

Dec. 9, 1969

H. L. JAFFE ET AL

3,483,565

COLOR ADAPTER FOR MULTIDETECTOR SCANNER

Filed May 21, 1968

4 Sheets-Sheet 1

FIG. 1.

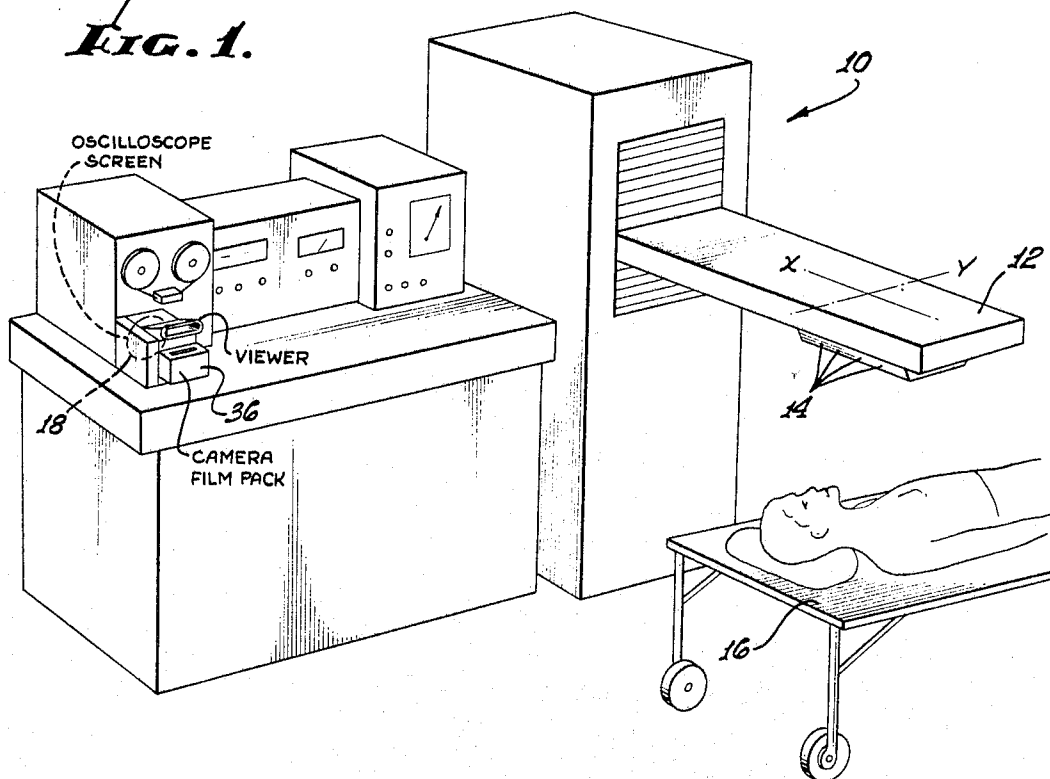
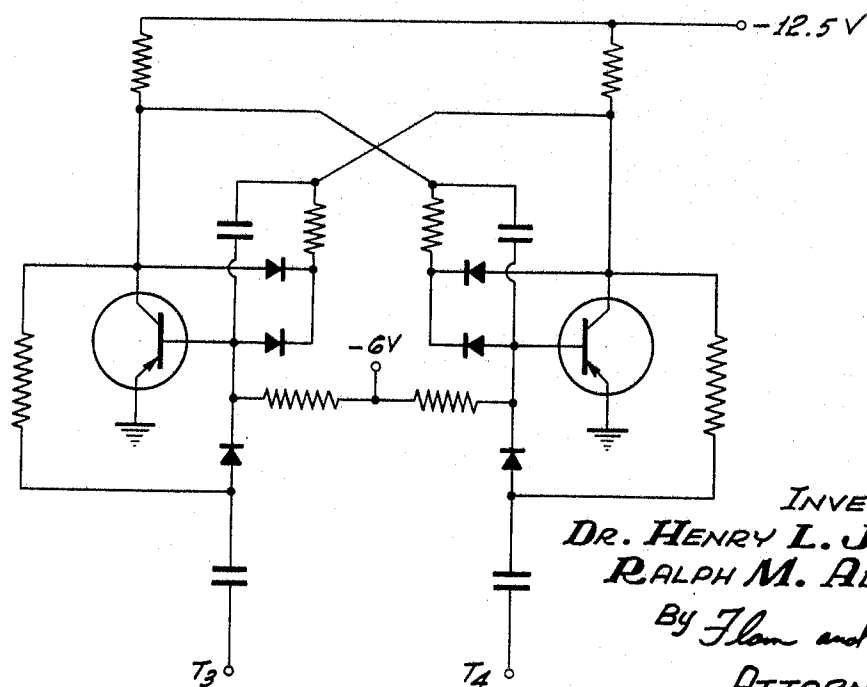


FIG. 4.



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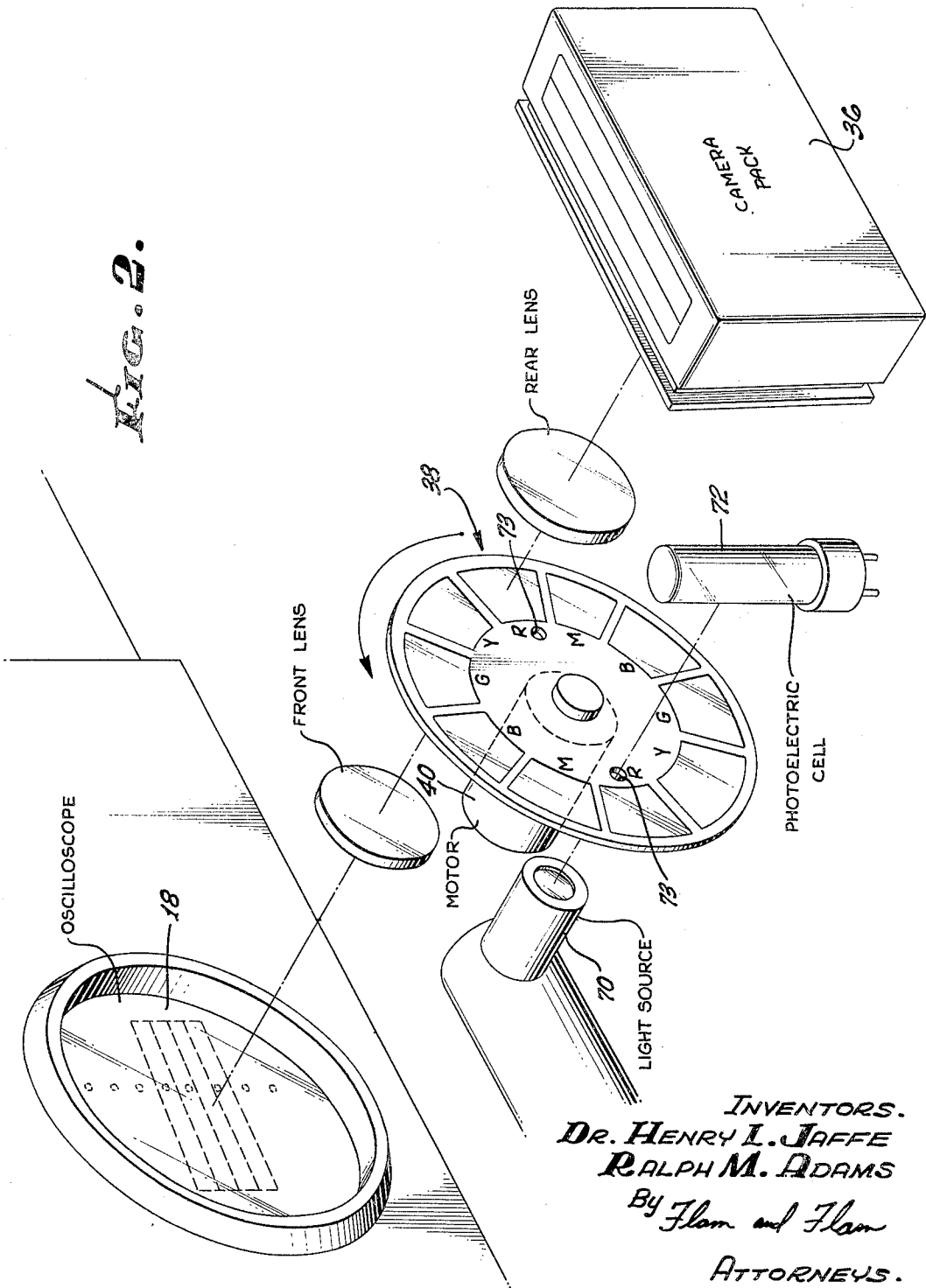
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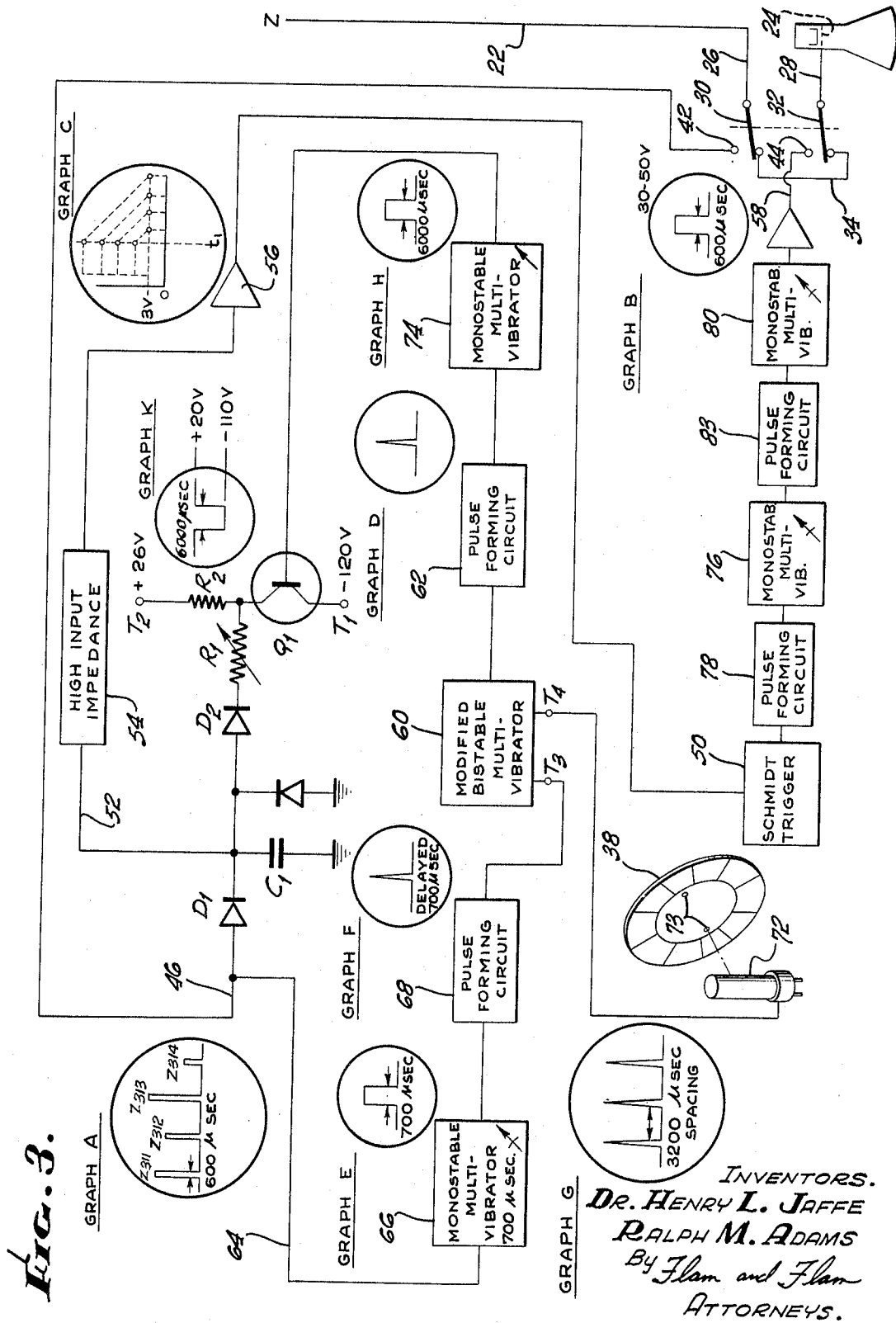
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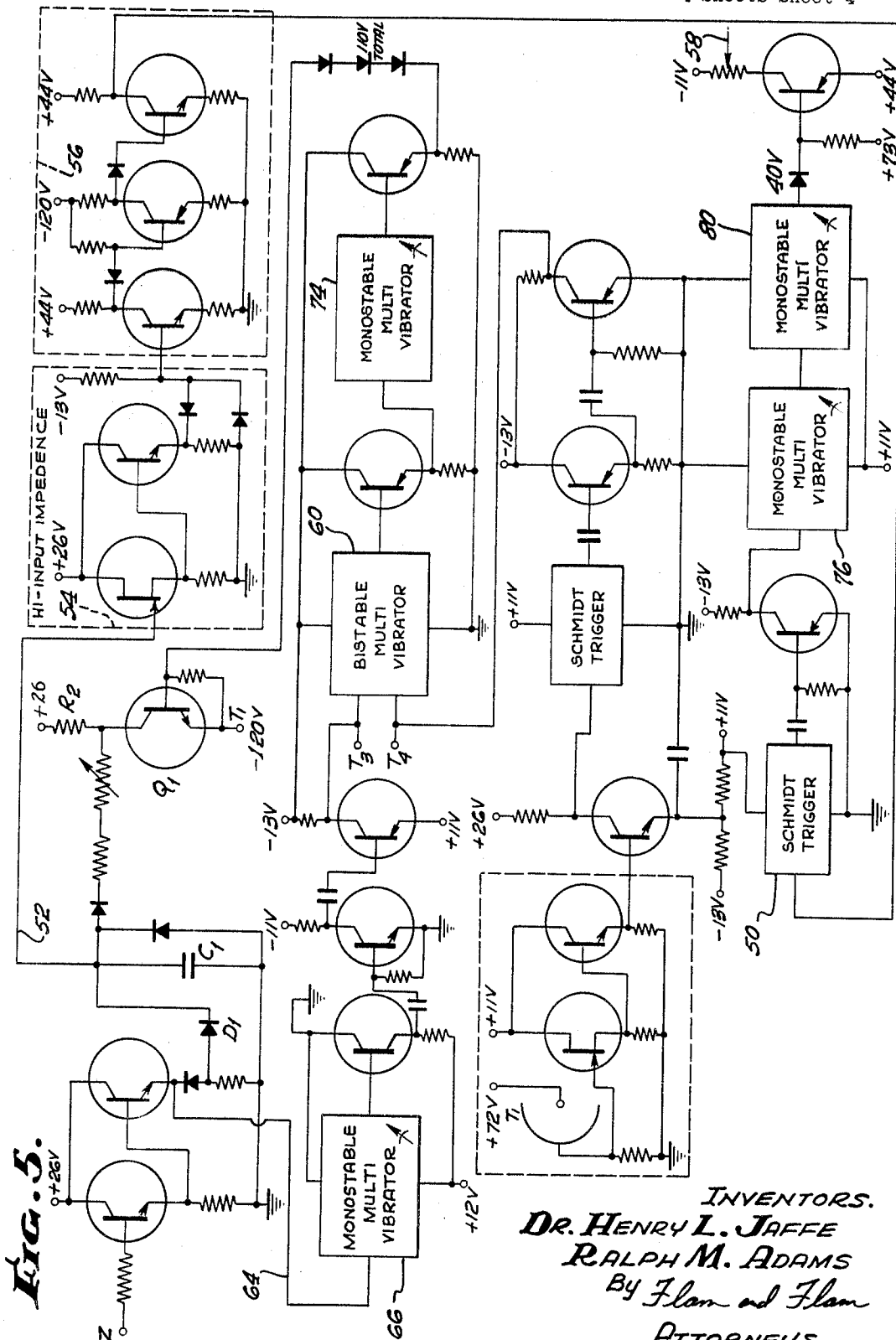
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COLOR ADAPTER FOR MULTIDETECTOR SCANNER

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4 Sheets-Sheet 4



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3,483,565

COLOR ADAPTER FOR MULTIDETECTOR SCANNER

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Filed May 21, 1968, Ser. No. 730,796

Int. Cl. G01d 9/34, 9/42

U.S. Cl. 346—33

20 Claims

ABSTRACT OF THE DISCLOSURE

A photographic color scanning apparatus has a head supporting ten equally spaced detectors that sense radiation. The apparatus produces a time spaced series of z signals corresponding in amplitude to the radiation count of the corresponding detectors. Signals are also produced corresponding to the then positional coordinates of the detector. These signals are normally translated into visual form by a cathode ray oscilloscope and photographed. To provide a color scan, a filter disc is interposed between the oscilloscope screen and the film and rotated at a high rate of speed. The z signal, operates certain logic circuitry instead of directly gating the oscilloscope beam. The oscilloscope beam is gated for a controlled period of time commencing at a time synchronized with the start of the spectral band of the filter disc, and delayed by an amount proportional to the intensity of the z signal. Accordingly, the color characteristic of the photographic image corresponds in color code to the intensity of the z signal.

BRIEF SUMMARY OF THE INVENTION

This invention relates to the methods of making charts showing the distribution of radioactive isotopes in human organs for diagnostic purposes. Such charts are commonly called "scans." In our prior U.S. Letters Patent No. 3,303,508 there is shown and described a system for producing such scans in color whereby shades of concentration are vividly portrayed. The patent shows a single radiation detector that traverses along a pre-selected area. The traverse may be quite slow in order to minimize the ingested or injected dose of radioactive isotope. Scanning with a single detector may take as much as half an hour, depending on the size of the scanned organ. Complete immobilization of the subject is required. Even patients having good self-discipline become fatigued under such difficult circumstances.

In order to remedy this situation it has been proposed to multiply the number of detectors rather than to multiply the dose of radioactive material. Thus for example, Picker Corporation of White Plains, N.Y. produces a machine under the trademark Dynapix. This instrument has ten scintillation detectors mounted on one-inch centers in a straight row along the y direction in an x-y coordinate system. The detectors traverse back and forth a controlled amount in the x direction, indexing each time by a controlled amount in the y direction. After the required number of traverses, the entire field has been scanned by the combined action of the detectors. Various logic circuits, controllers, memory cores, etc. manipulate the data received from the detectors. The ultimate output is partly in the form of a sequence of analog voltage (z) signals corresponding to the intensity of radiation or scintillation counts. Such voltage signals are produced in sequence so that, for example, the third, thirteenth, twenty-third, etc. signals relate to the third detector head. Companion output signals are also analog voltages corresponding to the

then x and y positions of the detectors. These three output signals are used to expose a photosensitive sheet as follows: The oscilloscope beam is gated and modulated by the z signal whereby light intensity is a function of radiation count; and the voltages corresponding to coordinate position are applied to the deflection plates of the scope.

During the scanning, the scope screen has the appearance of a closely spaced row of ten vertically spaced flashing dots, the rows slowly traversing or indexing back and forth in the x direction. The dots appear at a rate that may approach approximately 200 per second. The photograph shows intensity in shades of gray.

The Dynapix has a tape recorder that may substitute for live signals. This minimizes the need for repeating the live scan.

It has proved highly desirable to obtain a scan in colors corresponding to intensity. But due to the high sequencing speed of the signals it is impossible to use any servomechanism for interposing a color filter or other device between the scope screen and the photosensitive sheet.

The primary object of this invention is to provide a simple system for producing colors with a multiple head scanning apparatus of this type. For this purpose, we use a disc interposed between the screen of the oscilloscope and the photosensitive sheet, the disc having a series of substantially contiguous filters in the order of blue, green, yellow, red and magenta. Instead of angularly positioning the disc in accordance with intensity, we continuously rotate the disc at constant high speed and instead, delay the time that the spot appears on the screen in direct proportion to the signal intensity. By suitable controls, the magenta filter is in position when a spot of highest intensity appears, the blue filter is in position when a spot of lowest intensity appears, and the other filters correspondingly in position when spots of intermediate intensities appear.

Another object of this invention is to provide a simple adaptation that requires only minimal modifications of the existing scanning apparatus. For this purposes, the lead to the oscilloscope control grid (z control) is opened and two lead branches provided for connection to the added delay circuitry; the cathode ray screen is changed if need be to provide a wide spectral emission characteristic; and a simple mechanical adaptation is made for installation of the rotating disc and accompanying position sensing apparatus. The x-y signals are not disturbed.

This invention possesses many other advantages and has other objects which may be made more clearly apparent from a consideration of one embodiment of the invention. For this purpose, there is shown a form in the drawings accompanying and forming a part of the present specification. This form will now be described in detail, illustrating the general principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a diagrammatic view showing the major components of the scanning apparatus.

FIG. 2 is an exploded view showing the color adapter components of the system.

FIG. 3 is a simplified system diagram.

FIG. 4 is a schematic diagram of the modified bistable multivibrator.

FIG. 5 is a more detailed system diagram showing some of the shaping, coupling, biasing and isolation circuits between the operational components depicted in FIG. 2.

DETAILED DESCRIPTION

In FIG. 1 there is diagrammatically illustrated a scanning apparatus 10. This apparatus includes traversing head 12 that supports ten detectors 14. The head 12 is sup-

ported above an examining table 16. Suitable tracking control devices cause the head to track and index in a horizontal x - y coordinate system. The ten detectors are equidistantly spaced in a row parallel to the y axis, track in the x direction and index in the y direction. Tracking and indexing are controlled so that the entire field is scanned.

The apparatus 10 produces an image on the screen 18 (see FIG. 2) of a cathode ray oscilloscope. The image comprises a series of vertically arrayed equidistant flashing spots corresponding to the ten detector heads 14. The spots undergo excursions within the confines of ten contiguous imaginary bands corresponding to the rectangular boundaries of traverse of the detector heads. Thus the row of spots traverses in the x direction and indexes in the y direction with the detector heads, until all areas of the oscilloscope bands have been exposed. Suitable controls determine the height and width of the spot according to traverse conditions to ensure complete exposure.

The spots flash in uniform sequence and the intensity of each spot is a function of the radiation count from the corresponding detector. In practice, the flashing frequency is subject to control.

While each spot flashes, control signals are provided in the form of voltages that correspond to x and y coordinate positions of the spots. These signals are applied to the deflection plates of the cathode ray oscilloscope. The apparatus 10 also produces a signal (z) that valves the electron beam of the oscilloscope. This z signal is in the form of a voltage of approximately 600 microseconds in duration, the amplitude of which is directly proportional to the radiation count from the corresponding detector. This signal is applied to a lead 22 (FIG. 3) that normally directly connects to the control grid 24 of the oscilloscope. Thus the intensity of the spot corresponds to intensity of radiation at the corresponding position of the detector.

Two leads 26 and 28 tap into the lead 22 for purposes of adapting the system for color scanning. The leads 26 and 28 connect with arms 30 and 32 of a bistable double pole, double throw switch. In the position illustrated, the arms 30 and 32 are connected together by a lead 34 whereby the lead 22 directly connects to the control grid 24 for normal operation. During such normal operation, a Polaroid or equivalent camera 36 (FIG. 1) photographs the oscilloscope screen 18, whereby a graphic record is produced showing in shades of gray the concentration of radioactive isotopes in the organ under study.

The spots on the cathode ray screen 18 are produced at an adjustable rate with a minimum periodicity of, say, 10,000 microseconds. In order to produce a color scan, a rotating filter 38 (FIG. 2) is provided. This filter is divided into substantially contiguous sectors or frames of different spectral characteristics arranged in spectral sequence. The screen may be divided into any suitable number of sectors or the disc may be spectrally graded if so desired. One or more spectral sets may be provided. In the present instance, there are two sets of five filters having the characteristics of blue, green, yellow, red and magenta, with the blue and magenta filters of the respective sets adjoining. Various combinations of filter colors can be used. They are preferably arranged in spectral order to produce proper blending of shades. The disc 38 is mounted so as to be interposed between the screen 18 and the photosensitive sheet carried by the camera film pack. In practice, the disc is positioned at or near the operative center of the lens system of the camera so that the entire exposed area of the film changes color uniformly and gradually as successive filter segments are operatively positioned. FIG. 2 diagrammatically illustrates lens elements on opposite sides of the disc. A suitable enclosure 39 (FIG. 1) shields the photosensitive sheet from all but the screen 18. A viewer 40 permits monitoring, but does not allow light to enter the enclosure 39.

The disc 38 is mounted for rotation about an axis parallel to but spaced from the lens axis. A motor M (FIG. 2)

rotates the disc at a sufficiently high rate of speed so that the "spectrum" or color pattern is repeated at a rate greater than the maximum flashing rate of the spots to allow at least one spectral sweep for each spot. Preferably, the disc is rotated at a rate of at least 9,400 r.p.m.

The actual time when each spot flashes on the oscilloscope screen 18 is delayed by an amount proportional to z signal amplitude so as to allow interpositioning of a filter sector that denotes such amplitude. This is accomplished by the system diagrammatically shown in FIG. 3. In order to activate the system, the switch arms 30 and 32 are moved to the upper dotted-line position whereby the arms 30 and 32 respectively engage contacts 42 and 44.

In the graph A, the z signals from the lead 22 are depicted corresponding to detector heads 1, 2, 3, etc. The signal z_{311} represents one of the series of signals produced by the first detector. The next signals z_{312} , z_{313} , z_{314} are derived from the second, third and fourth detectors, etc.

A cycle of operation will be described with reference to the signal z_{311} . The signal z_{311} is applied via lead 46 and a rectifying diode D_1 to one plate of a then uncharged capacitor C_1 . The other plate is grounded. The capacitor C_1 charges to a value corresponding to the amplitude of the signal z_{311} . The diode D_1 prevents the capacitor C_1 from discharging back to the lead 46 when the input signal z_{311} subsides. The signal z_{311} immediately "flips" a Schmitt trigger circuit 50. When the trigger circuit is flopped at a delayed time dependent upon the z signal intensity, the oscilloscope beam is gated in a manner to be hereinafter described. The signal z_{311} is applied to the trigger circuit via lead 52, a high impedance isolation network 54, and a D.C. amplifier 56. When the Schmitt trigger 50 is flopped, a square wave signal (graph B) of controlled amplitude and width is supplied via a lead 58, contact 44 and arm 32 to the oscilloscope control grid 24.

The time delay between onset of the signal z_{311} and onset of the oscilloscope gating signal (graph B) depends upon when the input voltage to the circuit 50 drops to a critical value, say, 3 volts. This input voltage depends directly on the charge of the capacitor C_1 . The charge on the capacitor C_1 is allowed to leak off only through a discharge circuit including a diode D_2 , an adjustable potentiometer resistor R_1 , the collector and emitter of a transistor Q_1 to a terminal T_1 that is held at a large negative potential. The high input impedance network 54 does not significantly drain the capacitor C_1 . The collector of the transistor Q_1 is connected through a load resistor R_2 to a terminal T_2 . The terminal T_2 is held at a voltage substantially higher than the maximum voltage of the z signals. Accordingly, when the transistor Q_1 throttles current, the collector has a positive voltage sufficient to back bias the diode D_2 whereby the capacitor C_1 is then isolated from its discharge circuit.

The transistor Q_1 is opened only upon a sequence of events: First, the signal z_{311} must subside to allow the capacitor C_1 to come up to a charge predictably related to the amplitude of z_{311} . Secondly, the spectral pattern provided by the filter 38 must have returned to a starting position. If then the z signal is small, the capacitor charge will be correspondingly small and thus quickly return to a value (graph C) to cause the trigger circuit 50 to flop. The signal depicted at graph B will occur shortly thereafter, whereby the blue sector of the filter 38 is in operative position. If, however, the charge on the capacitor C_1 is high, a longer time will be required for the voltage to drop to the value sufficient to flop the Schmitt trigger 50 (graph C). The grid gating signal (graph B) will be correspondingly delayed so as to allow interpositioning of the magenta sector of the filter 38.

The relationship between z signal intensity and time delay is desirably linear. But the decay characteristics of the capacitor C_1 are inescapably exponential. This is remedied by using only the starting portions of the exponential curves which are virtually straight. This is accomplished by the high negative potential at terminal T_1 .

Adjustment of the potentiometer resistor R_1 changes the slope of the voltage decay curves (graph C). The intercepts with the "flop" voltage accordingly spread out or contract as the resistance of R_1 is increased. By such means, the time span between the "flop" signal of the maximum expected z signal and the minimum expected z signal (or background) can be made to correspond substantially to the time taken for repeat of the spectral pattern. Accordingly, the adjustment ensures use of the entire spectral band.

Even though proper spreading is accomplished, position synchronism is still required so that the minimum or background signal flashes the scope screen when the start of the spectral band is in position and so that the maximum signal flashes the scope screen when the end of the spectral band is in position. This is provided by an adjustable delay circuit associated with the trigger circuit 50, and in a manner to be hereinafter described.

The switching transistor Q_1 is controlled by a logic device that produces a signal only upon the above mentioned sequence: (1) z subsides and (2) spectral pattern positioned. The logic device is in the form of a modified bistable multivibrator 60. The modified bistable multivibrator 60, in this example, is identical to that shown at page 199 of the General Electric Transistor Manual, 7th edition, copyright 1964, except that the input terminal is split in two as shown in FIG. 4. Second and subsequent pulses at the same terminal T_3 or T_4 without interposition of a signal at the opposite terminal, will be ineffective to flip or flop the multivibrator. Thus if the multivibrator 60 is in a flop condition, a signal at the terminal T_3 will switch it to the flip condition. But subsequent signals at the terminal T_3 will have no effect if the multivibrator is then in the flip condition. In order thereafter to switch the multivibrator 60 to the flop condition, a signal must appear at the terminal T_4 . Output may be derived from the collector terminal of one of the transistors.

A pulse-forming circuit 62 (FIG. 3) operates in response to the flop step of the bistable multivibrator to produce a spike or sharp signal depicted at the graph D. The signal at graph D accordingly occurs only when signals have occurred in the proper sequence first at terminal T_3 and then at terminal T_4 .

A signal is provided at the terminal T_3 of the bistable multivibrator 60 at a controlled time following the onset of each z signal. The time delay is just sufficient to allow the z signal to subside, or approximately 700 microseconds. This allows the capacitor C_1 to charge fully as heretofore explained. For this purpose, the z signal is applied via a lead 64 to a monostable multivibrator 66 that is adjusted to provide a controlled 700 microsecond on-time as depicted at graph E. A pulse-forming circuit 68 operates on the off step to produce a spike (graph F) that is delayed 700 microseconds from the onset of signal z_{311} . The spike (graph F) is directly applied to the terminal T_3 .

The other terminal T_4 is pulsed once every time the spectral pattern of the filter 38 repeats. For this purpose, (FIG. 2) the peripheral frame of the filter 38 is interposed between a light source 70 and a photosensitive device 72. The frame has holes or notches 73 to produce a spike (graph G, FIG. 3) every time the spectral pattern repeats. The light source 70 and device 72 are 180° from the lens axis. The notches are about one-half frame ahead of the first or blue filter element which is just adequate to allow the first part of the filter spectrum to be used without wasting time in the flashing cycle of the z signals. Should the disc have but one set of filters, only one hole or notch will be provided.

The bistable multivibrator 60 and circuit 62 accordingly provide a spike (graph D) synchronized with the filter disc 38, but only immediately following a 700 microsecond delay from the preceding z signal. The signal shown at the graph D switches the transistor Q_1 on for a controlled period of time to produce the decay curves (graph

C). This is accomplished by a monostable multivibrator 74 that provides a signal (graph H) having an amplitude matched by suitable means to the operating values of the transistor Q_1 . The width of the pulse (graph H) is adjustable by conventional circuit means incorporated in the monostable multivibrator 74. The one-time of the transistor Q_1 may be 6,000 microseconds, sufficiently short so as to avoid interference with the successive z signals. The voltages on capacitor C_1 have sufficient time to decay to zero potential for any value of z signal before the next cycle of operation. Graph K shows voltage at the collector terminal of transistor Q_1 .

Position synchronism between the grid gating signal (graph B) and the filter disc 38 as heretofore discussed, is achieved by a monostable multivibrator 76 having an adjustable on-time. The multivibrator 76 is turned on in response to the flop step of the Schmitt trigger 50. This is achieved by a pulse-forming circuit 78. The off going step (flop) of the monostable multivibrator 76 produces a spike by the aid of a pulse-forming circuit 83. This spike operates an exposure control monostable multivibrator 80. The monostable multivibrator 80 is adjusted in order to control the on-time of the grid gating signal (graph B) which has a constant amplitude. In practice, the on-time is long enough to allow two different filter segments to be operative. This results in a blending of color shades that enhances readability of the scan.

All of the events described occur before the succeeding z signal z_{312} appears. When the succeeding signal appears, the cycle repeats with filter delay times determined by the amplitude of the next z signal. The signals for plate deflection of the oscilloscope beam operate independently of the position of switch arms 30 and 32.

In FIG. 5 further circuit details are shown, including conventional pulse-forming circuits, amplifiers, isolation and coupling networks, biasing and compensating circuits.

We claim:

1. In photographic color scanning apparatus:

a head having a plurality of radiation detectors spaced from each other in one direction corresponding to the y coordinate of a rectangular coordinate system; a traverse mechanism for moving said head relative to a support in a direction corresponding to the x coordinate and for indexing said head in the y direction; means producing a time spaced series of z signals having amplitudes corresponding to the activity of the detectors along with signals corresponding to the then coordinate position of the corresponding detector;

a holder for a photosensitive sheet;

means producing a spot of illumination for exposing said sheet;

means positioning said spot relative to said sheet at a coordinate position on said sheet corresponding to said coordinate position signals;

means having preselected color coded characteristics interposed between the illumination producing means and said holder;

means rotating said color coded means at a substantially constant rate of speed sufficient to repeat the pattern of said color coded means at a rate faster than the rate of repetition of said time spaced signals; means operating said illumination producing means for a controlled predetermined time period and at a time lagging the recurrence of said color coded means in direct proportion to the amplitude of said z signal whereby the color characteristic of the illumination spot corresponds to the activity of the corresponding detector.

2. The combination as set forth in claim 1 together with bandspreading means to cause the highest amplitude z signal to interpose one end of the color coded means and the lowest amplitude z signal to interpose the other end of said color coded means.

3. The combination as set forth in claim 1 together with adjustable time delay means for position synchronism of said color coded means.

4. The combination as set forth in claim 2 together with adjustable time delay means for position synchronism of said color coded means.

5. In photographic color scanning apparatus:

a head having a plurality of radiation detectors spaced from each other in one direction corresponding to the y coordinate of a rectangular coordinate system; a traverse mechanism for moving said head relative to a support in a direction corresponding to the x coordinate and for indexing said head in the y direction; means producing a time spaced series of z signals having amplitudes corresponding to the activity of the detectors along with signals corresponding to the then coordinate position of the corresponding detector;

a holder for a photosensitive sheet;

means producing a spot of illumination for exposing said sheet;

means positioning said spot relative to said sheet at a coordinate position on said sheet corresponding to said coordinate position signals;

means having preselected color coded characteristics interposed between the illumination producing means and said holder;

means rotating said color coded means at a substantially constant rate of speed sufficient to repeat the pattern of said color coded means at a rate faster than the rate of repetition of said time spaced signals; means gating said illumination producing means for a controlled predetermined time period;

means producing a clock signal synchronized with said color coded means;

means operating said gating means at a time following said clock signal directly proportional to the amplitude of said z signal whereby the color characteristic of the illumination spot corresponds to the activity of the corresponding detector.

6. The combination as set forth in claim 5 together with means adjusting the proportionate relationship between time following said clock signal and the amplitude of said z signal to spread the said z signal over said spectral band.

7. The combination as set forth in claim 5 together with adjustable time delay means for position synchronism of said color coded means.

8. The combination as set forth in claim 6 together with adjustable time delay means for position synchronism of said color coded means.

9. A logic gate including a bistable multivibrator having two separate input terminals and operable to produce a characteristic output only upon a sequence of input signals to said input terminals.

10. In photographic color scanning apparatus:

a head having a plurality of radiation detectors spaced from each other in one direction corresponding to the y coordinate of a rectangular coordinate system; a traverse mechanism for moving said head relative to a support in a direction corresponding to the x coordinate and for indexing said head in the y direction;

means producing a time spaced series of z signals having amplitudes corresponding to the activity of the detectors along with signals corresponding to the then coordinate position of the corresponding detector;

a holder for a photosensitive sheet;

means producing a spot of illumination for exposing said sheet;

means positioning said spot relative to said sheet at a coordinate position on said sheet corresponding to said coordinate position signals;

means having preselected color coded characteristics

interposed between the illumination producing means and said holder;

means rotating said color coded means at a substantially constant rate of speed sufficient to repeat the pattern of said color coded means at a rate faster than the rate of repetition of said time spaced signals;

means gating said illumination producing means for a controlled predetermined time period;

a capacitor;

unidirectionally conductive means charging said capacitor by said z signals;

a trigger circuit that switches to one state upon the existence of a signal of predetermined value and that switches to another state upon absence of a signal of predetermined value;

means operating said trigger circuit in accordance with the voltage of said capacitor;

means operating said gating means after said trigger circuit returns to its said other state;

a discharge circuit for said capacitor;

means switching said discharge circuit on after subsidence of the corresponding z signal and in clock synchronism with said color coded means whereby the color characteristic of the illumination spot corresponds to the activity of the corresponding detector.

11. The combination as set forth in claim 10 in which said discharge circuit includes an adjustable impedance element to spread the said z signals over the said spectral band.

12. The combination as set forth in claim 10 together with adjustable means for controlling the time after said trigger circuit returns to its said other state when said gating means is operated, whereby position synchronism with said spectral band is achieved.

13. The combination as set forth in claim 11 together with adjustable means for controlling the time after said trigger circuit returns to its said other state when said gating means is operated, whereby position synchronism with said spectral band is achieved.

14. The combination as set forth in claim 10 together with means terminating said discharge circuit in a large voltage of a sign opposite that of said z signals, whereby the starting slope of the discharge characteristics is substantially straight; and means clamping the capacitor voltage at zero potential for resetting the capacitor for the succeeding z signal and for minimizing the discharge time.

15. The combination as set forth in claim 14 together with adjustable means for controlling the time after said trigger circuit returns to its said other state when said gating means is operated, whereby position synchronism with said spectral band is achieved.

16. In photographic color scanning apparatus having means producing a time spaced series of z signals corresponding in amplitude to a measured value together with signals corresponding to positional coordinates of the measured value, a holder for a photosensitive sheet, means producing a spot of illumination on said sheet, means positioning said spot relative to said sheet at a coordinate position corresponding to said coordinate signals; the combination therewith of:

means having color coded characteristics interposed between said illumination producing means and said holder and defining one or more spectral bands, with the band ends substantially contiguous;

means rotating said color coded means at a substantially constant rate of speed sufficient to repeat the spectral band at a rate faster than the repetition rate of said time spaced signals;

means operating said illumination producing means for a controlled period of time commencing at a time synchronized with the start of the spectral band and delayed by an amount proportional to the intensity of the corresponding z signal of said series.

17. In photographic color scanning apparatus having means producing a time spaced series of *z* signals corresponding in amplitude to a measured value together with signals corresponding to positional coordinates of the measured value, a cathode ray tube having a screen and means for producing an electron beam, said tube having deflection means for positioning the beam in accordance with said coordinate signals; a camera having a holder for photosensitive material for photographically recording the screen of said tube; the combination therewith of:

a color wheel having graded filter means for producing a coded sequence of color characteristics;
 means supporting said color wheel for rotation with said filter means interposed between said screen and said camera holder;
 means rotating said color wheel at a substantially constant rate of speed sufficient to repeat the color pattern at a rate faster than the repetition rate of said time spaced signals;
 a bistable multivibrator having a pair of input terminals; means forming a control pulse when the bistable multivibrator reassumes one of its states;
 means applying an input pulse to one said multivibrator input terminals to cause said multivibrator to assume its said one state and in response to initiation of the cycle of said color pattern;
 means applying an input pulse to the other of said multivibrator input terminals at a time just following subsidence of the corresponding *z* signal;
 a capacitor;
 unidirectionally conductive means charging said capacitor by said *z* signals;
 a trigger circuit that switches to one state upon the existence of a signal of predetermined value and that switches to another state upon absence of a signal of predetermined value;
 means operating said trigger circuit in accordance with the voltage of said capacitor;
 means gating said electron beam for a controlled period commencing after said trigger circuit returns to its said other state;
 a discharge circuit for said capacitor including a controllable switching device; and
 means producing a signal for switching said device on for a predetermined time and in response to the existence of said control pulse whereby the color characteristic of the photographed image corresponds in the color code to the intensity of the said *z* signal.

18. In photographic color scanning apparatus having means producing a time spaced series of *z* signals corresponding in amplitude to a measured value together with signals corresponding to positioned coordinates of the measured value, a cathode ray tube having a screen and means for producing an electron beam, said tube having deflection means for positioning the beam in accordance with said coordinate signals; a camera having a holder for photosensitive material for photographically recording the screen of said tube; the combination therewith of:

a color wheel having graded filter means for producing a coded sequence of color characteristics;
 means supporting said color wheel for rotation with said filter means interposed between said screen and said camera holder;
 means rotating said color wheel at a substantially con-

stant rate of speed sufficient to repeat the color pattern at a rate faster than the repetition rate of said time spaced signals;

a bistable multivibrator having a pair of input terminals;

means forming a control pulse when the bistable multivibrator reassumes one of its states;

means applying an input pulse to one of said multivibrator input terminals to cause said multivibrator to assume its said one state and in response to initiation of the cycle of said color pattern;

means applying an input pulse to the other of said multivibrator input terminals at a time just following subsidence of the corresponding *z* signal;

a capacitor;

unidirectionally conductive means charging said capacitor by said *z* signals;

a trigger circuit that switches to one state upon the existence of a signal of predetermined value and that switches to another state upon absence of a signal of predetermined value;

means operating said trigger circuit in accordance with the voltage of said capacitor;

means gating said electron beam for a controlled period commencing after said trigger circuit returns to its said other state;

a discharge circuit for said capacitor including a controllable switching device;

a monostable multivibrator operated by said control pulse for producing a signal for switching said device on for a predetermined time and operated by said control pulse;

said discharge circuit including a terminal held at a voltage having a high value in the opposite sense as the said *z* signals, whereby the discharge characteristics of said capacitor are substantially straight;

a diode for preventing said capacitor from acquiring a charge opposite that provided by said *z* signals to reset said capacitor and to limit the reset time.

19. The combination as set forth in claim 17 together with means for adjusting the time following switching of said trigger circuit to its said other state when said gating means is operated; said gating means being operable for a time that is adjustably controlled.

20. The combination as set forth in claim 18 together with means for adjusting the time following switching of said trigger circuit to its said other state when said gating means is operated; said gating means being operable for a time that is adjustably controlled.

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U.S. Cl. X.R.

250—71.5; 346—110