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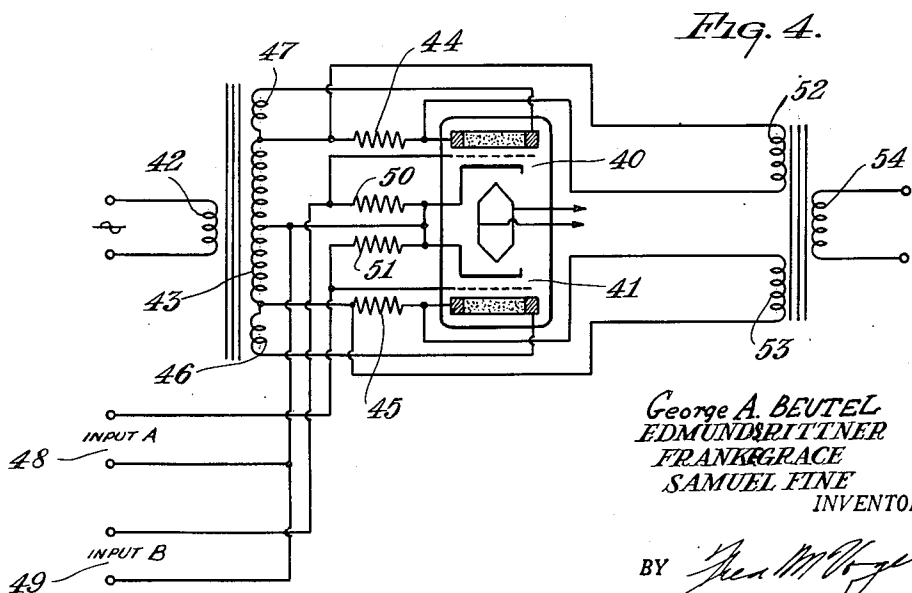
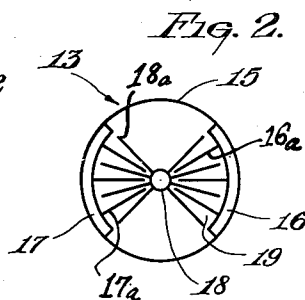
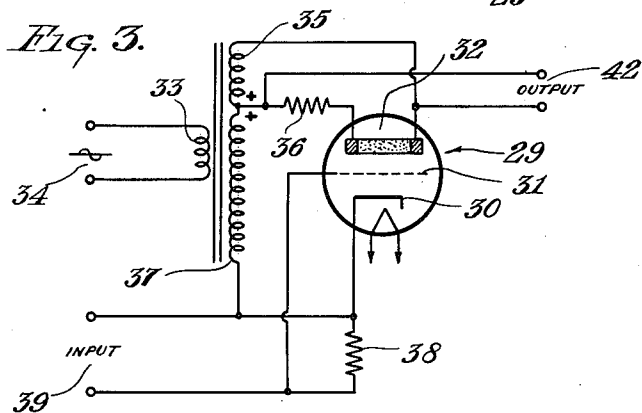
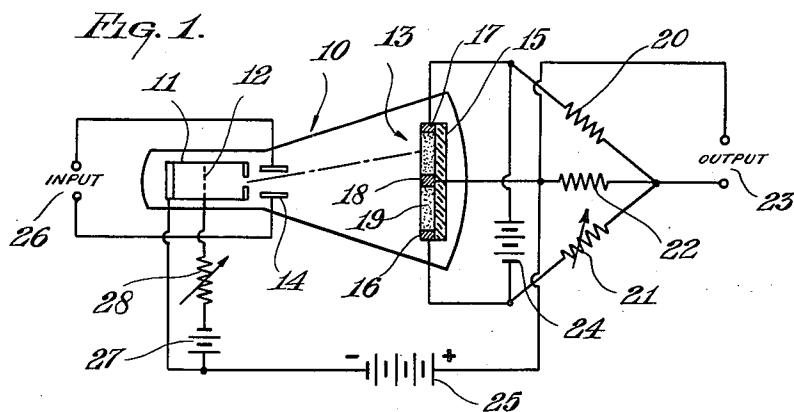
E. S. RITTNER ET AL

2,588,292

ELECTRON SWITCHING TUBES AND CIRCUITS THEREFOR

Filed April 20, 1950

2 SHEETS--SHEET 1



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2 SHEETS—SHEET 2

Fig. 5.

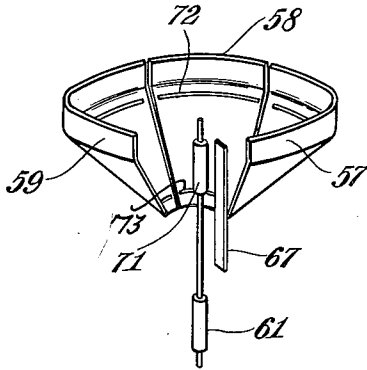


Fig. 6.

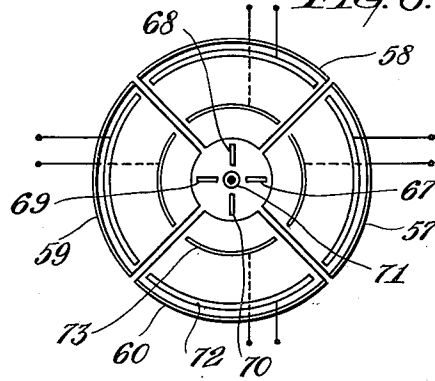
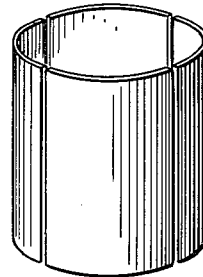
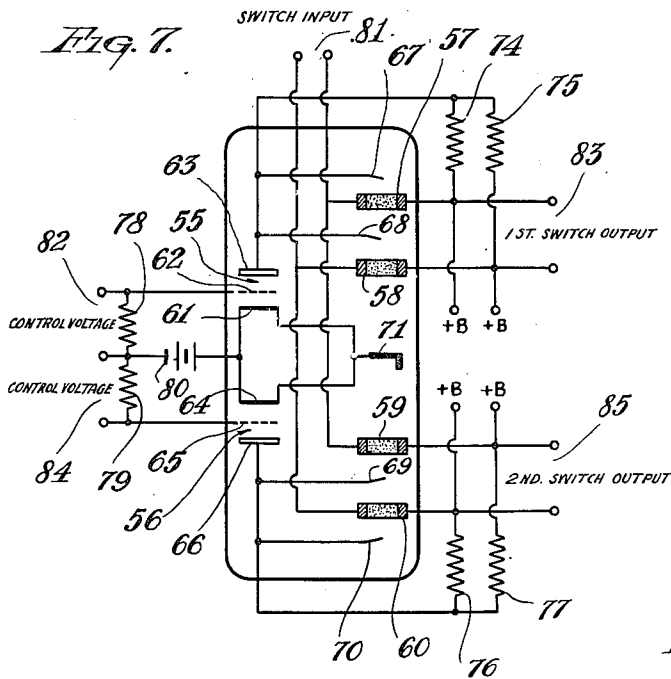


Fig. 8.

Fig. 7.



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ELECTRON SWITCHING TUBES AND
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9 Claims. (Cl. 315-1)

1

The present invention pertains to improve-
ments in electron devices of the type wherein
a stream of electrons is caused to impinge on a
target of photoconducting semiconductive ma-
terial whose internal impedance varies as a func-
tion of the stream intensity and velocity, and to
improved circuit arrangements incorporating
such devices.

In the copending application of E. S. Rittner,
filed March 29, 1948 and given Serial No. 17,636,
issued on February 16, 1951 as Patent No. 2,540,490,
there is disclosed electron devices in which an electron
beam is directed onto a photoconductive semiconduc-
tive element preferably constituted either by silicon,
germanium, thallous sulfide, or lead sulfide, these
substances each exhibiting a resistivity which de-
pends on the beam intensity and velocity. The prin-
cipal object of the present invention is to provide im-
proved structural arrangements for such devices, as
well as new and useful switching circuits embodying
said improved devices.

For a complete understanding of the present
invention reference is made to the following de-
tailed description thereof to be read in conjunc-
tion with the accompanying drawing where-
in:

Fig. 1 is a schematic diagram of an electron
switching tube circuit in accordance with the
invention and in which the photoconducting
semiconductive target is illustrated in section.

Fig. 2 is a separate plan view of the target
structure.

Fig. 3 is a schematic circuit diagram of an
amplifier incorporating an electron device which
is energized directly from an alternating-current
source.

Fig. 4 is a schematic circuit diagram of a dif-
ferential amplifier employing a pair of ampli-
fiers of the type disclosed in Fig. 3.

Fig. 5 is a perspective view of the electrodes in
another electron device in accordance with the
invention.

Fig. 6 is a plan view of the electrode structure
shown in Fig. 5.

Fig. 7 is a schematic diagram of a switching
system employing a tube of the type disclosed in
Figs. 5 and 6, and

Fig. 8 is a perspective view of a modified tar-
get structure for a tube of the type disclosed in
Fig. 5.

Referring now to Figure 1, there is shown a
voltage-responsive switching system including
an electron device 10 in accordance with the in-
vention provided with a cathode-ray gun struc-

2

ture 11 possessing an intensity-control electrode
12, the cathode-ray beam projected by said gun
impinging on a target structure 13 and being
deflectable by a pair of electrostatic deflecting
plates 14. As shown in Figs. 1 and 2, the target
structure 13 is formed by a disc-shaped base
member 15 of dielectric material along whose
circular edge is mounted a pair of arcuately
shaped electrodes 16 and 17 each having a plu-
rality of conductive spokes 16a and 17a attached
thereto. A hub electrode 18 is affixed centrally
to said base and provided with radial spokes
18a disposed in intermeshing relationship with
respect to spokes 16a and 17a. Coated on the
surface of said base in the interstices of spokes
16a, 17a and 18a is a layer 19 of semiconduc-
tive material preferably constituted either by ger-
manium, thallous sulfide, silicon or lead sulfide.

The semiconductive path lying between the
spokes on arcuate electrode 17 and hub electrode
18 acts as one arm, and the path lying between
the spokes on arcuate electrode 16 and hub elec-
trode 18 acts as a second arm in a Wheatstone
bridge circuit whose remaining arms are formed
by the external resistors 20 and 21, the latter
resistor being variable to effect balancing.

Connected between hub electrode 18 and the
junction of resistors 20 and 21, which electrode
and junction represent the output diagonals of
the bridge, is an output resistor 22 whose ends
are also connected to output terminals 23. Con-
nected between arcuate electrodes 16 and 17 at
the input diagonals of the bridge is a direct vol-
tage source 24. Connected between the cathode
of the electron gun 11 and the hub electrode
of target 13 is a source of accelerating voltage
25. The control voltage for activating the
switching system is applied to the input ter-
minals 26 connected to deflecting plates 14. A
bias voltage from a source 27 is applied to in-
tensity control electrode 12 through variable
resistor 28.

The behavior of the switching system is as
follows: In the absence of a control voltage
across the deflecting plates, the beam from gun
11 strikes the hub electrode 18, and thereby
avoids contact with the semiconductive sub-
stance on the target. Assuming an initial con-
dition of bridge balance, and with zero voltage
on the deflecting plates, no voltage is developed
across output resistor 22 of the bridge. The
introduction of a voltage across deflecting plate
14 deflects the beam from hub electrode onto
the semiconductive layer 19 in a direction de-
pending on the polarity of the control voltage.

Thus depending on the direction of deflection, either the resistivity of the semiconductive path interposed between electrodes 16 and 18 or the path between electrodes 17 and 18 is altered to unbalance the bridge in one direction or the other. In consequence, the polarity of voltage established across output resistor 22 is contingent on the polarity of the control voltage applied to the deflecting plates.

The output voltage appearing at terminals 23 may be used to effect a desired switching action in various ways. For example it may be impressed on a polarized relay to effect a switching action in a sense depending on the polarity of the control voltage. The extent to which the resistivity of a particular semiconductive path is altered, and hence the sensitivity of the relay, may be controlled by adjusting resistor 28 to obtain a desired beam intensity. It is also to be noted that a modulating signal may be applied to grid 12 whereby the tube acts to amplify the signal and then by its switching action directs it into a desired channel.

Referring now to Fig. 3, there is shown a switching system employing an electron device 29 in which the voltage imposed across the target and the beam accelerating voltage is derived, without rectification, from an alternating-current source. Electron device 29 includes an indirectly heated cathode 30, a control grid 31 and a target electrode 32 formed by a semiconductive substance of the type hereinabove described interposed between two end terminals.

A transformer is provided having a primary winding 33, connected at terminals 34 to an alternating-current line, a secondary winding 35 connected through an output resistor 36 across the end terminals of target 32, and a tertiary winding 37 arranged in phase opposition to winding 35 and connected between one terminal of target 32 and cathode 30. A grid leak resistor 38 is connected between grid 31 and cathode 30, a pair of input terminals 39 being connected across resistor 38, and a pair of output terminals 42 being connected across resistor 36.

In operation, a pulsating direct-current component will appear across resistor 36 whose amplitude will depend on the magnitude of the control voltage impressed on the grid 31. The voltage established across resistor 36 may be used to actuate a relay, and due to the increased amplification afforded by the electron device, the system is responsive to input control signals of small amplitude. Thus a highly sensitive control device is provided entailing a minimum number of components.

Referring now to Fig. 4, there is disclosed a differential amplifier employing a pair of electron devices of the type disclosed in Fig. 3, preferably enclosed in a single envelope, whose combined output depends on the relative values of the applied input voltages. As in Fig. 3, the voltages imposed across the targets of the tubes 40 and 41 and the beam accelerating voltages are derived without rectification through a transformer whose primary 42 is connected to an alternating current source. The transformer is provided with a centertapped secondary winding 43 whose ends are connected through resistors 44 and 45 to one terminal of the targets of tubes 40 and 41 respectively, and whose centertap is connected to the interconnected cathodes of said tubes. Auxiliary secondary windings 46 and 47 are provided, one end of each auxiliary secondary being connected to a respective end of said sec-

ondary 43, the other end of each auxiliary secondary being connected to the other terminal of a respective target.

The input voltages A and B are applied at terminals 48 and 49 which are connected respectively across grid resistors 50 and 51 connected between the grid and cathodes of tubes 40 and 41. The voltage developed across resistor 44 is applied to one primary 52 of an output transformer, and the voltage developed across resistor 45 is applied to an oppositely wound primary 53 of the transformer. In consequence the average voltage developed in the secondary 54 represents the differential resultant of the primary voltages. In operation, since the accelerating voltages applied to the targets of tubes 40 and 41 are 180 degrees out of phase, the tubes operate alternately, the voltages developed across resistors 44 and 45 depending on the relative amplitudes of the input voltages A and B respectively. It is to be noted that in the control systems disclosed in Figs. 1, 3 and 4, the input circuits are independent of the output circuit and no interaction therebetween can occur.

Another embodiment of an electron device is shown in Figs. 5, 6 and 7, the device comprising in a single envelope, a pair of high-mu triodes 55 and 56 and a cone-shaped target constituted by four electrically separated sections 57, 58, 59 and 60. Triode 55 is constituted by a cathode 61, a grid 62 and an anode 63, and triode 56 by a cathode 64, and grid 65 and an anode 66. Connected directly to the anode 63 are a pair of blade-like control electrodes 67 and 68, electrode 67 being associated with target section 57 and electrode 68 with section 58. Similarly, connected directly to anode 66 is a pair of blade-like control electrodes 69 and 70, electrode 69 being associated with target section 59, and electrode 70 with section 60. In Fig. 5, only electrode 67 is shown, the others being omitted for purposes of clarity. The target is irradiated by an electron beam emitted from a cylindrical cathode 71, triode cathodes 61 and 64 being mounted on a common support therewith. For purposes of clarity cathode 64 has not been shown in Fig. 5 nor have the remaining elements of the triode structures been included since these are conventional.

Each section of the target is formed of non-conductive material and is provided with a pair of spaced arcuate terminals 72 and 73, the surface between the two terminals being coated with a semiconductive photoconductive substance of the type described supra. The anode 63 is connected to one terminal of target section 57 through a high resistance 74, said one terminal being connected to the positive pole of a high-voltage source. The anode 66 is also connected to one terminal of target section 58 through a high resistance 75, said one terminal being connected to the positive pole of a high-voltage source.

Anode 66 is connected to one terminal of target section 60 through a high resistance 76, a high positive voltage being applied at this point. Grid 62 is connected to cathode 61 through a grid resistance 78 and a bias battery 80, grid 65 being connected to cathode 64 through a grid resistance 79 and the same bias battery.

Considering section 57 separately, in operation, with zero control potential on the grid 62 of tube 55, electrons from the cathode 71 strike the entire surface of section 57 except for a sector in the region of blade electrode 67, which being at a lower potential than the target section because

of the voltage drop across resistance 74 acts as a shield. When however, a negative control potential is applied to grid 62, the anode current is reduced with a resultant decrease in the voltage drop across resistances 74 and 75, thereby reducing the sector of the target section 57 which is not irradiated. Thus as the shielded sector on the target section varies with the control voltage applied to grid 62, the internal resistance of the target section is accordingly altered. Blade 68 has the same control influence on section 58. The same effect is experienced with respect to the influence of a control voltage on grid 65 on the internal resistance of sections 59 and 60.

This effect may be used for example to provide a double pole double throw switching action by applying the signal to be switched to terminals 81, one of which is connected to one arcuate terminal of both sections 57 and 59, and the other of which is connected to one arcuate terminal of sections 58 and 60. The other arcuate terminals of sections 57 and 58 are connected to one pair of output terminals 83 while the other arcuate terminals of sections 59 and 60 are connected to output terminals 85.

By applying a negative control voltage to terminals 82 connected to grid 62, the signal to be switched is fed to output terminals 83 and by applying a negative control voltage to terminals 84 connected to grid 65, the signal to be switched is fed to output terminal 85. While there has been shown a target arrangement employing four sections, it is obvious that a greater number may be used in conjunction with blade electrodes coupled to the anodes of amplifier tubes to effect more complex switching functions.

By using a conically-shaped target the formation of a sensitive layer on the inner surface thereof is greatly facilitated. This is accomplished by inverting the cone and applying the material by vacuum evaporation. Preferably the cathode is protected by a small cap (not shown) attached to the end of the support. The conical target structure shown in Fig. 5 may be replaced by one of tubular shape, as illustrated in Fig. 8 or by other shapes if desired. While the terminals 72 and 73 in Fig. 5 are shown in circumferential positions, it is to be understood that radially disposed terminals may alternatively be employed, in which case should the sensitive area intermediate the terminals not be irradiated then the resistance therebetween would effectively constitute an open circuit. Similarly in the target shown in Fig. 8, the terminals may be arranged either longitudinally or circumferentially. It is also to be noted that several targets may be contained in a common envelope.

While there have been shown what at present are considered preferred embodiments of the invention, it will be evident that many changes and modifications may be made therein without departing from the essence of the invention, and it is intended in the annexed claims to cover all such changes and modifications as fall within the scope and true spirit of the invention.

What is claimed is:

1. An electron switching device comprising a cathode-ray gun for generating an electron beam, a target structure positioned to intercept said beam and including a pair of spaced end terminals, a hub terminal positioned intermediate said end terminals and an active element interconnecting said hub terminal and said end terminals to define first and second control paths, said element being formed of semiconductive photoconductive material, and means to deflect

said beam across said target structure whereby the internal resistance of the impinged path is varied by said beam.

2. An electron switching device comprising a cathode-ray gun for generating an electron beam and provided with a control electrode to control the density of said beam, a target structure positioned to intercept said beam and including a pair of spaced end terminals, a hub terminal positioned intermediate said end terminals and an active element interconnecting said hub terminal and said end terminals to define first and second control paths, said element being formed of semiconductive photoconductive material selected from group IV of the periodic table, and means to deflect said beam to impinge selectively on one of said paths, whereby the internal resistance of the impinged path is varied by said beam.

3. An electron switching device comprising a cathode-ray gun for generating an electron beam, a target structure positioned to intercept said beam and including a pair of spaced end terminals, a hub terminal interposed between said end terminals and an active element interconnecting said hub and said end terminals to define first and second control paths, said element being formed of thallous sulfide, and means to deflect said beam to impinge selectively on one of said paths, whereby the internal resistance of the impinged path is varied by said beam.

4. An electronic switching circuit comprising an electron device including a cathode-ray gun for generating an electron beam, a target structure positioned to intercept said beam and including a pair of spaced end terminals, a hub terminal interposed between said end terminals and an active element interconnecting said hub terminal and said end terminals to define first and second control paths, said element being formed of semiconductive photoconductive material and means to deflect said beam to impinge selectively on one of said paths, a Wheatstone bridge including first and second resistances connected in series across the end terminals of said target structure and an output resistance connected between the hub terminal and the junction of said first and second resistances, and means to apply a control voltage to said deflecting means.

5. An electronic switching circuit comprising an electron device including a cathode-ray gun for generating an electron beam, a target structure positioned to intercept said beam and including a pair of spaced end terminals, a hub terminal interposed between said end terminals and an active element interconnecting said hub terminal and said end terminals to define first and second control paths, said element being formed of semiconductive photoconductive material and means to deflect said beam to impinge selectively on one of said paths, a Wheatstone bridge including first and second resistances connected in series across the end terminals of said target structure and an output resistance connected between the hub terminal and the junction of said first and second resistances, means to apply a direct voltage across said end terminals, means to apply an accelerating potential to said hub terminal, and means to apply a control voltage to said deflecting means.

6. An electronic switching circuit comprising an electron device including a cathode-ray gun for generating an electron beam and provided with a control electrode, a target structure positioned

7

to intercept said beam and including a pair of spaced end terminals, a hub terminal interposed between said end terminals and an active element interconnecting said hub terminal and said end terminals to define first and second control paths, said element being formed of thallous sulfide, and means to deflect said beam across said target structure, a Wheatstone bridge including first and second resistances connected in series across the end terminals of said target structure and an output resistance connected between the hub terminal and the juncture of said first and second resistances, and means to apply a control voltage to said deflecting means.

7. In an electron switching device, a target structure comprising a circular insulating disc, a pair of arcuate terminals mounted on the opposing edges of said disc, a hub terminal mounted centrally on said disc, and an active element constituted by a semiconductive photoconductive material coated on the surface of said disc between said hub terminal and said arcuate terminals.

8. In an electron switching device, a target structure comprising a circular insulating disc, a pair of arcuate terminals mounted on the opposing edges of said disc and provided with a plurality of radial spokes, a hub terminal mounted centrally on said disc, and provided with a plurality of radial spokes disposed in intermeshing relationship with the arcuate terminal spokes, and an active element coated on the surface of

8

said disc between said spokes, said element being constituted by a semiconductive photoconductive material.

9. An arrangement, as set forth in claim 8, wherein said material is constituted by lead sulfide.

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