Dec. 9, 1947. A. G. THOMAS 2,432,260

ELECTRONIC SWITCH

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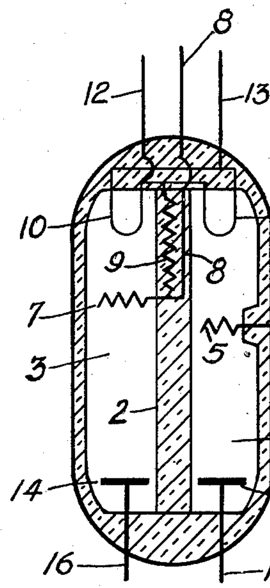


Fig. 1

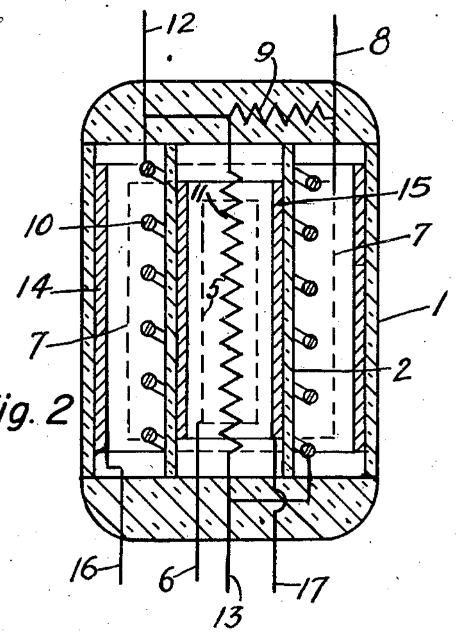
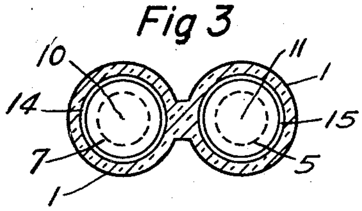


Fig. 2

Fig 3



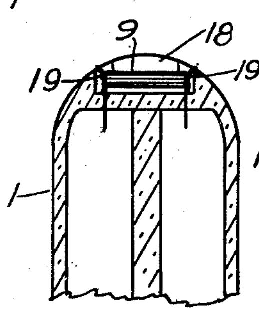


Fig 4

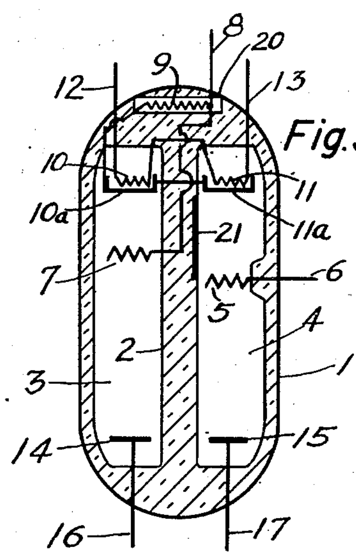


Fig. 5

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Fig. 6

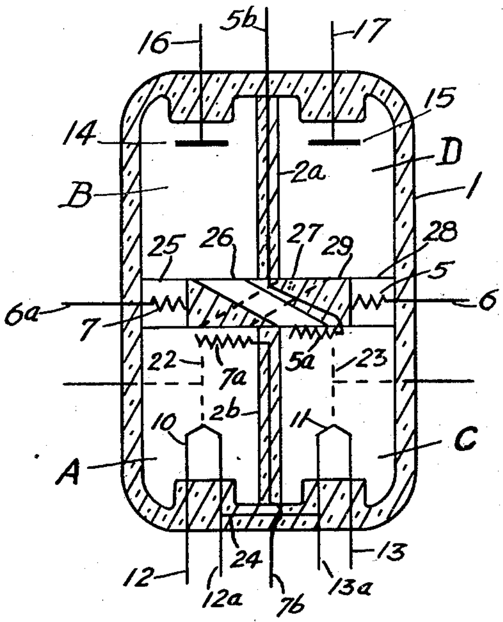

Fig. 7

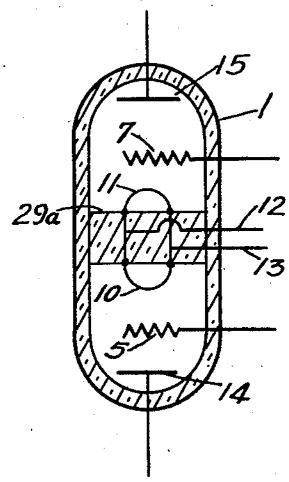

Fig. 8

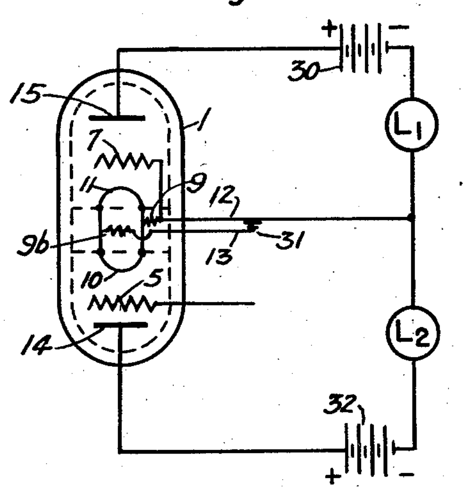

Fig. 9

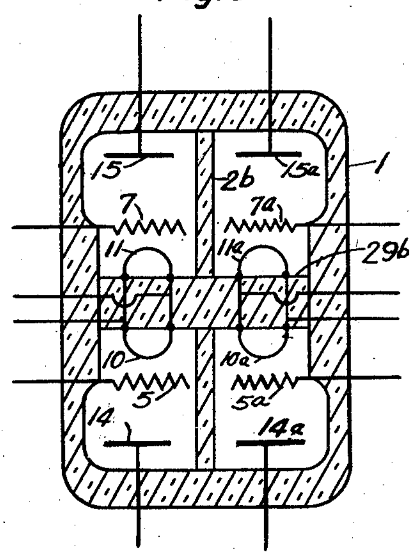

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Fig. 10

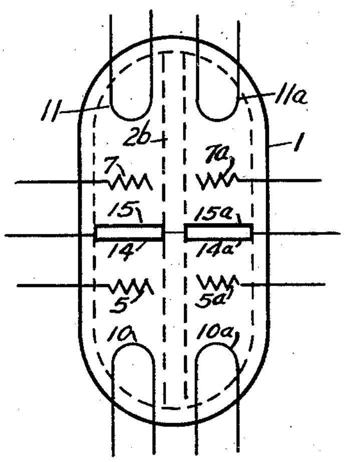
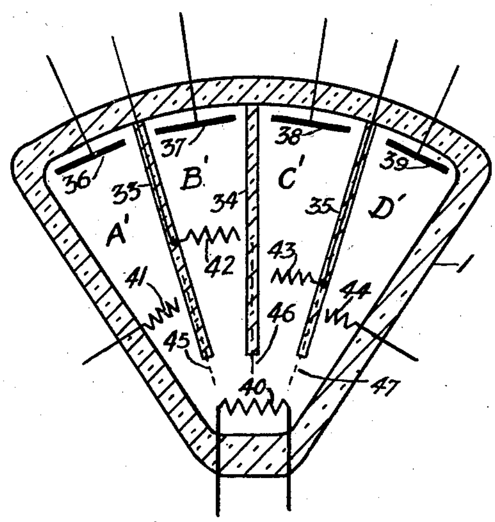


Fig. 11



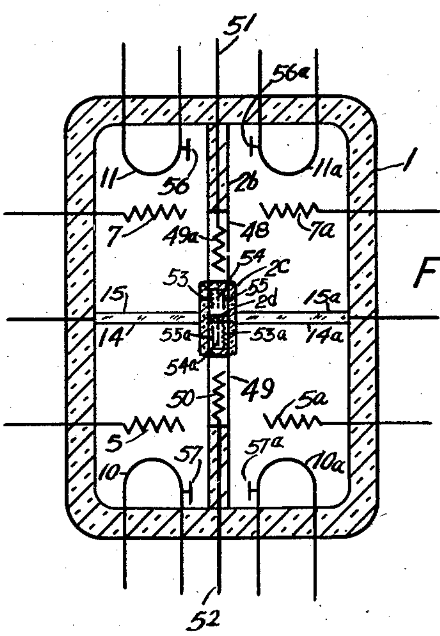


Fig. 12

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UNITED STATES PATENT OFFICE

2,432,260

ELECTRONIC SWITCH

Albert G. Thomas, Lynchburg, Va.

Application January 18, 1945, Serial No. 573,366

12 Claims. (Cl. 250—27.5)

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This invention relates to electronic devices and has particular reference to electronic switches, electronic relays, and the like.

In many electrical circuits it is desirable and sometimes necessary to open and close one or more circuits by electronic relays or switches rather than by mechanical switches such as knife switches, mercury switches, toggle switches, or usual types of relays of varied construction. Where very fast speed of operation or frequent making and breaking of circuits is encountered, electronic switches are highly advantageous. In the past, however, the employment of electronic switching has entailed a complexity of apparatus involving various electronic tubes, condensers, resistors, reactances or coupling coils, and the like, all connected together to achieve the desired result. A trigger circuit, for instance, has required two gaseous relay tubes, one or more condensers, and one or more impedances, in order to provide alternate switching action of two branches of a circuit.

With my improved electronic switches, it is possible to connect a simple device in circuit and have it perform satisfactorily although it is substituted for numerous parts or devices formerly required.

An object is to provide an electronic reversing switch.

An additional object is to provide a simple electronic switch comprising two or more branches or electrical paths so that when one branch conducts current, another associated branch is made nonconducting substantially.

Another object is to provide an electronic tube with in-built impedance for producing potential drop.

A further object is to provide an electronic tube with a readily detachable associated impedance element.

Another object is the provision of electronic switches which may be used in place of single pole, single throw switches; or double pole, double throw switches.

Further objects are to provide electronic switches having common cathodes and two or more anodes; and having common anodes and two or more cathodes.

An additional object is the provision of an electronic switch having a common cathode and a plurality of controlled branches with separate anodes, or with a common anode and a plurality of controlled branches with separate cathodes.

A still further object is the provision of an electronic tube with a perforated partition and means for controlling current flow through the perforation.

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Additional objects will be evident in the following description.

In the drawings:

Figure 1 is a part sectional elevation of an electronic tube or switch with in-built grid biasing impedance or resistance.

Figure 2 is a part sectional elevation of a device similar to that of Figure 1 but having cylindrically shaped elements.

Figure 3 is a plan view, with envelope in section, of a double branch tube which may be used for the devices shown in Figures 1 or 2.

Figure 4 is a part sectional fragmentary view of a tube with recessed, removable, resistor or impedance element.

Figure 5 is a part sectional elevation of a double branch electronic tube or switch with indirectly heated cathodes and in-built resistor or impedance.

Figure 6 is a part sectional elevation of a double branch tube or switch with cross channels, which may be used as a multiple switch.

Figure 7 is a part sectional elevation of an electronic single pole double throw switch.

Figure 8 is a circuit diagram showing a modified form of the device of Figure 7 connected in a double circuit.

Figure 9 is a part sectional elevation of an electronic device useful as a double pole double throw switch.

Figure 10 shows an elevation of another form of electronic device useful as a double pole double throw switch.

Figure 11 is a part sectional elevation of an electronic device useful as a multi-contact switch.

Figure 12 is a part sectional elevation of a partitioned electronic tube or switch with plural chambers and controlled openings in the partition, for various uses.

In the following description like parts are designated by like numbers:

In Figure 1, envelope **1**, preferably of glass or the like, has inner partition **2** sealed to it forming separate chambers **3** and **4** which may be evacuated or filled with argon, mercury vapor, or other gases at relatively low pressure, as desired. In fact one chamber **4**, for instance, may be evacuated and chamber **3** may be gas filled, or vice versa, for reasons to be described.

A suitable control element for branch **4** such as grid **5** is connected with lead **6** sealed in the envelope and a control element for chamber **3** such as grid **7** is connected with lead **8** which may be sealed in partition 2 as shown. If desired, a channel may be formed in the partition for passage of lead 8 and resistor 9 which is connected between grid 7 and the parallel connected filaments or cathodes 10 and 11 as shown. These filaments could be connected in series, however. The filaments are connected with leads 12 and 13 as indicated and the filament connections may be imbedded in the end walls of the envelope as shown.

Anode 14 with connected sealed-in lead 16 is provided for branch 3 and anode 15 with connected sealed-in lead 17 is provided for chamber 4. Usual materials may be used for the various parts such as cathodes, leads, anodes, grids, and the like. Where the word "grid" is used it is intended to denote any suitable control element for affecting an electron stream.

In operation, cathode leads 12 and 13 are connected to the terminals of a suitable source of filament current such as a battery, transformer, or line. Anode lead 16 is connected to lead 12 or 13 through a load and a source of potential such as a battery, line, or the like.

Anode lead 17 is connected to lead 8 through a load and a suitable source of potential. The anodes are of course made positive with respect to leads 12 and 8. Now if lead 6 is connected to one terminal of a source of potential, the other terminal of which is connected to lead 13, then current will, in the conventional sense, pass from anode 15 through branch 4 and from cathode 11 through resistor 9 and out lead 8 and thence through the rest of the circuit containing anode 15. When this happens the potential drop across resistor 9 biases connected grid 7 negatively with respect to cathode 10, to the point of cut-off, if desired, so that no current passes through chamber 3 when current is passing through branch 4. By proper choice of resistor 9 or the anode potential of chamber 3 and perhaps other factors, the amount of current in branch 3 can bear a predetermined relationship to the amount of current in branch 4.

The chambers 3 and 4 may be highly evacuated or they may contain gas to increase current conduction.

As previously stated, chamber 4 may be evacuated and branch 3 may contain gas. Then the current in chamber 4 may be controlled by grid 5 at any time but a fluctuating potential should be applied between leads 12 and 16, in order for grid 7 to regain control on account of ionization. It will be seen that if grid 5 is made negative with respect to cathode 11, even to the point of cut-off, current will be conducted through chamber 3 since it is not then biased negatively by current through resistor 9. It is obvious, therefore, that this device will serve in effect as a single pole double throw switch. The two circuits including anodes 14 and 15 are under the control of the one grid 5. This grid may be charged to the point of cut-off or to a lesser degree depending upon the results desired.

Lead 12, instead of being connected directly to cathode 10, as shown, could be connected to resistor 9 at a suitable point so that grid 7 would be given a slight positive bias when chamber 3 is conducting and chamber 4 is not conducting current. Then the negative bias could overcome the positive bias of grid 7 when grid 5 is charged positively. If it is desired to control grid 7 independently, it can be done by applying suitable potential between leads 12 and 8.

Suitable metal or other shielding can be placed in or on wall or partition 2 between the grids and cathodes, or elsewhere, in order to prevent interference between the cathode-grid fields or other fields. This shielding may be grounded or connected as desired.

While this device is shown primarily as a highly flexible, electronic switch or relay of great adaptability and rapidity of action, it may also be used in other manner as an oscillator or oscillators, for instance. In fact one chamber may be caused to oscillate while the other branch carries steady current or is non-conducting or both chambers may be caused to oscillate, each at a different frequency. This may be done by charging the grids independently, in effect, i. e., using lead 8 as described. In that case potentials should be applied to grid 7 of sufficient magnitude to override any biasing due to resistor 9, or the phasing between the branches should be adjusted to overcome interference.

The same relay or switch essentially, is shown in Figure 2 except that the parts are shaped differently. In this case partition 2 is cylindrical and anodes 14 and 15 are similarly shaped. These elements are preferably concentric and situated as shown. Filament 10 is helical, but may be shaped otherwise and filament 11 may be bent or straight. These filaments are connected in parallel. Cylindrical grids 5 and 7 surround filaments 11 and 10 respectively and biasing resistor 9 is connected between leads 8 and 12. The position of this resistor has been changed so that it is situated in the end wall indicated.

The connections and operation are as described in relation to Figure 1. The current passing from anode 15 to filament or cathode 11 passes through resistor 9 and out lead 8 to complete the circuit. As before, the potential drop across resistor 9 biases grid 7 negatively. Grid 5 controls the operation as described previously. The cylindrically shaped elements provide greatly enlarged surfaces and greater current carrying capacity for a given volume, than the device of Figure 1.

Figure 3 shows an alternate form of construction to that of Figure 1 or Figure 2. In this case envelope 1 comprises two joined cylinders which contain cylindrical anodes and grids as indicated and the filaments or cathodes may be straight wires or any suitable shape. This construction also enlarges the current capacity as compared to the device of Figure 1.

The resistor, or condenser, or other part may be snapped or otherwise fastened in a recess outside the envelope as illustrated in Figure 4. Resistor 9 is snapped in place between resilient contacts 19 so that the element may readily be changed when desired. Suitable leads from contacts 19 can be connected as desired.

Figure 5 shows the same general device as in Figure 1 except that heater type cathodes are used and resistor 9 is encased in chamber 20 in envelope 1. The resistor may be surrounded with heat insulation material such as asbestos or the like. Filaments 10 and 11 are shown connected in series but they can be connected in parallel. Cathodes 10*a* and 11*a* are indirectly heated by filaments 10 and 11 respectively. The cathodes are preferably treated with barium oxide or other material in order to provide copious electron emission. The cathodes are shown connected but not necessarily so.

Lead 8 is connected to one end of resistor 9 which is connected to grid 7, as in Figure 1, the other end of the resistor being connected to cathodes 10a and 11a as indicated. Substantially as described previously, current flowing through chamber 4 will pass through cathodes 11a and 10a and through resistor 9 and out lead 8, thereby biasing grid 7 negatively. One or more conducting shields 21 may be placed in or on partition 7 to separate the grid-to-cathode fields or other fields in the two branches. This shield may be grounded if desired.

In Figure 6 envelope 1 has cross partition 29 of glass or the like and glass partitions 2a and 2b sealed to the inside of the envelope and to partition 29, forming chambers A, B, C, and D as shown. Channels or openings 25 and 28 in partition 29 join chambers A and B and chambers C and D respectively. Likewise, inclined channels 26 and 27 in partition 29 join chambers A and D, respectively. Grids 5 and 7 are positioned in openings 28 and 25, respectively and are connected with suitable leads 6 and 6a sealed in envelope 1. These grids could be placed near the openings, on either side of partition 29.

Grid 7a is placed near the lower end of opening 27, although it can be situated in the opening, and is connected with lead 7b and sealed in envelope 1 and partition 2b. Similarly, grid 5a is placed near the lower end of opening or channel 26, although it could be in the channel, and is connected with lead 5b sealed in partitions 29, 2a, and envelope 1. These leads could be brought out in other manner if desired.

Anodes 14 and 15, with leads 16 and 17, are provided in chambers B and D, respectively and cathodes or filaments 10 and 11 with leads 12—12a and leads 13—13a, are provided in chambers A and C, respectively. These cathodes may be connected by conductor 24 sealed in envelope 1, or snapped in an outside recess as in Figure 4. Then the cathodes may be energized in series by connecting leads 12 and 13 to a current source, or in parallel by employing leads 12—12a and 13—13a. Screens 22 and 23, with connected leads sealed in envelope 1, may be provided. The chambers may contain gas or they may be highly evacuated.

In operation, considering an evacuated device, if grids 7a and 5a are made negative with respect to cathodes 10 and 11, and if grids 7 and 5 are made positive with respect to the cathodes by connecting them to suitable potential sources or otherwise, then flow of electrons through passages 26 and 27 can be prevented and flow of electrons from cathode 10 to anode 14, through passage 25, can be induced or allowed by grid 7. Similarly positively charged grid 5 will induce or allow flow of electrons from cathode 11 to anode 15, through passage 28. If grids 7 and 5 are charged sufficiently negatively then virtually all current flow through passages 25 and 28 will cease. The amount of electron flow can be controlled by the kind and degree of charges on the grids.

Now if grids 7 and 5 are negatively biased to stop flow of electrons through passages or channels 25 and 28 and if grids 7a and 5a are made positive (or less negative) with respect to the cathodes sufficiently to allow flow of electrons through passages 27 and 26, respectively, then electrons from cathode 10 will flow through passage 27 to anode 15 and electrons from cathode 11 will flow through passage 26 to anode 14. The strength of the currents can be regulated by the charges on the grids.

This device therefore can be made to function as an electronic double pole reversing switch the

currents through which may be regulated in both direction and strength. This furnishes a highly flexible relay or switching device for use in circuits generally.

The positive terminal of a common source of potential can be connected to anodes 14 and 15 through a load for each anode, the negative terminal of the source being connected to one of the leads of the joined cathodes. In this way fields can be established between cathode 10 and anode 14 and between cathode 10 and anode 15 and between cathode 11 and anode 15 and also between cathode 11 and anode 14.

Screens or grids 22 and 23 may be used if desired, in order to help separate the electrostatic fields. These may be grounded or charged in any desired way. Other screens may be placed at strategic points for similar purposes. The locations of the various grids and channels can be chosen in order to prevent least counteraction or interference between various fields. The cathodes may be spread over a considerable area in order to help prevent such interference. It is obvious that the cathodes might be separate and the anodes can be joined.

The grids can be charged in any desired combinations or sequence to produce a variety of connections and effects.

In case gas is enclosed in the chambers, a plurality of screens can be used adjacent the grids or other elements or passages in order to minimize spilling over of ions from one channel to another.

Separate anode potential sources joined at the common terminal, may be used.

Figure 7 shows a tube or switch substantially equivalent to that of Figure 1 except that the parallel-connected cathodes 10 and 11 have their leads sealed in cross partition 29a from which they project as shown. Leads 12 and 13 are led out of partition 29a and envelope 1 as indicated. A resistor similar to element 9 of Figure 1 can be included if desired. The other parts are used as previously described. This device has the advantage of large cross sectional area for each branch, relative to the construction of Figure 1.

Figure 8 shows a switch or electronic relay similar to that of Figure 7, connected in circuit, including a grid bias resistor. Anode 15 is connected to the positive terminal of battery or other potential source 30 the negative terminal of which is connected to lead 12 of the cathodes, through load L_1 and resistor 9. Grid 7 is connected to the load terminal of resistor 9. Battery or other current source 31 is connected to leads 12 and 13 and anode 14 is connected to the positive terminal of potential source 32 the negative terminal of which is connected to the cathodes through L_2.

Grid 5 may then be used to control the current through both loads since if it is biased positively or not sufficiently negatively with respect to cathode 10, current flowing through resistor 9 will bias grid 7 negatively to the point of cut off, if desired. Then, if grid 5 is made sufficiently negative to stop flow of current through load L_2, grid 7 will be positive or not sufficiently negative to prevent current flow through load L_1. Another resistor 9b, preferably equal to or greater than the resistance of element 9 may be included in the circuit as shown to distribute the current flow through the leads 12 and 13 properly. This device is equivalent to a single pole double throw switch.

Figure 9 shows a double pole double throw electronic switch or relay which is, in effect, the device of Figure 7 in duplicate. Partitions 2b and 29b divide the space into four chambers with the additional anodes 14a and 15a, and cathodes 10a and 11a, and grids 7a and 5a. The operation is essentially the same as before except the elements may be charged in duplicate or singly as desired.

In Figure 10 the double pole double throw electronic switch is for the same purpose as in Figure 9 except that the anodes are common to the two sides rather than the cathodes. The anodes 14—15 and 14a—15a serve also as partitions. The two devices of Figures 9 and 10 can be used for the same purpose in some cases and for different purposes, due to the different arrangements, in others. The anodes may be connected as shown, or separate.

In Figure 11 envelope 1 has inner somewhat radially disposed partitions 33, 34, and 35 sealed to the upper curved inner surface. These partitions are shown as stopping short of the cathode 40, but they can pass around the cathode and seal off separate chambers against the adjacent walls. In that case a portion of the cathode would be in each chamber A′, B′, C′, and D′. Anodes 36, 37, 38, and 39 with connected leads sealed in envelope 1 are provided for chambers A′, B′, C′, and D′ respectively. Grids 41, 42, 43, and 44 are likewise provided for chambers A′, B′, C′, and D′. These grids may be staggered as shown or placed in any suitable positions. The leads to grids 41 and 44 are sealed in envelope 1 as may be the leads for grids 42 and 43. These latter leads are shown, however, as being sealed in partitions 33 and 35 and brought out through the envelope. One cathode is shown extended to furnish electrons for each anode, but a plurality of cathodes can be used, either connected together or independent.

In operation, the anodes are made positive with respect to cathode 40 by means of a potential source, or sources with common negative terminal. One or more devices to be controlled, such as a relay, or input circuit for an amplifier, or other means, can be connected in series with each anode and the potential source or sources. A source of current is connected to the terminals of cathode 40. Then by charging grid 41, say, positively, and charging the other grids negatively, current conduction can be prevented in branches or chambers B′, C′, and D′ and anode 36 alone will be effectively in circuit. Now anode 36 can be cut out of circuit by charging grid 41 sufficiently negatively and anode 37 can be cut into circuit by making grid 42 positive or less negative with respect to cathode 40. Similarly, any branch can be put into or out of circuit by charging its grid properly. The branches can be connected consecutively or in any desired order or in any desired combination. This device serves as a multiple contact switch which can be used to distribute current to various circuits and at the same time to regulate the strength of current by controlling the charges on the grids.

Screens or shields 45, 46, and 47 may be used to assist in controlling the fields. These screens may be charged or grounded, or connected to cathode.

In case gas is enclosed in envelope 1 it would, for some purposes, be preferable to extend partitions 33, 34, and 35 to the bottom envelope, thus forming separately sealed chambers A′, B′, and C′ with cathode 40 passing through the partitions and entering each chamber; or a plurality of connected cathodes, one for each chamber, can be used. Again, it is apparent that a common anode and a plurality of separate cathodes can be used.

Figure 12 shows a device similar to that of Figure 10 with the addition among others of passages 48 and 49 in partition 2b, one on either side of anodes 14—15 and 14a—15a which can be connected or separate. Grid 49a with connected lead 51, is provided in passage 48. Similarly, grid 50 is placed in passage 49 and has lead 52 sealed in partition 2b and envelope 1. Lead 51 is likewise sealed in partition 2b and envelope 1.

Partition 2b may be enlarged in thickness near its mid point to form container 2c and in conjunction with insulating cross partition 2d, two small chambers containing respectively, filament 53 connected to anode 14—15, grid 54, and plate 55 connected to anode 14a—15a; and filament 53a connected to anode 14a—15a, grid 54a, and plate 55a connected to anode 14—15. The filaments and grids are provided with suitable leads, not shown brought out of the envelope through partition 2b similarly to lead 51.

In operation, if grid 49a is made negative with respect to grids 7 and 7a or with respect to filaments 11 and 11a which may be connected, then electrons from filament 11a will not pass through opening 48 to anode 14—15 and electrons from filament 11 will likewise not pass through opening 48 to reach anode 14a—15a. If, however, in conjunction with positively charged grids 7 and 7a grid 49a is made positive, then electrons from both cathodes 11 and 11a can reach both anodes 14—15 and 14a—15a; or grid 49a may be made positive with respect to grid 7 or cathode 11 so that electrons from that cathode will pass through opening 48 to reach anode 14a—15a and at the same time grid 49a can be made negative with respect to grid 7a or cathode 11a so that no electrons from cathode 11a will reach anode 14—15. It is assumed here that the anodes are connected or that the anodes are biased with respect to the proper cathode. At the same time, however, grid 7a can be positively charged with respect to filament or cathode 11a so that electrons from that cathode will reach anode 14a—15a which is suitably charged.

The same considerations hold for the elements on the opposite side of anodes 14—15 and 14a—15a. Grids 5, 5a, 7, and 7a may be placed in any desired positions relative to openings 48 and 49 or with relation to the cathodes or anodes. A positively charged grid is, in this description, considered as a grid not sufficiently negative to stop flow of electrons to the designated anode or electron receiver. A negatively charged grid is considered as a grid charged negatively to the point of cut-off.

Other combinations of charged elements can be employed.

If it is desired to connect anodes 14—15 and 14a—15a for the conventional passage of current from the former to the latter, then filament 53a will be energized to emit electrons and grid 54a can be used to control the electron flow from that filament to positively biased plate 55a and connected anode 14—15. Conversely, if current flow is desired from anode 14a—15a to anode 14—15, then filament 53 is energized and grid 54 can be charged to control electron flow to positively biased plate 55 connected with anode 14a—15a. If current flow in both directions is desired, either intermittently or constantly, both filaments can be energized and the electron flow in both directions can be controlled or stopped altogether. By the above described means the anodes can be electrically connected and disconnected very rapidly for any desired purpose such as for conditions in which a common potential source might be used, for switching operations, or for other circuit adaptations. Anodes or plates **55** and **55***a* may be positively charged with relation to the proper cathodes **53** or **53***a* by any suitable means.

Similar electronic bridging or connecting means can be placed between cathodes **11**—**11***a* or between cathodes **10**—**10***a* when it is desired to join them electrically, as for instance, in the device of Figure 1.

Openings **48** and **49** could be extended or placed near the cathodes so that electrons from one cathode could be attracted to the adjacent cathode through the openings, the flow being controlled by grids **49***a* and **50**. Small metal or graphite elements **56** and **56***a*, and **57** and **57***a* may be attached to cathodes **11**, **11***a*, **10**, and **10***a*, respectively, in order to receive electrons from the adjacent cathodes. These elements may be of such size and so positioned that they will receive the electrons in order to prevent cathode disintegration. Either cathode may be made positive with respect to the adjacent cathode by means of a battery or other potential source or an electronic switch similar to that shown for the anodes may be used for one or both pairs of cathodes in order to connect them rapidly either positively or negatively with respect to each other.

It is apparent that this electronic device furnishes switching or relay means of exceptional simplicity, flexibility, and versatility, and can be operated at great speed.

Many variations of detail and many combinations, sub-combinations and altered arrangements of the devices described, can be readily made without departing from the principles I have disclosed.

What I claim is:

1. An electron discharge device comprising, an envelope, crossed partition means forming four chambers; and a grid, an anode, and cathode in each chamber.

2. Same as in claim 1, said cathodes being connected in pairs.

3. Same as in claim 2, said cathodes being supported by one said partition.

4. An electron discharge device comprising, an envelope, crossed partitions within said envelope forming one pair of chambers and another pair of chambers, an anode in each said chamber, a cathode in each said chamber supported by one of said partitions, the cathodes for said one pair of chambers being electrically connected and the cathodes for said other pair of chambers being electrically connected and separate from the cathodes for said one pair of chambers.

5. Same as in claim 4, and including grid means for controlling electron flow in each said chamber.

6. An electron discharge device comprising, an envelope, an anode adjacent one end of said envelope, another anode adjacent the opposite end of said envelope, a partition intermediate said anodes forming two chambers within said envelope, a cathode for one said chamber supported by said partition, a cathode for the other said chamber supported by said partition, said cathodes being directly intermediate said anodes.

7. An electron discharge device comprising, an envelope, an anode adjacent one end of said envelope, another anode adjacent the opposite end of said envelope, a partition intermediate said anodes forming two chambers within said envelope, and cathode means for said chambers supported by said partition and in substantial alignment with an axis passing through said anodes and said partition.

8. An electron discharge device comprising, an envelope, an anode adjacent one end of said envelope, another anode adjacent the opposite end of said envelope, a partition intermediate said anodes forming two chambers within said envelope, cathode means for said chambers supported directly between said anodes, and a grid for each said chamber situated between said cathode means and the anode in said chamber.

9. An electron discharge device comprising, an envelope, an anode adjacent one end of said envelope, another anode adjacent the opposite end of said envelope, a partition substantially midway between said ends and forming two chambers within said envelope, cathode means supported by said partition directly between said anodes, and a grid for each said chamber situated between said cathode means and the anode associated with said grid.

10. An electron discharge device comprising, an envelope, a first anode adjacent a first end of said envelope, a second anode facing said first anode and adjacent the opposite end of said envelope, a third anode adjacent said first end, a fourth anode facing said third anode and adjacent said opposite end, partition means forming four chambers within said envelope, cathode means supported by said partition means and associated with said first and second anodes, other cathode means supported by said partition means and associated with said third and fourth anodes, and a plurality of grids to control electron flow in said chambers.

11. An electron discharge device comprising, an envelope, a first anode adjacent an end of said envelope, a second anode facing said first anode and adjacent the opposite end of said envelope, a third anode adjacent said first end, a fourth anode facing said third anode and adjacent said opposite end, partition means forming four chambers within said envelope, cathode means for said first and second anodes supported by said device directly between said anodes, other cathode means for said third and fourth anodes supported by said device directly between said third and fourth anodes, and a grid in each of said chambers for controlling electron flow therein.

12. An electron discharge device comprising, an envelope, a first anode within said envelope, a second anode within said envelope facing said first anode, a third anode within said envelope adjacent said first anode, a fourth anode within said envelope adjacent said second anode and facing said third anode, partition means forming four chambers within said envelope with one of said anodes in each chamber, cathode means for said first and second anodes supported by said device directly between said first and second anodes, other cathode means for said third and fourth anodes supported by said device directly between said third and fourth anodes, and a grid in each of a plurality of said chambers for controlling electron flow therein.

ALBERT G. THOMAS.

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1,592,075	Bruskin	July 13, 1926
1,684,104	Mavrogenis	Sept. 11, 1928
1,744,653	Loewe	Jan. 21, 1930
1,789,186	Mavrogenis	Jan. 13, 1931
1,916,408	Bol	July 4, 1933
2,047,959	Gebhard	July 21, 1936
2,094,470	Roberts	Sept. 28, 1937
2,190,515	Hahn	Feb. 13, 1940
2,198,317	Roberts	Apr. 23, 1940
2,203,249	Bohme	June 4, 1940
2,250,187	Schleimann-Jensen	July 22, 1941