

Current regulator tubes (Barretters)

When the heaters of the receiving and rectifying valves in a receiver are connected in series, fluctuations in the mains voltage will produce under- and over-heating of the filaments very much more quickly than when the heaters are arranged in parallel. The reason for this is that, primarily, there is usually a resistor in series with the heaters, to reduce the supply voltage to the sum of the heater voltages. When the mains voltage rises, the current increases, as does also the resistance of the heaters, so that the current does not increase as quickly as the voltage; the resistor included in the heater circuit does not show an appreciable increase in value, however, seeing that, owing to the presence of this resistor, the increase in the total resistance is less than if the heater circuit consisted of heaters only. In A.C./D.C. receivers the heaters, with the resistor in series with them, are therefore subjected to a heavier strain than the heaters of A.C. sets which are usually connected in parallel, and it is a very much better procedure in such cases to employ a current regulator tube, or barretter, in series with the heaters instead of a resistor.

These barretters comprise an iron wire suspended in a bulb containing hydrogen, and they possess the particular feature that the resistance of the iron wire increases to such an extent on an increasing voltage that the current remains practically constant. In certain cases the current will even tend to diminish, but this applies only to a certain range of voltages.

When one of these tubes is included in the heater circuit of a receiver, the heater current, within certain voltage limits, is maintained at a constant level, this being all to the good for the valves from the point of view of their life. The use of a barretter is particularly important in A.C./D.C. receivers since, due to under-heating, the internal resistance of the rectifying valve and consequently also the voltage loss in the latter increase very considerably; the anode voltage, which will have dropped as a result of the decrease in the mains voltages, is thus further reduced.

The voltage range within which the heater current is kept constant is in certain circumstances so wide that the heater circuit of the receiver can be connected directly to mains voltages of very different values, e.g., 220 and 170 V.

A factor to be taken into account is the current surge occurring when the receiver is switched on, the valves being in the cold condition; if this surge is too great, the life of the barretter will be endangered and it is therefore usual to include a resistor in series with the tube, to limit the surge. Taking the simplest case, this resistor might consist of the heaters of the receiving valves themselves, whose resistance value in the cold condition is about $\frac{1}{7}$ th to $\frac{1}{10}$ th of the value when hot. In this connection, Philips quote for their barretters both the maximum voltage that may occur in the tube when the set is switched on, and the minimum total heater voltage of the receiving valves with which the tube is in series.

The minimum total heater current of the valves thus represents the minimum resistance which must be in series with the barretter when

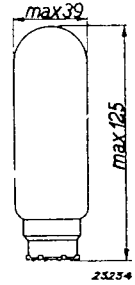


Fig. 1
Dimensions of
barretters C 1, C 3
and C 8 in mm.

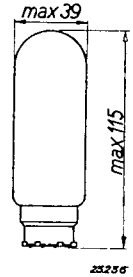


Fig. 2
Dimensions of
barretters C 2, C 9
and C 10 in mm.

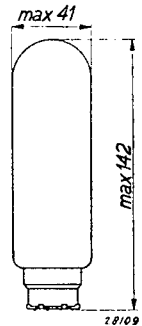


Fig. 3
Dimensions of
the barretter C 12
in mm.

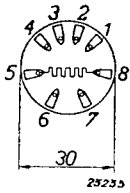


Fig. 4
Base connections of
the C 1 and C 2.

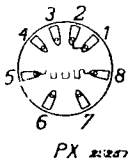


Fig. 5
Base connections of
the C 3 and C 8.
Contacts 1 and 2 are
connected together
so that A.C./D.C.
receivers can be
switched for high
voltage mains.

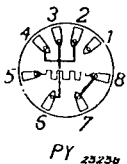


Fig. 6
Base connections of
the C 10. Contacts
2, 3, 4 and 6, as
well as 7 and 8 are
shorted so that
A.C./D.C. receivers
may be switched
for operation on
low voltage mains.

the "cold" receiver is switched on. In the case of the C 1, for instance, the minimum total heater voltage of the receiving valves in the working condition must be 52 V; the resistance of the hot valves is then $\frac{52}{0.2} = 260$ ohms and in the cold condition about $\frac{1}{7} \times 260 = 37$ ohms. In this instance the mains voltage must not exceed 250 V. At lower mains voltages the surge is smaller, which fact can be taken into account. If the sum of the heater voltages of the particular valves used is less than the minimum total heater voltage it may be advisable to include a small resistance in series with the valves, to augment the resistance of the latter in the cold condition.

Any pilot lamp in series with the valve heaters is especially likely to suffer as a result of surges; the ordinary pilot lamp is normally quite useless for this type of receiver, as it burns out too quickly, and special lamps have to be employed. The current surge on the pilot lamps will always be greatest when a receiver, fitted with a large number of valves, is operated on a low mains voltage and may even reach seven times the amount of current consumed under normal working conditions. Less stringent requirements are placed upon the pilot lamp when a current regulator such as the C 1 or C 2 is employed.

In order to eliminate the surge entirely, barretters have been designed incorporating a built-in resistor apart from the resistance wire; the value of this limiting resistor at, say, 20° (i.e. when cold) will be 2,000 ohms and when hot (300°) 100 ohms. When the receiver is switched on the resistance consists mainly of the limiter resistor (2,000 ohms), the electrical energy being there converted to heat. The time required to raise this resistor to its "hot" temperature is sufficient also for the wire in the barretter to heat up, so that, by the time the value of the limiter has reached its lowest resistance the barretter is able to absorb the whole of the surplus voltage arising from the fact that the more tardy cathodes of the receiving valves are by then not sufficiently hot. The pilot lamp is then not overloaded when the receiver is switched on, and an ordinary 200 mA lamp may be used.

The presence of a limiting resistor has the effect of reducing slightly the range of control of the barretter, but not to such an extent as to impair the practical uses of these tubes, and Figs 9 and 10 illustrate the action of the barretter with built-in resistor, in limiting the surge.

When D.C. receivers are operated on different mains voltages, it is usually sufficient to change the resistor in series with the valve heaters; the resistors in the cathode, screen-grid and anode circuits need not be changed as these are generally of such a value that the valves will be operating at their specified voltages when used on 220 V mains. On a lower voltage, however, of say 110 V, the screen resistors are no longer of the correct value and the receiver would be operating on lower voltages than those which would give the best results.

In A.C./D.C. receivers this simple solution is not applicable, since many A.C. mains are of lower voltage (127 V) and it is necessary to ensure that the set will work properly when operated on these as well. In order to obtain satisfactory performance and output when

Barretters

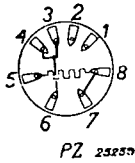


Fig. 7
Base connections of the C 9. Contacts 3, 4, and 6, also 7 and 8 are shorted to enable A.C./D.C. receivers to be adapted for low mains voltages.

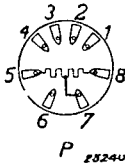


Fig. 8
Base connections of the C 12. For high mains voltages contacts 5 and 8 are used; for low voltages contacts 5 and 7, i.e., switching should be provided between 7 and 8.

base is known as the C 10, and with PZ base as the C 9. There is also a tube having two different

changing over to lower voltage mains, it is necessary not only to change the barretter in the heater circuit but also to short-circuit some of the resistors in the anode and screen circuits, and readjust the matching of the speaker transformer; fig. 11 shows how these changes may be made. Here, all the screens are fed from a common resistor R_1 , to reduce the potential to 100 V with high voltage mains; further, a resistor R_2 is placed in series with the screen grid of the output valve to lower the already reduced voltage to 75 V for the CL 2, or 83 V for the CL 6. It is not necessary to modify the value of the cathode resistors. When the receiver is to be used on low mains voltages both the resistors R_1 and R_2 are short-circuited; resistor R_3 , which serves to protect the rectifying valve when the set is working on high voltage, is also shorted on low voltage in order that full use may be made of the available potential. The matching impedance is usually changed by altering the anode voltage (for the CL 6, $V_a = 100$ V, $R_a = 2,000$ ohms, or $V_a = 200$ V, $R_a = 4,500$ ohms) and provision must therefore also be made for changing the ratio of the output transformer. By suitably linking up certain contacts on the base of the barretter which would otherwise not be used, all the resistors in question can be short-circuited and the output transformer suitably strapped, simultaneously. Barretters for high voltages are supplied with a shorting link between contacts 1 and 2, the base in this case being known as type PX (Fig. 5); the base for low mains barretters is the PY (Fig. 6) and that in which the connection to contact 2 is omitted is type PZ (Fig. 7).

For high mains voltages Philips also supply a barretter without a limiting-resistor fitted with a P-type base having no shorting links. Another, similar type for low voltages is also supplied. These are the C 1 (high voltage) and C 2 (low voltage). Barretter C 2 with PY

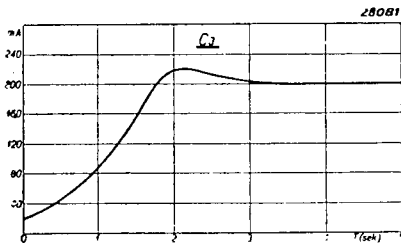


Fig. 10
Heater current as a function of time, after switching on a receiver of which the valve heaters are in series with a barretter fitted with a limiting resistor.

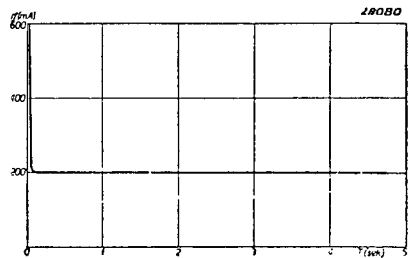


Fig. 9
Heater current as a function of time after switching on a receiver, the valve heaters being in series with a barretter without a limiting resistor.

internal resistance wires, one having the properties of the C 1 and the other those of the C 2 and, needless to say, this tube has no shorted contacts on the base. As the regulating range of barretters with limiting resistor is slightly smaller than otherwise, several of these tubes are required in order to cover all possible mains voltages. However, with a view to limiting the number

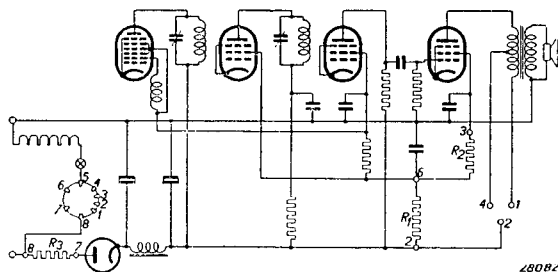


Fig. 11

Circuit diagram showing method of switching A.C./D.C. receivers from 220 V to 110 or 127 V mains, using barretters for high and low voltages. The numbers of the different points in the diagram correspond to those indicated on the base of the barretter.

of barretter types, and since a different barretter would be required for every value of mains voltage, it is usual to employ the barretter only for the high voltages, in this case the C 3. Complete data regarding Philips barretters for A.C./D.C. receivers are given in the table below.

200 mA Barretters

	Without resistor to limit the surge						With limiting resistor
	C 1	C 2	C 8	C 9	C 10	C 12	C 3
Controlled current . . .	0.200	0.200	0.200	0.200	0.200	0.200	0.200 A
Control range. . .	80-200	35-100	80-200	35-100	35-100	80-200	100-200V
Maximum working voltage. . .	200	100	200	100	100	200 100	200 V
Max. voltage across barretter on switching on the receiver	250 ¹⁾	160 ²⁾	250 ¹⁾	160 ²⁾	160 ²⁾	250 ¹⁾ 160 ²⁾	250 V ¹⁾
Dimensions . . .	Fig. 1	Fig. 2	Fig. 3	Fig. 2	Fig. 2	Fig. 3	Fig. 1
Base	P 30	P 30	P 30 X	P 30 Z	P 30 Y	P 30	P 30 X
Base connections	Fig. 4	Fig. 4	Fig. 4	Fig. 7	Fig. 6	Fig. 8	Fig. 5
Curves	Fig. 12	Fig. 13	Fig. 15	Fig. 16	Fig. 17	Fig. 18	Fig. 14

¹⁾ The total heater voltage of the receiving valves connected in series with the barretter must be at least 52 V.

²⁾ The total heater voltage of the receiving valves connected in series with the barretter must be at least 74 V.

The rectangles shown in dotted lines in the following characteristics indicate the tolerances on the current as regulated by the barretters and the voltage limits on the range of control.

Barretters

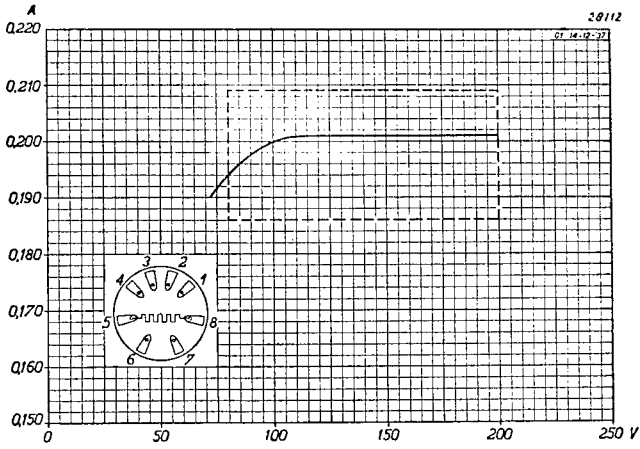


Fig. 12
Current as a function of the voltage across the C 1

Fig. 13
Current as a function of the voltage across the C 2.

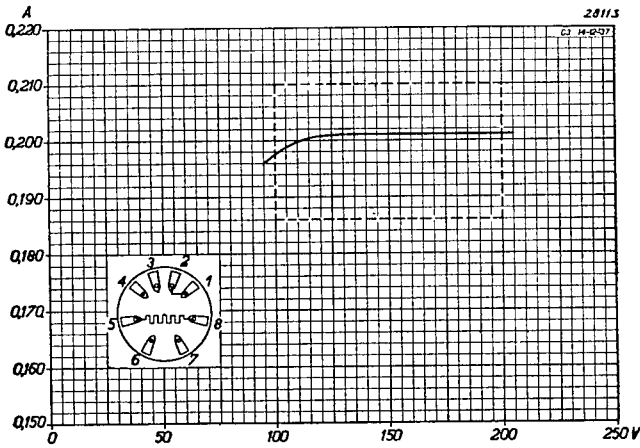
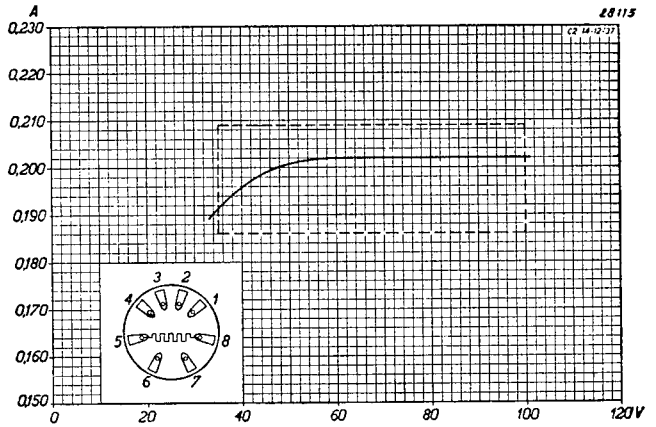


Fig. 14
Current as a function of the voltage across the C 3.

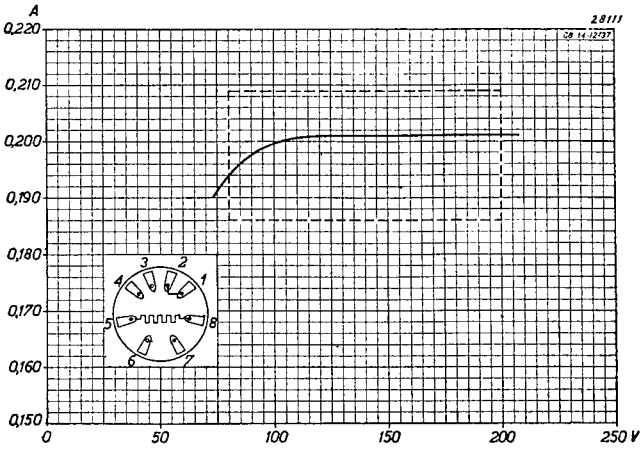


Fig. 15
Current as a function of
the voltage across the C 8.

Fig. 16
Current as a function of
the voltage across the C 9.

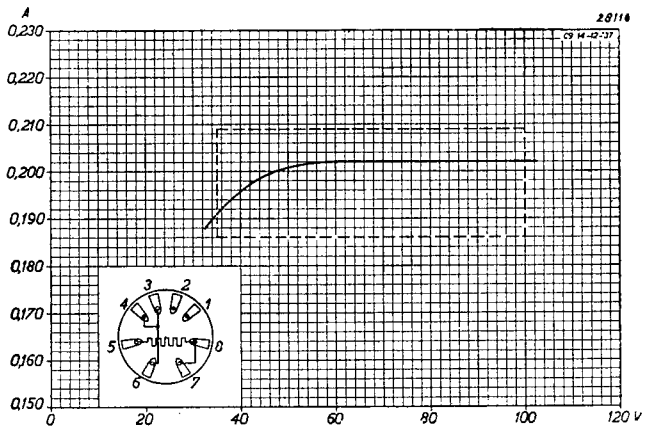
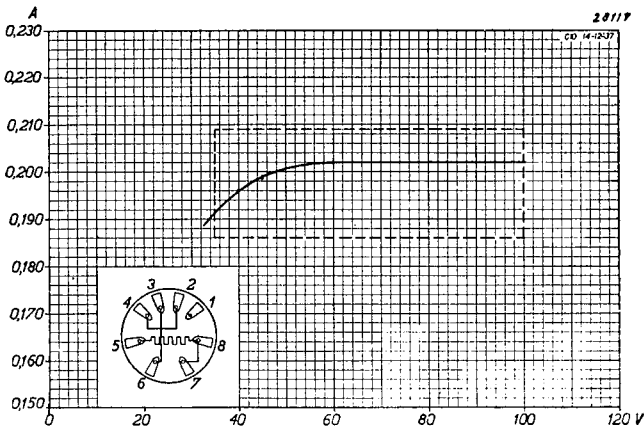


Fig. 17
Current as a function of
the voltage across the C 10.



Barretters

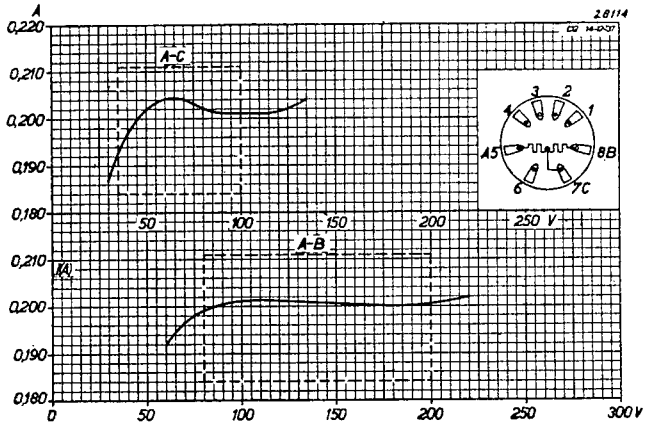


Fig. 18

Upper diagram. Current as a function of the voltage across the section A-C of the resistance wire of the tube C 12.

Lower diagram. Current as a function of the voltage across the section A-B of the resistance wire of the tube C 12.