

Jan. 23, 1940.

G. H. ROCKWOOD, JR

2,188,159

GAS-FILLED SPACE DISCHARGE TUBE CIRCUITS

Filed Oct. 27, 1937

2 Sheets-Sheet 1

FIG. 1

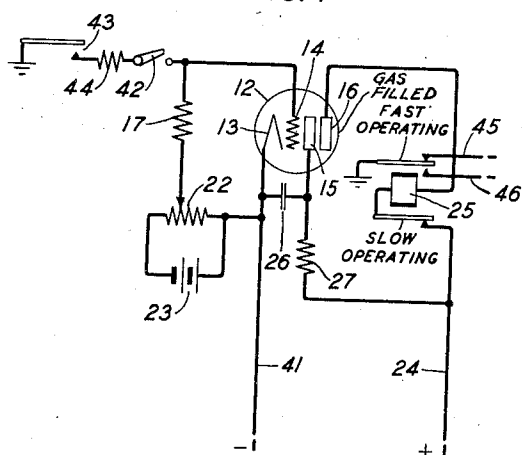


FIG. 2

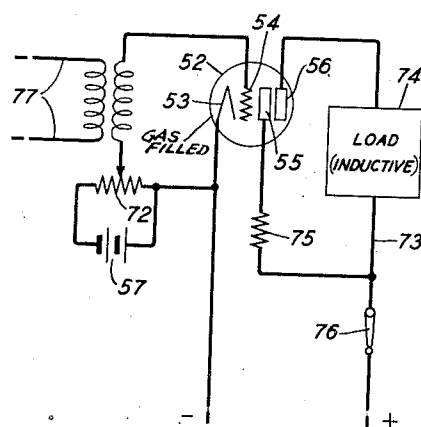
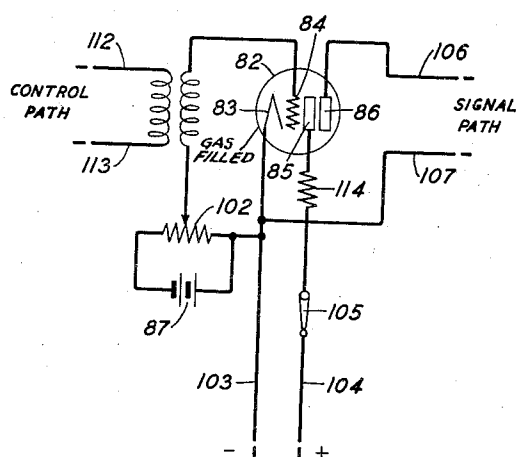


FIG. 3



INVENTOR
G. H. ROCKWOOD JR.
BY
H. A. Burgess
ATTORNEY

Jan. 23, 1940.

G. H. ROCKWOOD, JR

2,188,159

GAS-FILLED SPACE DISCHARGE TUBE CIRCUITS

Filed Oct. 27, 1937

2 Sheets-Sheet 2

FIG. 4

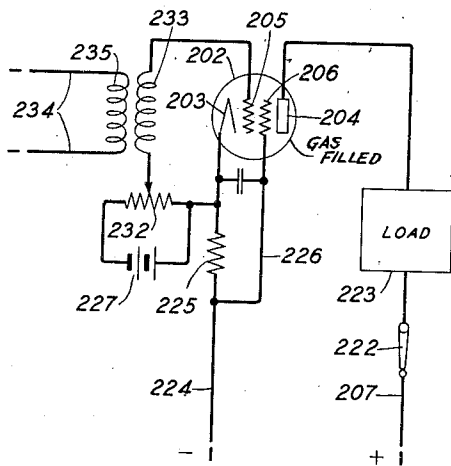


FIG. 5

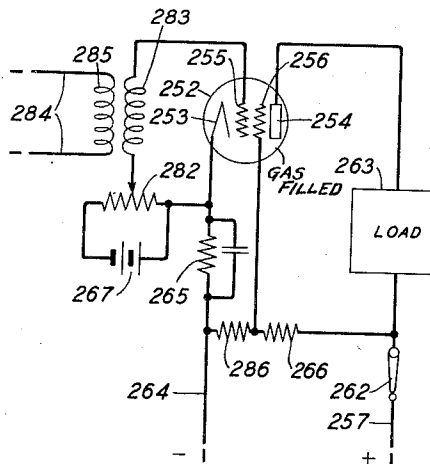
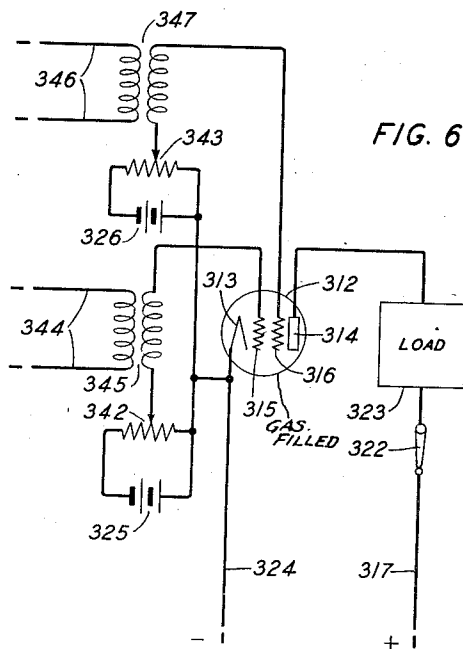


FIG. 6



INVENTOR
G. H. ROCKWOOD JR.
BY
H. A. Burgess
ATTORNEY

UNITED STATES PATENT OFFICE

2,188,159

GAS-FILLED SPACE DISCHARGE TUBE
CIRCUITS

George H. Rockwood, Jr., Summit, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application October 27, 1937, Serial No. 171,250
In Great Britain May 21, 1937

2 Claims. (Cl. 250—27)

This invention relates to circuits employing electric space discharge tubes and particularly gaseous or gas-filled space discharge tubes of the trigger type wherein initiation of a discharge between the cathode and anode is controllable by the potential of a third electrode.

An object of the invention is the improvement of the operation of circuits utilizing gas-filled space discharge tubes.

In accordance with one embodiment of the invention novel circuit arrangements utilize a gas-filled discharge tube provided with a cathode, a grid and a plurality of anodes. The structure of the tube in this instance may be, for example, as disclosed in Patent 2,061,254, issued to me November 17, 1936.

In accordance with another embodiment of the invention novel circuit arrangements utilize a gas-filled discharge tube provided with a cathode, an anode and a plurality of grids. The structure of the tube in this instance may be, for example, as disclosed in Patent 2,061,255, issued to me November 17, 1936.

Full understanding of the invention may be had from consideration of the following detailed description in connection with the accompanying drawings in which:

Fig. 1 shows a circuit utilizing a multianode gas-filled tube and arranged to produce periodic impulses in an associated work circuit or to repeat incoming impulses into an associated work circuit;

Fig. 2 shows a circuit utilizing a multianode gas-filled tube for causing an indication in the output circuit of impulses occurring in the input circuit, the anode circuit load having a relatively high ratio of inductance to resistance;

Fig. 3 shows a circuit utilizing a multianode tube and arranged to complete a signal path associated with one of the anodes only if a discharge be passing to the other anode;

Fig. 4 shows a circuit utilizing a multigrid tube, one grid being used solely for deionization purposes while the second grid fulfills the usual control function;

Fig. 5 shows a modification of the circuit of Fig. 4; and

Fig. 6 shows a circuit utilizing a multigrid tube and so arranged that ionization of the tube results only when a signal impulse is applied to both grids simultaneously.

Referring now to the drawings, Fig. 1 shows the use of a multianode gas-filled tube in a circuit arranged to produce periodic impulses in an associated work circuit or to repeat incoming

impulses into the work circuit. Somewhat similar circuit arrangements utilizing single anode gas-filled tubes have been proposed heretofore, such a circuit being described, for example, in Patent 1,979,054, issued October 30, 1934 to W. H. Scheer. In the use of these earlier circuits, however, trouble has often been encountered due to the fact that the condenser discharge is so rapid that the tube does not remain in ionized condition for a sufficiently long period to assure operation of the recording device in the associated work circuit. In accordance with the present invention, as will be evident from the following detailed description, the tube after being ionized remains in that condition until reset by operation of the relay or other recording device in the work circuit.

Referring to Fig. 1, gas-filled trigger tube 12 is provided with cathode 13, grid 14 and two anodes 15 and 16. Normally grid 14 is supplied with a negative bias, being connected through resistances 17 and 22 to battery 23, resistance 22 being variable to permit suitable adjustment of this bias. Cathode 13 is provided with a conventional energizing circuit (not completely shown).

Anode 16 is connected to the positive terminal of a suitable source of potential through conductor 24, this path leading through the winding and the lower break contact of relay 25.

A charging path for condenser 26 is provided from the positive terminal of the potential source, conductor 24, resistance 27, condenser 26, conductor 41 to the negative terminal of the potential source.

Relay 25 is so adjusted that the upper armature operates to engage with the upper make contact before the lower armature leaves the lower break contact.

The arrangement thus far described, when certain of the elements are properly adjusted, functions to produce periodic impulses in a manner to be described in detail subsequently. Should it be desired that the arrangement function to repeat incoming impulses, switch 42 may be closed whereupon incoming impulses transmitted under control of contact 43 may be applied through resistance 44 to grid 14. Accomplishment of this function involves readjustments of certain of the elements previously mentioned; the proper adjustments and the detailed operation of the modified arrangement will be described subsequently.

Assuming now that switch 42 is in open position as shown, let us see how the arrangement

functions to produce periodic impulses; i. e., to operate relay 25 periodically, it being assumed that conductors 45 and 46 are connected to suitable impulse recording means.

Condenser 26 is gradually charged, from the positive terminal of the potential source through conductor 24, resistance 27, condenser 26, conductor 41 to the negative terminal of the potential source. When the potential across the plates of condenser 26 reaches the ionization potential of tube 12, the tube ionizes and becomes conducting whereupon space current paths are set up within the tube from anode 15 to cathode 13 and from anode 16 to cathode 13, respectively. Condenser 26 discharges through the first of these paths thereby bringing the potential across the plates thereof below the ionization potential of tube 12.

An operating path for relay 25 is completed through the second space current path, this operating path being traced from the positive terminal of the potential source, conductor 24, lower break contact of relay 25, winding of relay 25, anode 16, cathode 13, conductor 41 to the negative terminal of the potential source.

Relay 25 operates at this time, therefore, and transmits, through the upper make contact and conductor 46, a pulse to the pulse recording or responsive device provided. The relay is so adjusted that the upper armature is faster to operate than the lower thereby assuring transmission of the pulse through conductor 46 before the lower armature leaves the lower break contact.

The arrangement is so timed that the potential across the plates of condenser 26 will be brought below the ionization potential of tube 12 before the operation of the lower armature of relay 25. Once the tube has been ionized through discharge of condenser 26, it remains in this condition, due to the positive potential applied to anode 16, until relay 25 has operated whereupon the circuit over which this potential is applied is broken at the lower break contact of relay 25. This fact assures a transmission of a pulse over conductor 46 before deionization of tube 12.

Operation of relay 25 removes the potential from anode 16 whereupon tube 12 deionizes interrupting the discharge path of condenser 26 and the operate path of relay 25. Condenser 26 now again charges and the cycle is repeated.

Assuming now that switch 42 be in closed position let us see how the arrangement functions to repeat incoming impulses. In this instance the grid voltage is so adjusted by means of variable resistance 22 that the ionization potential of tube 12 is slightly greater than the voltage across condenser 26 when it is fully charged.

The arrangement functions, in general, as described above, condenser 26 being charged over a path from the positive terminal of the potential source, conductor 24, resistance 27, condenser 26, conductor 41 to the negative terminal of the potential source.

An incoming pulse, transmitted under control of contact 43, connects grounded positive potential through resistance 44 to grid 14, this potential combined with the potential across the plates of condenser 26 rendering the grid sufficiently positive to cause tube 12 to ionize thereby setting up, as before, two space current paths within the tube from anode 15 to cathode 13 and from anode 16 to cathode 13, respectively. Condenser 26 discharges over the first of these paths while relay

25 operates over the second of these paths (as previously described) thereby repeating the impulse over conductor 46.

In view of the fact that tube 12 after having been ionized, remains in this condition until relay 25 operates, repeating of the impulse over conductor 46 is assured even though the incoming impulse through contact 43 may be very brief.

Referring now to Fig. 2, a circuit is shown utilizing a multianode gas-filled tube for causing an indication in the output circuit of impulses occurring in the input circuit, the anode circuit load being of a relatively high inductance. In the instances of circuits used heretofore for performing a similar function, that is, circuits utilizing single anode tubes, difficulty has arisen in instances when the impulses occurring in the input circuit were brief transients, short compared to the time constant of the inductive load circuit, due to the fact that the plate current does not build up to a sufficient value, during the brief impulse in the input circuit, to prevent the normal negative grid bias from cutting off the plate current. This difficulty is overcome, however, by the invention as will be apparent from the following detailed description thereof.

Referring to Fig. 2, gas-filled trigger tube 52 is provided with cathode 53, grid 54 and two anodes 55 and 56, respectively. A negative bias is normally applied to grid 54 from battery 57, resistance 72 being so adjusted that grid 54 is normally at a sufficiently negative potential to prevent ionization of tube 52.

Anode 56 is connected through conductor 73 to the positive terminal of a suitable potential source, load 74, which is of a relatively high inductance, being included in this path. Anode 55 is connected, through resistance 75, to the positive terminal of the same potential source. The supply of potential to anodes 55 and 56 may be interrupted when desired by operation of switch 76.

For purposes of further description let us assume that resistance 72 is so adjusted that a negative bias is applied to grid 54 just sufficient to prevent ionization of tube 52 and let us assume, further, that a positive impulse be transmitted over input line 77 which is of sufficient magnitude, when transmitted to grid 54, to drive the grid sufficiently positive to cause ionization of the tube. Tube 52 therefore ionizes or breaks down and space current paths are set up within the tube from anode 55 to cathode 53 and from anode 56 to cathode 53, respectively. Two parallel paths from the positive terminal of the potential source to cathode 53 and thence back to the negative terminal of the potential source are set up, therefore, one path through switch 76, conductor 73, load 74, anode 56 to cathode 53 and the second path through switch 76, resistance 75, anode 55 to cathode 53. Due to the high inductance of load 74, the anode current in the first path builds up relatively slowly; in some cases so slowly that if the impulse transmitted over line 77 were relatively short, the anode current in the first path might not have built up to a sufficient value at the cessation of the impulse to prevent the tube being extinguished by return to the normal negative grid bias. However, such undesirable action is prevented by provision of the second path as here anode 55 is fed directly through resistance 75 and the anode current builds up rapidly and quickly reaches a sufficiently high value to prevent de-

ionization of the tube upon return to the normal negative grid bias. The tube remains in ionized condition, therefore, even upon termination of the incoming impulse. The current gradually builds up in the first path as rapidly as the inductance of load 74 permits.

The tube may be deionized when desired by any suitable method, for example, by opening switch 76 thereby interrupting the supply of plate potential.

Referring now to Fig. 3, a circuit is shown in accordance with which a signal path associated with one anode of a multianode tube is not completed unless a discharge is passing to the second anode of the tube.

Referring to Fig. 3, gas-filled tube 82 is provided with cathode 83, grid 84 and anodes 85 and 86. Grid 84 is provided with a negative bias from battery 87, resistance 102 being so adjusted that grid 84 is normally at a sufficiently negative value to prevent tube 82 from ionizing. A suitable source of potential is connected across conductors 103 and 104, switch 105 being provided as a means of interrupting the supply of potential as desired.

While tube 82 is in deionized condition, there is, of course, an infinitely high impedance across conductors 106 and 107 which comprise the signal path.

Let us assume now that a positive control impulse occurs in the control path, comprising conductors 112 and 113. This impulse is transmitted to grid 84 and drives the grid sufficiently positive to cause ionization of tube 82. A path is established, therefore, from the positive terminal of the potential source, conductor 104, switch 105, resistance 114, anode 85, cathode 83, conductor 103 to the negative terminal of the potential source, the tube being held in ionized condition over this path even though the control impulse over conductors 112 and 113 ceases.

As soon as tube 82 has been ionized, the high impedance across the signal path is removed, as a path is completed from conductor 106, anode 86, cathode 83 to conductor 107, so that the arrangement acts, in effect, to establish or complete the signal path whenever a control impulse is transmitted over the control path.

Tube 82 may be deionized when desired by any suitable method, for example, by opening switch 105 thereby interrupting the supply of anode potential.

Referring now to Fig. 4, a circuit is shown utilizing a multigrid gas-filled tube. In the instance of similar circuits utilized heretofore, that is, circuits utilizing single grid tubes, design difficulties have often arisen due to the fact that, while it is known that a high grid impedance is undesirable from the deionization time standpoint, it is often desirable for other reasons that the grid circuit impedance be high. In accordance with the circuit invented by applicant these design difficulties are avoided; one grid is normally operated with a large negative bias from a low impedance source and used solely for deionization purposes while the second grid is fed from a high impedance source and used for the usual control function.

Referring to Fig. 4, gas-filled tube 202 is provided with cathode 203, anode 204 and grids 205 and 206. The positive terminal of a suitable potential source is connected to anode 204 over conductor 207, switch 222 and load 223 being included in the path, while the negative terminal of the potential source is connected through con-

ductor 224 and resistance 225 to one side of cathode 203.

While the tube is in deionized condition, deionization grid 206 is held at cathode potential through conductor 226 while control grid 205 is biased negatively from battery 227 through a relatively high impedance path including variable resistance 232 and secondary winding 233 of the input transformer. Variable resistance 232 is so adjusted that, in the absence of positive impulses in control line 234, control grid 205 will be held at a sufficiently negative value to prevent ionization of tube 202.

Assuming now that a positive impulse occurs in control line 234, it will be repeated through windings 235 and 233 of the input transformer to control grid 205 which is thereby driven sufficiently positive to cause tube 202 to break down or ionize thereby setting up the usual space discharge path within the tube. Once established the ionized condition persists until the plate potential supply is interrupted by some suitable method, for example, by opening switch 222.

As is usual in tubes of this type, deionization results from the action of the control grid in reducing the number of positive ions in the cathode-anode field. The deionization time is largely dependent, therefore, upon the impedance of the grid circuit and, in the present instance, if we were to depend upon the action of control grid 205 (the circuit of which is of relatively high impedance) for deionization, the time required for deionization might be longer than desirable. However, deionization grid 206 acts to quickly deionize tube 202 as soon as the plate current has been interrupted, this grid being biased negatively, after ionization of the tube, an amount equal to the drop across resistance 225 in the cathode return lead. As this negative bias is applied to grid 206 over a low impedance path, the deionization time is relatively short.

The circuit of Fig. 5 is similar in general to that of Fig. 4 except that in this instance the deionization grid is held at a positive potential before breakdown of the tube.

Referring to Fig. 5, gas-filled tube 252 is provided with cathode 253, anode 254 and grids 255 and 256. The positive terminal of a suitable potential source is connected to anode 254 over conductor 257, switch 262 and load 263 being included in the path, while the negative terminal of the same source is connected through conductor 264 and resistance 265 to one side of cathode 253.

While tube 252 is in deionized condition, deionization grid 256 is held at a positive potential through connection to conductor 257 through resistance 266. Control grid 255, on the other hand, is biased negatively from battery 267 through a relatively high impedance path including variable resistance 282 and secondary winding 283 of the input transformer. Variable resistance 282 is so adjusted that, in the absence of positive impulses in control path 284, control grid 255 will be held at a sufficiently negative potential to prevent ionization of tube 252.

Assuming now that a positive impulse occurs in control path 284 it will be transmitted through windings 285 and 283 of the input transformer to control grid 255, which is thereby driven sufficiently positive to cause tube 252 to break down or ionize thereby setting up the usual space charge path within the tube. Once established, the ionized condition persists until the plate po-

tential is interrupted by some suitable method, for example, by opening switch 262.

As explained above in connection with Fig. 4, deionization in tubes of this type results from the action of the grid in reducing the number of positive ions in the cathode-anode field and the deionization time is largely dependent upon the impedance of the grid circuit. If we were to depend in the present instance upon the action of control grid 255 (the circuit of which is of a relatively high impedance) for deionization, the deionization time might be longer than desirable. However, deionization grid 256 acts to quickly deionize the tube as soon as the supply of plate potential has been interrupted, this grid being biased negatively while the tube is in ionized condition an amount equal to the drop across resistances 265 and 266. As this negative bias is applied to grid 256 over a low impedance path, the deionization time is relatively short.

In the circuits of Figs. 4 and 5 it is desirable that the time constant of the self-biasing circuit be long compared to the deionization time of the tube.

Referring now to Fig. 6, a further adaption of the multigrid gas-filled tube is shown, a circuit arrangement in accordance with which both grids must be driven positive simultaneously in order to cause the tube to ionize.

Referring to Fig. 6, gas-filled tube 312 is provided with cathode 313, anode 314 and control grids 315 and 316. The positive terminal of a suitable potential source is connected to anode 314 over conductor 317, switch 322 and load 323 being included in the path, while the negative terminal of the source is connected through conductor 324 to one side of cathode 313.

Grid 315 is biased negatively from battery 325; grid 316 is biased negatively from battery 326. Variable resistances 342 and 343 are so adjusted that substantially the same bias is applied to the two grids. This bias is of sufficient magnitude in each instance and the signal levels are so adjusted that a positive impulse occurring in only one control path, (for example in control path 344 from which it is repeated through input transformer 345 to grid 315 or in control path 346 from which it is repeated through transformer 347 to grid 316) will not drive the associated grid sufficiently positive to cause the tube to ionize. When a positive impulse occurs in both con-

trol paths simultaneously, however, and both grids are driven positive at the same instant the tube ionizes and the usual space current path is set up within the tube.

Once ionization occurs, the condition persists until the anode supply has been interrupted by some suitable method, for example, by opening key 322.

While certain specific embodiments of the invention have been disclosed, the invention is not limited in its application to such embodiments. For example, gas-filled tubes utilizing more than two anodes and/or two or more grids may be utilized. The embodiments disclosed should be taken as illustrative of the invention rather than as restrictive thereof.

What is claimed is:

1. In combination, a gaseous conduction device having a cathode, a grid and a plurality of anodes, a potential source for supplying a difference of potential between said cathode and said anodes, a second potential source, a grid circuit for supplying a certain potential from said second source to said grid, a load circuit of relatively high inductance connected in circuit with one of said anodes, a second load circuit of relatively low inductance connected in circuit with another of said anodes, means inductively associated with said grid circuit for causing a sufficient change in the potential supplied to said grid to cause said device to break down to provide a discharge path for current between said cathode and said second-mentioned anode and means effective after establishment of said path for causing transfer of said discharge path from said second anode to said first-mentioned anode.

2. In combination, a gaseous conduction device having a cathode, a grid and a pair of anodes, an input circuit for said device, a potential source, a path connecting said source and the first of said anodes, said path having a high ratio of inductance to resistance, a second path connecting said source and the second of said anodes, said second path including substantially no inductance, means responsive to currents in said input circuit for establishing a discharge path for current between said cathode and said second anode, and means for transferring said discharge path from said second anode to said first anode.

GEORGE H. ROCKWOOD, JR.