April 19, 1938. K. SCHLESINGER 2,114,614

CIRCUIT WITH GAS-FILLED GRID CONTROLLED GLOW DISCHARGE TUBES

Filed May 1, 1936

Fig. 1

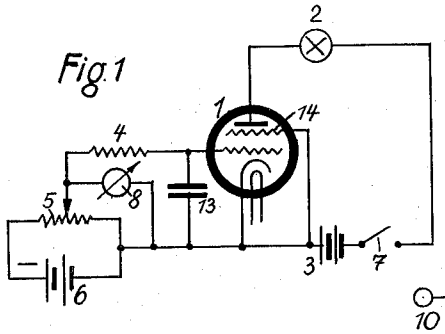
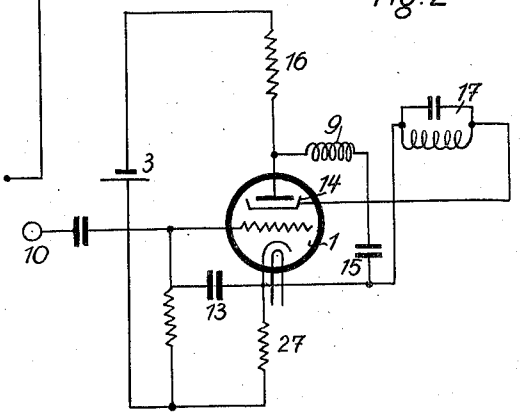


Fig. 2



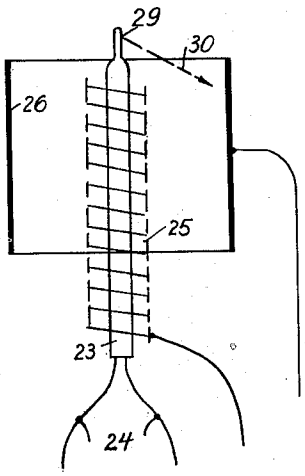


Fig. 3

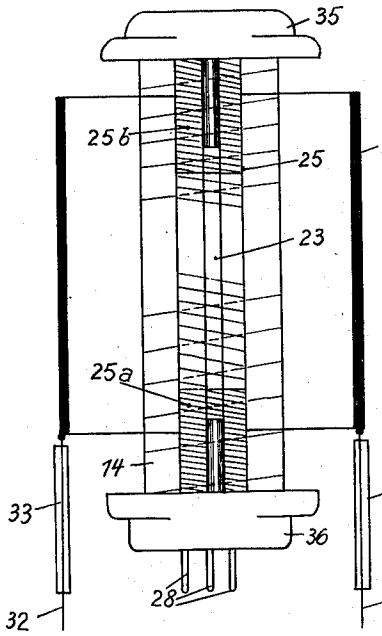


Fig. 4a

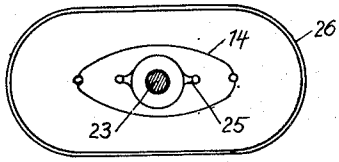


Fig. 4b

Inventor:
Kurt Schlesinger

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CIRCUIT WITH GAS-FILLED GRID CONTROLLED GLOW DISCHARGE TUBES

Kurt Schlesinger, Berlin, Germany

Application May 1, 1936, Serial No. 77,418
In Germany May 3, 1935

6 Claims. (Cl. 250—36)

If in the case of a grid-controlled gas-filled tube a measurement is made of the potential at which with a given anode potential the ignition takes place, it will be observed that the first ignition is obtained at a more negative bias than the following ignitions performed immediately after the arc is quenched. In practical operation this "after-effect" is extremely disturbing. It results in the fact that, with definitely adjusted grid bias, in the course of time the frequency of the relaxation oscillations becomes greater and the amplitude smaller.

This effect will be explained and the means to remove it according to the invention will be best understood by means of the accompanying drawing, in which

Fig. 1 shows a connection used for investigation,

Fig. 2 shows a relaxation circuit comprising means for avoiding the after-effect,

Fig. 3 shows a tube of the prior art, and

Figs. 4*a* and 4*b* show two views of a tube modified in accordance with the invention.

The applicant has examined the conditions of the after effect by means of a circuit according to Fig. 1. In this circuit the thermionic tube **1** is connected by way of an incandescent lamp **2** having a maximum current capacity of approximately 100 milliamperes with a battery **3**. The grid is connected through the medium of a series resistance **4** with a potentiometer **5**, at which there may be adjusted the bias from the battery **6**. After each ignition the anode circuit is interrupted by means of a switch **7**, the bias again made somewhat more negative, the switch again closed, and the new ignition potential measured at the voltmeter **8**. There resulted, for example, a grid-bias of −8 volts for the first ignition, whilst there resulted values of −10, −12 and −13 volts for the later ignitions. It was found that this after-effect depends to a very great degree on the size of the series resistance **4**. If the resistance **4** is made smaller and smaller, and finally is wholly short-circuited, it may be accomplished even in the case of operations extending over a desired period that the after effect disappears and that the ignition potential becomes quite definite.

The applicant has found an explanation for these conditions in the following:

In the case of a discharge there are produced by the impact of the primary electrons a very much larger number of secondary electrons and ions. After the quenching the anode is effective as intercepting electrode in respect of the (negative) electrons, and it conveys these very rapidly out of the discharge space, as the inner resistance of the anode circuit is sufficiently small. On the other hand the (positive) ions require to be removed from the space between grid and anode primarily by way of the grid, as usually they do not reach the cathode sufficiently quickly or are prevented from reaching the cathode space by the positive space charge enveloping the cathode and the grid during the burning. The discharge by way of the grid-resistance **4** takes place, however, too slowly, because this resistance, by several reasons, cannot be reduced below a certain value. It is accordingly necessary to adopt measures by which a very rapid removal of the positive space charge after the quenching may be effected without to lead the current through the control grid.

As the first measure the applicant has hit upon a condenser **13**. Its operation will readily be understood in view of the above remarks: The positive ions find in the first place a short-circuiting in the grid circuit by charging the condenser **13**, which after completed quenching is again discharged by way of **4**. The minimum size of **13** depends on the intensity of the discharge current flowing during the burning. With a discharge of 100 milliamperes the applicant found a capacity of about .001 mf. to be sufficient. In the case of control impulses which are not too rapid a condenser of this kind does not represent any appreciable load on the grid circuit.

Another effective means to counteract the after-effect has been found, according to the invention, in the form of a quenching grid **14**. This quenching grid is located in the space between grid and anode. It is connected with the cathode. It has the effect of intercepting positive ions which remain after the quenching and of deionizing the discharge space. Preferably, therefore, the quenching grid is provided in the immediate vicinity of the control grid so that it is located at the point of the positive space charge cloud and is able to properly intercept the ions. It has also been found to be favourable to fill the tube with a gas having a low atomic number, as such gases have the greatest ability of the ions. Helium and hydrogen are well suitable. In the presence of **14** a short-circuiting condenser **13** may be dispensed with. The latter, however, if used at all, may also be of the order of approximately 0.00005 to 0.0001 mf., i. e. 10% of the value stated above.

A particularly effective circuit employing the quenching grid is illustrated in Fig. 2. There is shown a relaxation circuit which is employed in practice in the television art, whereby the tube **1** is intended to discharge a storage condenser **15**

which has been charged by a positive potential 3 through the medium of a charging resistance 16. The discharge takes place when a positive synchronizing impulse is imparted to the grid via the terminal 10. In the discharge circuit there is provided a coil 9 coupled to an oscillatory circuit 17 arranged in the lead connecting the quenching grid 14 to the cathode.

That particular pole of this circuit which is negatively charged against earth upon the discharge is applied to the quenching grid 14. It is thus accomplished that shortly after the quenching not only the potential of the cathode but even a stronger negative potential is applied to the quenching grid 14, so that the suctional effect of the latter on the residual positive ions is considerably increased. This negative potential endures a certain time corresponding to about a quarter of the period of the circuit 17.

Particular significance is also to be attached to correct adjustment of the ignition value in a tube of this kind. By generating the grid bias from a resistance 27 (in Fig. 2) traversed by the charging current it is possible to make the frequency of the relaxation connection independent of the mains potential. This invariability is accomplished if the grid bias, in the case of an increase in the mains operating potential, is increased exactly by such amount that the anode ignition point is raised by the same percentage as the mains potential. A fluctuation in the mains potential then merely takes effect in the form of an equal fluctuation in the size of the image, whilst the frequency, and accordingly the synchronization, are unaffected.

Despite the stated basic methods a practical operation with tubes of the described kind frequently cannot be performed satisfactorily for a considerable length of time in view of certain incidental technical circumstances. Lack of control of the relaxation oscillations occurs in view of certain structural defects which arise in the assembly of normal amplifying valves.

In Fig. 3 there is shown a normal triode, such as employed in the radio art. 23 is the cathode sleeve, which is heated indirectly, 24 are the ends of the filament, 25 is the control grid which surrounds the cathode in cylindrical fashion, and 26 is a likewise cylindrical anode. This construction, however, has not been found to be satisfactory for the purpose of the invention. The principal interferences resulted from parasitic discharges. These were usually caused outside of the grid space, for example at the point 29, owing to the fact that a trace of oxide reached the ends of the cathode sleeve outside the grid space and, avoiding the grid, then produced a continuous discharge in the direction of 30 between cathode and anode. By reason of this current the gas space is preliminarily ionized to such extent that the ignition conditions are abnormally facilitated, and it may even occur that the tube burns permanently as glow lamp and is no longer affected at all by the grid. Similar incidental effects have also been shown to exist in the case of the ends 24 of the filament. An additional disadvantage of tubes of this kind resided in their comparatively low ignition potential in the cold state. Naturally a tube of this kind can never be operated in the vicinity of this potential, as it would then enter the circuit as detrimental leakage resistance before the normal ignition, in which manner non-linearity in charging would be caused.

There has been found as remedy in respect of all drawbacks referred to, to encase the cathode completely by means of a screening element which has substantially cathode potential. It is particularly convenient to employ as screening means the quenching grid 14.

Figs. 4*a* and 4*b* show a tube according to the invention in about double full size. The anode 26 is situated completely outside of the inner system encased by the quenching grid 14. The quenching grid 14 has a coarse pitch of approximately 1 mm. and is produced from wire of such thickness that it is capable of intercepting the powerful discharge currents continuously. The ends of the screening grid are provided with metallic caps 35, 36, so that the inner parts are perfectly screened off. In the interior of the quenching grid, very close to it, there is located the control grid 25. The cathode 23 is coated with oxide over a shorter length than is represented by the height of the anode. By-passing is voided by the fact that the control grid at the upper and lower portions is furnished with a closed metal cylinder or has closely disposed turns. These parts of the control grid 25 are designated 25*a* and 25*b*. The wires 32 leading from the anode to the base of the tube also require to be screened off against the discharge space, so that cold ignition is avoided. For this purpose glass tubes 33 are sufficient.

Obviously the tube must have for a given grid bias a given anode ignition potential According to the invention this important adjustment is made by cutting-out some of the grid and quenching grid meshes, preferably only in the middle part of the tube system. The missing meshes are to be recognized in Fig. 4*a*. The fine tuning takes place at the inner grid 25. If the pitch thereof amounts, for example, to ½ mm., each mesh removed represents an increase of approximately 5 volts in the grid ignition potential with an anode potential of approximately 100 volts, and vice versa approximately 20 volts anode ignition potential with fixed grid bias. An advantage of this method of adjusting the ignition potential consists in the fact that a jumping discharge is avoided because it is initiated always at this point of large reciprocal where the meshes are missing. After the ignition commences the discharge spreads rapidly over the entire tube system and continues to burn primarily between quenching grid 14 and anode 26, whilst the inner space participates in the discharge only to small extent and requires to supply electrodes only in such amount that the discharge is upheld. For the same purpose glass tubes may also be placed over the leads 28 proceeding from the inner system.

I claim:

1. A gas filled thermionic discharge tube having cathode, control grid and anode, said control grid and said cathode being encased by means of a special screening grid system having set-on cover plates, said grid systems closely and homogeneously wound in itself being tuned to the desired electrical ignition values by cutting out a certain number of meshes from the middle.

2. A gas filled thermionic discharge tube having cathode, control grid and anode, said control grid and said cathode being encased by means of a special screening grid system having set-on cover plates, a certain free length amounting to a multiple of the pitch of said control grid being cut out from said outer grid system, whilst windings are cut out from said control grid only for fine tuning of the ignition values.

3. A circuit comprising a gas filled thermionic discharge tube having cathode, control grid, and anode, means for effecting the discharge of said tube, means for quenching said tube and a condenser for removing the ions present after the quenching of said tube, one terminal of said condenser being connected to said control grid, the other terminal of said condenser being connected to said cathode.

4. A device for producing relaxation oscillations comprising a storage condenser, means for charging said condenser and a gas filled thermionic tube having cathode, grid and anode shunting said condenser, means for applying a synchronizing potential to the grid of said tube and a condenser connected between said cathode and said grid, said condenser having a capacity sufficient to remove the ionization in said tube but so small as not to constitute a short-circuit for said synchronizing potential.

5. A circuit comprising a gas filled thermionic discharge tube having cathode, control grid, anode and a quenching grid, means for effecting the discharge of said tube, means for quenching said tube, said quenching grid being situated in the vicinity of said control grid and an oscillatory circuit, said oscillatory circuit being connected between said quenching grid and said cathode, and having such a natural oscillation as to give said quenching grid during the quenching operation a negative potential with respect to said cathode.

6. A device for producing relaxation oscillations comprising a gas-filled, thermionic discharge tube having cathode, control grid, quenching grid and anode, a discharge circuit connecting cathode and anode of said tube and an oscillatory circuit connecting the quenching grid to the cathode of said tube, said discharge circuit consisting of a storage condenser in series to the primary of a high-frequency transformer and said oscillatory circuit consisting of a condenser shunted by the secondary of said transformer, the connection being made so as to give the quenching grid during the quenching period a negative potential towards said cathode.

KURT SCHLESINGER.