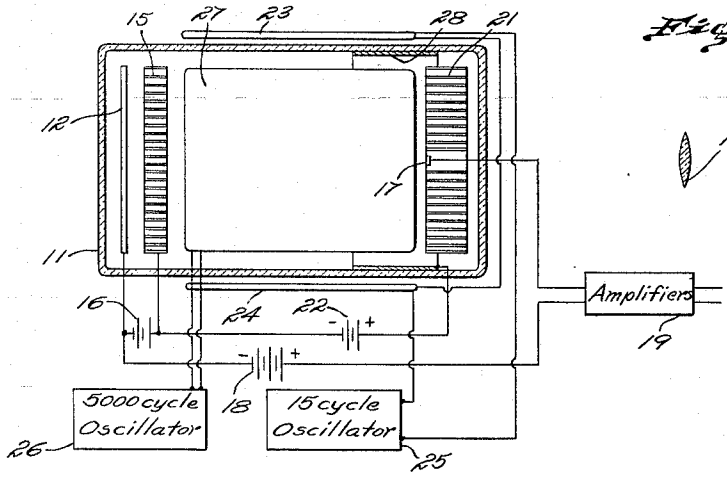
Nov. 17, 1936. T. W. SUKUMLYN 2,061,113

CONTROL SYSTEM FOR ELECTRON EMISSION

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Fig. 1



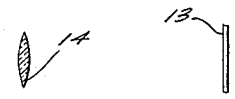


Fig. 3

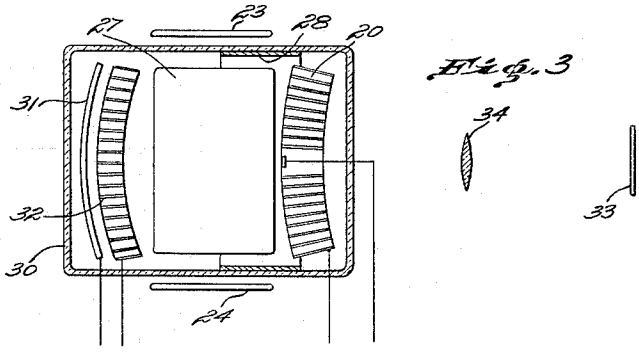


Fig. 2

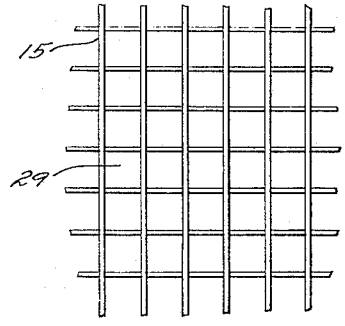
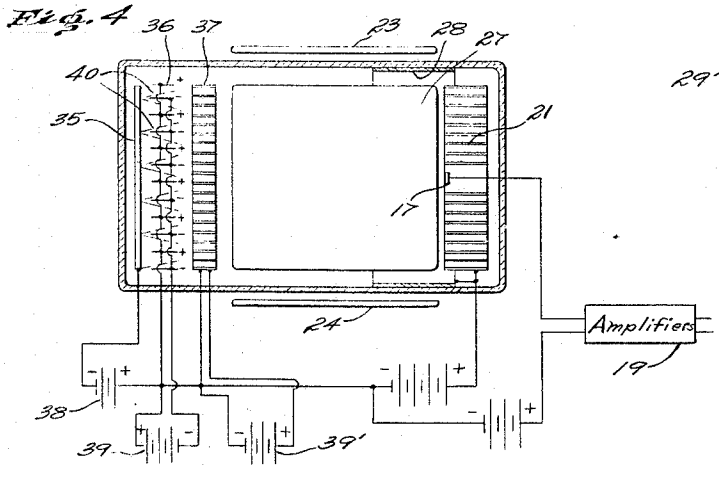


Fig. 4



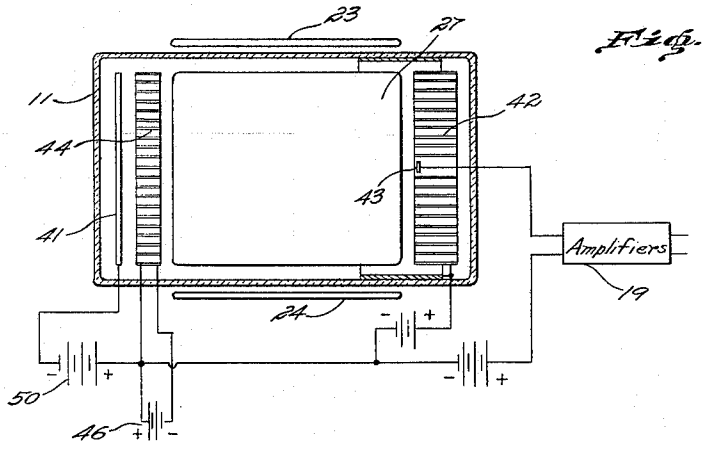
Inventor
Thomas W. Sukumlyn
by John Flam
Attorney

Nov. 17, 1936. T. W. SUKUMLYN 2,061,113

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Fig. 5



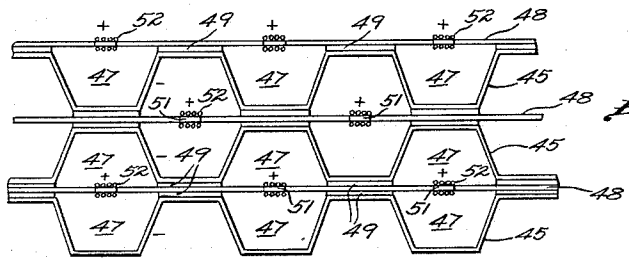
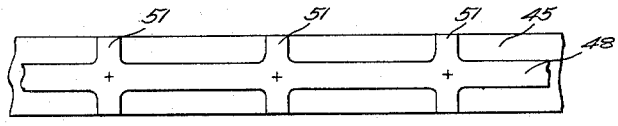


Fig. 6

Fig. 7



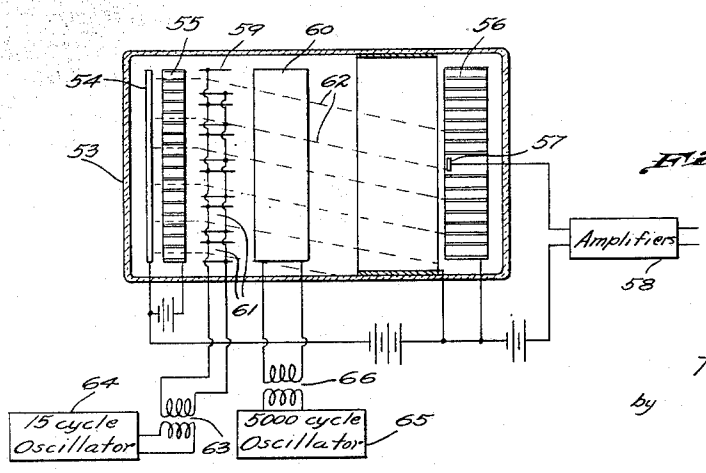


Fig. 8

Inventor
Thomas W. Sukumlyn
by John Flam
Attorney

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2,061,113

CONTROL SYSTEM FOR ELECTRON EMISSION

Thomas W. Sukumlyn, Los Angeles, Calif.

Application May 20, 1931, Serial No. 538,723

7 Claims. (Cl. 178—6)

This invention relates to a system for controlling electron emission.

There are numerous applications now known for electron emission devices. Among others may be mentioned the scheme for electrically scanning an image to be transmitted for television. In such schemes, an image is focussed on a photoelectric surface, as for example, may be formed by a layer of sodium, potassium or other suitable compounds. Electrons are emitted from each element of this surface in accordance with the intensity of illumination reaching it. The whole area of this surface thus projects a beam of the same cross sectional dimensions as the surface, formed of electrons. The scanning is obtained by causing relative movement across the beam, of a target or anode which is maintained positive with respect to the photoelectric surface or cathode. The number of electrons reaching the target at any instant thus depends upon the intensity of electron discharge from that elemental area of the surface which is at that instant active to send electrons to the target.

The relative movement of the beam and target must be cyclic and so rapid that the whole area is scanned during the period that is within the period of the persistence of vision; that is, so that the complete scannings occur at such a frequency as to give the impression of continuity. This speed is of the order of one-tenth or one-fifteenth of a second, which represents the time for one complete scanning of the beam, whereby ten or fifteen images are produced every second.

The varying electron flow to the target is made use of for varying the current flowing in an output circuit, which can be reproduced synchronously at a distant point for translating the currents into light impulses reassembled to form the image.

It is apparent that since each image must be subdivided into a large number of elements, the scanning must be extremely rapid, and appropriate amplifiers must be used to provide sufficient variations in current to be effectively transmitted. To secure the rapid scanning, it has been proposed to secure the relative motion of the electron beam and the target by moving the beam cyclically and leaving the target stationary. This permits the use of electricity for the movement of the beam, as by appropriate magnetic or electric forces. For example, across one direction of the beam, an electromagnetic force can be applied, alternating at a high rate and of sufficient intensity to swing the beam clear across the target; and across another transverse direction, another electromotive force can be provided, alternating at a lower rate and of sufficient intensity to swing the beam along this direction clear across the target. The resultant motion of the beam is compound, and can be described as a series of back and forth movements successively at different levels until the whole beam is scanned, when the cycle is repeated.

Definite difficulties arise in such scanning systems. For example, a high driving potential must be used, as by the aid of a positive screen, for impelling the electrons across the evacuated space between the emitter and the target. However it has been found that emission from the photoelectric surface is complex in response to the energizing light. Some of the electrons proceed at such slow rate as never to reach the target; and others instead of proceeding in a direction normal to the surface, are oblique. These cause distortion of the reproduced image.

It is one of the objects of my invention to make it possible to reduce this cause of distortion very materially; and more particularly by a definite structure of the positive screen which acts either to straighten the elemental beam from the elemental area, or to reduce the diverging component thereof.

It is a further object of this invention to make it possible to reduce the size of the transmitter tube.

In the prior schemes of this general character, the whole beam of electrons is influenced by a common set of electrical influencing devices, such as coils or condenser plates. It is apparent that the edges of the beam, nearest these devices, is influenced most, so that a further cause of distortion is introduced. It is another object of my invention to obviate this distortion by influencing elements of the beam separately.

My invention possesses many other advantages, and has other objects which may be made more easily apparent from a consideration of several embodiments of my invention. For this purpose I have shown a few forms in the drawings accompanying and forming part of the present specification. I shall now proceed to describe these forms in detail, which illustrate the general principles of my invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of my invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a diagram of a system embodying one form of the invention;

Fig. 2 is an elevation of a portion of the novel type of screens used in the form of Fig. 1;

Fig. 3 is a diagram of a modified form of the invention, in which the transmitter tube is kept compact;

Figs. 4 and 5 are further modifications of the system;

Figs. 6 and 7 are greatly enlarged detail fragmentary views of the screen used in connection with the form of the invention shown in Fig. 5; and

Fig. 8 is a diagram of a still further modification.

In Fig. 1 there is shown an envelope or tube 11 which is highly evacuated and which encloses the elements of the electronic transmitter. Thus there is a cathode 12 having a suitable photo-sensitive surface facing an illuminated object 13 exterior of the tube 11. This object has an image focussed on cathode 12 as by a lens system 14. The electron beam emanating from cathode 12 is accelerated by a screen 15 (Fig. 2) which is kept at a suitable high positive potential, such as 500 volts, with respect to cathode 12. A battery 16 is indicated as supplying this suitable potential.

A target or anode 17 is disposed at the opposite end of tube 11, and is kept at a suitable positive potential with respect to cathode 12, as by a battery 18. The circuit connecting anode 17 with cathode 12 also can be connected to appropriate amplifiers 19 and to a transmission line. This target 17 has an area corresponding to an elemental portion of the beam. In order to ensure that only one element of the beam is active at one time to pass electrons to target 17, use can be made of an electric shutter or shield 21 of mesh form, and held at a suitable positive potential with respect to cathode 12, as by a battery 22. This shield can pass the light from object 13, and has a central aperture exposing target 17. Thus this shield captures all electrons except those that pass directly to the target, and acts as an electric shutter.

The movement of the electron beam relatively to target 17 can be effected either by capacity action or by electromagnetic action. In the present instance, there is shown a pair of coils 23, 24, to affect the beam magnetically, and arranged on opposite sides of tube 11, and energized by an oscillator 25 for causing the beam to swing in a vertical direction, say at the rate of fifteen times a second. Horizontal oscillation of the beam is similarly effected, but at a much higher rate, say five thousand times a second, by the aid of horizontally arranged coils, energized from oscillator 26. Only one of the pair of coils so energized is shown at 27; but it is to be understood that on the other side of tube 11, a similar coil energized similarly to coil 27, is provided.

Some of the electrons in the beam have a tendency to diverge from the straight normal path; and some are emitted from cathode 12 at a low velocity. To keep the electrons normal and to absorb those at low velocity, the screen 15 is made deep, as by the use of side interconnecting plates forming elemental areas 29. Due to the positive charge on screen 15, and to its depth these low velocity electrons are readily attracted thereto; and the high speed electrons are given a greater impetus in the direction intended for them. The elemental areas or open spaces 29 of the screen are merely illustrated diagrammatically; ordinarily they may be much smaller. They can be formed by thin intersecting or honeycombed plates in an obvious manner.

Shield or shutter 21 can be also made deep, to eliminate as much as possible, any charges on the back wall of tube 11. The angled beam of electrons are thus more apt to be caught thereon instead of passing through the shield. The light beams from lens 14 can, however, pass because they are substantially in line with the shield openings.

A thin metal deposit 28 inside tube 11 and kept at a positive potential, serves as a plate extending shield 21 to return the electrons to the cathode when the beam is angled to reach the sides of the tube.

Furthermore, for effective operation, the tube 11 should be very highly evacuated, and the potentials of elements 15, 21, and 17 should be high, of the order of five hundred to a thousand volts, to provide the desired acceleration of the electrons.

Fig. 3 illustrate a form of the invention in which the length of the transmitter tube can be reduced. Thus in the evacuated vessel or tube 30; the cathode or photosensitive device 31 as well as the wide screen 32 are concave toward the target 33, producing a converging electron beam. The illuminated object 33 has its image focused as by lens 34 onto the concave surface of cathode 31. The beam being more restricted, can also be more readily controlled by the devices 23, 24, 27. The shield 20 can be also deep and concave.

The idea of concentrating or straightening the electron beam by appropriate design of the screen can be carried out in other ways. For example, in Fig. 4, the cathode 35 emits electrons through a pair of sets of plates 36, 37 which together form the screen. The set 36 is arranged horizontally, and set 37 is arranged vertically. Both sets are in general kept at a high positive potential with respect to cathode 35, as by the aid of battery 38. However, each set of plates includes alternate plates that are maintained positive with respect to the other plates of the set. In other words, the plates form alternate positive and negative elements, which can be kept at constant potenials as by batteries 39, 39'.

As an elemental stream of electrons passes between the plates 36, the positive plates pull the stream away from the negative plates, causing the elemental stream to be flattened as indicated by the dotted lines 40, in a horizontal direction. The angularities of these dotted lines are exaggerated for clarity, it being understood that these lines converge on the shield 21. Each of these flat streams is split up into a series of elements by the plates 37, which act on each of the split up elements to concentrate them in a vertical direction. Thus by the action of the two sets of plates, the electron stream is divided and again subdivided into the desired small elements which are concentrated in both directions, and keep them moving in a straight line. As in the prior forms described, the depth of the entire screen structure 36—37 is sufficient to capture the very slow moving electrons and the greatly deviating electrons, and ensure distortionless transmission. However, most of the electrons will here be concentrated into straight beams without absorption.

Of course, no attempt is made to indicate a practical separation of the plates in elements 36, 37; as preferably a much larger number can be used in each set, to provide smaller elemental beams.

The successive compression of the elemental beam in two transverse directions to obtain concentrated beam elements, can also be produced by a compound shield structure, such as is illustrated in Figs. 5, 6 and 7. In this instance the cathode **41**, shutter **42**, and target **43** are arranged substantially as before; as well as the scanning elements **23**, **24**, **27**. The screen **44**, however, has two series of plates of definite arrangement, which are kept positive and negative with respect to each other.

One set of plates **45** (Fig. 6) is convoluted to form a series of bends. These plates are so arranged that the bends come opposite each other, the series of bends thus forming a series of cellular spaces or honeycombs **47**. All of these plates are kept at a potential negative with respect to another set of plates to be described, as by a battery **46**. It is through the spaces **47** that the elemental beams of electrons travel.

Another set of plates **48** is used, which intersect the spaces **47**, as by being spaced between adjacent plates **45**. These plates are, however, insulated from plates **45**, as by very thin pieces of insulation **49**. This insulation can be formed by a thin film of enamel, or a thin plate of mica, or the like. All of the plates **48** are connected together, and maintained positive with respect to plates **45**, as by battery **50**. Furthermore, at the center of each space **47** formed between plates **45**, the plates **48** are provided with projections **51**.

It is now possible to explain the action of the screen **44** as the electrons progress through spaces **47** (in Fig. 6, in a direction normal to the plane of the drawings). Since plates **48** and accordingly projections **51** are positive with respect to plates **45**, these projections attract the electrons, while the sides of the spaces **47**, being negative, repel the electrons. The net result is that the electrons cluster near the projections **51** as indicated diagrammatically by the dots **52**. Many electrons deviating from the straight normal, as well as the slow moving electrons, will be straightened out and accelerated. Because the width of plates **45**, **48** is quite substantial, as illustrated in Figs. 5 and 7, the very slow moving electrons and those greatly deviating from normal will be captured by plates **48**.

In this form of the invention, the scanning is effected as before by the coils **23**, **24**, **27**, or equivalent devices. Such devices, however, influence those elemental electron beams most strongly which are adjacent the edges of the tube. In the form of my invention illustrated in Fig. 8, the elemental beams are not so discriminated against.

In this form, the evacuated tube **53** encloses the usual photoelectric cathode **54**, the positive concentrating and accelerating shield **55** (constructed in any of the ways heretofore described), the positive shutter **56**, and anode or target **57**. The circuit connecting target **57** with cathode **54** can include the appropriate amplifiers **58**. The deflecting of the elemental beams from cathode **54** to produce the scanning effect is provided by a pair of sets of plates **59**, **60**. The set **59** is arranged horizontally inside tube **53** and is used for swinging the elemental beams in a vertical direction. The set **60** is arranged vertically inside tube **53** and is used for swinging the elemental beams horizontally.

Since both sets of plates are similarly constructed, set **59** only, need be described in detail. This set includes a series of paired plates, the number shown being diagrammatic and it being understood that many more could be used in an actual embodiment, to secure a fine subdivision of the whole beam. The plates are alternately of opposite polarities. In the instance shown, the top plate and every other plate is negative, while the remaining plates are positive. The plates are in closely adjacent pairs, providing spaces such as **61** for the elemental beams to pass between a pair of opposite polarity plates. The plates can be held separated in any desired manner as by insulation layers.

At the instant shown, the beams are swung downwardly in these spaces **61** as indicated by the dotted lines **62**, because the top plate of each space is negative and repels the electrons, while the bottom plate is positive and attracts the electrons. However, the relative polarities change, say at the rate of fifteen times a second, so that the beams are oscillated at that frequency in a vertical direction. This change in polarity is accomplished by connecting the alternate plates to opposite terminals of a source of alternating current, such as transformer **63**, fed by oscillator **64**.

The horizontal oscillation of the elemental beams is accomplished at a much faster rate, as by providing the oscillator **65** of 5,000 cycles, feeding transformer **66**. The opposite terminals of this transformer are connected to alternate plates of the set **60**. This set operates in a manner similar to set **59**.

I claim:

1. In a system for electric scanning, a photoelectric cathode, an anode, means for causing relative movement between the beam of electrons emitted from the cathode, and the anode, and means in the path of the beam for dividing the beam into concentrated elemental beams, said dividing means comprising a series of electrical plates that are alternately negative and positive with respect to each other.

2. In a system of electrical scanning, a photoelectric cathode, an anode, means for causing relative movement between the beam of electrons emitted from the cathode, and the anode, and a positive screen in the path of the beam, said screen having deep cellular spaces, the cathode and screen being concave toward the anode.

3. In a system of electrical scanning, a photoelectric cathode, an anode, means for causing relative movement between the beam of electrons emitted from the cathode, and the anode, a series of spaced plates in the electron stream and having alternately opposite polarities, another series of similar plates but transverse to the first series, and means for maintaining said two series of plates positive with respect to the cathode.

4. In an electronic emission device, a cathode, an anode, and a positive screen in the path of the electrons, and between the anode and cathode, the cathode and screen being concave toward the anode, and the screen having deep cellular spaces.

5. In an electronic emission device, a cathode, an anode, a series of spaced plates in the path of the electrons and having alternately opposite polarities, another series of similar plates but transverse to the first series, and means for maintaining said two series of plates positive with respect to the cathode.

6. In a system of electric scanning, a photoelectric cathode, an anode, an evacuated vessel enclosing the anode and cathode, a series of plates defining elemental spaces and located in the vessel, and means for varying the potentials

of the plates on opposite sides of each space to swing the electron beam passing through the space.

7. In a system of electric scanning, a photoelectric cathode, an anode, an evacuated vessel enclosing the anode and cathode, a pair of series of plates inside the vessel, one series being transverse to the other and defining elemental spaces for the passage of electrons, and means for varying the potentials of the plates on opposite sides of each space to swing the electron beam passing through the space.

THOMAS W. SUKUMLYN.