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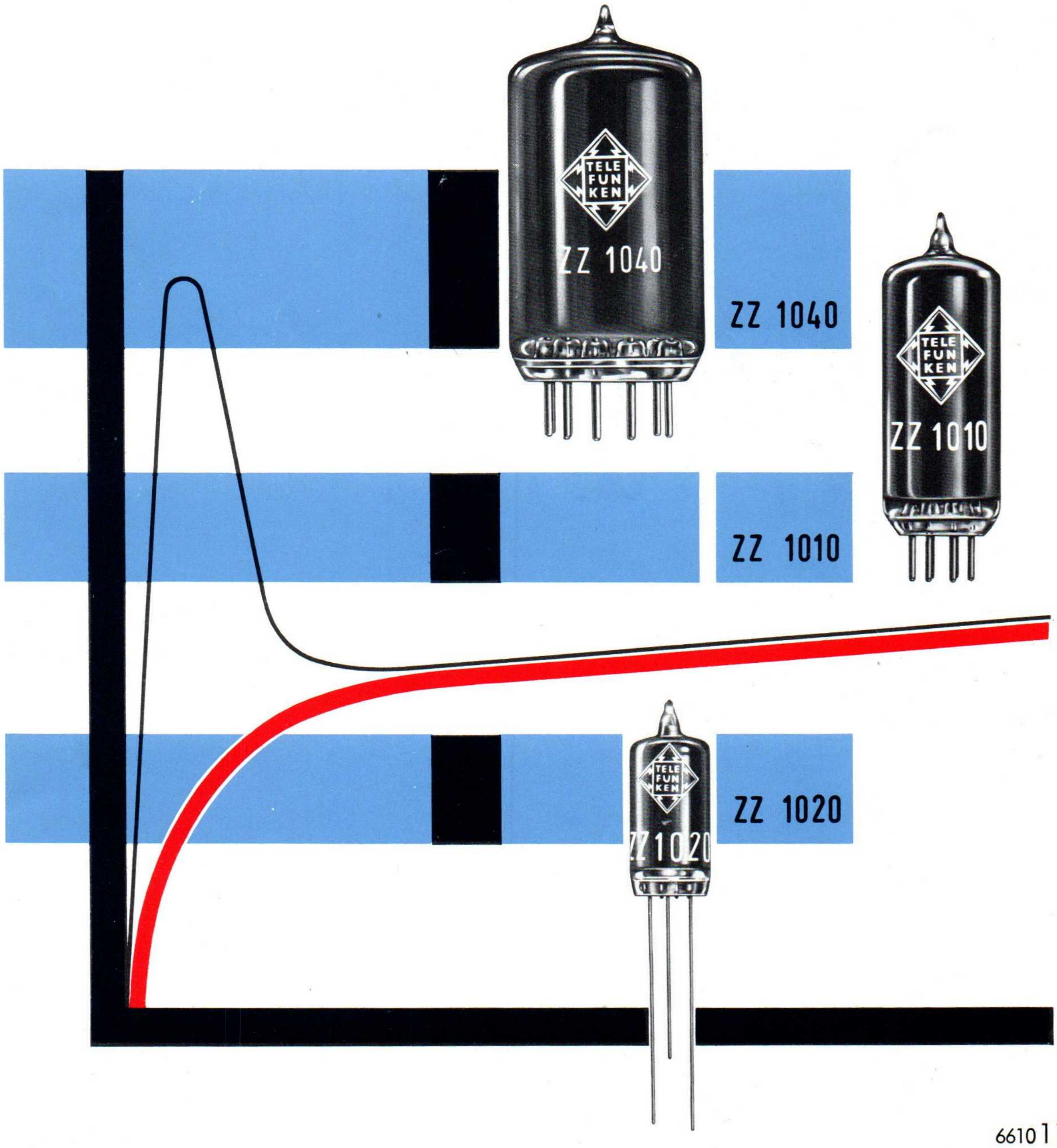
# New Voltage Stabilisers with Ignition Electrode

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# New Voltage Stabilisers with Ignition Electrode

## by G. Marx

A series of new neon stabilisers designated ZZ 1010, ZZ 1020 and ZZ 1040 is now available for applications in regulating and control circuits for industrial automation. These new types differ from customary tubes in that they are provided with an additonal ignition electrode, which can carry a weak auxiliary current. Due to this additional discharge the static characteristic, which is shown in Fig. 1 for a tube without auxiliary current, can be altered in the section where the characteristic drops for low transverse currents. This section of the characteristic, in which the differential resistance assumes negative values, is the cause of a number of possible interferences that must be prevented in automatic industrial electronic circuits for reasons of reliability.

The characteristic of a tube operated with auxiliary current is shown in Fig. 2. In addition, by this additional discharge the occurence of interfering ignition peaks is prevented, the control range is extended, the thermal load is reduced and the circuit complexity is reduced. Moreover, arbitrary large capacitances may be connected in parallel without the occurrence of interfering oscillations. This feature in particular renders the new stabiliser suitable for control circuits in industrial electronics because in such applications constant voltage sources are frequently required which need to supply only weak mean currents but shall be loaded with high transient currents.

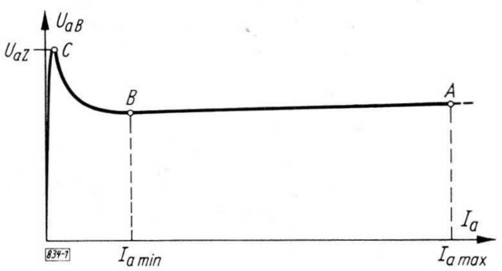



**Fig. 1.** $U_{aB} = f(I_a)$ characteristic of a neon stabiliser operated without auxiliary current

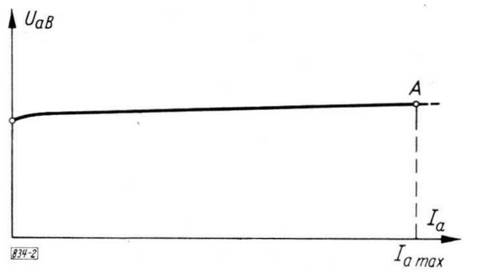



**Fig. 2.** $U_{aB} = f(I_a)$ characteristic of a neon stabiliser operated with auxiliary current

Fig. 3 a shows an example for such a circuit, in which a capacitor C charged to the voltage $U_B$ shall generate a strong current pulse in the load resistor $R_A$ on the arrival of a control signal at the control electrode z of the switching tube SR. Circuits, in which the electrical energy stored in a capacitor is converted into a current pulse, are frequently employed in control systems where, for example, the load resistor $R_A$ may be an electro-mechanical relay or step switch mechanism to which a high power peak is applied for the moment when the armature pulls up. The circuit shown is also frequently used as pulse amplifier or as a so-called self-quenching pulse shaper stage in which output pulses of constant amplitude and shape are generated across the usually low-impedance load resistor $R_A$ on the arrival of weak control signals at the control electrode z.

The circuit shown in Fig. 3 b supplies a stabilised bias for the control electrode of switching or amplifier tubes. The neon stabiliser STV used to generate the stabilised voltage must be shunted by the capacitance C if the tube Rö shall be driven by pulses or RF voltages. In this manner a short-circuit in respect of AC shall be established for the discharge gap of the stabiliser whose resistance is greatly dependent on frequency. This measure is most important in cases where the stabiliser shall be employed for the simultaneous voltage supply of several tubes featuring different switching functions.

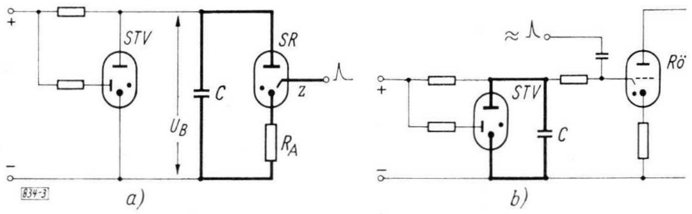



**Fig. 3.** Circuit for neon stabilisers with capacitive load
a) pulse shaper stage with relay tube
b) generator stage for stabilised biasses

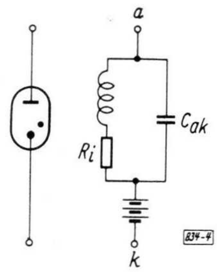



**Fig. 4.** Simplified equivalent circuit of a gas discharge gap

Where neon stabilisers could be used for the circuit examples indicated here as regards the current requirement, far more complex methods of stabilisation were employed in practice hitherto due to the fact that neon stabilisers without an ignition electrode cannot be operated with arbitrary large parallel capacitances.

## 1. The Discharge Gap without Auxiliary Current with Parallel Capacitor

For previous neon stabilisers the limitation of parallel capacitances to the permissible maximum ratings $C_{pmax}$ quoted in the data sheet is closely associated with the permissible minimum current $I_{min}$. The ratings for $P_{pmax}$ invariably refer to the case that the characteristic of the stabiliser type can be fully exploited to the minimum current $I_{min}$ quoted. However, if care is taken by appropriate circuit ratings that the transverse current flowing in the discharge gap always remains higher than the minimum current indicated, then the parallel capacitance may also be increased. Inversely, at parallel capacitances $C_p < C_{pmax}$, the permissible tube current may drop below the value for $I_{min}$ within certain limits. In the past the circiut designer was unable to find adequate data on the relationships implied here in the appropriate literature: in consequence this relationship will be explained in the following as far as necessary for proper appreciation.

First of all, let us consider the characteristic of a discherge gap without an ignition electrode, as is customary for all neon stabilisers (cf. Fig. 1). Normally the section between points A and B is exploited for stabilisation, and is termed the control range. This range is limited by the maximum permissible transverse current $I_{amax}$ (point A), which must not be exceeded for continuous operation without the tube being thermally overloaded. Towards lower transverse currents the control range is limited by the minimum current $I_{amin}$ (point B), at which the operating voltage reaches its lowest rating. When the transverse current drops further the operating voltage rises rapidly to reach its maximum rating at point C at very low currents, namely the ignition voltage $U_{aZ}$. At this point the automatic discharge ceases and changes into a dependent discharge. Though the section between points B and C, which is called the "subnormal range" of a neon discharge, is not used for stabilisation since the current is highly dependent on the operating voltage, it nevertheless plays an important part in the design of a stabilisation circuit with a parallel capacitance, as we shall see in the following.

The differential resistance $\Delta U_{aB}/\Delta I_a$ of the static characteristic, which is frequently (erroneously) termed the internal AC resistance $R_i$, has negative values in the range below normal as is shown in Fig. 1. Moreover, since the discharge gap in operation may be considered an inductance and the electrode arrangement is loaded by the unavoidable capacitance $C_{aK}$, an equivalent circuit results in accordance with Fig. 4. Accordingly self-excitation can arise for each operating point within the subnormal range. And in actual fact the occurrence of sine oscillations can also be easily proved, just as the conductance values of the discharge gap can be measured along the entire characteristic. The sine oscillations are stimulated by the noise and can be limited in amplitude, reproduced and kept stable by appropriate circuit measures.

If the frequency of the sine oscillations arising is varied by a variable capacitor $C_{pm}$ connected in parallel to the tube (Fig. 5), then at a known capacitance the inductance can be stated from the frequency for the static operating point adjusted in each case. The frequency of the stimulated sine oscillations reaches a maximum value of some kc/s. When the capacitance $C_{pm}$ is further reduced the oscillations can no longer be self-excited. It is found namely

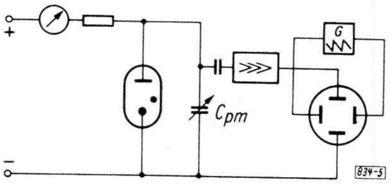



**Fig. 5.** Circuit for the measurement of the incipience of oscillations of a discharge gap in the subnormal range

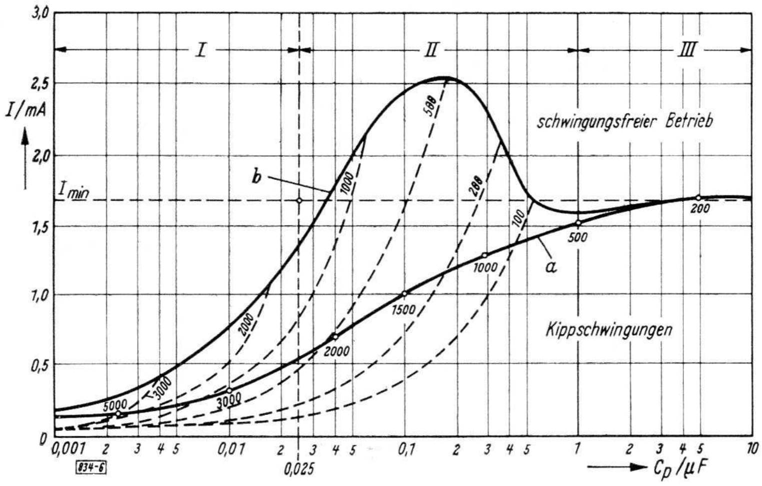



**Fig. 6.** Resonance ranges of the ZZ 1020 operated without auxiliary current as a function of $C_p$ and $I_a$: ---- curves of the same relaxation frequency

that the negative resistances, which can be observed in the static characteristic for the subnormal range, drop very quickly with rising frequency, become zero and change their sign.

This dependence on frequency of the complex conductance, which occurs as a delay effect, is noticeable at very low frequencies due to the different inertia of the charge carriers involved in gas discharges contrary to the phenomena in vacuum tubes. For further considerations it is quite sufficient to state here that the real and imaginary portions of the conductance of a gas discharge tube are dependent on both frequency and current. This dynamic behaviour arises in principle irrespective of whether the operating point is situated in the rising of talling section of the static characteristic. Self-excitation can only occur in discharge ranges with falling characteristic, and even then only up to frequencies at which the real component of the resistance dependent on frequency remains negative still. Due to this last reason only is it possible at all to measure the static characteristic in the subnormal region. However, it is assumed that the parallel capacitance $C_p$ is kept low enough to drive the frequencies, for which stimulation would possibly not be conceivable at all, so high that the real component of the path resistance has already become positive for them and self-excitation can therefore not take place. In such cases the circuit capacitance must be rated so much lower the further the static characteristic shall be measured free of oscillations in the subnormal region towards lower currents because both the inductive and negative real components of the track conductance are approximately proportional to the direct current flowing in the circuit. It is thus obvious that for each current value in the subnormal region there exists a very definite rating of the parallel capacitance at which the boundary is reached between self-excitation and operation free of oscillations, or at which the discharge current does not drop below a definite minimum value for each parallel capacitance, if self-excitation shall be prevented.

In Fig. 6 the curve a, which refers to a tube ZZ 1020 operated without auxiliary current, constitutes the boundary below which self-excitation does not occur. The figures along the curve indicate the sine frequency at which the circuit Fig. 5 commences to oscillate when the current starts to drop below the boundary at this point. Once oscillations have started the amplitude of the sine oscillation rapidly swings to such a height that the momentary voltage across capacitor $C_p$ drops below the minimum voltage (point B in Fig. 1) and relaxation oscillations result. The amplitude of these relaxation oscillations are approximately equal to the voltage diffrence between ignition voltage $U_{az}$ and the minimum voltage associated with point B. Relaxation may be initiated by one single slight drop below the boundary a in Fig. 6 and will now be sustained, and cannot be stopped again simply by shifting the operating point just over this boundary.

To this end the current applied by the voltage supply must be substantially increased, which can be achieved by increasing the supply voltage or by reducing the input resistance rating. The current which then results as a stationary transverse current immediately after relaxation oscillations cease, corresponds to curve b in Fig. 6.

It is useful to divide this curve into three sections. Section 1 covers the range of small capacitance up to approx. 25 nF, in which the operating point may be situated below $I_{amin}$ — thus more or less far inside the subnormal region — without self-excitated relaxation oscillations being sustained. Section II ranges from approx. 25 nF to approx. 1µF. In this range the constant operating point must be more or less situated as a function of the parallel capacitance if self-excited relaxation oscillations shall be precluded. In Section III with parallel capacitances in excess of 1 µF, there is no tendency to oscillate at currents above $I_{a\,min}$.

A number of interrelated factors are responsible for this differing behaviour, which cannot be dealt with here in detail. During the relaxation operation discharges take place dynamically to such an extent that there is no sense in orientation by the static characteristic. By recording oscillograms it can be shown graphically how the dynamic current-voltage lines swing over the static characteristic in both directions, draw closer and closer to it with increasing current and appropriately rising relaxation frequency and relaxation oscillations then cease.

Hitherto, the occurrence of relaxation oscillations was considered the sequel of a previous self-excitation of sine oscillations. To this end the current in the tube already in operation would have to be decreased to a greater or or less extent below the minimum current depending on the rating of the parallel capacitance. In practice this effect may occur when the mains voltage drops for a short period. Moreover, the primary initiation of a relaxation process always takes place when the feed voltage is applied to the stabilisation circuit and the tube is ignited because part of the relaxation cycle is performed. The permanent operating point must be situated above the boundary curve b in Fig. 6 in both cases. But this means that the characteristic cannot be exploited for capacitance ratings within Section II, and in Section III there is no adequate security against relaxation oscillations. From these factors it is obvious that a rating of $C_{pmax}$ is quoted in data sheets for which the characteristic may be exploited to the minimum current without the risk of relaxation oscillations existing. However, the first ignition peak is still present when the tube is switched on. It often gives rise to improper switching in modern automatic circuits which are mainly driven by pulses, and thus limits the applications of neon stabilisers not provided with an ignition electrode.

## 2. The Discharge Gap with Ignition Electrode and Parallel Capacitance.

Since the difficulties encountered in neon stabilisers not fitted with an ignition electrode may all be attrituted in principle to the same cause, namely the difference between ignition and operating voltages, ways and means must be found to reduce the ratio between ignition voltage and operating voltage to 1:1 as far as possible. This was achieved in the new neon stabilisers by sustaining a discharge by introducing an additional discharge near the main gap. The auxiliary discharge gap comprises the cathode k, which is common for the auxiliary and main discharges, and an auxiliary anode z, through which a weak auxiliary current $I_z$ may be carried without influencing the discharge features of the main gap in the control range. The influence of the auxiliary discharge on the characteristic curve of the main gap ka is shown in Fig. 7 for the subnormal range. The ignition voltage, which corresponds to the customary ratio ignition voltage to operating voltage $U_{za}/U_{aB} \approx 4/3$ in neon diodes when the auxiliary current $I_z = 0$ at 110 V is lacking, is reduced to the operating voltage rating at a mean operating current by an auxiliary current $I_z = 0.1$ mA. Actually we can no longer speak of an anode ignition voltage in the customary sense of the word because the main discharge is sustained in any case, irrespective of the magnitude of the anode current. It is more appropriate to indicate the highest excessive voltage arising in the subnormal region with respect to the minimum voltage, the excessive voltage being dependent on the magnitude of the auxiliary current. At $I_z = 0$ A this excessive voltage amounts to approx. 30 V, but only approx. 0.4 V at $I_z = 0.1$ mA, and drops to zero at $I_z = 0.25$ mA approximately.

As long as the excessive voltage increase exists, the static characteristic curve drops in a certain sense. But this range decreases with growing auxiliary current $I_z$ because at anode currents less than $I_z/0.3$ (dashed line in Fig. 7), the characteristic rises and stimulated resonance is no longer possible. *)

*) Since the dashed function $U_{aB} = f(I_a)$ with $I_z/I_a$ = const. = 0.3 is the envelope for all operating points at which $\triangle U_{aB}/\triangle I_a$ = const. has positive ratings, self-excitation cannot arise although the function constitutes a curve featuring a falling characteristic.

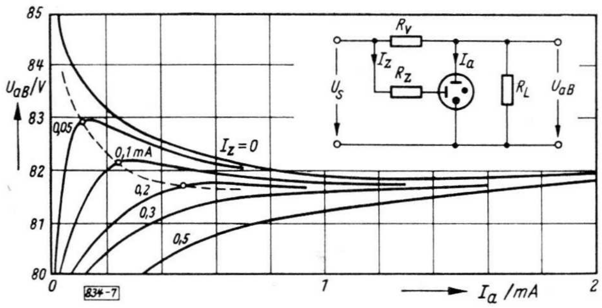



**Fig. 7.** $U_{aB} = f(I_a)$ characteristic of the ZZ 1020 in the range of low anode currents, parameter $I_z$.

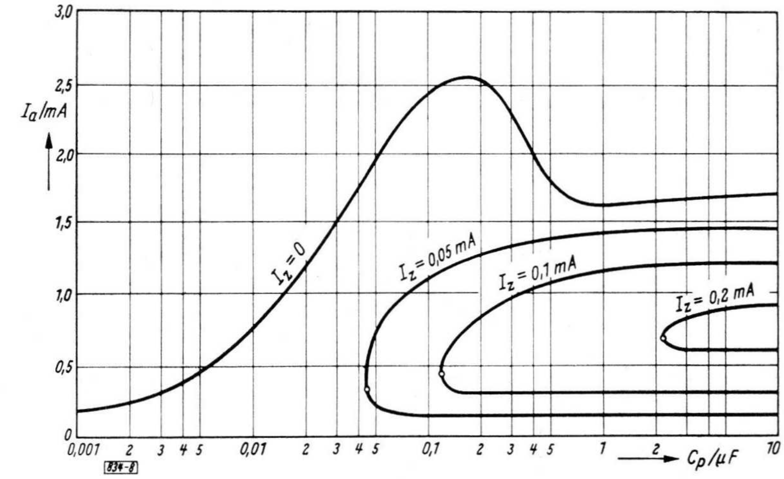



**Fig. 8.** Resonance ranges of the ZZ 1020 operated with auxiliary current, as a function of $C_p$, $I_a$ and $I_z$

In accordance with the presentation given in Fig. 6, which indicates the tendency to oscillate as a function of parallel capacitance on the absence of auxiliary current, Fig. 8 indicates the ranges in which the tube still oscillates if the auxiliary currents $I_z$ are 0.05 mA, 0.1 mA and 0.2 mA. The experimental result shown in Fig. 8 confirms the behaviour to be expected in view of the family of static characteristics. (Fig. 7). With rising auxiliary current $I_z$ the ranges, in which the stimulation of oscillations is possible at all diminishes more and more to disappear completely at $I_z = 0.25$ mA, even at higher parallel capacitances. For each capacitance rating $C_p$ a definite auxiliary current $I_z$ may be stated, which is a minimum if the start of oscillations shall be prevented completely. However, if the current drops slightly below the critical auxiliary current $I_z$ associated with each parallel capacitance, then oscillations tend to start only if the anode current assumes a quite definite critical value $I_{akrit}$. For all ratings $I_a \neq I_{akrit}$ there is no possibility of the stimulation of oscillations. In Fig. 8 the associated pairs of ratings for $I_z$ and $I_{akrit}$ may be read off for each capacitance: for example an auxiliary current having the minimum rating $I_z = 0.1$ mA is associated with a parallel capacitance $C_p = 0.12\,\mu F$ if the anode current assumes its critical value $I_{akrit} = 0.47$ mA. For the design of practical stabilisation circuits using the tube ZZ 1020 Fig. 9 may be considered a reference. An adequate degree of safety has been included, which takes into consideration the customary tolerances of the components and production tolerances of the voltage stabiliser tube. From this graph presentation we must read off for each parallel capacitance $C_p$ the minimum current $I_z$ for the auxiliary gap which must invariably flow for operation without undesired oscillations if the anode current may reach a critical value $I_{akrit}$.

## 3. The Design of Stabilising Circuits using Neon Stabilisers with Ignition Electrode

### 3.1. The auxiliary current

On designing a stabilising circuit it must be borne in mind that the auxiliary current is not constant and changes in accordance with supply voltage fluctuations since it is applied as a rule by the supply voltage source.

Whereas the auxiliary current $I_z = (U_s - U_{zB})/R_z$ is substantially independent of the anode current $I_a$ (cf. Fig. 10) for all cases encountered in practice, the anode current $I_a = [(U_s - U_{aB})/R_v] - I_L$ is dependent on both supply voltage $U_s$ and on load current $I_L$. Due to the requirement that for operation free of oscillations the auxiliary current does not drop below the minimum rating shown in Fig. 9 at the associated critical anode current $I_{akrit}$, we may differentiate between two typical cases of operation when selecting the rating of resistor $R_z$.

In the first case the load current $I_L$ changes, which is derived from the circuit. It may happen that the anode current passes through all values $I_a \gtrless I_{akrit}$ and $I_z$ must be rated by suitable selection of the input resistance $R_z$ in such a manner that the minimum current $I_z$ read off in Fig. 9 flows when the supply voltage reaches its minimum rating $U_{smin}$. This happens when $R_z \leqq (U_{smin} - U_{zB})/I_z$.

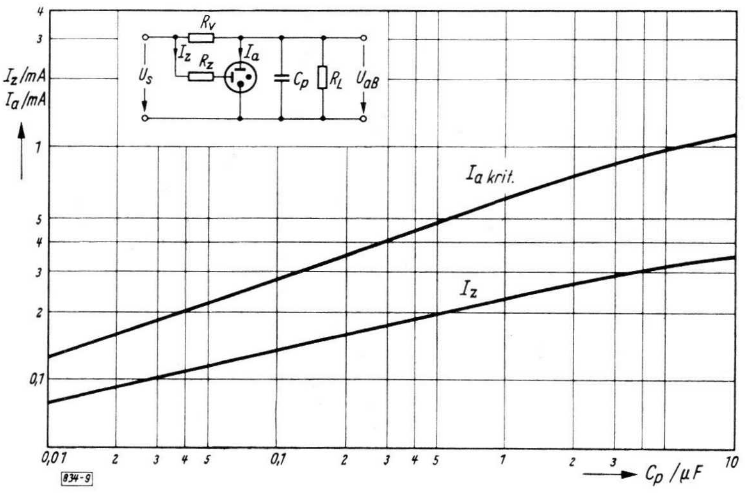



**Fig. 9.** $I_z$ and $I_{akrit}$ as a function $C_p$ for the ZZ 1020

In the second case the load current remains constant, and auxiliary current and anode current change in the same sense only with the supply voltage. The auxiliary current $I_z$ indicated in Fig. 9 need only be maintained at the appropraite value for $I_{akrit}$. For fixed ratings of $I_L$ and $R_v$ this is the case at a definite supply voltage $U_s$. When $U_s$ drops further $I_z$ is also reduced though $I_a$ drops at the same time and in a relatively greater measure than $I_z$ so that the ratio $I_z/I_a$ grows, the operating state drawing away more and more from the range of the greatest tendency to oscillate despite the drop below the rating for $I_z$. Since for each operating state $R_z = (U_s - U_{zB})/I_z$ and $U = R_v (I_a + I_L) + U_{aB}$ it follows that

$$R_z = \frac{1}{I_z} [U_{aB} + R_v (I_a + I_L) - U_{zB}]$$

and if for $I_a$ and $I_z$ the critical anode current and the associated values for $I_z$ from Fig. 9 and $U_{zB} = U_{aB}$ are inserted, then

$$R_z \leqq \frac{R_v}{I_z} (I_{akrit} + I_L) \qquad (1)$$

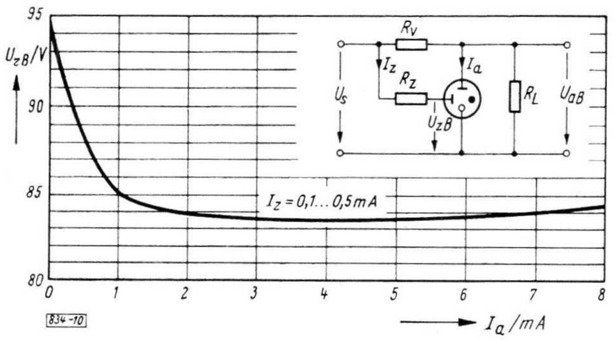



**Fig. 10.**
Operating voltage of the auxiliary discharge gap when the main discharge of the ZZ 1020 is taking place: $U_{zB} = f(I_a)$ at low auxiliary currents $I_z = 0.1$ to 0.5 mA

### 3.2. Prevention of ignition peaks

Automatic circuits are often required to automatically resume their normal functions after a mains failure has been rectified. If the voltages needed to supply such units are stabilised with conventional stabilisers, then the ignition peak already mentioned occurs when mains voltage is applied again. It may happen that in this manner incorrect switching is initiated in the unit in consequence. This problem does not arise when voltage stabilisers provided with an ignition electrode are used because the proper ignition of the auxiliary gap can be forced before the voltage across the anode has accumulated to such a value where excessive voltage would be present. Once the auxiliary gap has been properly ignited the anode effects discharge even at voltages below the normal operating voltage (cf. Fig. 7).

A possibility would be given for the delayed accumulation of anode voltage in respect of ignition voltage for the auxiliary gap if the capacitor $C_p$ is rated high enough to ensure that the time contstant $\tau_1$ from the circuit components $R_v$, $R_L$ and $C_2$ (Fig. 9) is higher than the time constant $\tau_2$ from $R_z$ and the capacitor $C_{zk}$. In respect of the tube types discussed here the necessary parallel capacitance would have to be in the order of 1 μF approximately. However, by this method ignition peaks can only be prevented if the supply voltage is applied momentarily at full value. If the supply voltage were to rise slowly, as is the case when generously rated filter elements are used after rectification and the time constant $\tau_1$ would not suffice to ensure the requisite delay, then the output voltage could still rise to the anode ignition voltage without a load being connected. To prevent ignition peaks in such circumstances a fixed load resistor $R'_p$ is added which, in conjunction with the preceding resistor $R_v$, acts as voltage divider and reduces the voltage across the anode to such an extent that the anode can perform the discharge when the auxiliary gap is ignited at voltage $U_{zZ}$ but no excessive voltage is present (cf. circuit in Fig. 11). In the tubes described here discharge is performed by the anode when a voltage $U_a = 2\,U_{zZ}/3$ is applied to it. Hence the following equation describes the condition for the continuous entering of the output voltage in the value of the operating voltage (operation free of ignition peaks even when the supply voltage rises very slowly).

$$\frac{R_v + R'_p}{R'_p} \leqq \frac{U_{zZ}}{U_a} \leqq \frac{3}{2} \quad \text{or } R'_p \leqq 2\,R_v \tag{2}$$

Should the load not constitute a ballast in itself which is equal to twice the rating of the preceding resistor, then for operation free of ignition peaks the voltage divider ratio must be obtained under all circumstances by adding a fixed resistor $R_p$ parallel to the output.

The rating of components $R_v$ and $R_p$ is dependent just as much on the condition given at the output by the load as on the tube data and the available supply voltage with its fluctuations which must be eliminated.

If the load varies the current $I_L$ consumed by the load should preferably be divided into a fixed component $I_{Lmin}$ corresponding to the minimum load current, and into the component

$$\delta\, I_L = I_L - I_{Lmin} \leqq \triangle\, I_L = I_{Lmax} - I_{Lmin}$$

Should it be necessary to connect an additional resistor $R_p$ in parallel due to the requirement for operation free of ignition peaks, in order to satisfy the condition $R'_p \leqq 2\,R_v$ even at the minimum load current $I_{Lmin}$, then the stabilisation circuit must provide additionally the current $I_p$, which can be combined with $I_{Lmin}$ to $I'_p = I_{Lmin} + I_p$. Then namely at a fixed supply voltage

$$U_s = U_{aB} + R_v\,(I_a + \delta\, I_L + I'_p) \tag{3}$$

the sum $(I_a + \delta\, I_L)$ as well as $I'_p$ is also stable even when the load fluctuates. At $R_v = R'_p/2 = U_{aB}/(2\,I'_p)$ the supply voltage for a stabilisation circuit free of ignition peaks becomes

$$U_s = \frac{1}{2}\,U_{aB}\left(3 + \frac{I_a + \delta\, I_L}{I'_p}\right) \tag{4}$$

The minimum rating $U_{smin}$ is obtained by inserting for $I_a$ the minimum tube current as recommended for the various tubes in the table, by inserting for $U_{aB}$ the operating voltage at this current and for $\delta\, I_L$ the maximum load fluctuation $\triangle\, I_L$. The maximum permissible supply voltage $U_{smax}$ results if we insert the admissible tube current $I_{amax}$ for $(I_a + \delta\, I_L)$ and the operating voltage at $I_{amax}$ for $U_{aB}$. If the operating voltage at maximum tube current is referred to the operating voltage at minimum tube current by inserting

$$U_{aB}\,(I_{a\,max}) = U_{aB}\,(I_{a\,min}) + R_i\,(I_{a\,max} - I_{a\,min}) = U_{aB}\,(I_{a\,min}) + \triangle U_{aB}$$

then the equations for minimum and maximum supply voltages read

$$U_{smin} = \frac{1}{2}\,U_{aB}\left(3 + \frac{I_{amin} + \triangle\, I_L}{I'_p}\right) \tag{5a}$$

$$U_{smax} = \frac{1}{2}\,U_{aB}\left(3 + \frac{I_{amax}}{I'_p} + \frac{3\,\triangle\, U_{aB}}{U_{aB}}\right) \tag{5b}$$

where the difference in operating voltages $U_{aB}\,(I_{amax}) - U_{aB}\,(I_{amin})$ must be inserted for $\triangle U_{aB}$, and the operating voltage at minimum tube current $I_{amin}$ for $U_{aB}$. The relationship

$$\frac{U_{s\,max}}{U_{s\,min}} = \frac{100 + p}{100 - q} = K = \frac{3 + \dfrac{I_{a\,max}}{I'_p} + \dfrac{3\,\triangle U_{aB}}{U_{aB}}}{3 + \dfrac{I_{a\,min} + \triangle I_L}{I'_p}} \tag{5c}$$

indicates the permissible voltage fluctuation factor K (p% above and q% below the nominal rating) for full exploitation of the characteristic. From this we obtain the constant current component at the load end

$$I'_p = \frac{I_{amax} - K\,(I_{amin} + \triangle\, I_L)}{3\,(K - (\triangle\, U_{aB}/U_{aB}) - 1)} \tag{6}$$

at which with given fluctuation factor K (at the supply voltage input end the tube characteristic is fully exploited from $I_{amin}$ to $I_{amax}$, and load $\triangle I_L$ is regulated.

These relationships are presented in Figs. 11, 12 and 13 for the tubes ZZ 1020, ZZ 1010 and ZZ 1040, and will be illustrated here by means of some calculation examples. These diagrams indicate clearly the tube type suitable for the specified load and voltage conditions. The other data required from the data sheet for the calculation may be obtained from the table and the characteristic $U_{aB} = f(I_a)$ Figs. 14, 15 and 16) for the types in question.

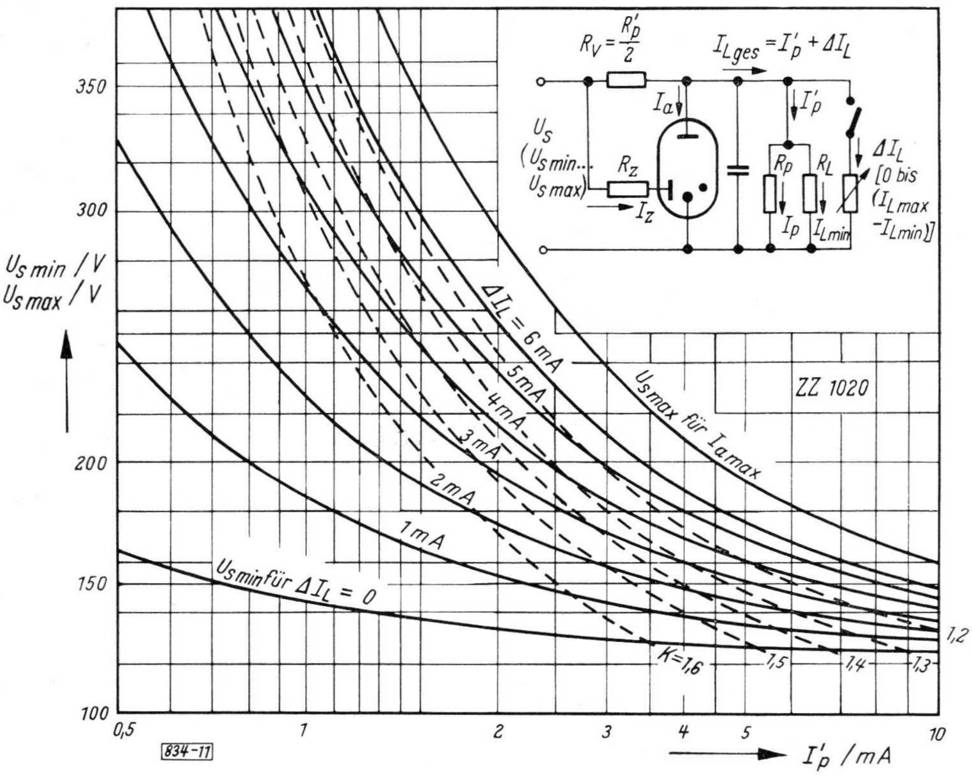



**Fig. 11.** Supply voltage of ZZ 1020 as function of $I'_p$, $\triangle I_L$ and K with $I_{a\,max} = 8$ mA

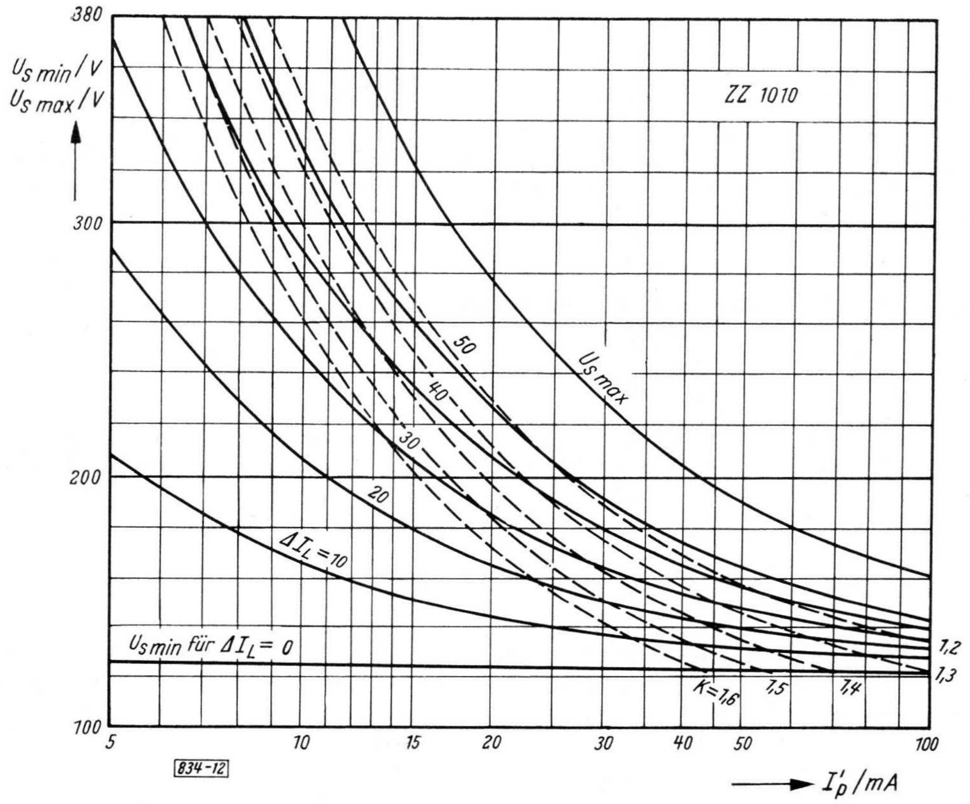



**Fig. 12.** Supply voltage of ZZ 1010 as function of $I'_p$, $\triangle I_L$ and K with $I_{a\,max} = 70$ mA

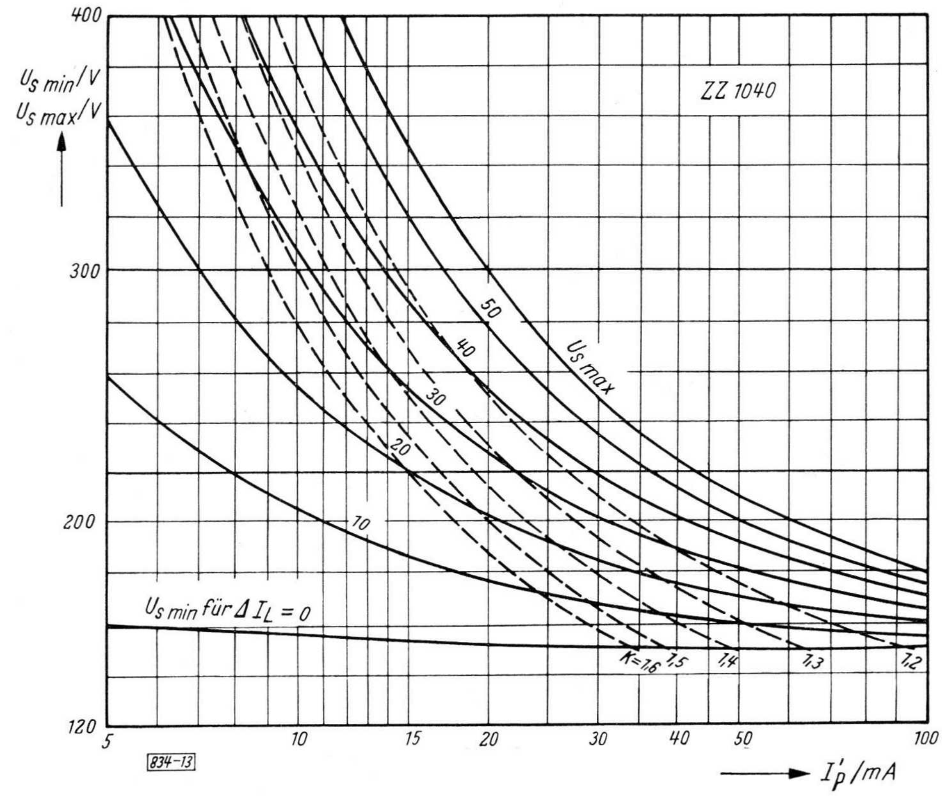



**Fig. 13.** Supply voltage of ZZ 1040 as function of $I_p$, $\Delta I_L$ and K with $I_{a\,max} = 60$ mA

**Table: The data of stabiliser tubes with ignition electrode required to design a stabilisation circuit**

| Tube type | | | ZZ 1020 sub-min. | ZZ 1010 min | ZZ 1040 magnoval |
|---|---|---|---|---|---|
| Operating voltage at $I_{a\,min}$ | $U_{aB}$ | V | 81.4 | 81.4 | 100 |
| Max. anode current | $I_{a\,max}$ | mA | 8 | 70 | 60 |
| Min. anode current *) at auxiliary current $I_z$ | $I_{a\,min}$ | mA | 0.5 | 0.5 | 1 |
| Max. operating voltage difference for full drive $I_{a\,min} \ldots I_{a\,max}$ | $U_{aB}$ | V | 3.2 | 6.5 | 0 |
| Auxiliary discharge current *) | $I_z$ | mA | 0 2 | 0.2 | 1 |
| Operating voltage of auxiliary discharge gap at $I_{a\,min}$ | $\Delta U_{zB}$ | V | ~ 85 | ~ 85 | ~ 106 |
| Ignition voltage of auxiliary discharge gap = min. supply voltage *) | $U_{zZ}$ $U_{s\,min}$ | V V | 122 | 122 | 150 |

*) recommended rating for operation free of oscillations and ignition peaks.

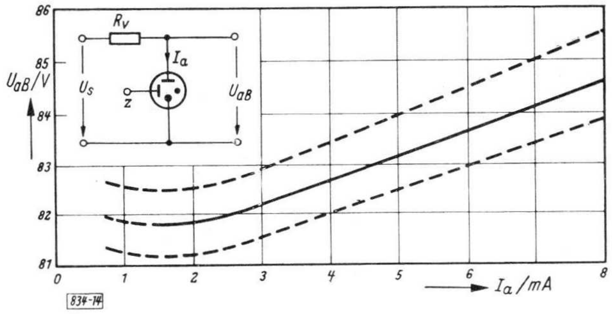



**Fig. 14.**
$U_{aB} = f(I_a)$ characteristic for ZZ 1020 for $I_z = 0$

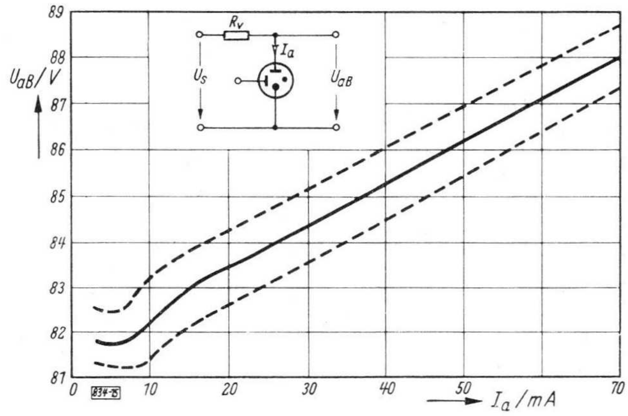



**Fig. 15.**
$U_{aB} = f(I_a)$ characteristic for ZZ 1010 for $I_z = 0$

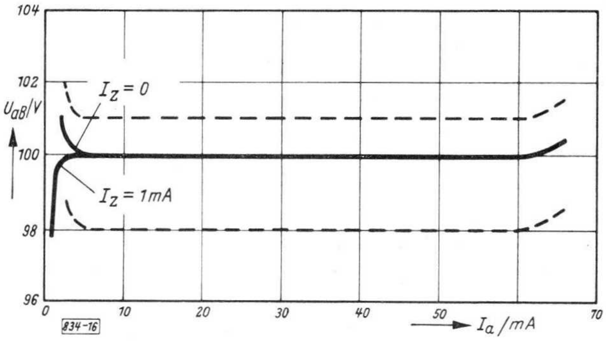



**Fig. 16.**
$U_{aB} = f(I_a)$ characteristic for ZZ 1040

## 4. Calculation Example

### 4.1. Example 1

The design of a circuit containing the ZZ 1020 with auxiliary current in accordance with Fig. 11 shall be carried out in such a manner that it supplies at the output a constant current of $I_L = 5$ mA at a stabilised voltage $U_{aB} \approx 83$ V into a load $R_L$, and that it is fed at the input with a supply voltage $U_s$ whose nominal rating may fluctuate by (+ 15%, − 20%). At the same time it shall be possible to exploit to the fully the characteristic from $I_{amax} = 8$ mA to $I_a = 0.5$ mA in this selected example. The parallel capacitance $C_p$ shall be 4 µF: ignition peaks shall not occur. We must now ascertain the nominal supply voltage $U_{snenn}$, the input resistance $R_v$ and the resistance $R_z$ preceding the auxiliary discharge gap.

The load constitutes a fixed resistance $R_L = 16.6$ kΩ. Due to the requirement for freedon from peaks the input resistance must be $R_v = 0.5$ kΩ and $R_L = 8.3$ kΩ. Since the anode current shall be $I_a = 0.5$ mA at the minimum supply voltage $U_{smin}$, the overall current in the input resistance will be $I_{Rv} = I_a + I_L = 5.5$ mA and the voltage drop $U_{Rv} = R_v \cdot I_{Rv} = 45.6$ V. In accordance with Fig. 14 the operating voltage $U_{aB}$ amounts to approx. 81.4 V for $I_a = 0.5$ mA and $I_z = 0.2$ mA, and thus we have a minimum supply voltage $U_{smin} = U_{Rv} + U_{aB} = 127$ V, or the nominal rating of the supply voltage $U_{snenn} = U_{smin}/0.8 = 159$ V.

At the maximum permissible anode current $I_{amax} = 8$ mA the overall current is $I_{Rv} = I_{amax} + I_L = 13$ mA and the voltage drop $U_{Rv} = R_v \cdot I_{Rv} = 108$ V. As regards operating voltage the characteristic indicates the rating $U_{aB}$ (8 mA) = 84.6 V, and thus the maximum permissible supply voltage is

$$U_{smax} = 192.6 \text{ V} = U_{snenn} + 21\%$$

To exploit to the full the characteristic $I_a = 0.5$ to 8 mA the permissible fluctuation factor amounts to

$$K = \frac{U_{smax}}{U_{smin}} = \frac{100 + 21}{100 - 20} = 1.51$$

The values ascertained can be read off from the diagram Fig. 11. At a constant load current $\triangle I_L = 0$ and the curve for $U_{smin}$ at $\triangle I_L = 0$ intersects the abscissa value $I'_p + 5$ mA at $U_{smin} = 127$ V. For this point we also find the fluctuation rating K at 1.51 for full exploitation of the characteristic up to $I_a = I_{amax} = 8$ mA. The maximum permissible supply voltage $U_{smax}$ is read off for $I_{amax}$ at approx. 193 V at $I'_p = 5$ mA.

For the case considered here, namely that the supply voltage exceeds the nominal rating by maximum 15% only, the characteristic is not utilised up to $I_{amax}$. The voltage value arising at 15% in excess voltage is $U_s = 1.15$, $U_{snenn} = 183$ V and the current flowing in the preceding resistor

$$I_{Rv} = (U_s - U_{aB})/R_v \approx 12 \text{ mA}$$

The tube current is then $I_a = I_{Rv} - I_L \approx 7$ mA and when the supply voltage changes from $U_{smin} = 127$ V to $U_s = K \cdot U_{smin} = 183$ V, the tube current changes by $\triangle I_a = 6.5$ mA from 0.5 mA to 7 mA. This figure may also be obtained from the diagram (Fig. 11) by estimating the current change $\triangle I$ at approx. 6.5 mA for $I'_p = 5$ mA and for supply voltage $U_s = 183$ V. According to the diagram $\triangle I = 4$ mA and the tube current $I_{anenn} = \triangle I + I_{amin} = 4.5$ mA for the nominal voltage $U_{snenn} = 159$ V.

The characteristic reveals a change in operating voltage from $-1.4$ V and $+1.4$ V respectively or $\pm 1.7$% approximately. At a supply voltage fluctuation of $-20$% and $+15$% respectively the stabilisation factor is $S = \triangle U_{aB}/\triangle U_s \approx 10$ in this design. To ascertain the receding resistance Fig. 9 shows for $C_p = 4\ \mu$F the values $I_z$ and $I_{akrit}$ at 0.3 mA and 0.9 mA respectively. From equation (1) $R_z = R_v (I_{akrit} + I_L)/I_z$ we obtain for the resistor rating $R_z \leqq 164$ kΩ.

## 4.2. Example 2

The load current derived from a stabilisation circuit containing tube ZZ 1020 shall change between 0 and 4 mA, and the tube current shall be maintained within the limits of $I_a = 0.5$ to 8 mA as in Example 1. The parallel capacitance shall again be $C_p = 4\ \mu$F, and ignition peaks must not occur. As regards feed voltage a fluctuation of (+ 15%, − 20%) shall be permitted corresponding to a fluctuation factor $K = (100 + 15)/(100 - 20) = 1.44$. We must now find the necessary nominal supply voltage, and circuit design must be indicated.

Since we may assume that the load resistance reaches the rating $R_L = \infty$, an additional paralell resistance $R_p = 2 \cdot R_v$ must be inserted in accordance with equation (2) for the suppression of ignition peaks. This resistance rating is dependent on the supply voltage selected, but must be high enough on the other hand to satisfy the requirement relating to the fluctuation factor. In accordance with equation (6) the current in the parallel resistance amounts to $I_p = I'_p = 1.28$ mA at $I_{amin} = 0.5$ mA, $\triangle I_L = 4$ mA, $I_{amax} = 8$ mA, $\triangle U_{aB} = 3.2$ V, $U_{aB}$ (0.5 mA) = 81.4 V and $K = 1.44$, and thus the parallel resistance is $R'_p = 81.4$ V/1.28 mA = 63.6 kΩ and the preceding resistance is $R_v = R'_p/2 = 31.8$ kΩ. The minimum supply is thus $U_{smin} = R_v (I'_p + \triangle I_L + I_{amin}) + U_{aB} = 31.8 \cdot 5.78 + 81.4 = 265$ V in agreement with equation (5a) and the maximum supply voltage in accordance with equation (5b) is $U_{smax} = K \cdot U_{smin} = 380$ V. In the diagram (Fig. 11) we read off the minimum supply voltage at 265 V as a function of $I'_p = 1.28$ mA at $\triangle I_L = 4$ mA, and the utilisable fluctuation factor follows as $K = 1.44$. The curve for maximum supply voltage indicates the rating $U_{smax} = 380$ V at maximum tube current $I_{amax}$ for $I'_p = 1.28$ mA. At the nominal rating of supply voltage $U_{snenn} = U_{smax}/1.15 = U_{smin}/0.80 = 330$ V the supply current injected is $I_{smax} = (U_{snenn} - U_{aB})/R_v = 7.7$ mA. The auxiliary current, derived from Fig. 9 at $I_z = 0.3$ mA for $C_p = 4\ \mu$F, must be maintained at the indicated rating for $U_{smin}$ too since the anode current can assume all possible ratings between 0.5 and 4.5 mA, including $I_{akrit} = 0.9$ mA, due to the envisaged load change. With an operating voltage of the auxiliary discharge gap $U_{zB} = 85$ V (Fig. 10) at $I_a = 0.9$ mA, then $R_z \leqq (U_{smin} - U_{zB})/0.3 \leqq 600$ kΩ.

## 4.3. Example 3

The supply voltage is given at a nominal rating $U_{snenn} = 285$ V (220 V AC mains after rectification) and the fluctuation to be stabilised is (+ 10%, − 15%) ($K = 1.3$). At a stabilised voltage of 100 V the load consumes a constant current $I_{Lmin} + 10$ mA. Moreover, it shall be possible to drive an additional variable load current, whose permissible magnitude shall be determined by $\triangle I_L$. A capacitance $C_p = 10\ \mu$F is connected in parallel to the load: interfering oscillations and ignition peaks shall not arise. A stabiliser tube type 1040 is used, whose data are quoted in the table. We obtain from equation (6)

$$I'_p = \frac{I_{amax} - K (I_{amin} + \triangle I_L)}{3 (K - (\triangle U_{aB}/U_{aB}) - 1)}$$

after inserting the values for stabiliser tube ZZ 1040 at $U_{aB} = 100$ V: $\triangle U_{aB}/U_{aB} = 0$: $I_{amax} = 60$ mA: $I_{amin} = 1$ mA and $K = 1.3$ for the permissible load current change the expression $\triangle I_L = 45 - 0.7\, I'_p$ which, inserted in equation (5a) gives the rating for $I'_p$ at 18.5 mA from $U_{smin} = U_{snenn} \cdot 0.85 = 242\ V = U_{aB}\ [3 + (I_{amin})/I'_p + (\triangle I_L/I'_p)]/\ 2$. This rating should ensure operation free of ignition peaks under the given conditions. The permissible change of load current is $\triangle I_L = 45 - 0.7\, I'_p = 32$ mA if, by means of an additional parallel resistance $R_p$ the current $I_p = I'_p - I_{Lmin} = 18.5 - 10 = 8.5$ mA flows, corresponding to a resistance $R_p = 100\ V/8.5\ mA = 11.8\ k\Omega$.

In equation (2), to ascertain the resistance $R_v = 0.5 \cdot R_L$ the highest value occurring in operation must be inserted, viz. $R_L = U_{aB}/I'_p = 100\ V/18.5\ mA = 5.4\ k\Omega$: thus $R_v$ is 2.7 kΩ.

As regards tube type ZZ 1040, operation free of oscillations is ensured with anode currents $I_a$ down to 1 mA and below and at arbitrary parallel capacitances, if the auxiliary current $I_z$ amounts to 1 mA approximately. Hence the resistance $R_z$ for the auxiliary discharge gap is rated $R_z \leqq (U_{smin} - U_{zB})/I_z = (242\ V - 106\ V)/1\ mA = 136\ k\Omega$.

## 5. Series Connection of Neon Stabilisers with Ignition Electrode

Higher stabilised voltages (Fig. 17) may be produced in a simple manner by connecting several similar stabiliser tubes in series. A circuit incorporating a number n of tubes connected in series is designed in the same manner as for the single tube, the values for supply voltage $U_s$, the operating voltage $U_{aB}$, the resistance $R_v$ and load resistance $R_L$ must be multiplied by factor n, but the value for the parallel capacitance must be multiplied by 1/n. When tubes

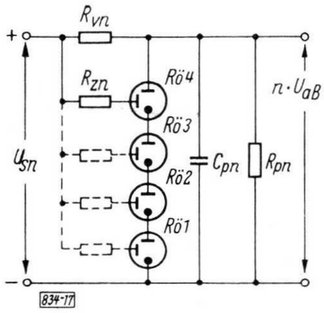



**Fig. 17.** Series connection of stabilisers provided with ignition electrode

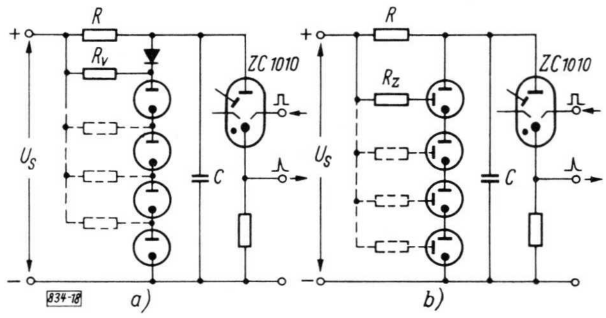



**Fig. 18.** Neon stabilisers for voltage limitation
(a) without ignition electrode
(b) with ignition electrode

dispensing with an auxiliary discharge are used, the reduction of the parallel capacitance permissible for the series circuit means a limitation of the applications in some cases. However, if tubes provided with an auxiliary discharge gap are used, arbitrary capacitances may be connected in parallel again, and interfering ignition peaks prevented.

The voltage required to ignite all auxiliary discharge gaps is not n times the ignition voltage $U_{zZ}$ of the single tube, but is only $(U_{zZ} - U_{aB})$ higher than n times the operating voltage $U_{aB}$. When no load is connected to the output $(U_{zZ} - U_{aB})$ is the ignition peak, which arises just as in the single tube, and its absolute rating is not dependent on the number of tubes connected in series.

Here too, the excessive voltage is suppressed by the same measures as with the single tube (cf. section 3.2) by dividing the supply voltage by inserting a parallel resistor $R_p$ to such an extent that the voltage across the final tube (Rö 4 in Fig. 17) cannot exceed the operating voltage if the supply voltage just reaches the value at which this tube is ignited via its auxiliary anode. This is the case if

$$\frac{U_{aZ} - U_{aB}}{n \cdot U_{aB}} = \frac{R_{vn}}{R_{pn}} \quad \text{or} \quad R_{pn} = \frac{n \cdot R_{vn}}{(U_{zZ}/U_{aB}) - 1}$$

For tube types ZZ 1010, ZZ 1020 and ZZ 1040 we have $(U_{zZ}/U_{aB}) - 1 = 0.5$, and hence the condition for the suppression of the ignition peak is $R_{pn} = 2 \cdot n \cdot R_{vn}$. The magnitude of the auxiliary current $I_z$ may again be obtained from the diagram Fig. 9 but, however, as already mentioned, the abscissa values $C_p$ must be divided by the number of tubes n. Only the magnitude of the auxiliary current for the final tube (Rö 4 in Fig. 17) is important to ensure operation free of oscillations for neon triodes connected in series since all other tubes must carry this current at least across the cathode.

Hence, the following formula applies for the rating of the preceding resistance

$$R_{zn} = \frac{1}{I_z} [n \cdot U_{aB} + R_{vn}(I_a + I_L)] - n \cdot U_{zB}$$

This corresponds to the relationship (1) derived for the single tube:

$$R_{zn} = \frac{R_{vn}}{I_z} (I_{akrit} + I_L)$$

Further resistors $R_z$, via which the ignition electrodes of the other tubes could be coupled to supply voltage $U_a$, are unimportant for the maintenance of operation free of oscillation, and merely serve to facilitate the ignition of these tubes. Their ratings are not critical in any way and should be so selected that the auxiliary current amounts in each case to approx. 50 $\mu$A at the nominal supply voltage.

## 6. Voltage Limitation with Stabilisers

In Fig. 18 a a circuit is shown for voltage limitation by stabilisers without an ignition electrode, and Fig. 18 b indicates a modification of the same circuit for the use of the same type of stabiliser with ignition electrode. The principle circuit shown in Fig. 3 is concerned with feeding a switching tube (ZC 1010) operating by pulses and featuring self-quenching, for which high pulse power and high pulse repetition frequency are specified at the same time. In such cases the capacitance C cannot be charged direct by the stabiliser gaps because due to the high charging current peak the discharge would be extinguished immediately after the pulse and C would subsequently be inadmissibly charged to the ignition peak. But if C is charged in accordance with Fig. 18 a by the higher supply voltage $U_s$ via R the discharge gaps are not affected by the charging current flowing into C. When the voltage across C has risen to the operating voltage of the gaps, the lower current resulting from the voltage difference $U_s - U_{aB}$ and resistor R flows via diode D into the stabiliser tubes.

Contrary to customary stabilisation circuits, in which the charging current is derived from the discharge gaps, in a voltage limiter circuit in accordance with Fig. 18 a current flows into the discharge gaps as soon as C has been charged. Accordingly the limiter circuit must be so designed that when the voltage across C has dropped in the pulse in the stabiliser gaps, the necessary minimum transverse current is maintained, which may rise to the permissible maximum current $I_{amax}$ after completion of capacitor charging. In Fig. 18 a the minimum transverse current for the neon diodes is conducted via $R_v$. The current which flows via R and $R_v$ in the discharge gaps on completion of capacitor charging depends on the rating of parallel capacitance C (cf. Fig. 6 too for type ZZ 1020 on absence of auxiliary current). In consequence the current range, which is available for the regulation of mains fluctuations and for the acceptance of the incoming current from diode D, is limited to smaller or greater extent depending on the rating of the incorporated capacitor.

When stabilisers fitted with an ignition electrode are used that is not the case because when the auxiliary gap is in operation the anode current can drop to zero without excessive voltages occurring, and the entire current range is available from zero to the permissible maximum current. It must only be ensured that the auxiliary current $I_z$ read off in Fig. 9 flows at the minimum supply voltage. The lowest value of R is then determined by the maximum supply voltage and the maximum current of the stabiliser tube as $R \geqq (U_{smax} - U_{aB})/I_{amax}$. Since in this case diode D is superfluous the circuit Fig. 18 b corresponds to the simple stabilisation circuit with neon triodes with the exception of the design modification just mentioned. The remarks in section 3.2 apply here too as regards the prevention of ignition peaks.

# TELEFUNKEN ZZ 1010

**Voltage Stabiliser Tube with Ignition Electrode**

## Tentative Technical Data

### Typical Operation

| | | Min. rating | Mean rating | Max. rating | |
|---|---|---|---|---|---|
| Operating voltage at $I_a$ = 5 mA | $U_{aB}$ | **81.1** | **81.8** | **82.6** | V |
| at $I_a$ = 30 mA | $U_{aB}$ | 83.6 | 84.4 | 85.2 | V |
| Control range | $I_a$ | 4 [1]) to 70 [2]) | | | mA |
| Ignition voltage at mean illumination | | | | | |
| Main gap a/k | $U_{aZ}$ [3]) | | 105 | 112 | V |
| Auxiliary gap z/k | $U_{zZ}$ [1]) | | 115 | 120 | V |
| Voltage difference in control range | $\Delta U_{aB}$ | | | 6.5 | V |
| Max. differential AC resistance | $R_{i\sim max}$ | | 100 | 150 | Ω |
| Temperature coefficient | $TK_{UaB}$ | | | −3 | mV/°C |
| Voltage jumps at operating current between 15 and 70 mA | | | | | |

### Change of Operating Voltage during Life

| | | |
|---|---|---|
| for first 300 hours | 0.3 | % |
| each further 10,000 hours | 0.3 | % |

### Maximum and Minimum Ratings

| | | | | |
|---|---|---|---|---|
| Initial current for duration of max. 120 sec | $I_k$ [4]) | max. | **200** | mA |
| Cathode current in ignition peak | $I_{k\,sp}$ | max. | **1** | A |
| Supply voltage | $U_b$ | min. | **130** | V |
| Ambient temperature | $t_{amb}$ | min. | **−55** | °C |
| at $I_a$ = 40 mA | | max. | **+120** | °C |
| at $I_a$ = 70 mA [2]) | | max. | **+90** | °C |
| Permissible shock acceleration | $b_{stoss}$ | max. | **3000** | g |
| Permissible parallel capacitance on absence of auxiliary current | $C_p$ [5]) | max. | **25** | nF |

[1]) Notes for using the tube with auxiliary gap. The tube contains an ignition electrode z via which a constant current $I_z$ may be carried. In this manner ignition peaks and interfering oscillations may be prevented if the main gap shall be operated with parallel capacitances $C_p$ > 25 nF and $I_a$ could drop below 4 mA due to load fluctuations. In such conditions the positive pole of the supply voltage must be connected with the ignition electrode z via a high-impedance resistor. This resistor should be connected with as low a capacitance as possible to the base contact for pin 6. The rating of this resistor is dependent on the lowest supply voltage, recommended rating $R_z = \frac{U_{b\,min} - 85}{0.2}$ (kΩ)

[2]) Max. permissible constant current with adequate air circulation. Temperature $t_{amb}$ must not constantly exceed +90° C.

[3]) On absence of auxiliary current $I_z$. When $I_z$ is approx. 0.1 mA the ignition voltage drops to the value of $U_{aB}$.

[4]) This temporary overload must not occur more the once or twice within 8 hours.

[5]) Arbitrary capacitances parallel to the main discharge gap for operation with ignition electrode.

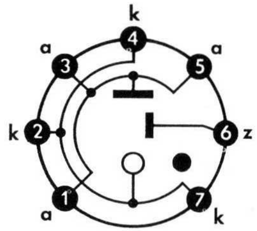
010862

# ZZ 1010 TELEFUNKEN

The tube withstands accelerations of 10 g over 10 hours at frequencies between 20 and 500 c/s and its operating voltage changes by less than 1 mV in respect of the ratings for a stationary tube.

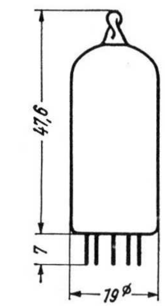
The discharge gaps must always be operated only with the specified polarity, cathode connected to —, anode and ignition electrode connected to +. Incorrect polarity gives rise to changes in tube data even when operated for a short period under these conditions

Base connection



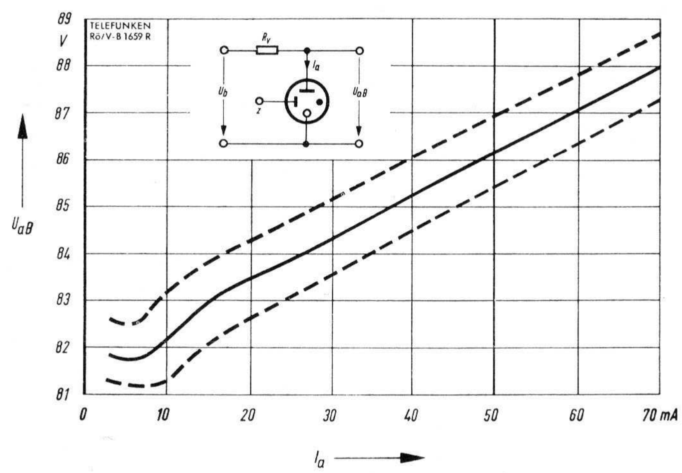

Pico 7. Miniature

Max. dimensions
DIN 41 537, outline 40,
form A




Weight approx. 10 g

Special precautions must be taken to prevent the tube from becoming dislodged.

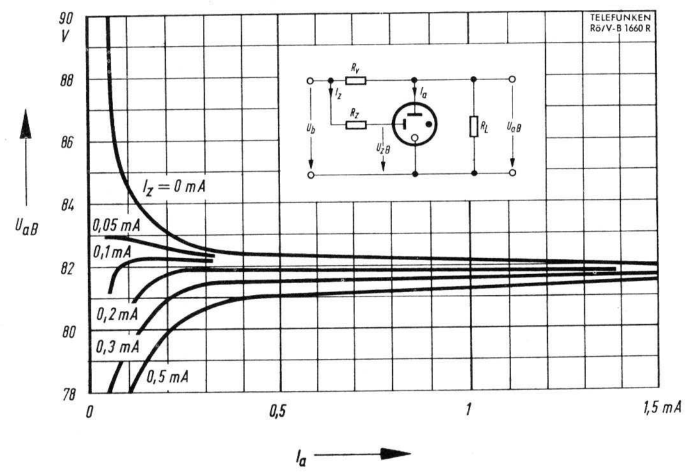



$U_{aB}$ = f ($I_a$)

——Mean rating - - - - Spread ratings



ZZ 1010 TELEFUNKEN




$U_{aB}$ = f ($I_a$)

$I_z$ = parameter

# TELEFUNKEN

**ZZ 1020**
**STV 85/8**

**Voltage Stabiliser Tube with Ignition Electrode**

Voltage stabiliser tube with cold pure metal cathode in sub-miniature design with electrode terminals for soldering.

## Tentative Technical Data

### Typical Operation

| | | Min. rating | Mean rating | Max. rating | |
|---|---|---|---|---|---|
| Operating voltage at $I_a$ = 3 mA | $U_{aB}$ | **81.5** | **82.2** | **82.9** | V |
| at $I_a$ = 8 mA | $U_{aB}$ | 83.9 | 84.6 | 85.3 | V |
| Control range | $I_a$ [1]) | 1.7 [2]) | | 8 | mA |
| Ignition voltage at mean illumination | | | | | |
| Main gap a/k | $U_{aZ}$ | | 108 | 112 | V |
| Auxiliary gap, dead | | | | | |
| Auxiliary gap z/k | $U_{ZZ}$ | | 115 | 120 | V |
| Anode voltage 90 V | | | | | |
| Voltage difference in control range | $\Delta U_{aB}$ | | | 30 | V |
| Max. differential AC resistance | $R_{i\sim max}$ | | 480 | 500 | Ω |
| Temperature coefficient | $T_{KU_{aB}}$ | | | −3 | mV/°C |
| AF noise voltage in control range | $U_{rss}$ | | | 1 | mV |
| Voltage jumps at operating current between 3 and 8 mA | | | | 1 | mV |

### Change of Operating Voltage during Life

| | | |
|---|---|---|
| for first 300 hours | 0.3 | % |
| each further 10,000 hours | 0.3 | % |

### Maximum and Minimum Ratings

| | | | | |
|---|---|---|---|---|
| Initial current for duration of max. 120 sec | $I_k$ [3]) | max. | **25** | mA |
| Cathode current in ignition peak | $I_{ksp}$ | max. | **0.3** | A |
| Supply voltage | $U_b$ | min. | **130** | V |
| Ambient temperature | $t_{amb}$ | min. | **−55** | °C |
| | | max. | **+90** | °C |
| Permissible shock acceleration | $b_{stoss}$ | max. | **3000** | g |
| Permissible parallel capacitance on absence of auxiliary current | $C_p$ [4]) | max. | **25** | nF |

[1]) Permissible operating current when used as stabiliser. An operating current between 3.0 and 4.5 mA is recommended when used as reference tube.

[2]) Minimum current $I_{min}$ which must always be present where there is danger of interfering oscillations if the tube is operated without auxiliary current. Regarding operation with auxiliary current refer to special instructions on sheet 020161.

[3]) This temporary overload must not occur more than once or twice within 8 hours: not permissible when tube is used as high-constant reference voltage source.

[4]) Arbitrary capacitances parallel to the main discharge gap for operation with ignition electrode.

010163

# TELEFUNKEN

**ZZ 1020**
**STV 85/8**

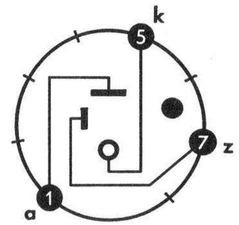
### Capacitances

| | | | | |
|---|---|---|---|---|
| Anode – cathode | $c_{a/k}$ | average | 1.5 | pF |
| Ignition electrode – cathode | $c_{z/k}$ | average | 0.35 | pF |
| Ignition electrode – anode | $c_{z/a}$ | average | 0.25 | pF |

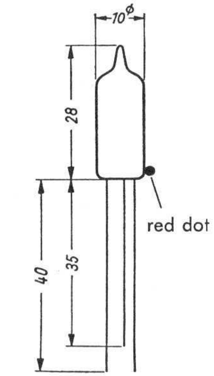
The tube withstands accelerations of 10 g over 10 hours at frequencies between 20 and 500 c/s and its operating voltage changes by less than 1 mV in respect of the ratings for a stationary tube.

The discharge gaps must always be operated only with the specified polarity, cathode connected to —, anode and ignition electrode connected to +. Incorrect polarity gives rise to changes in tube data even when operated for a short period under these conditions

Base connection




Max. dimensions




Weight: max. 2 g

The anode is marked with a red dot, the ignition electrode is characterised by the shorter terminal wire.

The input resistance for the ignition electrode must be connected directly to this terminal wire. If the ignition electrode is not used the terminal wire may be cut off just below the tube base.

Solder points on the terminal wires must be at least 5 mm and any bends at least 1.5 mm, from the glass seal.

## Instructions for Using the Tube with Auxiliary Current $I_z$

In the tube an auxiliary discharge gap z/k is incorporated which can be used if

(a) complete suppression of ignition voltage peaks is specified for the main discharge gap

(b) interfering oscillations shall definitely be prevented in the event the anode current may occasionally exceed the rating for $I_{min}$

(c) the ignition voltage $U_{aZ}$ is not reached when the tube is switched on due to a corresponding load being present across the anode

(d) ignition delays shall be prevented in complete darkness.

To this end the ignition electrode z must be connected to the supply voltage source $U_b$ (positive) via a resistor $R_z$: the rating for $R_z$ can be ascertained in individual cases by means of the diagrams.

To prevent ignitions peaks when the tube is switched on, a capacitance from 2 to 4 µF must be connected in parallel to the main discharge gap and a resistor $R_z \leqq \frac{U_b - 85}{0.05}$ kΩ must precede the ignition electrode.

Interfering oscillations may arise if, in the absence of auxiliary current, the minimum tube transverse current $I_{min}$ drops below the specified rating due to temporary drops of supply voltage or due to temporary increases of load current, and if at the same time capacitances above 25 nF are connected in parallel to the main discharge gap. The auxiliary current $I_z$, at which the tube can be operated down to even the lowest transverse currents without the danger of interfering oscillations, depends on the rating of any capacitance $C_p$ in parallel to the main discharge gap and may be determined from diagram 4. In this diagram is indicated the auxiliary current $I_z$ which must flow when the anode current passes through the range the characteristic in which there is the greatest tendency to oscillate. This critical anode current $I_{a\,kr}$ is likewise dependent on the rating of the parallel capacitance $C_p$. The rating for the preceding resistance is calculated at $R_z \leqq \frac{R_v}{I_z}\left(I_{akrit} + \frac{83}{R_L}\right)$ kΩ when $R_v$ and $R_L$ are determined by the customary design rules.

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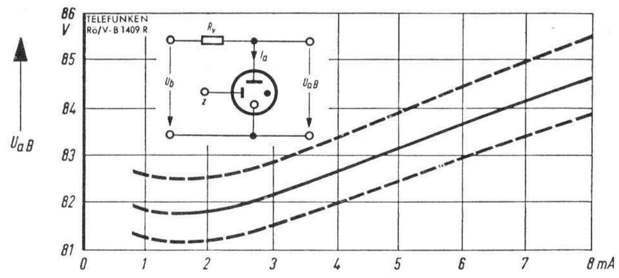
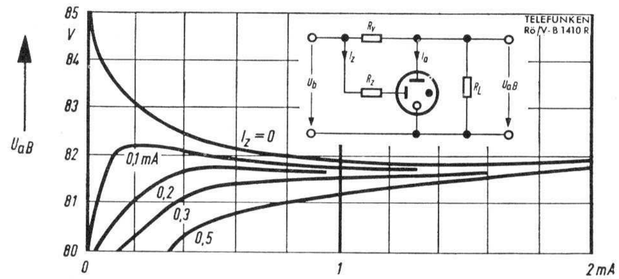



$U_{aB} = f\,(I_a)$

——— Mean rating

– – – ·· Spread ratings



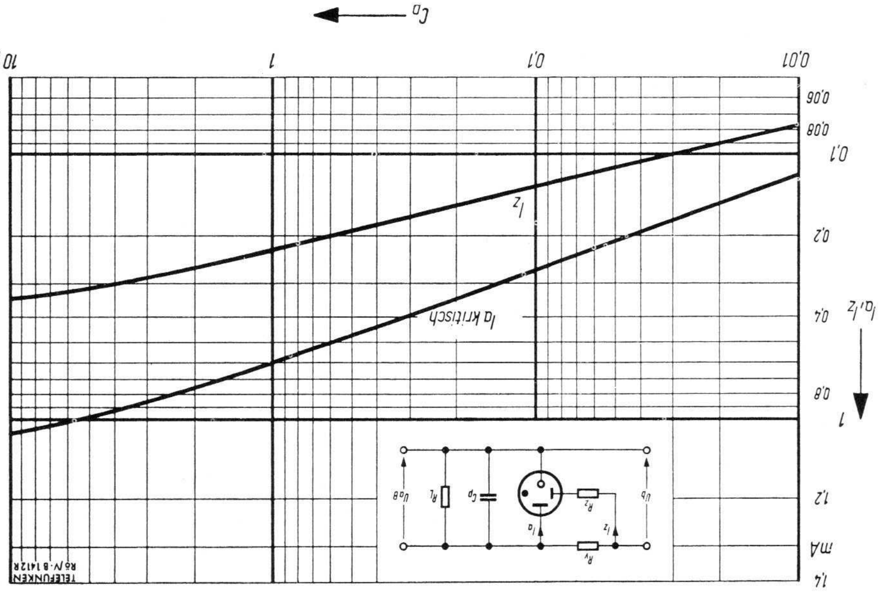

$U_{aB} = f\,(I_a)$

$I_z$ = parameter

**TELEFUNKEN**

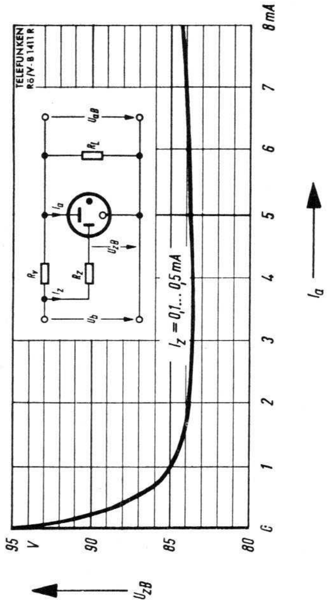
| ZZ 1020 |
|---|
| STV 85/8 |

$I_a, I_z = f(C_p)$




**TELEFUNKEN**

| ZZ 1020 |
|---|
| STV 85/8 |




$U_{aB} = f(I_a)$

$I_z = 0,1 ... 0,5$ mA

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**Voltage Stabiliser Tube with Ignition Electrode**

## Tentative Technical Data

### Typical Operation

| | | Min. rating | Mean rating | Max. rating | |
|---|---|---|---|---|---|
| Operating voltage at $I_a$ = 5 mA | $U_{aB}$ | **98** | **100** | **101** | V |
| at $I_a$ = 60 mA | $U_{aB}$ | 98 | 100 | 101 | V |
| Control range | $I_a$ | 5 [1] | | 60 | mA |
| Voltage change in control range | $\Delta U_{aB}$ | | | 0.5 | V |
| Voltage jumps at operating current between 5 and 60 mA | | | | 0.3 | V |
| Ignition voltage at mean illumination | | | | | |
| Main gap a/k | $U_{aZ}$ [1] | | | 125 | V |
| Auxiliary gap z/k | $U_{zZ}$ | | | 135 | V |
| Ignition voltage in complete darkness[2] | | | | | |
| Main gap a/k | $U_{aZ}$ [1] | | | 125 | V |
| Auxiliary gap | $U_{zZ}$ | | | 135 | V |

### Change of Operating Voltage during Life

| | | | |
|---|---|---|---|
| for first 2000 hours | | +1 | % |
| each further 5000 hours | | 0.6 | % |
| Expected life | > | 20.000 | hours |

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ZZ 1040 STV 100/60 Z TELEFUNKEN

### Maximum and Minimum Ratings

| | | | | |
|---|---|---|---|---|
| Cathode current ($I_a + I_z$), constant | $I_k$ | max. | **65** | mA |
| Initial current, t = max. 120 sec | $I_k$ [3] | max. | **200** | mA |
| Cathode current in ignition peak | $I_{ksp}$ | max. | **10** | A |
| Supply voltage | $U_b$ | min. | **135** | V |
| Ambient temperature | $t_{amb}$ | min. | **−55** | °C |
| at $I_a$ = 35 mA | $t_{amb}$ | max. | **+120** | °C |
| at $I_a$ = 60 mA | $t_{amb}$ | max. | **+90** | °C |
| Permissible parallel capacitance on absence of auxiliary current | $C_p$ [1] | max. | **50** | nF |

[1] These ratings apply for operation of the tube without auxiliary current. At an auxiliary current $I_a$ = approx. 1 mA interfering oscillations are definitely prevented at arbitrary large capacitances $C_p$ up to anode currents $I_a \geq$ 1 mA. The discharge is undertaken by the main discharge gap at an anode voltage of approx. 100 V, and the occurrence of ignition peaks is prevented. The ignition electrode z must be connected to the positive pole of the supply voltage via a high-impedance resistance $R_z$. If possible $R_z$ must be connected directly to the base contact for pin 6 with as low capacitance as possible, its rating depends on the lowest supply voltage $U_{b\,min}$, recommended rating

$$R_z = \frac{U_{bmin} - 106\,V}{1\,mA}\ k\Omega$$

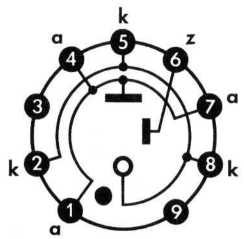
[2] After at least 24 hours storage in complete darkness without current.

[3] Such temporary overloads must not occur more than once or twice within 8 hours.

**TELEFUNKEN**

**ZZ 1040**
STV 100/60 Z

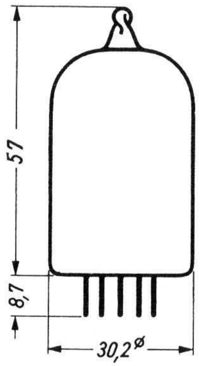
Base connection




Magnoval

When the adapter (Magnoval/Europa) stock No. 30 521 is used the ZZ 1040 may be employed as replacement for STV 100/60 Z 11 in earlier equipment with Europa base.

Max. dimensions




Weight: max. 22 g

If necessary precautions must be taken to prevent the tube from becoming dislodged.

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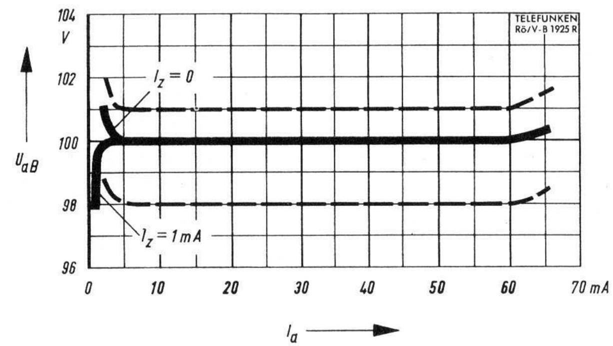
**ZZ 1040**
STV 100/60 Z

**TELEFUNKEN**




$I_z$ = parameter

$U_{aB} = f(I_a)$

# DIE DEUTSCHE WELTMARKE

| | | |
|---|---|---|
| Empfänger-Röhren | Receiving tubes | Tubes Réception |
| Verstärker-Röhren | Amplifying tubes | Tubes amplificateurs |
| Fernseh-Bildröhren | TV picture tubes | Tubes Image |
| Germanium-Dioden | Germanium diodes | Diodes Germanium |
| Silizium-Dioden | Silicon diodes | Diodes Silicium |
| Germanium-Transistoren | Germanium transistors | Transistors Germanium |
| Silizium-Transistoren | Silicon transistors | Transistors Silicium |
| Spezialröhren | Special tubes | Tubes Spéciaux |
| Mikrowellen-Röhren | Microwave tubes | Tubes hyperfréquences |
| Oszillographen-Röhren | Cathode ray tubes | Tubes «R.C.» Mesure |
| Klein-Thyratrons | Small thyratrons | Petits Thyratrons |
| Kaltkathoden-Röhren | Cold-cathode tubes | Tubes à cathode froide |
| Bildwandler-Röhren | Image converter tubes | Tubes convertisseurs d'images |
| Photovervielfacher | Photo multipliers | Photomultiplicateurs |
| Photozellen | Photo tubes | Cellules photo-électriques |
| Photowiderstände | Photo conductors | Cellules photo-résistances |
| Stabilisatoren | Voltage stabilizers | Stabilisateurs de tension |
| Senderöhren | Transmitting tubes | Tubes Emission |
| Vakuum-Kondensatoren | Vacuum capacitors | Condensateurs à vide |

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