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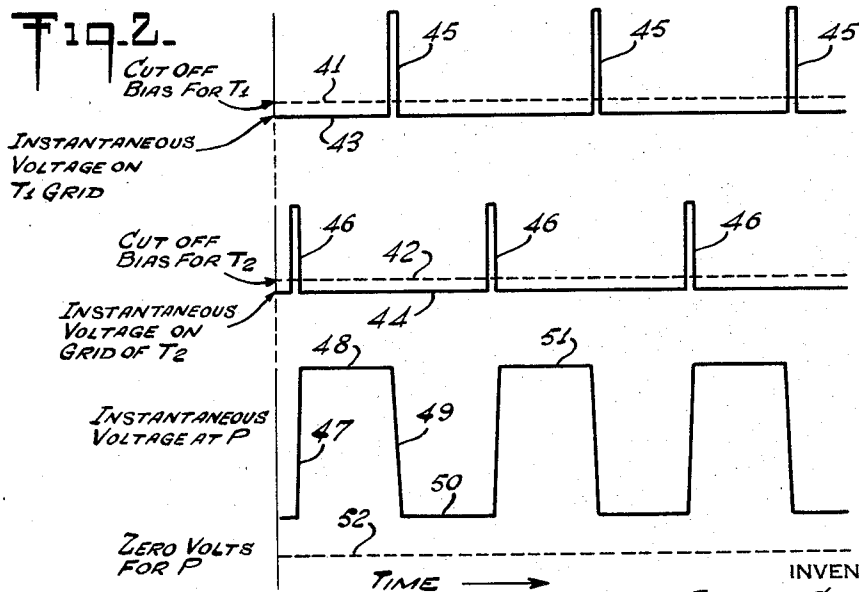
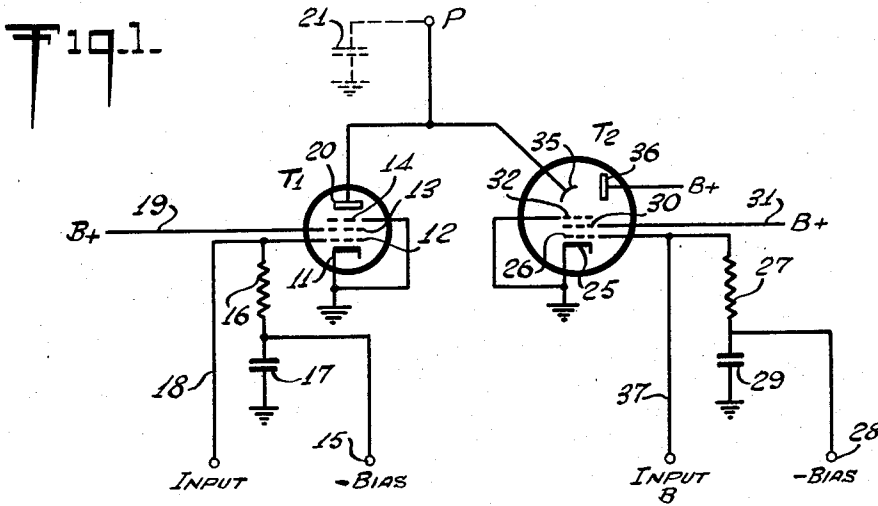
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2,954,466

ELECTRON DISCHARGE APPARATUS

Filed July 9, 1956

2 Sheets-Sheet 1



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Fig. 3.

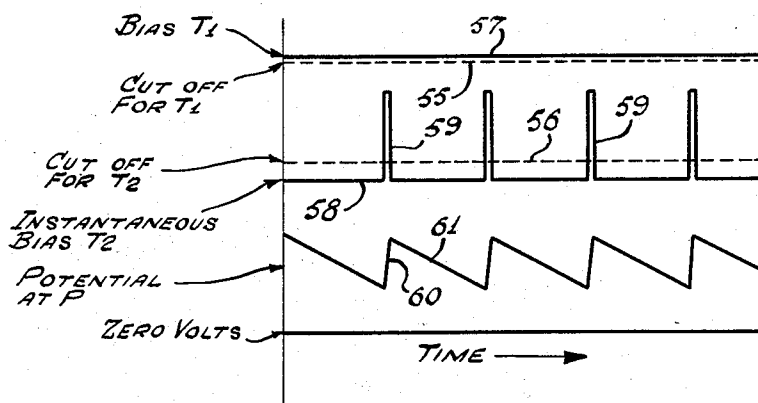
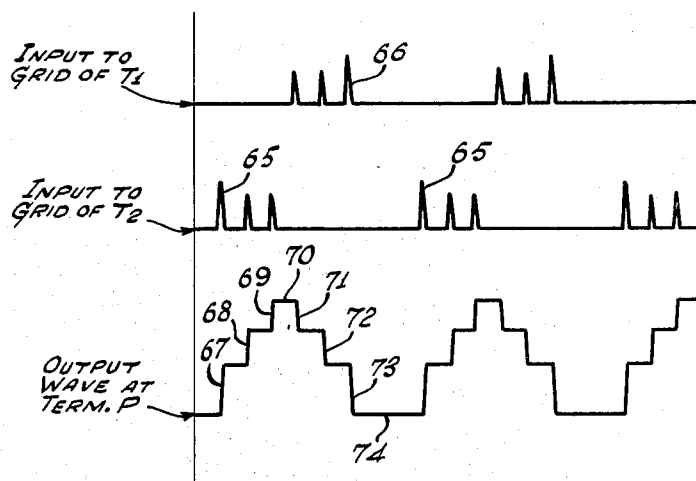


Fig. 4.



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ELECTRON DISCHARGE APPARATUS

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The present invention relates to electron discharge apparatus for producing or transforming electrical wave forms or handling electrical information.

It is frequently desirable to generate electric waves or pulses of a particular form. Such waves may have saw-tooth, square wave, stepped wave or other types of continuous or discontinuous wave forms. In the case of square or rectangular pulses and saw-tooth waves, it is often desirable that the pulses have a very steep rise or fall. It is also frequently desired to obtain such pulses with an amplitude of several hundred volts and with very precise synchronization.

It is an object of my invention to obtain all these desiderata in a simple and effective manner.

It is another object of my invention to provide a novel technique of producing electrical wave forms.

The objects of the invention are attained by connecting a pair of electron discharge devices to a load and controlling these devices so that one of them supplies electrical charge carriers to the load and the other extracts charge carriers in such a manner that a desired voltage wave form is produced across the load. Simple and effective circuits for producing these functions are provided by using electron tubes, one of which is adapted to supply a secondary emission current to the load.

The invention will be more fully understood and other objects and advantages thereof will become apparent from the following description and the drawing in which:

Fig. 1 is a circuit diagram of one embodiment of my invention;

Figs. 2 to 4 are wave form diagrams illustrative of the operation of the circuits.

Referring to the drawing, Fig. 1 shows a circuit comprising a pair of electron tubes T1 and T2. Tube T1 may be a pentode tube having a grounded cathode 11, a control grid 12, a screen grid 13 and a suppressor grid 14 which may be connected to the cathode. Control grid 12 is preferably biased to cut off by a biasing source connected by a lead 15 and resistor 16. A condenser 17 may bypass the bias connection 15 to ground. Input signals of any desired wave form may be applied to the electrodes of tube T1 for controlling the discharge current thereof. Such input signals may be impressed on the control grid 12 by lead 18. Screen grid 13 is maintained at a suitable positive potential, which may be of the order of several hundred volts, by a lead 19 to a source of B+ voltage. It will be understood that all voltage sources and signal sources may be returned to ground. The anode 20 of tube T1 is connected to terminal P of any desired load. If, for example, the circuit is used as a saw-tooth wave generator, the load may be the electrostatic deflection plates of a cathode ray tube. In this case the load will be substantially capacitive as indicated by the condenser 21.

Tube T2 includes a grounded cathode 25 and a control grid 26 connected through a resistor 27 to a source of biasing potential at terminal 28. The biasing source may be bypassed to ground by condenser 29. A screen

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grid 30 has a connection 31 to a suitable source of positive voltage. A suppressor grid 32 is connected to the cathode but, if desired, the suppressor grid may be omitted. In the path of the electron stream there is a secondary electron emitting anode or dynode 35 connected to terminal P of the load. Dynode 35 may be formed of such a material or may be coated so as to enhance its electron emission when bombarded by high velocity electrons. The anode 36 is maintained at a suitable B+ voltage, the other side of the B+ source being returned to ground or the cathode in the usual manner. The discharge current in tube T2 is controlled by input signals supplied by lead 37 to one of the electrodes thereof, for example, control grid 26.

The operation of the circuit illustrated in Fig. 1 may be explained with reference to Figs. 2, 3 and 4. Referring to Fig. 2, let it be assumed that tubes T1 and T2 are cut off when the bias is below the values indicated by dotted lines 41 and 42, respectively. The actual biases supplied to tubes T1, T2 through leads 15 and 28, may be more negative than the cut off biases 41 and 42, as indicated by the lines 43 and 44. Tubes T1 and T2 will then be normally biased to cut off. Input circuits 18 and 37 supply pulses 45 and 46 to tubes T1 and T2 in the time sequence indicated in Fig. 2. The first pulse 46 will render tube T2 conductive and cause a stream of high velocity electrons to strike dynode 35. The voltages applied to screen grid 30 and anode 36 will cause each electron striking dynode 35 to produce a plurality of secondary electrons and the secondary electrons will be attracted to anode 36. Suppressor grid 32, if used, is helpful in preventing secondary electrons from being attracted by screen grid 30. Hence pulse 46 will cause a large current to flow from point P through dynode 35 to anode 36 and thence through the B+ source to ground. This current will cause the voltage across load 21 to rise rapidly, as indicated by line 47, to a positive value 48. The voltage across the load will remain substantially constant until the first pulse 45 of Fig. 2 is applied to control grid 12 of tube T1. As pulse 45 rises above the cut off value 41 of tube T1, a large electron current will flow to anode 20 and terminal P so that the voltage across the load will fall as indicated by line 49 to a value 50. Upon termination of pulse 45, the voltage across load 21 will remain at value 50 until the next pulse 46 is applied to tube T2, whereupon the second rectangular wave 51 will be produced in the same manner as the preceding wave. The zero voltage line for the load is indicated by line 52.

The manner in which the circuit of Fig. 1 may be operated to generate saw-tooth waves will be explained with reference to Fig. 3. Dashed lines 55, 56 indicate the values of the bias at which tubes T1 and T2 respectively, will be cut off. Assume that the input signal applied to control grid 12 of tube T1 is a steady potential 57 slightly more positive than the cut off bias of that tube, so that tube T1 will have a steady small discharge current. Assume that the bias applied to tube T2 is as indicated by line 58, that is, that it has a value such as to maintain tube T2 biased below cut off. When a positive pulse 59 is applied to control grid of tube T2 so as to drive it out of cut-off, high velocity electrons will strike dynode 35. Current multiplication will occur at dynode 35 to cause a large momentary current to flow from loads 21 through dynode 35, anode 36, the B+ voltage source connected to the latter and then to ground. This action will cause a steep rise in the voltage across load 21, as indicated by the line 60. Upon the termination of pulse 59, tube T2 will be cut off. Tube T1, however, is conducting and by virtue of its being a pentode, supplies electrons to terminal P at a nearly constant rate so that the voltage across load 21 falls steadily as indicated by the

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line 61. This action will continue until the second pulse 59 occurs and causes tube T2 to conduct again and suddenly raise the voltage to the maximum value. It is clear therefore that the voltage across load 21 will have the saw-tooth form indicated by lines 60, 61.

Still another manner of operating the circuit of Fig. 1 is illustrated in Fig. 4. Here, again, let it be assumed that tubes T1 and T2 are normally biased below cut off and that pulses 65 are applied to tube T2 and pulses 66 are applied to tube T1. Pulses 65 cause conduction in tube T2. Electrons thus flow from terminal P to the dynode 35 and produce series of rises 67, 68, 69 in the voltage across load 21. After the last pulse 65, the voltage across the load remains at the value 70 until pulses 66 are applied to tube T1. Each of the latter pulses causes a stream of electrons to flow to terminal P and produces a sharp drop 71, 72 and 73 in the voltage across load 21. The load voltage then remains at the value 74 until the next series of pulses 65 is applied to tube T2, whereupon a second stepped voltage wave will be generated. Figs. 2, 3 and 4 are to be considered merely illustrative of the many ways the circuit may be operated to generate a desired wave form.

It will be understood that the circuit herein illustrated is an exemplary embodiment of my invention, which lends itself to a great variety of applications. Various modifications of the embodiment of the invention herein illustrated will be evident to those skilled in the art. Therefore I do not wish the invention to be construed as limited except as defined in the following claims.

I claim:

1. An electron discharge circuit comprising a load, an electron tube having its anode connected directly to one side of said load and a cathode connected directly to the other side of said load, a control electrode in said tube, means for biasing said control electrode substantially to cut off and means for applying potentials to said tube for producing discharge current therethrough, a second electron tube including a secondary electron emitting electrode connected directly to the anode of said first tube and a cathode connected to the said other side of the load, means including an accelerating electrode in said second tube for causing the electrons leaving the cathode thereof to strike the secondary electron emitting electrode with a sufficient velocity to produce the current

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multiplication thereat, means including an anode juxtaposed to said secondary emitting electrode for collecting the secondary electrons emitted therefrom and means including the control electrode of said second electron tube for biasing said second tube to cut off and for applying input potentials for causing discharge current through said second tube alternately with said first tube and an output lead connected to said one side of the load.

2. A saw-tooth wave producing circuit comprising a nonoscillatory load, a pentode electron tube having its anode connected directly to one side of said load and its cathode connected directly to the other side of said load, means for applying potentials to said tube for producing a steady discharge current therethrough, a second electron tube including a secondary electron emitting electrode connected directly to the anode of said first tube and a cathode connected to the said other side of the load, means including an accelerating electrode in said second tube for causing the electrons leaving the cathode thereof to strike the secondary emitting electrode with a sufficient velocity to produce a current multiplication thereat, means including an anode juxtaposed to said secondary emitting electrode for collecting the secondary electrons emitted therefrom and means including the control electrode of said second electron tube for biasing said second tube to cut off and for applying positive voltage pulses to said control electrode for causing discharge currents through said second tube and an output lead connected directly to said one side of said load.

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