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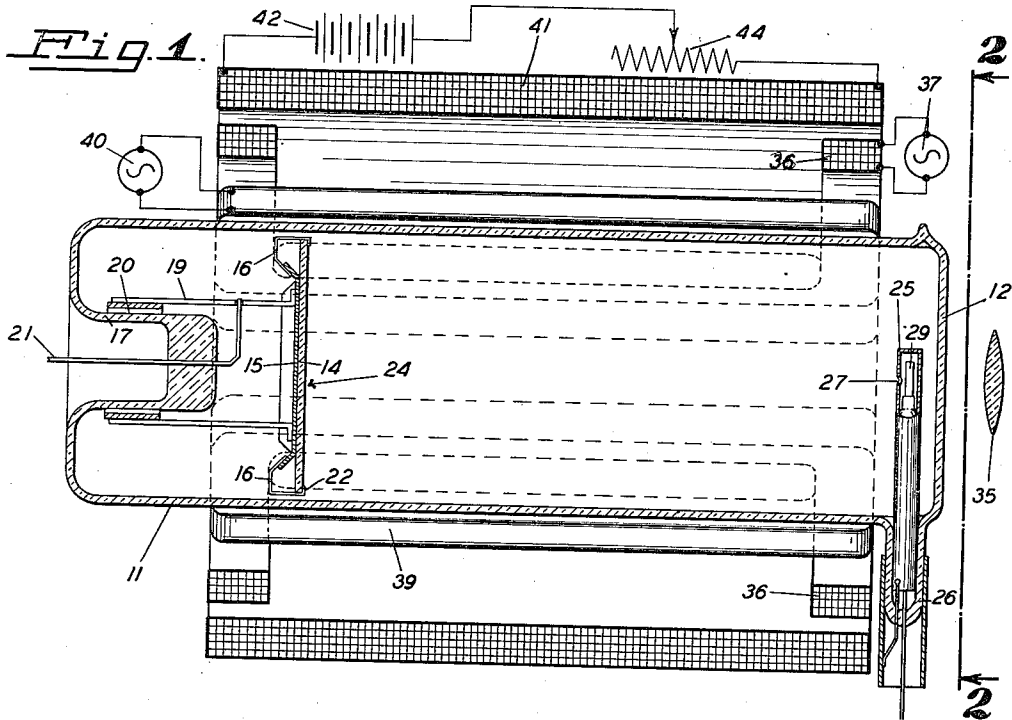
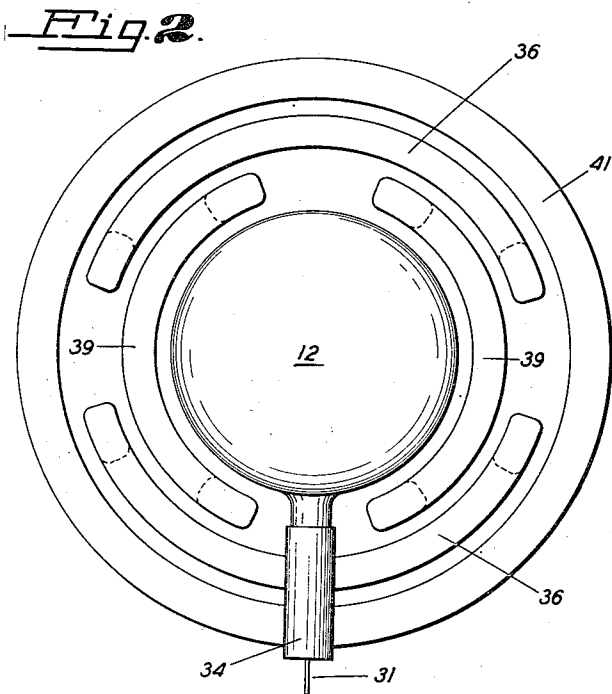
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2,135,149

IMAGE DISSECTOR AND METHOD OF ELECTRON BEAM ANALYSIS

Filed Nov. 7, 1933

2 Sheets-Sheet 1



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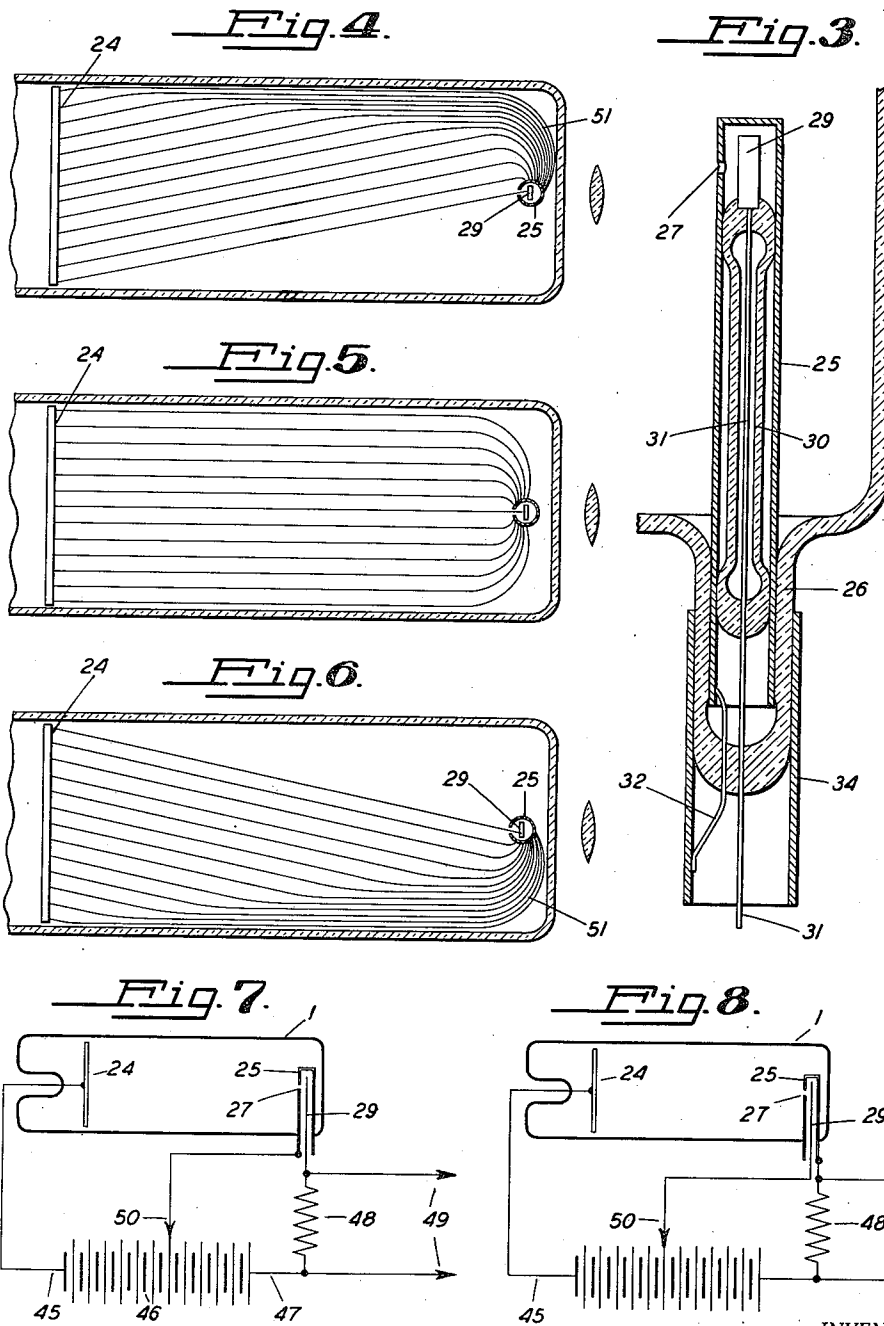
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IMAGE DISSECTOR AND METHOD OF ELECTRON BEAM ANALYSIS

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2 Sheets-Sheet 2



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2,135,149

IMAGE DISSECTOR AND METHOD OF ELECTRON BEAM ANALYSIS

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8 Claims. (Cl. 178-7.2)

My invention relates to an image dissector and electron current analyzer, and more particularly to an electron discharge tube and associated apparatus and methods which may be used for the dissection of an optical image, as for example, in a television transmitter.

Among the objects of my invention are: To provide a simple and efficient image dissector for television or like use; to provide a method of image dissection; to provide a means and method of analyzing an electron discharge of varying densities; to provide a compound anode for a cathode ray tube; to provide a method of selecting portions of a photoelectric discharge having an intensity proportional to the intensity incident light upon the area emitting that portion of the discharge, when the entire discharge is accelerated in a non-uniform electro-static field; to provide a combination of fields acting on a cathode ray beam so that successive portions of the beam may be selected having a substantially rectilinear mean path when the remainder of the beam is forced into distorted mean paths due to the action either of said fields or other factors; and to provide a means of separating electrons arriving at an anode in a substantially rectilinear mean path from electrons arriving substantially simultaneously in curvilinear mean paths.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of my invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawings:

Figure 1 is a longitudinal sectional view, partly in elevation showing the dissector tube of my invention, together with a representation of the field forming apparatus.

Figure 2 is a face view in elevation taken as indicated by the line 2-2 in Figure 1.

Figure 3 is an enlarged longitudinal sectional view of the composite anode shown in the tube of Figure 1.

Figures 4, 5 and 6 are diagrams drawn to indicate the mean paths of the electrons emitted from various portions of the cathode during certain steps in scansion.

Figure 7 is a diagram of a hook-up wherein the inner anode directly collects the electrons selected.

Figure 8 is a diagram of a hook-up wherein secondary emission within the anode structure is utilized to augment the signal.

The image dissector herein described is an improvement on the dissectors disclosed and claimed in Patent No. 1,773,980, issued August 26, 1930, to Philo T. Farnsworth for a Television system, and in the copending application of Philo T. Farnsworth, Serial Number 245,334, filed January 9, 1928. In the cathode ray dissector tubes therein shown, an optical image is projected on a cathode capable of emitting electrons, and the beam of electrons emitted therefrom is accelerated in a uniform electrostatic field along substantially parallel lines toward an electrical shutter. The beam has a current intensity at each elementary cross sectional area proportional to the light intensity at the corresponding elementary emitting area of the photosensitive surface. Farnsworth terms this cross sectional correspondence an "electric image", as the beam is held in spatial relationship so that the optical image would reappear if a fluorescent screen could be placed, without disturbing the operation of the tube, to intersect the beam at any point between the photosensitive surface and the shutter. The beam, so constituted, is then oscillated past the shutter opening preferably in two directions to select successive portions of the beam thus dissecting the electrical image to form a train of television signals.

In the dissector tubes above-referred to, an anode screen is placed between the shutter aperture and the cathode surface. The anode is in the form of a screen of substantially the same size as the cathode, and when energized causes the electrons to accelerate through a substantially uniform electrostatic field. The electrons are maintained therefore in practically parallel paths during scansion, thus maintaining the electrical image in substantially undistorted form during the scanning cycle. Under the circumstances described, either the anode or cathode should be a screen permeable to light in order that the optical image may effectively reach the photosensitive surface. Such screens reduce both light and definition and reduce the output level of the device.

I have found that a uniform electrostatic field is not essential, as I am able to obtain proper scansion of the successive elementary areas even though the remainder of the discharge is distorted and the electron paths therein depart from parallel relationship.

In broad terms, as to my method, I accelerate the beam of electrons emitted from a cathode in a non-uniform electrostatic field, move the beam with a varying electromagnetic field, and select

successively the electrons in a portion of the discharge having a mean rectilinear path from the cathode to the scanning aperture. This rectilinear path is due to the resultant effect of the fields acting on the electrons, and irrespective of the divergent paths taken by the portions not selected in a tube containing a photosensitive surface having an optical image projected thereon, the number of electrons in the rectilinear path are proportional to the light intensity on the elementary areas of the cathode surface emitting those electrons. I prefer to collect the electrons following other than mean rectilinear paths by shielding the selecting electrode and collecting the remaining electrons on the shield.

I may also desire to utilize a magnetic focusing field such as disclosed by Farnsworth in his application, Serial No. 270,673, filed April 17, 1928, for an Electrical discharge apparatus, wherein a magnetic field is established parallel to the mean path of the electrons in order to sharply focus the emitted beam in the plane of the anode or collector. The resultant actual path of each electron which endeavors to diverge is a helix whose axis is parallel to the magnetic field. The electrons from an elementary area will return at intervals to the same spatial relationship as emitted. Adjustment of the focusing current may be made to "focus" or place the electrons in the same spatial relationship as emitted, in the plane of the anode. As the present application is not concerned with the focusing per se, but only with dissection and selection in a given plane removed from the cathode, the term "mean path" is used to indicate that the electrons of each elementary area arrive in the plane of the scanning aperture in the same spatial relationship as emitted, regardless of the helical path actually followed. The magnetic focusing aids in obtaining sharp definition in the plane of selection, but otherwise does not change the methods of operation as herein disclosed and claimed.

The apparatus involved, in broad terms, is a cathode ray tube in which an electron-emitting surface is preferably excited by the projection of an optical image thereon. It is, however, not necessary for the purpose of practicing the methods involved that the source be a photoelectric surface. The methods are capable of analyzing any electron beam initiated from any emitting means.

A target or selecting anode, preferably a finger inserted from one side of the tube, is positioned so that all but a small predetermined area is shielded from the emission of the cathode. I prefer to shield the collecting anode by another or collecting anode, tubular in shape, to enclose the target anode, with an aperture therein directed toward the emitting surface, or at least having the opening directed to receive the incoming electrons. It is convenient to space the composite anode, which may be made relatively small in diameter, some distance away from the emitter firstly, to allow space for controlling fields to act on the beam and secondly, to position the finger, as it is usually placed in the path of the light to the cathode, away from any focus of the optical system which may be used to project an optical image on the cathode when the tube is to be used to initiate television signals by dissecting an image. The anode finger, as the structure may be called, obstructs very little light, and being apart from any focus destroys practically no optical definition on the cathode. The anodes may be energized by the usual external battery in two

different ways, one to utilize secondary emission, the other being a direct selection, as will be later described.

Coils energized by scanning oscillators are preferably used to magnetically deflect the field, and the usual solenoids provided to create the focusing field.

The tubular finger, therefore, acts as a selector of the desired portions of the discharge necessary for dissection; it acts as a collector of the remaining non-selected electrons, and is, when energized, the sole means used to create the electrostatic field along which the electrons are accelerated, a field so distorted that the electron image is also distorted and ceases to correspond spatially with the optical image almost immediately after the beam leaves the cathode.

The preferred means and method by which I obtain proper dissection, even though the electron image is spatially distorted, may best be understood by reference to the drawings.

In Figures 1, 2 and 3, which represent a preferred form of image dissector as used in a television system, an envelope 11 is provided with a transparent, preferably optically flat face 12. At the other end of the tube is mounted a cathode mirror 14 held on a plate 15 by clips 16. The cathode assembly is mounted on a reentrant stem 17 by uprights 19 welded to clamp 20. A cathode lead 21 is sealed through the stem and connects to one of the uprights to form a cathode connection.

The front face of the mirror is preferably made smooth, and is silvered before assembly. The end bends 22 of the clips 16, therefore, contact the silver film. The silver film forms a base on which photosensitive material such as caesium or potassium or like metals may be later distilled. The composite film thus formed is the cathode 24.

Spaced apart from the cathode, preferably just inside the flat face 12, is the anode finger. This finger, an enlarged view of which is shown in Figure 3, comprises an outer tubular collecting anode 25 which is sealed in an anode arm 26 in the side of the tube, the tube extending toward the center of the device.

A scanning aperture 27 is cut in the tube at a point where the central longitudinal axis of the large tube intersects the finger, preferably opening toward the cathode. This aperture exposes a limited portion of the surface of an inner anode or target which I wish to call the selecting anode 29, as it is upon this anode that the selected electrons successively fall to initiate the television signals.

The selecting anode is held in place back of the aperture by an insulated spacer 30 through which a selector lead 31 is sealed. This selector lead passes through the end wall of the anode arm 26 so that the selecting anode may be energized. Potential is supplied to the collecting anode through a collector lead 32. It is convenient to continue the shielding of the selector lead after it leaves the envelope by applying an outside sleeve 34 over the anode arm and fastening the collector lead thereto.

After the tube has been thoroughly exhausted and degassed, the photosensitive film is deposited, and processed if desired. The device is then sealed from the pump and mounted to operate as an image dissector.

A lens or other optical system 35, diagrammatically represented, is positioned to throw or project an optical image of an object on the photosensitive cathode. While the anode finger is in the

light path, it is so far removed from the focus of the optical system that definition of the image on the cathode is not appreciably impaired, and, as the finger obstructs relatively little light, the
5 brilliancy of the image is not greatly reduced.

Two sets of scanning coils are provided for moving the electron beam, a vertical pair 36—36 provided with a vertical scanning oscillator 37, and a horizontal pair 38—39 provided with a
10 horizontal scanning oscillator 40. The magnetic fields produced by the oscillating currents in these coils are so proportioned and applied to the beam as to sweep the entire electron beam across the scanning aperture 27 in successive
15 elementary areas to dissect the entire beam within the optical period. For example, one of the oscillators may be set to produce a scanning frequency of from 1–5,000 cycles, the other from 16–60 cycles, the fields being applied at substan-
20 tially right angles to cover the entire beam in successive dissections.

A focusing field is produced by a focusing solenoid 41 energized by a source 42 controlled through a variable resistor 44. The proper ad-
25 justment of this resistor will focus the electrons in the plane of the aperture 27.

There are two ways of energizing the anodes, as shown in Figures 7 and 8. Figure 7 shows diagrammatically a hook-up wherein the nega-
30 tive end 45 of an anode source 46 is connected to the cathode, the most positive connection 47 being made to the interior selecting anode 29 through an output resistor 48. The collecting anode 25 is then connected to the source by a tap
35 50 at a point less positive than the selecting anode. In this case the electrons entering the aperture are absorbed by the selecting anode directly and the current passing through the output resistor 48 is a function of the difference
40 between the number of electrons absorbed by the selecting anode 29 and those picked up by the collecting anode 25. Output leads 49 are connected to the ends of output resistor and go to the usual amplifier system.

The hook-up shown in Figure 8 differs only in that the potentials of the inner and outer anodes are reversed, the collecting anode being made the more positive. In this case, the high velocity electrons entering the aperture 27 initiate
45 secondaries upon impact with the face of the selecting electrode. These secondaries, being relatively slow moving, are collected by the interior walls of the surrounding collecting anode, in addition to those collected by the same anode
50 from the electron stream. A large increase in current is thereby obtained through the output resistor, thus increasing the signal intensity.

Figures 4, 5 and 6, in my opinion, diagrammatically represent the mean electron paths due to the resultant fields during certain steps in the scanning cycle, the sections being taken with the anode finger showing in cross section. Three
60 views are presented; the scansion of a central point in Figure 5, and that of opposite edge points in the other figures. These figures represent only the distortion of the paths along the particular plane shown, the distortions in other planes probably being even greater, due to the asymmetrical insertion of the anode finger. The
70 views shown, however, fully illustrate the operation, as in all cases the electrons under scansion will have a mean rectilinear path from the point of origin on the cathode to the point of selection,
75 i. e., the scanning aperture, irrespective of the

distortion of the remaining portions of the beam in any plane.

The anode finger when energized creates an asymmetrical, non-uniform electrostatic field and the electrons tend to converge toward the
5 finger along the lines of force of that field. Even though no magnetic focusing is used, however, the normal divergence of the beam will partly compensate for the convergence, so that a condition approximating that shown in Figure 5
10 will obtain, assuming no scanning fields. It is, however, preferable to use a focusing field and thus hold the mean paths as parallel as possible against the tendency of the electrons to converge due to the converging static field. Still
15 assuming that there are no scanning fields in action, the mean paths with the focusing field applied will be substantially as shown in Figure 5, the electrons moving along mean paths which are due to the resultants of the focusing and
20 the static fields, keeping in parallel array until near the finger, those following paths other than rectilinear then swinging inwardly to the finger to be collected. Electrons emitted from an ele-
25 mentary area near the center of the cathode will follow a mean rectilinear path to enter the scanning aperture 27, landing on the selecting anode, all others eventually arriving at the exterior surface of the collecting anode.

When, under the above conditions a varying
30 scanning field is applied to the beam by a scanning coil energized by a scanning oscillator, the beam is moved to one side or the other, as shown in Figures 4 and 6. As the beam is moved, portions of the beam nearest the envelope wall be-
35 come directed at the wall. The electrons in these portions of the beam are unable to follow the lines of force in the resultant field and progress along the envelope surface, becoming more and more crowded as they approach the anode
40 finger. As they near the anode they form a bend 51 on one side of the finger and curve inwardly to finally arrive on the collecting anode. The inner wall of the envelope charges up immediately after scansion starts and remains at
45 a constant potential throughout, not affecting scansion in any way. It is also to be noted that in this device acceleration potentials are high and currents relatively small, so that space charge effects are negligible in determining the
50 paths of the electron.

During the sweep, and during the distortion of the beam, successive portions of the beam are entering the scanning aperture, all of these portions entering the aperture along that portion
55 of the resultant field wherein the mean path from the point of origin on the cathode to the scanning aperture is rectilinear. Thus, while there may be large distortions of the beam in other portions than those selected, there is no
60 divergence from a mean rectilinear path of the electrons under scansion during the entire scanning cycle, and the output current is proportional to the illumination of the successive areas from which the selected electrons emerge.

In the above manner I have been able to dissect an image projected on a photosensitive cathode wherein the electrons emitted from ele-
65 mentary areas of the cathode are not held in spatially undistorted image relationship proportional to the intensity of illumination of the elementary areas during their passage to a selector. All portions of the beam actually selected
70 to initiate the television signal, however, do have an electron intensity proportional to the inten-
75

sity of illumination of the elementary area of the cathode emitting the electrons selected. I have, therefore greatly simplified the construction of the cathode ray dissector tube, not only without sacrificing of detail in dissection, but also with improvement in optical efficiency due to the removal of all screens.

I claim:

1. A photoelectric tube having an envelope and electrodes therein consisting solely of a photosensitive cathode and a pair of concentric anodes, one of said anodes surrounding the other, the exterior anode having an aperture therein disposed toward said cathode.
2. A photoelectric tube having an envelope and electrodes therein consisting solely of a photosensitive cathode and a pair of narrow cylindrical anodes, one of said anodes surrounding the other, the exterior anode having an aperture therein disposed toward said cathode.
3. A photoelectric tube having an envelope and electrodes therein consisting solely of a photosensitive cathode and a pair of concentric anodes, one of said anodes surrounding the other, the exterior anode having an aperture therein disposed toward said cathode, said anodes being energized at slightly differing potentials relative to said cathode.
4. A photoelectric tube having an envelope and electrodes therein consisting solely of a tubular anode, a light-sensitive cathode positioned in front of said anode, and an additional anode positioned inside of said tubular anode and having all except a minute area shielded from said cathode by said tubular anode.
5. A photoelectric tube having an envelope and electrodes therein consisting solely of a photoelectric surface and an opaque tubular anode assembly, means for focusing an optical image on said surface, said anode having an aperture therein positioned to admit a selected portion of the emission from said surface, said anode be-

ing located in the light path of said image, but away from any focus thereof and forming the sole obstruction in said path.

6. A photoelectric tube having an envelope and electrodes therein consisting solely of a photoelectric surface and an opaque tubular anode assembly, means for focusing an optical image on said surface, said anode having an aperture therein positioned to admit a selected portion of the emission from said surface, said anode being positioned in the light path of said image in a location whereby the definition of said image on said surface is not appreciably affected by the shadow of said anode.

7. A photoelectric tube comprising a photosensitive surface, means for forming an optical image on said surface to form an electron discharge therefrom, anode means for accelerating the electrons emitted by said surface in a non-uniform electrostatic field sufficiently distorted to destroy electron image relationship of said electrons, a varying magnetic field adapted to move said discharge, and means for successively intercepting the portion of said discharge wherein the mean path of said electrons from point of origin to the point of selection is substantially rectilinear.

8. A photoelectric tube comprising a photosensitive surface, means for forming an optical image on said surface to form an electron discharge therefrom, anode means for accelerating the electrons emitted by said surface in a non-uniform electrostatic field sufficiently distorted to destroy electron image relationship of said electrons, a varying magnetic field adapted to move said discharge, means for successively intercepting the portion of said discharge wherein the mean path of said electrons from point of origin to the point of selection is substantially rectilinear, and means for separately collecting the remainder of said discharge.

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