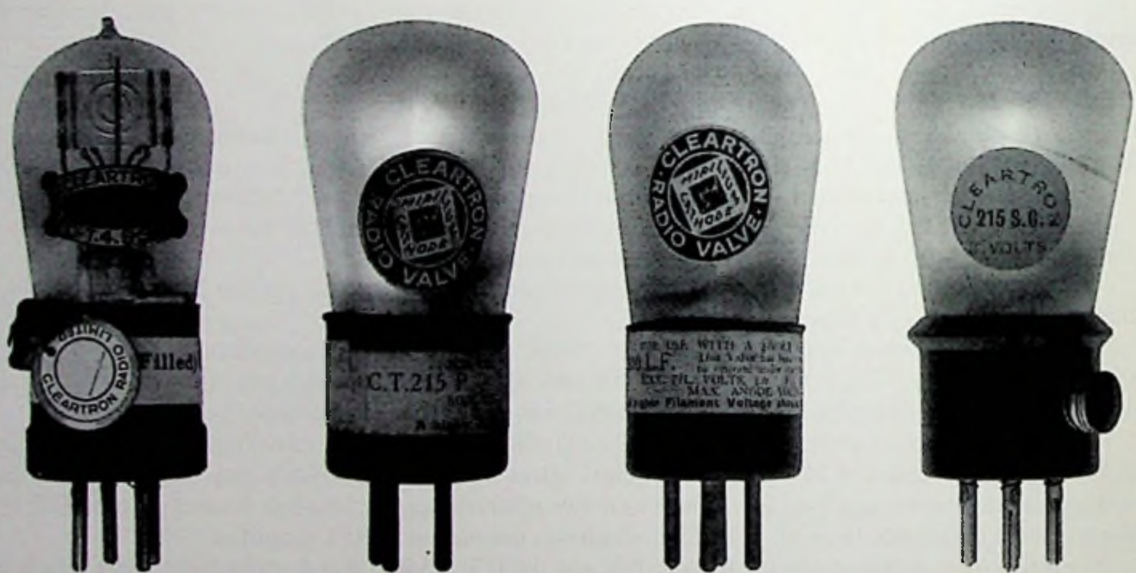


Clarion AC/PN:
4-volt a.c. output pentode.

C.T.08:
general-purpose triode.
(Earlier type of 1925.)

C.T.15+
2-volt output triode.

C.T.25+
5-volt output triode.



C.T.4.S/S.D:
4-volt gas triode detector.

C.T.215P:
output triode.

C.T.410LF:
a.f. triode.

C.T.215SG:
r.f. tetrode.

Figure 12.10: The Clarion AC/PN output pentode, together with a selection of Cleartron valves. (Note the term 'Mirilium Cathode' for the two 1929 types shown at the centre.)

EKCO

E.K. Cole Ltd. was founded in 1926 in some rooms above a tailor's and a confectionery shop in London Road, Southend. Initially the company manufactured battery eliminators, but the business soon expanded into the manufacture of domestic radio receivers. By 1928, the company had 200 employees and this number increased to 2,000 by 1930. Many of the major set manufacturers were linked to valve manufacturers which put them at a distinct advantage to those, like Ekco, without such links. In 1935, the company decided to enter the valve manufacturing business and set out to recruit experienced design staff. By 1937, the company was producing eleven varieties of indirectly heated valves, all for use in their radio receivers. The last of the valves, the TX41 triode heptode was released in 1938. The valves had similar characteristics to the current Mullard four-volt range, thus allowing Ekco to use either type in their radio receivers. The company sold its goodwill and valve interests to Mullard in June 1938. Under the agreement with Mullard, Ekco undertook 'not to manufacture electronic discharge tubes', an agreement that did not expire until December 1950. During their short excursion into valve manufacturing, Ekco produced about two million devices, all of which were used in their own radio receivers.

Table 12.2 lists the complete range of EKCO valves together with their Mullard equivalents; a selection of these can be seen in Figure 12.11.

Ekco type	Description	Mullard equivalent	Ekco type	Description	Mullard equivalent
2D41	Triode	2D4B	OP42	Output pentode	PenB4
D41	Detector triode	—	R41	Full-wave rectifier	DW3
DO42	Double diode output pentode	Pen4DD	T41	Triode	354V
DT41	Double diode triode	TDD4	TX41	Triode heptode	TH4B
DTU1	Double diode triode	TDD13c	VP41	VM r.f. pentode	VP4B
OP41	Output pentode	Pen4B	VPU1	VM r.f. pentode	VP13C

Table 12.2: Ekco valves and their Mullard equivalents.

Figure 12.11: Examples of EKCO valves.

LOUDEN

Louden valves were manufactured by the Fellows Magneto Co Ltd with premises in Cumberland Avenue, Willesden, north London. The first valves were produced in 1924 and featured a spiral anode which was patented by T W Lowden, see Figure 12.12 [4]. (Note the spelling difference between Louden and Lowden.)

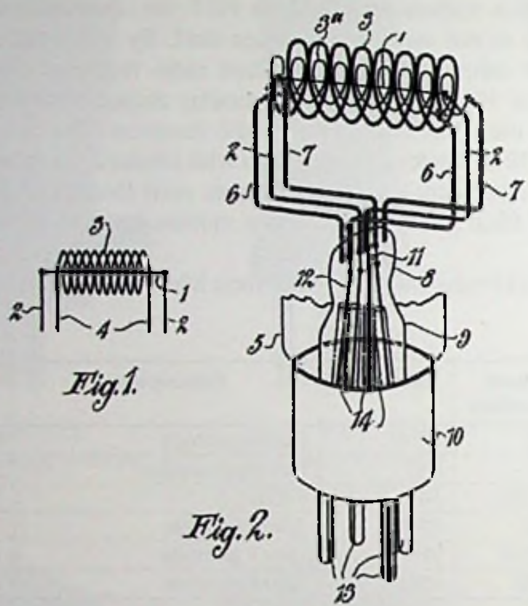
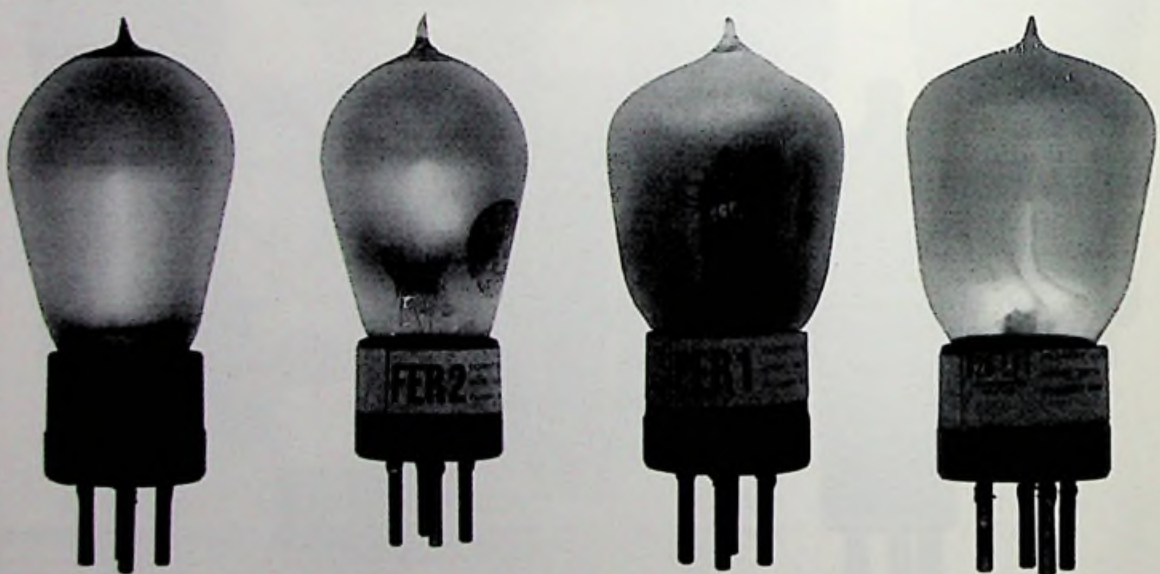


Figure 12.12: Construction of the Louden valves which featured a spiral anode. (From British patent GB217,647.)



FER1: detector or a.f. triode (4- and 6-volt versions).

FER2: r.f. triode (4- and 6-volt versions).

PER1: output triode (4- and 6-volt versions).

620LFT: 6-volt a.f. triode.

Figure 12.13: Some examples of Louden valves.

The early valves have been covered in Volume 1 and included the following types: F.1 (detector/a.f. amplifier). F.2 (r.f. amplifier). F.E.R.1 (detector/a.f. amplifier), and F.E.R.2 (r.f. amplifier). Both the F.1 and F.2 were bright emitter valves. The F.E.R.1 and F.E.R.2 were available in four- and six-volt versions.

In 1926, Louden introduced the L.E.R.1 a.f. triode, the L.E.R.2 r.f. triode and the L.E.R.3 detector triode, all having 2-volt filaments. There were also two types of output triode, each having both 4- and 6-volt filament versions: the P.E.R.1, with an impedance of 8k ohms, was intended for transformer-coupled input and the P.E.R.2, with an impedance of 20k ohms,.was intended for resistance-capacitive coupled input.

The range was further extended in 1927 to include the F.E.R.3 detector triode, again available in both four- and six-volt versions. The complete range of Louden valves featured in a two-page advertisement in an April 1927 issue of *Wireless World* [5].

There were no further valves. However, an advertisement appeared in an April 1930 issue of *Wireless Trader* magazine under the name of Lowden Valve Works [6]. This referred to barium-coated filaments, together with the patented spiral anode. The advertisement also referred to a screened grid valve and various types of triode. However, nothing further was heard of these valves and no data seems to exist for them.

Some examples of the Louden valves can be seen in Figure 12.13.

LUSTROLUX

Lustrolux Ltd was registered on 16 November 1925 and was formed to acquire the property and assets of Osborn Ltd (in liquidation). The valves were manufactured at Lower House Mill, Bollington in Cheshire. Most of the valves were produced during the two-year period of 1926 to 1927 and all of these were dull emitter triodes except for one bright emitter, the 4VBE (later re-named 470BE), which had similar characteristics to the R-valve. Later additions were a range of coated filament valves and a single screened grid tetrode, the 210SG. Some of the valves were also sold under the Dreadnought and Ensign trade names.

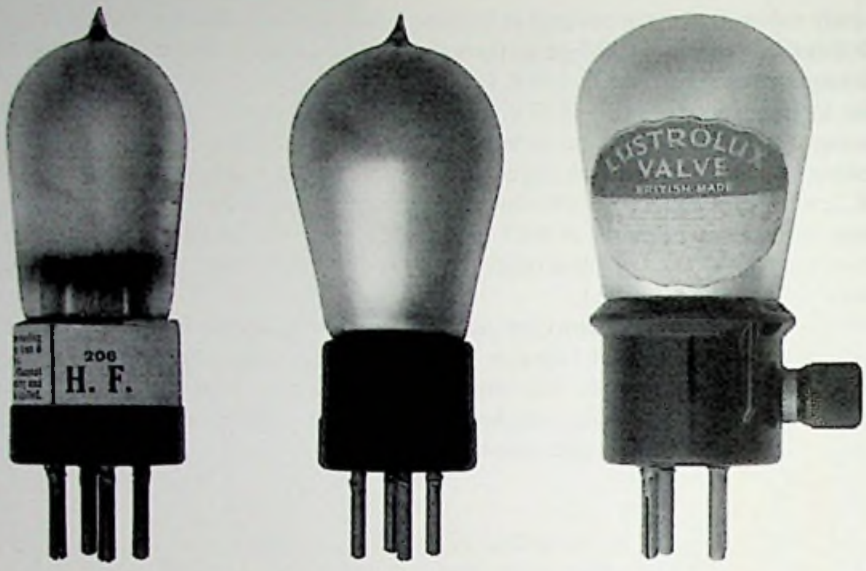
A brief history of the company was provided by Ian MacWhirter in 1979 [7]. He showed that 'At their peak, Lustrolux had some 160 employees and made and repaired some 1 million valves'. Manufacture of valves ceased in about 1934. However, the company also manufactured electric light bulbs and activity in this field continued for several more years.

The dull emitter valves produced by the Company are shown in Table 12.3 and typical examples in Figure 12.14.

Filament voltage	Function	Types	Anode resistance (r_a)
2-volt	RF or detector	206HF, 212HF, 234HF	approx. 50k ohm
	AF amplifier	206LF, 212LF, 234LF	approx. 20–25k ohm
	Output	234P, 234P (Astra), 234PV	approx. 12–13k ohm
2-volt tetrode	RF amplifier	210SG	240k ohm
3-volt	RF or detector	306HF	approx. 50k ohm
	AF amplifier	306LF	approx. 25k ohm
	Output	312P, 312PV	approx. 10k ohm
4-volt	RF amplifier	406HF	approx. 40k ohm
	AF or detector	406LF	approx. 18k ohm
	Output	412P, 412PV, 434P, 434PV	approx. 12k ohm
	General-purpose	4VBE, 470BE (bright emitters)	approx. 25k ohm
5.5-volt	General-purpose	525B	approx. 40k ohm
	Output	525, 534P, 534PV	approx. 7.5k ohm
6-volt	AF or output triode	606P, 606PV	approx. 12k ohm

Table 12.3: Lustrolux dull emitter valves.

In common with many other manufacturers at the time, the numbers in the valve designations indicate the filament voltage and current. For example, the 206HF has a 2-volt, 0.06-amp filament and the 534PV has a 5-volt 0.34-amp filament.



206HF: r.f. or detector triode (Ensign label). 312P: output triode. S210: r.f. tetrode

Figure 12.14: Lustrolux valves.

NEUTRON

Neutron Ltd, with head office in Southampton Row, London, WC1, produced a small range of triode valves from late 1925 to 1927, together with a single tetrode (see Table 12.4 and Figure 12.15). The Company name was changed in 1927 to Neutron (1927) Ltd. Most of the valves had octagonal bases. It is believed that the company also traded under the name Octron.

Range	RF tetrode	General-purpose	AF amplifier	RCC amplifier	Output
2-volt	SG2	H210, H220, HF2	L220	RC2	PP2
4-volt		H406	L406		P430
6-volt		P525B			P525, P525A.

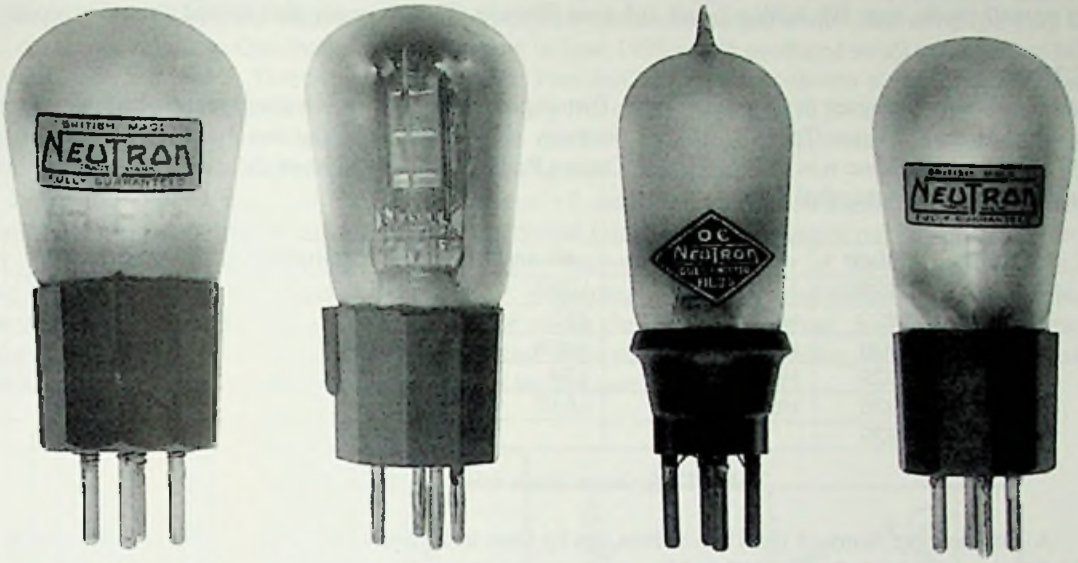
Table 12.4: Neutron valves.

The two-volt triode valves initially consisted of the general-purpose H220 and the a.f. L220, both having a 0.2-amp filament. In the four-volt range there were the H406 detector and L406 a.f. amplifier, both with 0.06-amp filaments, and the P430 output valve with a 0.3-amp filament. There were three six-volt types: the P525 and P525A were both output valves and the P525B was a general-purpose type. These all had 0.25-amp filaments.

The HF2, H210, RC2 and the output triode PP2 were added in 1927, together with the SG2 screened grid tetrode. These all had 2-volt filaments.

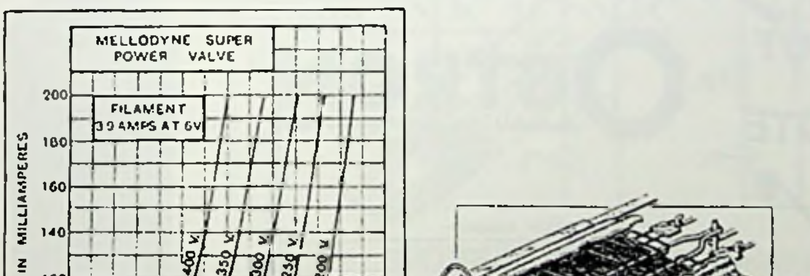
NORTH LONDON VALVE CO

This Company, founded in about 1923, had premises in Cazenove Road, north London. Its full name was North London Valve & B.U.R.T.S. Ltd. and is believed to be the forerunner of the 362 Valve Company. The company claimed to have made valves for several other British companies, including Autoveyors; however it has proved difficult to locate many of the valves produced. Two of these were power valves: the 'Mellodyne' and 'Leo the Lion' The Mellodyne had an unusual construction. It consisted of four sets of electrodes, all connected in parallel, and having a common anode. The anode was divided into two sections and in each were assembled two grids and two filaments. The valve wasn't gettered but had a long pumping period. The Mellodyne had a filament rating of six volts, 3.9 amps. The rated anode dissipation was about 60 watts and an anode resistance was 800 ohms.



HF2: general-purpose triode. RC2: RCC triode. L406: a.f. triode. PP2: output triode.

Figure 12.15: Neutron 2-volt valves. (Many of the types also appeared as Octron valves.)



Characteristic curves and electrode construction of the NLV Mellodyne power triode.

'Leo the Lion' power triode.

Figure 12.16: Power valves of the North London Valve Company.

The 'Leo the Lion' valve was of similar construction to the Mellodyne but had a slightly higher anode resistance of 1000 ohms. A photograph of this can be seen in Figure 12.16 together with a diagram showing the electrode assembly of the Mellodyne.

Three other valves that have been identified are the PA60 output triode, a 5-volt rectifier called 'Lion' and a small triode, type HF, with a 2-volt, 0.1-amp filament. The Company also carried out valve repair.

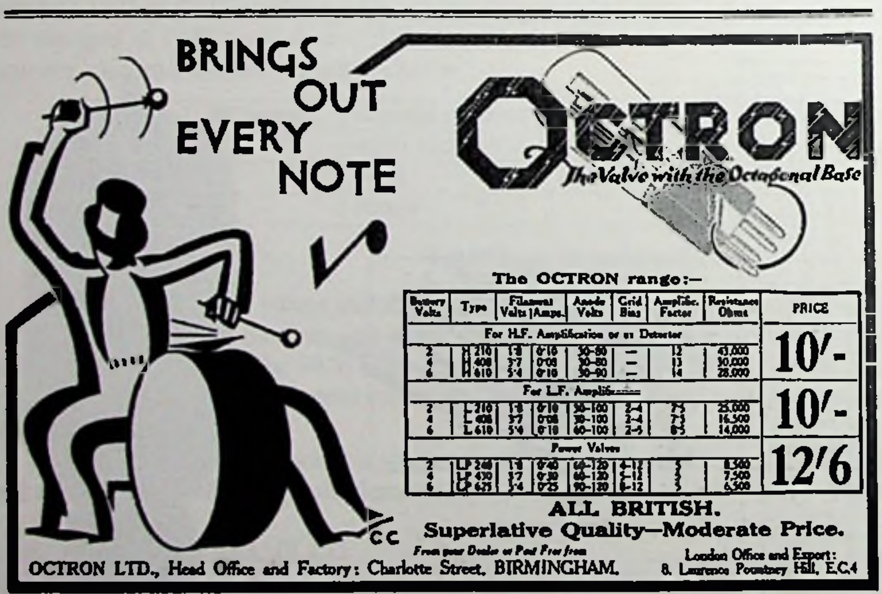
OCTRON

Octron Ltd, with premises in Charlotte Street, Birmingham, manufactured a small range of triode valves for a few years from 1926 (see Table 12.5). The company also traded under the name of H S Electric Ltd. After 1931 the company name was changed to the Clarion Radio Valve Co. Most of the valves, in common with the Neutron types, had octagonal bases.

Range	Year	RF or detector	AF amplifier	RCC amplifier	Output
2-volt	1926	H210, HR210	L210	HR210	LP240
	1929	HF2	LF2	RC2	LP2
4-volt	1926	H408, HR408	H408	HR408	LP430
	1929	HF4	LF4	RC4	LP4, PP4
6-volt	1926	H610, HR610	L610		LP625
	1929				LP6

Table 12.5: Octron triode valves of 1926 to 1929.

A list showing many of the 1926 valves can be seen in Figure 12.17, together with a photograph of the L210 detector or a.f. triode. The 1929 additions were improvements on the earlier types.



A 1927 advertisement for Octron valves.

L210 a.f. triode.

Figure 12.17: Octron valves.

QUADRUPLE VALVE CO

In July 1926, Alfred Garrod applied for two patents for three- and four-valve receivers employing resistance-capacitance coupling between the stages, a frame aerial and a single tuning coil consisting of three coupled windings [8,9] (see Figure 12.18). In July of the following year he applied for a third patent, this time for a multiple valve containing the electrode assemblies of four triodes contained within one envelope [10]. This led to the formation of the Quadruple Valve Company in June 1928 which produced small quantities of both a 'Four-in-One' valve and a 'Three-in-One' valve. The Four-in-One valve was shown at the British Industries Fair early in 1929 and was briefly reviewed by *Wireless World* in a February 1929 issue [11]. A photograph of the valve, together with its electrode construction, can be seen in Figure 12.19. Its filament was rated at 1.8-volts, 0.5-amps and the electrodes brought out to a special 12-pin base.

In the circuit of Figure 12.18 the first triode is an r.f. amplifier, the second a grid detector, the third an a.f. amplifier and the fourth the output stage. The received signal from the frame aerial is connected through the coil *c* to the grid of the first triode, with tuning by the variable capacitor, *d*. The amplified r.f. is then passed to the detector via the coupling capacitor *g*. According to the patent specification, *g* may either be connected directly to the anode of the r.f. amplifier or via the feedback winding, *p*. The principal reactive feedback, however, is from the anode of the detector stage via the third winding, *k*. The suggested anode resistance of the r.f. amplifier is 3M ohm and that of the detector abut 50k ohm.

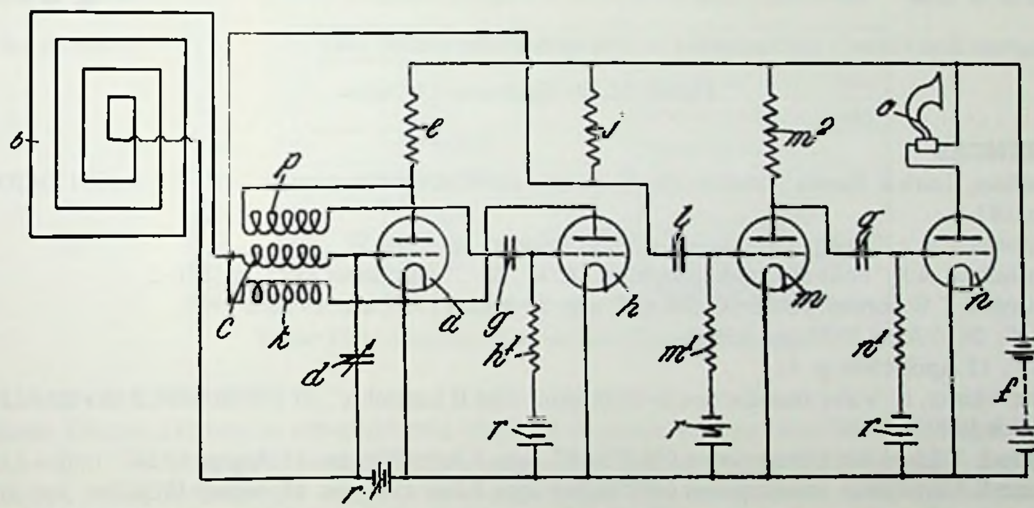


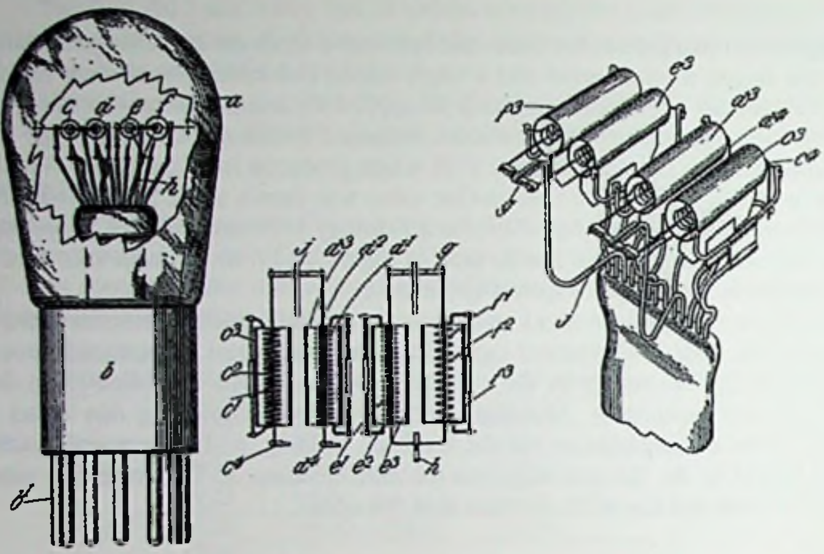
Figure 12.18: Circuit of the four valve receiver patented by Alfred Garrod in July 1926.

RADION

Radions Ltd was formed in August 1923 by W J Pattison, who had been a glass blower at the BTH works during World War I. The company initially had premises in Marsden Street, Manchester but moved to larger premises at High Mill, Bollington, Macclesfield in 1925. The initial activity of the company was valve repair, which was a fairly straightforward activity when the filaments were bright emitters. By 1924, the company was manufacturing their own bright emitter valves, followed by dull emitter types in 1925. Their founder, Pattison, left the company in 1925 to set up Lustrolux Ltd.

It's not clear when manufacture ceased but no new types appeared after 1927. The small range of triode valves produced during the period 1926 to 1927 can be found in the Valve Data Supplement. The earlier types are covered in Volume 1 of this series.

More information on the company can be found in Part 1 of Ian MacWhirter's article in the December 1978 issue of the BVWS Bulletin [12].



Diagrams from Garrod's 1927 patent for the Four-in-One valve (GB280,258).

The Four-in-One valve.

Figure 12.19: The Four-in-One valve.

REFERENCES

1. Geddes, Keith & Bussey, Gordon, *The Setmakers* (BREMA publication of 1991, ISBN 0951704206), pp. 191-2.
2. *Harmsworth's Wireless Encyclopedia,* Third Volume, pp. 2146-52.
3. Castellain, A P, 'Four-Electrode Amplifier', *W.W.*, **21**, 29 December 1927, pp. 850-2.
4. Lowden, T W, British patent GB 216,647, app. 19 March 1923, acc. 19 June 1924.
5. *W.W.*, **20**, 6 April 1927, pp. A18-9.
6. *W.T.*, 12 April 1930, p. 41.
7. MacWhirter, I. 'Valve manufacture in Bollington. Part II Lustrolux', *BVWS Bulletin*, **3**, no. 4, March 1979, pp. 62-3.
8. Garrod, Alfred John, British patent GB 275,387, app. 2 July 1926, iss. 11 August 1926.
9. Garrod, Alfred John, British patent GB 275,388, app. 2 July 1926, iss. 11 August 1926.
10. Garrod, Alfred John, British patent GB 289,258, app. 9 May 1927, iss. 17 November 1927.
11. 'Radio at the British Industries Fair', *W.W.*, **24**, 27 February 1929, pp. 223-4. See also *W.T.*, 29 September 1928, p. 356.
12. MacWhirter, I. 'Valve manufacture in Bollington. Part I Radions and the Pattison family', *BVWS Bulletin*, **3**, no. 3, December 1978, pp. 35-6.

Chapter 13
Suppliers of British and Continental Valves

During the 1920s several British companies were set up or expanded their existing business to sell valves manufactured by other companies. A few of the supply companies were British, such as Mullard and STC, but the majority were produced in continental Europe, notably in Austria, France, Hungary and Holland.

AMPLION

Alfred Graham and Co. was better known as a manufacturer of horn loudspeakers. During the period 1926 to 1927 it sold Cosmos valves of Metrovic manufacture. The company name was changed to Graham Amplion in 1927 but it went into liquidation a few years later. However, it was resurrected in 1932 as Bush Radio. Table 13.1 shows the valves sold by Amplion, together with their Cosmos equivalents.

Amplion type	Cosmos equivalent	Description
AMG.2/25	DE11	General-purpose triode
AMG.6/9	DE55	General-purpose triode
AML 2/30	SP18/RR	Output triode
AML.6/25	SP55/R	Output triode
AMR 2/9	SP18/B	RF or RCC triode
AMR.6/9	SP55/B	RF or detector triode
AMS.6/100	—	Output triode

Table 13.1: Amplion valves and their Cosmos equivalents.

BENJAMIN SHORTPATH

Benjamin Electric Ltd was an old-established electrical company with premises in Tariff Road, Tottenham, north London. The company was registered in August 1908. During the period 1926 to 1927 it sold Cosmos valves but, unlike Amplion, the company used the Cosmos type designations. A full list of the valves is shown in Table 13.2.

Type	Description
DE55	General-purpose triode
SP18 (blue spot)	RCC triode
SP18 (green spot)	RF triode
SP18 (red spot)	Output triode
SP55 (blue spot)	RF or RCC triode
SP55 (red spot)	Output triode
DE55	General-purpose triode
SP18 (blue spot)	RCC triode
SP18 (green spot)	RF triode
SP18 (red spot)	Output triode
SP55 (blue spot)	RF or RCC triode
SP55 (red spot)	Output triode

Table 13.2: Benjamin valves.

BSA-STANDARD

BSA was founded in Birmingham in 1861. Initially the company manufactured small arms but branched out into bicycles, motor cycles and cars. The subsidiary company, BSA Radio Ltd, was formed in 1926 and produced a small range of radio receivers and sold a few valve types of STC manufacture (see Table 13.3).

Type	Description
G125	General purpose triode
G125A	General purpose triode
G225	General purpose triode
H125	RF or detector triode
H125A	RF or detector triode
P125	Output triode
P125A	Output triode
P425	Output triode
P425A	Output triode
P485	Output triode
P612	Output triode

Table 13.3: BSA-Standard valves of 1926 to 1927.

DARIO

The French valve manufacturer La Radiotechnique adopted the trade name Dario in 1927. As a result of patent litigation with Philips, which was won by La Radiotechnique, Philips was ordered to pay damages. However, the end result was that Philips negotiated to purchase La Radiotechnique in 1931. After this time all the Dario receiving valves were of Philips design.

The Dario valves were sold in Britain by Impex Electrical Ltd. from 1928 until the late 1930s (see Figure 13.1). The various ranges available over this time have been broken down into six categories:

- Early two- and four-volt battery valves
- Later two-volt battery valves
- Four-volt a.c. valves
- 20-volt, 0.18-amp d.c. valves
- 0.18-amp a.c./d.c. valves
- 0.2-amp a.c./d.c. valves

Early two- and four-volt battery valves. These valves are shown in Table 13.4 with similar types in both voltage ranges. The two-volt types were known as 'Bivolt' and the four-volt as 'Forvolt'. The function of the various types may be inferred from the name:

Resistron ....High impedance amplifier triode for RC coupling
Universal....................General-purpose triode suitable as a detector or transformer-coupled audio amplifier
Super HF....................Medium impedance, general-purpose triode
Super Detector ....Triode suitable as a leaky-grid detector or a transformer-coupled audio amplifier
Super Power...............Output triode
Hyper Power ....High-power output triode (0.5 watts from a 200-volt supply)
Mag Power.................High-power output triode (0.75 watts from a 200-volt supply)
Screenodion................RF tetrode
VM Screenodion........Variable-mu r.f. tetrode
Pentodion ....Output pentode
Polyodion ....Output pentode

Range	Year	RF tetrode	Triode	Output triode	Output pentode
2-volt	1928		Resistron-2V	Super Power-2V	
	1929		Universal-2V	Hyper Power-2V	Pentodion-2V
	1930	Screenodion-2V	Super HF-2V, Super Detector-2V		Polyodion
	1932	VM Screenodion			
4-volt	1928		Resistron-4V	Super Power-4V	
	1929		Universal-4V	Hyper Power-4V	Pentodion-4V
	1930	Screenodion-4V	Super HF-4V, Super Detector-4V	Mag Power	

Table 13.4: Early two- and four-volt Dario battery valves.

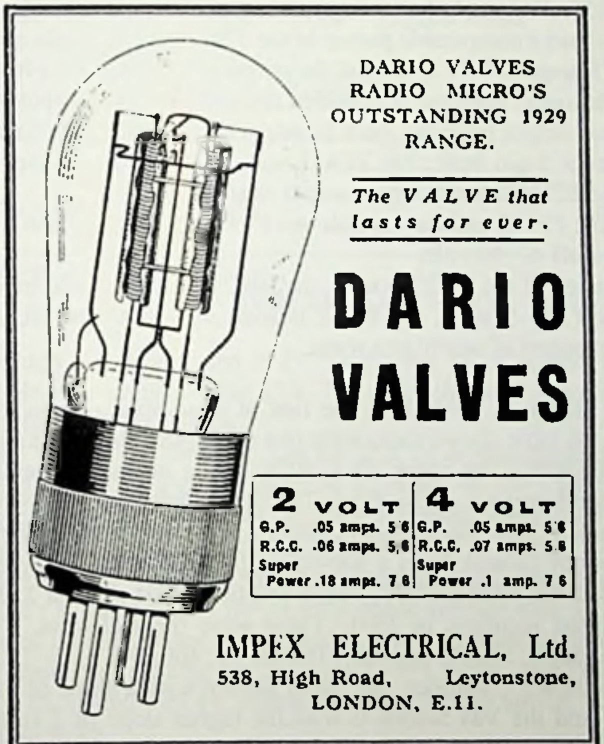


Figure 13.1: Dario advertisement from October 1928. (Note the vertical striations around the base which were typical of all the early Dario valves.)

By 1930 the two Pentodion output pentodes had been dropped and only the two-volt Polyodion continued to be offered.

Later two-volt battery valves. A new range of battery valves appeared in 1933. These, like the earlier ones, had oxide-coated filaments but with improved characteristics (see Table 13.5). The TB422 was an r.f. tetrode and the TB452 a variable-mu tetrode. The TB172 was a low-impedance detector triode, the TB282 a medium-impedance, general-purpose triode, although probably best suited as a detector and the TB122 a low-impedance a.f. triode. The TB032A was a low-power output triode and the TC432N an output pentode. The last of the 1933 valves was the TC432N output pentode.

Year	RF tetrode	Freq. changer	Triode or DDT	Output triode	Output pentode
1933	TB422, TB452		TB122, TB172, TB282	TB032A	TC432N (B4)
1934			TB102	TB032, TB052, TB062, TB402	TC432 (B4&B5), TCH432 (B4&B5)
1935	PF462, TB622, PF472				
1936		BK22	BBC12		
1938	TB552	BH12 (hexode)			BLL32

Table 13.5: Later Dario two-volt battery valves.

There were seven new valves in 1934. The TB102 was a general-purpose triode. The output triodes consisted of the TB032 with a power of 450mW, nearly twice that of the TB032A; the TB052 was a low-power valve, and the TB062 which initially had a comparable power to the TB032 but a couple of years later its filament current was increased from 0.18 amps to 0.33 amps and the output power increased from 350mW to 550mW; the TB402 was a Class B double triode, operated at zero bias and capable of an output of 1.5 watts from a 150-volt supply. There were also two output pentodes, both having a choice of a 4-pin base with side terminal for the screen grid connection or a 5-pin base; the TC432 was an improvement on the earlier TC432N, with an output of 420mW, and the TCH432 had a higher output of 600mW.

Two r.f. pentodes appeared in 1935: the PF462 and the variable-mu PF472. There was also a long grid-base r.f. tetrode, the TB622, which had a cut-off of –50 volts.

Later valves from 1936 to 1938 consisted of the BK22 octode, the BBC12 double diode triode, a short grid-base tetrode, the TB552, with a cut-off of –9 volts, the BH12 hexode mixer and the BLL32 double pentode for QPP operation and providing an output of nearly two watts.

Four-volt a.c. valves. These valves are shown in Table 13.6, the first of them appearing in 1930 a year before the Philips acquisition of Dario. As the table shows there were just six types. The r.f. tetrode was the Screenodion, which was also designated as I.4091. The Super HF (I.4078) was a medium impedance triode having a slope of 2mA/V and suited for general-purpose applications. The Super Detector (I.4078) was a low-impedance triode, also having a slope of 2mA/V. The Mag Power (I.4046) was a directly heated output triode with a slope of 3.8mA/V, delivering a power of 750mW from a 200-volt supply. In addition, there were two directly heated full-wave rectifiers; the V3880 was rated at 300V, 75mA and the V4001 rated at 250V, 40mA.

There were three further directly heated rectifiers in 1931. These were the full-wave V90 (450V, 120mA) and the two half-wave types, V105 (550V, 50mA) and the V165 (850V, 100mA).

In the following year there were three new r.f. tetrodes: the Super Screen with a slope of 3mA/V, the VM Screen A with a low slope of 1mA/V and the VM Screen B with the higher slope of 2.4mA/V (these latter two valves both being variable-mu). There were also two new output valves: the Super Power was a triode with an output of 600mW and the Polyodion a two-watt pentode. Finally there were three directly heated, full-wave rectifiers: the FW1 (300V, 75mA), FW2 (350V, 120mA) and the FW3 (500V, 120mA).

All of the 1933 valves appear to be a re-designation of earlier types, i.e. TE424 = Screenodion, TE524T = Super Screenodion and TE554 = VM Screen A. Similarly, with the triodes, TE244N = Super Detector, TE384 = Super HF and TE094 = Super Power. Finally the output pentode TE434A = Polyodion.

The first r.f. pentodes appeared in 1934 along with some additional tetrodes. The r.f. pentodes were the TE464 and the variable-mu TE474; initially these both had 5-pin bases but 7-pin versions became available in the following year. The r.f. tetrodes were the TE444, which incorporated a single diode, the TE524 and the variable-mu TE564. The TE504 was an octode frequency changer having a conversion conductance of 0.65mA/V and the TE4 a double diode. The TE244 was a medium-mu detector triode and the TE384 a general-purpose triode. There were three directly heated output valves: the 3.5-watt TD24 triode, the 2.8-watt

TC434 pentode and the 3.4-watt TE434 pentode. There were also two indirectly heated output pentodes. These were the 2.5-watt TE534 and the 3.4-watt TE634. Initially the TE534 had a 5-pin base but a 7-pin version became available a couple of years later. The only other 1934 valve was the SW1, a half-wave directly heated rectifier, rated at 400V, 60mA.

Year	RF tetrode or pentode	Freq. changer	Diode	Triode, DDT or Tuning Indicator	Output triode	Output pentode	Rectifier
1930	Screenodion			Super HF, Super Det	Mag Power		V3880, V4001
1931							V90, V105, V165
1932	Super Screenodion, VM Screen A, VM Screen B				Super Power	Polyodion	FW1, FW2, FW3
1933	TE424, TE524T, TE554			TE244N, TE384	TE094	TE634A	
1934	TE444, TE464 (B5), TE474 (B5), TE524, TE564	TE504	TE4	TE244, TE994	TD24*,	TC434*, TE434*, TE534 (B5), TE634	SW1
1935	TE464 (B7), TE474 (B7)	TK24	TB24				IFW1
1936				TBC14		TE534 (B7), TL44	
1937				TM14 (tuning indic.)		TL34, TL54	
1938	TF44, TF64	TCH24			TD044*, TF104, TF364	TBL14, TBL44	TZ34

*Directly heated output valves

Table 13.6: Dario 4-volt a.c. valves of 1930 to 1938.

Two new valves released in 1935 were the TK24 octode, a replacement for the TE504, and the TB24 double diode which replaced the TE4. The only other new valve was the IFW1, an indirectly heated full-wave rectifier rated at 500V, 120mA.

In the following year there was the TBC14 double diode triode and the TL44 output pentode having a slope of 9.5mA/V and a rated output of 3.5 watts. In 1937 there was the TL34 output pentode which had a similar output power to the TL44 but with increased heater current and anode dissipation. There was also the higher power TL54 with an output of 8.5 watts. The only other 1937 valve was the TM14 tuning indicator.

The last of the Dario a.c. valves appeared in 1938. There was the high-slope TF44 r.f. pentode, the TF64 variable-mu r.f. pentode and the TCH24 triode hexode with a conversion conductance of 0.75mA/V. There were several output triodes and pentodes. These included the TD044 directly heated triode with an output power of about three watts, the 5.7-watt TF104 triode, the TF364 triode, and the two double diode output pentodes, TBL14 and TBL44, which were very similar valves, both having a slope of 9.5mA/V and an output of about four watts.

20-volt, 0.18-amp d.c. range. These valves, which were released in the period 1932 to 1933, had similar designations to the early four-volt a.c. valves (see top row of Table 13.7). There were two r.f. tetrodes, a detector triode, an output triode and an output pentode.

0.18-amp a.c./d.c. valves. This range was issued in 1937. It consisted of the TB4620 r.f. pentode, the TB4720 variable-mu r.f. pentode, the TB9920 detector triode, the TBL226 output pentode and the TBY233 voltage-doubler rectifier.

0.2-amp a.c./d.c. range. This range was introduced in 1934 and many of the valves were available with both British and the continental side contact base (this difference has been identified by adding either an M or a P at the end of the type designation). For several of the valves the author has been unable to determine the year of issue so, for these, a guess has been made.

Range	Year	RF tetrode or pentode	Frequency changer	Diode	Triode or diode triode	Output triode or pentode	Rectifier
0.18-amp d.c.	1932/33	Screenodion, Super screen			Super Det	Polyodion, Super Power	
0.18-amp a.c./d.c.	1937/38	TB4620, TB4720			TB9920	TBL226	TBY233
0.2-amp	1934	TB4613,TB5613M	TE5013	TB13	TC113	TE4313, TE4320	TW1
a.c./d.c.	1936	TF313M, TF713M	TBC5013	TB213	TBC113M	TB4320M, TL413	TW2
	1937		TB5013M, TCH229				
0.2-amp (Ct8)		TB5613P, TF313P, TF713P	TB5013P		TB8013, TBC113P	TB4320P	

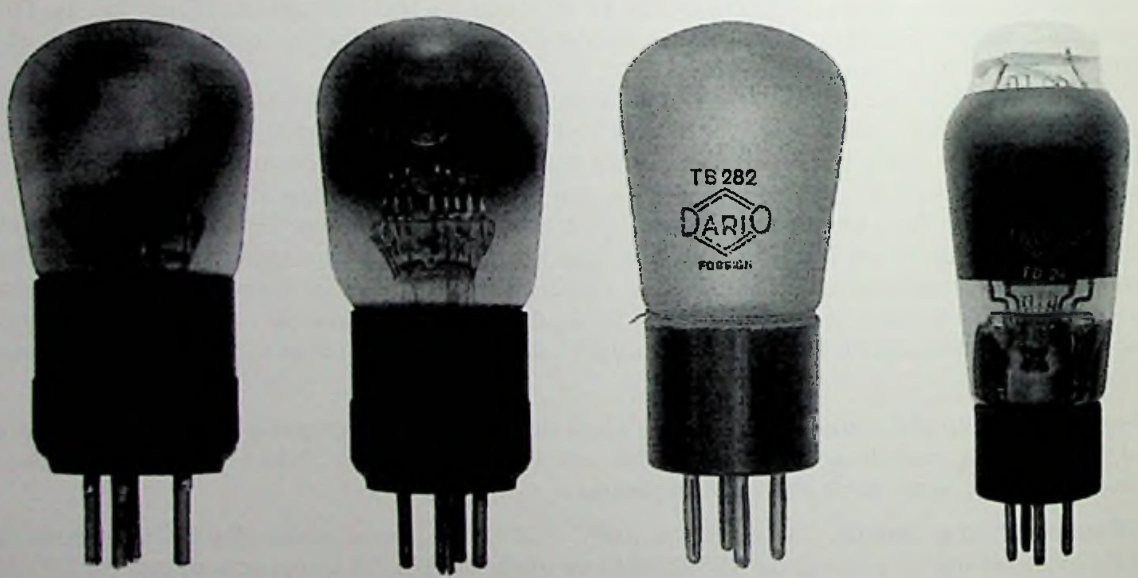
Table 13.7: Dario d.c. and a.c./d.c. valves.

The initial r.f. pentodes of 1934 were the TB4613 and the variable-mu TB5613. The TE5013 was an octode frequency changer and the TB13 a double diode. The TC113 was the only triode. There were two short-lived output pentodes: the TE4313 and the TE4320. To complete these initial types there was the TW1 half-wave rectifier, rated at 250V, 75mA.

The next set of valves made their appearance in 1936. There was two r.f. pentodes, the TF713 and the variable-mu TF313. There was also a new octode frequency changer, the TBC5013, and the TB213 double diode, which superseded the TB13. Other new valves were the TBC113 double diode triode, the TB4320 and TL413 output pentodes, and the TW2 voltage-doubler rectifier.

The last of the valves in this range, which is believed to have appeared in 1937, was the TCH229 triode hexode. To complete the range Dario produced just one 0.2-amp barretter, the T1.

Some examples of Dario valves are shown in Figure 13.2.



Super Power-Bivolt: 2-volt output triode.   Early 4-volt a.c. triode.   TB282: 2-volt detector or a.f. triode.   TD24: 4-volt output triode.

Figure 13.2: Dario valves.

EAGLE

Eagle valves were manufactured during the 1920s by Joh. Kremenezky, an Austrian Company located in Vienna. They were sold in Britain by Eagle Valves Ltd. from premises in Farringdon Road, London, EC1, commencing in 1928. Little information has been found on these but an early advertisement from *Wireless Trader* announcing the valves can be seen in Figure 13.3 together with a photograph of a two-volt output triode. (This valve has a reddish-brown moulded base.)

Figure 13.3 Advertisement for Eagle valves from *Wireless Trader* 3 December 1927 (left) and Eagle E2P output triode (right).

ETA

The Electrical Trading Association Ltd. sold the French UNIS valves for a few years from 1931. The small range of two- and four-volt battery valves is shown in Table 13.8 and the a.c. types, including those with US bases in Table 13.9. Figure 13.4 shows an advertisement for ETA valves together with a photograph of the BY1210, low-mu a.f. triode.

Range	Year	RF tetrode	Triode	Output triode	Output pentode
2-volt	1931	BY6	BY1210, BY1814, BY2020	BW303, BW602, BW1304, BX604	
	1933		BY1815		BY3
4-volt	1931			DW302, DW702, DX502	
	1932				DW3

Table 13.8: ETA battery valves.

Range	Year	RF tetrode	Triode	Output triode	Output pentode	Rectifier
British bases	1931	DW2, DW6	DW4023	DW302*, DW704, DW1003		D3-50B, D3-80B
	1932	DW7, DW8	DW1508	DW802, GW402*	DW9	D5-125B, G7-85
	1933		DW4011			
US bases	1931	EY624, EY635	EX645	EX645, EX650		EX-680, EX-681
	1932		EX626, EY627	EX610	EY647	

*Directly heated

Table 13.9: ETA a.c. valves.

Figure 13.4: Advertisement for ETA valves (*Wireless World* 11 November 1932).

ETA-UNIS, BY1210 triode.

EVER READY

The Ever Ready Radio Co. Ltd. was established after its parent company, Ever Ready (Great Britain) Ltd., purchased Six-Sixty from Mullard in 1935. The company bought all its supplies from Mullard, which it sold under the trade name EVER READY. Under the agreement with Mullard for the exclusive purchase of valves, the company undertook to fit its receivers only with Mullard valves and not to sell valves to other equipment manufacturers outside the Ever Ready Group. Furthermore, the valves had to be sold on the same terms as Mullard. Ever-Ready did, however, supply valves to Lissen Ltd., an important set manufacturer which was part of the same group of companies and had previously manufactured valves themselves.

In the period covered by this book, the author has identified 66 different types, although several of these were improved versions of earlier ones (see Table 13.10).

Ever-Ready	Mullard	Ever-Ready	Mullard
A11A, A11B	IW4-350	C39A	EM1
A11C	IW4-500	C50B	SP13C
A11D	IW4-350	C50N	VP13C
A20B	2D4A	C70D	Pen36C
A23A	TDD4	C70E	Pen36C
A23B	TDD4	C80B	FC13C
A27D	Pen4DD	K23A	TDD2A
A30B	904V	K23B	TDD2A
A30D	354V	K30A	PM2HL
A36A	TH4	K30B	PM1LF
A36B	TH4B	K30C	PM2HL
A36C	TH4B	K30D	PM2HL
A39A	TV4	K30E	PM2DX
A40M	MM4V	K30G	PM2A
A50A	SP4	K30K	PM2HL
A50B	SP4B	K33A	PM2B
A50M	VP4	K33B	PM2BA
A50N	VP4A	K40B	PM12
A50P	VP4B	K40N	PM12M
A70B	Pen4VA	K50M	VP2
A70C	PenA4	K50N	PM12M
A70D	PenA4	K70B	PM22A
A70E	PenB4	K70D	PM22D
A80A	FC4	K77A	QP22A
C10B	UR1C	K77B	QP22B
C20C	2D13C	K80A	FC2
C23B	TDD13C	K80B	FC2A
C27D	Pen40DD	S11A	DW2
C30B	HL13C	S11D	DW4-350
C36A	TH21C	S30C	AC044
C36B	TH30C	S30D	AC042
C36C	TH22C	S50C	AC044
C36N	TH30C		

Table 13.10: Ever-Ready valves and Mullard equivalents.

In this table the type designations consist of a single letter, followed by two digits and then a further single letter. The first letter indicates the type of cathode used, as shown below:

A Four-volt indirectly heated
C a.c./d.c. types with 0.2-amp heaters
K Two-volt directly heated filaments
S a.c. types with directly heated filaments.

The first digit indicates the class of valve:

1 Rectifiers
2 Double diodes, double diode triodes or double diode output pentodes
3 Triodes, triode hexodes or tuning indicators
4 RF tetrodes
5 RF pentodes
7 Output pentodes
8 Octodes

FOTOS

During WW1 there were two French companies manufacturing valves, starting with the TM bright emitter triode. These two companies were Compagnie des Lampes (trade name Métal) and E. C&A Grammont (trade name Fotos). The Fotos valves were sold in Britain for a few years from 1929 by Concertron Radio & Electrical Ltd., a company with premises in High Holborn, London, WC2 (see Table 13.11 and Figure 13.6).

Range	RF tetrode	Triode	Output triode	Output pentode
2-volt	BC150	BA9, BC9, BC18, BC40	BD5, BD9	BD100, BF100,
4-volt	C150	C9, D15, D40	D5, D9, D100	
4-volt a.c.	S4150	S415, S440, T415	F5*, F10*	F100*

* Directly heated

Table 13.11: Fotos valves of 1929 to 1930.

FRELAT

These valves, of Dutch manufacture, appeared on the UK market in 1926 and were distributed initially by L Kremner of Manchester. Adverts at the end of 1928 and early in 1929, however, indicated that they were then distributed by the Samden Wireless Co. Ltd. and Continental Radio Import Co. Ltd (see Figure13.5).

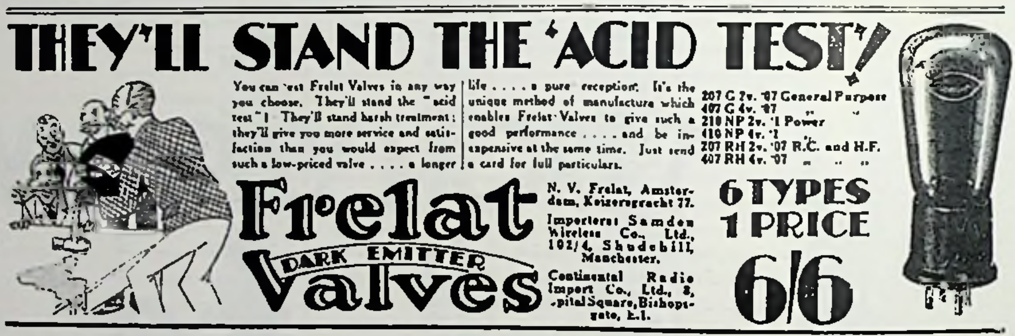


Figure 13.5: Frelat advertisement from January 1929.

There would appear to have been only 14 types, all triodes, as indicated in Table 13.12. The first six of these appeared in the 1928 and 1929 advertisements and the remaining eight were earlier, probably about 1926.

Type	Description	V_f
207 G	General-purpose triode	2.0
207 RH	RF or RCC triode	2.0
210 NP	Output triode	2.0
407 G	General-purpose triode	4.0
407 NP	Output triode	4.0
407 RH	RF or RCC triode	4.0
A.V.L.	General-purpose triode	3.8-4.0

Type	Description	V_f
D.E.	General-purpose triode	1.8-2.0
D.E.P	Output triode	3.5-5.0
D.K.P.	Output triode	1.8-2.0
H	Detector triode	3.8-4.0
K	Detector triode	1.8-2.0
L	Detector or AF triode	3.0-4.0
P	Output triode	3.8-4.0

Table 13.12: Frelat valves of 1926 to 1928.

GRAHAM FARISH

Graham Farish was a small radio company with premises in Bromley, Kent. Together with its associate company, Formo Products Ltd., it supplied a range of radio components, including valve holders, a.f. transformers, variable capacitors, tuning coils and complete kit sets.

During the period 1935 to 1936 the company marketed a small range of valves of continental origin, starting with two-volt battery types. This was followed, in 1936, with a four-volt mains series. All the valves were fairly basic types such as triodes, r.f. tetrodes and pentodes, output triodes and pentodes, and a couple of mains rectifiers. There were no frequency changers or double diode triodes (see Table 13.13). The company used the trade name Ring, although the Graham Farish name was also printed on the glass bulb.

Range	Year	RF tetrode or pentode	Triode	Output triode	Output pentode
2-volt battery	1935	HP2, SG2, SGW2, SX2, VP2, VS2	DX2, LF2	LP2, MP2, XP2	PP2, PT2, QP2
4-volt, a.c	1936	AC/HG, AC/HP, AC/SG, AC/VG, AC/VP, AC/VS	AC/DX, AC/LP		AC/PP, AC/PT

Table 13.13: Graham Farish valves of 1935 to 1936.

Two-volt battery range. The SG2, SX2 and SGW2 were straight r.f. tetrodes and the VS2 a variable-mu tetrode. The HP2 was a straight r.f. pentode and the VP2 a variable-mu pentode. The SGW2, shown in Figure 13.7, was of special interest, being intended for short wave use, otherwise it characteristics were identical to the VS2.

The DX2 was a detector triode and the LF2 an a.f. triode (also shown in Figure 13.7). The three output triodes, in ascending order of output power, were the LP2, MP2 and XP2.

The output pentodes were the low power PT2, the higher power PP2 and the QP2 double pentode for QPP operation.

Four-volt a.c. range. In this range there were six r.f. tetrodes and pentodes. The tetrodes were the AC/HG, AC/SG and the variable-mu types AC/VG and AC/VS. The pentodes were the AC/HP and the variable-mu types AC/VP.

The AC/DX was a detector triode and the AC/LP an a.f. triode. Finally there were two output pentodes: the low power AC/PT and the higher power AC/PP.

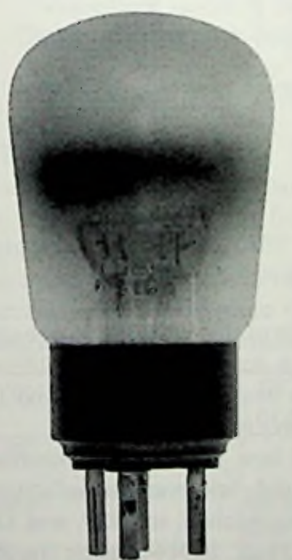


Figure 13.6: Fotos BD9 2-volt output triode.

Figure 13.7: Graham Farish advert showing the SWG2 for short wave use (left). LF2: two-volt a.f. triode (right).

LOEWE

An article by Dr H Kröncke was published in a September 1925 issue of *Wireless World* which summarized the work of von Ardenne and H Heinert of the German Loewe-Radio Company in resistance-capacity coupled amplifiers [1]. It was shown that high amplification was possible without the need for step-up transformers if a very high value of anode load was used (typically 3M ohm). At this time (1925) resistors suffered from both high capacitance (30pF was quoted) and a significant change of resistance with variation of voltage. The Loewe Company, however, had produced metal film resistors which did not suffer from these defects and a circuit was shown of a three-valve receiver where the first stage had regenerative feedback (reaction) and RC coupling was used between the stages.

In a subsequent article, published in December 1925, Kröncke showed a photograph of a Loewe valve which incorporated two electrode assemblies in a single bulb, together the resistors and capacitor [2]. This construction had the benefit of minimizing stray capacitances and ensuring that the resistors and capacitor were protected from the ingress of moisture or other forms of contamination.

This early work led directly to the two best known Loewe multiple valves, the 2HF and 3NF, which were shown at the Berlin Wireless Exhibition in 1926 held from 3 to 12 September 1926 [3,4]. The 2HF combined two, double-grid valves in one envelope and the 3NF had three triodes in one envelope. A circuit showing these two valves connected together in a five-stage receiver is shown in Figure 13.8 [5].

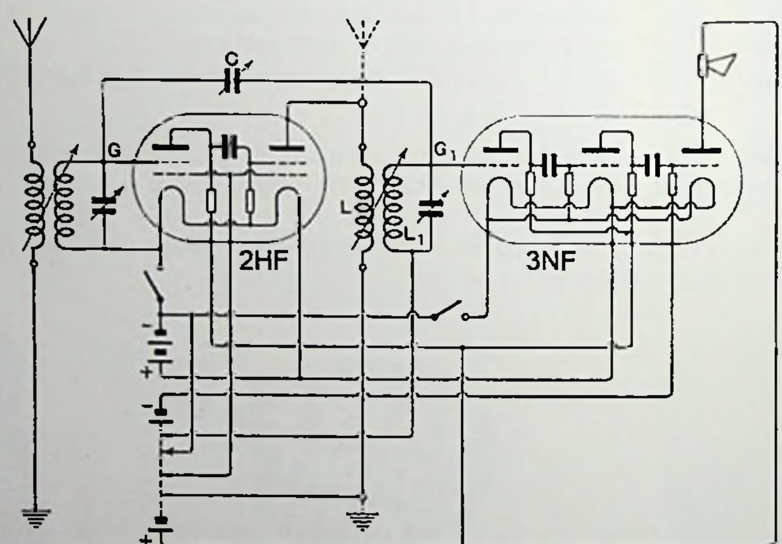


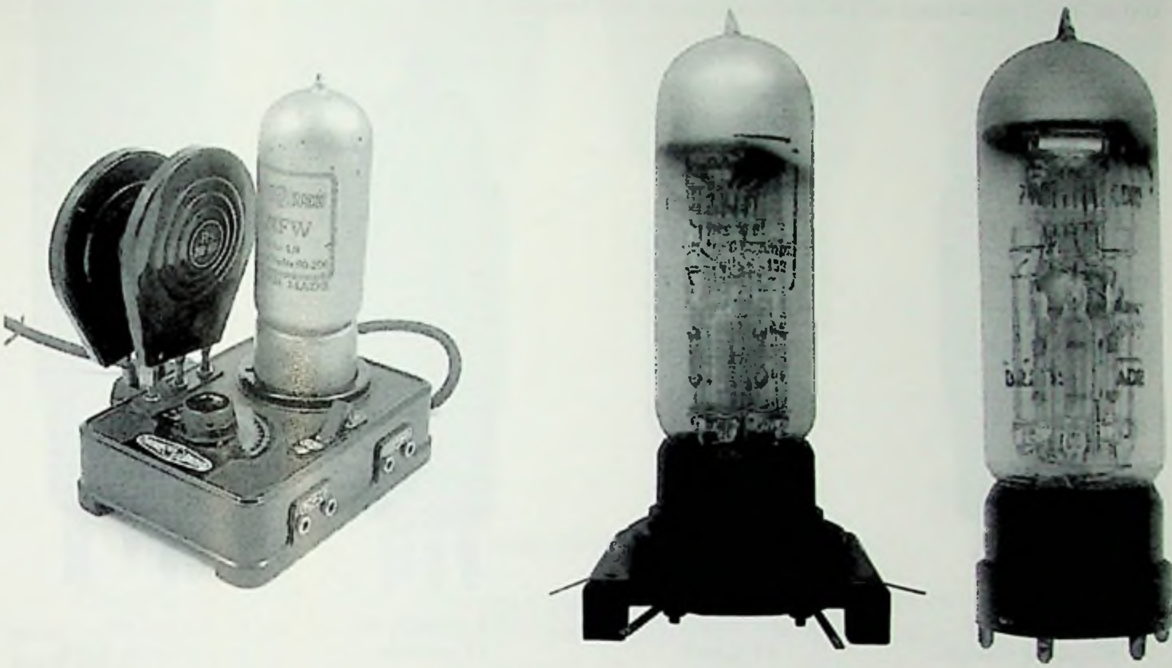
Figure 13.8: Loewe receiver circuit using the 2HF and 3NF valves.

In this circuit the 2HF valve acts a two-stage r.f. amplifier; the inner grids of this valve are space-charge grids and biased at about +15 volts. The second valve, the 3NF, combines a detector, audio amplifier and output stage driving the loudspeaker. The variable capacitor C was used to couple the grids G and G_1 to ensure uniformity of performance with variation in characteristics from one valve to another.

Loewe manufactured some of these valves in Britain but it is not clear how much of the manufacture took place and whether it was just assembly from imported parts. Loewe did, however, manufacture the OE333 receiver in Britain which used the 3NF valve. The selling price for this receiver, in 1929, was £4 10s (excluding coils, batteries and loudspeaker [6]. A reaction version of the receiver, RO444, using the RNF7 valve, was reviewed in 1930 [7].

A photograph of the OE333 receiver, which used a metallised version of the 3NF, is shown in Figure 13.9, along with photographs of the 3NF and 2HF valves.

Loewe continued to produce various versions of their multiple valves throughout the 1930s. Details of these can be found in the Valve Data Supplement, but it's not clear how many of these types were available in Britain.



Loewe OE333 receiver using the 3NFW valve, a metallised version of the 3NW. (Photograph supplied by Bengt Svensson.)

3NF valve incorporating three triodes, one being an output stage.

2HF with two double-grid valves.

Figure 13.9: British-made Loewe receiver and valves.

OSTAR-GANZ

These valves were manufactured by Gustav Ganz and Co., an Austrian Company located in Vienna. They were marketed in Britain by Eugen Forbat of Southampton Street in central London, commencing in 1932 and continuing into the late 1930s. All the valves were indirectly heated and were quite unique in that the heaters were operated directly from the a.c. or d.c. mains supply of nominally 100 volts or 250 volts. According the Tyne, the heaters were made from tungsten wire 0.015mm in diameter and four metres long [8]. Table 13.14 summarizes those valves available in the UK.

Year	Frequency changer	RF tetrode or pentode	Double diode	Triode or diode triode	Output triode	Output pentode	Rectifier
1932				A520, W310	L1525, U920		EG50, EG100, NG40, VG45
1933		MS18, MS70, S25, S100		BA1, BA2, D130	K3560	Pt3	NG100
1934	G5	H3, V3	B2		K2060	M43	NG50
1936						M44	

Table 13.14: Ostar-Ganz valves.

The G5 was a heptode frequency changer. There were four r.f. tetrodes: the S25, S100 and the two variable-mu types MS18 and MS70. The H3 was a straight r.f. pentode and the V3 a variable-mu r.f. pentode. The B2 was a double diode and the BA1 and BA2 single diode triodes. The BA1 had an anode impedance of 40k ohm and the BA2 of 10k ohm. The A520 was a low-impedance triode, whereas the D130 and W130 both had an anode impedance of 40k ohm and a slope of 3.5mA/V.

G5: heptode frequency changer.

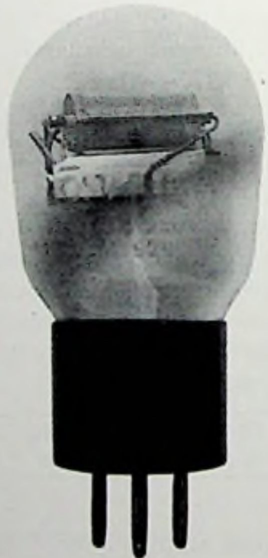
MS18: variable-mu r.f. tetrode.

V3: variable-mu r.f. pentode.

D130: high-mu triode.

A520: general-purpose triode (horizontal electrodes).

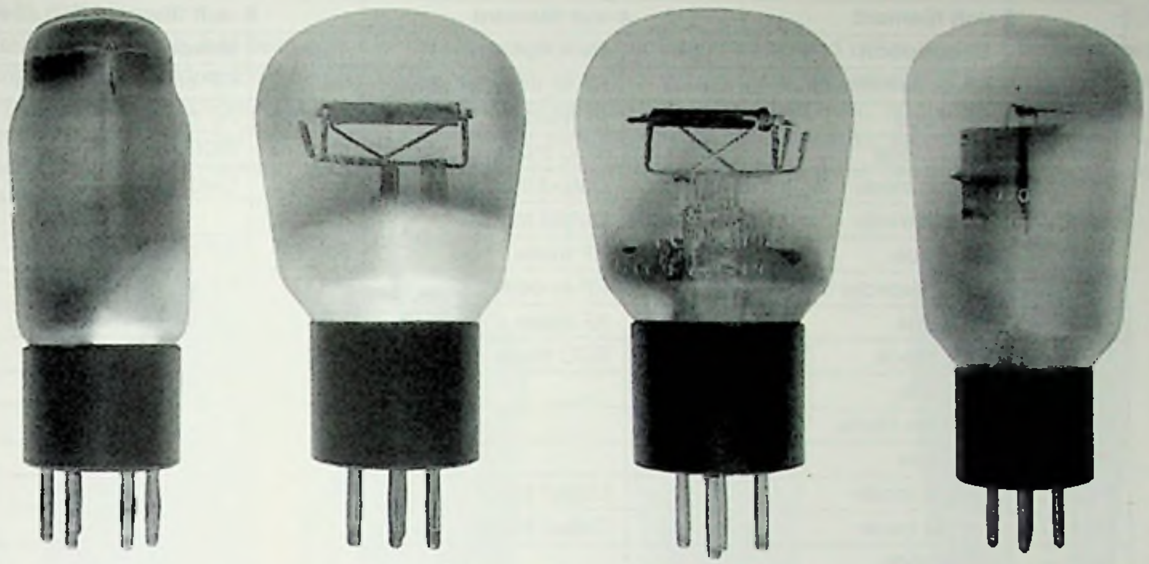
A520: general-purpose triode (vertical electrodes).



U920: low-power output triode.

K3560: 'super-power' output triode.

Figure 13.10: Ostar-Ganz valves.



Pt3: output pentode. | EG50: half-wave rectifier. | EG100: half-wave rectifier. | NG40: voltage doubler rectifier.

Figure 13.11: Ostar-Ganz valves, cont.

There were four output triodes, all having 5-pin bases. Of these the U920 and L1525 were of the lowest power, with rated outputs of 0.75 watts and 0.9 watts respectively. The K2060 had an output power of 3.5 watts and the K3560 of four watts.

There were three output pentodes. The 1.5-watt Pt3 was described as a multi-grid because its suppressor grid was taken to a separate pin rather than being internally connected to the cathode. The M43 had an output power of 3.5 watts and the M44 of nine watts.

All the valves described so far, except for the four output triodes, had 7-pin bases, but the A520 also had a choice of a 5-pin base. There is some confusion about the 7-pin bases because these are shown in the *Wireless World* valve data sheets as having the continental version (C7), whereas valves sold in the UK were also available with the British 7-pin base.

The first four rectifiers appeared in 1932. The EG50 and EG100 were both half-wave types with rated output currents of 50mA and 120mA respectively. Both these valves had 4-pin bases. The other two rectifiers were the voltage-doubler NG40, rated at 40mA output, (soon upgraded to the 50mA to become the NG50) and the short-lived, full-wave VG45 with an output current of 45mA. The NG100 appeared in 1933. This was another voltage-doubler with an output current of 100mA. Both the NG50 and NG100 had 7-pin bases.

Some examples of Ostar-Ganz valves can be seen in Figures 13.10 and 3.11. Several of these valves were fitted with wire mesh screens which completely covered the glass bulbs.

PETER RUSSELL (P.R.)

Peter Russell valves appeared on the British market in 1928 (see Figure 13.12). British manufacture was claimed for these but the author has been unable to establish where they were produced. Initially, 13 types were offered, all battery dull-emitter valves with two- and four-volt filaments. Six-volt valves were added later in 1928 and a screened grid valve in 1929. Table 13.15 lists the full range of valves. Two examples of P.R. valves can be seen in Figure 13.13. The valves are quite distinguishable by their red-brown moulded base with the underneath description of 'P.R. VALVES PATERNOSTER SQ. E.C.4 BRITISH MADE'.

2-volt filament		4-volt filament		6-volt filament	
Type	**Description**	**Type**	**Description**	**Type**	**Description**
GPR2	RF or detector triode	GPR9	RF or detector triode	GPR17	RF or detector triode
GPR3	AF triode	GPR10	AF triode	GPR18	AF triode
GPR4	RCC triode	GPR11	RCC triode	GPR19	RCC triode
GPR20	Output triode	GPR40	Output triode	GPR60	Output triode
GPR120	Output triode	GPR140	Output triode		
PR1	RF triode	PR8	RF triode	PR16	RF triode
PR2	RF or detector triode	PR9	RF or detector triode	PR17	RF or detector triode
PR3	AF triode	PR10	AF triode	PR18	AF triode
PR4	RCC triode	PR11	RCC triode	PR19	RCC triode
PR5	RF triode				
PR6	Detector triode				
PR7	AF triode				
PR20	Output triode	PR40	Output triode	PR60	Output triode
PR120	Output triode	PR140	Output triode		
SG2	RF tetrode				

Table 13.15: P.R. valves of 1928 to 1931.

Figure 13.12: P.R advertisement of January 1928.
(Note: The types listed here were sold by the Brittania.)

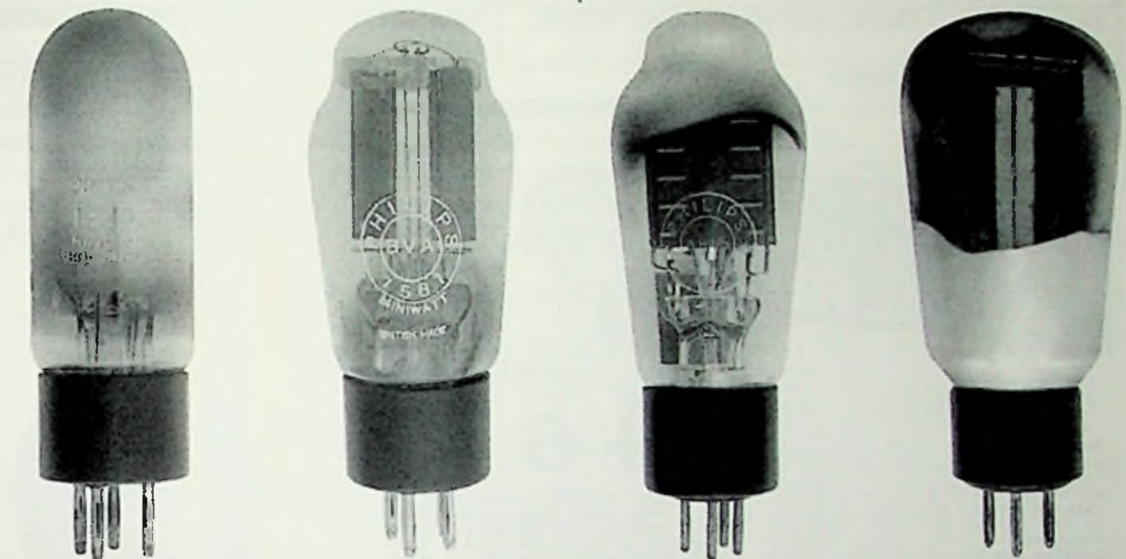
2-volt r.f. triode
designated HF.

GPR3:
2-volt a.f. triode.

Figure 13.13: Two examples of P.R. valves.

PHILIPS

Philips Lamps Ltd. had been set up in the UK to sell filament lamps; their head office was in Charing Cross Road, central London. Being a foreign manufacturer of valves the company was prevented from selling most types of radio valves but they were able to sell rectifiers and barretters. Philips did, of course, sell their radio receivers in the UK but, with the exception of the rectifiers and barretters, all the valves were supplied by their UK subsidiary company, Mullard. Figure 13.14 shows a few examples of the valves and barretters sold in the UK.

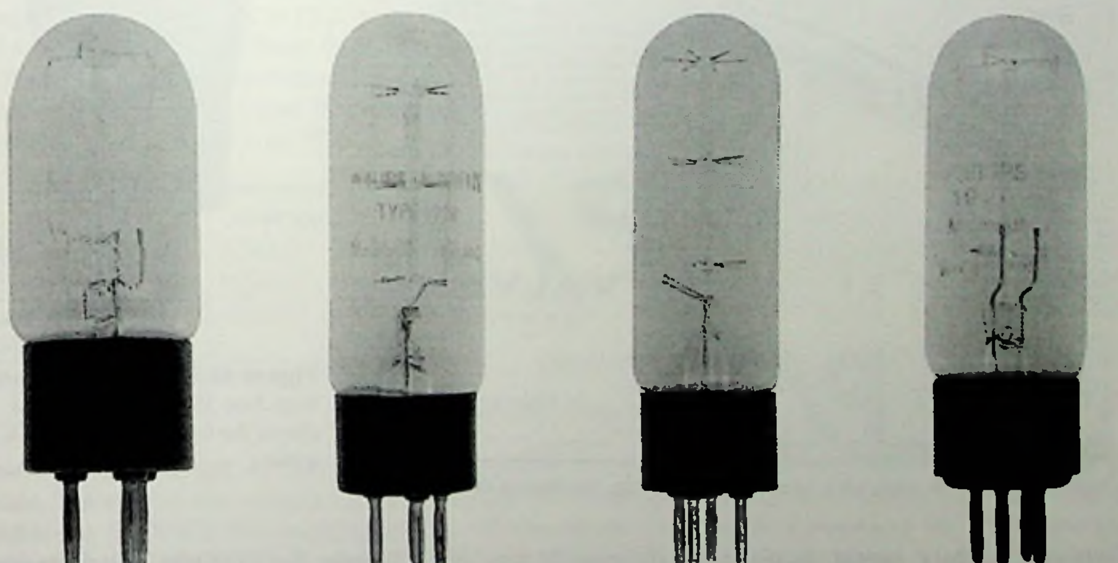


1110: full-wave rectifier, gas-filled (60V, 2A).

1561: full-wave rectifier (500V, 120mA).

1815: full-wave rectifier (500V, 180mA).

1832: half-wave rectifier (800V, 100mA).



1904: 0.1-amp barretter.

1928: 0.18-amp barretter.

C1C: 0.2-amp barretter.

1920: 0.25-amp barretter.

Figure 13.14: Selection of Philips rectifiers and barretters.

PIX

These valves were supplied by the British Pix Company Ltd of Southwark St., London, SE1 over the period 1932 to 1937 (see Figure 13.15). British manufacture was claimed but the supplier has not been identified. There were three ranges: two-volt battery, four-volt battery and four-volt a.c (see Table 13.16).

Range	RF tetrode	Triode	Output triode	Rectifier
2-volt battery	25, 215SVM	2, 3, 4, 210	20, 120, 230	—
4-volt battery	45	9, 10, 11	40, 140, 420,	—
4-volt a.c.	450/AC, AC4VM	90/AC, 100/AC	P430*, P475*, P4100*	40/250, 500, 120/500

*Directly heated output triodes

Table 13.16: Pix valves of 1932 to 1937.

Figure 13.15: Pix advertisement from June 1933 (left). Above is shown the type 11, a 4-volt RCC triode.

Two-volt battery range. In this range the type 25 was an r.f. tetrode, the 215SVM a variable-mu r.f. tetrode (soon discontinued), the type 2 an r.f. or detector triode, the type 3 an a.f. triode, and the type 4 an RCC triode. There were three output triodes; in increasing order of output power these were the 150mW type 20, the 200mW type 120 and the 300mW type 230.

4-volt battery range. In this range the type 45 was an r.f tetrode, the type 9 an r.f. or detector triode, the type 10 an a.f. triode and the type 11 an RCC triode. There were four output triodes. In increasing order of output power these were the types 40, 140 and 420. This range was soon discontinued.

4-volt a.c. range. In this range the 450/AC was an r.f. tetrode, the AC4VM a variable-mu r.f. tetrode (soon discontinued), the 90/AC an r.f. or detector triode and the 100/AC an a.f. triode. There were three output triodes, all directly heated: the 800mW P430, the 1.5-watt P475 and the four-watt P4100. There were also three directly heated full-wave rectifiers. These were the 40/250 (250V, 40mA), the 500 (300V, 60mA) and the 120/500 (500V, 120mA).

RADIO RECORD

According to Tyne [9] 'N V Gloelampenfabriek Radium started in business repairing tubes in 1922 in Amsterdam. Later they moved to Tilburg...In 1927 they began manufacturing tubes, adopting the name Radio Record.' (According, however, to a reliable Dutch source, manufacture started in 1924.) The company was taken over by Tungsram in 1935, although their involvement started a few years earlier. The valves were marketed in early- to mid-1930s in the UK by Record Radio Ltd which had premises in Eldon Street, London, EC2.

There were three ranges of valves: two-volt battery, four-volt a.c. and 0.2-amp a.c./d.c. (see Tables 13.17 to 13.19).

RF tetrode or pentode	Octode	Triode or DDT	Output triode	Output pentode
S2, VS2	OC2	DL2, H2, L2	LP2, P2, SP2	PT2, PT2C
HFP2, VHP2		DDTR2	BB2A, BB2B	

Table 13.17: Radio Record two-volt battery valves.

Two-volt battery range. In this range the S2 was an r.f. tetrode and the VS2 a variable-mu tetrode. Similarly, the HFP2 was an r.f. pentode and the VHP2 a variable-mu pentode. There was just one frequency changer, the octode OC2. The DL2 was a detector triode, the H2 a general-purpose triode, the L2 an a.f. triode and the DDTR2 a double diode triode. The output triodes consisted of the 200mW LP2, the 260mW P2 and the 360mW SP2. There were two Class B double triodes; the two-watt BB2A was operated with three volts of negative bias and the 1.7-watt BB2B was operated at zero grid bias. There were two output pentodes: the 600mW PT2 and the one-watt PT2C.

RF tetrode or pentode	Frequency changer	Double diode	Triode or DDT	Output triode	Output pentode	Rectifier
AC/S, AC/VS	AC/DC4, AC/OC4		AC/HL, AC/NHL	AC/P*, AC/PX4	AC/PT, AC/PT4VB, AC/PTA, PT24M*	FW3, FW5, FW6, FW/350
AC/HFP, AC/HPB, AC/VHFP, AC/VHPB	AC/TH4	AC/DD4A	AC/DDTR			IFW4A

*Directly heated output valves

Table 13.18: Radio record four-volt valves.

Four-volt a.c. range. In this range the AC/S was a straight r.f. tetrode and the AC/VS a variable-mu tetrode. There were two straight r.f. pentodes and two variable-mu pentodes. Of these the AC/HFP and the variable-mu AC/VHFP had one-amp heaters, whereas the AC/HPB and the variable-mu AC/VHPB had 0.65-amp heaters. Both the AC/HFP and AC/VHFP had a choice of 5- or 7-pin bases.

The AC/DC4 and AC/OC4 were octode frequency changers and both of these had 0.65-amp heaters. The AC/TH4 was a triode hexode and had a one-amp heater.

The AC/DD4A was a double diode and the AC/DDTR a double diode triode. Both the AC/HL and AC/NHL were medium-mu triodes, the former having a one-amp heater and the latter a 0.65-amp heater.

There were two output triodes: the one-watt AC/P was directly heated and the 2.8-watt AC/PX4 indirectly heated. Of the four output pentodes the AC/PT and AC/PTA had a slope of 3.5mA/V and an output power of three watts, the AC/PT4VB had a higher slope of 10mA/V, and the directly heated, three-watt PT24M had a slope of 4mA/V. The first two of these pentodes had a choice of 5- and 7-pin bases.

There were five full-wave rectifiers of which four were directly heated and one indirectly heated. The directly heated valves were the FW3 (350V, 120mA), FW5 (500V, 120mA), FW6 (600V, 180mA) and the FW350 (350V, 80mA). The indirectly heated valve was the IFW4A (400V, 120A).

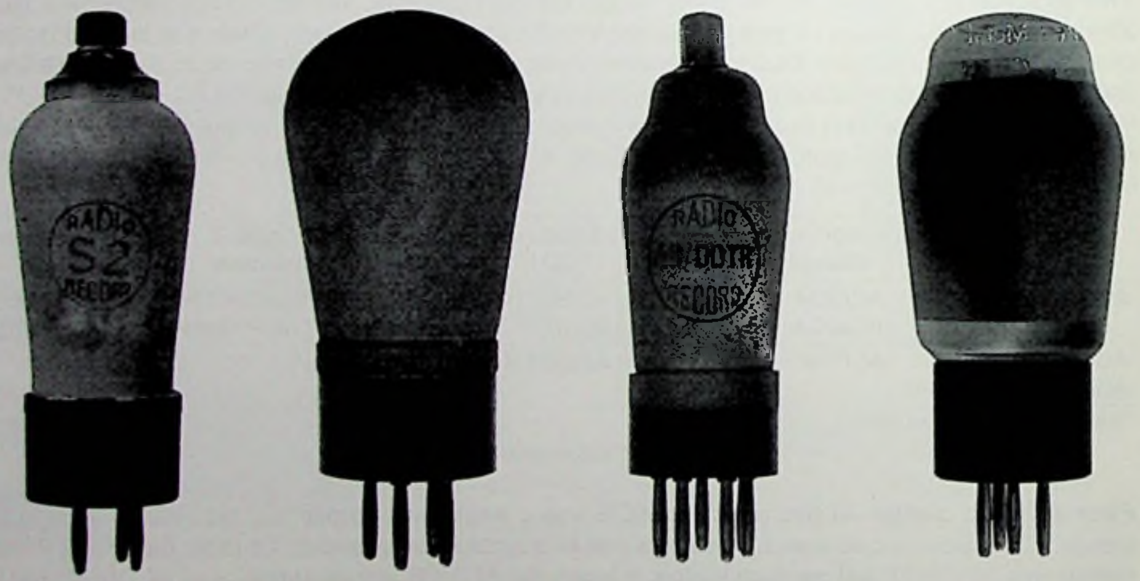
Bases	RF pentode	Octode	Double diode	Triode or DDT	Output pentode	Rectifier
B5 & B7	HFP/13, HPB/13, VHFP/13, VHPB/13	OC/13	DDA/13	DDTR/13, NHL/13	PT/24DA, PT/35DA	UFW/30
Ct5 & Ct8	HFP13/L, VHP/13L	OC/13L	DDA/13L	DDTR/13L, NHL13/L	PT/24DAL	UFW/30L

Table 13.19: Radio Record 0.2-amp a.c./d.c. range.

0.2-amp a.c./d.c. range. As can be seen from Table 13.19 most of these valves were available with both British and side contact bases (indicated by the addition of an L at the end of their type designation). With these valves the numbers in the type designation refer to the heater voltage, e.g. 13, 24, 30 and 35.

Many of these had similar characteristics to the four-volt valves—for example AC/HFP and HFP/13. Two valves with quite similar characteristics are the PT/24DA and PT/35DA output pentodes. Apart from their heater voltages they had slopes of 8mA/V and 8.5mA/V respectively and output power of about three watts. The UFW/30 was a half-wave rectifier rated at 275V, 120mA.

Some examples of Radio Record valves can be seen in Figure 13.16.



S2: 2-volt r.f. tetrode. | H2: 2-volt general-purpose triode. | AC/DDTR: 4-volt double diode triode. | PT24M: 4-volt output pentode.

Figure 13.16: Radio Record valves.

SIX-SIXTY

The Electron Company Ltd was registered in May 1923 as a valve manufacturer with works at Acton Lane. Harlesden. Its valves were sold under the brand name SIX-SIXTY. In 1926 the company entered into a ten-year agreement with Mullard for the exclusive supply of valves and from then on ceased manufacture. In 1928 Mullard purchased all the shares in the company and changed the name to Six-Sixty Radio Co. Ltd. Mullard made a new ten-year agreement in 1935 and then sold the company to Ever Ready Ltd.

Altogether, there were over 100 different types of valves. The Mullard equivalents of these can be found in the Valve Data Supplement.

SCOTT-TAGGART (S.T.)

John Scott-Taggart was a colourful figure in the radio industry. After distinguished army service during World War I. he joined the Edison Swan Valve Company where he designed two of their early valves, the E.S.2 and E.S.4. He was later to edit two wireless magazines: *Modern Wireless* and *Wireless Weekly*. He devised many circuits including one using a four-electrode valve which he patented in 1919 [10], his well-regarded S.T.100 reflex receiver [11] and the 'Resistoflex', another version of a reflex receiver [12]. He was also the inventor, in 1922, of the dual-anode Negatron valve which had negative resistance characteristics [13].

The valve company S.T. Ltd. commenced business in 1926 and appears to have ceased trading by 1927. All the valves were made by Mullard but carried the S.T. label. In all there were 13 valve types and these are listed in the Supplement with their Mullard equivalents.

TRIOTRON

According to Tyne 'Triotron tubes were made by Radiowerk E. Schrack, of Vienna, beginning about 1926.' [15] An initial advertisement in *Popular Wireless*, dated 8 May 1926 by H E Nicholls, indicated that there was a range of two- and four-volt 'Dull Emitter' valves (a view of one of these, the T10, can be seen in Figure 13.17). A later advertisement in *Wireless Trader*, dated 12 November 1927, showed the Southern agents as the Electric Lamp Service Co. Ltd. which had premises in central London, and the northern agent as Chorlton Metal Co. Ltd. with premises in Manchester. This advertisement was for the ZD2 and ZD4 power triodes and were stated to be 'Dark Emitters' (by this one must assume them to have oxide-coated filaments). The valves were later sold directly by Triotron Radio Co. Ltd. from their London office.

During the period 1927 to the late 1930s Triotron sold a very large range of their 'dark emitter' valves. These have been divided into four groups:

(1) Early battery valves (Table 13.20)
(2) Later battery valves (Table 13.21)
(3) Four-volt a.c. valves (Table 13.22)
(4) DC and a.c/d.c. valves (Tables 13.23)

Early two- and four-volt battery valves. The first of these appeared in 1927 and consisted of the usual mixture of screened grid tetrodes, detector triodes, RCC triodes and output triodes. Many of the triodes continued to be available well into the 1930s and over this time there were improvements in characteristics, such as higher slope and lower impedance. For example the HD2, which was a detector or a.f. triode, initially had an impedance of 14.4 kΩ and a slope of 0.75mA/V, but this was later improved to 8 kΩ and 1.25mA/V.

Range	Year	RF tetrode	Triode	Output triode
2-volt	1927/28		TD2, WD2	UD2, ZD2
	1929/30	SC2	HD2, SD2	SP2, YD2,
4-volt	1927/8		AD4, RD4, SD4, WD4	UD4, YD4, ZD4
	1929	SC4		XD4
	1930	MD4, CWN4		

Table 13.20: Early Triotron two- and four-volt battery valves.

The output triodes have the following ascending order of power: two-volt—ZD2, UD2, YD2 and SP2; four-volt—UD4, YD4 and ZD4. (The ZD4 was very soon discontinued.)

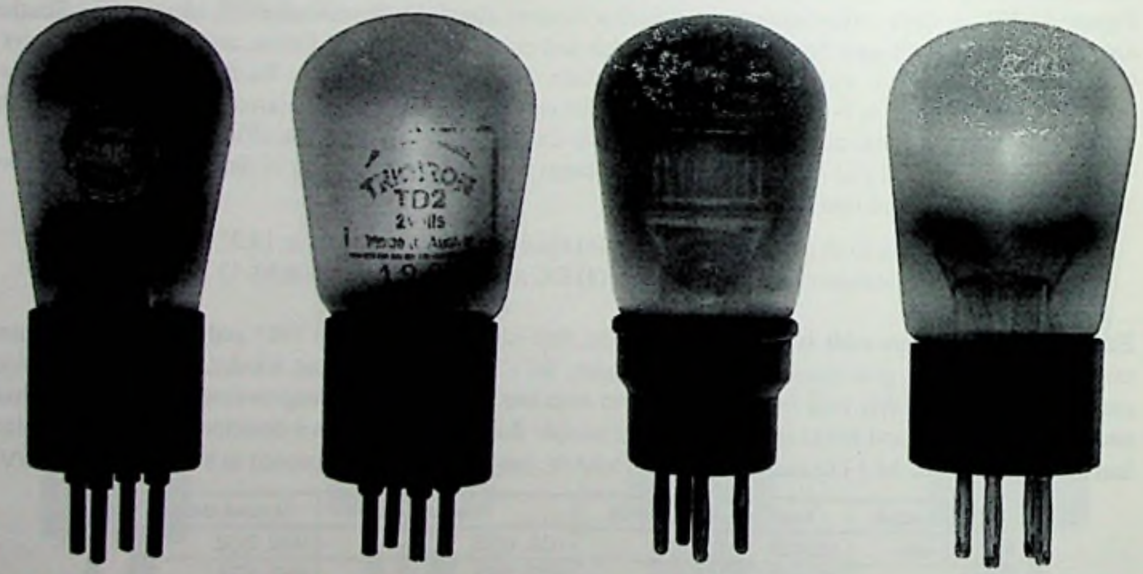
Later two- and four-volt battery valves. These valves were introduced in 1931 and new types continued to be issued up to about 1936 (see Table 13.21). The four-volt types, in common with other valve manufacturers, were soon discontinued.

Range	Year	RF tetrode or pentode	Freq. changer	Double diode	Triode or DDT	Output triode	Output pentode
2-volt	1931		D210*				P215 (B4)
	1932	S207, S208				E235	
	1933/34	S215			A214	E220B	P225 & P215 (B5)
	1935/36	S209, S210, S213, S217, S218	O202	D200	W213, DT215	YD02	P225 (B4)
4-volt	1931		D410*		A420, W412	E414, E420, E422, K420	P420, P425
	1932				H412	E425	

*Bi-grid

Table 13.21: Later Triotron two- and four-volt battery valves.

In the two-volt range the r.f. tetrodes were the S207 and the variable-mu S208 (both later superseded by the S213 and S215); there were also the economy types S209 and the variable-mu S210, both having 0.05 amp filaments. The r.f. pentodes were the S217 and the variable-mu S218. The D210 (and its four-volt equivalent, the D410) was a double-grid valve which was intended as a frequency changer in early superhets, where it combined the oscillator and mixer functions. These two valves could also be used as space-charge tetrodes with +10 to +20 volts on both the inner grid and anode.



T10: an early dull emitter triode of 1926.

TD2: detector or a.f. triode.

Two versions of the ZD2 output triode. The one at the left has the electrodes mounted horizontally.

Figure 13.17: Early Triotron two-volt battery valves of 1926 to 1927.

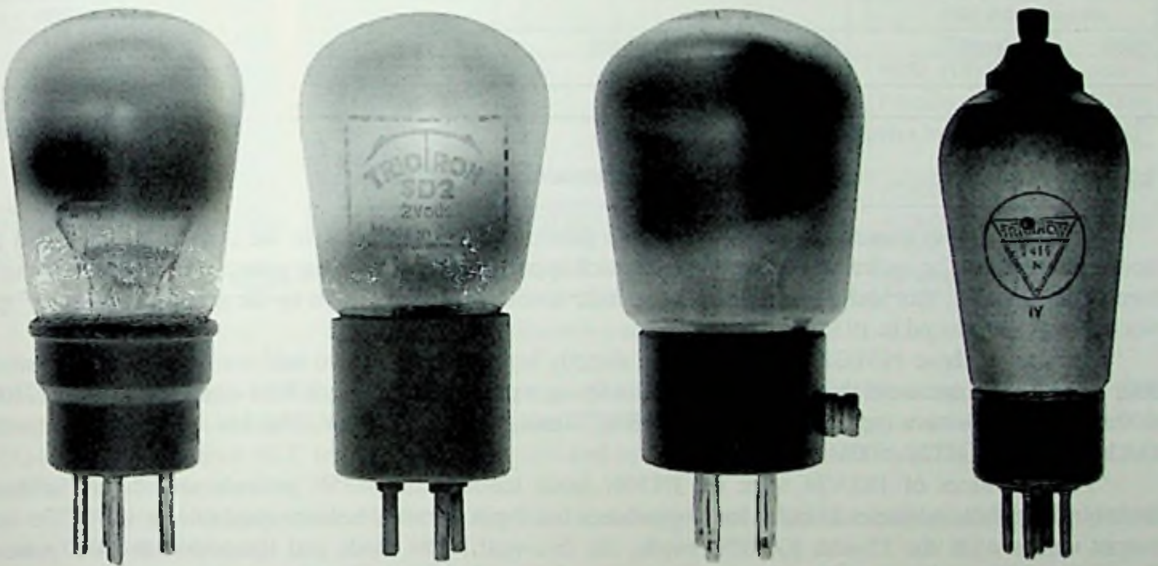
For superheterodyne receivers there were the O202 octode, the D200 double diode and the DT215 double diode triode. The A214 was a low impedance triode and the W213 a general-purpose triode.

The E235 was a 0.55-watt output triode and the E220B a Class B double triode for operation at zero grid bias. A later output triode, the 0.35-watt YD02, appeared in 1936.

There were just two output pentodes. The first of these was the P215 and this was followed a couple of years later by the P225. These both had the same output power of 0.5 watts but the P225 had slightly lower filament consumption. Initially, the P215 had a 4-pin base, with a side terminal for the screen connection but a 5-pin version was introduced later. The P225, however, was first fitted with a 5-pin base and a 4-pin version was introduced in 1935.

In the four-volt range, apart from the D410 already mentioned, there were three triodes, five output triodes and two output pentodes. The A420 and the H412 were detector triodes, and the W412 a medium impedance RCC triode. The output triodes, in ascending order of power, were the 200mW E414, the 350mW E420, the 400mW E422, the one-watt E425 and the K420, which was almost identical to the E425 but had a slightly lower slope. The two output pentodes were the 750mW P420 and the 1.5-watt P425, both of which were also suitable for a.c. operation on their filaments.

Two valves not shown in Table 13.21 are the 072 and 084. These were r.f. tetrodes and were re-numberings for the SC2 and SC4. Some examples of the Triotron battery valves can be seen in Figures 13.17 and 13.18.



UD2: 2-volt, 0.5-watt output triode. | SD2: 2-volt, 1-watt output triode. | P225: 2-volt, 0.5-watt output pentode. | S415: 4-volt, a.c. variable-mu r.f. tetrode.

Figure 13.18: Triotron two-volt battery valves and a four-volt a.c. valve.

Four-volt a.c. valves. The first of these valves, introduced in 1928, were the AN4 general-purpose triode and the WN4 RCC triode (see Table 13.22). In 1929/30 there were two r.f. tetrodes, the CWN4 (later 104AC) and the SCN4 (later 124AC); there were also two triodes: the SN4 detector and the YN4 output. The other 1929/30 valves were three directly heated rectifiers. Of these the GN14 (250V, 30mA) was half-wave and probably intended for battery eliminators, the GN24 (250V, 30mA) was full-wave and the GA24 was also full-wave but rated at 250V, 60mA.

Several new types were released in 1931/32. There were five r.f. tetrodes; these were the S210N, the S412N, the variable-mu S415N, and the two steep-slope types S430N and the variable-mu S431N. The D410N was a double grid valve intended as a frequency changer. The A430N was a detector triode, which replaced the SN4, and the W413N an RCC triode which replaced the WN4. The A440N of 1932 was a general-purpose triode with a slope of 4mA/V. There were four output triodes; these were the indirectly heated E430N, which replaced the YN4, and the three directly heated types: K435/10 (2.5 watts output), K450/25 (five watts output) and K450/40 (12 watts output).

Year	RF tetrode or pentode	Freq. changer	Double diode	Triode or DDT	Output triode	Output pentode	Rectifier
1928				AN4, WN4			
1929/30	CWN4, SCN4			SN4	YN4		GA24, GN14, GN24
1931		D410N[†]		A430N, W415N	E430N, K435/10*, K450/25*, K450/40*	P430*, P440*	G429, G431, G470, G4100, G4120
1932	S410N, S412N, S415N, S430N, S431N			A440N	E425*	P440N (B5)	
1933/34	B430N, S434N (B5), S435N (B5)				K450/50*, K480*	P435*	G4150, G4110, G4120N
1935	S434N (B7), S435N (B7)	O406	D400	DT436		P495 P440N (B7)	
1937/38	S420	TH401				P460*, DP495	

*Directly heated output valves, [†]Bi-grid

Table 13.22: Triotron four-volt a.c. valves.

The two output pentodes of 1931 were both directly heated. These were the three-watt P430 and the seven-watt P440. The indirectly heated P440N, which appeared in the following year, had a reduced output of two watts. Initially this had a 5-pin base with a side terminal for connection to the screen grid but a 7-pin version was introduced in 1935.

The last of these 1931/32 valves were five directly heated rectifiers: two half-wave and three full-wave. The half-wave types were the G429 (250V, 30mA)—a replacement for the GN14—and the G4100 (750V, 100mA). The full-wave types were the G431 (250V, 30mA), the G470 (300V, 75mA)—a replacement for the GA24—and the G4120 (500V, 120mA).

The r.f valves of 1933/34 were the B430N diode tetrode, the S435N pentode and the variable-mu S434N. Both these pentodes initially had 5-pin bases but 7-pin versions became available in 1935. The new output valves were the 12-watt K450/50 triode, the five-watt K480 triode and the two-watt P435 pentode (later upgraded to 2.8 watts). These three valves were all directly heated. There were also three new rectifiers, two of which were directly heated and the other indirectly heated. The directly heated types were the half-wave G4150 (750V, 150mA) and the full-wave G4110 (250V, 120mA). The indirectly heated rectifier was the full-wave G4120N, released in 1934, and rated at 500V, 120mA.

The new valves of 1935 were the O406 octode with a conversion conductance of 0.6mA/V, the D400 double diode, the DT436 double diode triode, and the 3.5-watt P495 output pentode.

The only new valve of 1937 was the seven-watt P460 directly heated pentode. The last of the Triotron a.c. valves appeared in 1938. These were the S420 variable-mu r.f. pentode, the TH401 triode hexode with a conversion conductance of 0.75mA/V, and the DP495 double diode output pentode.

DC and a.c./d.c. ranges. Triotron produced four ranges of these valves over the period from 1927 to 1938 (see Table 13.23):

- 0.07-amp d.c. range
- 0.1-amp d.c. range
- 0.18-amp a.c./d.c. range
- 0.2-amp a.c./d.c. range

0.07-amp d.c. range. All the valves in this range had directly heated filaments. The SC4 was an r.f. tetrode with a slope of only 0.8mA/V. The AN4 was an r.f. or detector triode of medium impedance, the RD4 a general-purpose triode and the WD4 a high impedance RCC triode. All of these valves had four-volt filaments. The YG5 was an output triode with a five-volt filament. This valve, together with the AD4 and RD4, were used in the Triotron A11 d.c. mains receiver.

Around 1930/31 there was three more valves in this range. The 084 tetrode was a re-designation for the earlier SC4, the H412 was an r.f. or detector triode and the W412 an RCC triode.

Range	Year	RF tetrode or pentode	Octode	Diode	Triode or DDT	Output triode	Output pentode	Rectifier or barretter
0.07-amp d.c.	1927	SC4			AD4, RD4, WD4	YG5		
	1931	084			H412, W412			
0.1-amp d.c.	1927/29	SCG4			SG4, WG4	YG6		V85 (resistance lamp)
	1930/31	094, S409			A430, W420		P520	V60 (barretter)
0.18-amp a.c./d.c.	1931/32	S2010N			A2030N	E2020N	P2020N	
	1933	B2030N, S2031N, S2034N, S2035N			A2040N			
	1934/35	S2030N, S2031N					P2460	G3412, G3070
0.2-amp a.c./d.c.	1935/36	S1323, S1328	O1307	D1300	DT1336		P2060, P3580	G2080, G3060
	1937/38	S1324					DP4480	

Table 13.23: Triotron d.c. and a.c./d.c. ranges.

0.1-amp d.c. range. All the valves in this range also had directly heated filaments. The SCG4 (later designated 094) and the S409 were both r.f. tetrodes. The SG4 was a low-impedance detector triode and the WG4 a high impedance RCC triode. These were replaced by the A430 and W420 in 1931. All of these valves had four-volt filaments.

There were two output valves. The YG6 was a triode having a six-volt filament and the P520 a pentode with a five-volt filament.

It must be remembered with directly heated d.c. valves that provision should be made for the anode current of the valves which flows from the negative leg of the filament. (This topic has been dealt with quite fully in Chapter 8 (see pages 192-3).

0.18-amp a.c./d.c. range. This range was the first to have indirectly heated cathodes. Initially there were just four valves, all having 20-volt heaters. The S2010N was an r.f. tetrode, the A2030N a detector triode, the E2020N a 350mW output triode and the P2020N an output pentode.

These were followed a couple of years later by the B2030N diode tetrode, the S2031N r.f. tetrode, the S2035N r.f. pentode, the S2034N variable-mu r.f. pentode and the A2040N high-mu triode. These five valves also had 20-volt heaters.

In 1934/35 there were two new r.f. tetrodes: the S2030N and the variable-mu S2031N. These were both high gain with a slope of 3mA/V. There was also a new pentode, the P2460, which had an output power of 3.5

watts. Finally there were two rectifiers: the G3412 was a voltage doubler rated at 250V, 120mA, and the G3070 was half-wave rated at 250V, 70mA.

0.2-amp a.c./d.c. range. This range was introduced in the mid-1930s and was the only range suitable for superhet receivers. The S1323 was a variable-mu r.f. pentode, the S1328 an r.f. tetrode, the O1307 an octode frequency changer, the D1300 a double diode and the DT1336 a double diode triode. All of these valves had 13-volt heaters. The S1324, introduced later, was a straight r.f. pentode and also had a 13-volt heater. Initially there were two output pentodes, the 3.5-watt P2060, with a continental P base, and the four-watt P3580. The DD4480 double diode output pentode was introduced later. Finally there were two new rectifiers. The G2080 (250V, 80mA) was half-wave and the G3060 was a voltage doubler where each section was rated at 125V and the output current was 120mA.

MISCELLANEOUS COMPANIES

Several other small companies traded in the 1926 to 1927 period but were only offering a limited range of valves. Data for these can be found in the Valve Data Supplement.

ALL BRITISH. It is believed that these valves were manufactured by the North London Valve Company.

A.R.A. valves were marketed by Steven & Wells of Gt. Eastern St., London, EC2. In all there were about ten types.

BRITTANIA. This company marketed the small range of valves which can be seen in Figure 13.12 on page 268. The British manufacturer of these has not been identified.

CITY ACCUMULATOR COMPANY. These valves were produced by C.A.C. and is probably the full name of the Company.

BEAM valves were marketed by Lester & Marquis of Thavies Inn, London, EC1. There appears to have been only two types, both general-purpose triodes: the two-volt DE2 and the four-volt DE.06.

ELKA valves were marketed by L Kremmer, a company located in Manchester. There were just two valves, both general-purpose triodes: the two-volt C and the four-volt D.

HELIKON valves were made in Austria and distributed in the UK by John Abrahams & Co of Red Cross St., London, EC1. Eight valves with two-, four- and six-volt filaments were offered for sale at the end of 1927 [14].

HUMAVOX: This Company marketed a small range of valves of unknown British manufacture.

LEWIS. Marketed C.A.C. valves.

MIDLAND VALVES LTD had premises in Stafford St., Birmingham. The company sold a small range of ten dull emitter valves in 1927. The source of manufacture has not been discovered but British manufacture was claimed.

QUIKKO valves were distributed by J W Pickavant & Co. Ltd. which had premises in Lombard St., Birmingham. They offered a small range of ten dull emitter valves and these had almost identical characteristics to the Midland valves.

RADIO VICCO (See Vatea).

RADVACO & RATRACO valves were of Dutch manufacture. Eleven types appeared on the UK market in 1926. These included two bright emitter triodes, types B and B.E., eight dull emitter triodes and the SB5 bi-grid.

SPLENDOR. These valves were manufactured by the Dutch company, N.V. Splendor Gloeilampen-fabrieken.

STAL valves were of French manufacture and distributed in the UK by Lester & Co Ltd of Fore Street, Moorgate, London, EC2. Three triodes were submitted for review with *Wireless Trader* in June 1928: the general-purpose types A1 and A2 and the A4 output triode. The A1 and A3 were also reviewed by *Wireless World* in September 1928. According to *Wireless World* their samples were all two-volt valves, however, the *Wireless Trader* tested their samples at 3.5 volts. The A2 and A3 had two sets of electrodes inside the bulb with provision for using one or two filaments.

All British:
output triode.

ARA type 7:
a.f. triode.

Brittania 406d:
detector triode.

Humavox type B:
detector triode.

Splendor V1010:
4-volt triode.

Vatea PX4200:
4-volt output triode.

Vita TP3:
general-purpose triode.

Voltron 210HF:
2-volt h.f. triode.

Figure 13.19: Some examples of miscellaneous valves.

TELA-RADIO valves were made in Austria and distributed in the UK by the Monowatt Lamp Co which had premises in Wallingford, Oxon in 1926.

VATEA valves were made in Hungary by the Vatea Radio and Electrotechnics Co. of Budapest which was established in November 1925, although its origins go back to the early 1920s. Philips took a major holding in the company in 1928.

A small range of their four-volt triodes was distributed by Abbey Radio of Victoria Street, London, SW1 in 1930. There were also plans to market multi-electrode valves but no evidence of this has been found. The company also had the trade name Radio-Vicco and a couple of these valves were marketed by Radioland Ltd, 65 Houndsditch, London, E1. These were the T.B. Baby and the T.E.

VITA valves were marketed by Peter Curtis Ltd. Only one type has been identified, the T.P.3 general-purpose triode which appeared in 1926.

VOLTRON was a US company and a small range of nine triode valves were sold in 1927 through their British company Voltron Co Ltd which had offices in City Road, London, EC1. All the valves were fitted with the British 4-pin base.

REFERENCES

1. Kröncke, Dr H, 'The Resistance-Coupled Amplifier', *W.W.*, **17**, 23 September 1925, pp. 395-8.
2. Kröncke, Dr H, 'A New Resistance-Coupled Amplifier', *W.W.*, **17**, 16 December 1925, p. 857.
3. 'The Berlin Wireless Exhibition', *W.E.*, **3**, November 1926, pp. 654-8.
4. 'Seen at the Berlin Show', *W.W.*, **19**, 3 November 1926, pp. 597-8.
5. British patent, GB 274901, app. 27 July 1927 (Convention date, Germany, 26 July 1926), acc. 27 October 1927.
6. 'Broadcast Receivers: Loewe Type O.E.333', *W.W.* **24**, 16 January 1929, pp. 79-81.
7. 'Broadcast Receivers: Loewe Type R.O.433', *W.W.*, **26**, 12 March 1930, pp. 286-7.
8. Tyne, Gerald, *Saga of the Vacuum Tube* (Howard W Sams & Co Inc, 1977, ISBN 0-672-21470-9), pp. 463-4.
9. Ibid pp. 426-7.
10. Scott-Taggart, John, British patent GB 153681, app. 14 August 1919, acc. 15 November 1920.
11. Blake, G G, *History of Radio Telegraphy and Telephony* (Radio Press Ltd, 1926), p. 273.
12. Ibid p. 273.
13. Scott-Taggart, John, *Elementary Textbook on Wireless Vacuum Tubes* (Radio press Ltd, 1922) pp. 191-6.
14. *W. T.*, 24 December 1927, p. 6.
15. Tyne op cit, p. 463.

ADDENDA: TRIOTRON

Since this chapter was written further information has come light concerning the Triotron Company and for this I am grateful to Bengt Svensson and Dr Franz Pichier. According to Dr Pichier, the company Radiowerk E Schrack commenced valve production in 1919 with the type S1 and by 1924 was in production of receiver valves. The trade name Triotron appeared in 1925. In July 1929 the company name Radiowerk E Schrack GmbH was changed to an AG. In 1930, Philips acquired shares in the company and took full control in 1938. The company name was then and changed to Wiener Radiowerke AG (WIRAG).

Chapter 14
US valves available in Britain

This chapter does not set out to give a comprehensive review of US valves. An excellent early account of these may be found in Tyne's book [1] and a more general treatment, up to the mid-1970s, in various sections of Stokes' book [2]. There are also many useful short articles in the *Tube Collector* magazine which covers the history, preservation and applications of valves [3]. It is, however, useful to know how the valve industry in America developed following the formation of RCA.

RCA

In 1919 the Marconi Telegraph Company of America had placed an order with General Electric (GE) for twenty-four of the company's Alexanderson high-power, r.f. alternators. However, it was feared that this would give Marconi a monopoly position in worldwide wireless communication. Consequently, steps were put in place to create a US communications company that would be powerful enough to counter foreign competition in this vital market. It was proposed that GE should create such a company and negotiations for the sale of the alternators to Marconi were broken off. The plan put in place by GE was to buy out the American Marconi Company and to acquire rights to use circuits and equipment of other US companies.

This led to the formation of the Radio Corporation of America (RCA) on 17 October 1919. The American Marconi company was merged with RCA a couple of months later on 20 November 1919. On 1 July 1920 a cross-licensing agreement was established between RCA and GE and there was a further agreement between RCA and Western Electric. A further cross-licensing agreement was signed between RCA and Westinghouse Electric and Manufacturing Company on 30 June 1921.

As a result of these agreements, RCA held a significant portfolio of patents and circuits which enabled the company to become a major force in US radio communications.

At the time of its formation the prime aim of the new company was to provide radio services for trans-oceanic communications, ship-to-shore communications and ship installations. There was no intention at this early stage of the company's history to manufacture radio valves—this came later with the formation of RCA Radiotron Inc. in 1930. Up until this time RCA did, however, market valves that were manufactured by GE and Westinghouse using the Radiotron brand name and also permitted Cunningham to market valves bearing the Cunningham label. (For a brief period Cunningham was permitted to market a limited number of valves of their own manufacture.)

Following the formation of RCA Radiotron Inc in 1930, the company was soon to become a major American valve manufacturer which continued until 1976 when RCA ceased production of receiving valves in America. The company then became a distributing operation that branded other companies' valves and also imported miniature valves from its plant in Brazil. (As an aside, RCA bought control of Cunningham and, by 1932, the RCA Radiotron Co. and the E. T. Cunningham Co. were collocated at the Harrison works. A couple of years later the two companies were merged and Elmer Cunningham became President of the surviving RCA Radiotron Co.)

VALVE BASES

In the US there was no attempt to use European valve bases, notably the 4-pin base produced in France for the TM triode and its derivatives. Many of the early US valves used the UV base which had four short pins plus a bayonet pin for location in the valveholder. The first major change came with the introduction in 1925 of the

4-pin UX base which had the two filament pins of larger diameter than the other two. (Drawings for all the relevant bases used on US valves can be found in the Valve Data Supplement.) Early valves with this base had a small bayonet pin extending from its side to enable them to be inserted into UV sockets for replacement purposes.

The next important change came in 1927 with the introduction of a 5-pin base to provide the additional connection for the cathode of indirectly heated valves. With this base all the pins were of the same diameter.

The 6-pin base appeared in 1932 and was first used on the Arcturus 'Wunderlich' detector valve and then on the RCA double diode triode type 55. The 7-pin base was also introduced in 1932 and was used, initially, on the RCA-designed 59 indirectly heated output pentode. Both the 6- and 7-pin bases had the two filament or heater pins of larger diameter.

In the UK it was common practice to refer to all the US4-, 5-, 6- and 7-pin bases as UX, and the UX5 was usually shown with larger filament pins even though this was incorrect. In this book these bases are referred to as US4, US5, US6 and US7 respectively. These bases also had small and medium diameter shells. With the 7-pin base, however, there were two different pin spacings, the smaller being identified as USS7 and the larger as USM7. (For example, 2A7 had the smaller spacing and the 59 the larger spacing.)

The most notable change in base types came in August 1935 when metal valves were introduced with a centrally keyed octal base. This base was later used with glass valves (see section on 'Bulbs'). A further octal base, known as the Loctal, was introduced by Sylvania in November 1938 and was first used on the type 1231 r.f. pentode for television receivers.

The last of the receiving valve bases to appear during the duration covered by this book was the 7-pin button base (known later in the UK as the B7G). This appeared in late-1939 and was used initially for the four 1.4-volt battery valves types 1R5, 1S4, 1S5 and 1T4.

BULBS

Unlike in Europe, there was far greater standardization of the bulb profiles for US valves, with the following letters used to distinguish the shape:

- G for Globular. These were used for the earliest types and also for many of the Western Electric telephone repeater valves
- T for Tubular
- S for Straight-sided tapered
- PS for Pear Shaped
- ST for the dome topped valves, being a combination of S and T
- GT for Glass Tubular

Figures 14.1 and 14.2 show outline drawings of the various bulbs used with US glass valves. The numbers that follow the letter indicate the maximum diameter of the bulbs in eights of an inch, although it will be seen that the maximum diameters given are usually a little larger this.

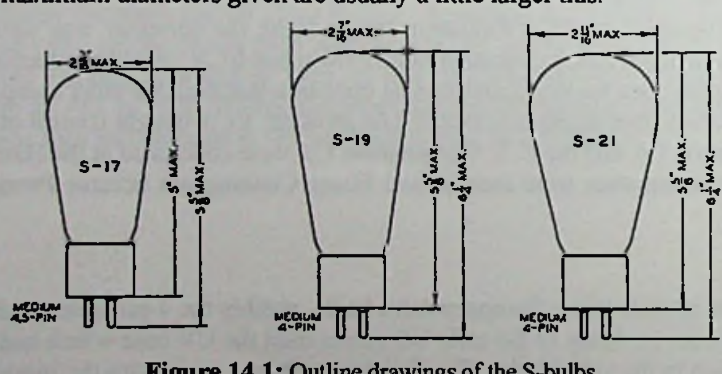
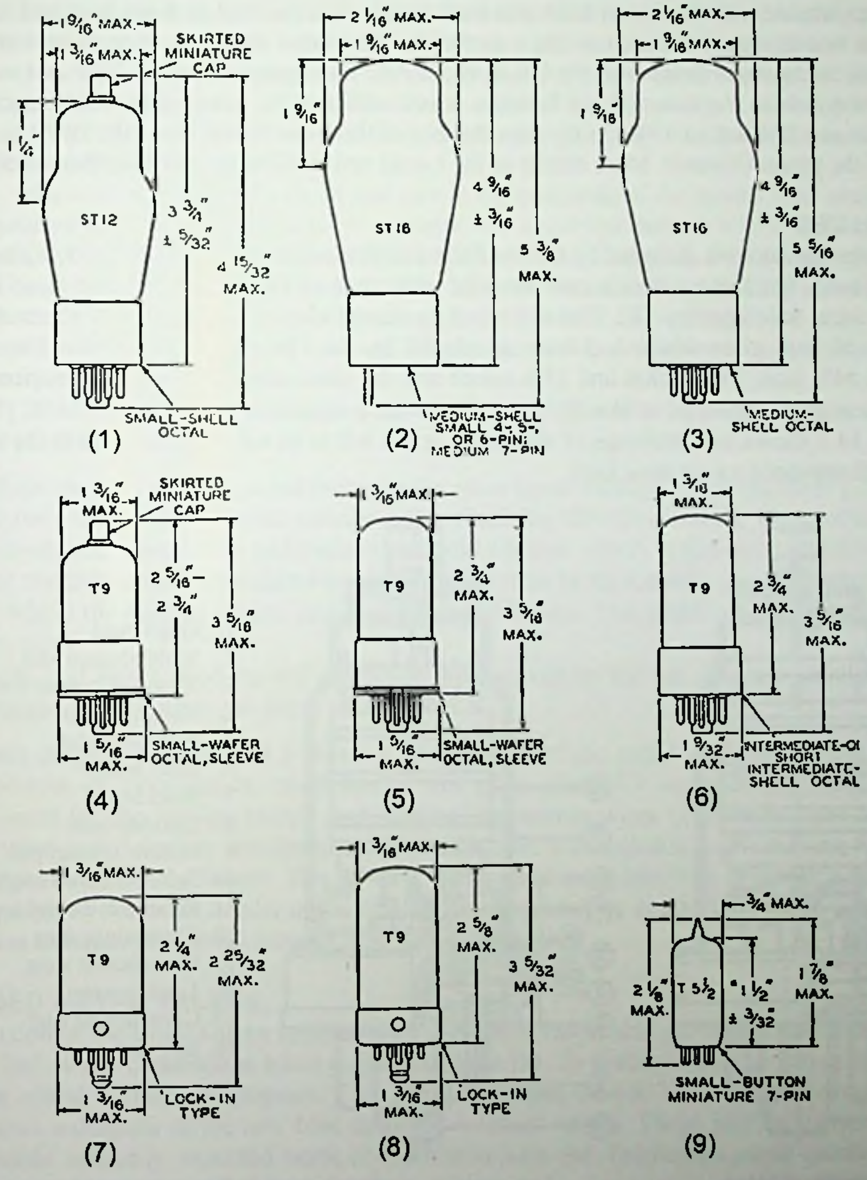


Figure 14.1: Outline drawings of the S-bulbs.

The S and T bulbs were very soon replaced by the dome-topped ST bulbs to clasp the top mica support and thereby reduce microphony. From 1935 several of the older six-volt valves with the US 4-, 5-, 6- and 7-pin bases were modified and fitted with the new octal base, this being a reaction to the metal octal valves described in the next section. These valves had a change of designation which included a letter G added; for example the 6C6 with a 6-pin base became the 6J7G.



Typical examples of valves outlined above.

(1) 6J7-G sharp cut-off pentode
(2) 2A3 output triode
(3) 6L6-G output beam tetrode
(4) 6K7-GT remote cut-off pentode
(5) 6J5-GT medium-mu triode
(6) 6V6-GT output beam tetrode
(7) 7A4 medium-mu triode
(8) 7A5 output beam tetrode
(9) 1S5 remote cutoff pentode

Figure 14.2: Outline drawings for a selection of ST and later T bulbs.

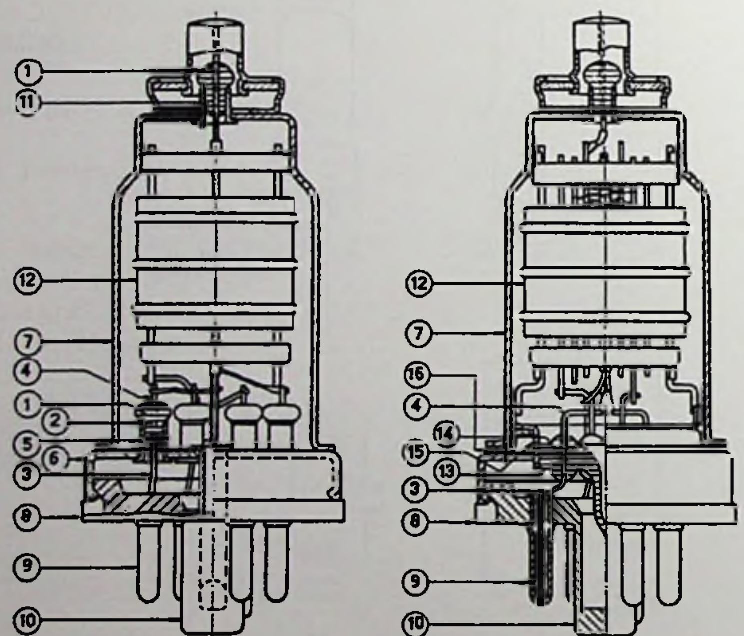
Most of the G types were later discontinued in favour of the glass bulb GT construction (termed for a while GT/G). The GT types were introduced in 1938 with the advantage of having all eight contact pins available for connections to the electrodes, an essential requirement for many of the multi-electrode and dual triode valves. (With the metal valves pin 1 was used for connection to the metal bulb.)

Another notable introduction in 1938 was the Loctal valve; this had an 8-pin base and a centrally keyed spigot which was designed to lock into the valveholder. One other important type to be introduced was the 7-pin all-glass button base (known in the UK as the B7G). This appeared late in 1939 and was used initially only for battery valves. As it turned out 7-pins was not sufficient for many of the multi-electrode, indirectly heated valves and this led, in 1946, to the introduction of the 9-pin Noval base (the B9A) but this is outside the scope of the present volume. More details of the Loctal and B7G valves are described later in this chapter.

METAL VALVES

Metal envelope valves were designed by GE for RCA and first announced in April 1935, with production later in the year [4–6]. For these valves a new metallic alloy, known as Fernico (formed from iron, nickel and cobalt), had been developed by GE. This alloy had an almost identical coefficient of thermal expansion to a special type of hard glass which had been developed by the Corning Glass Works. The composition of Fernico was 54% iron, 31% nickel and 15% cobalt and the glass used 705-AO. The temperature coefficient for Fernico was approximately -4.95×10^{-6} per °C over the temperature range 0°C to 300°C [7].

Figure 14.3 shows two drawings of the valve: at the left is an early version and at the right a modified version which appeared a year or so later.



1. Glass bead
2. Molybdenum lead
3. Nickel or copper connecting wire
4. Nickel support wire
5. Fernico eyelet
6. Steel header
7. Steel bulb
8. Bakelite base
9. Hollow contact pin
10. Bakelite keyed spigot
11. Fernico eyelet for top lead
12. Electrode system
13. Glass button stem
14. Lead-in wire
15. Chrome-iron ring
16. Iron ring

Early version of valve | Later version of valve | Key to various components of the valves

Figure 14.3: Diagrams showing construction of the metal valve.

Looking first at the left-hand diagram, it can be seen that the steel header (6) extends the whole width of the base and is shaped like an inverted dish. The Fernico eyelets were welded through (up to) eight holes punched through the header and arranged uniformly in a circle. A molybdenum lead (2) was passed through each eyelet and sealed with a bead made from hard glass (1). The bottom end of this lead was attached to a nickel or copper connecting wire (3) for soldering into the contact pin (9). Support wires for the electrode assembly (4) were attached to the top end of the molybdenum leads. Further support wires were welded to the header to ensure rigidity of the electrode assembly.

A metal exhaust tube was welded to the centre of the header in readiness for the pumping process. First, however, it was necessary to attach the steel bulb and make a top connection to the grid, if required. This connection also came through a Fernico eyelet (11) in a similar way to the connections at the base. The steel bulb was then welded in place using a short but intense pulse of electric energy controlled by a thyratron switching circuit. Once the seal had been made and the vacuum pumping completed, the exhaust tube was squeezed, welded and the surplus cut off.

The base, which fitted snugly into the dished part at the underside of the header, was made of Bakelite and had eight pressed-in hollow contact pins (9) arranged in a circle and through which the connecting wires passed and were soldered in place. (Eyelets and contact pins were omitted when fewer than eight connections was required. However, pin 1 was always connected to the metal structure for grounding purposes.) It can be seen that at the centre of the base there is a keyed spigot (10), which enabled the valve to be rotated in its socket to ensure correct orientation for the contacts. The spigot, which was hollowed at its centre, also served to house the short length of exhaust tube.

Soon after its introduction in the autumn of 1935 there were found to be several quality and reliability problems, three of which were:

- Vapour from the flashed getter condensing on the glass beads through which the leads passed, and also on the mica spacer. This caused leakage paths, rendering the valve useless. The problem was solved by spraying the glass beads and mica with liquid ceramic which, when hardened, formed a pebbly surface and prevented a continuous conduction path from being formed.
- Leakage where the Fernico eyelets passed through the header. This problem was overcome by brazing each eyelet.
- There were grid losses from the top cap which were solved by the use of a new moulded material to insulate the grid cap from the metal shell.

The second diagram in Figure 14.3 shows a later version of the metal valve which was introduced in 1936 to reduce cost of manufacture. With this, a soft glass plate (13) replaced the metal header. This eliminated the need for the Fernico eyelets and, instead, the lead-in wires (14), made from nickel-iron and copper plated, were sealed directly into the glass. The glass plate was sealed to a chrome-iron ring (15) which had a matching temperature coefficient. This, in turn, was welded to an iron ring (16) which served the same function as the edge of the metal header of the earlier design, namely to ensure the bulb to header weld. The other change was to replace the metal exhaust tube with a glass tube.

SINGLE-ENDED METAL VALVES

A modified version of the metal valves appeared in 1938 where valves that previously had their grid taken to a top cap now had all the connections taken to the octal base [8]. To distinguish these valves from the earlier types an S was added to their designations. Thus the 6J7 became the 6SJ7 and the 6K7 became the 6SK7. Figure 14.4 shows a diagram of the new base designed for these valves. These, like the earlier metal valves, had their electrode assembly mounted vertically, whereas with the Telefunken metal valves discussed in Chapter 11 the assembly was mounted horizontally.

The Telefunken arrangement provided two groups of lead-in wires which could be screened by a transverse metal partition. The RCA design had a different means of screening. As with the earlier types, the contact pins were arranged uniformly in a circle to form the octal base and the control grid pin positioned diametrically opposite to the anode pin. This would, of course, minimize the capacity between the two to some extent but not sufficiently for an r.f. pentode. Therefore, further protection was provided by a cylindrical base shield which fitted into a recess in the central spigot and over the sealed-off exhaust tube, which was then grounded through pin 1.

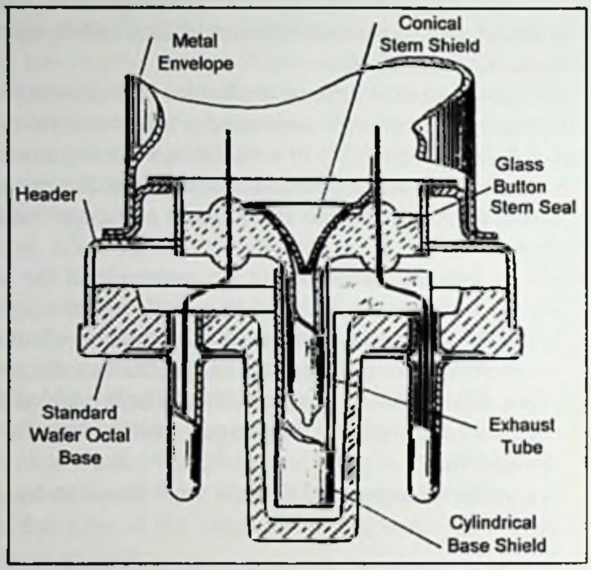


Figure 14.4: new base for the single-ended metal valves.

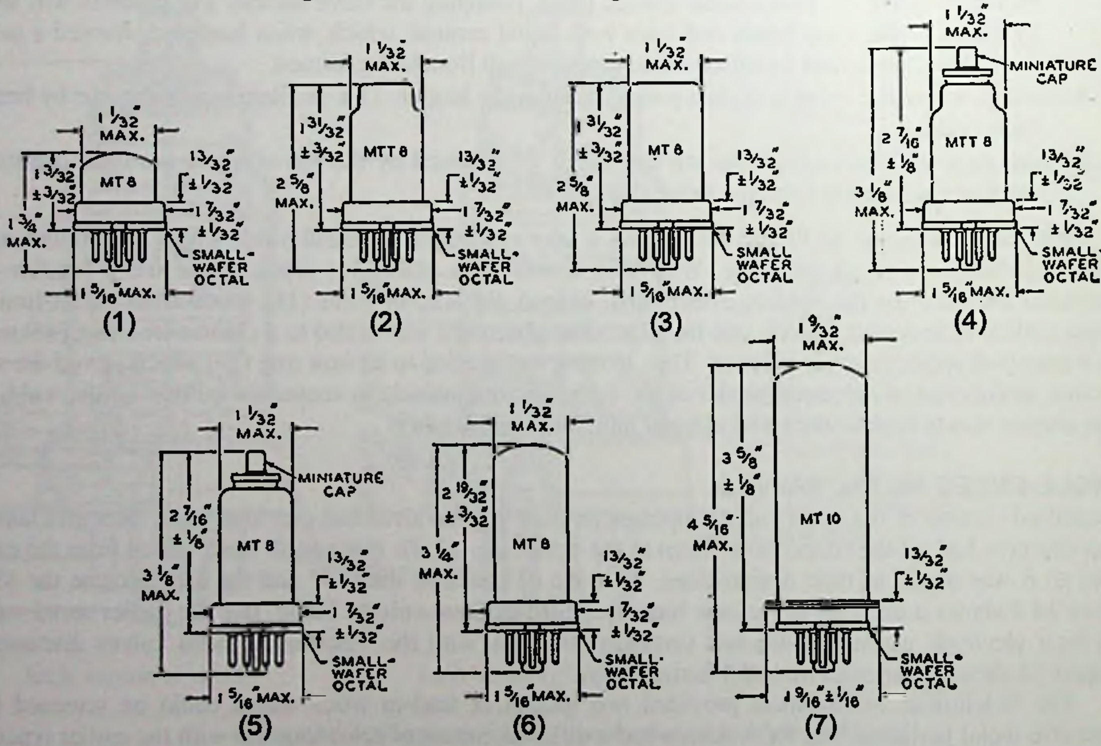


Figure 14.5: outline drawings of metal valves.

Figure 14.5 shows outline drawings of the RCA metal valves. Typical examples of the valves are as follows:

(1) 6H6 twin diode
(2) The original 6C5, later changed to Outline (3)
(3) 6J5 medium-mu triode; 6SA7 pentagrid converter; 6SK7 remote cut-off pentode
(4) 6F5 high-mu triode; 6J7 sharp cut-off pentode
(5) 6K8 triode hexode converter; 6S7 remote cut-off pentode
(6) 6N7 high-mu Class B double triode; 6V6 beam power tetrode
(7) 6L6 beam power tetrode

GLASS TUBULAR OCTAL-BASED VALVES

In 1938 Sylvania announced a new series of octal-based valves which reverted to the tubular style and had the T9 bulb, having an overall height of 3-27/32in. This was a range of 1.4-volt battery valves and consisted of the 1N5-G (r.f. pentode), 1A7-G (heptode converter), 1H5-G (single diode triode) and the two output pentodes, 1A6-G and 1C5-G.

Also in 1938, Hyton introduced the short glass tubular range of indirectly heated valves where the type designation was distinguished by GT. These valves, like the Sylvania battery types, used the T9 style of glass bulb; they were a little larger than their metal-bulb equivalents and were marketed using the name BANTAL. Their short length was made possible by reducing the glass length below the pinch. These valves had metal shells around their base which were connected to pin 1. However, when RCA commenced production of the GT valves they used a Bakelite base and this permitted all eight pins to be available for connections to the electrodes.

The situation now arose that there were three different constructions: the metal version, the large G version with the ST bulb and the shortened GT glass version. The result was that the G version lost out and production of this type slowly died out except for some output valves and rectifiers. By the mid-1940s production of the GT valves was about twice that of the metal valves. There were also some valves, such as the 6SN7-GT and similar double triodes which could not be manufactured in the metal form simply because they required use of all of the eight pins for connections to the electrodes

LOCTAL/LOKTAL VALVES

Another significant development occurred late in 1938 when a new type of valve construction was announced by Sylvania. As mentioned earlier, this also had an octal base but was not the standard type already described. Instead, the pins were sealed directly through a glass base and were of smaller diameter than the standard octal pins. Thus it was possible to dispense with the glass pinch seal and mount the electrode assembly nearer to the base, which meant shortened connections to the electrodes and wider spacing between the lead-out, all of which improved the performance of the valves at very high frequencies. A further feature of the valve was a central metal spigot with a recessed groove which enabled the valve to lock-in to the holder. The metal spigot had the additional benefit of providing screening between the control grid and anode pins and was grounded by a connection on the valveholder. The trade name adopted by Philco was Loctal. Sylvania, National and Ken-Rad used Loktal. RCA and Tung-Sol used 'lock-in' and GE 'locking-in'.

VALVE TYPE DESIGNATIONS

The early receiving valves produced during the second half of the 1920s and the early 1930s were initially coded with three numbers. (Cunningham used 3 for the first digit, e.g. 326, De Forest used 4 and 5, RCA generally used 2 and several other manufacturers used 1 for the first digit. Later just two digits were used, sometimes with a letter added at the end.

In 1933, a new type designation system was adopted by the Radio Manufacturers Association (RMA) which consisted initially of one or two digits followed by a letter and then a further number.

The first digit (or digits) indicated the filament or heater voltage in steps of one volt, 0 was for a cold cathode. The figure 1 was used for voltages below 2.1 volts, the figure 2 for voltages between 2.1 and 2.9, the figure 3 for voltages between 3.0 and 3.9, etc.

The letter that followed the first numeral was a serial designation, with rectifiers starting at Z and going backwards through the alphabet, and other valves starting A and moving forward.

The numeral following the letter indicated the number of useful elements brought out to the base. A filament or heater counted as one element, a separate cathode as another. Grids which were internally connected within the valve, such as a suppressor grid connected to the cathode, were not counted. An internal screen or connection to the metal bulb (as in later valves) which came out to a separate pin was also counted as a useful element.

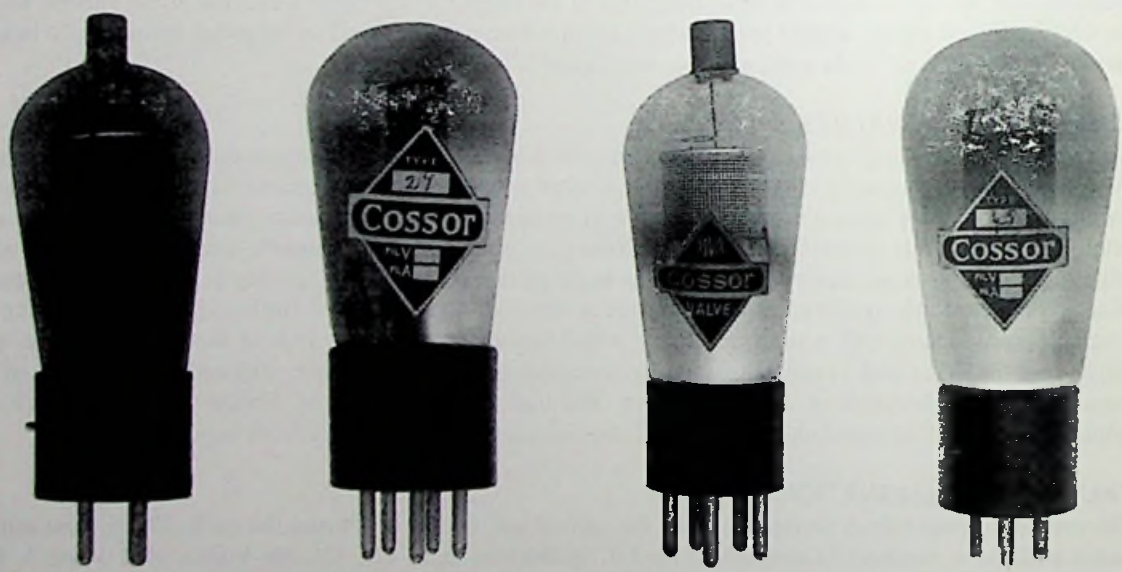
As an example of an early valve, the 2A7 pentagrid converter had a heater, cathode, anode and five grids. Of these grids g_3 and g_5 were connected together and brought out to pin 3, g_1 was connected to pin 5 and g_2 connected to pin 4, thus utilising all 7 of the base pins. However, g_4 was taken to the top cap and so did not count in the numbering.

Before long, as more and more valve types appeared, it was not possible to continue with high letters for rectifiers and low letters for other valves. So, for example, the 6U7-G was a variable-mu pentode and the 6Z7-G a Class B double output triode. Also, as can be seen, a G was added at the end when the glass octal valves were introduced in 1936. Later it also became necessary to have two letters between the numerals such as 6SN7-GT.

When the loctal valves were introduced it was felt necessary to distinguish these from the standard octal valves so the preceding number became 7 for the 6.3-volt valves and 14 for the 12.6-volt valves, whereas the 1.4-volt types continued with 1 as the preceding number.

VALVE PHOTOGRAPHS

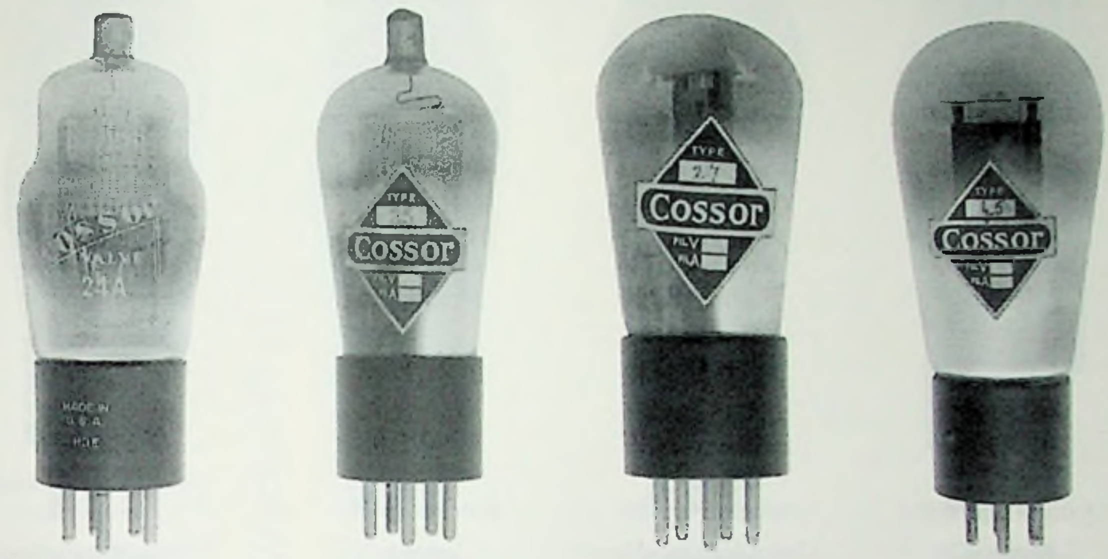
Figure 14.6 shows a selection of early valves with the S-bulb. The Arcturus type 132 has blue-tinted glass and a bayonet pin in the base.



Arcturus r.f. tetrode 132 with blue tinted glass bulb. | Cossor type 27. An early IH general-purpose triode. | Cossor type 15: battery r.f. pentode. | Cossor type 45: directly heated a.c. output triode.

Figure 14.6: Early S-bulb valves. (Note the bayonet pin on the type 132.)

The second group of valves, shown in Figure 14.7, are early 2.5-volt, indirectly heated and most have ST bulbs with the US 4- and 5-pin bases and have the numeric type designation that preceded the revised system introduced by the RMA in 1933.

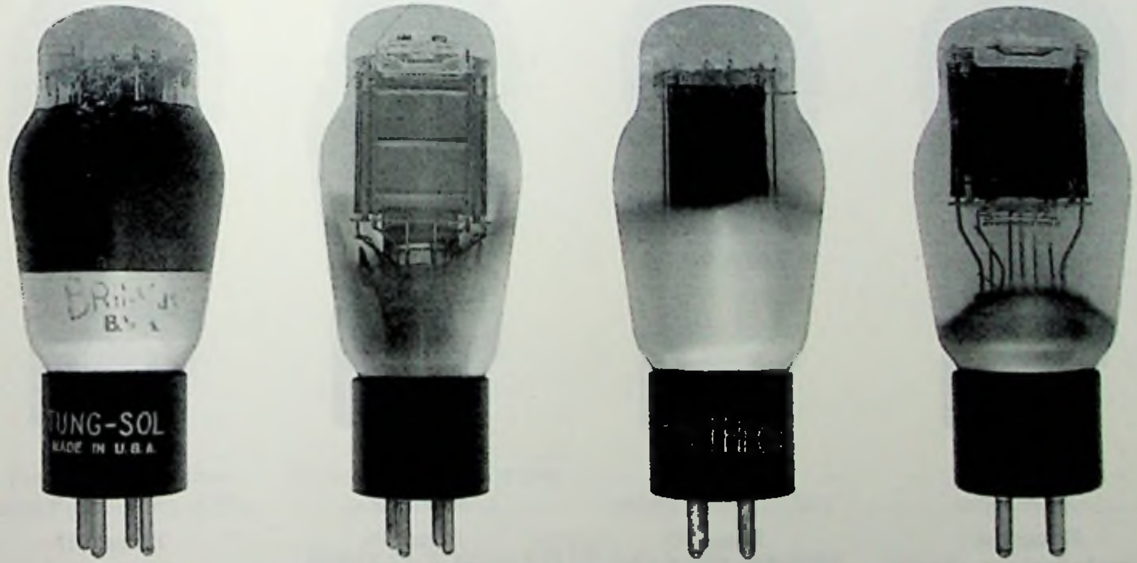


Cossor 24A: r.f. tetrode.

Cossor 35: variable-mu r.f. tetrode.

Cossor 27: general-purpose triode.

Cossor 45: output triode.



Brimar/Tung-Sol 2A3.

Cunningham 2A3.

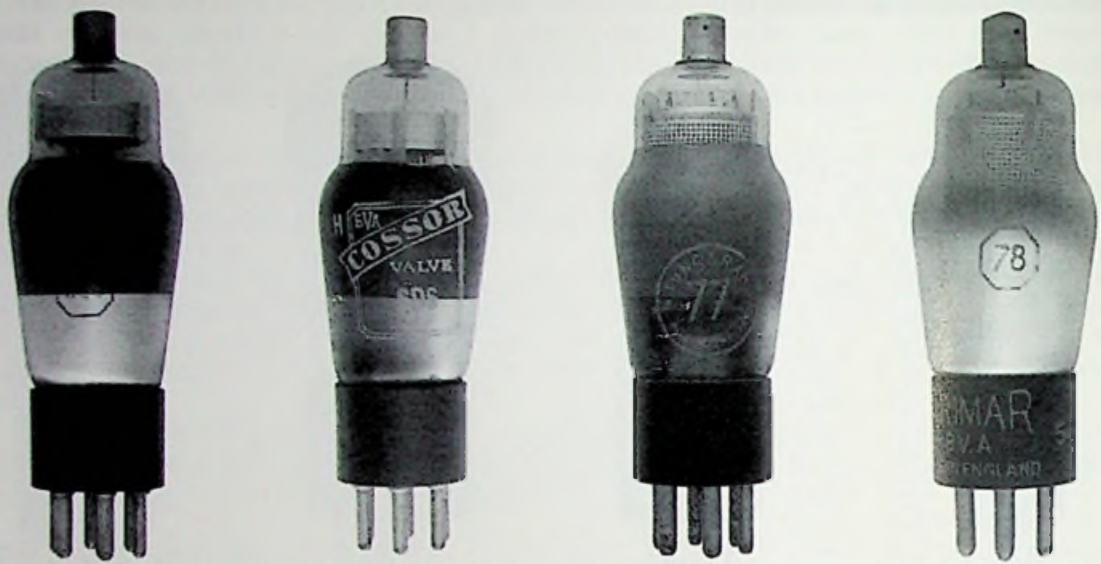
Raytheon 2A3.

Westinghouse 2A3.

Various versions of the 2A3 output triode. The Tung-Sol and Raytheon types consist of two triodes in parallel. The Cunningham has a harp-shaped filament and mono-plate. The Canadian Westinghouse has dual grids.

Figure 14.7: 2.5-volt a.c. valves with US 4- and 5-pin bases.

The third group of valves, shown in Figures 14.8 and 14.9, have 6.3-volt heaters and are fitted with the US 4-, 5-, 6- and 7-pin bases. Also shown in Figure 14.9 are three 0.3-amp a.c./d.c. valves.

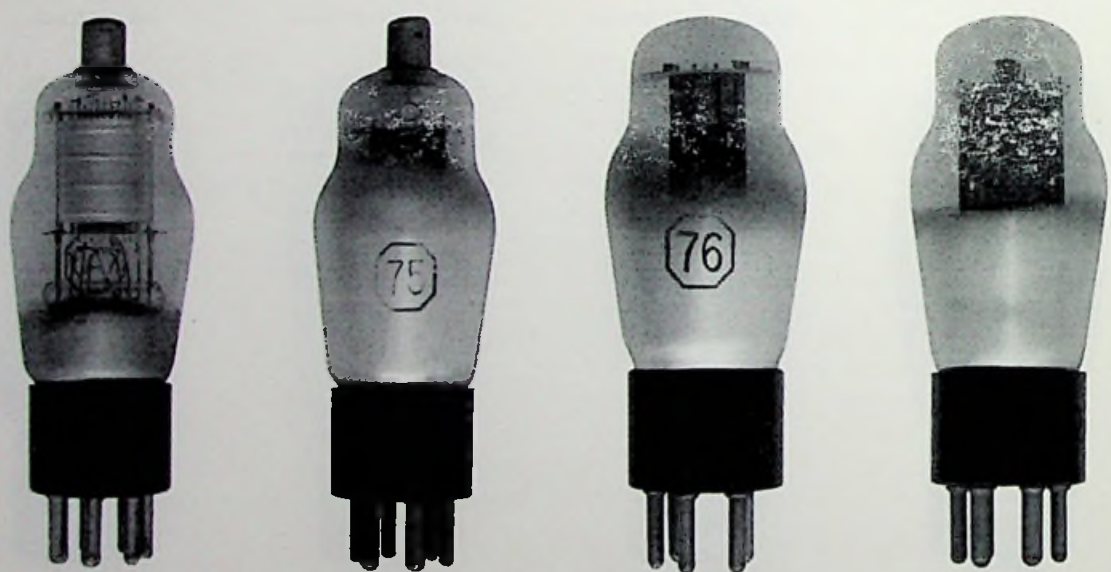


Brimar 6C6: r.f. pentode.

Cossor 6D6: variable-mu r.f. pentode.

Tungsram 77: r.f. pentode.

Brimar 78: variable-mu r.f. pentode.



Brimar 6A7: heptode frequency changer.

Brimar 75: double diode triode.

Brimar 76: general-purpose triode.

Brimar 41E: output pentode.

Figure 14.8: 6.3-volt a.c valves with the US 4-, 5-, 6- and 7-pin bases.

(All these are of early design except for the 807 (see below) which appeared during WW2 and was used in transmitting equipment. Later, the 807 was used as a series regulator in stabilized power supplies and as an output valve in audio amplifiers.)

Mullard 42: output pentode (Lend Lease valve).

Brimar 807: beam power tetrode.

Brimar 5Z3: full-wave rectifier.

Tungsram 80: full-wave rectifier.

Brimar 80S: full-wave rectifier (IH version of 80).

Brimar 2103: double output pentode (0.3A).

Brimar 43: output pentode (0.3A).

1D6: half-wave rectifier (0.3A).

Figure 14.9: Valves with US 4-, 5- 6- and 7-pin bases.
The first five are all 6.3-volt a.c. types and the last three are 0.3-amp a.c./d.c. types.
(Note: the 1D6 is a Brimar valves and not a US type.)

The fourth group of valves, shown in Figures 14.10 to14.12, have the ST bulb and octal bases. These valves made their appearance in the US from 1936. The British glass octals first appeared in 1937 and many of these were re-branded US imports. For example the Mullard 'Amerty' range was mostly RCA types.

Brimar 6J7-G:
r.f. pentode.

Cossor 6K7-G:
variable-mu r.f. pentode.

Brimar 6B8SG-G:
double diode r.f. pentode.

Tungsram 6A8-G:
heptode frequency changer.

Brimar 6K8-G: triode
hexode frequency changer.

Tungsram 6C5-G:
general-purpose triode.

Cossor 6J5-G:
general-purpose triode.

Cossor 6Q7-G :
double diode triode.

Figure 14.10: 6.3-volt, indirectly heated, glass octal valves with the ST bulbs.

Cossor 6C8-G:
medium-mu double triode.

RCA 6N7-G: Class B
double output triode.

Brimar 6AG6-G:
output pentode.

Brimar 6CD6-G: line
timebase output tetrode.

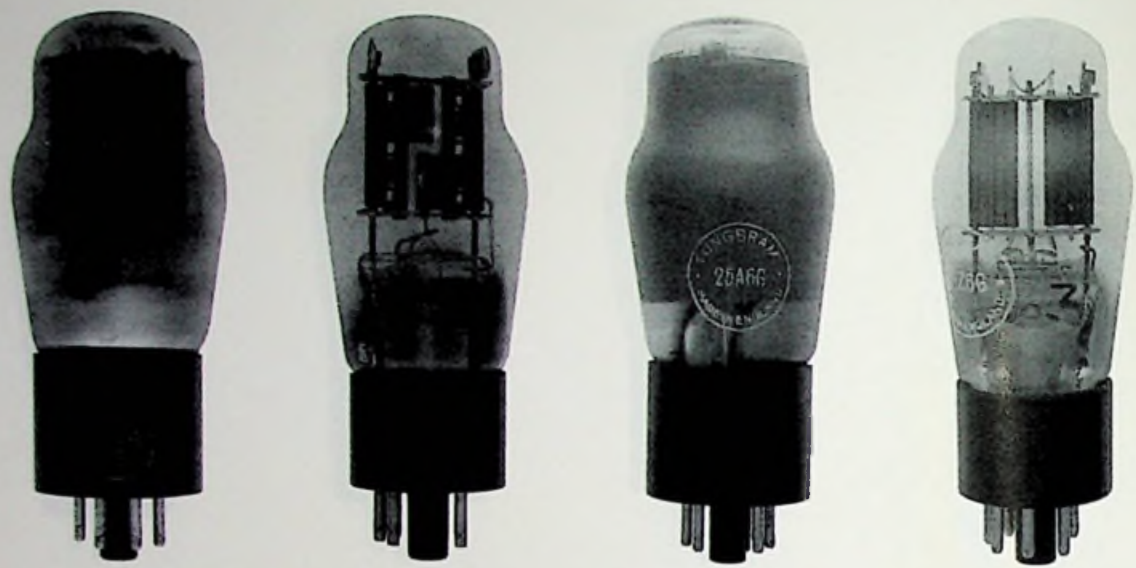
Brimar 6L6-G:
output beam tetrode.

6V6-G:
output beam tetrode.

6U5-G:
tuning indicator.

Tungsram 5U4-G:
full-wave rectifier.

Figure 14.11: Glass octal valves with the ST bulbs (cont.).
All the valves have 6.3-volt heaters except for the 5-volt 5U4-G rectifier.



Brimar 5V4-G: full-wave rectifier (5V).

Tungsram 6X5-G: full-wave rectifier (6.3V).

Tungsram 25A6-G: output pentode (0.3A).

Tungsram 25Z6-G: half-wave rectifier (0.3A).

Figure 14:12: Glass octal valves with ST bulbs (cont.).

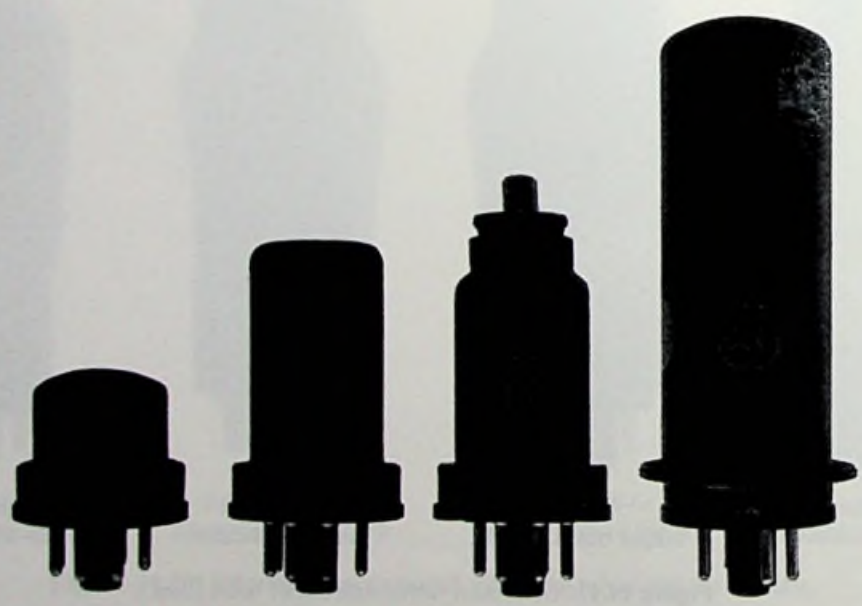


Figure 14.13: Range of metal octal valves:
6H6 double diode, 6J5 triode (VT-94), 6K7 (VT-86) variable-mu r.f. pentode and 6L6 output beam tetrode.

The fifth group of valves is shown in Figure 14.13. Here a size comparison is shown between four different types. The smallest of these, the 6H6, Style (1) in Figure 14.5 has an overall height of 1¾ in (approx. 50mm) and the largest, the 6L6 Style (7) has an overall height of a little over 4¼ in (approx. 110mm).

Figure 14.14, shown at the left, provides a comparison between the metal and glass versions of the 5Z4 full-wave rectifier. With these two valves the metal version has an overall height of 3¼ in and the glass version a height of 4¾.

The next group of valves, shown in Figures 14.15 and 14.16, is a selection of the GT glass tubular valves. These all have quite short stems, sometimes almost concealed below the valve's moulded base. The 6C5-GT, 6Q7-GT, 6J5-GT and the 1N5-G (Figure 14.16) have a metal shell around the bakelite base which is grounded via pin 1 as in the metal valves. The remainder have a bakelite base.

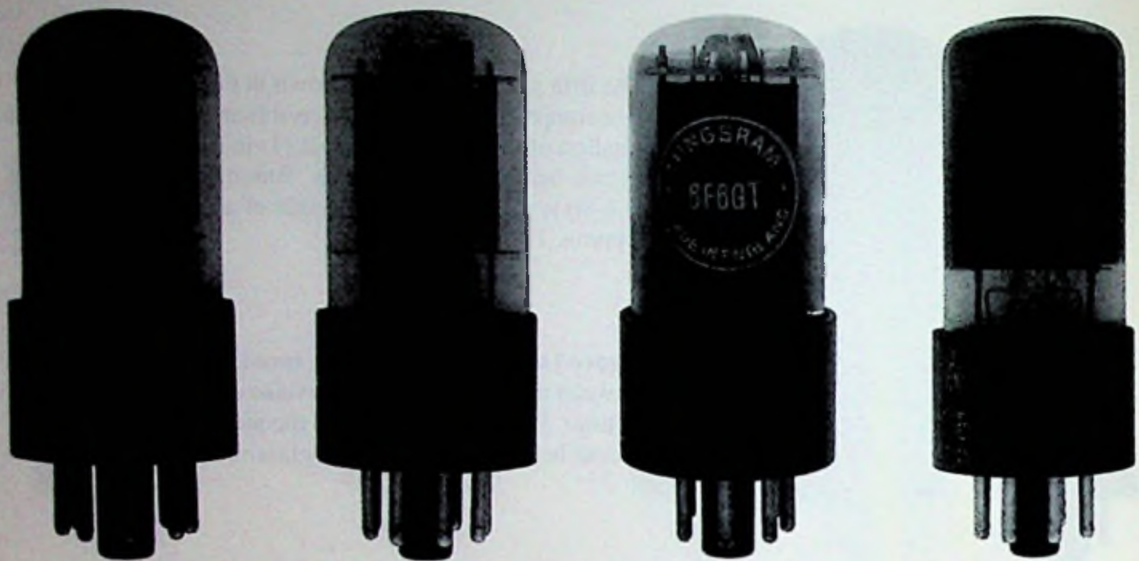
Brimar 6C5-GT: general-purpose triode.

Sylvania 6Q7-GT : double diode triode.

Sylvania 6J5-GT (VT94D): general-purpose triode.

Brimar 6H6-GT: double diode.

Figure 14.15: A selection of 6.3-volt glass tubular valves.

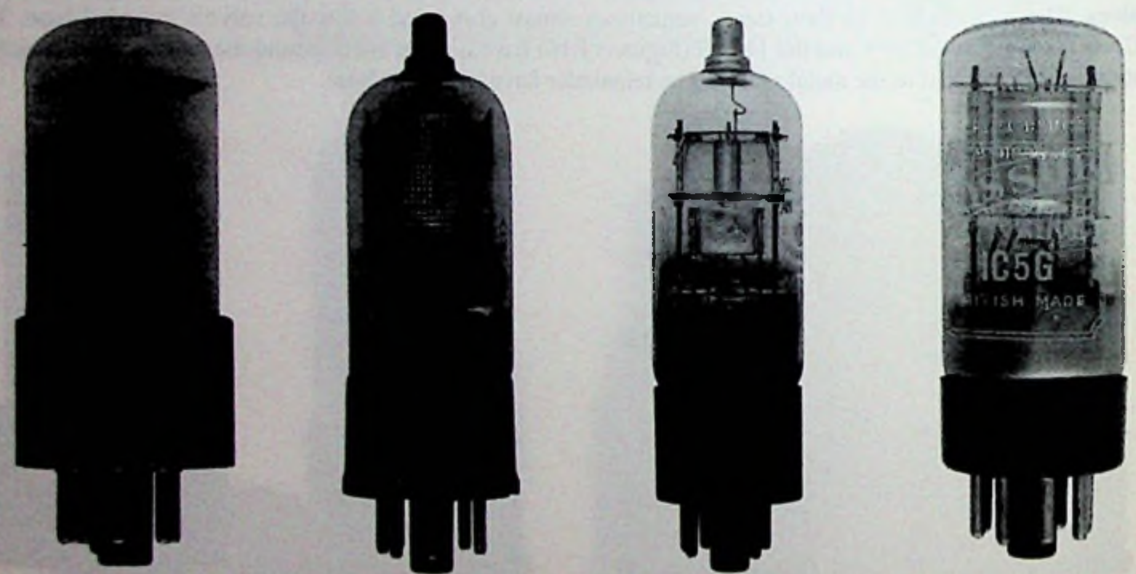


Brimar 6SN7-GT: double triode.

Brimar 6N7-GT: Class B double output triode.

Tungsram 6F6-GT: output pentode.

Brimar 6V6-GT: output beam tetrode.



Brimar 6X5-GT: full-wave rectifier.

Brimar 1N5-G: r.f. pentode (1.4V).

Mullard 1H5-G: double diode triode (1.4V).

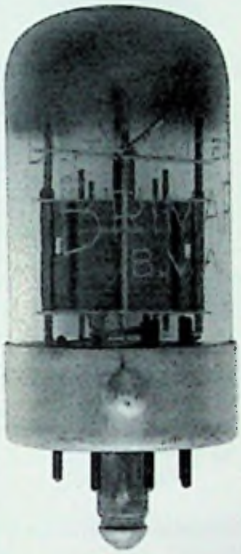
Cossor 1C5-G: output pentode (1.4V).

Figure 14.16: A selection of glass tubular valves (cont.).
The first five are 6.3-volt types and the last three 1.4-volt, 0.05-amp battery types.

Figure 14.17 shows a group of eight loctal valves which have dispensed with the pinch stem [9]. With these valves the keyway in the metal spigot which provides the means for locking the valve into its holder can be seen clearly. Also visible is a raised dimple in the side of the base which assists in locating the valve into its holder.

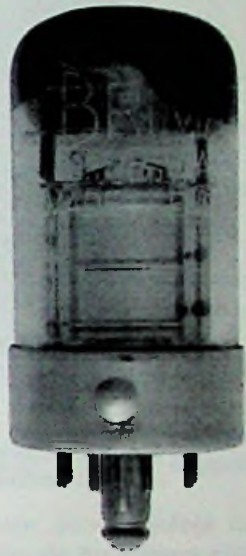
The first four of these loctal valves have 1.4-volt filaments, although the filament of the 3D6 is centre-tapped and can, therefore, also be operated at 2.8 volts. The three 7-series valves have 6.3-volt heaters and the 14-series valve has a 12.6-volt heater; all four of these valves, however, were intended for use in motor vehicles where the battery voltages could be considerable higher than the nominal 6 and 12 volts when being charged by the dynamo.

Brimar 1LN5:
r.f. pentode.



Brimar 1LD5:
single diode pentode.

Brimar 1LA6:
heptode.



Brimar 3D6:
output beam tetrode.

Brimar 7R7: double diode
and r.f. pentode.

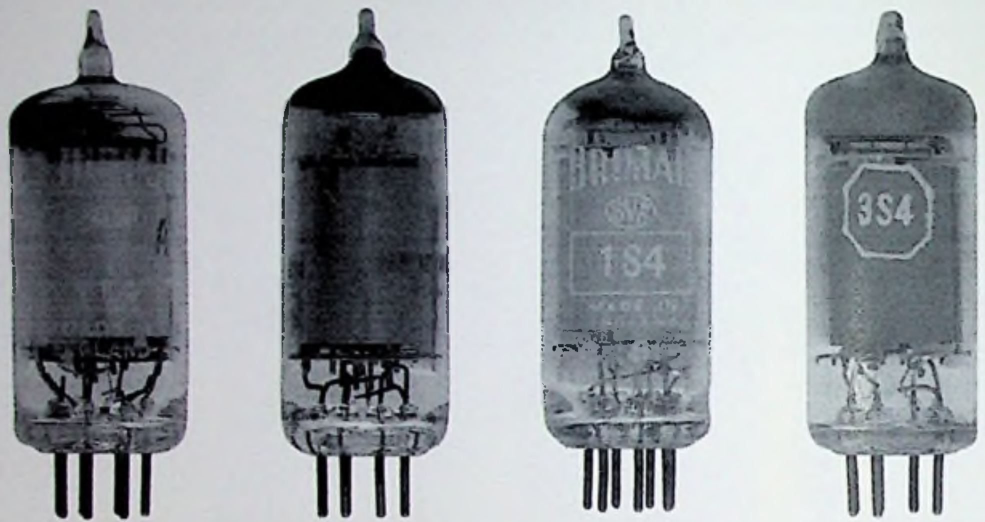
Brimar 7B5:
output pentode.

Brimar 7Y4:
full-wave rectifier.

G.E. 14A7/12B7:
variable-mu r.f. pentode.

Figure 14.17: A selection loctal valves.

The final group of valves is the miniature B7G types that appeared on the US market in 1940. Four examples of these can be seen in Figure 14.18.



Brimar 1T4: variable-mu r.f. pentode. RCA 1R5: heptode frequency changer. Brimar 1S4: output beam tetrode. Philips 3S4: output beam tetrode.

Figure 14.18: Button base B7G miniature valves of 1940.

SUPPLIERS OF US VALVES IN THE UK: 1937/38

Arcturus	Impex	Raytheon
Brimar	Ken-Rad	Sylvania
British Belmont	Mullard	Triad
Champion,	National Union	Tung-sol
Ferranti	Philco	Tungsram
Hytron	Rogers	Yale

REFERENCES

1. Tyne, Gerald, *Saga of the Vacuum Tube* (Howard Sams & Co. Inc. 1977, ISBN 0-672-21470-9).
2. Stokes, John W, *70 Years of Radio Tubes and Valves* (The Vestal Press, Ltd, 1982, ISBN 0-911572-27-9).
3. *Tube Collector* (The Tube Collectors Association Inc., Ashland, Or., USA).
4. 'All-metal receiving tubes', *Elec.*, April 1935, pp. 116-7.
5. 'All-metal receiving tubes: The industry viewpoint', *Elec.*, May 1935, pp. 148-51.
6. 'New All-metal valves', *W.E.*, **12,** May 1935, p. 245.
7. Hull, A W, et al 'Glass-to-Metal Seals II' *J. App. Sci.*, September 1941, pp. 698-707.
8. 'New American valves: single-ended radio-frequency pentodes', *W.W.*, **43**, 8 December 1938, pp. 509-10.
9. 'American Loctal Valves', *W.W.*, 1 June 1939, p. 508.

Chapter 15
Military and Post Office valves

Up until the outbreak of the Second World War the majority of low-power valves used by the three armed services were standard commercial types, although sometimes specially selected or modified in some way in order to meet a more stringent specification. Many of the high-power valves, however, were designed to meet the requirements of medium- and high-power radio and radar transmitters. There was also a diverse range of u.h.f. valves which were also used in radar receivers.

The Post Office had quite different requirements. The valves were used in their radio stations, relays and telephone exchanges. Many of these valves, particularly the low-power ones, were also commercial types but they were often fitted with US bases.

For all these users valves were sourced mainly from the larger manufacturers such as GEC, STC, Mullard and Ediswan.

During the 1920s and 1930s the three armed services had their own codes for marking the valve types. Inevitably there was a wide and diverse range of types with considerable duplication occurring, requiring cross-reference lists.

This chapter is composed of four main sections. The first considers the early Service valves that preceded the Common Valve CV) register, introduced in 1941. The second considers the high-power silica valves that were developed for the navy for use in their shore-based and shipborne radio and radar equipment. The third section deals with the v.h.f. and u.h.f. valves used by all three of the armed services in their radar equipment. The final section is concerned with the valves used by the Post Office.

BRITISH ARMED SERVICES VALVES

Prior to the introduction of the CV numbering system, the three British armed services had their own valve numbering systems. All the numbers were preceded by letters which were meant to distinguish between the various classes of valves. There were, however, some grey areas. For example several of the VT numbers used by the RAF were receiving valves.

Army		Royal Navy		Royal Air Force	
ACR	Cathode-ray tube	NC	Cathode-ray tube	VCR	Cathode-ray tube
AR	Triode or diode(s) triode	NGT	Gas triode	VGT	Gas triode
ARD	Diode	NR	Receiving	VI	Neon or tuning indicator
ARDD	Double diode	NS	Stabilising/regulating	VR	Receiving
ARH	Hexode or heptode	NT	Transmitting	VS	Stabilising
ARP	Pentode	NU	Rectifying	VT	Transmitting
ARS	Screen grid tetrode			VU	Rectifying
ARTH	Triode hexode			VW	Selected types
ARTP	Triode pentode				
AT	Transmitting triode				
ATP	Transmitting pentode				
ATS	Transmitting tetrode				
AU	Rectifying				
AW	Stabiliser or tuning indicator				

Table 15.1: 'Construction' prefixes used on early Service valves prior to introduction of the CV register.

Full lists of the various types are provided in the Valve Data Supplement; however, the tables below provide a cross reference where duplication of types occurs.

Army	Navy	RAF
AR5	NR42	VR22
AR6	NR42	VR22
AR7	NR55	VR109
AR9		VR21
AR16		VR32
AR17	NR31	VR37
AR21	NR48	VR55
ARD2		VR78
ARDD5		VR54
ARH1	NR67	
ARP1	NR39	VR118
ARP3		VR106
ARP13	NR41	VR83
ARP15	NR86	
ARP16	NR83	VT74
ARP17	NR85	
ARP19		VR65A
ARP20	NR79	
ARP23	NR70	VR124
ARP25	NR59	
ARP34		VR53
ARP35		VR91
ARP36		VR65
AT35		VT25
AT75	NT39	
ATP35	NT74	
ATP75	NT38	
ATS25		VT60A
ATS25A		VT60A
AU1	NU12	
AU3	NU3	VU64
AU3A	NU17	VU39
AU4	NU18	VU113
AU5		VU111
AU6	NU16	VU72
AU12	NU13A	
AU13	NU20	
AW2		VS70
AW3		VS110
AW4		VS68
AW6		VI77

Navy	Army	RAF
NGT2		VGT128
NR26		VR28
NR28		VR19
NR31	AR17	VR37
NR39	ARP1	VR118
NR41	ARP13	VR83
NR42	AR5	VR22
NR47		VR40
NR48	AR21	VR55
NR49		VR56
NR55		VR109
NR59	ARP25	
NR67	ARH1	
NR69		VI103
NR70	ARP23	VR124
NR79	ARP21	
NR80		VR135
NR83	ARP16	VT74
NR85	ARP17	
NR86	ARP15	
NR95		VR502
NT38A	ATP75	
NT39	AT75	
NT58		VT62
NU3	AU3	VU64
NU12	AU1	
NU16	AU6	VU72
NU17	AU3A	VU39
NU18	AU4	VU113
NU20	AU13	
NU33		VU120
NU34		VU134

RAF	Army	Navy
VR19		NR28
VR21	AR9	
VT25	AT35	
VR28		NR26
VT31	ATS250	
VR32	AR16	
VR37	AR17	NR31
VR38		NR26
VU39	AU3A	NU17
VR40		NR47
VR53	ARP34	
VR54	ARDD5	
VR55	AR21	NR48
VR56		NR49
VT60A	ATS25	
VT62		NT58
VU64	AU3	NU3
VR65	ARP36	
VR65A	ARP19	
VR67	6J5G	6J5G.
VS68	AW4	
VS69		NS1
VS70	AW2	
VU72	AU6	
VT74	ARP16	NR84
VI77	AW6	
VR78	ARD2	
VR83	ARP13	NR41
VR91	ARP35	
VI103		NR69
VR106	ARP3	
VR109	AR7	NR55
VS110	AW3	
VU111	AU5	
VU113	AU4	NU18
VR118	ARP1	NR39
VU120		NU33
VR124	ARP23	NR70
VGT128		NGT2
VU134		NU34
VR135		NR80

Table 15.2: Cross reference indexes for Army, Navy and RAF valves.

The photographs shown in Figure 15.1 are for a few types that have not been shown in previous chapters or are variants of them.

NR15A = L410 (MOV): Battery 4-volt a.f. triode.

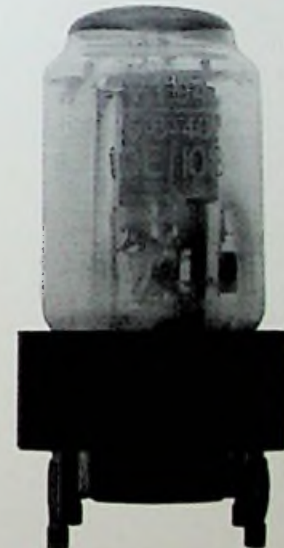
VW36 = 220PA (Cossor): 2-volt output triode selected for capacitance from VR22.

VR99 = X66 (MOV): 6.3-volt triode hexode (CV1099).

ARP3 = 9D2 (Brimar): 13-volt variable-mu r.f. pentode.

NGT1 = GDT4C (Cossor): 4-volt argon-filled thyratron. (See also Figure 3.25.)

AT20 = MZ05-20 (Mullard): 13.8W r.f. transmitting triode, 6-volt directly heated filament.



VT94 = CV1094): transmitting triode, 6-volt directly heated, 40W dissipation.

Figure 15.1: Various Service valves. (Note: another version of the Brimar 9D2 can be seen in Figure 9.3.)

SILICA & COOLED ANODE POWER VALVES

Valves constructed from conventional glass are unable to dissipate more than a few hundred watts before becoming overheated to a point where the glass begins to soften. Of course it was always possible to connect several valves in parallel if a higher transmit power was required. Indeed the Caernarfon radio station had 48 Marconi MT2 valves in its final output amplifier—apart from the cost involved the final equipment was large and prone to unreliability.

The British Navy began developing its first valve transmitters during WW1 and there was a requirement for high-power equipment to enable ships to communicate over very long distances. It was this requirement that led the Navy to investigating silica envelope valves [1]. Silica, or fused quartz, has a very high melting point, high insulation resistance and a low coefficient of thermal expansion. The material is also almost transparent to infra-red radiation, which greatly simplifies extraction of heat from the internal valve electrodes. The valves were designed at the Royal Naval Signal School, with silica manufacture by the Silica Syndicate Company of Wallsend, and valve manufacture by the fledgling Mullard Radio Valve Company. The first type to be produced was the 2.5kW NT22, which became available in August 1921, followed by the NT23 in May 1922, three of which were used in the 8kW Pembroke W/T Station. Before long, higher power types were produced, many of which were water cooled.

Two early examples of silica valves can be seen in Figure 15.2. At the left is the 4kW NT24 and at the right the 15kW NT22A, which entered service in 1922.

Silica valves continued in use well into WW2 [2]. An important application was in the early experimental Chain Home (CH) radar station of 1937 which used the NT46 or NT57 to provide a peak output of several hundred kilowatts in the frequency range 22.7–29.7 MHz. Apart from the CH radar, the NT57 was also used in the Type 79 shipborne radar and the MB2 mobile ground radar. The electrodes were made from molybdenum and connected to tungsten rods which were sealed through the silica envelope. A later version of the NT57, known as the NT57T, had the more-efficient thoriated tungsten filament (see Figure 15.3) which required only one sixth of the heating power. As explained later, the silica valves were superseded by the type 43 demountable tetrode in production versions of the CH radar.

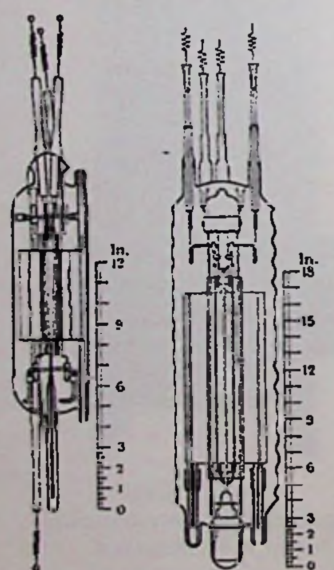


Figure 15.2: Typical examples of early silica valves. (Left) 4kW, NT24). (Right) 15kW, NT22A.

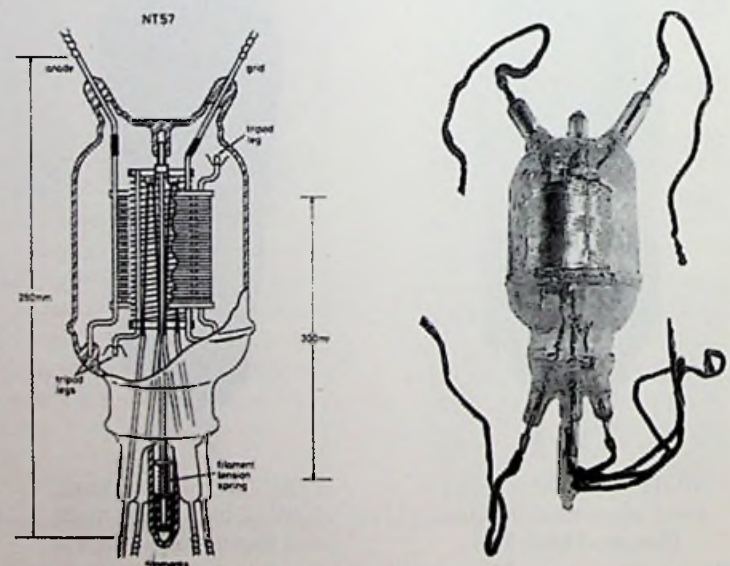


Figure 15.3: The NT57 of 1937 design is shown at the left and its 1939 replacement, the NT57T, at the right.

The most powerful of the silica valves was the NT86. A pair of these, used in the Type 291 early warning radar, generated a peak power of 1MW at 90 MHz.

A more versatile, and easier to construct, high-power valve is the cooled anode type where the anode forms part of the valve envelope, which can then be cooled by liquid or an air flow. The first type to be produced was the Western Electric 220-A in 1922 [3]. This valve was produced for civil applications such as radio telephony or broadcasting. The slightly later 220-B (or its STC equivalent 4220-B) was used by the British Post Office in the Rugby high-power radio station which opened service on 1 January 1926. The water-cooled output stage of the transmitter utilized 54 of these valves, arranged in three banks of 18, one bank of which was used as a standby.

The M-O Valve Company also produced cooled anode transmitting (CAT) valves for the Marconi Company from about 1924. The first of these was the CAT1 which was similar to the 220-B (see Figure 15.4).

In 1938 GEC produced the VT58, a cooled anode transmitting triode, shown in Figure 15.5. This was used in experimental models of the Chain Home Low (CHL) 200 MHz radar. The valve had a tungsten filament. In the following year the valve was re-designed with a thoriated tungsten filament and designated VT98. The VT98 was used in production models of CHL and replaced the silica NT57T in the MB2 mobile ground radar transmitter. It had a peak power of 100kW.

DEMOUNTABLE VALVES

The demountable valve was developed in France during the early 1920s, the earliest of these being the Holweck valve which was installed in the Eiffel Tower transmitter in 1923. The valve had an output power of 10kW and for typical telephony transmissions the power was about 5.6kW [4]. The special feature of demountable valves is that they are connected continuously to a vacuum pump but can be readily stripped down, repaired and then put back into service.

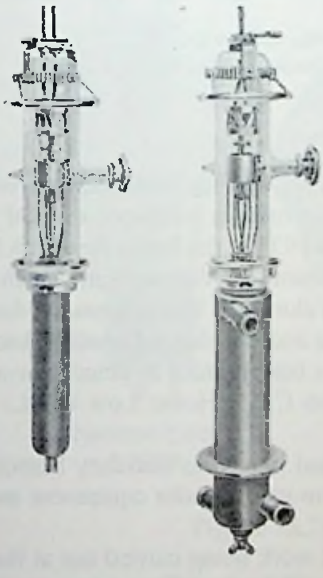


Figure 15.4: Marconi cooled anode transmitting triode, CAT1. The photograph at the right shows the valve enclosed within its water-cooling jacket.

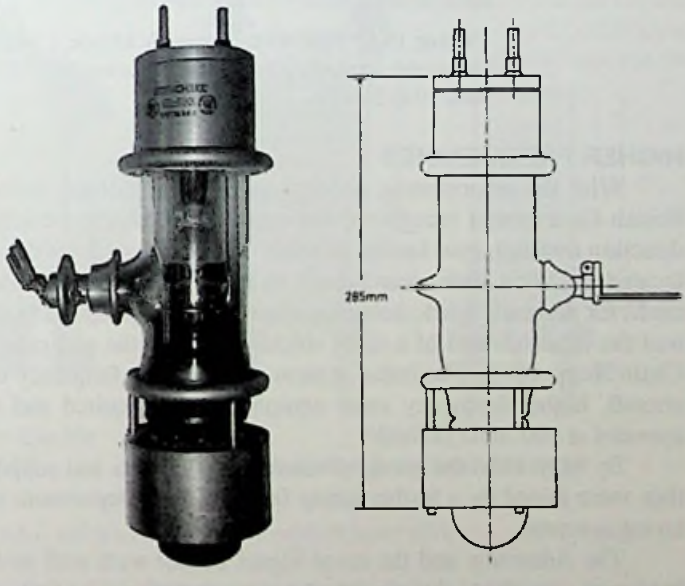


Figure 15.5: Photograph and diagram of the NT58 and NT98 cooled anode transmitting triodes. The NT58 of 1938 had a pure tungsten filament and was superseded by the NT98 with a thoriated tungsten filament in the following year.

Production versions of the CH radar transmitter used a pair of BTH water-cooled tetrodes, Type 43 (Figure 15.6), which was of demountable construction to permit replacement of the filament and grids. The valves were operated in Class C and generated a peak power of 750kW at four spot frequencies from 20 to 50MHz. The valves were connected to a vacuum plant using a two-stage oil-diffusion pump backed up by a rotary pump.

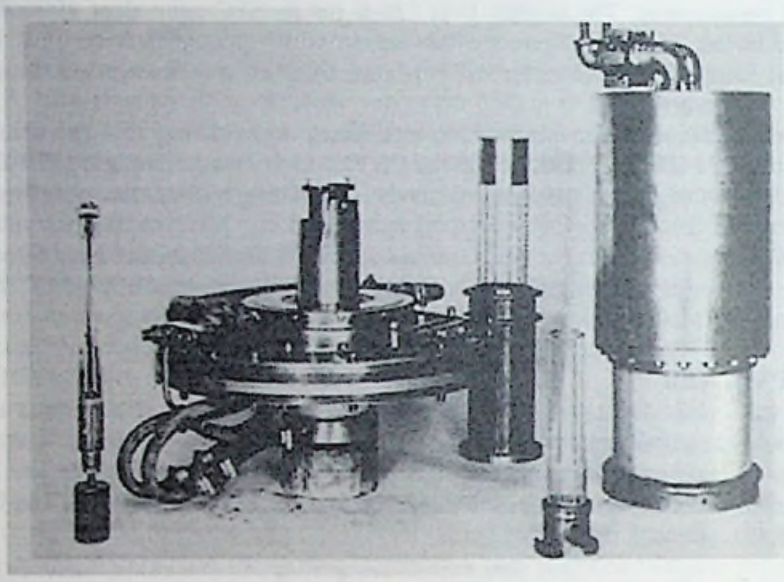


Figure 15.6: Type 43 demountable tetrode, a pair of which was used in the CH transmitter to produce a peak output power of 750kW at four frequencies in the band 20 to 50MHz.

HIGHER FREQUENCIES

With the deteriorating political situation in Europe during the 1930s and the possibility of war, the British Government recognized the urgent need to detect enemy bombers using a technique of RDF (radio direction finding), later known as radar. The initial work on this started in 1935 at the Radio Research Station located at Ditton Park, near Slough in Buckinghamshire, under the direction of Watson-Watt. Much of the credit for this early work, however, must go to the group led by Arnold Wilkins [5]. The outcome of this work was the establishment of a radar shield protecting the east coast, London and the Home Counties, known as Chain Home (CH). The initial system operated at a frequency of 26MHz but, in order to detect low-altitude aircraft, higher frequency radar equipment was required and this led to Chain Home Low (CHL) which operated at 200 MHz (1.5m).

By May 1936 the group of scientists, engineers and support staff had moved to Bawdsey Manor. Here they were joined by a further group from the War Department working on mobile radar equipment and gun-laying systems.

The Admiralty and the naval Signal School were well aware of the work being carried out at Bawdsey but it was considered that the naval requirements for radar systems were sufficiently different from land-based and airborne requirements to warrant an independent approach.

All these radar systems, including many used in ships, together with their shore stations, required operation as frequencies in the v.h.f. and u.h.f. bands from around 30 MHz to 600 MHz. Later, with the introduction of microwave radar, the frequency requirement was stretched first to 3 GHz and later to 10 GHz, corresponding to wavelengths of 10cm and 3cm. For these frequencies, however, the prime requirement was for high-power magnetrons and klystrons, devices not dealt with in this book [6,7].

At the time, the late 1930s, there were few valves available for operation at the frequencies required for the metric radar frequencies. As mentioned in Chapter 7, the RCA Company had produced miniature 'acorn' valves which were capable of operation up to around 400 MHz. The acorn valves, however, were of limited use because of their low power dissipation and their low slope made them unsuitable for wideband amplifications. They also proved very difficult for UK companies to manufacture and were subsequently withdrawn from Service use.

The principal US companies developing valves for use at high frequencies at this time were RCA and Western Electric (part of the Bell Telephone system). Typical examples of these are shown in Figure 15.7. On the left is the Western Electric 304A (STC type 4304A), which was first described by Fay and Samuel in 1935 [8]. This valve was capable of oscillating up to 300 MHz with a power output of 15 watts, increasing to 60 watts at 100 MHz. There was close spacing between the grid and filament to give a high mutual conductance and provide a short electron path. The inductance of the lead-out terminations from both the anode and grid electrodes was minimized by bringing these directly through the glass at the top of the valve. Other important constructional details were the use of hard glass and constructing the anode from graphite.

The centre diagram shows the Western Electric 316A (STC type 4316A) of about 1936. This is an example of a 'doorknob tube' and experimental work on this design goes back to around 1934. Similar types were produced by RCA, such as the 368A, and the German Gema company (TS1). With this construction, all the output leads were kept to a minimum length by bringing them directly through the glass bulb (as with the earlier acorn valves). The 316A was capable of an output of 8.5 watts at 300 MHz or four watts at 600 MHz, with an oscillation limit of 750 MHz. At these high frequencies it was essential to use concentric lines for the filament and anode/grid circuits with connections to nodal points.

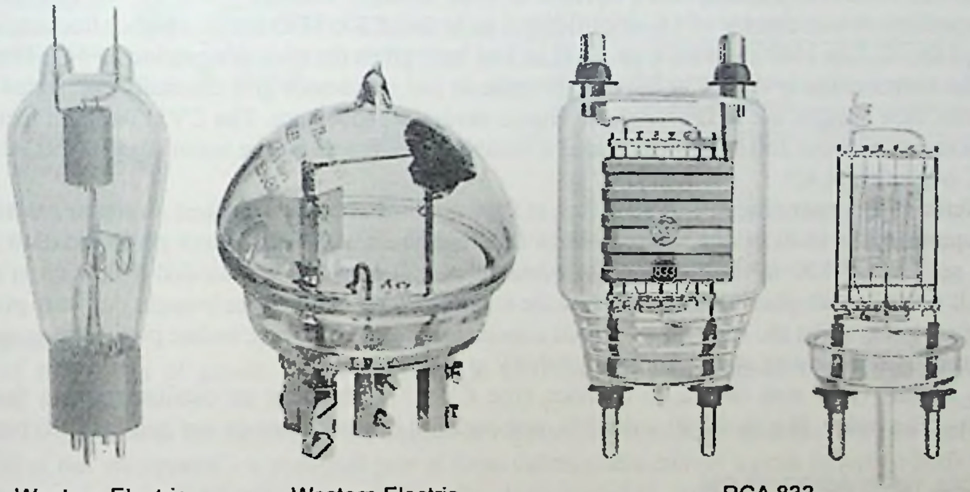


Figure 15.7: Various v.h.f. and u.h.f. valves of the mid- to late-1930s.

At the right of Figure 15.7 is shown the RCA type 833, described by Wagener in 1938 [9]. As with the 316A, all the leads are taken directly through the glass wall. The anode is made from tantalum. The valve could deliver an output power of 400 watts in Class C telephony at 75 MHz. Its maximum frequency was about 100 MHz. The 833 was also used as an audio frequency power modulator; two valves connected in push-pull could then deliver an output of up to 1650 watts. (The 833 was soon superseded by the 833A where the anode was coated with zirconium and its dissipation increased from 300W to 400W.)

Typical British metric radar systems used during WW2 were the 200 MHz GL2 gun-laying radar, ASV (Air to Surface Vessel) and AI (Air Interception), the latter requiring small size for fitting in aircraft. There were also the shipborne radars, the 43 MHz Type 79, its successor the 90MHz Type 79, and the 600 MHz Type 284 fire control system.

Following informal meetings between the naval Signal School and GEC towards the end of 1938 a coordinating group known as CVD* was set up in February 1939. Its initial purpose was to review the valve development for RDF. Meetings of the group were later extended to include other government establishments and companies involved in valve development to meet services' requirements.

Apart from the need to direct valve development, there was also a need to rationalize and approve valve types. This led, in late 1941, to the establishment of CV types (Common Valve), a numbering system used for all new valves, together with eventual obsolescence of the numbering systems used by the three armed services and the Post Office. A register of the approved CV types was produced which gave detailed specification details including test data, outline drawings and base connections. This register, entitled 'Electronic Valve Specification' was issued by the Ministry of Supply and eventually required eight volumes containing about 7000 pages. These specifications are now available on a CD-ROM†.

In this chapter space does not permit a detailed examination of the many valve types used by the three armed services and the British Post office. As already mentioned, many of the low-power types had commercial or near-commercial equivalents. The main concentration in this chapter, therefore, is on some of the more commonly met v.h.f. and u.h.f. valves which were specifically designed for military purpose.

THE MULLARD EF50 & RL TYPES

The EF50 (CV1091) has already been covered in some detail in Chapter 8 and, so, the following includes some repetition. It was capable of r.f. amplification up to about 100 MHz but, for higher frequencies, Mullard produced the RL7 in 1940 (Service type CV1136 and later given the civil designation EF54). This valve was of similar construction to the EF50 but had the cathode and suppressor grid internally connected to a screen which was then brought out to four separate pins to minimize inductance. The CV1136 could then be used at frequencies up to about 250 MHz. It provided a suitable replacement for the acorn pentode (RCA type 954 or its GEC equivalent ZA2).

Metric radars operating at 200 MHz had, at first, used acorn triodes for their oscillator circuits but these were superseded in 1940 by the Mullard RL18 (Service type CV1197 and later given the civil designation EC53), see Figure 8.35 in the Chapter 8). It had an overall length of 54mm and a maximum diameter of 16mm. It was of an all-glass construction with the anode and grid connections brought out from pins at the top of the glass bulb, whilst the heater and cathode connections were from three in-line pins at the base. The valve could produce about a watt at 200 MHz and 300mW at 400 MHz.

A further valve was the RL16 (Service type CV1137); this was an oscillator triode for use up to 300 MHz. This valve, like the EF50 and EF54, was enclosed in a metal screen and had the B9G base.

RADICAL NEW APPROACH

In order to push the frequency up to and beyond 600 MHz it became clear that a radical new approach was required. To achieve this goal there were four major improvements:

- Reduction of the grid-cathode spacing to 0.25mm or less.
- Increasing the space current density up to 5 A/cm^2 under pulsed conditions. (For radar applications a duty cycle of 1:200 or more was all that was required.)
- Reducing the electrode lead inductance by the use of disc seals.

---

* CVD was an acronym for 'Communication Valves Development' but was later changed to 'Co-ordination of Valve Development' and later still to 'Components Valves and Devices'.

† 'Electronic Valve Specifications' with data on 1700 CV valves. Available from rod.burman@btopenworld.com.

• Making the valve part of the circuit by including it in a transmission line.

(As an aside, the electron transit time, which determines the maximum operating frequency, is proportional to the cube root of the ratio between the grid-cathode spacing and the space current density. Here can be seen one of the advantages of using pulse operation, where the space current density is increased by the duty cycle ratio.)

The valves were operated in one of four ways, as shown in Figure 15.8, each connected in concentric lines: (a) common-anode, earthed anode, (b) common-grid, earthed-grid, (c) common-grid, earthed-anode, (d) common-grid, earthed-cathode.

Several companies were involved in these improvements and the valves to be described fall into three broad categories: 'micropup' metal-glass power valves, disc-seal valves, US 'lighthouse' tubes.

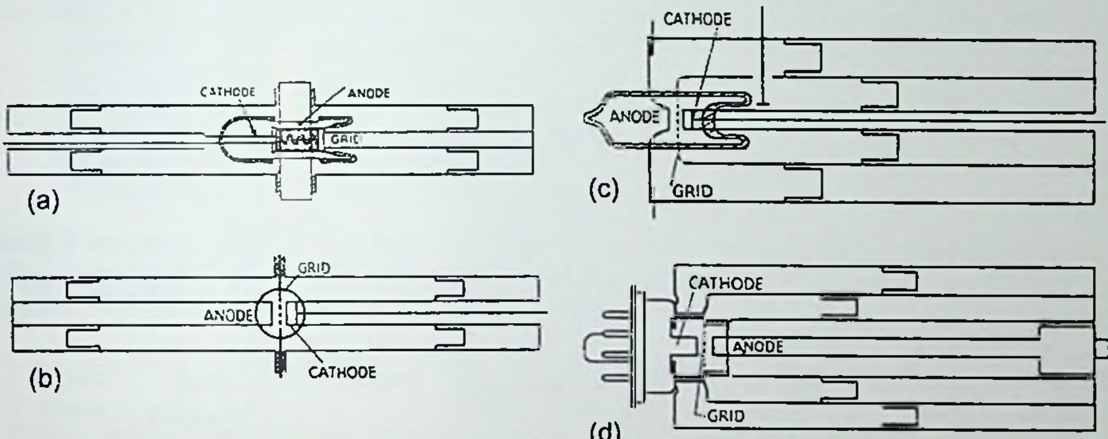


Figure 15.8: Various ways for connecting valves in concentric lines. (a) Common-anode, earthed-anode—CV52, CV55, CV240, NT99 and VT90. (b) Common-anode, earthed-anode—CV90, CV153 and CV273. (c) Common-grid, earthed-grid—CV16, CV53, CV88, CV257 and CV288. (d) Common-grid-earthed cathode—Lighthouse tubes.

1. 'Micropups'

The first of this series of power valves appeared in 1939 and was designated E1046 (later VT90, see Figure 15.9).

The NT99, shown in the diagram at the bottom of Figure 15.9, was developed in 1941 and was the most widely used of the 'micropups'. A push-pull pair of these valves could deliver a peak power of 200kW at 600 MHz. It was used in the RAF 600 MHz mobile radar, type AMES11, and also in 200 MHz AI and ASV equipment.

All the valves in the series had the external ribbed type of anode shown in the figure and were made of copper. Apparently the copper-glass seals presented no difficulty either in manufacture or use. The grids were of the 'squirrel-cage' form with the wires uniformly spaced around a cylinder and attached to a narrow ring at the open end and a shallow dish at the closed end. The wires were of molybdenum. The filaments of the early valves, such as the VT62 and VT90, were made from thoriated tungsten. The later valves used oxide-coated cathodes which were more efficient and allowed for a closer spacing between the grid and cathode, thereby reducing the electron transit time and enabling the valves to be used at a higher frequency. In CW operation the anode voltage must be kept relatively low, usually below a kilovolt, to avoid stripping of the oxide coating from the cathode. However, it was found that many kilovolts could be applied to the anode in pulse operation at a duty cycle of greater than 1 in 200 without damage to the cathode. The 'micropup' valves were operated in the common-anode, earthed-anode configuration shown in diagram (a) of Figure 15.8.

Apart from the VT90 and NT99, the series included NT93, CV55, CV155 and CV240. The 'micropups' were normally operated in push-pull with the two anodes connected together and parallel wire circuits connected the two grids and two cathodes. The CV55 was intended for c.w. operation and a pair of these provided an output of 20 watts in push-pull. The CV155 was a pulsed version of the CV55 and a push-pull pair of these provided an output of 40kW.

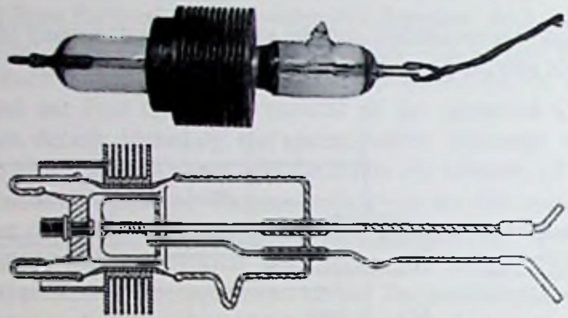


Figure 15.9: The VT90, shown at the top, was designed by Aldous and Bell of the GEC Transmitting Valve Group in 1939 and was the first of the 'micropup' valves. The NT99 (CV199), below, was the most widely used of this class of valves.

Table 15.3 summarizes the performance of micropup valves used in WW2 radar equipment. It should be noted that the output power is under pulsed conditions and is for a pair of valves operating in push-pull. The first four valves in the table had thoriated tungsten filaments, whereas the last three, of later design, had indirectly heated oxide cathodes.

Type	Cathode type	Filament or heater		Anode		Max frequency	Pulse power
		Volts	Amps	kV	Watts	MHz	kW
VT90 (CV1090)	Thoriated	8.25	7.0	9.0	100	300	10
CV15	Thoriated	3.25	6.75	4.0	1	300	1
NT93 (CV1253)	Thoriated	10.6	12.0	9.0	100	600	25
NT97 (CV1254)	Thoriated	11.0	12.25	9.0	100	300	30
NT99 (CV1256)	Oxide	6.0	6.5	12.0	150	600	200
CV55	Oxide	6.3	2.7	4.5	50	1200	40
CV240	Oxide	6.0	17.0	15.0	1000	100	500

Table 15.3: Performance of various common-anode, earthed-anode oscillator triodes.

2. Disc-seal triodes

The initial work on the disc-seal triode was carried out by a group at STC under the direction of W T Gibson. GEC, together with the M-O Valve Company, also produced this class of valves, including high-power oscillators [10,11].

Disc-seal triodes were used both as amplifiers and oscillators and were usually connected in the common-grid, earthed-grid configuration, as shown in diagram (b) of Figure 15.8. The first of this class of valves, the STC type S25A (later designated CV16, see Figure 15.10), became available in 1941 and was developed by a team led by J Foster. The CV90 and CV88 and were later variants (see also Figure 15.10). The CV90 was a GEC design (original prototype E1368) and intended as an oscillator, whereas the CV88 (original prototype S28A) was intended as a grounded-grid amplifier for frequencies up to 600 MHz. The diagram on the right of the figure shows a section through the CV88 where the copper disc holding the grid can be seen extending through the glass wall of the valve. The disc, which is earthed, acts as a screen between the cathode and anode. The cathode is a rectangular nickel tube, coated only on the side facing the grid. To reduce capacitance most of the grid wires facing the uncoated side of the cathode were removed: this enabled the valve to be used as an amplifier up to 1GHz, which was a considerable improvement on the CV16. The CV53 (original prototype S26A), shown at the extreme right of Figure 15.10, was of simpler construction for use at 200 MHz, but could be used up to 450 MHz.

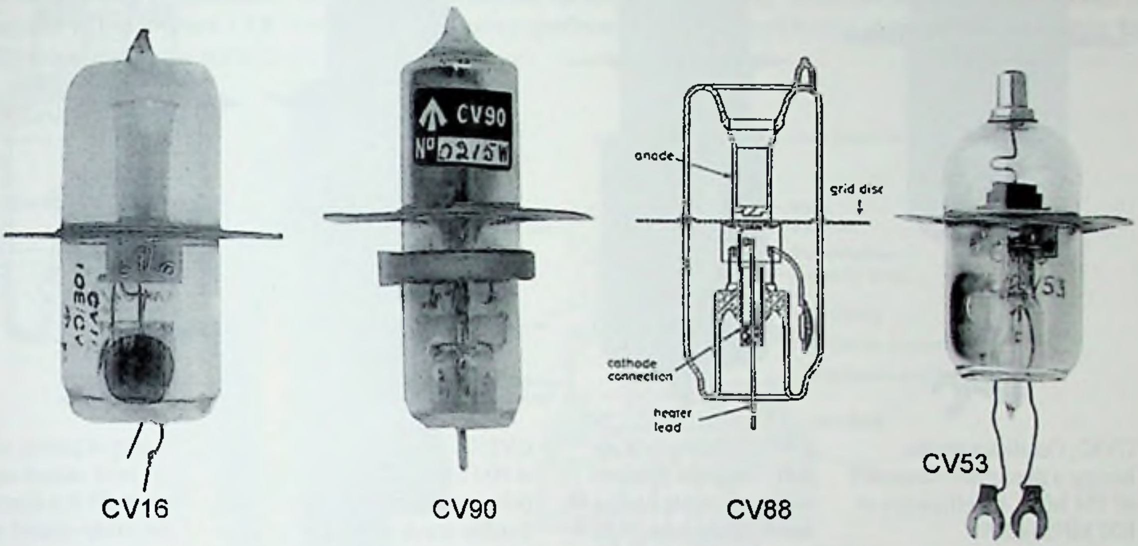


Figure 15.10: Selection of disc-seal, grounded-grid triodes.

Three further examples of disc-seal valves are shown in Figure 15.11. The CV82 (originally STC type S27A) was the first local oscillator to be designed for use at 600 MHz. It was similar in design to the CV53 but had a lower amplification factor (34 rather than 100). This valve was produced in 1941 and generated 1.5 watts at 600 MHz with an efficiency of 20%. Its maximum frequency of operation was 750 MHz.

The CV127 was another STC design (originally S30A). This is a medium-power oscillator triode and has a thoriated tungsten filament. The grid makes contact through a starfish spring and is connected to a copper disc which is sealed through the glass wall. The anode also connects to a copper disc through the bulb. The maximum anode dissipation was 40 watts and the output power at 600 MHz was 25 watts. Under pulse conditions the peak output at 600 MHz was 20kW.

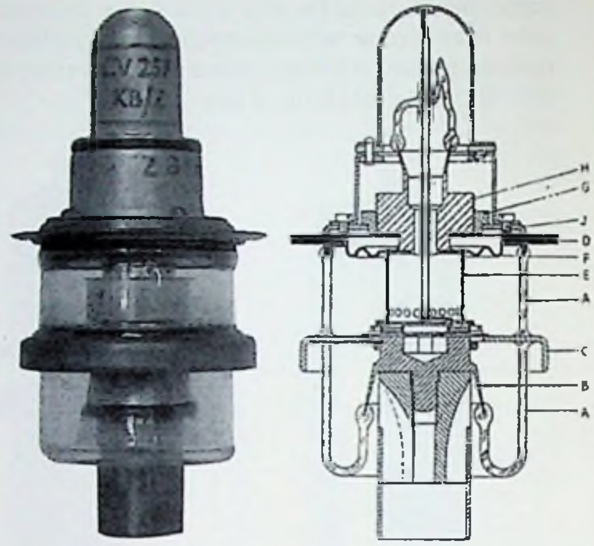
The CV257 was a GEC design (originally E1457). It has an indirectly heated cathode with an area of 2cm^2. It was used as an r.f. oscillator or amplifier. As an amplifier it had a gain of 11dB at 500 MHz, falling to 4dB at 1GHz. To achieve this high frequency of operation the cathode-grid distance had been reduced to a mere 0.25mm and the grid-anode distance to 0.5mm. The peak anode dissipation was 75 watts, which necessitated forced air cooling.

In the photograph and diagram of the CV257 shown in the figure it can be seen that that the valve has a metal-glass envelope with two glass portions, A. Sealed through these, and connected to the grid is a copper-plated nickel-iron disc, marked C in the diagram. Sealed near one end of the valve is a flared copper thimble, B, which forms the anode. Towards the other end is the copper-plated nickel-iron cathode flange, D.

The last of these disc-seal valves to be described is the CV288, shown in Figure 15.12. The same techniques were used in the construction of this valve as with the CV257. However, the electrodes are short cylinders rather than planar. In the diagram, C is a squirrel-cage grid mounted on a copper tube, D, and is connected to the external radiator, D. The anode, A, consists of a thick-walled copper tube, soldered to a copper disc, B. The cathode is an annular box, F, mounted on the nickel tube, G, which is fixed to the disc, K.

CV82: Oscillator triode having a maximum frequency of 750 MHz. Its efficiency at 600 MHz is 20%.

CV127: Example of an early thoriated filament oscillator triode having an anode dissipation of 40W



CV257: This disc-seal triode had a CW output power of 110W at 600 MHz, falling to 60W at 1GHz. Its peak output under pulse conditions was 20kW. In the diagram, B is a copper thimble anode, C the grid disc and D the oxide-coated cathode.

Figure 15.11: Disc-seal grounded grid oscillator triodes.

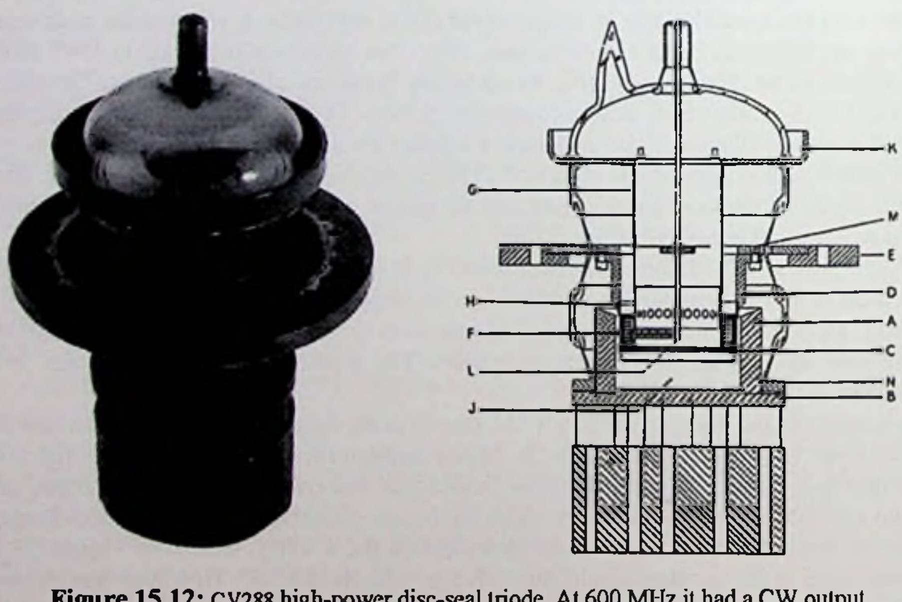


Figure 15.12: CV288 high-power disc-seal triode. At 600 MHz it had a CW output power of 300 watts and under pulse conditions the peak power was 50kW.

3. 'Lighthouse' tubes

These valves had the distinctive stepped shape shown in Figure 15.13 and were a variant of the disc-seal construction [12, 13]. The anode connection is shown at the top, and immediately below this is the disc that connects to the grid. Further down, at the next step, is the cathode. The heater wires are connected to pins on the octal base. 'Lighthouse' tubes were connected in the common-grid, earthed-cathode mode shown in diagram (d) of Figure 15.8. Good high frequency performance was possible but it was not so suitable for anode cooling as the earthed-anode types.

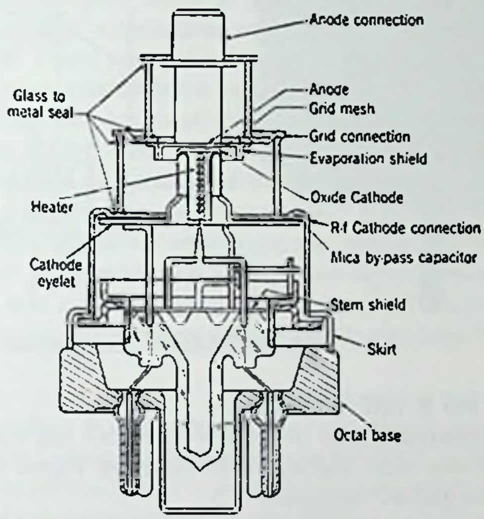


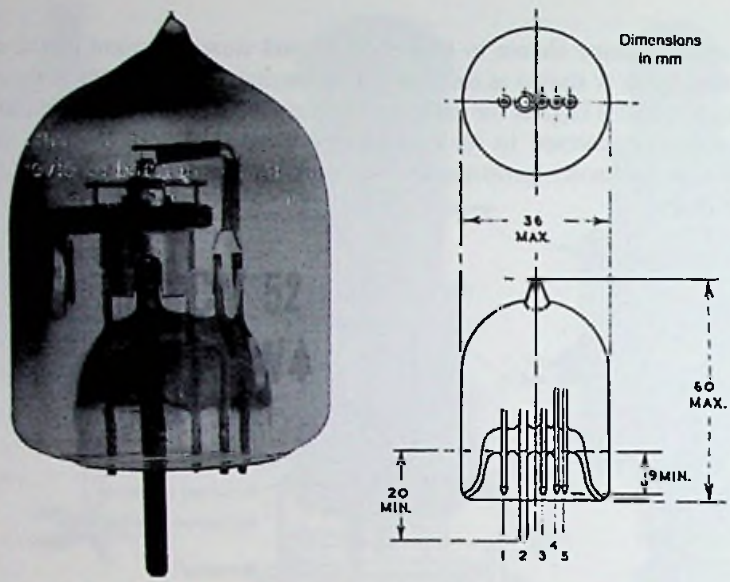
Figure 15.13: GL-446A (CV932) 'Lighthouse' tube manufactured by General Electric. This was a variant of the disc-seal triode. The anode connection is at the top, the grid at the next step down, the cathode at the bottom step and the heater is connected to the octal base.

CV52

The CV52 (Figure 15.14) was designed to be plugged directly into a concentric line and was used as an oscillator triode at 600 MHz. It useful upper frequency limit was 1 GHz. The large pin connecting through the base is connected to the grid and has a diameter of 2.5mm. The anode is connected to pins 1 and 3, the cathode to pin 4 and the heater to pins 4 and 5. The diameter of these remaining four pins is 1mm. The anode was described as a 'monel' metal plate with a diameter of 18mm and carbonized on its outer surfaces. The grid is a squirrel-cage, similar to those used on the larger valves and has 60 molybdenum wires 0.05mm in diameter on a circle of pitch 4.95mm and held between nickel bands 2.2mm apart. The cathode is a nickel shell 2mm long and oxide coated on its cylindrical surface. The grid-cathode spacing is 0.09mm.

FREQUENCY RANGE

The valves described so far had been designed for operation in the range 200 MHz to 1GHz, but valves had been produced capable of operation up to up to even higher frequencies. For example the E1321 could provide a gain of 8dB at 3GHz, although its noise performance was no better than a crystal mixer above 1.6GHz. In addition, the E1344 could be used as an oscillator up to 3GHz, although resonance in the support wires caused some blank spots at around 2GHz. It would appear that 3GHz was more-or-less the upper limit of these types of valves, after which magnetrons and klystrons took over.

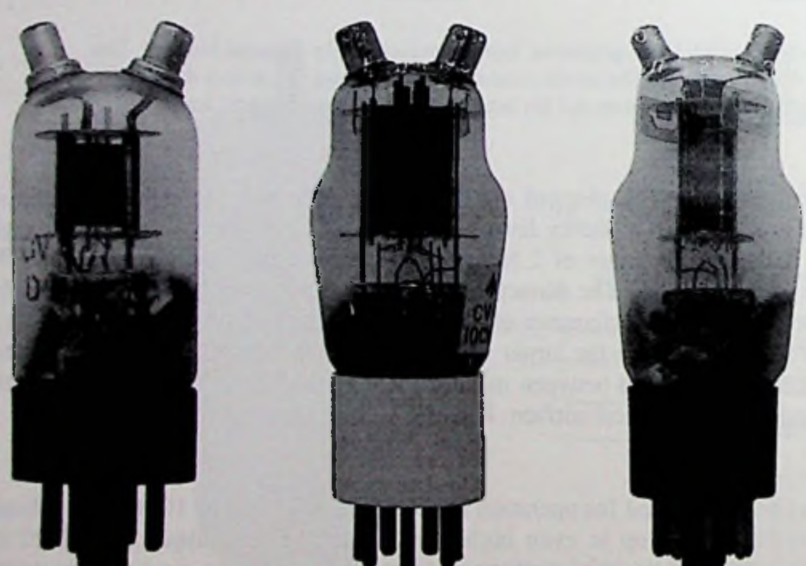


Pin No	Electrode
1	Anode
2	Grid
3	Anode
4	Cathode & Heater
5	Heater

Figure 15.14: CV52 u.h.f. triode for use up to 1GHz.

LOW-POWER HF & VHF VALVES

As previously mentioned, most of the low-power h.f. and v.h.f. valves had commercial equivalents and had been used in pre-war radio and television receivers. Figure 15.15 shows three r.f. low-power triodes which were used in radio and IFF apparatus.



CV6 = DET20: r.f. triode used in IFF equipment.

CV18 = DET19: r.f. double triode with USM7 base.

CV63 = E1323: v.h.f. triode for operation up to 300 MHz.

Figure 15.15: Three examples of v.h.f. triodes.

CV2: midget gas triode for artillery fuzes.

Figure 15.16

FUZE VALVES

In the early part of the war the British Pye Company embarked on a programme to develop a radio-controlled artillery fuze for shooting down enemy aircraft [14]. It was already recognized that existing artillery shells were practically useless, for it had been calculated that during the London Blitz the anti-aircraft guns each night fired off 30,000 shells, wore out 20 gun barrels, and brought down only two or three German aircraft.

The work at Pye, which started in 1940, was aimed at building a tiny transmitter and receiver inside the shell to set off the fuze when the shell was within killing distance of the aeroplane. High priority was given to the development programme with miniature, rugged valves manufactured by Hivac and GEC.

British industry was unable to solve the complex technical problems involved in the design and manufacture of the fuze, particularly valves capable of withstanding enormous gravitational forces. The basic design of the fuze was passed to America by the Tizard mission in 1940 where 1500 engineers and scientists worked on perfecting its design. The valves were manufactured by Sylvania where, at the peak, 400,000 valves were being produced each day [15]. The final design of the fuze consisted of a Hartley oscillator coupled to an antenna receiver in the nose cap of the shell. The presence of a conducting object near the antenna altered its radiation resistance. This resulted in a change of the direct anode current flowing in the oscillator valve which was filtered, amplified and passed to a thyratron valve. When the grid voltage of the thyratron exceeded its threshold value the thyratron conducted and trigged the explosive charge.

Although a few thousand fuze valves were produced by Hivac they were never used operationally. The valves did, however, have CV numbers. CV1 was a triode, CV2 a thyratron and CV4 a pentode. The CV2, shown in Figure 15.16 has dimensions of 44mm length and 16mm diameter. (See also page 98.)

POST OFFICE VALVES

Soon after the first introduction of amplifying valves in 1913, the British Post Office began serious work on both the evaluation of existing valves, such as the Lieben Reisz valve and the de Forest audion, and the design of valves in their own laboratories. The initial requirement was to provide repeater stations to amplify signals on their telephone cables. The French TM hard valve was introduced into Britain in 1916 and the Post Office very soon realized that this valve, or variants of it, would be most suitable for repeater circuits.

With the introduction of repeaters it was possible make a reduction in the weight of the copper cable used from 70 lb per mile to 40 lb per mile. By 1926 there were 1100 two-wire and 320 four-wire repeater circuits, using 2800 valves [16].

Typical repeaters at that time had a gain of 40dB for the four-wire two-stage circuits, 25dB for the four-wire, single-stage circuits and 20dB for the two-wire single-stage circuits.

From the very start, the Post Office introduced a numbering system for the valves used in their equipment. The numbers, which ran sequentially from 1, were preceded initially by the two letters VA (meaning Valve Amplifying). However, from 3 onwards, the letters were changed to VT (Valve Thermionic). These letters can cause some confusion with present-day valve collectors because VT was also used by the RAF for transmitting valves[1] and by the US Signal Corps. To avoid the confusion many of the later Post Office valves were marked POVT. The VT designations were eventually superseded by the CV numbering system for all new types and for older types still in service.

Post Office Radio Stations

Whereas repeaters continued to be a major requirement for the Post office, given the rapid expansion of the telephone network, there was, likewise, a growing importance for wireless stations, particularly for trans-continental telegraph and telephone communication.

In January 1923, a 920-acre site was acquired by the Post office at Hillmorton for the building of what became known as the Rugby Radio Station. The first transmitter, operating at a frequency of 16 kHz

[1] As mentioned earlier in this chapter not all the RAF VT valves were transmitting types: several were receiver valves, such as the VT50 which was an HL2K or the VT73 which was an H63.

and a power of 500kW, came into service in January 1926 to provide a worldwide, reliable telegraph service. The power for this transmitter was derived from two banks of eighteen 10kW water-cooled valves in parallel, with a further bank acting as a reserve in event of failure. The valves used in this output stage were the Western Electric type 220-B or its STC equivalent 4220-B.

A further transmitter, operating at 60 kHz and having a power of 300kW, was opened for the first two-way transatlantic telephony service on 1 January 1927 [17]. The transmissions were from Rugby to Houlton in one direction and from New York to Wroughton in the other. Some of the low-power valves used on this link were the VT33 (DER), LS5B, VT25 (LS5) and the DE4.

The important feature of this service was the use of single sideband (s.s.b.), a system whereby the carrier frequency and one of the sidebands was suppressed. The benefits of s.s.b. are:

- There is a significant increase in signal-to-noise-ratio since power is not wasted in the carrier.
- Only half the bandwidth is required.
- Distortion effects due to carrier fading are avoided.
- Two-channel operation is possible with independent sideband operation (one channel in each sideband).

The original receiving station at Wroughton in Wiltshire employed a Beverage aerial five miles long. In order to reduce noise, however, a new receiving station was established at Cupar in Fife.

Perhaps the most important development at this time was the short-wave beam system for telegraphy (and, later, telephony) transmissions, which was developed by the British Marconi Company and particularly by its brilliant engineer, Charles S Franklin [18,19]. Short wave development by the Marconi Company goes back to 1916. By 1921, successful trials had been carried out over a 97-mile distance from Hendon to Birmingham using a 700-watt transmitter at a frequency of 20 MHz (15m). The important feature of this system was the use of aerials with reflectors, which resulted in a very high gain directional beam. This was followed, in 1923, by a 12kW beam station at Poldhu in Cornwall operating at a frequency of about 3.26 MHz (92m), which communicated with Senatore Marconi's yacht, *Electra*. Later experiments between Poldhu and Sydney, Buenos Aires, Rio de Janeiro, and Montreal established beyond any doubt the economical and technical advantages to be obtained from a short-wave beam system.

Following these conclusive trials, the Marconi Company entered into an agreement with the British Post Office in July 1924 to construct a network of Imperial Wireless Stations to connect Britain with its Dominions and the United States. The first of these stations, linking England to Canada, opened service in October 1926. The transmitter power was 10kW and the frequency could be adjusted anywhere between nine to 19 MHz. Other links were soon opened to India, South America, the United States, Egypt, Australia and the Far East.

The following is a list of the advantages obtained by the beam stations compared with the previous high-power, long-wave stations:

- Reduced capital expenditure.
- Considerably less electrical power required, with great cost savings.
- More message throughput.
- The narrow transmission beams reduced interference problems.
- The beam station could be used for multi-channel telegraphy or for the simultaneous transmission of telephony and telegraphy messages.
- The system was capable of carrying facsimile transmissions.

Some of the valves used in the receiver stations at Bridgewater and Skegness were the DE5, LS5D, DE5B and LS5.

The Portishead radio station was opened in February 1928 [21]. Valves used in the transmitter were three VT16 silica triodes (Mullard OC2.5), three VT17 silica rectifiers (U4) and the VT19 (VT9B). The receiver used LS5B, three VT25 (LS5), DE5B, two VT94 (LS8A), DE5 and two VT33 (DER).

A short wave transmitter was installed later at Portishead [22]. This used two T26F silica triodes for the r.f. output.

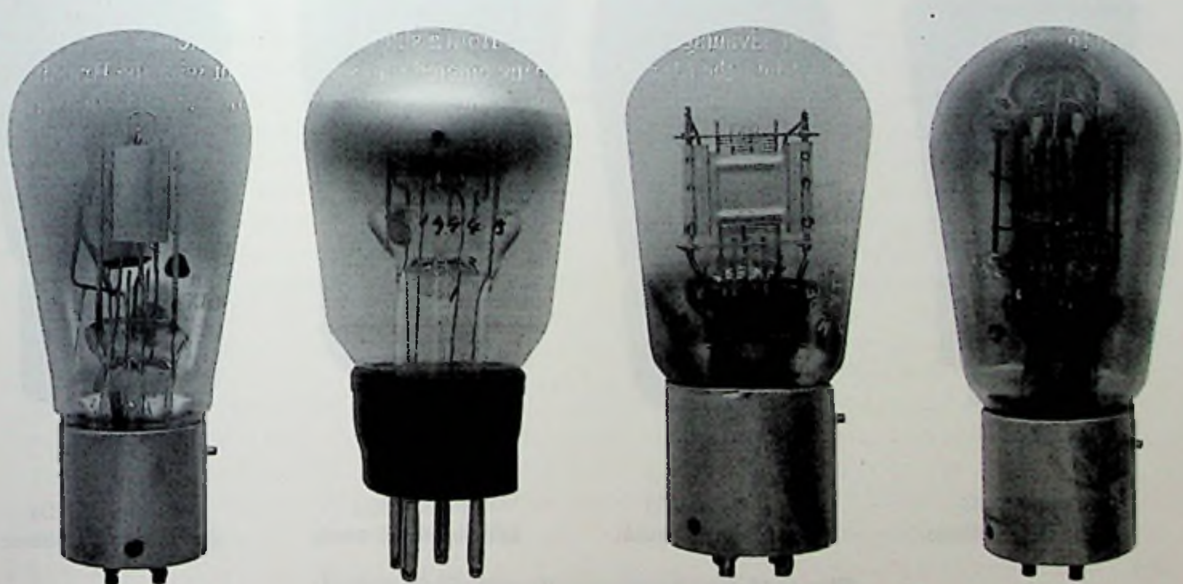
The 1930s saw an extension of commercial services into the v.h.f. band. In 1931, a telephony link at 50–75 MHz was established across the Severn Estuary. In 1934, a six-channel telephony system was opened across the North Channel, and in the following year a nine-channel link was established from Gris Nez to St. Margaret's Bay. In 1937, a 76/83 MHz, nine-channel, four-wire link spanned the 35-mile distance from Stranraer in Scotland to Belfast [23]. All these multi-channel systems relied on the technique of frequency division multiplex using sophisticated LC filters to separate the channels. They also used amplitude modulation and the resulting non-linearity was the major cause of crosstalk between channels. The problem was overcome by converting to f.m., but this method of modulation was not used in the UK until the 1940s.

Post Office types

The post Office VT numbers ran sequentially from 3 to 207 with some types also having suffixes A, B and C. All the types that the author has identified can be found in the Valve Data Supplement, together with some which are believed to have existed but were soon discontinued, such as VT29 and VT30. Those earlier than VT10 were not issued with CV numbers so one must assume that these were no longer in service. Post office valves included in Volume 1 went up to VT34 so there is some duplication of types in this present volume.

The two principal suppliers of valves to the Post Office were GEC/MOV and STC. However valves were also supplied by Ediswan/Mazda, Mullard, Cossor, Tungsram, Brimar and Hivac. Several of the later valves were US types, although Brimar may have supplied these. A small selection of the valves can be seen in Figures 15.17 to 15.19.

Many of the directly heated triode valves were fitted with the American BC4 base rather than the more usual British 4-pin, B4 base; examples of these can be seen in Figures 15.17 and 15.18. A small bayonet pin, which is used to ensure correct location in the socket, extends from the side of the BC4 base and this is located midway between the anode and grid pins.



VT25 (LS5): output triode for telephone repeaters.

VT37B (E132): general-purpose triode.

VT37C (E1644): as VT37B but with BC4 base.

VT38 (E133): low-impedance triode.

Figure 15.17: Miscellaneous Post Office valves.

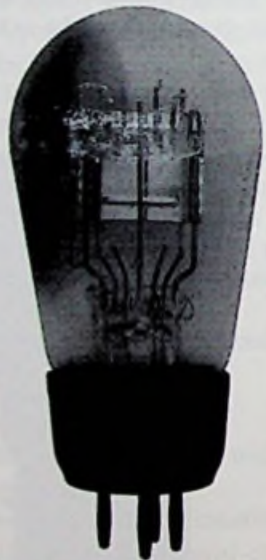
VT38A (E1453):
low-impedance triode.

VT39 (LS5A):
output triode.

VT40 (LS5B):
general-purpose triode.

VT64:
unknown MOV triode.

VT66 (LS5A):
as VT39 but B4 base.



VT68 (G445B):
low impedance triode.

VT78 (LS8):
low impedance triode.

VT80A (LS9B):
general-purpose triode.

Figure 15.18: Miscellaneous Post Office valves (cont.).

VT82 (LS7):
general-purpose a.f. triode.

VT88 (4022AR):
detector or a.f. triode.

CV1672 = VT103B (Pen36):
output pentode.

VT106 (MS/Pen):
r.f. pentode.

VT107 (N43):
output pentode.

VT108 (LS8A):
repeater triode.

VT115 (MP/Pen):
output pentode.

VT125 (PA1)
power triode.

Figure 15.19: Miscellaneous Post Office valves (cont.).

REFERENCES

1. Thrower, Keith R, *British Radio Valves. The Vintage Years: 1904-1925* (Speedwell, 1999, ISBN 0-9537166-0-0), pp. 72-5.
2. Foley, F M, 'History of naval radar 1935–1945: a history of the silica valve', *JNS*, **17**, no, 3, pp. 154-65.
3. Thrower, op. cit., p.75.
4. 'The Holweck Valve', *W.W.*, **13**, 9 January 1924, pp. 458-61.
5. Latham, Colin and Stobbs, Anne, Eds. *The Birth of British Radar: the Memoirs of Arnold 'Skip' Wilkins*, (Speedwell, Reading, England, 2007, ISBN 0-9537-166-2-7).
6. Callick, E B, *Metres to Microwaves: British development of active components for radar systems.* (Peter Peregrinus Ltd, 1990, ISBN 0-86341-212-2).
7. Callick, E B, *The Beginnings of British Radar* (Obtainable from the DEHS, http://www.dehs.org.uk).
8. Fay, C E & Samuel, A L, 'Vacuum tubes for generating frequencies above 100 hundred megacycles', *Proc IRE*, **23**, March 1935, pp. 199-212.
   See also Kelly, M J & Samuel, A L, 'Vacuum Tubes as High-Frequency Oscillators', *BSTJ*, **14**, January 1935, pp. 97-134.
9. Wagener, Winfield, G, 'The developmental problems and operating characteristics of two new ultra-high-frequency triodes', *Proc IRE*, **26**, April 1938, pp. 401-14.
10. Foster, J, 'Grounded-grid amplifier valves for very short waves', *JIEE*, **93**, Part IIIA, no. 5 (1946), pp. 868-74.
11. Bell, J, et al, 'Triodes for very short waves', *JIEE*, **93**, Part IIIA, no. 5 (1946), pp. 833-46.
12. McArthur, E D, 'Disk-seal triodes', *Elec.*, February 1945, p.99.
13. Hamilton D B, Knipp, J and Kuper J, *Klystrons and Microwave Triodes* (McGraw-Hill Book Company Inc, 1948), pp. 9-11 and pp. 163-9.
14. Frankland, Mark, *Radio Man: the remarkable rise and fall of C O Stanley* (Published by The Institution of Electrical Engineers—now re-named The Institution of Engineering and Technology, 2002, ISBN 0-85296-203-7). See 'The Deadly Fuze' pp. 103-12.
15. Burns, R W, 'The early history of the British radio proximity fuzes'. Paper presented to the 22nd IEE weekend meeting on 'The History of Electrical Engineering', pp 21-41. Conference held at the University of Liverpool from 8-10 July 1994.
   See also Burns, R W, 'Early history of the proximity fuze (1937–1940)', *Proc IEE.-A*, **140**, No. 3, May 1993, pp. 224-36.
16. Scowen, Frank, 'The first twenty years of valves in the Post Office Engineering Department'. Paper 2 read at the 12th IEE Weekend Meeting on 'The History of Electrical Engineering', held at the University of Lancaster, 6-8 July, 1984.
17. 'The history of the Rugby Radio Station', BT Engineering Services (September 1995). See also Shaughnessy, E H, 'The Rugby Radio Station of the British Post Office', *JIEE*, **64** (1926), pp. 683-713.
18. 'The Marconi short wave system', *Pamphlet No. 242.* (Published by the Marconi's Wireless Telegraph Company Ltd., *circa* 1927.)
19. Jones, K E. 'Forgotten revolution, forgotten genius? The Marconi short wave beam system of wireless telegraphy 1926–27'. Paper presented to the 27th IEE weekend meeting on 'The History of Electrical Engineering', pp. 12/1-15. Conference held at the University of Bristol, July 1999.
20. The Vice-Presidential Address by A G L Mason to the "Standard" Radio-Engineering Society (24 September 1964), p. 12.
21. 'Portishead Radio Station', *POEEJ*, **21**, No. 3 (October 1928), pp. 243-50.
22. 'Portishead Short Wave Transmitter', *POEEJ*, **23** (April 1930), pp. 69-75.
23. Mirk, D B, 'The Belfast-Stranraer 9-Circuit Ultra-Short Wave Radio Telephone System', *POEEJ*, **31**, (April 1938), pp. 33-40. (Note: at the time this paper was written the frequency band from 30–300 MHz was known as ultra short wave, u.s.w., whereas today it is the v.h.f. band.)

Appendix 1
Glossary of Valve Terms

Acorn valve. A valve so named because its shape and size resembled those of an acorn. The valve was developed by RCA in 1933 for use at v.h.f. and u.h.f. The first British versions were produced in 1936.
Aligned grid valve. A type of valve in which the wires of the screen and control grids are aligned in order to reduce the screen current. See beam tetrode.
All-dry valves. Valves with low-power filaments designed to operate from dry batteries. British all-dry valves were first produced in 1940 and had 1.4V filaments, most of which only required a current of 50mA.
All-glass valve. A valve in which both the envelope and the foot are made entirely of glass. The first British examples were the EE50 and EF50, which were introduced in the late 1930s and were of Philips design.
Amplification factor. A fundamental property of a valve that relates the small change of voltage at one electrode (usually the anode) to a corresponding small change of voltage at the control grid, both giving the same change of current at the first electrode. Its value remains substantially constant over the working range of the valve. Symbol μ or mu.
Anode. Usually the outer electrode of a valve which, when positively biased, attracts the electron current. Multiple valves often have several anodes: for example, a double diode triode has three anodes—one is used in the triode and one each in the two diodes. See also plate.
Anode bend detector. Detection of a radio signal by operating the valve over the curved potion of the anode-current/grid-voltage characteristic.
Anode dissipation. The power dissipated at the anode, which is given by the product of the mean values of anode current and anode-to-cathode voltage.
Anode dynamic resistance. A fundamental property of the valve that relates a small change of anode voltage to a corresponding small change of anode current, with the potential of all other electrodes held constant. Symbol is r_a and the value is given in ohms. Also known as anode slope resistance and dynamic anode resistance.
Audion. A name given by Lee de Forest for his soft valves. The first audion was a two-electrode valve similar to Fleming's diode. Late in 1906, however, de Forest produced the grid audion, a triode valve which was originally used only as a radio wave detector. The grid audion was first used as an amplifier in 1912.
Auto bias. A means for obtaining grid bias by use of a resistor in series with the cathode connection.
Auxiliary electrode. Any electrode in a valve that plays a secondary part in its operation.
Auxiliary grid. A name sometimes used for the screen grid or suppressor grid (q.v.).
Barium filament. Another name for a filament coated (principally) with barium oxide.
Barretter A ballast resistor made of a coiled iron filament in an evacuated glass envelope and filled with hydrogen to a low pressure. Used in d.c. or a.c./d.c. receivers as a current regulator for the series-wired valve heaters. The barretter can maintain a near constant current over a wide variation of mains voltage.
Base. The bottom part of the valve through which the connecting pins or wires are terminated.
Beam plates. Metal plates placed inside a valve to focus the electron current from the cathode into a beam. See also beam tetrode.
Beam tetrode. A valve originally developed for use in the power output stage of an audio amplifier but later also used as an r.f. amplifier. It uses beam plates to concentrate the electron current to the anode and to repel secondary electrons back to the anode. The screen current is usually minimized by careful alignment of the wires that form the control and screen grids. The alignment of these grids causes the electrons to concentrate

into sheets. The beam tetrode is more linear than an equivalent pentode valve; in particular, it produces less odd order harmonic distortion.

Bi-grid valve. An early type of valve having two grids, both used for control purposes. Its main use was as a mixer in superheterodyne receivers.

Bi-grille valve. A French name for the bi-grid valve (q.v.).

Blue glow. A condition that occurs in a valve due to the ionization of residual gas, which glows with a blue colour. It is usually a sign that the valve has gone soft but can also occur in high-vacuum power valves.

Bright emitter. Name given to valves that had pure tungsten filaments. In order to achieve a satisfactory emission, it was necessary to operate the filament at a high temperature (typically 2400K). At this temperature, the filament glows bright yellow.

Bulb. The glass or metal envelope that encloses a valve.

Cap. A name given to an electrode termination at the top of a valve. Also known as top cap. The name has also been used for the valve base.

Cathode. The primary electrode used as the source of electron current.

Cathode ray. A stream of electrons that flows from the cathode and is focused into a beam by electric or magnetic fields.

Cathode-ray relay. An early amplifying device developed by von Lieben in 1906. A focused electron beam from an incandescent parabolic cathode was directed towards a pair of concentric anodes. Holes were provided in the anodes to allow the electron beam to enter and to flow in each anode circuit. The beam was deflected by external coils connected to the input signal. The output signal was taken from the inner anode. Deflection of the beam by the input signal caused a variation of current to the inner anode and this resulted in amplification of the signal.

Catkin valve. A type of low-power radio valve produced by Marconi-Osram in 1932. Most of the outer envelope was made of metal, which formed the anode. The name was derived from a series of Cooled Anode Transmitting (CAT) valves which, although much larger, also had an outer metal anode. The valves were discontinued after a couple of years because of manufacturing problems.

Characteristic curve. Graphical representation of a valve's characteristics. The most common of these are (i) the anode current/grid voltage characteristics for various values of anode voltage and (ii) the anode current/anode voltage characteristics for various values of grid voltage.

Cold cathode. A type of cathode that can emit electrons without being heated. Emission takes place due to non-thermionic effects, such as a high electric field, exposure to light, or bombardment by radioactive particles.

Control grid. An electrode, normally formed into a wire helix and surrounding the cathode, which is used to control the current that flows in the valve.

Control ratio. The amount by which the anode potential for ionization in a thyratron valve must be raised for each volt of bias applied to the grid.

Conversion conductance. A parameter of a mixer valve that relates the anode current at the desired intermediate frequency to the signal voltage. It is normally expressed in mA/V or µA/V. Symbol g_c.

Converter. See frequency changer.

Critical distance tetrode. A tetrode output valve developed by Owen Harries in 1935 and used by Hivac. The anode was spaced at a 'critical distance' (ideally 3cm) from the screen grid. It was found to have lower distortion and better efficiency than an equivalent pentode output valve. In practice the spacing usually much less then 3cm.

Cut-off. A condition that occurs when the voltage applied to the control grid reduces the anode current to zero. The condition can arise because of a high negative bias applied to the grid, or can occur during part of the negative excursion of an input signal.

Demodulator. A device used to separate the modulating signal from a carrier. See detector.

Demountable valve. Name given to a type of transmitter valve that can be disassembled for repair—typically to replace a burnt-out filament. The best known of these was the Holweck demountable valve (q.v.).

Detector. A device responsive to an r.f. carrier. The earliest thermionic detector was the Fleming diode that was used to detect c.w. signals. Detectors of amplitude modulated signals rely upon non-linear characteristics of the valve to demodulate the signal.
Diode. A two-electrode valve consisting of a cathode and anode. The earliest applications were as a detector of radio frequency signals and as a mains rectifier.
Directly heated cathode. A filamentary cathode which, when heated to a sufficient temperature, emits electrons and provides the prime source of current in a valve. See also bright emitter, dull emitter and oxide-coated cathode.
Disc-seal valve. A type of valve specially developed for use at u.h.f. in which the grid (and, sometimes the anode and cathode) is brought out as an annular ring projecting through the glass envelope. The valve is typically operated in the grounded-grid configuration either as an oscillator or an amplifier and is frequently integrated into a transmission line.
Dispenser cathode. A cathode made of fine molybdenum wires in a tubular mesh, embedded with barium oxide. During use the barium oxide slowly evaporates to the surface to replace that lost through bombardment by positive gas ions.
Doorknob valve. A compact valve, of bulbous construction, designed for use at v.h.f. and u.h.f. The connecting pins were sealed directly through the glass bulb to minimize capacitance and inductance.
Double diode/Duo diode. A valve which contains two diode valves within one envelope. The diodes may have separate cathodes or a common cathode.
Double diode triode. A valve which combines two diodes and one triode in the same envelope. Commonly used in superheterodyne receivers for the a.m. demodulator, a.g.c. rectifier and audio amplifier functions.
Double diode pentode. A valve which contains two diode valves and one pentode valve within the same envelope. The diodes are typically used as an a.m. demodulator and a.g.c. rectifier, the pentode is normally used as a power output valve, but sometimes as an i.f. amplifier.
Double grid valve. A valve which has two separate control grids. See also bi-grid.
Dull emitter. Originally, a valve with a directly heated filament made from thoriated tungsten and operated at a temperature of about 1800K. At this temperature the filament glowed yellow. In later years the name was also used for valves having oxide-coated cathodes (q.v.) which operated at a temperature of about 1050K.
Durchgriff. A valve parameter that relates the effectiveness of the potentials at the grid and anode in determining the electric field at the cathode. Equal to the reciprocal of the amplification factor ($D = 1/\mu$). Also known as penetration factor. (From German *durchgreiffen* to reach through).
Edison effect. The unilateral flow of current from the filament of an incandescent lamp to a specially inserted plate, which is externally connected to the positive leg of the filament. This discovery was made by the American inventor, Thomas Alva Edison, in 1883.
Efficiency diode. A television diode used to boost the beam deflection voltage.
Electrode. An element within a valve which is used to emit, control, deflect or collect electrons.
Electrometer triode. A high vacuum valve of special internal construction used for the measurement of very low currents. The amplification factor of the valve is usually less than unity.
Electron. A fundamental particle which has a rest mass of 9.109×10^{-31}kg and a negative charge of 1.606×10^{-19}C. The electrons are grouped in shells around the nuclei of atoms. The outermost electrons in metals are responsible for electric conduction. Electrons also have wave properties.
Electron-ray tube. Another name for 'magic-eye' tuning indicator (q.v.).
Electron tube. A more recent term for thermionic valve.
Electrostatic screen. A metal screen placed inside or outside a valve to prevent electrostatic coupling.
Emission. The release of electrons from a surface due to heat, electromagnetic radiation, electric field, bombardment by electrons or positive gas ions, or by nuclear radiation.
Envelope. The outer structure of a valve. Normally made of glass or metal.
Equivalent noise resistance. A fictitious resistor which, if placed in the grid circuit of a valve, would produce the same noise output from the valve as that due to the internal noise of the valve.

Exhaust tube. A glass or metal tube that passes through the stem into the valve and is connected to the vacuum pumps during the evacuation process. The final seal is formed at the end of the tube.
Field emission. Electron emission which is caused by a high electric field.
Filament. Type of directly heated cathode, usually made from tungsten or nickel wire. The wire is often treated with various metallic oxides to improve the thermionic emission. See also bright emitter, dull emitter and oxide-coated cathode.
Filamentary cathode. A directly heated cathode consisting of a wire filament. Typically the filament is a straight wire, or formed into a V or W shape, although many other shapes have been used over the years.
Fleming diode. The name given by Fleming to his early diode detector valves. The original Fleming diode had a carbon filament and a cylindrical anode. Later valves used a tungsten filament.
Flicker noise. Noise of low frequencies due to random fluctuations in the electron emission from the cathode.
Footless valve. A metal envelope valve developed by Telefunken where the electrode assembly is mounted horizontally. A Tungsram version of the valves had a glass bulb with a covering metal envelope.
Four-electrode valve. A generic name for any valve with four electrodes, but the name was usually applied to one having two grids, an anode and cathode.
Frame grid valve. A valve in which the grid, which is made from fine tungsten wire, is wound under tension on to a rigid frame, giving a precision structure.
French valve. A low-power, high-vacuum, triode valve developed by the French Military Telegraphic Service in 1915. The valve was manufactured in large numbers by the two companies Métal and Fotos. Also known as the TM valve. See also R-valve.
Frequency changer. A type of valve that combines a mixer and local oscillator in one envelope. Typical frequency changer valves are: heptode, octode, triode hexode, triode heptode and triode pentode. Also known as a converter.
Full-wave rectifier. A type of double diode valve which is used to convert both negative and positive half-cycles of an alternating voltage into a pulsating direct voltage. Its principal use is in power supply circuits.
Gas triode. See thyratron.
Getter. A substance placed inside a valve and volatized during the evacuation process. The getter adsorbs residual gases and helps maintain the vacuum. The most common material used is barium, which is usually mixed with aluminium and magnesium. During the 1920s, the getter was normally made from pure magnesium, but phosphorus was also used to a lesser extent.
Grid. A valve electrode usually made of wire and formed into a helix. All amplifying valves contain at least one grid for control purposes. See also control grid, screen grid and suppressor grid.
Grid audion. A valve produced by Lee de Forest at the end of 1906. It consisted of a wire filament, flat plate anode (also known as a wing) and a spiral grid. The valve had a poor vacuum and was used initially only as a radio wave detector. Some versions of the valve had two plate anodes. Usually known as the Audion.
Grid bias. The negative bias voltage applied to the control grid to enable the valve to operate under optimum conditions.
Grid-controlled tube. See thyratron.
Grid emission. Electron or ion emission from the grid of a valve, often caused by heat from the cathode.
Grounded-grid triode. A type of triode first produced in 1940 for use as a u.h.f. amplifier or oscillator. The grid was connected to a copper disc which was sealed through the glass envelope. As the name suggests, the grid was connected to ground. See also disc-seal valve.
Half-wave rectifier. A device which conducts during one half-cycle only of an alternating voltage, converting it to a pulsating direct voltage.
Hard valve. A high vacuum valve. Typically the gas pressure within the valve is less than 10^{-5} Torr (q.v.).
Heater. A wire element used to heat an indirectly heated cathode (q.v.). It is usually made from alumina-coated tungsten.

Heptode. A seven-electrode valve used as a frequency changer or a mixer in a superheterodyne receiver. The electrodes consist of a cathode, an anode and five grids. With the frequency changer version one of the grids act as an oscillator anode (see also pentagrid). The mixer version is a hexode plus a suppressor grid.
Hexode. A six electrode-valve used as a mixer. The electrodes consist of a cathode, an anode and four grids.
Houskeeper seal. A copper-to-glass seal developed in 1918 by William Houskeeper for use with high-power valves.
Holweck valve. A water-cooled transmitting valve that could be assembled and disassembled at will. It was designed by Dr. F. Holweck and used initially for the Eiffel Tower transmitter in 1923. The vacuum was maintained by a Gaede-type molecular pump, which was also developed by Holweck.
Indirectly heated cathode. A cathode, usually made of an oxide-coated nickel tube, which is heated by a separate element. The indirectly heated cathode was developed for use with mains power operated equipment. The heating element is constructed to minimize magnetic fields, and electrostatic shielding is provided: both of these measures are necessary to prevent mains-frequency modulation of the anode current.
Induced grid noise. The noise current induced into the grid wires of a valve by random fluctuations in the anode current. Its magnitude is proportional to the transit time component of the input resistance, and thus increases with frequency.
Injection grid. A grid in a mixer to which the local oscillator signal is applied.
Inter-electrode capacitance. The internal capacitance which exists between the various electrodes of a valve. The most important of these are the anode to control grid and the control grid to cathode capacitances.
International octal. An eight-pin valve base with central, keyed locating spigot developed in America in 1935 for the new range of metal valves. It was used extensively in Britain from 1937 to the mid-1950s.
Ion. An atom or a group of atoms that possess an electric charge. Within a valve, positive gas ions arise when high velocity electrons from the cathode strike the gas molecules and dislodge electrons from the outer shells of their atoms.
Ionic tube. An early type of soft valve that relied upon ionic conduction for its sensitivity.
Ionisation. A process whereby a substance gains or loses electrons and is left with a net positive or negative charge
Johnson noise. See thermal noise.
Kalenised filament. Term used by Cossor in 1927 for the oxide-coated filament of their new 'Point One' series of valves. Origin of the name is unknown.
Kenotron. Name given by Langmuir in 1915 for his high vacuum diode valve. (Derived from Greek, *kenos* for vacuum, and *tron* for instrument.)
Kinkless tetrode. See beam tetrode.
Lead-out. The wire that comes through the valve seal and connects to the inner electrode, supports or screens.
Lighthouse tube. A valve designed for use at u.h.f. which has cylindrically-shaped parallel electrode with close spacing to minimize the transit time. The stepped construction resembles that of a lighthouse Similar to disc-seal and megatron valves (q.v.).
Load line. A line drawn on the anode voltage/anode current characteristic of a valve to determine its operation range as a voltage or power amplifier.
Loctal/Loktal base. An eight-pin valve base which locks into the valveholder. The valve pins are sealed into the glass base.
Loewe multiple valves. A series of valves developed by the German engineer von Ardenne for the Loewe company over the period 1926 to 1937. Several valves, for example three triodes, were combined within one envelope and coupled together with internal capacitors and resistors.
Long grid-base valve. A variable-mu valve where the grid cut-off voltage is high, e.g. –30V.
'Magic-eye'. A type of tuning indicator which consists of a triode amplifier and elementary cathode-ray tube inside a common envelope. A V-shaped shadow is formed on a fluorescent screen at the top of the valve, which closes as the grid voltage of the triode is made more negative.

Magnification factor. See amplification factor.
Magnification ratio. Another name for amplification factor.
Mazda octal. An octal valve base introduced by Mazda in 1938. It was very similar to the international octal (q.v.) base, but the dimensions were slightly different.
Megatron. See disc-seal and lighthouse valves.
Metallising. A thin layer of metal, usually zinc or copper that is sprayed onto the outer glass surface of a valve to provide electrical screening from external r.f. fields.
Metal valve. Valve with a bulb made of metal.
Microphony. Noise in a valve resulting from mechanical movement of the internal electrodes and their supports. This was a serious problem with early valves.
Mixer. A non-linear device which produces sum and difference frequencies at the output from two or more frequencies, or harmonics of the frequencies, applied at its inputs.
Micropup. A high-power pulsed valve produced by GEC in the late 1930s for radar applications. The valve has an external ribbed anode made of copper. The first type to be produced by GEC was the E1046, later given the Service number VT90.
Modulator valve. A valve where the alternating anode potential is applied to a second valve for modulating its current, the resulting output being an amplitude modulated waveform.
Multi-electrode valve. A valve having more than three electrodes.
Mutual conductance. A fundamental property of a valve that relates a small change of anode current to a small change of control grid voltage, with the potential of the anode and all other electrodes held constant. Symbol g_m, and the value is usually given in mA/V or μA/V. Also known as transconductance or slope.
Negative resistance region. In a screen grid tetrode valve, it is the region of decreasing anode current for increasing anode voltage. This region is where the anode voltage is less than the screen grid voltage and is caused by secondary emission electrons from the anode being collected by the screen grid.
Negatron. A type of negative resistance valve patented by Scott Taggart in 1919. The valve had a filament, two anodes and no control grid.
Neon tube. A small tube filled with neon gas to a low pressure. When the applied voltage exceeds a certain value, the gas ionizes, resulting in a visible red glow. The tube was used as a voltage stabilizer.
Noise diode. A diode operated in its saturation region (i.e. without a space charge) and used as a noise generator for measurement purposes. In the saturation region, the noise generated depends upon the cathode temperature.
Noise factor. The noise factor, F, of an amplifier is defined as the ratio of the total noise power at the output, divided by the noise power at the output arising from the signal source alone.
Noise figure. The same as noise factor (q.v.), but usually expressed in decibels.
Noval base (B9A). A miniature nine-pin valve base with pins that come directly through the glass base of the envelope.
Nuvistor. A tiny valve introduced by RCA in 1959, which has closely spaced cylindrical electrodes mounted in a metal envelope with a ceramic foot.
Oxide-coated cathode. A type of thermionic cathode, where the filament or metal sleeve is usually made of nickel (or a nickel alloy), and coated with the oxides of barium and strontium. For early directly heated cathodes the filament wire was often platinum, and for later, low-power filaments the wire was usually tungsten or a tungsten alloy. Various other earth oxide combinations have been used for the coating.
P-base. A continental valve base having eight side contacts.
Partition noise. Noise in multi-electrode valves caused by the random division of the cathode current passing to the various electrodes.
Peanut valve. See Wecovalve.
Penetration factor. See durchgriff.
Pentagrid. An American name for the heptode frequency changer.
Penthode. A name originally used by Philips for the pentode (q.v.).

Pentode. A five-electrode valve consisting of anode, cathode, control grid, screen grid and suppressor grid.
Pentone. A trade name used by Mullard for the pentode (q.v.).
Photo electric cell. A vacuum device in which the cathode emits electrons when irradiated by light. The cathode is typically coated with cesium oxide.
Photo emission. Emission from a cathode when irradiated by light.
Photo multiplier. A photo electric device in which the primary electrons from a photo cathode pass through a series of cascade stages, where further electrons are released by secondary emission. Photo multiplication takes place at each stage. The overall multiplication depends upon the construction, but can vary between about a thousand and a million.
Pin. A metal termination connection, usually at the base of the valve.
Pinch. The top portion of the internal glass stem of a valve, in which a vacuum seal is formed for the electrode support wires and their connecting leads.
Pip. The place in the glass envelope where the final vacuum seal is made.
Plate. An American name for the anode.
Pliotron. The name that Irving Langmuir used in 1915 for his high vacuum triode. (Derived from Greek, *pleion* for more, and *tron* for instrument.)
Primary emission. The principal emission within a valve. See also secondary emission.
Protective net. A primitive form of screen grid invented by Schottky in 1916, which was placed between the control grid and anode. Its purpose was to increase the amplification factor by reducing the retroactive coupling between the anode and control grid. In a similar way to a screen grid, it was biased at a positive potential, lower than that of the anode.
Push-pull valve. A power output valve in which two matched triodes or pentodes are mounted within one envelope.
Quiescent Push-Pull (QPP) valve. A battery-operated double pentode which is biassed almost to cut-off and operated in Class-B. This ensures low current consumption except at peaks of power output.
Quadrode. A name used for four-electrode valves (q.v.).
Quintode. The original name used by Cossor for the pentode.
R-valve. An early, low-power, high-vacuum valve that was derived from the 'French' valve (q.v.). The R-valve and its many derivatives were produced by most British valve manufacturers during the period 1916-25.
Rectifier. A device which conducts during one half-cycle only of an alternating voltage.
Remote cut-off valve. See variable-mu valve.
Rimlock. A type of valve having eight pins sealed into a glass base. A metal ring is fitted at the bottom end of the glass envelope, which has a small hemispherical projection, used for locking the valve into its holder.
Saturation. A condition which occurs when the entire cathode current has been collected by the anode or other positive biased electrodes. Any further increase of anode voltage has little effect on the current.
Schroteffect. The random variation in current that occurs in a temperature limited diode. The effect was discovered by Schottky in 1918.
Screen(ed) grid. A positively biased grid, placed between the control grid and anode, to provide electrostatic screening and thereby reduce the capacitance between them.
Screen(ed) grid valve. A four-electrode valve for use primarily as a radio frequency amplifier. It consists of an anode, a cathode, a control grid and a screened grid. The first British screened grid valve was the MOV type S625, which became available at the end of 1927.
Seal. Usually refers to the pip (q.v.) of the valve where the final vacuum seal is made.
Secondary emission. The emission of electrons within a valve caused by the impact of charged particles. It usually results from the primary cathode electrons impacting the anode or other electrodes.
Secondary emission valve. A valve where the primary electrons from the cathode pass through the control grid and screen grid, after which they are diverted to an auxiliary cathode where secondary electrons are released on impact and collected by the anode. This results in a considerable increase in the mutual conductance.

Shielded grid valve. Another name for screened grid valve (q.v.).
Short grid base valve. A variable-mu valve where the cut-off voltage is relatively low, e.g. –10V.
Shot effect. Random variations in the space current of a valve caused by variations in the number of electrons flowing between the electrodes.
Shot noise. Noise resulting from the random emission of electrons from the cathode. See also Schroteffect.
Side contact base. A type of valve base used by Philips, Mullard, Tungsram and several other European companies which had flat contacts at the base, with connection made at the edges. See also P-base and V-base.
Shadow grid. Another name for aligned grid (q.v.).
Side terminal. A terminal at the side of a valve connecting to one of the internal electrodes. With early output pentode valves, the connection was to the screen grid; with early indirectly heated triodes, the connection was to the cathode.
Slope. Another name for mutual conductance.
Socket. The holder into which a valve plugs.
Soft valve. A poorly evacuated valve or a valve which has been deliberately filled with gas at a low pressure. The gas pressure is typically greater than 10^{-1} Torr (q.v.).
Space charge. A negative charge close to the cathode due to the emission of electrons. Provides the source of current that flows to the anode and other positively charged electrodes. The space charge is reduced virtually to zero when the valve reaches saturation.
Space charge grid. A grid placed between the control grid and cathode in early four-electrode valves (q.v.). It was biased at a low positive potential with the purpose of reducing the space charge (q.v.) and enabling the anode to be operated at a low voltage.
Spigot. A keyed pin centrally located in a valve base to facilitate insertion into the valve socket.
Stem. A glass tube within the valve through which the connecting leads pass. A vacuum-tight pinch (q.v.) is formed at the top, where the leads connect to the internal support wires. From the mid-1920s, the exhaust tube (q.v.) also passed through the stem.
Suppressor grid. A grid placed between the screen grid and the anode and connected to a low potential, to minimize the flow of secondary electrons between them.
Target. A fluorescent coated anode used in a tuning indicator. It glows when impacted by electrons.
Tetrode. A four-electrode valve. It normally consists of an anode, a cathode, a control grid and a screened grid.
Thermal noise. Noise due to the random fluctuations of electrons within a conductor. The noise power is directly proportional to the absolute temperature.
Thermionic cathode. A cathode which emits electrons when raised to a high temperature.
Thermionic emission. The emission of electrons from a surface, such as a cathode, by raising it to a high temperature.
Thermionic valve. A vacuum device in which current flows from a thermionic cathode (q.v.) to one or more other electrodes.
Thoriated filament. A tungsten filament which includes a small quantity of thoria to improve its thermionic emission. By a special activation process pure thorium is deposited as a monatomic layer on the surface. The filament is then operated at a temperature of 1800-1900K, considerably lower than that of a pure Tungsram filament.
Three-electrode valve. Any valve with three electrodes, but the term usually refers to a triode (q.v.).
Thyratron. A gas filled relay valve which may be switched into conduction by applying a suitable voltage to a control electrode, analogous to a grid. After the valve switches into conduction, the grid loses control of its action and the current can only be switched off by reducing the anode potential. (From Greek *thura*, a door.)
TM valve. A name used for the 'French' valve (q.v.) developed by Ferrié in 1913.
Top cap. An electrode connection made at the top of the valve. Originally a screw connection was used, but a small metal thimble later replaced this.

Torr. A unit of gas pressure equal to 1mm Hg. Named after the Italian physicist, Evangelista Torricelli, who discovered atmospheric pressure in 1644.
Transconductance. An American name for mutual conductance (q.v.).
Transit time. The time it takes for the electrons to travel between the electrodes of a valve. Special techniques are used to reduce this time in valves designed for operation at u.h.f.
Triode. A three-electrode valve consisting of an anode, a cathode and a control grid.
Triode heptode. A frequency changer valve which combines the electrode assemblies of a triode and a heptode in the same envelope. The triode is used as a local oscillator and the heptode as a mixer.
Triode hexode. A frequency changer valve which combines the electrode assemblies of a triode and a hexode in the same envelope. The triode is used as a local oscillator and the hexode as a mixer.
Triode pentode. A valve which combines the electrode assemblies of a triode and a pentode in the same envelope. When used as a frequency changer, the triode is used as a local oscillator and the pentode as a mixer.
Triple Grid pentode. An output pentode where the suppressor grid is brought out to its own base pin rather than internally connected to the cathode.
Tube. An American name for valve, but also frequently used in Britain.
Tuneray. Name used by MOV for their 'magic-eye' tuning indicators.
Tuning indicator. A device which responds to the strength of a signal and provides a means to assist the tuning, for example of a radio receiver. See also 'magic-eye'.
Universal valve. A valve designed for series heater operation, for use on a.c. or d.c. mains supplies.
Uniwatt. A range of low heater consumption, indirectly heated valves introduced by MOV in 1939. The principal application was for car radios.
V-base. A continental valve base having five side contacts.
Vacuum. A space totally devoid of gas. In practice, the gas pressure of a hard valve is typically 10^{-6} Torr.
Vacuum tube. An American name for a high vacuum valve.
Valve. An electronic device in which electrons flow from a cathode to one or more other electrodes. The name includes both gas filled and vacuous devices.
Valveholder. The socket into which a valve plugs.
Variable-mu valve. A valve so designed that the amplification factor and, hence, the mutual conductance varies widely over the operating range of the grid voltage. It provides a means for automatic gain control in radio receivers.
Virtual cathode. Any region in a valve where the electric field between the electrodes is zero.
Water cooled valve. A high-powered valve which has an outer jacket through which cooling water is passed.
Wecovalve. A small valve manufactured, initially, by Western Electric in 1919. The first of these was the type N, and this was superseded by the 215A in 1920. The valve had an oxide-coated filament. It was sold in Britain, under the name 'Wecovalve', by STC (types 4215A and 4215B), BSA and Mullard. The first British versions of the valve had a miniature four-contact base, but later versions were fitted with the standard four-pin base.
Wehnelt cathode. An oxide-coated cathode named after the inventor, Wehnelt, who first demonstrated its emissive properties in 1904.
Wembley filament. A name used by MOV for an improved form of oxide-coated filament introduced in 1931. Developed at the GEC Research Laboratories in Wembley.
Wing. Early American name for plate (q.v.).
Wuncell. A name used by Cossor for their early 2-volt oxide-coated filament valves introduced in 1924. Two valves in the series had a switched resistor included in their base, allowing them to be operated from two-, four- or six-volt batteries.

Appendix 2
Miscellaneous Abbreviations & Symbols

A	ampere	kHz	kilohertz
a.c./AC	alternating current	kV	kilovolt
a.f./AF	audio frequency	kW	kilowatt
a.g.c.	automatic gain control	l.t./L.T.	low tension
AI	Air Intercept	m	metre, milli (one thousandth)
a.m.	amplitude modulation	M	mega (one million times)
amp.	Amplifier	mA	milliamp
ASV	Air to Surface Vessel	mA/V	milliamp per volt
C	Celsius or coulomb	MHz	megahertz (one million hertz)
CRT	cathode-ray tube	mm	millimetre
cap.	capacitance	mu	amplification factor (also written as μ)
c.w./C.W.	continuous wave	mV	millivolt
d.c./DC	direct current	osc.	oscillator
det.	detector	p.d.	potential difference
Ed(s)	editor(s)	ppm	parts per million
e.h.t.	extra high tension	Q.P.P.	quiescent push-pull
e.m.f.	electromotive force	q.v.	which see
eV	electron volt (1.602 x 10^{-19} Joules)	r.c.c./RCC	resistor-capacitor coupled
ft	foot	r.f./RF	radio frequency
gm	gram	r.m.s.	root mean square
GP	general purpose	sq	square
h.f.	high frequency (3-30 MHz)	s.s.b.	single sideband
h.t./H.T.	high tension	s.w.	short wave
Hg	chemical symbol for mercury	t	time or time period
Hz	hertz (formally c/s, cycles per second)	t.r.f.	tuned radio frequency
i.f./IF	intermediate frequency	TV	television
in	inch	v.h.f.	very high frequency (30-300 MHz)
k	kilo (one thousand times)	u.h.f.	ultra high frequency (300-3000 MHz)
K	Kelvin	V	volt
kg	kilogram	W	watt

Appendix 3

Manufacturers & Suppliers of Valves in Britain 1926 to 1946

Trade name	Year	Company name and address	Notes
Adey	1933	Adey Radio Co. Ltd., Union Mews, 99 Mortimer St., Regent St., London, W1.	Valve with r.f. choke incorporated.
All British	1926		Valves believed to have been manufactured by the North London Valve Company.
Amplion	1926	Alfred Graham & Co., St Andrews Works, Crofton Pk., London, SE4. Graham Amplion Ltd., 25 Saville Row, London, W1.	Non-manufacturer. Sold Cosmos valves. Name changed in 1927.
Aneloy	1926	Aneloy Products, Eton Works, Upton Rd., East Dulwich, London, SE22.	Manufactured four-electrode valves.
ARA		Stephen & Weill, 55 Gt. Eastern St., London, EC2.	
Autoveyors	1925	84 Victoria Street, London, SW1.	Valves manufactured by North London Valve Company.
Beam		Lester & Marquis, 15-16 Thavies Inn, London, EC1.	Non-manufacturer.
Belmont	1937	British Belmont Radio Ltd., Belmont House, Ridgmount St., London, WC1.	American-made valves.
Benjamin Shortpath	1926	The Benjamin Electric Ltd., Brantwood Works, Tottenham, London, N17.	Sold Cosmos valves during 1926-27.
Beriton	1927	Merchant Manufacturing Co., Ltd., 20 Bartlett's Blds., Holborn Circus, London, EC1.	British manufacture claimed.
Brimar	1934	Standard Telephones & Cables ltd., Brimar Valve Works, Footscray, Kent.	Previously Micromesh. Manufactured principally American valves. Ceased manufacture in 1961.
Brittania	1926		Valves of an unknown British manufacture. Possibly linked to P.R.r
Brivaron	1940s	British Valve & Acces. Mfg. Co. Ltd., 30 Liverpool Rd., London, N7.	Only manufactured rectifier valves.
BSA-Standard	1926	B.S.A. Radio Ltd., 21 Small Heath, Birmingham.	Sold STC-Standard valves in 1926.
BTH	1916	British Thomson-Houston Co. Ltd., Crown House, Aldwich, London, WC2.	Initially linked to General Electric Co. of US. Ceased manufacture of radio valves in 1928.
Burndept	1925	Burndept Wireless Ltd., Bedford St, London, WC2 and Blackheath, SE3.	Ceased manufacture in 1927.
C.A.C.	1925	C.A.C. Radio Ltd., 10 Rangoon St., Crutched Friars, London, EC3.	Ceased manufacture in 1927.
City Accumulator Company			Possibly the full or original name of C.A.C.

Trade name	Year	Company name and address	Notes
Clarion	1932	Clarion Valve Co., Tyburn Rd., Erdington, Birmingham & 7 Duke St., London, WC2.	Successor to Octron. Ceased manufacture in 1936.
Cleartron	1925	Cleartron Radio Ltd., 7 Duke St., London, WC2. Works at Cumberland St., Birmingham. Cleartron (1927) Ltd., 27 Cumberland St., Birmingham.	Valves manufactured by parent US company with some British assembly. Company re-formed in 1927. Ceased supply in 1929.
Cosmos	1917	Metro-Vick Supplies Ltd., 145 Charing Cross Rd., London, WC2.	Trade name not used after 1929, following the formation of AEI.
Cossor	1917	A C Cossor Ltd., Aberdeen Works, Highbury Grove, London, N5.	Company reorganized business in 1945 and formed Electronic Tubes Ltd, which was acquired by EMI in 1949.
Dario	1928	Impex Electrical Ltd., 538 High Rd., London, E11.	French valves. Dario purchased by Philips in 1931.
Double Two	1926?		Hungarian valves.
Dreadnought			Trade name used by Lustrolux
Dulivac	1927	M & A Wolff, 9-15 Whitecross St., EC1.	
Eagle	1928	Eagle Valves Ltd., 47 Farringdon Rd., London, EC1.	Sold Austrian valves manufactured by Joh. Kremenezky.
Ediswan	1904	Edison Swan Electric Co. Ltd., 123-125 Queen Victoria St., London, EC4.	Made valves for the Marconi Co. until 1919. Name used only for industrial and export valves after 1929.
Ekco	1935	E K Cole Ltd., Ekco Works, Leigh on Sea, Essex.	Valves used in Ekco radios. Ceased manufacture in 1938.
Elka		L Kremmer, 49a Shudehill, Manchester.	Non-manufacturer.
Ensign			Trade name used by Lustrolux.
ETA	1931	The Electrical Trading Association Ltd., Aldwych House, Aldwych, London, WC2.	Sold French Unis valves.
Eton 'British Valve'	1929	Eton Glass Battery Co., 46 St. Mary's Rd., Leyton, London, E10.	
Ever Ready	1935	Ever Ready Radio Valve Co., Ltd., Fontwell Works, Clifton Terrace, London, E1.	Non-manufacturer. Valves supplied by Mullard and used in Ever Ready radios.
Fama	1925	H D Zealander & Co. (Dept C), St. Johns House, 126-127 Minories, London, E1.	Supplier of Dutch valves.
Ferranti	1933	Ferranti Ltd., Radio Works, Moston, Manchester.	
Fotos	1929	The Concertron Radio & Electrical Co., 329 High Holborn, London, WC2.	Sold French Fotos valves manufactured by Grammont.
Four-in-One & Three-in-One	1928	Quadruple Valve Co. Ltd., 1 Hood St., Nottingham.	Manufactured multiple valves with three or four triodes in one bulb.
Frelat	1926	Samden Wireless Co. Ltd., 102/4 Shudehill, Manchester & Continental Radio Import Co. Ltd. Spital Sq., Bishopsgate, London, E1.	Sold Dutch valves manufactured by N V Frelat, Amsterdam, Keizersgracht 77.
GEC	1917		See Osram.
Graham Farish Ring	1935	Graham Farish Ltd., 153 Mason's Hill, Bromley, Kent.	Non-manufacturer.
Helikon	1927	John Abrahams & Co., 54 Red Cross St., London, EC1.	Non-manufacturer.
Humavox	1926?		Valves of unknown British manufacture.
Hivac	1932	High Vacuum Valve Co. Ltd., 113-117 Farringdon Rd., London, EC1.	In later years company concentrated on miniature valves.

Trade name	Year	Company name and address	Notes
Lewis			Supplied C.A.C. valves.
Lissen	1929	Lissen Ltd., Lissenium Works, Worple Rd., Isleworth, Middx.	Ceased manufacture in 1935 and supply in 1939.
Loewe-Audion	1925	Audion Radio Co. and R Stichling Ltd., 52 Dorset St., London, W1. Loewe Radio, 4 Fountayne Rd., Tottenham, London, N15.	Valves made by parent German company. Claimed British manufacture. 1929 address.
Louden	1924	Fellows Magneto Co., Cumberland Av., Park Royal, London, NW10.	Ceased manufacture in late 1920s.
Lowden	1930	Lowden Valve Works, Southall, Middx.	Company formed by the original designer of Louden valves (see above).
Lustrolux	1926	Lustrolux Ltd., West Bollington, Macclesfield.	Ceased manufacture circa 1934.
Marconi (Rx valves)	1919 1925	General Electric Co., Magnet House, Kingsway, London, WC2. Marconiphone Co. Ltd., 212 Tottenham Court Rd., London, WC2.	Valves manufactured by MOV. Valves manufactured principally by MOV. Trade name used after 1925.
Marconi (Tx valves)	1919	Marconi's Wireless Telegraph Co. Ltd., Electra House, Victoria Embankment, London, WC2.	Earlier valves made by Ediswan.
Marconi-Osram	1919		See Osram.
Mazda	1928	The Edison Swan Electric Co. Ltd., 155 Charing Cross Rd., London, WC2.	Trade name used after formation of AEI for radio valves. (See also Ediswan.)
Métal	1924	John Rae Ltd., 60 Blackfriars Rd., London, SE1.	Valves of French manufacture.
Micromesh	1932	Standard Telephones & Cables Ltd., Connaught House, Aldwich, London, WC2.	Valves of STC manufacture. Trade name changed to Brimar in 1934.
Midland	1924	Midland Valves Ltd., Stafford St., Birmingham.	Initially a valve repairer. Supplied valves in 1927.
Mullard	1919 1920 1925	S R Mullard. 71 Standen Rd., Southfields, London, SE18. Mullard Radio Valve Co. Ltd. Original works at Claybrook Rd. Hammersmith. Mullard Wireless Service Co. Ltd., Mullard House, Denmark St., London, W1.	Valves initially made at 'Z' Electric. Company fully acquired by Dutch Philips in 1927. Name changed to Mullard Ltd. in 1951.
Neutron	1925	Sentinel House, Southampton Row, London, WC.	Ceased manufacture in 1927.
North London Valve Co	1923	The North London Valve Co. Ltd., 22½ Cazenove Rd., Stoke Newington, London, N16.	Believed to be the forerunner of 362. Trade names include 'Mellodyne' and 'Leo the Lion'. Valves also made for other British companies.
Octron	1926	Octron Ltd, Charlotte St., Birmingham.	Ceased manufacture circa 1929.
Osram	1917	General Electric Co., Magnet House, Kingsway, London, WC2.	After 1919 valves made by MOV and the Marconi-Osram trade name used until 1925.
Ostar-Ganz	1932	Eugen Forbat, 1 Rosebury Avenue, London, EC1. 28-29 Southampton St, Strand, London, WC2.	Austrian valves manufactured by Gustav Ganz & Co. 1933 address.
Peter Russell (P.R.)	1928	P.R Valves, 20 St. Paul's Blds., 29 Paternoster Rd., London, EC4. 5 P.R. House, Newgate St., London, EC4.	Non-manufacturer. 1929 address.

Trade name	Year	Company name and address	Notes
Philips	1928	Philips Lamps Ltd., Philips House, 145 Charing Cross Rd., London, WC2.	Sold rectifier and barretters manufactured by Dutch Philips Company. Name changed to Philips Radio in 1929.
Pix	1932	The British Pix Co., 118 Southwark St., London, SE1.	British manufacture claimed. Ceased supply in 1937.
Power Tone	1928	Lichtenberg & Jones Ltd., 40-44 Holborn Viaduct, London, London, EC4.	Non-manufacturer. Valves imported.
Quikko	1927	J. W. Pickavant & Co. Ltd. Quikko Works, Lombard St., Birmingham.	Non-manufacturer. Sold Midland valves
Radio Micro		H Lloyd Marshall & Co., 43 Blackfriars Road, London, SE1.	Valves of French manufacture.
Radion	1924	Radions Ltd., Radion Works, Bollington, Nr. Macclesfield.	Also valve repairers. Ceased manufacture circa 1927.
Radio Record	1930s	Record Radio Ltd, Eldon St. House, London, EC2.	Dutch valves manufactured by Radio Record. Company acquired by Tungsram in 1935.
Radio Vicco		See Vatea.	
Radvaco Ratraco	1926		Valve of Dutch manufacture.
S.T.	1926	S.T. Ltd., 2 Melbourne Place, Aldwych, London, WC2.	Company formed by Scott Taggart. Sold valves manufactured by Mullard in 1926-27.
Six-Sixty	1924	Electron Co. Ltd., Triumph House, 189 Regent St., London, WC2.	Ceased manufacture in 1926 and then supplied Mullard valves.
Splendor			Valve of Dutch manufacture.
Stal	1928	Lester & Co., Ltd., 45 Fore St., Moorgate, London, EC2.	French valves.
Standard	1925	Standard Telephones and Cables Ltd., Connaught House, Aldwich, London, WC2.	Previously Western Electric.
Sutra	1927	C.A.S.E. 10/12 Ludgate Hill, London, EC4	French valves.
Tela-Radio	1926	The Monowatt Lamp Co., 28 High St., Wallingford, Oxon.	Austrian valves.
362	1933	The 362 Radio Co. Ltd., 415 Mare St., Hackney, London, E3.	Previously North London Valve Co.? Ceased manufacture in 1937.
Triotron	1926	Distributors: (1) Electric Lamp Service Co. Ltd. 39-41 Parker Street, Kingsway, WC2. (2) Chorlton Metal Co. Ltd., Millgate House, 18 Amber St., Manchester. Triotron Radio Co. Ltd., Triotron House, Bloomsbury St., London, WC1. 91 Gt. Russell St., London, WC2.	Austrian-made valves. 1929 address. 1931 address.
Tungsram	1929	Tungsram Electric Lamp Works (G.B.) Ltd., 72 Oxford St., London, W1. 82 Theobalds Rd., London, WC1. British Tungsram Radio works Ltd., Tungsram House, 82/84 Theobalds Rd., London, WC1.	Valves assembled from parts made in Hungary. Later address (1936). Company name changed in 1939. British manufacture after 1938.
Univella	1928	Uneeda Supplies Co. Ltd., 76/78 Petty Frances, London, SW1.	Non-manufacturer.
Valco	1925?	Valco Ltd., Tabor Grove, Wimbledon, London, SW19.	Valve repairers. Also produced a single dull emitter valve.

Trade name	Year	Company name and address	Notes
Vatea	1930	Abbey Radio, 47 Victoria St., Westminster, London, SW1.	Sold Hungarian valves manufactured by the Vatea Radio & Electrotechnics Co. of Budapest. Company fully acquired by Philips in 1928.
Weco	1923	Western Electric Co. Ltd., Connaught House, Aldwich, London, WC2.	Valves of US design. Company name changed to STC in 1925.
Vita	1926	Peter Curtis Ltd.	Non-manufacturer.
Voltron	1927	Voltron Co. Ltd., 169 City Road, London, EC1 Queensway, Ponders End, Middx.	Valves manufactured in the US.

BVA UTILITY EQUIVALENTS

There were two Wartime Civilian receivers, one for battery operation and the other a.c. mains operation. The table below shows the valves used in these, together with their equivalent types.

BVA No.	Civilian No.	BVA. No	Civilian No.	BVA No	Civilian No.
132	HL23DD	172	TP25	266	EL33
142	VP23	216	DW4/350	276	ECH35
162	Pen25	246	EF39		

Replacement valves for BVA numbered types use in the a.c. model

Valve	BVA No	Brimar	Cossor	Ever Ready	Ferranti	Mazda	MOV	Mullard	Philips
V1*	274, 275, 276	6K8-G	OM10	ECH35	6K8-G	—	X61M	ECH35	—
V2	243, 246, 247	6K7-G	6K7-G OM6	EF39	6K7-G	—	—	EF39	—
V3	264, 265, 266, 267	6AG6-G		EL33	—	—	—	EL33	—
V4	211, 214, 215, 216	R2, R3	43IU	A11D, S11D	R4	UU5	U14, MU14	DW4/350 IW4/350	1641 1867

*Although two additional BVA numbers for V1—273 and 277—may appear in the instructions issued with the a.c. receiver these types had not been produced.

The last digit of the BVA number identifies the valve manufacturer, as indicated below.

1 ------- Cossor
2 ------- Ediswan (Mazda)
3 ------- Ferranti
4 ------- GEC
5 ------- Marconiphone
6 ------- Mullard
7 ------- Standard Telephones (Brimar)

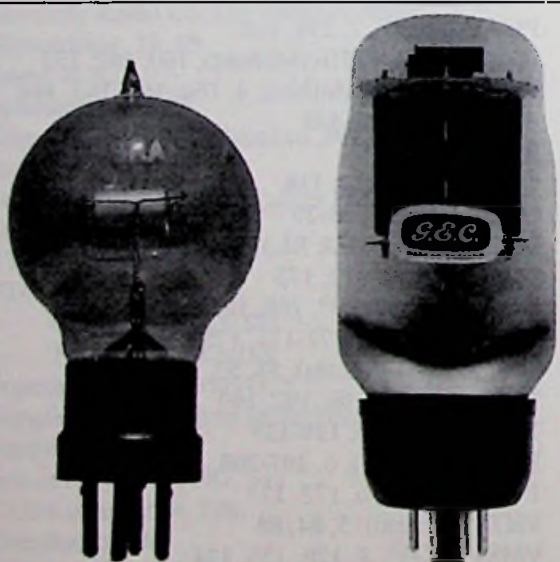
Bibliography

1. Callick, E B, *Metres to Microwaves* (Peter Peregrinus Ltd., 1990), ISBN 0-86341-212-2.
2. Deketh, J, *Electronic Valves I: Fundamentals of Radio-Valve Technique* (N. V. Philips Gloeilampenfabrieken, Eindhoven, 1949).
3. *Electronic Valves II: Data and Circuits of Receiver and Amplifier Valves* (N. V. Philips Gloeilampenfabrieken, Eindhoven, 1949).
4. Geddes Keith & Bussey Gordon, *The Setmakers*, (BREMA, London, England, 1991), ISBN 0-951-7042-0-6.
5. Hallows R W & Milward, H K, *Introduction to Valves* (Iliffe & Sons Ltd., 1953).
6. Harvey A F, & Moullin, E , *High Frequency Tubes* (Chapman & Hall, London, 2nd ed., 1946).
7. Henderson, F E, *Introduction to Valves* (Wireless World, 1942).
8. Kohl, Walter H, *Materials and Techniques for Electron Tubes* (Reinold Publishing Corporation, US, 1960).
9 Round, H J, *The Shielded Four-Electrode Valve* (Cassell & Co. Ltd., 1927).
10. Sibley, L, *Tube Lore: A Reference for Users and Collectors* (Chernay Printing Inc, Coopersburg, PA, 1996), ISBN 0-9654683-0-5.
11. Stokes, John W, *70 Years of Radio Tubes and Valves* (The Vestal Press Ltd., NY 13859, USA, 1982), ISBN 0-911572-27-9.
12. Thrower, Keith R, *History of the British Radio Valve to 1940*, (MMA International Ltd, England), ISBN 0-952-0684-0-0.
13. Thrower, Keith R, *British Radio Valves: The Vintage Years 1904–1925* (Speedwell, Reading England), ISBN 0-953-7166-0-0.
14. Tyne, Gerald F J, *Saga of the Vacuum Tube*, (Howard W Sams & Co. Inc, Indianapolis, US), ISBN 0-672-21470-9.
15. Vyse, Barry & Jessop, George, *Saga of Marconi Osram Valve* (Vyse Ltd, Pinner, Middx, England), ISBN 0-953-9127-0.

General Index

Valve Index

The index below lists valves that were notable for being amongst the first of their kind, many of which incorporated some new construction technique. Also included are valves for which push-pull data have been given.


G.E.C.

The book provides a comprehensive overview of valves available in the UK from both British and foreign manufacturers.

- *Background to the manufacturers and suppliers.*
- *Valve progress and development over a 20 year from the simple battery- operated triode to the modern multi-electrode valves*
- *Details of more than 4,000 valves from over 50 suppliers*
- *Photographs of over 1,000 valves*
- *Tables show details of the various ranges of valves, together with their dates of introduction*
- *Extended sections on audio power valves*
- *Post Office valves for telephone repeaters and radio stations*
- *Valves produced for the three Armed Services, including special types for radar applications*
- *Extensive references*
- *Separate data supplement with base connections*

About the author

Keith Thrower is a professional engineer who has spent his entire working career in the electronics industry, specialising in research and advanced product development. For many years he has taken a special interest in the history of technology and is an active member of several organisations specializing in this field. He has published many papers and lectured extensively.

His first book History of the British Radio Valve to 1940 was published in 1992.

This was followed, in 1999, by British Radio Valves. The Vintage Years: 1904–1925.

ISBN 978-0-9537166-3-0