Current regulators and stabilizers

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.

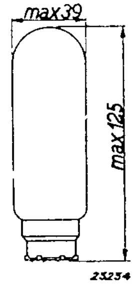


Fig. 1
Dimensions of barretters C 1, C 3 and C 8 in mm.

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.

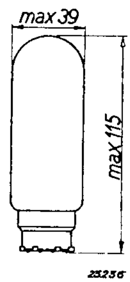


Fig. 2
Dimensions of barretters C 2, C 9 and C 10 in mm.

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 $^1/_7$th to $^1/_{10}$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.

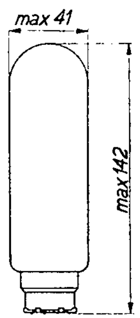


Fig. 3
Dimensions of the barretter C 12 in mm.

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

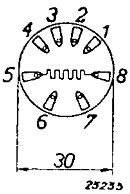
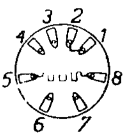


Fig. 4
Base connections of the C 1 and C 2.

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.

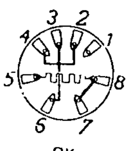


PX

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.

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.



PY

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.

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

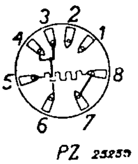


Fig. 7
Base connections of the C 9. Contacts 3, 4, and 6, also 7 and 8 are shorted to enable A.C./D.C. receivers to be adapted for low mains voltages.

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 know 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).

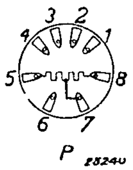


Fig. 8
Base connections of the C 12. For high mains voltages contacts 5 and 8 are used; for low voltages contacts 5 and 7, i.e., switching should be provided between 7 and 8.

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 base is known as the C 10, and with PZ base as the C 9.

There is also a tube having two different 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.

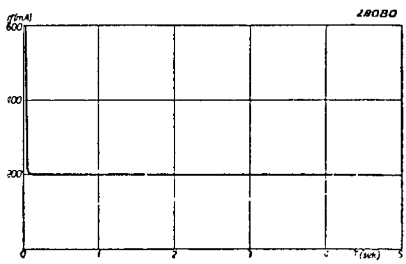


Fig. 9
Heater current as a function of time after switching on a receiver, the valve heaters being in series with a barretter without a limiting resistor.

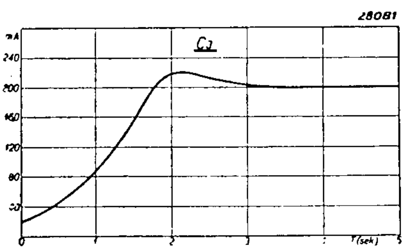


Fig. 10
Heater current as a function of time, after switching on a receiver of which the valve heaters are in series with a barretter fitted with a limiting resistor.

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

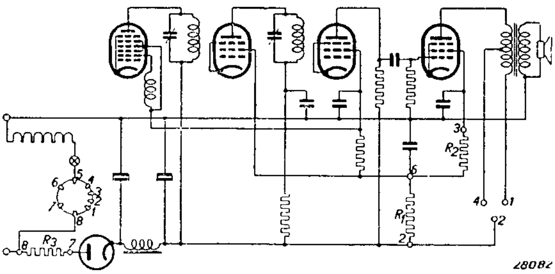


Fig. 11
Circuit diagram showing method of switching A.C./D.C. receivers from 220 V to 110 or 127 V mains, using barretters for high and low voltages. The numbers of the different points in the diagram correspond to those indicated on the base of the barretter.

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 35-100	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. 5	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.

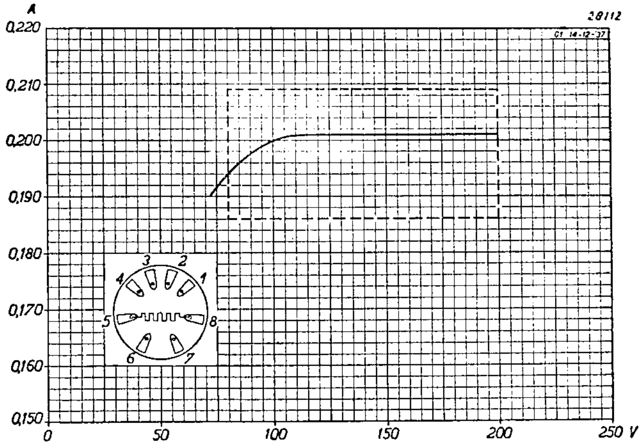


Fig. 12
Current as a function of the voltage across the C 1

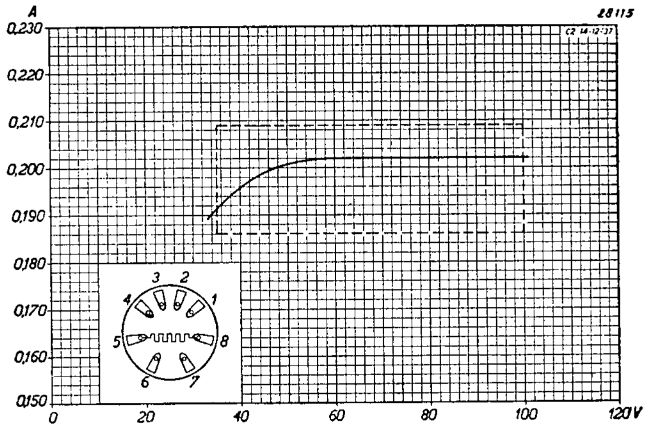


Fig. 13
Current as a function of the voltage across the C 2.

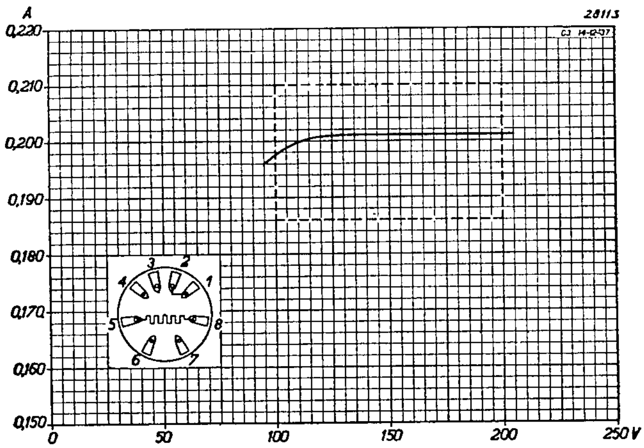


Fig. 14
Current as a function of the voltage across the C 3.

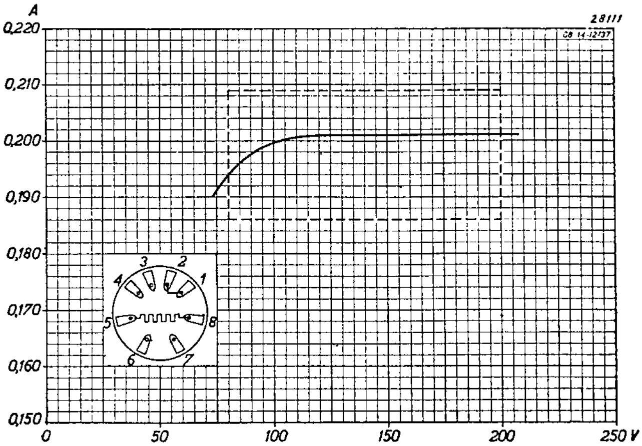
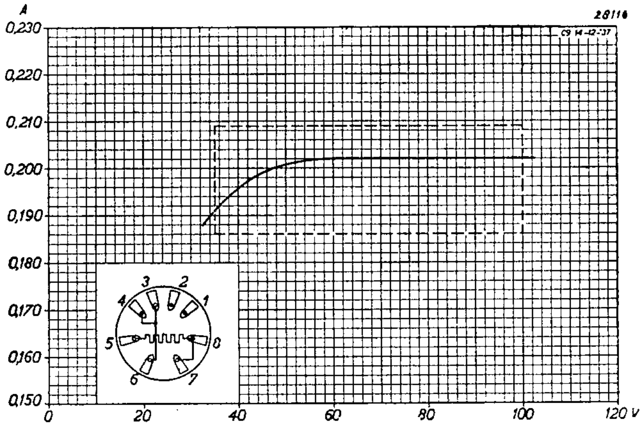


Fig. 15
Current as a function of the voltage across the C 8.

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



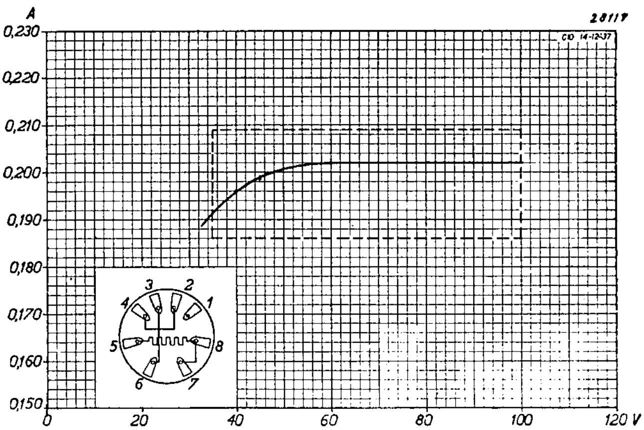


Fig. 17
Current as a function of the voltage across the C 10.

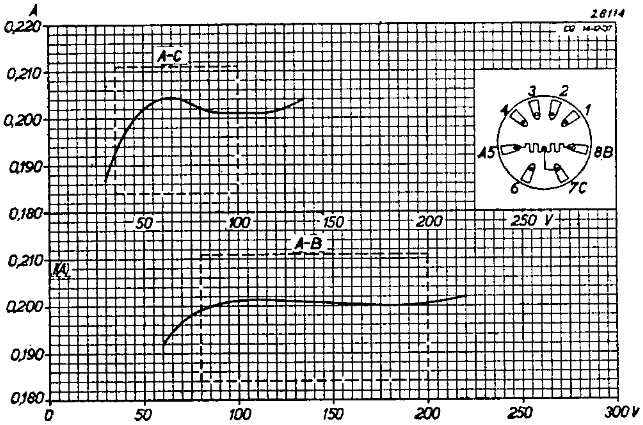


Fig. 18

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.

Stabilizing tubes

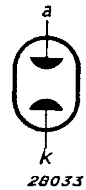


Fig. 1
Arrangement of electrodes in a neon stabilizer tube.

Stabilizers are used in all cases where it is necessary to keep the voltage in a receiver or component thereof as constant as possible, so that the latter may be sufficiently independent of the current consumption and of fluctuations in the applied mains or battery voltage; in this way the fixed grid bias of an amplifier or measuring instrument may be stabilized.

The neon stabilizer tube depends for its action on the fact that the current flowing through it rises rapidly as the voltage is increased. When the voltage is applied to the tube through a resistor, the rise in current produces a corresponding increase in the voltage drop across that resistor, thus partly neutralizing the increase in potential; in many instances the internal resistance of the voltage source is sufficient to provide a stabilizing effect, in which case the resistor may be dispensed with.

Fluctuating loads produce voltage variations in the series resistor, which in turn are compensated by variations in current in the neon tube. To ensure effective stabilization, small voltage variations on the tube must occasion the greatest possible variations in current, and the ratio of the voltage increase to the corresponding current increase in the tube is known as the A.C. resistance. The latter should be as low as possible, being actually about 250 ohms in the case of the tube type 4687, so a voltage increase of 2.5 V on the tube will produce an increase in the current of 10 mA. The D.C. resistance indicates the relationship between the current through and the voltage across the tube.

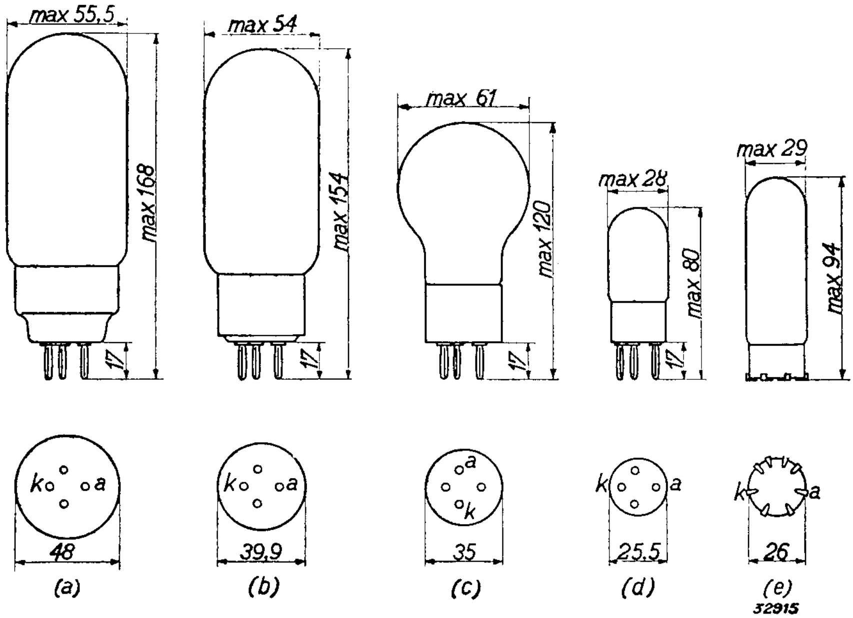


Fig. 2
Dimensions in mm. and base connections of the various Philips Neon Stabilizers.
a) Type 100 E 1 c) Type 4357 e) Type 4687
b) Type 13201 d) Type 7475

The 4687, with 90 V, will pass a current of 20 mA and the D.C. resistance is therefore 4,500 ohms.
A neon tube has to be "started up" by an "ignition" voltage, which is in every case higher than the normal working voltage, and precautions must be taken to ensure that when the switch is closed the receiver does not take so much current that the voltage drop across the series resistor prevents the tube from igniting. The "quenching" voltage must also be borne in mind; at a given voltage, which is somewhat lower than the working voltage, the discharge is quenched and re-ignition will take place only when the load has decreased to the extent where the voltage on the tube is once more equal to the ignition voltage. When the tube has been quenched, therefore, there will be a period during which no stabilization takes place.
A rectifier provided with one of these stabilizers may be looked upon as a source of voltage of very low internal resistance, since the voltage at the terminals of the stabilizer is independent of the load and remains practically constant. It follows, then, that a stabilized rectifier will tend to reduce R.F. or A.F. coupling through the medium of the internal resistance. Further, the neon tube improves the smoothing

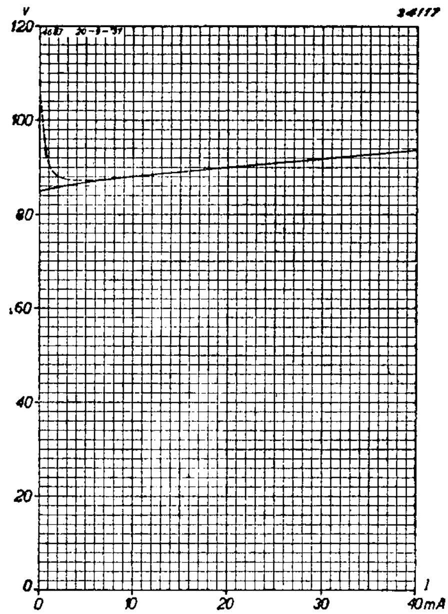


Fig. 3
Voltage-current curve of the 4687.

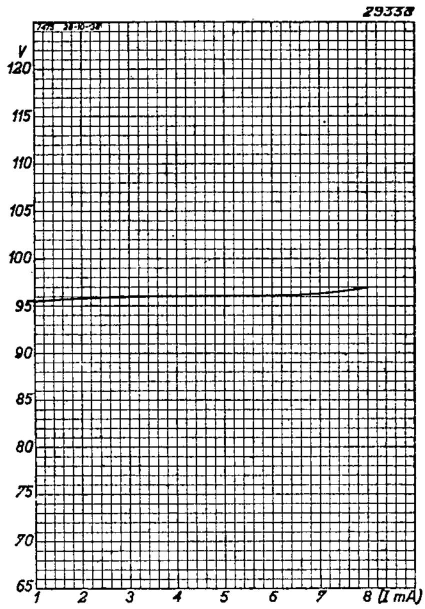


Fig. 4
Voltage-current curve of the 7475.

of the rectified voltage, because voltage variations arising from the ripple are also stabilized.
Admittedly, the A.C. resistance of the neon tube increases with the frequency, but at normal mains frequencies it will not deviate to any great extent from the published value.
If the voltage to be stabilized is very much higher than the tube voltage a number of tubes may be connected in series with each other, in which case, however, at least one of them must be shunted by a fairly high resistor, say 0.1 megohm; otherwise the tubes will not ignite (see Fig. 8).

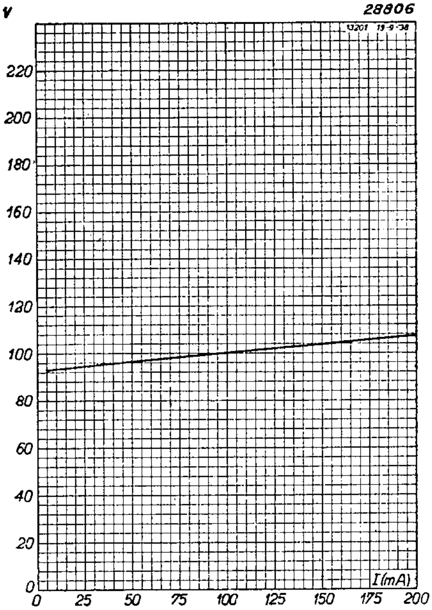


Fig. 5
Voltage-current characteristic of the 13201.

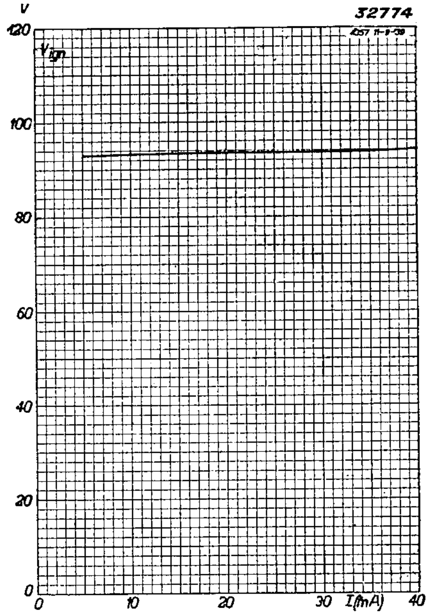


Fig. 6
Voltage-current characteristic of the 4357.

It should be noted here that neon tubes are used for stabilizing D.C. voltages only; further, these tubes must never be connected in parallel to stabilize heavy currents. Owing to the unavoidable circumstance that the ignition voltage varies between one tube and another, the tube having the lowest ignition voltage would start up first

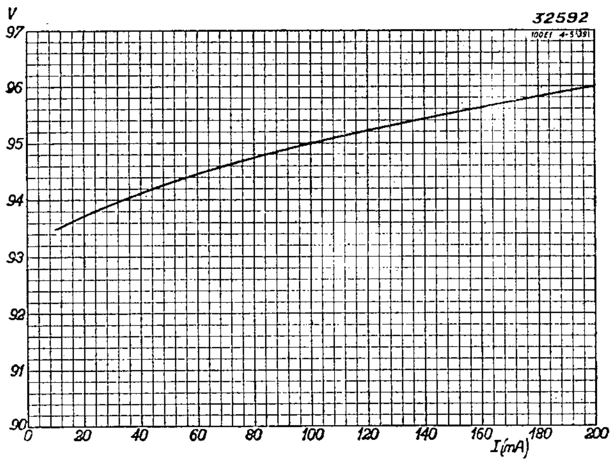


Fig. 7
Voltage-current characteristic of the 100 E 1.

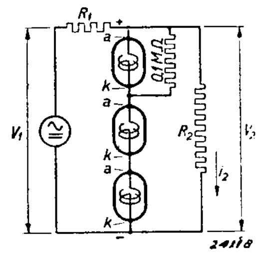


Fig. 8
Three neon tubes connected in series to stabilize approximately 270 V. The output circuit is represented by the resistor R_2, passing a current I_2 at a voltage V_2. V_1 is the D.C. voltage source with superimposed alternating voltage (voltage fluctuations), and R_1 is the internal or series resistance of the voltage source. A resistor of 0.1 megohm is connected across one of the tubes to enable ignition to take place.

and immediately consume current, thus reducing the voltage across the other tubes in parallel with it, which would thus have no further chance of ignition.
Philips make five different types of neon voltage stabilizers suitable for use in large or small equipment and the working values of these tubes have been so selected as to provide a tube for almost any conceivable project. The general data are as given in the following table:

DETAILS OF PHILIPS STABILIZING TUBES

Type	Dim. and Base connections	Base	Operating voltage at stated quiescent current (V)	Maximum starting voltage (V)	Quiescent current [1] (mA)	Upper current limit for stabilization (mA)	Lower current limit for stabilization (mA)	Max. A.C. resistance (ohms)
4357	Fig. 2c	A 35	85—100	125	20	40	10	75
4687	Fig. 2e	P 26	85—100	115	20	40	10	250
7475	Fig. 2d	A 25.5	90—110	140	4	8	1	700
13201	Fig. 2b	A 48	90—110	140	100	200	15	90
100 E 1	Fig. 2a	A 40	90—105	140	125	200	50	30

[1]) To ensure a reasonable life, the specific average value for the current passing through the tube should not be exceeded.

Philips neon stabilizers are "burned" or screened first on A.C. and then on D.C.; it is recommended that the negative pole of the voltage source be connected to the electrode indicated as cathode and the positive pole to the anode.