Explanations relating to the technical data of Philips receiving and amplifying valves

Introduction

Technical data relating to receiving and amplifying valves fall under three headings :

a. Typical characteristics
b. Operating characteristics
c. Limiting values

Typical characteristics cover the properties of the valve alone, with no electrical components connected to the electrodes. They include the mutual conductance, the internal resistance, the I_a/V_g and I_a/V_a characteristics, etc.

Under *operating characteristics*, the particular applications with appropriate circuits, working conditions and properties are given. Although it is generally advisable to adhere as closely as possible to the published data, deviations are permissible provided that no value is allowed to exceed the maximum specified for the valve in question under the heading *limiting values.*

Limiting values are the maximum permissible values for the voltages, currents, loads, etc. to be applied to the valve. Failure to observe these limits will undermine the quality and effective life of the valve; this subject is dealt with more fully in a subsequent paragraph.

I. General observations

a. The data given for any one valve should be regarded as applicable to the average valve, representative of the type in question.
b. Data relating to a valve used for a specific purpose are usually based on the anode current; this means that the grid bias should be adjusted to secure the anode current specified, without input signal, the grid bias being as a rule only approximate.
c. The various electrode potentials of a valve are usually given with respect to a certain basic point, namely the cathode of indirectly heated valves, or the negative side of the filament of directly heated valves.
d. In all circumstances, a D.C. conductor must be provided between each of the electrodes and the cathode of an electronic valve. Generally speaking, the resistance in an electrode circuit should not be higher than is necessary to ensure satisfactory performance of the valve. If the valve has a suppressor grid with a separate external contact, this grid should, unless it is used for a special purpose, be connected direct to the cathode.
e. The output power W_o of an output valve is the power the valve is capable to deliver; owing to losses in the output transformer, amongst other things, the effective power is usually lower.
f. As a rule, good air circulation is essential to avoid overheating of valves, and this is particularly true in the case of output and rectifying valves. For the same reason, other valves and components radiating heat should be kept sufficiently far apart.

II. Limiting values

IIA. General observations

Among the technical data of the electronic valves, a section headed "Limiting values" will be found. None of the electrical values listed under this heading should be exceeded when the valve, an average specimen of the type in question, is used in a circuit in which:

a. the components are of nominal value,
b. the voltages are of nominal value,
c. there is no input signal. [1])

Since in actual practice these conditions are not usually fulfilled, it is impossible always to remain within the specified limits. For normal variations in components and voltages, however, the valves possess enough reserve to ensure that their properties or life will not be affected. To clarify the phrase "normal variations", the following definition has been accepted : *Provided that, when an average valve is used in the circuit conforming to a, b and c above, none of the limiting values is exceeded, it is permissible*:

1. *to use any valve of the type in question in that circuit;*
2. *to allow such variations in the voltages as will correspond to a mains voltage fluctuation not exceeding ±10% (the voltage of an H.T. battery may drop to two-thirds of its nominal value; for L.T. batteries see para.* IID);
3. *to allow such tolerances on the components, and apply such input signals as are specified in para's* IIB *and* IIC.

In car-radio sets and other vibrator-driven receivers operating on a 6 V (or 12 V) battery, allowances must be made for the pronounced voltage fluctuations liable to occur under normal working conditions: with this in view, the valve voltages in such sets are adjusted for a battery voltage of 7 (or 14 V); the filament voltage being then also 7 V. It is then permissible for the battery voltage to vary between 5.5 and 8 V (or between 11 and 16 V)- (see also para's IIB and IIC).

If variations in voltages or components greater than would be permissible according to the foregoing are anticipated, the working point of the valve must be reduced accordingly, although it is not permissible to raise the working point when variations encountered are below the limits set, seeing that the valve reserve is not usually sufficient to permit of continuous operation on values higher than the specified maxima. Nor is it permissible to allow variations in one voltage or component in excess of the maximum permissible limit when the variations in other voltages or components do not reach this limit.

IIB. Limiting values for anode and screen grid dissipations (W_a, W_{g2})

Anode and screen grid dissipations in an output valve may exceed the limit by max. 15% as a result of variations in the values of the components, or owing to the rise in voltage when the A.G.C. comes into operation.

[1]) For class B push-pull circuits this should read: *where the input signal is such that the anode dissipation reaches its maximum.*

In mains receivers, the different mains voltages are usually divided into a number of groups, covered by a tapping plate. Deviations arising from the fact that the nominal voltage in any one such range differs from the average voltage, fall within the above-mentioned 15%.
It is usual to include in the limiting values for output valves the maximum screen grid dissipation in the absence of an input signal (W_{g2} at $V_i=0$); this value should not be regarded as the maximum permissible dissipation, as it is given merely to assist in determining the working point of the valve: if this value is not exceeded in the absence of an input signal, it is unlikely that the maximum permissible dissipation will be exceeded when the signal is applied.
The limiting value for the screen grid dissipation in an output valve delivering maximum output power (W_{g2} at W_0=max.) is to be regarded as a limit which may be approached during brief periods only, under normal working conditions. Therefore, if the valve is required to deliver its maximum output continually, e.g. for measuring purposes, a lower working point must be employed.
To avoid excessive anode dissipation, the anode should be loaded continuously; this means that the anode circuit should never be interrupted, or the loudspeaker disconnected unless replaced by an equivalent resistor.

IIC. Limiting values for the positive voltages (V_a, V_{g2}, etc.)

The positive voltages in a circuit may exceed the limiting values, as a result of the causes enumerated in para. IIB, provided that the anode and screen grid dissipations of the output valve(s) remain within the limits defined in the same paragraph.
When switching on, and also owing to the subsequent effects of the A.G.C. coming into operation, the positive voltages may increase to the limiting values applicable when no current flows to the electrode in question (V_{a_0}, V_{g2_0}, etc.). If both alternating and direct voltages are applied to an anode simultaneously, the peak value may also approach this limit, provided that the current at that moment approximates to zero.

IID. Limiting values for heater voltages and currents (V_f, I_f)

Electronic valves may be divided into three classes, according to the filament or heater supply.

a. *Valves for parallel feed* : Valves of which the filaments or heaters may be connected in parallel with a voltage source (transformer, battery or accumulator). The technical data of valves in this category are based on the filament or heater voltage as specified, whereas the current is only approximate.
b. *Valves for series feed* : The filaments or heaters of these valves are connected in series with the voltage source (mains or battery). The technical data are applicable for the filament or heater current specified, the voltage being regarded as approximate.
c. *Valves for parallel or series feed* : In this case the technical data are based on both the voltage and the current.

Apart from the condition that mains voltage fluctuations should not exceed 10% of the nominal value, the following has been laid down for the various types of valves :

1. Generally speaking, the filament or heater voltage of valves fed in parallel from a transformer should not vary by more than 5% of the nominal value as a result of tolerances on the transformer.
   The mains voltage is usually divided into a number of ranges by means of tappings on the primary of the transformer. To prevent over- or under-heating, the highest and lowest nominal values in any such range should not differ by more than 5% from the average voltage in the range in question.
2. When indirectly heated valves are operated on a 6.3 (or 12.6) volt battery (car radios and other vibrator-driven sets), the battery voltage should never be allowed to drop below 5.5 (or 11) volts, or to exceed 8 (or 16) volts (see also para. IIA).
3. When a fixed series resistor is employed for series-fed valves, the heater or filament current should not vary by more than 3% of the nominal value as a result of tolerances on the value of the resistor, or in consequence of the nominal mains voltage failing to correspond to the average voltage within the range to which the set is adjusted. If a barretter is used instead of a fixed resistor, a tolerance in the heater or filament current of max. 5% is permissible.
   Fig. 1 shows the voltage ranges which can be accommodated on the tapping plate when a fixed resistor is employed: $\Delta R/R$ represents the tolerance on the resistors involved, V_f the total heater voltage, and V_m the average voltage within a given range. The limits of a voltage range are determined by V_m $(1 \pm \Delta V_m/V_m)$.
4. The set of valves UCH 41 (or UCH 42, or UCH 21), 2×UAF 42, UL 41 and UY 41 can be fed in series from mains supplying a nominal voltage of 110—127 V, without employing any series resistor.
   The UCH 41 (or UCH 42), UAF 42, UL 41 and UY 41 can be operated on such mains in conjunction with a 130 ohm resistor, whilst the UCH 21, UAF 42, UL 41 and UY 41 require a 70 ohm resistor (tolerances on these resistors not to exceed ± 5%).
   At higher mains voltages it should be borne in mind that the minimum heater current of the Rimlock U-range and the UCH 21 is 92.5 mA, and the maximum heater current 110 mA; these limits must be maintained, even when mains voltage fluctuations are

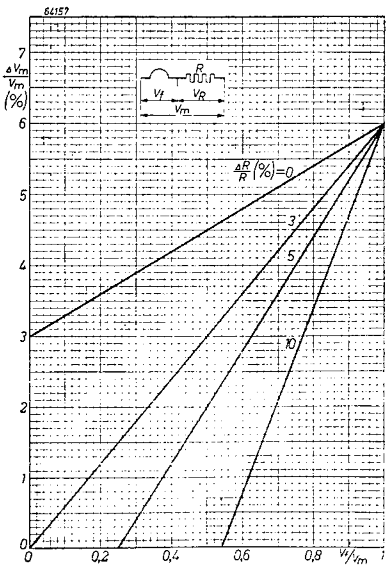

Fig. 1. For explanation see text.

likely to occur. In this connection the barretter U 30 described in this book is important.

For other valves, used with a series heater chain, reference should be made to para. 3.

5. If the filaments of battery valves are operated in series, a resistor must be connected across each filament to divert the cathode currents of the other valves. If the filament has a central tapping, a similar resistor should be connected across the negative section of the filament, to divert the cathode current of the other half of the filament.
6. Battery valves of which the nominal filament voltage is 1.4 (or 2.8) V should be operated from batteries supplying a voltage of the same nominal value, the maximum being 1.5 (or 3.0) V, and the minimum 1.1 (or 2.2) V. If the filaments of such valves are operated in series from D.C. mains, or, by using a rectifier, from A.C. mains, the filament voltages should be reduced to 1.3 (or 2.6) V.
7. When the switch of a set in which the heaters are fed in series, is closed, the differences between the warming-up times of the various cathodes may cause the heater voltages of some of the valves to rise above the nominal value. In an average valve this rise should not exceed 50% of the nominal voltage. If greater fluctuations occur, a current-limiting resistor (varite) must be used to reduce the variation, or, as an alternative, a relay connected across the heaters concerned can be made to short-circuit them when the set is first switched on.

   Note: In broadcast receivers employing standard series of valves, the rise in heater voltage is always well within the 50% limit mentioned, and no precautions are necessary.

IIE. Limiting values for the voltage between heater and cathode (V_{fk})

The limits specified under this heading are applicable to direct voltage, to the r.m.s. value of an alternating voltage, or to the sum of both and relate to the voltage between the cathode and that end of the heater at which the voltage is the higher. For direct voltage it is usually best if the cathode is made positive with respect to the heater. Furthermore, it is generally advisable to prevent voltages at signal frequency from occurring between the heater and the cathode; owing to lack of uniformity in the insulation of the cathode, such voltages may lead to crackle or interfering modulation.
If a limiting value of $V_{fk}=0$ V is specified, the cathode should be connected to one end of the heater.

IIF. Limiting values for the grid and diode starting current (V_g at $I_g=+0.3$ μA and V_d at $I_d=+0.3$ μA)

In contrast with the other limiting values, these are not limits in the sense that they must never be exceeded, but represent the limit below which the current flowing to the particular grid (or diode-anode) will remain below 0.3 μA. This limit is determined when the valve is used in a normal circuit, operating on normal voltages.

IIG. Limiting values for the external resistance between control grid and cathode (R_g, R_{g1})

In the case of output valves, two limiting values are often specified for this resistance, one relating to fixed grid bias and the other to automatic bias (bias derived from a cathode resistor). If semi-automatic grid bias is employed (bias obtained by means of a resistor in the common negative line of the valves), the maximum permissible value of the grid leak can be determined with the aid of the formula:

$$R_{g1} = \text{max.} \frac{\text{cathode current of output valve}}{\text{total current flowing through the common neg. line}} \times R_{g1}',$$

where R_{g1}' is the maximum permissible grid leak when automatic bias is employed.

IIH. Limiting values for the protecting resistance for rectifying valves (R_t)

In order to avoid sputtering (momentary flash-over between anode and cathode) in a rectifying valve, a certain D.C. resistance should be included in each anode circuit; the minimum value for this resistance is always specified. If a transformer is connected between the mains and the rectifier, the D.C. resistance of this transformer will provide all, or part of, the resistance required. In this case the following formula applies :

$R_t = R_s + n^2 R_p + R_1$, where, for half-wave rectifiers :

R_t = the necessary protecting resistance,
R_s = the D.C. resistance of the secondary winding,
n = the transformation ratio,
R_p = the D.C. resistance of the primary,
R_1 = the extra resistance required.

For full-wave rectifiers, the symbols have the following meanings :

R_t = the necessary protecting resistance, per anode,
R_s = the D.C. resistance of half the secondary winding,
n = the transformation ratio between the primary and half the secondary,
R_p = the D.C. resistance of the primary,
R_1 = the extra resistance required in each anode circuit.

If the rectifier is followed by a reservoir capacitor, the fact that ripple current as well as direct current will flow through the protective resistor should be taken into account in determining the wattage of this resistor. Accordingly, it is usual to take a wattage about three times as high as would be necessary for direct current only.

IIK. Limiting values for the cathode current of pulse-operated valves

In the pulse-operation of receiving or amplifying valves, cathode current pulses of up to 25 times the maximum permissible average cathode current, as stipulated under the heading "Limiting values", are usually permissible. The duration of the pulse, however, should not exceed 10% of the repetition period, and should not in any case exceed 50 μsec. Any departure from this condition will always be specified in the data of the valve concerned.

III. Mounting of electronic valves

Unless otherwise indicated, a valve may be mounted in any position, provided that the following conditions are observed :

a. Valves of pinch construction must not be so mounted that the base is on a higher level than the top of the bulb.
b. Should a directly heated rectifying valve be mounted in any other position than the vertical, the filament(s) must lie in a vertical plane.

If necessary, precautions must be taken to ensure that valves will not fall out of their holders as a result of jolting or vibration, either in transit or in use. Any cans fitted round the valves for this purpose must not interfere with the essential air circulation for cooling the valve (see Chapter I, para. f).

IV. Microphony in A.F. amplifying valves

In the data for A.F. amplifying valves minimum values are given for the input voltage, which can be allowed to result in a given power output from the amplifier, without the need for special precautions to prevent microphony. The significance of this will be seen from the following explanation.

Microphony may be caused in various ways, e.g. by vibration of the components of the valve. Such vibrations may be of mechanical origin, as for instance vibration of the speaker cone, transmitted to the electrode system either mechanically through the chassis, valveholder and valve pins, or acoustically (sound waves striking the bulb). In an A.F. valve this might affect the anode current, with the result that sound is emitted from the speaker in the form of a continuous or gradually diminishing note, or as crackle or background noise, even when no A.F. signal is applied to the grid of the valve.

The most important factors affecting microphony are the amplification of the valve concerned and that of the valve or valves next in sequence, the acoustic efficiency of the speaker, etc. Other factors, however, such as cabinet resonance, may also have an effect.

In order to illustrate the conditions under which microphony is not likely to occur, the operating characteristics of the A.F. amplifying valves state the permissible strength of the input signal, applicable to the entire frequency range, when the output valve delivers 50 mW to the speaker, it being assumed that the speaker has an acoustic efficiency of 5% and that the valve and the speaker are at least 10 cm apart, but in the same cabinet. It is emphasized, however, that this value of the input signal is given for general information only, since microphony might occur at lower signal strengths under adverse conditions, or it could be due to causes other than inter-action between speaker and valve, e.g. when the chassis is subjected to mechanical vibration or jolts.

In amplifiers where, as a rule, the loudspeaker is not mounted in the vicinity of the valves, microphony does not usually occur so readily.
The general rule applicable here is that no special measures need be taken to avoid microphony if the sound intensity with respect to the valve, at the input signal strength specified, corresponds to that described above. If it is desired to use a greater amplification than would be in keeping with the restrictions mentioned, special measures will generally have to be taken to avoid microphony, such as using an antimicrophonic valveholder, or the fitting of rubber grommets between valveholder and chassis (necessitating flexible leads), or an acoustic shield round the valve.

List of symbols

1. Symbols for electrodes and base connections

Anode	a
Anode of detector diode	d
Filament, heater or resistance wire	f
Central tapping of filament or heater	f_c
Grid	g
Terminals not for external connection	$i.c.$
Cathode	k
External conductive coating	m
Internal screening	s

Remarks

a. Where there are a number of identical electrodes in a valve, they are distinguished by the use of accented letters; the anodes of a full-wave rectifier, for example, are indicated thus: a and a'.

b. Electrodes of the same kind in any one electrode system are differentiated by the use of subscripts, the electrode nearest the cathode being numbered 1. The grids of a pentode, for instance, are indicated thus: g_1, g_2, g_3. Figures are also used to qualify two or more diodes contained in a single envelope; that diode which is the most suitable for detection of the signal is always numbered 2 (d_2).

c. Electrodes of the same kind in different electrode systems contained in the same envelope are distinguished by means of the following subscripts :

for a triode	T
for a tetrode	Q
for a pentode	P
for a hexode, or heptode	H

2. Symbols denoting voltage

Voltage between anode and cathode	V_a
Ditto., with no anode current flowing	V_{a_o}

Peak inverse anode voltage	V_{ainvp}
Supply voltage	V_b
Voltage range of a barretter	V_{contr}
Voltage between anode and cathode of a detector diode	V_d
R.M.S. value of a voltage	V_{RMS} or V_{eff}
Filament or heater voltage	V_f
Voltage between heater and cathode	V_{fk}
Voltage between grid and cathode	V_g
Ditto., with no current flowing to the grid concerned	V_{g_0}
Alternating input voltage	V_i
Direct voltage delivered by a rectifier, or alternating output voltage	V_o
Oscillator voltage	V_{osc}
Peak voltage	V_p
Voltage for A.G.C.	V_R
Output voltage of a transformer (not under load)	V_{tr}

3. **Symbols denoting current.** Positive electric current flows in the opposite direction to the electron stream.

Anode current	I_a
Current of a detector diode	I_d
R.M.S. value of a current	I_{RMS} or I_{eff}
Filament or heater current	I_f
Grid current	I_g
Cathode current	I_k
Direct current delivered by a rectifying valve	I_o
Peak value of a current	I_p
Stabilized current of a barretter	I_{reg}

4. **Symbols denoting power**

Anode dissipation	W_a
Grid dissipation	W_g
Input power	W_i
Output power	W_o

5. **Symbols denoting capacitance** (measured with cold valve)

Capacitance between anode and all other electrodes and screens, excluding the control grid	C_a
Capacitance between anode and grid (all other electrodes and screens earthed)	C_{ag}
Capacitance between anode and cathode (all other electrodes and screens, not connected to the cathode, earthed)	C_{ak}
Input capacitance of smoothing filter	C_{filt}
Capacitance between cathode and heater	C_{fk}
Capacitance between grid and all other electrodes and screens, excluding the anode	C_g

Capacitance between two grids (all other electrodes and screens earthed)	C_{g1g2}
Capacitance between grid and cathode (all other electrodes not connected to the cathode, earthed)	C_{gk}
Capacitance between cathode and all other electrodes	C_k

6. Symbols denoting resistance

External resistance in anode circuit, or optimum load	R_a
Optimum load in push-pull circuit (anode to anode)	R_{aa}
R.F. damping resistance of a diode circuit	R_d
Equivalent noise resistance	R_{eq}
External resistance between cathode and heater	R_{fk}
External resistance in grid circuit	R_g
Internal resistance	R_i
Resistance in cathode circuit	R_k
Protective resistance in each anode circuit of a rectifying valve	R_t

7. Miscellaneous symbols

Distortion factor	d
Noise factor	F
Frequency	f
Maximum or limiting frequency	f_{max}
Power amplification	G
Voltage gain	g
Cross-modulation factor	K
Hum-modulation factor	m_b
Transformation ratio	n
Mutual conductance	S
Conversion conductance	S_c
Effective slope of an oscillator	S_{eff}
Slope of grid 1 with respect to grid 2	S_{g2g1}
Slope of oscillator triode with V_g=0 V and V_{osc}=0 V	S_o
Phase angle	φ
Efficiency	η
Wavelength	λ
Resonance wavelength	λ_{res}
Amplification factor	μ
Amplification factor, grid 2 with respect to grid 1	μ_{g2g1}
a less than b	$a<b$
a greater than b	$a>b$

Introduction

Over recent years Philips have introduced a range of valves under the trade-mark of "Miniwatt" for radio receivers and other purposes, and the more important types in this range have already been described in volumes II and III; the latest additions are dealt with in this volume.
The entire evolution of the radio valve is reflected, as it were, in this range of valves, the interesting point about the development being that it has followed three different trends. First there was the evolution of the electrode system. Whereas all the functions in earlier radio receivers were fulfilled by triodes, it was not long before most of these functions were taken over by valves of more intricate design. In consequence, most valves today are made with three or more grids. The advantages of multi-grid valves in their various fields of application are fully discussed in the first volume of this series of books, so that there is no need to dwell on the subject here.
The second direction in which development took place was perhaps not quite so obvious, but it has nevertheless contributed considerably to the general progress of radio technology and is mainly responsible for the high quality and sensitivity of present-day receivers. We refer to the development of the components from which the electrode system is built up.
During the last decades, extensive scientific research has furnished us with a great deal more information regarding such factors as thermal and secondary emission, valve noise, microphony, distortion, and so on. Electronics and material research, too, have made enormous strides, added to which the accuracy and reliability of tools and machines have both reached much higher levels. All these factors have made possible a better choice of materials, and improved design and disposition of the components, thus continually bringing to the fore the more useful properties of the valves, whilst suppressing the less advantageous characteristics.
Quite apart from the ingenious principle upon which it is based, a modern radio valve may therefore be regarded as one of the greatest accomplishments in science and technology.
One aspect of the development under discussion is of special interest ; originally, in endeavouring to improve the properties of the radio valve, the spacing of the various electrodes was continually being reduced. At one particular phase in the development, however, some of the spacing, notably that between the cathode and the control grid, did not appear to be undergoing any further changes. The reason for this will be obvious : any further reduction would undoubtedly have yielded still greater improvements, but these would not have outweighed the disadvantages of the more critical construction and consequent increased risk of a short circuit or other defects. It will thus be seen that the more critical spacing within the electrode system in a modern radio valve very nearly corresponds to that of older types, in spite of the fact that the external dimensions have been considerably reduced. A typical example of this is given in Figs. 2 and 3. Fig. 2 shows that the reduction in the overall height of the valve is obtained entirely by eliminating ineffective space, whilst in Fig. 3 we see that, although the diameters of both envelope and electrode system have been reduced, the

distance from the cathode to the control grid is only slightly smaller than before.

At the same time, it should be noted that in some valves intended for special purposes these critical dimensions have actually been reduced, although this was made possible only by taking special precautions to maintain the reliability of the valve.

The third factor in the evolution was concerned with the envelope of the valve; since this subject is reviewed fully in volume I, a brief summary will here suffice.

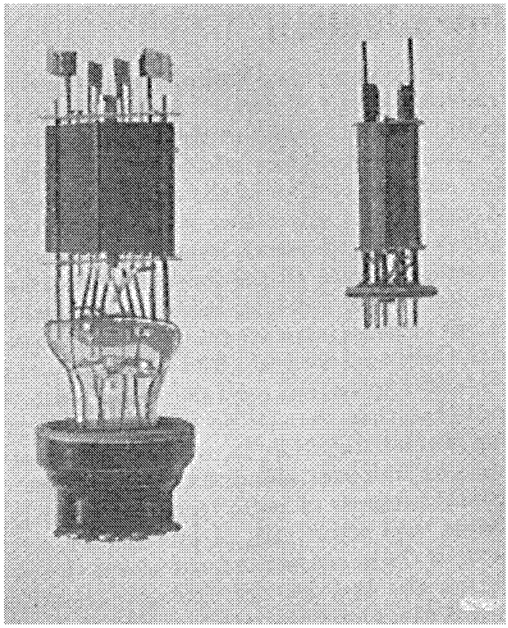

Fig. 2. Left: the electrode system of an old type of output pentode (EL 3N).
Right: the electrode system of a Rimlock output pentode (EL 41).
The maximum anode dissipation of both valves is 9 W, the slope being about 10 mA/V.

Originally, valves of all types were designed on the principle of the incandescent lamp, employing the so-called glass "pinch" through which the leading-in wires passed to the various electrodes, the other ends being soldered to pins or contacts on a "Philite" base attached to the envelope.

For a long time the "pinch" method of construction gave every satisfaction, but eventually it was found to have certain disadvantages, mainly owing to the demand for better quality reception and to the ever-increasing importance of short-wave broadcasting. Some of the difficulties were overcome

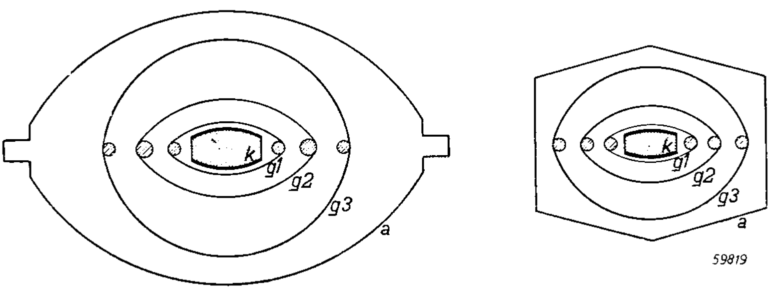

Fig. 3. Cross-sections of the two electrode systems shown in Fig. 2. The distance from cathode to control grid is roughly the same in both diagrams.

by altering the design, but no definite improvement was achieved until the "pinch" was replaced by a flat, glass base. With this method of construction, a number of pins sealed in the base, so as to be vacuum-tight, serve as the electrode connections, ensuring a robust, compact assemblage. The "Philite" base previously used was thus rendered superfluous.

The excellent properties of valves designed on this principle are fully described in Volumes I and III, and can be summarized as follows :

1. Owing to the reduced length of the connections to the various electrodes, the capacitances, self-inductances and electrical losses in these connections are very low, whilst undesirable coupling between these connections is also considerably reduced. This is the reason for the very satisfactory performance of these valves in the short-wave bands.
2. As no "Philite" base is used, the capacitances of the valve are only to a small degree dependent on the temperature; hence, tuned circuits used with the new type of valve suffer only slight detuning while the valves are warming up. This is particularly important in oscillator circuits, since the troublesome frequency drift that occurs when the valve is warming up, is now much less pronounced.
3. Since the electrodes are welded to the contact pins, there are no soldered joints and there is no risk of interference due to faulty soldered connections.
4. In all-glass valves with flat bases it is a simple matter to provide screens, so that all the electrode connections may be taken through one end of the valve. Even the grid-to-anode capacitance is thus reduced to the low value prevailing in earlier types of valve with top caps. The wiring of the chassis can now be arranged in a simple, logical manner, and the awkward arrangement of the lead to the top cap is eliminated.
5. Owing to the absence of the "pinch" and "Philite" base, the overall dimensions of the valve are now very much smaller, without necessitating any reduction in the critical dimensions of the electrode system itself. The smaller dimensions of the valve in no way affect the electrical properties of the valve, nor have they rendered the valve more sensitive to interference.

Apart from the Loctal valves described in Volume III, Philips manufacture three different types of valves with flat glass bases, namely the Rimlock, miniature and Noval valves. All these types are dealt with in this volume.