June 16, 1959 R. M. WALKER 2,891,153

ELECTRO-STATIC SWITCHING APPARATUS

Filed Oct. 21, 1955 2 Sheets-Sheet 1

Fig. 1.

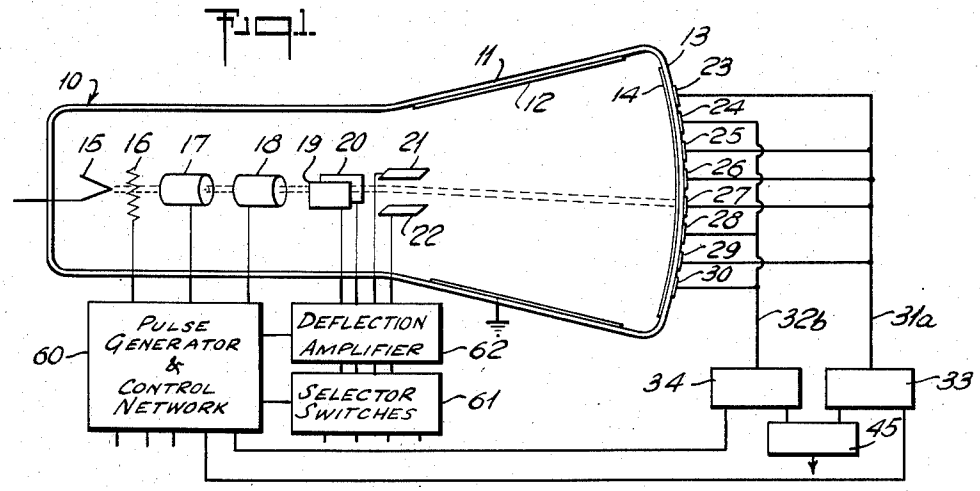
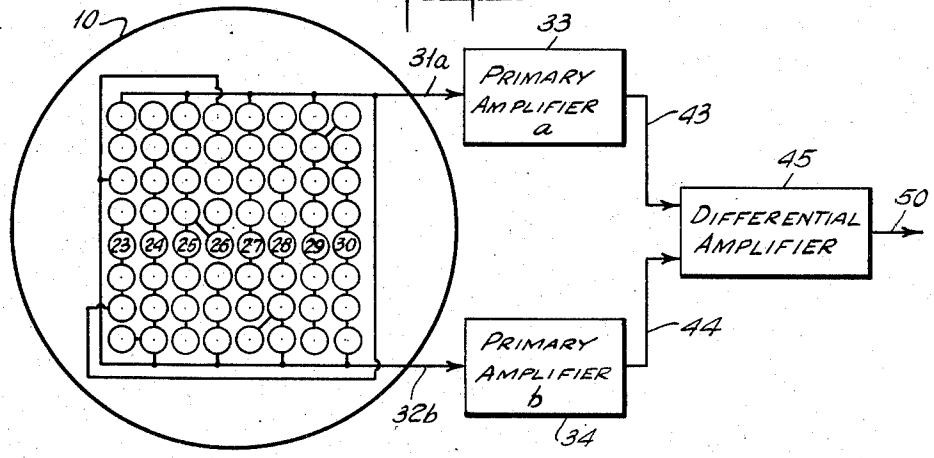


Fig. 2.



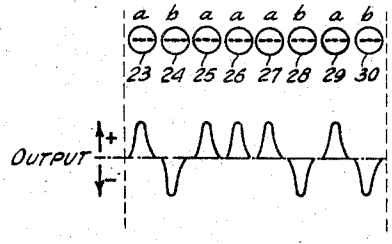


Fig. 3.

INVENTOR.
ROBERT M. WALKER

BY

Van Deventer & Shively,
ATTORNEYS

June 16, 1959 R. M. WALKER 2,891,153

ELECTRO-STATIC SWITCHING APPARATUS

Filed Oct. 21, 1955 2 Sheets-Sheet 2

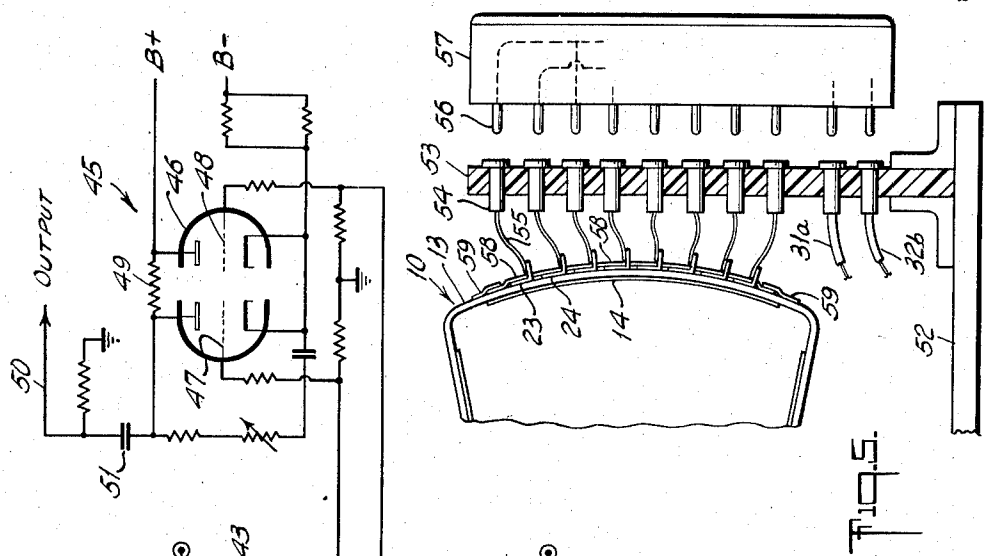


FIG. 5.

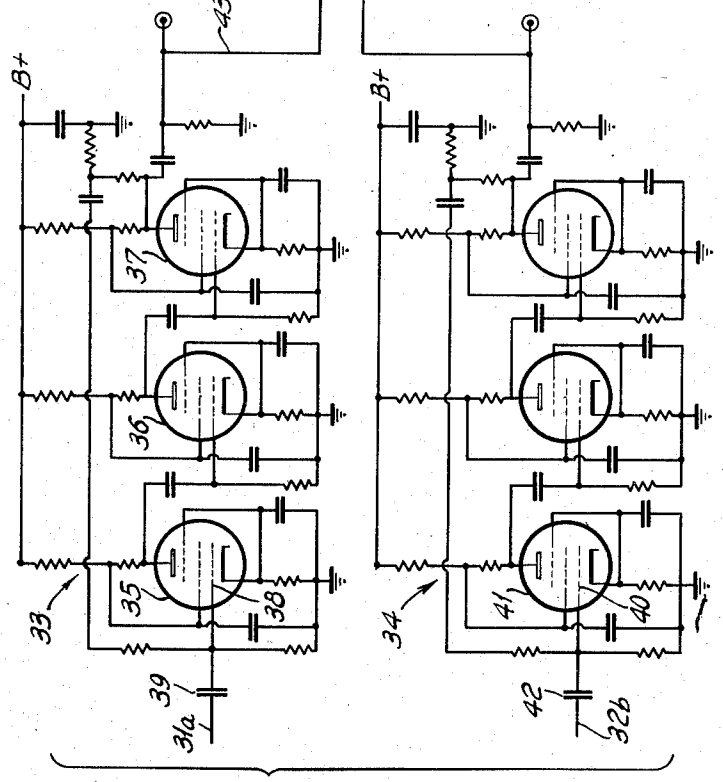


FIG. 4.

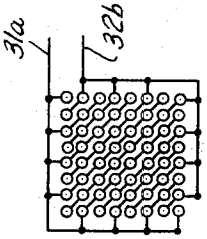


FIG. 6.

INVENTOR.
ROBERT M. WALKER
BY
Van Deventer & Shively,
ATTORNEYS

United States Patent Office 2,891,153
Patented June 16, 1959

2,891,153

ELECTRO-STATIC SWITCHING APPARATUS

Robert M. Walker, Closter, N.J., assignor to International Business Machines Corporation, a corporation of New York

Application October 21, 1955, Serial No. 541,922

1 Claim. (Cl. 250—27)

The present invention pertains to improvements in electro-static switching apparatus.

An object of the invention is to provide an improved electro-static table look-up system for generating generalized switching functions in large numbers of variables.

A further object of the invention is to provide electrostatic function switching means adapted to give improved distinction between read-out signals derived from electron bombardments directed by differing input combinations.

A further object is to provide apparatus of the above nature for use in devices employed in automation control systems and the like, and wherein the output signals representative of two differing input combinations may be of maximum amplitude but of opposite polarity.

A further object is to provide apparatus of the above type adapted to establish simultaneous individual amplifications of signals derived from previously selected and unselected target areas of a cathode ray tube, while differentially combining the two amplified pulses to produce a single output pulse of distinctive character.

Another object is to provide apparatus of the above nature in which the output signals may be picked up from two separate but inter-related systems of backing electrodes disposed on the outer face of the cathode ray tube, performing the above noted advantageous functions without the necessity for complicated structures within the tube.

A further object is to provide apparatus of the above nature which is readily adaptable to various special functional processes.

Other objects and advantages of the invention will become evident during the course of the following description in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic longitudinal view of a cathode ray tube suitable for use in the invention;

Figure 2 is a block diagram illustrating a preferred arrangement of main components of the system;

Figure 3 illustrates the outputs from a typical row of the pick-up electrodes shown in Fig. 2;

Figure 4 is a circuit diagram of a typical arrangement of the primary signal and differential amplifiers;

Figure 5 illustrates a pluggable form of the pick-up electrode connections by which various optional arrangements may readily be set up for different functional requirements, and

Figure 6 shows one form of alternative electrode arrangement as provided by the apparatus illustrated in Figure 5.

Referring to Figure 1, the numeral **10** generally designates a typical cathode ray tube comprising an envelope **11** coated on its interior lateral portion with a conducting material **12**, and having the glass end screen portion **13** interiorly coated with a suitable phosphor **14**. The tube contains the usual cathode **15**, control grid **16**, focussing anode **17**, accelerating anode **18**, vertical deflector plates **19** and **20**, and horizontal deflector plates **21** and **22**.

An array of small conducting electrodes **23**, **24**, **25**, **26**, **27**, **28**, **29**, **30**, etc. is attached to the outer surface of the end screen portion **13**. In simplest form as illustrated in Figures 1 and 2, these electrodes are divided into two electrically separated groups (*a*) and (*b*), the electrodes of group (*a*) being connected to a common output conductor **31***a*, while those of group (*b*) are similarly connected to a conductor **32***b*. By reference to Figure 2 it will be seen that the typical array of sixty-four individual electrodes is arranged in rectangular form with the electrodes of the two groups interspersed in an arbitrary manner determined by the requirements of a particular combinational problem to be resolved. Thus in the fifth horizontal row, electrodes **23**, **25**, **26**, **27** and **29** are connected to output conductor **31***a*, while the electrodes **24**, **28** and **30** are all connected to conductor **32***b*, various other respective connective combinations being provided throughout the remainder of the array. It will be understood, however, that the device is not limited to the exact number or combinational arrangement shown for illustration, since as hereinafter set forth, the pick-up array is adapted to many other arrangements set up for dealing with different types of problems.

The conductor **31***a* comprises the input connection to a primary amplifier **33**, while conductor **32***b* similarly leads to a second primary amplifier **34**. The amplifiers **33** and **34** are preferably of similar or identical construction as shown in Figure 4. Referring to the latter figure, it will be noted that the illustrated amplifier **33** is a three stage type employing pentodes **35**, **36** and **37**, the control grid **38** of the first tube **35** being connected to the conductor **31***a* via a condenser **39**, while in the second primary amplifier **34** the control grid **40** of the first tube **41** receives its signal from the pick-up conductor **32***b* via a condenser **42**.

The outputs **43** and **44** of the amplifiers **33** and **34** jointly feed a differential amplifier **45**, also shown in illustrative detail in Figure 4. This amplifier employs a double triode **46** having its left and right-hand grids **47** and **48** connected to conductors **43** and **44** respectively. The two tube circuits are in parallel, separated on the B+ side by a resistor **49** as shown. A common output **50** is taken via a condenser **51** from the left-hand side of the dual network. The illustrated components of the system are so proportioned that the single amplified signal at the output conductor **50** is representative of the difference potential between the two simultaneous inputs and is positive or negative in sign dependent on which of the two grid potentials is preponderant. Thus if the left-hand grid **47** is driven a certain amount positive while the right remains at or is driven to a lower potential, the output is positive, while if the right grid **48** is driven positive while the left is at lower potential the output is negative, the output amplitude in each case being a function of the net input difference.

For actuation and control of the CRT **10**, the system is provided with a pulse generator and control network **60**, selector switches **61**, and deflection amplifier **62**. These units are shown in block diagram, Figure 1, as the internal structures and operation of suitable devices of this nature are well known in the electronic art and hence do not call for detail description herein.

A typical operation of the switching system is as follows, it being borne in mind that the pick-up electrode array has been arranged in accordance with a specific problem:

The particular test values of the variables of the problem are applied in terms of deflecting voltages to the tube **10**, and the beam is turned on for a short period such as 10 microseconds, the combination of deflecting voltage determining a particular spot of the inner target surface

14 upon which the beam impinges, i.e., an "X, Y" position behind one of the external pick-up electrodes. In preferred practice the beam is moved laterally across the selected target area during the above time period, this movement being designed to erase the charge at the initial position of contact to ensure that a pulse will again be obtained if the same target is again selected within a short time.

When the beam is thus applied to the selected target spot, the result is a positive pulse at the output of the primary amplifier to which the selected pick-up electrode is connected. At the same time, due to proximity effects, lesser signals are picked up by neighboring unselected electrodes and transmitted to their respective primary amplifiers or amplifier. In the case of unselected electrodes of the same (*a*) or (*b*) group as the selected spot, the effect obviously is to increase the signal to the latter's primary amplifier, while the other primary amplifier receives any signal effects from electrodes of the other group and produces its own corresponding output. However, the signal from the selected target is always preponderant (a typical ratio being about four to one), so that the final output from the differential amplifier in each case is a sharp and distinctive pulse, positive if the combination of controlling variable values fulfills a "yes" condition of the problem and negative if the control combination selects a "no."

To illustrate, referring to Figures 2 and 3, if control combinations are applied which direct the electron beam to target areas behind the designated electrodes, electrodes **23**, **25**, **26**, **27** and **29** will report "yes" by sharp positive output pulses as illustrated in Fig. 3, while electrodes **24**, **28** and **30** will report "no" by similarly sharp and distinctive negative pulses. The assignment of positive sign to "yes" and negative to "no" is purely arbitrary, since obviously the reverse assignment may be made if called for by the nature of the process to which the system is applied. In either case, however, it will be seen that the differential combination provides sharp and completely unmistakable distinction between "yes" and "no" signals by difference in polarity rather than simply by difference in magnitude. The advantages in point of precision, reliability and adaptability will be evident. A further advantage is the tendency to balance out unwanted general effects such as electron cloud pulses.

For convenience in explanation, the apparatus has been depicted with a typical array of 64 pick-up electrodes. It will be understood, however, that the target array may be made to include larger numbers of electrodes limited only by the available operative area of the tube. For instance, using a single five-inch cathode ray tube and typical electrodes of .145 inch diameter spaced on .2 inch centers, 256 electrodes may be accommodated, capable of producing any switching function up to 8 variables. As generalized switching functions of more than four variables are usually complicated and expensive to produce by diode and vacuum tube circuits, it will be evident that the present invention provides marked improvements in simplicity, economy and adaptability. Respecting the latter quality, as previously mentioned, various differing arrangements of the pick-up array may be made to adapt the apparatus particularly to specific types of computational or other selective switching functions such as automation controls. Figure 5 illustrates an embodiment providing maximum versatility for ready set-up of new specific arrangements or quickly interchangeable set-ups of previously determined combinations without complicated or expensive changes in tube structure.

In Figure 5, the numeral **52** designates a forward extension of the base or supporting structure for the tube **10**. An insulating plate **53**, rigidly fastened to the support **52** and facing the screen end **13** of the tube, carries a plurality of small jacks **54**. The pick-up electrodes **23**, **24**, etc., disposed on the face **13** of the tube, are individually connected to corresponding individual jacks **54** by short conductors **55**, the latter preferably being sufficiently flexible to avoid any strain on the electrodes. Additional jacks in the panel **53** are also provided to accommodate the primary amplifier output conductors **31***a* and **32***b* as shown.

The jacks **54** are adapted to receive the prongs or plugs **56** of a hollow gang connector **57** within which the plugs may be pre-wired in suitable combinations as indicated in dotted lines. Obviously this internal pre-wiring may be made to establish any desired arrangement of the pick-up connections, in addition to that shown in Figure 2. An example is the combination shown in Figure 6, wherein "*a*" and "*b*" electrodes alternate both in the vertical and horizontal rows. As a further example of adaptability, by initial provision of additional jacks **54** and plugs **56**, a single tube may be set up for a number of different problems at the same time. To illustrate, by use of a properly pre-wired combinational connector **57** the pick-up electrode array may be divided into two or more sets of cooperative "*a*" and "*b*" electrodes, each set feeding to its own primary and differential amplifying system of the type described herein. To change from one type of set-up to another it is only necessary to substitute an appropriately pre-wired panel **57**.

It will be evident that the above advantages of practically unlimited versatility in set-up combination stem largely from the exterior location of the pick-up system, which avoids the interior structural complications and multiple lead-out difficulties obviously attendant on any system of multiple interior pick-up electrodes. With the preferred embodiment of the invention as illustrated herein the tube **10** may be of any suitable standard type, as previously mentioned. While if desired the pick-up electrodes **23**, **24**, etc., may be attached individually to the tube face **13**, Figure 5 illustrates a method of multiple attachment by which interchangeability or replacement of tubes is further facilitated. For this purpose the pick-up electrode assembly may be attached directly to a thin and flexible insulating sheet **58** which in turn is detachably secured on the tube face **13** by any suitable means such as a border **59** of adhesive cellophane tape or the like. By this provision replacement of defective or deteriorated tubes may readily be made without disturbing the electrical connections or relative electrode arrangement of the output system.

The preceding description has explained operational and structural features which render the present invention an improved generalized switching system of maximum precision, simplicity and adaptability. For purposes of the explanation the interrogation bombardment has been described as of the moving or "dash" type, but obviously other types such as the focus-defocus method may be used. Similarly, while the invention has been described throughout in preferred typical form, it is not limited to the precise structures and procedures illustrated, as various modifications may be made without departing from the scope of the appended claim.

I claim:

In an electro-static look-up system for deriving solutions of a generalized problem in a large number of variables, in combination, a cathode ray tube having an interior target surface, an array of spatially separated pick-up electrodes disposed on the external surface of said tube in capacitative relationship with said interior target surface, said tube having deflector electrodes adapted to direct the beam of said tube to pre-determined spots of said target underlying said pick-up electrodes in selective response to entered deflector voltages representative of pre-determined combinations of said variables, means to connect said electrodes in two electrically separated groups each having a common signal conductor, said pick-up electrodes of said two groups being arranged in a pattern adapted to establish responses to said beam representing solutional elements of said problem in correspondence with said entered combinations,

differential amplifying means having two input receiving means and adapted to establish a common output signal proportional to the potential difference between two input signals fed simultaneously thereto, said output signal being of alternatively positive or negative polarity dependent on the relative preponderance in amplitude between said simultaneous input signals, and means to connect said two common group conductors respectively to said two input receiving means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,361,766	Hadekel	Oct. 31, 1944
2,417,369	Luhn	Mar. 11, 1947
2,441,269	Hartig	May 11, 1948
2,498,688	Lesti	Feb. 28, 1950
2,589,460	Tuller	Mar. 18, 1952
2,778,009	Bridges	Jan. 15, 1957