April 13, 1954 S. KUCHINSKY 2,675,500

QUANTIZING BIAS INSERTION CIRCUIT

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FIG. I.

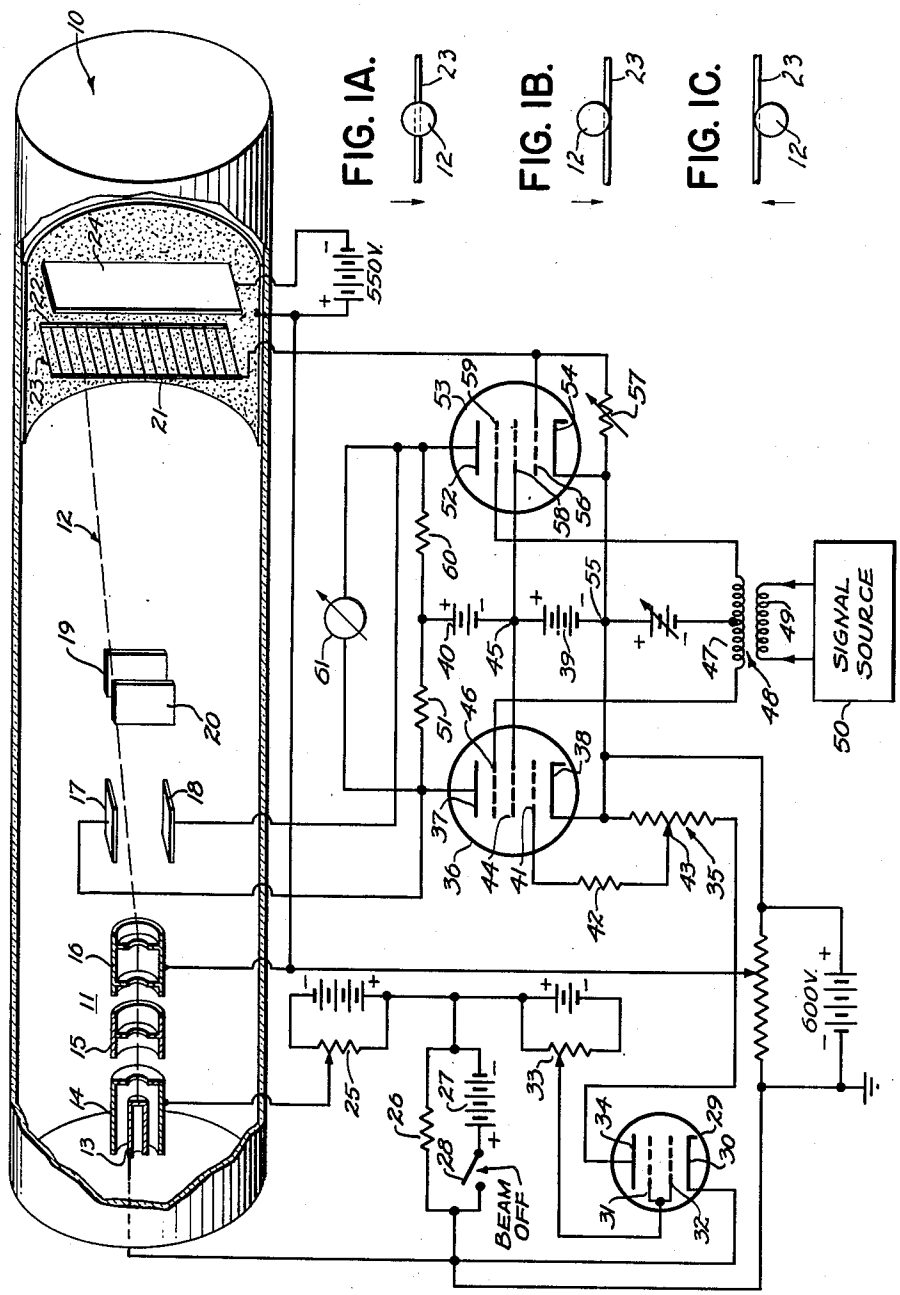


FIG. IA.

FIG. IB.

FIG. IC.

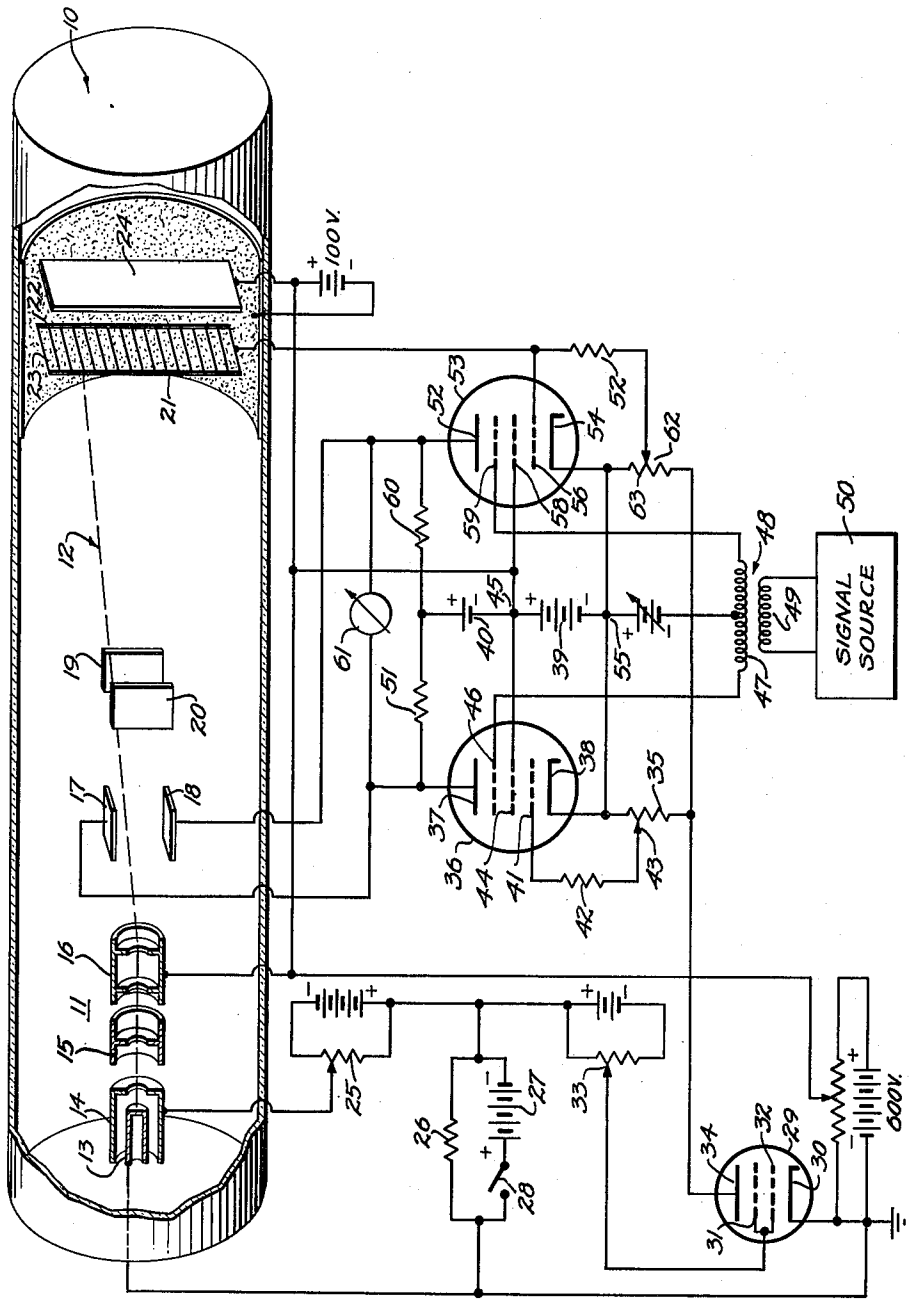
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FIG. 2.



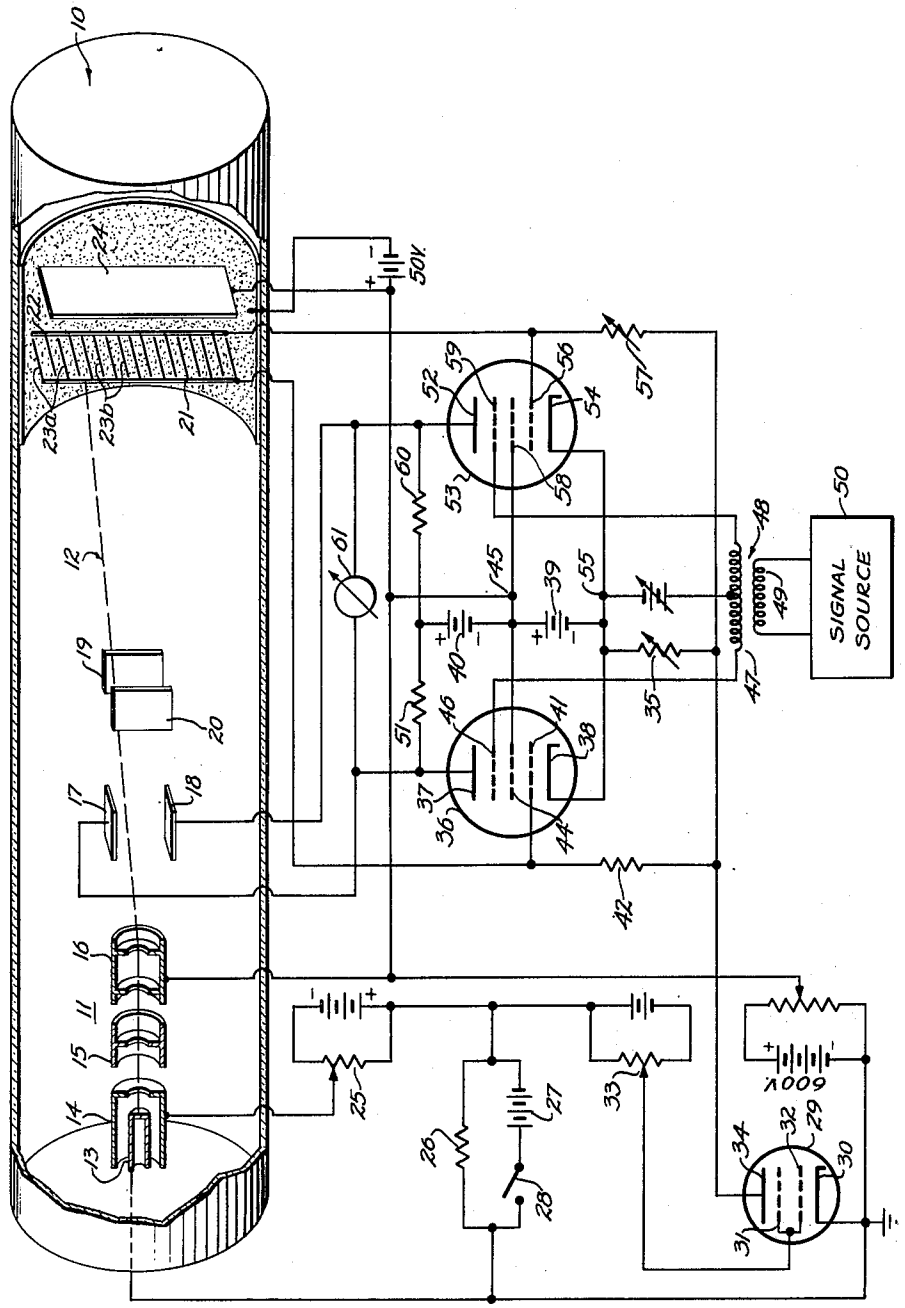
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Filed Feb. 11, 1952 3 Sheets-Sheet 3

FIG. 3.



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UNITED STATES PATENT OFFICE

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QUANTIZING BIAS INSERTION CIRCUIT

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Application February 11, 1952, Serial No. 270,946

11 Claims. (Cl. 315—21)

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This invention relates to voltage sampling systems and more especially to such systems employing cathode ray tubes.

The invention is in the nature of an improvement on the type of voltage sampling system disclosed in application Ser. No. 80,694, filed March 8, 1949, and issued as Letters Patent No. 2,564,908. There is disclosed in said patent an arrangement for sampling the voltage of a rapidly varying input signal by employing a special dual input holding circuit for the cathode ray beam. That dual circuit requires the use of two separate holding grids which are differentially excited by the primary electrons of the beam so as to produce a resultant beam holding voltage. This voltage which is derived directly from the beam, is fed back through respective amplifiers so as to hold the beam at the sampled deflected position. One of the requirements for proper operation of the prior arrangement is that two separate feed-back tubes are required, and both tubes must receive primary electron current from the beam in order to produce the differential holding voltage which is fed back to the respective beam deflecting plates. That may require a very precise adjustment of the various voltages, of the beam cross-section, beam intensity and a symmetric relation between the beam and both holding grids and their respective grid openings.

Accordingly, one of the principal objects of the present invention is to provide a voltage sampling arrangement using a deflectable cathode ray beam, wherein the beam can be accurately held at the sampling position by a single holding grid, and with a single grid wire or lateral for each such position. In other words, the feed-back circuit utilizes the primary beam current and a single input feed-back circuit.

Another object is to provide improved beam holding arrangements for voltage sampling systems of the cathode ray tube kind, which arrangements are simple to operate and exhibit a high degree of beam holding efficiency, rendering them more effective for such uses as pulse counting, direction finders, direct current regulators and the like.

A feature of the invention relates to a voltage sampling system employing cathode ray sampling, and wherein the sampling can be effected without presampling or without removing the voltage to be sampled.

A further feature relates to the novel organization, arrangement and relative locations and interconnections of parts which cooperate to provide an improved voltage sampling system.

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Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing which represents, by way of examples, certain preferred embodiments,

Fig. 1 is a schematic diagram of a voltage sampling system according to the invention.

Figs. 1*a*, 1*b*, and 1*c* are diagrams explanatory of various operating conditions of the system of Fig. 1.

Fig. 2 is a modifications of Fig. 1.

Fig. 3 is another modifications of Fig. 1.

Referring to Fig. 1, the numeral **10** represents any well known form of evacuated enclosing envelope, such as is used in the construction of cathode ray tubes. Mounted within the tube at one end thereof is a conventional electron gun **11** for developing a focused beam **12** of electrons. As is well known, such a gun includes an electron emitting cathode **13**, for emitting primary electrons, a beam intensity control grid **14**, and a beam accelerating and beam focusing system comprising, for example, first and second anodes **15**, **16**. It will be understood, of course, that any other well known beam accelerating and focusing arrangements can be used. The beam **12** passes between a pair of deflector plates **17**, **18** for deflecting it vertically, that is, in a plane parallel to the plane of the drawing, and, if desired, an additional pair of deflector plates **19**, **20** may be provided for controlling the position of the beam in a plane perpendicular to the drawing.

Suitably mounted at the opposite end of the tube is a ladder-like grid which may consist of a pair of metal side rods **21**, **22** between which extend the various parallel and equally spaced grid laterals **23**, one of which is shown in cross-section in Figs. 1*a*, 1*b*, and 1*c*, and there being one such lateral for each sampling position of the beam and at which the beam is to be held during sampling, as will be described hereinbelow. If desired, a plate electrode **24** is mounted in spaced relation to the holding grid on the side opposite that facing the gun and this plate electrode can be given a small positive bias, for example 50 volts, with respect to the cathode **13**. If desired, a target electrode may be mounted to replace the electrode **24**, and this target electrode may be coated with fluorescent material so as to give a visual indication of the held position of the beam. Alternatively a series of such target electrodes may be provided, one for each grid lateral, and each such target electrode may be connected to a corresponding signaling output circuit.

In accordance with the well known operation of a cathode ray tube, the beam 12 will be deflected in a plane parallel to the drawing, by varying the potential difference between the deflector plates 17, 18. If this potential difference is a fluctuating or alternating signal voltage to be sampled, the beam will change its deflected position instantaneously to correspond with that voltage. In many cases, however, it is desirable to be able to hold the beam at the particular deflected position corresponding to the value of the voltage at the instant of sampling. Thus, there is disclosed in said U. S. Letters Patent an arrangement for effecting such beam holding. However, the system of the said patent requires for the holding function a pair of beam holding grids and corresponding amplifiers to whose input circuits the respective holding grids are connected. The holding action is effected according to the present invention by employing a single holding grid and by using the primary electron beam current intercepted by the wires of the grid to control a single multi-grid tube.

The various potentials for the electrodes of the tube 10 can be derived from any well known direct current power supply, which for convenience is shown in the drawing by the various batteries. The cathode 13 is returned to the control grid 14 through a beam intensity control potentiometer 25 which is connected to the power supply so as to be able to vary the beam intensity. This return circuit also includes a parallel path one leg of which is comprised of a resistor 26, and the other leg of which is comprised of the direct current potential 27 poled as shown, and also the on-off micro-switch 28. When the switch 28 is closed to the "beam off" position, sufficient negative bias is applied to the control grid 14, to completely cut off the beam 12. However, when switch 28 is open, the grid 14 is biased so that the beam 12 is on and impinges on the holding grid.

A grid controlled tube 29 is provided, the cathode of which is connected directly to cathode 13, while the dual control grids 31, 32 are directly connected and both these grids are connected through a bias potentiometer 33 poled, as shown. A cathode load resistor is provided for another grid controlled tube 36 which has its anode 37 positively biased with respect to its cathode 38 by means of the direct current potentials 39, 40. The control grid 41 is connected through the grid resistor 42 to the adjustable bias potentiometer contact 43 by means of which the normal space current between cathode 38 and anode 37 can be adjusted to a predetermined value. Thus, the bias on grid 41 is a function not only of the plate current of tube 36 but also of tube 29. In other words, the resistor 35 and the plate-to-cathode circuit of tube 29 may be considered as a composite voltage divider.

Tube 36 is of the multi-grid kind, such as is known in the art as a triple grid tube. The three grids are successively traversed by the electrons passing from the cathode to the anode. The second grid 44 may be connected to the positive potential point 45 so as to cause it to act as a shield grid. The third grid 46 is arranged to act as a second control grid and is connected to one end of the secondary winding 47 of a signal input transformer 48. The primary winding 49 is connected to the source 50 whose voltages are to be sampled.

The anode 37 is connected to the power supply through a load resistor 51 and it is also connected to the beam deflector 17. Thus, the potential applied to deflector 17 is a function of the instantaneous voltage appearing at anode 37 which in turn is dependent on the normal bias on the first control grid 41 and the voltage on grid 44 from the signal source 50. The other beam deflector 18 is connected to the anode 52 of another triple grid tube 53 similar to tube 36. The cathode 54 is connected to the negative terminal 55 of the power supply, and the first control grid 56 is returned to the cathode through an adjustable resistor 57 which is also connected to the beam holding grid. Thus, the negative potential of grid 56 is a function of the intensity of the electron beam as it strikes a grid lateral and also a function of the amount of intercept between the beam and the lateral as indicated, for example, in Figs. 1*a*, 1*b*, and 1*c*. The second grid 58 is positively biased to act as a shield grid, and the third grid 59 is connected to the opposite end of secondary winding 49 from that to which the grid 46 is connected. In other words, the input voltages to be sampled are applied to the second control grids 46 and 59 in balanced or push-pull relation. Furthermore, the anode 52 is connected to the power supply through a load resistor 60 similar to resistor 51.

The operation of the system to sample is along the following lines. The signal input source 50 is continuously connected to the grids 46, 59. As long as micro-switch 28 is closed, the grid 14 and the grids 31, 32 are biased to cut-off and no plate current flows through tube 29. The grids 41 and 56 are at zero bias, therefore the monitoring meter 61 which may be a vacuum tube voltmeter will vary its indication to correspond with the signal voltages from source 50.

Should it be desired to produce a steady indication of the voltage at any given sampling instant without regard to the fact that the signal from source 50 may be varying in amplitude in either direction with respect to zero or some other predetermined base potential, the micro-switch 28 is opened. This causes the beam 12 and also the plate current of tube 29 to be switched on. This results in an average bias being applied to grid 41 which, in turn, causes the potential drop across resistor 51 to place the anode 37 at the average potential of anode 52 over its entire range. It should be noted that since the signal from source 50 is alternating or fluctuating, the potential at anode 52 assumes an average potential which is a function of the amount of intercept of that beam with the particular grid lateral it strikes at the instant of sampling. As an illustration, assume that the signal at the secondary winding 47 varies from 10 volts positive, to 10 volts negative. Then, by suitable choice of values for the various circuit components, the plate current of tube 36 will be such as to maintain the beam 12 at its uppermost position where it strikes the first or top grid lateral, assuming at that instant that the grid 46 is at the limit of its negative swing of 10 volts. The beam electrons which are intercepted by the grid lateral correspondingly increase the negative bias on grid 56 and tend to decrease the plate current of tube 53, but since at this instant grid 59 is positive, the potential at plate 52 is at its lowest value, as is also the deflector 18. Should the beam start to move downwardly away from the first grid lateral, the amount of intercept between the beam and that lateral will decrease as is evident from Fig. 1*a*, then the negative bias on grid 56 likewise decreases and results in a corresponding drop in potential of anode 52 which causes the

beam to move back upwardly in the direction of the dotted arrow (Fig. 1a) until the average potential at anode 52 remains such as just to maintain the beam centered on the top grid lateral. This holding condition of the beam remains stable as long as the micro-switch 28 is open.

A similar action takes place no matter at which grid lateral the beam finds itself at the instant of sampling, and it is independent of the direction of change of the signal before the sampling instant. In other words, the electron holding current applied to grid 56 is capable of holding the beam at the particular grid lateral at which it appears at the instant of sampling regardless of the direction from which the beam has approached the said lateral at the sampling instant.

It should be noted that while the holding grid is connected only to tube 53, the tube 36 controls the necessary insertion of the beam intensity control bias so as to minimize the effect of the signal swing on grid 46 to a point where the potential variation at anode 37 from its desired average holding voltage is small enough to be more than compensated by the beam holding action of tube 53. This is one of the distinct advantages of the invention since it does not require the signal input from source 50 to be removed or pre-sampled prior to opening switch 28.

Furthermore, while the holding feed-back is a function primarily of the amount of intercept between the beam and the grid lateral, if this amount is increasing with the beam "above" the lateral, and approaching it in the direction of the full line arrow (Fig. 1b), the action of tube 53 by the resultant increase in negative bias on grid 56 is to increase the positive potential on deflector 18, thus insuring that the beam continues to move downwardly until it reaches the central or stable holding relation with respect to the lateral. On the other hand, if the signal input is such at the instant of sampling, as to swing the grid 46 positively, that is, the beam is approaching the lateral in the direction shown in Fig 1c, the increased plate current of tube 36 resulting from the increasing intercept between beam and lateral increases the negative bias on grid 41. Thus, the beam is constrained to continue its upward movement until it reaches the center or stable holding intercept with the grid lateral. In that condition the holding system is in equilibrium and the beam stays in contact with the grid lateral.

Referring to Fig. 2, there is shown a system similar to that of Fig. 1 except that instead of controlling the tube 53 by negative or primary or electron current from the holding grid, it is controlled by positive or secondary electron current from the holding grid. The parts of Fig. 2, which are the same as those of Fig. 1, bear the same designation numerals. In Fig. 2 the electrode 24, instead of being biased positive, for example 50 volts, with respect to the cathode, is held at the same potential as the second anode so that when the primary electrons of the beam strike the holding grid laterals they release secondary electrons. If desired, the surface of the grid laterals may be coated with high efficiency secondary electron emission material as is well known in the art. Therefore, the holding grid lateral assumes a positive potential and the grid 56, instead of receiving a negative current by the beam intercept, receives a positive current. The operation of holding is similar to that described for Fig. 1. However, the grid 56, instead of being returned through resistor 57 directly to the cathode 54, as in Fig. 1, is returned to the adjustable contact 62 of a bias potentiometer 63 connected in the cathode load circuit of tube 53. This resistor is connected to the anode 34 of tube 29 to provide the desired grid bias for grid 56. When the beam 12 is not impinging on a grid lateral, that is, with no positive current flowing to grid 56 from the holding grid, the contact 62 can be adjusted to bias the tube 53 to cut-off. Therefore, when the beam impinges on a lateral at the sampling instant, it reduces the negative bias on grid 56. In other words, whereas in Fig. 1 the tube 53 has a normal average anode potential which is reduced by applying a negative electron current to grid 56, in Fig. 2 the tube 53 has a normal average anode potential which is reduced when the positive electron current flows to the grid 56. The holding operation is, therefore, the same as that described for Fig. 1.

Certain of the beam holding features above described are not limited to tubes having a single holding grid. Thus, there is shown in Fig. 3 a cathode ray tube similar to the tube of Fig. 2, with the exception that instead of using a single set of grid laterals all connected to the #1 control grid of tube 53, two sets of grid laterals are employed. Thus, one set of grid laterals 23a can be attached to a side rod 21, and a second set can be attached to the other side rod 22, with the respective laterals arranged in interspersed relation so that the two sets of laterals are insulated from one another. If desired, two separate grids, like the holding grid of Fig. 2, may be mounted in closely spaced parallel relation and with the laterals of one grid located midway between the laterals of the other grid. The parts of Fig. 3, which are the same as corresponding parts of Fig. 2, bear the same designation numerals. The anode 24 is connected to the same positive potential as the second anode 16 of the electron gun, and the grid laterals 23a and 23b can be coated or can be of a suitable metal or alloy so as to be efficient emitters of secondary electrons when struck by primary electrons from the beam 12. The beam holding action of Fig. 3 is similar to that of Fig. 2, except that the cathode load resistor 35 is connected in common between the cathodes 38 and 54, and the anode 34 of tube 29, so that, when the beam 12 is not impinging on any grid laterals, both tubes 36 and 53 are biased to cut-off.

Assume, for example, that at the instant of opening of switch 28, the beam 12 finds itself impinging on the first or top lateral 23a. Since both tubes 36 and 53 had been previously adjusted to plate current cut-off when the beam is off (or when it is not striking a lateral), when it does strike the lateral 23a, positive current flows to the control grid 41, thus tending to increase the plate current of that tube and lower its anode potential. This causes a drop in the potential of the deflector 17 and the beam tends to move downwardly until it strikes the next lateral 23b. The potential of deflector 17, therefore, again rises while the potential of anode 52 drops, thus causing the beam to move back upwardly towards lateral 23a. Therefore, the beam finally assumes a stabilized holding position where its intercept with lateral 23a and its intercept with lateral 23b prevents it moving beyond the holding area between the two adjacent laterals.

While certain preferred embodiments have been described, it will be understood that various changes and modifications may be made therein

without departing from the spirit and scope of the invention.

What is claimed is:

1. A beam holding arrangement for the beam of a cathode ray tube, comprising means to develop a beam of focused electrons, a single beam holding electrode on which said beam is arranged to impinge and having a series of spaced conductors one for each holding position of the beam, a pair of beam deflectors, a pair of grid-controlled tubes each having first and second input circuits and each having an output circuit, a source of variable voltage, means connecting said source in opposed balanced relation to the first input circuit of each of said pair of tubes, means connecting the said holding grid to only the second input circuit of one tube of said pair, a third grid control tube, and means connecting the second input circuit of the other tube of said pair to the anode-cathode circuit of said third tube.

2. A beam holding arrangement according to claim 1, in which means are provided for maintaining said third tube and said electron beam at cut-off except when said beam is to be held at a position determined by the instantaneous value of said variable voltage.

3. A beam holding arrangement according to claim 1, in which the first input circuit for said other tube of said pair has a control grid which is returned to an adjustable connection on a voltage divider, which divider is constituted in part of the anode-cathode resistance of said third tube.

4. A beam holding arrangement according to claim 1, in which the first input circuit of said other tube of said pair has a control grid which is returned to an adjustable connection on a voltage divider which divider is constituted in part of the anode-cathode resistance to said third tube and the cathode load resistance of said other tube of said pair.

5. A voltage sampling system comprising means to develop a beam of electrons, a pair of beam deflectors for shifting the beam trajectory, a pair of beam holding electrodes upon which the beam impinges and providing a series of similar spaced elements each corresponding to a particular position at which the beam is to be held for sampling, a first grid controlled tube, a second grid controlled tube, a third grid controlled tube, means connecting the output electrodes of said first and second tubes to respective deflector elements, each of said first and second tubes having first and second control grids, means connecting one holding electrode to the first control grid of the first tube, means connecting the other holding grid to the first control electrode of the second tube, a source of variable voltage to be sampled connected in opposed balanced relation to the second control grids of the first and second tubes, the cathodes of the first and second tubes being connected to a common cathode load resistor, and means connecting the first control grids of the first and second tubes to the plate-to-cathode circuit of said third tube.

6. A voltage sampling system comprising means to develop a beam of electrons, a pair of beam deflectors for shifting the beam trajectory, a beam holding electrode upon which the beam impinges and having a series of similar spaced elements, each corresponding to a particular position at which the beam is to be held for sampling, a first grid controlled tube, a second grid controlled tube, a third grid controlled tube, means connecting the output electrodes of said first and second tubes to respective deflector elements, means to control the output of the first tube by the primary beam electrodes impinging on the spaced elements of said holding electrode, means to control the output of said second tube by the internal resistance of said third tube, each of said first and second tubes having first and second control grids, means connecting the first control grid of the first tube to said holding electrode, means connecting the first control grid of the second tube to the plate-to-cathode circuit of said third tube, and means connecting a source of voltage to be sampled in balanced relation to the second control grids of said first and second tubes.

7. A voltage sampling system comprising means to develop a beam of electrons, a pair of beam deflectors for shifting the beam trajectory, a beam holding electrode upon which the beam impinges and having a series of similar spaced elements, each corresponding to a particular position at which the beam is to be held for sampling, a first grid controlled tube, a second grid controlled tube, a third grid controlled tube, means connecting the output electrodes of said first and second tubes to respective deflector elements, means to control the output of the first tube by the primary beam electrodes impinging on the spaced elements of said holding electrode, means to control the output of said second tube by the internal resistance of said third tube, the control grid of the first tube being connected to said holding electrode, and the control grid of the second tube being returned to the cathode thereof through a cathode load which is connected in series with the plate-to-cathode circuit of said third tube.

8. A voltage sampling system comprising means to develop a beam of electrons, a pair of beam deflectors for shifting the beam trajectory, a beam holding electrode upon which the beam impinges and having a series of similar spaced elements, each corresponding to a particular position at which the beam is to be held for sampling, a first grid controlled tube, a second grid controlled tube, a third grid controlled tube, means connecting the output electrodes of said first and second tubes to respective deflector elements, means to control the output of the first tube by the primary beam electrodes impinging on the spaced elements of said holding electrode, means to control the output of said second tube by the internal resistance of said third tube, said holding electrode comprising a wire grid having a series of spaced grid laterals, all connected to the control grid of the first tube to cause the plate voltage of said first tube to be controlled by the amount of intercept between the beam cross section and any selected grid lateral.

9. A voltage sampling system comprising means to develop a beam of electrons, a pair of beam deflectors for shifting the beam trajectory, a beam holding electrode upon which the beam impinges and having a series of similar spaced elements, each corresponding to a particular position at which the beam is to be held for sampling, a first grid controlled tube, a second grid controlled tube, a third grid controlled tube, means connecting the output electrodes of said first and second tubes to respective deflector elements, means to control the output of the first tube by the primary beam electrodes impinging on the spaced elements of said holding electrode, means to control the output of said sec-

ond tube by the internal resistance of said third tube, the control grid of the first tube being connected to said holding electrode, and the control grid of the second tube being returned to the cathode thereof through a resistor which is connected in series with the plate-to-cathode circuit of said third tube, and means for biasing said third tube to plate current cut-off except when a voltage is being sampled.

10. A voltage sampling system according to claim 9, in which means are provided for cutting off said electron beam as well as biasing said third tube to cut-off except when a voltage is being sampled.

11. A voltage sampling system comprising means to develop a beam of electrons, a pair of beam deflectors for shifting the beam trajectory, a beam holding electrode upon which the beam impinges and having a series of similar spaced elements, each corresponding to a particular position at which the beam is to be held for sampling, a first grid controlled tube, a second grid controlled tube, a third grid controlled tube, means connecting the output electrodes of said first and second tubes to respective deflector elements, means to control the output of the first tube by the primary beam electrodes

impinging on the spaced elements of said holding electrode, means to control the output of said second tube by the internal resistance of said third tube, said beam holding electrode having a surface for emitting a copious supply of secondary electrons when struck by said beam, said first grid controlled tube being biased to plate current cut-off when the said electron beam is not impinging on said holding electrode, a second grid controlled tube, a third grid controlled tube, means connecting the output electrodes of said first and second tubes to respective deflector elements, means to control the output of the first tube by the secondary electron emission from said holding electrode, and means to control the output of said second tube by the internal resistance of said third tube.

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