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ELECTROIONIC RELAY AND ITS APPLICATION TO THE SCANNING

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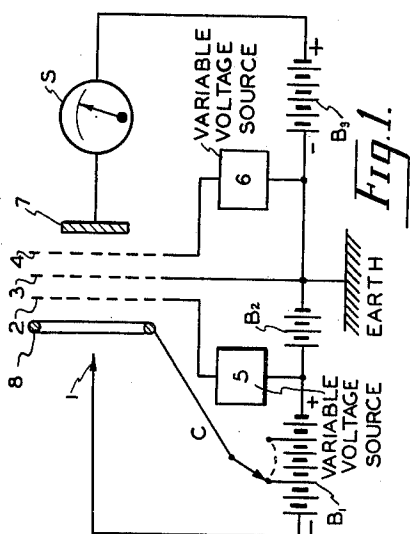


Fig. 1.

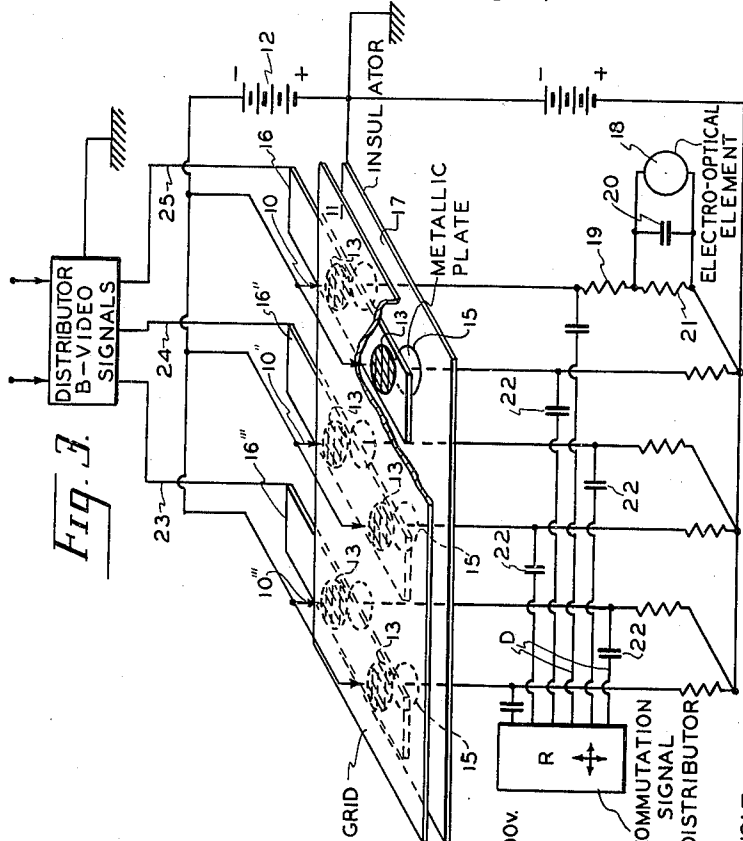


Fig. 3.

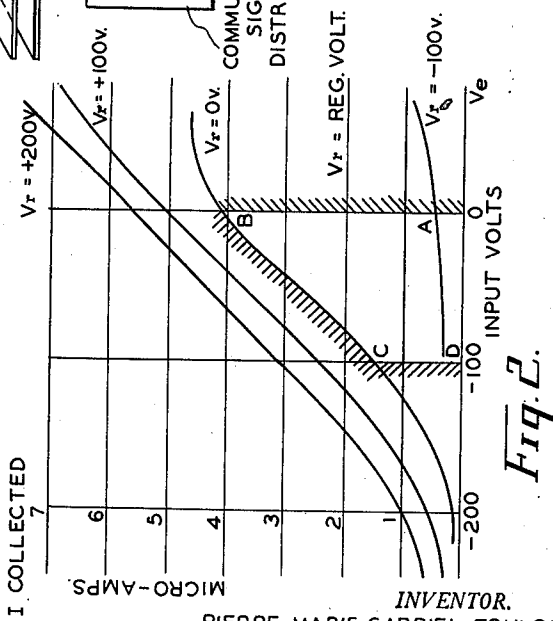


Fig. 2.

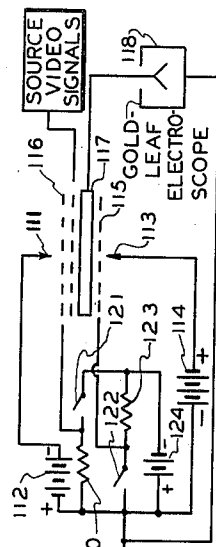


Fig. 4.

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ELECTROIONIC RELAY AND ITS APPLICATION TO THE SCANNING

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12 Claims. (Cl. 315-350)

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My invention relates to a new type of electroionic relay, the main characteristic of which is that it operates in the open atmosphere.

In accordance with one of its characteristic features the invention comprises a "point-electrode" placed opposite a collecting electrode and brought to a high voltage with respect to the latter. A discharge in the shape of a glow discharge takes place between the electrodes, in the neighbourhood of the point, the said discharge containing both positive and negative electrified particles. According to the polarity of the electrodes, the collecting plate will attract either the positive or the negative particles, thus determining the direction of flow of an electric current in an output circuit connected between those electrodes. By reversing the polarity of the latter, it is possible to reverse at will the direction of the current in the load circuit, and, by properly reducing the voltage between the electrodes, it is possible to cut off the current. Such a relay can, therefore, be used either as a rectifier or as an interrupting device.

My invention also relates to various forms of realisation of the above-described relay, which, if one or several control grids are added to its main electrodes, may either assume the function of an amplifier, or perform the duty of a coupling device interposed between two electric circuits for transmitting electric signals carried by one of the circuits to the other, this latter being independent of the former.

According to another modification, the relay may be made "tandem," or double comprising, for instance, two emitting electrodes or points with one collecting electrode only common to the two points.

According to another modification, the relay may have an electrode shaped as a ring surrounding the discharge current and placed in the neighbourhood of the point in order to stop or to release the discharge, or, in other terms, for blocking or unblocking the relay.

My invention also relates to the connections and settings which can be realised by means of the above outlined relay, to accomplish, for example, amplification of electric signals or their rectification, locking and unlocking of electric circuits associated therewith, unidirectional connection between two circuits, etc.

My invention also relates to the application of the above relay and its connections, for distributing incoming electric signals released successively through one and the same channel, between several receiving elements connected in multiple or

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parallel at the outlet of the said channel, the said element being thrown in operation successively on reception of signals, intended for them individually. In this respect my invention may be particularly useful for securing the distribution of television signals to the elements of a screen made out of a great number of such elementary components properly juxtaposed, so as to reproduce television pictures.

And lastly, my invention relates to various industrial applications of the above relays.

As they make use of the glow discharge, those relays can operate at atmospheric pressure. They do not, therefore, need a sealed enclosure, nor any seals, as are necessary for vacuum tubes. Therefrom results a considerable simplification of the wiring. The relays according to the invention can be mounted side by side and occupy a very small space. They can be assembled in groups, and easily dismantled.

A better understanding of my invention, of its objects and its embodiments, may be obtained by reference to the following figures of the drawings, which show representative instances of its applications and are of an illustrative but not a limitative character.

Fig. 1 illustrates the principle and the fundamental circuit diagram of a glow discharge relay;

Fig. 2 represents a characteristic curve of the same relay.

Fig. 3 illustrates the application of the glow discharge relay of Figure 1 to the scanning of a television screen;

Fig. 4 shows a relay in which the electrodes are disposed in "tandem," and, associated therewith, the circuits intended for operating an element of a television screen.

All the above figures are provided by way of example only, and are not intended to be limitative, and in order to exemplify the objects and the specific embodiments of my invention.

The basic principle of the relay lies in the control of a flux of electrified charges in the air, at atmospheric pressure. That flux is obtained by means of points carried at a high voltage, preferably negative.

When a sharp metallic point is carried to a high negative tension with respect to ground (for instance six thousand volts), it becomes covered with a glow (or corona) which gives birth to a flow of current through the air. That glow is particularly developed if a plane conductor is placed at a short distance from the point (5 mm. for instance), that conducting plate being connected between the positive pole of a source or

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voltage and ground. A glow discharge current may be observed, which may easily reach a magnitude of 50 or even 80 microamperes. The said current, issuing from the point and collected by the plate, can be controlled by means of metallic grids, maintained at appropriate voltages, and disposed along the trajectory of the electrified particles. The control thus obtained seems to have effect on both the electrons and the charged molecules or atoms constituting the current flow.

The grids are made out of very thin nickel wires ($\frac{5}{100}$ of mm. in diameter or so); the meshes are large in comparison with the diameter of the wire, but small, in absolute value (square meshes having for instance a dimension of 0.8 mm. by 0.8 mm.).

If several grids are placed in succession along the trajectory of the electrified flux, each one of them can exercise its control on the current collected by the plate.

Fig. 1 shows the general diagram of a relay of the type described, specially intended for television. 1 is a point carried to a negative high tension (-6000 volts) with reference to ground, by means of the battery B1. 2 is a first grid, the distance of which from the point amounts to about 5 mm. The voltage of the said grid may be varied by means of the additional variable voltage source 5. A polarisation battery B2 allows the selection of the most favorable condition of working. 3 is a second grid, connected to the ground and placed at a rather short distance from the first one (about 0.5 mm.). 4 is a third grid, also placed at a short distance from the second grid (about 0.5 mm.), and the mean voltage of which with regard to the ground can be varied by means of the source of variable voltage 6. 7 is a collecting plate, of about 5 mm. in diameter for instance, and placed at a short distance from the grid 4 (1 to 2 mm. for instance). The said plate is established at a rather high voltage with respect to ground (1000 to 2000 volts or so), by means of the battery B3. 8 is a ring surrounding the point 1 at a short distance (about 1 mm.) the voltage of which can be changed with regard to the said point by means of the commutator C.

Under those conditions, the current collected by the plate 7 is a function of the magnitudes of voltages supplied by both the variable outside voltage sources 5 and 6.

Fig. 2 shows the characteristic curves, plotted in static operation, of a relay of the above glow discharge type: they have for abscissae the volts V_e applied to the grid 2 with regard to the ground, and for ordinates the micro-amperes of current collected by the plate 7. Each one of the 3 curves V_r corresponds to a different value of the voltage of the grid 4 (V_g expressed in volts).

The grid 3, called a "stabilizing grid," plays an important part in the operation of the relay shown in Fig. 2. My experiments have shown that the grid 3 stabilizes and regulates the glow discharge issuing from the point, and improves considerably, from point of view of the proportionality of response, the response of the relay to the control voltage applied to the grid 4, interposed between the stabilizing grid 3 and the plate. The grid 3 offers also the advantage of increasing the sensitivity of the relay; an advantage which has been turned to account in Fig. 3 as will be explained hereinafter.

Although the above example refers to the application of a positive voltage to the plate and a

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negative voltage to the point, those polarities can be reversed, as the glow discharge includes both the positive and the negative charges; reversal of the polarities of point and plate, then, reverses direction of the current in the utilisation or load circuit of the system.

While the relay of my invention has a relatively small output and a limited efficiency, it offers the advantages of simple construction in a small space, and of exceptional simplicity of replacement and repair. It may find application in all sorts of electric installations intended for distributing electric signals between a very large number of receiving devices, connected in parallel on one common transmission channel; this latter being, either one cable, or one carrier wave. Such a condition is met with, especially, in television systems in which the picture is displayed on a large screen comprising a large number of electro-optical elements for converting video signals into optical impulses. Such a screen has been particularly described in my U. S. Patent No. 2,201,066, dated 1/7/37. All the component elements are connected in parallel to the same transmission line by means of relays which normally block their connections; and the distribution of the signals, coming through the transmission line in succession, is made by activating the respective relays, periodically, in a determined order of succession, such systems of television, the numbers of elements, and consequently the number of relays required, is necessarily very large, and for that reason the only type of relay which is suitable to such television systems is the relay arranged according to my invention. The mode of distribution of signals by means of relay activation has been described not only in the above mentioned U. S. patent, but also more recently in my applications Serial No. 102,062, filed 20.10.36, now abandoned, and No. 213,289, filed 11/6/38, now Patent No. 2,471,253.

For application of relays having the characteristics shown in Fig. 2, the only portion of the curve which should be utilised is the part comprised inside of the hatched lines ABCD, to which correspond for the plate an intensity of current nearly proportional to the voltage applied to the grid 2. Under those conditions V_r and V_e are comprised between 0 and -100 volts.

I have ascertained experimentally that the translation speed of the electric charges is rather high (about 300 meters per second), i. e. high enough to enable the second and third grids to exercise simultaneous control. The actual lapse of time between the passage of charge by the two grids amounts to a minimum of $\frac{1}{10,000}$ of a second in the relay under consideration. The time is variable as a function of the applied voltages, and of the distance between the grids.

For using the relay of Fig. 1 in television, the video signals are, for example, applied to the grid 2; and to the grid 4 are applied the activating impulses which enable the transmission of the said impulses to the utilisation circuits. On the plate 7 are collected the distributed signals, which are then stored in the capacity of an electrometer which represents the electro-optical element.

It is also possible to use a relay provided with only one control grid, and to apply the activating impulses to the plate. This latter solution, easier to realize than the former, has been adopted in the following examples.

The ring 8 exercises also control of the intensity of the glow discharge, but its action is

not so regular as the action of the grids 2 and 4. As long as the ring is carried to a potential negative enough, there is no appearance of a glow, and consequently no glow discharge current can be collected. On the contrary, if the potential difference between the point and the ring reaches a sufficient value, the glow makes a rather sudden appearance, and the point commences to deliver a discharge current. This characteristic of "locking" of the glow discharge current, can be utilised for reducing the dissipation of energy caused by the discharge current from the points, by putting into service only those points which are necessary at a given moment.

Fig. 3 shows the application of the above described glow discharge relays to the scanning of a television screen.

To that screen, shown in perspective are associated various points shown in 10', 10'', 10''', which correspond each to the relay point 1 of Fig. 1, and similarly give birth to respective glow discharges performing the same function as the glow discharge of Fig. 1. Those points of Fig. 3 are carried to a high negative voltage with regard to a grating or grid supporting plate 11, placed at short distance from points 10', 10'', 10'''. That grating corresponds to the stabilising grid 3 of Fig. 1 and is in the same way connected to ground. The voltage on the points 10', 10'', 10''' is obtained by means of the source of voltage 12. All the points are placed in one common plane and carried by one common support.

A short distance from the first grid or grating, between this latter and the plates 15, are placed the control grids 13 of each one of the relays, and behind those grids are placed the plates 15 through which flows the glow discharge current.

The grids of several relays are simultaneously carried to the same potential, which is common to the said relays. Therefrom results a great simplification of the wiring. In Fig. 3 the supports for grids 13 have been designated 16', 16'', 16'''. The plates 15 are all mounted on one common insulating plate 17. They receive through capacity the alternating voltage provided by the distributing device R, described briefly herebelow, which forms no part of the present invention. Each one of the plates 15 serves to supply an electro-optical element. On the Fig. 3 has been shown only one of them 18. Each one of the plates supplies current through an uncoupling resistance 19 connected in series with the electro-optical element. A capacity 20 and a resistance 21, parallel connected with the electro-optical element, extend the duration of the action exercised by the current on the element 18.

As can be seen in Figure 3, the use of the glow discharge relays offers a simpler solution than the use of high vacuum tubes. As the latter necessitate the production of sealed bulbs with independent terminals, they are considerably more complicated. Moreover, each one of the glow discharge devices occupies only an extremely small space: all of them may be placed exactly opposite to the electro-optical elements which they must operate. Thus is afforded a considerable simplification to the wiring. The cost of the points and of the grids is extremely low and their weight is negligible. The manufacturing cost can also be made very low; thanks to a series production which will be explained hereinafter.

The distributing device R, Fig. 3 is in the form of a generator producing successive voltage peaks, which are applied, by a system of lines D, to the

relays of the installation. The connections are made by means of capacitive couplings 22. The distributor and its operative characteristics in scanning in a multiple element receiver have been described in my co-pending U. S. application 213,289 filed February 6, 1938.

B, (Fig. 3) represents a high speed distributor, which receives the video signals transmitted from a distance, and distributes them successively via leads 23, 24, 25, to the supports 16', 16'', 16''' of the first line of relays. On account of the very high cadence of those signals, use is preferably made of a commutator without inertia, such as an electronic beam tube which will scan a series of the contacts (the number of which will be equal to, the number of the elements included in one line of the picture, namely 400 to 500).

The device shown in Fig. 3 works as follows:

The first signal, which corresponds to the first point of the picture, is switched by the high speed distributor B into the grids 13 of the support 16' and thus controls their potential during a certain time; that lapse of time may be lengthened by the effect of a capacity (not shown) introduced on the conductor 23. In the course of that time, the plate 15', the first one of the first line receives a positive voltage impulse from the distributor R. The glow discharge current starts at that moment and the amount of charge on the plate 15' is a function of the potential of the grid 13, so that the drop in voltage through the resistance 21, or in other terms the terminal voltage of the capacity 20 and the electro-optical element 18 becomes a function of the intensity of the first signal. Thus the electro-optical element corresponding to the first point reproduces the first signal, and this during a rather long time, due to the capacity 20 which lengthens the duration of its action; on the contrary the plate of the second line (or all the other plates if the number of the lines is larger) is left negative during all that time. It has, therefore, received no current from its glow discharge device. The voltage, varying in the course of time, which has been applied to the grid 13 has therefore had no effect on the said plate.

The same phenomenon is repeated, a very short time later on the arrival of the second signal, which corresponds to the second point of the picture; that signal, switched in turn by the high speed distributor B onto the grids 13 of the neighbouring support 16'', controls the potential of the said grids during a certain time. In the course of that time, the plate 15' (second plate of the first line) receives in turn a positive impulse. The second signal is thus "stored" by that plate and operates a second electro-optical element, (not shown in the figure). The process is repeated for each one of the elements up to the end of the first line of the picture. After the last element of the first line, it is the first element of the second line which is controlled, and the above phenomena repeat themselves. It must be observed that the various neighbouring plates 15', 15'', etc. of an horizontal line of the televised picture may simultaneously deliver current, since the duration of such release for each one of them may be nearly the same as the duration of the scanning of a line. It is easy to understand that all the elements composing the screen can be supplied simultaneously according to the above described process.

If one has to design a complete screen with the above described glow discharge relays, a cer-

tain difficulty is met with, due to the current consumed by the points. If each one of the points, for instance, should issue continuously a current of 80 microamperes, the 200,000 points of a picture would, in toto, represent a total intensity of 16 amperes at 6000 volts, i. e. a power of about 100 kw.

According to an improved form of realisation of my invention, (not illustrated) the output current of the successive rows of glow discharge devices is controlled by means of rings properly polarised and surrounding each one of the points, as already explained in connection with Fig. 1 (rings 8). In this way it becomes possible considerably to reduce the output of the high tension generator needed for the energy supply to the points. The voltages of the rings are, in the course of time, controlled in such a way that the glow discharge takes place only on the horizontal line which must release its current at the proper moment (or on a few neighbouring lines only). To this aim, the rings are supplied by means of voltages displaced in the course of time and provided by the distributor R.

Fig. 5 shows a further embodiment of the invention.

The two point electrodes 111 and 113 included in the device are connected to the oppositely polarized terminals of the high tension batteries 112 and 114, which provide them with opposite potentials with regard to ground. In the front of the point electrodes 111, 113, are disposed two grids 115 and 116, which correspond to the grids 13 of the Fig. 3, and between the two grids is interposed one sole plate 117 connected with the electro-optical element which is herein represented as a gold leaf electroscope 118. If it is necessary progressively to modulate the flux of the electrified charges as a function of the intensity of the televised point, it must be understood that another grid G must be added, and placed between the plate 117 and the grid 116 (as the equivalent grid 13 of the Fig. 3).

The battery 112 polarises the point 111 negatively with respect to the grid 116, the circuit including resistance 120. In series with resistance 120 are the switch 121 and the battery 124, connected as shown in the Fig. 5. To the grid negative terminal of battery 124 is connected the grid 115 through resistance 123, and between the grid 115 and ground is interposed the switch 122.

The device thus organised operates as follows:

When the switch 121 is open, the grid 116 and the plate 117 are at ground potential, provided, however, that the capacity of the electroscope 118 has no initial charge. As I have had the occasion of observing in my researches, when the stabilizing grid is at the same potential as the collecting electrode with respect to the point electrode, the whole of the flux (be it positive or negative) is attracted by the said grid and practically no current follows the path of the collecting electrode. At the precise instant of the arrival, however, of a signal intended for the electro-optical element 118, the switch 121 is closed. The closing of the switch 121 has for effect to impose, on the positive voltage of the grid 116 with reference to the point 111, a reduction in volts equal to the voltage of the battery 124; and this results in giving the plate 117 a positive potential higher than the grid potential with reference to the point electrode 115. Consequently, the plate now starts collecting the negative particles issued from the point electrode 115. At the same time, as the grid G has received the video signals, it so modulates the

discharge that a signal appears in the plate circuit and gives the condenser 118 a charge which is a function of the brightness of the corresponding image point. A negative charge with reference to the ground is now accumulated on the plate 117. And for enabling the plate to release the said charge in order that the electrometer may receive the video signal transmitted with the following image, the switch 122 is closed a short time before the arrival of the following video signal.

As long as the switch 121 remains open, the grid 115 is carried, on account of the battery 124, to a potential more negative than the plate 117 with reference to the point 113: no discharge therefore can reach the plate, the whole of the flux being then positive and attracted by the grid because it is more negative.

The closing of the switch 122 has for effect to ground the grid 115; and as the plate 117 is carried by the charge of the condenser 118 to a negative potential with reference to the ground, it collects the positive flux, which discharges the condenser 118. When the condenser is fully discharged and its discharge current has stopped, the plate is as the grid at the potential of the ground. The switch 122 must be opened only just before the arrival of the following signal intended for the same electrometer. The resistances 120 and 123 serve to stabilize the potential of their respective grids.

Lastly, my invention relates to the application of the relays of the above described types to the amplification of variable D. C. or A. C. electric currents, and more particularly the amplification of the telegraph and telephone currents. As the glow discharge devices have not a large output, there is advantage to dispose side by side, according to the invention, a large number of relays (for instance several hundred) which are parallel connected in order to be able to supply intensities of current convenient for an easy utilisation.

What I claim is as follows:

1. An electric discharge system, comprising, in a gaseous atmosphere substantially at atmospheric pressure, a sharp discharge member, an electric discharge pervious electrode located adjacent said sharp discharge member, means for maintaining a constant potential difference between said member and said electrode to establish a discharge of constant intensity, a discharge collector electrode for collecting discharge passing through said electric discharge pervious electrode, means for maintaining said collector electrode at a fixed potential with respect to said electric discharge pervious electrode, and a control electrode of controllable potential located intermediate said collector electrode and said discharge pervious electrode.

2. An electric discharge system, comprising, in a gaseous atmosphere, a sharp discharge member, an electric discharge pervious electrode located adjacent said sharp discharge member, means for maintaining a constant potential difference between said member and said electrode to establish a discharge of substantially constant intensity, a discharge collector electrode for collecting discharge passing through said electric discharge pervious electrode, means for maintaining said collector electrode at a fixed potential with respect to said electric discharge pervious electrode, and a control electrode of controllable potential located intermediate said col-

lector electrode and said discharge pervious electrode.

3. An electric discharge system, comprising, in a gaseous atmosphere, an elongated sharp discharge member, a ring shaped electrode located adjacent said sharp discharge member and having its axis co-axial with said elongated sharp discharge member, means for maintaining a constant potential difference between said ring shaped electrode and said sharp discharge member to establish a discharge of substantially constant intensity, a discharge collector electrode for collecting discharge passing through said ring shaped electrode, means for maintaining said collector electrode substantially at a fixed potential with respect to said electric discharge pervious electrode, a load circuit connected in series with said collector electrode, and a control electrode of controllable potential located intermediate said collector electrode and said ring shaped electrode.

4. An electric discharge system, comprising, in a gaseous atmosphere substantially at atmospheric pressure, a sharply pointed discharge member, a collecting electrode placed opposite said electrode, a plurality of grids disposed serially between said first mentioned electrodes in the trajectory of the glow discharge existing therebetween, and means for varying the potential of at least one of said grids in order to vary the intensity of said glow discharge at said collector electrode.

5. An electric discharge system, comprising, in a gaseous atmosphere substantially at atmospheric pressure, at least one sharply pointed electrode, a collecting electrode located opposite said sharply pointed electrode, and a ring shaped electrode arranged co-axial with and adjacent said sharply pointed electrode.

6. An electric discharge system, comprising, in a gaseous atmosphere substantially at atmospheric pressure, a sharply pointed electrode, a ring electrode substantially co-axial with and adjacent said sharply pointed electrode, means for impressing a constant potential difference between said electrodes to accomplish a glow discharge from said sharply pointed electrode, a discharge collector electrode, and a plurality of grids located intermediate said discharge collector electrode and said ring electrode for controlling the intensity of discharge collected by said collector electrode.

7. An electric discharge system, comprising, in a gaseous atmosphere substantially at atmospheric pressure, a discharge collecting electrode, a first sharply pointed glow discharge electrode located on one side of said collecting electrode, a further sharply pointed glow discharge member located on the other side of said collector electrode, means for maintaining a constant voltage difference between each of said glow discharge members and said collector electrode, and at least one control grid located on each side of said collector electrode intermediate said collector electrode and said sharply pointed discharge members.

8. An electric discharge system, comprising, in a gaseous atmosphere, a sharp glow discharge member, a discharge collecting electrode, means maintaining said electrodes at substantially a constant difference of potential, an output load circuit connected intermediate said electrodes, a plurality of control grids located intermediate said electrodes, means for maintaining one of said control grids at a constant potential inter-

mediate the potential between said electrodes, a source of signal to be amplified, and means for applying said signals to be amplified to the remaining one of said control grids.

9. An electric discharge device, comprising, in a gaseous atmosphere substantially at atmospheric pressure, a sharp discharge member, an electric discharge pervious electrode located adjacent said sharp discharge member, means for maintaining a constant potential difference of a first polarity between said member and said electrode to establish a discharge of constant intensity, a discharge collector electrode for collecting discharge passing through said electric discharge pervious electrode, means for maintaining said collector electrode at a fixed potential of said first mentioned polarity with respect to said electric discharge pervious electrode, a plurality of control electrodes located intermediate said electric discharge pervious electrode and said discharge collector electrode, and means for applying different control signals to each of said control electrodes.

10. An electric discharge system, comprising, in a gaseous atmosphere, a sharp discharge member, an electric discharge pervious electrode located adjacent said sharp discharge member, means for maintaining a constant potential difference of a first polarity between said member and said electrode to establish a discharge of constant intensity, a discharge collector electrode for collecting discharge passing through said electric discharge pervious electrode, means for maintaining said collector electrode at a fixed potential of said first sign with respect to said electric discharge pervious electrode, a further electric discharge pervious member located intermediate said first mentioned electric discharge pervious electrode and said collector electrode, means for maintaining said further discharge pervious electrode at a fixed difference of potential intermediate the potential of said first mentioned electric discharge pervious electrode and said collector electrode, a control electrode located intermediate said first mentioned electric discharge pervious electrode and said further electric discharge pervious electrode, means for maintaining said control electrode at a normal potential intermediate the potentials of said first mentioned electric discharge pervious electrode and said second further electric discharge pervious electrode, means for varying the potential of said first control electrode in response to a control signal, a second control electrode located intermediate said further electric discharge pervious electrode and said collector electrode, means for varying the potential of said further control electrode with respect to said further electric discharge pervious electrode comprising a source of signal voltage.

11. An electric discharge system comprising, in a gaseous atmosphere substantially at atmospheric pressure, a collection electrode, a first sharply pointed glow discharge member, a second sharply pointed glow discharge member, said collector electrode having oppositely disposed surfaces, said first discharge electrode located opposite one of said surfaces, said second discharge electrode located opposite the other of said surfaces, means for maintaining said discharge electrodes at potentials of constant and respectively opposite polarity with respect to said collector electrode, and means for independently controlling discharge between said discharge electrodes and said collector electrodes.

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12. An electric discharge system, comprising, a source of corona glow at atmospheric pressure, an electric charge pervious electrode located adjacent said source, means for establishing a constant flow of electricity between said glow and said electrode, said electricity at least in part penetrating said electrode, means for collecting said electricity after penetration of said electrode, and means for controlling the intensity of electric flow to said means for collecting, said last means comprising a control electrode.

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