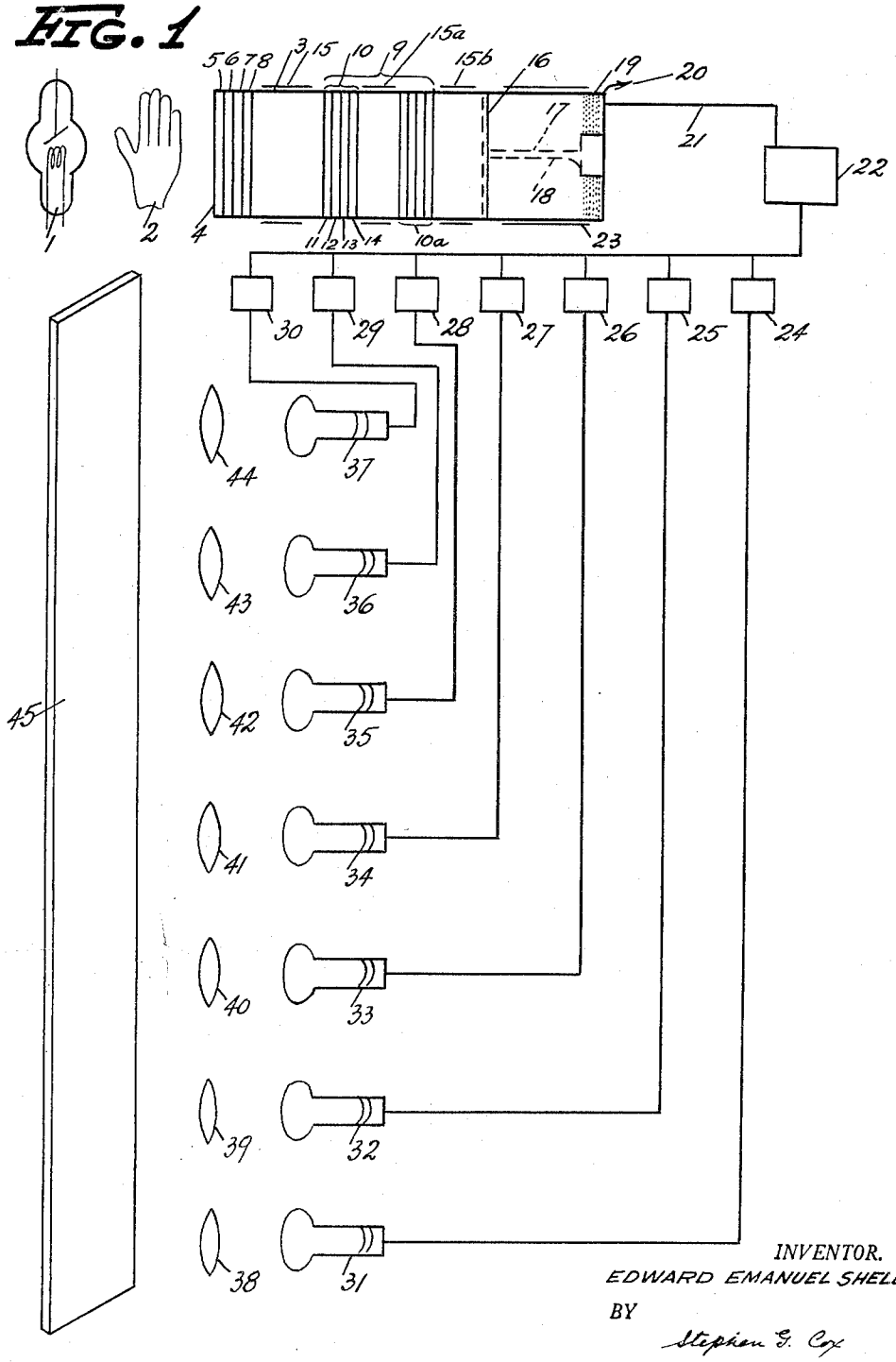
April 22, 1952 E. E. SHELDON 2,593,925

DEVICE FOR COLOR PROJECTION OF INVISIBLE RAYS

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FIG. 1



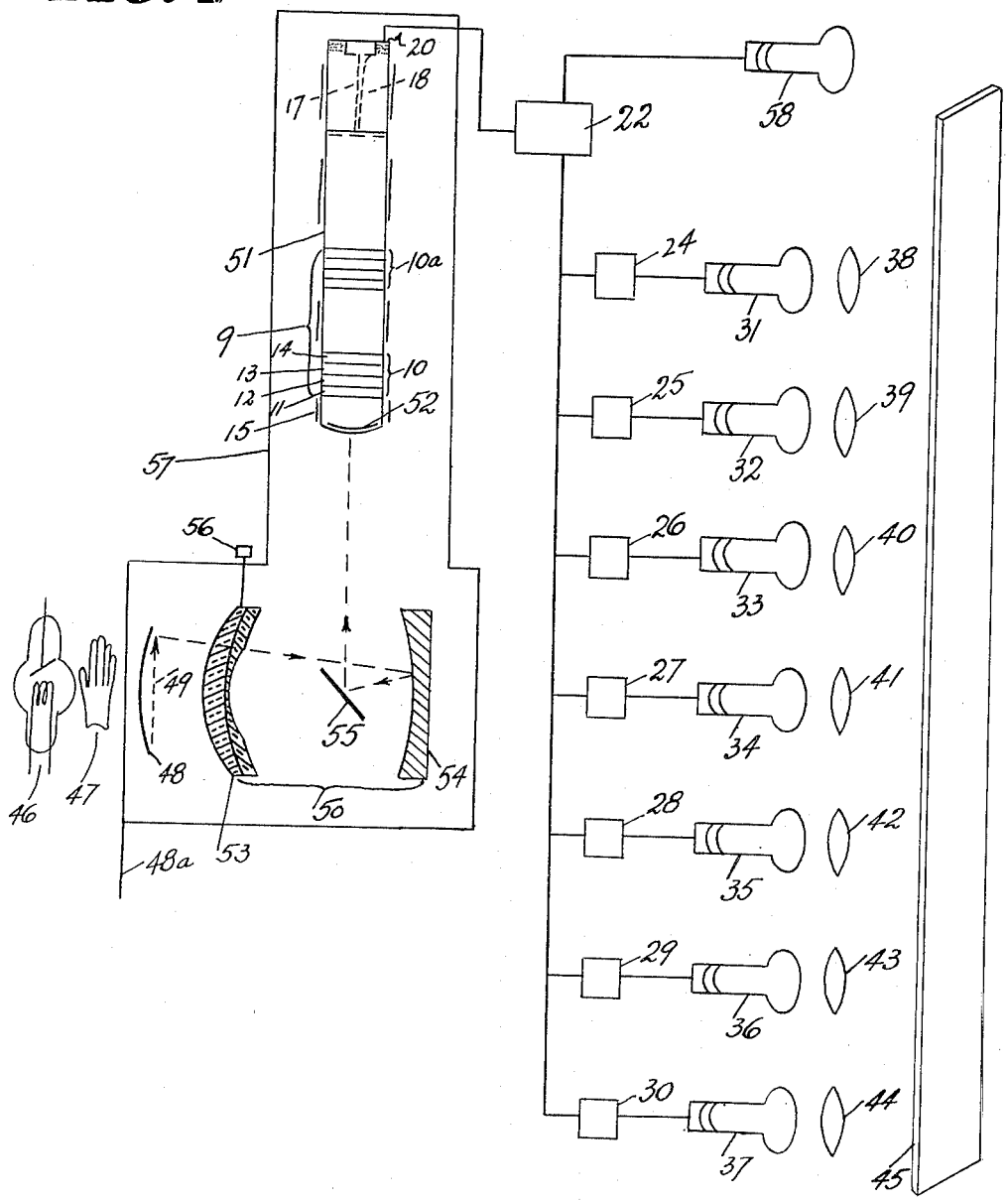

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DEVICE FOR COLOR PROJECTION OF INVISIBLE RAYS

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FIG. 2



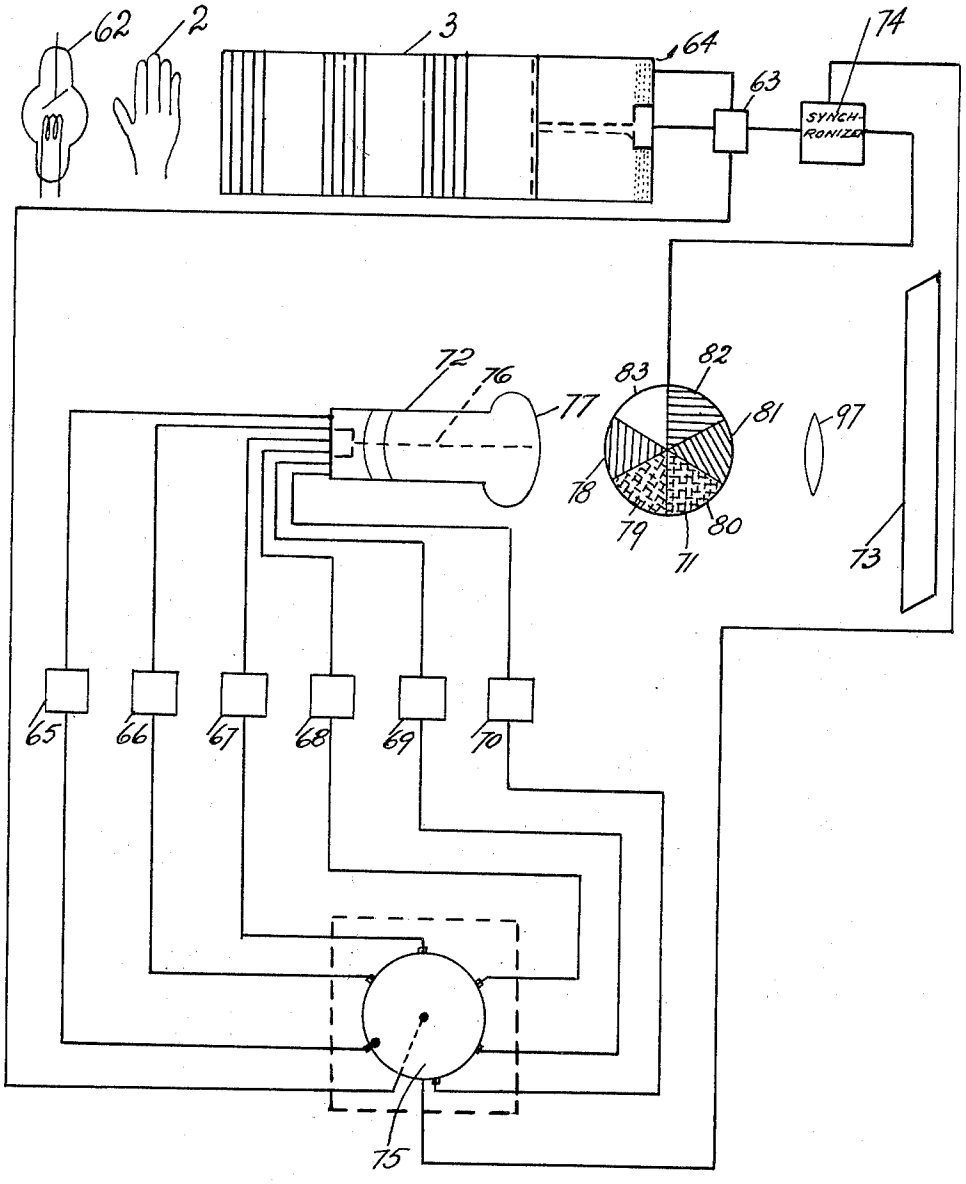

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DEVICE FOR COLOR PROJECTION OF INVISIBLE RAYS

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FIG. 3



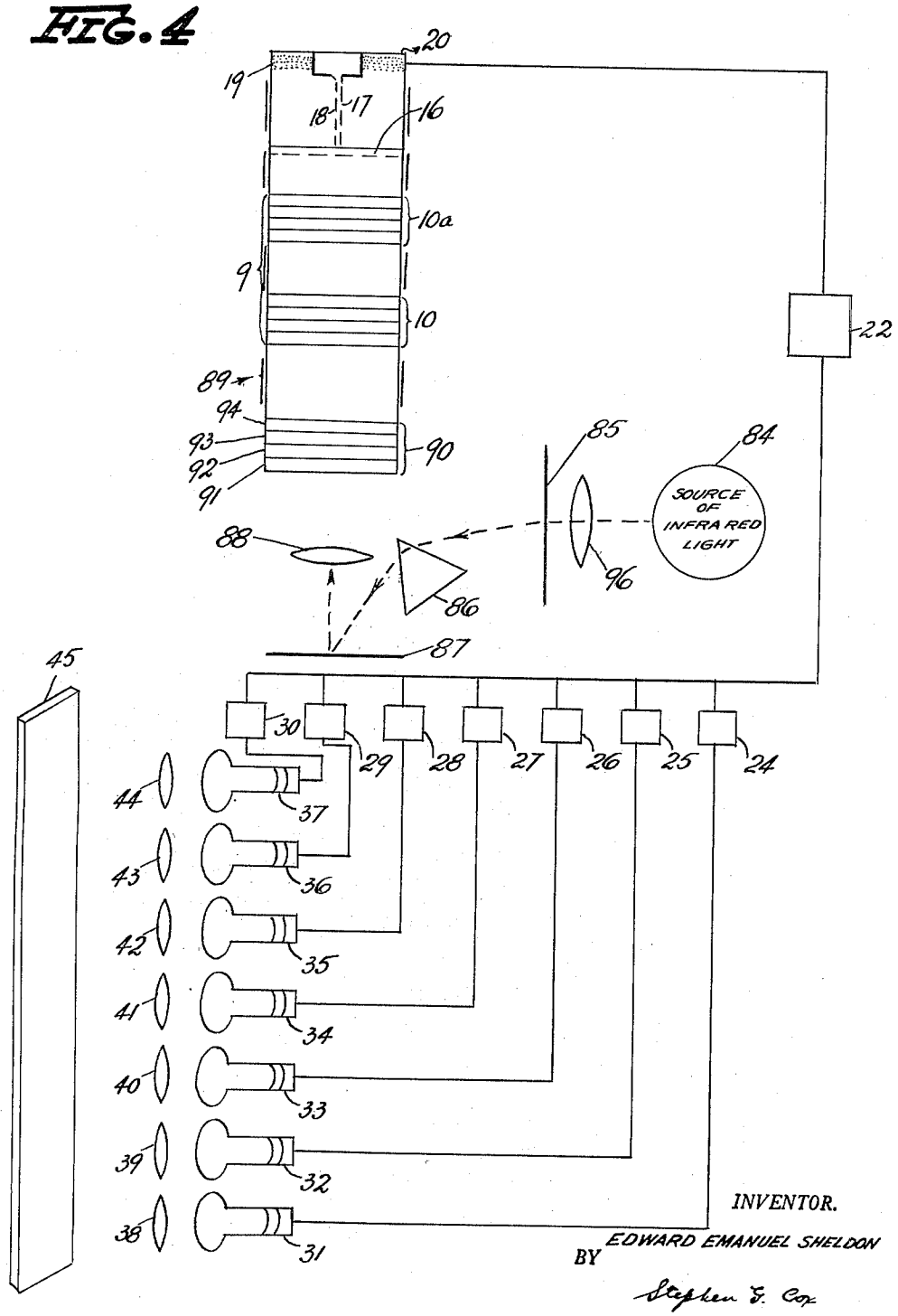

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DEVICE FOR COLOR PROJECTION OF INVISIBLE RAYS

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FIG. 4



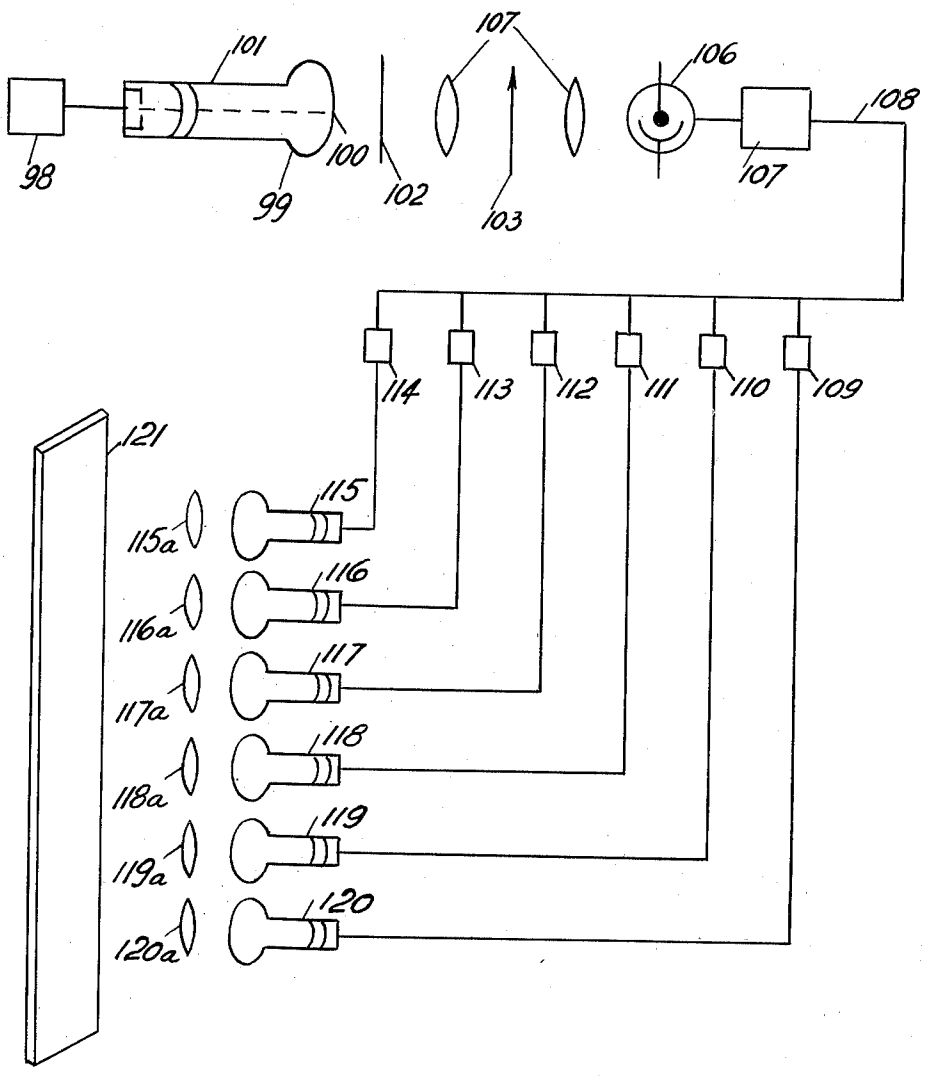

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DEVICE FOR COLOR PROJECTION OF INVISIBLE RAYS

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FIG. 5




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Patented Apr. 22, 1952

2,593,925

# UNITED STATES PATENT OFFICE

2,593,925

## DEVICE FOR COLOR PROJECTION OF INVISIBLE RAYS

Edward Emanuel Sheldon, New York, N. Y.

Application October 5, 1948, Serial No. 52,832

6 Claims. (Cl. 178—6.8)

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My invention relates to producing colored X-ray images which term is meant to include other invisible radiations such as ultra-violet or infra-red and also atomic particles such as electrons and neutrons.

The pattern of the X-ray image consists of gamut of different intensities of transmitted X-rays produced by different absorption values of various parts through which the X-ray beam passed. The absorption of X-rays is controlled by the fundamental law $A=K\gamma Z^4$ in which A expresses absorption, K is coefficient of absorption characteristic for each element, $\gamma$ is wave length of X-rays used and Z is the atomic number of the examined element. In the conventional X-ray films different intensities of transmitted X-rays are expressed in various shades of white and black. In particular light areas in the X-ray film represent complete absorption of X-rays, whereas the dark areas represent good transmission of X-rays. In fluoroscopic examinations we have a similar situation the only difference being that significance of white and black is reversed; it means dark areas here represent absorption of X-rays and lack of transmission, while light areas indicate good transmission of X-rays. It is well known that the X-ray diagnosis is based primarily on presence of various shades of black and white in the examined X-ray picture. Unfortunately the number of shades which X-ray film is able to register is very limited and in addition it is further reduced by the scattered X-ray radiation. The same limitations prevail in X-ray fluoroscopy.

It is therefore the purpose of my invention to provide the method and device for recording plurality of transmitted X-ray intensities present in the X-ray image by means of various colors, each color corresponding to a predetermined X-ray intensity. In this way colored X-ray images are obtained which obviously will present much more information about distribution of X-ray intensities than the present black and white images and therefore will offer much greater diagnostic possibilities.

Another purpose of this invention is to produce colored cinematographic X-ray pictures in order to record motion of examined bodies.

Another purpose of this invention is to produce color X-ray images for fluoroscopic examination.

The X-rays have no colorimetric values for the X-ray film, it means the X-ray film emulsion does not register different colors in response to different intensity of X-rays, nor in response to

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their different wave length. The same is true about the phosphors responding with fluorescence when excited by X-rays and which are used in fluoroscopic screens. The translation of X-ray intensity into chromatic values is accomplished in my invention by converting X-ray images into electronic images, transforming electronic images into plurality of electric signals representing point images and assigning different color values to said electronic signals according to their amplitude. In particular the invisible X-ray image is converted in the X-ray image intensifying tube into fluorescent image and then into photoelectron image. The photoelectron image after intensification by cascade amplification, electron-optical diminution and secondary emission is stored and then is scanned by electron beam. The electron point images obtained by scanning are converted after multiplication into video signals and are transmitted to amplifiers. The amplified video signals operate so-called stripping or discriminating circuits which are so designed that each of them responds only to certain arbitrarily chosen range of amplitude of said signals. We may arbitrarily divide intensities of transmitted X-rays into desired number of groups and assign to each group separate discriminating circuit. For example, the strongest signals will be assigned to the discriminating circuit connected with the blue color, the weakest signals may be represented by the red color and the intermediate strength signals may be expressed by remaining colors. Each discriminating circuit is connected separately with one receiver tube. There are obviously as many receiver tubes as many colors we want to have in the final X-ray image. Each kinescope produces one color only either by the use of special phosphor in its screen having sharply defined spectral emission or by means of colored filter in front of white fluorescent screen. Each kinescope receives video signals belonging only to one group of amplitude as it is operated by one discriminating circuit. Therefore each kinescope produces only a fragment of the total X-ray image and only in one color. The partial images from the receiver tubes are projected simultaneously on the viewing screen through the optical system and blend into one complete multicolor image due to observer's persistence of vision. In this way multicolor X-ray images are obtained with various colors representing different X-ray intensities.

It is obvious that the principle of my invention may be applied not only to X-ray images but

also to images produced by ultra-violet or by infra-red rays as well as by atomic particles such as electrons or neutrons. It is also evident that my invention applies not only to images produced by transmitted radiation but also to images obtained by reflected radiations or by scattered radiation.

The invention will be better understood when taken in connection with the accompanying drawings.

In the drawings—

Fig. 1 represents diagram of all-electronic device for producing X-ray color images;

Fig. 2 represents a modification of this invention in which alternate form of X-ray image intensifying device is shown;

Fig. 3 represents diagram of this invention in which electro-mechanical system for producing X-ray color image is shown;

Fig. 4 illustrates the form of this invention to produce multicolor infra-red images;

Fig. 5 illustrates the application of the invention to produce multicolor ultra-violet images.

Referring now to Fig. 1, there is shown X-ray source 1, body 2 to be examined and X-ray image intensifying tube 3. The face 4 of X-ray intensifying tube 3 must be of a material transparent to the type of radiation to be used. Inside of the face of the tube there is a very thin light reflecting aluminum layer 5 which prevents the loss of light from the fluorescent screen 6. An extremely thin barrier layer 7 separates the fluorescent screen 6 from the photo-emissive layer 8. The fluorescent screen 6 and photo-emissive layer 8 should be correlated so that under the influence of the X-rays used there is obtained a maximum output of photoemission. More particularly the fluorescent screen should be composed of a material having its greatest sensitivity to the X-rays to be used, and the photoemissive material likewise should have its maximum sensitivity to the wave length emitted by the fluorescent screen. Fluorescent substances that may be used are zinc silicates, zinc selenides, zinc sulphide, barium sulphate or calcium tungstate with or without activators. The satisfactory photoemissive materials may be caesium oxide activated by silver, caesium with antimony, with bismuth or antimony with lithium or potassium. The barrier layer 4 between the fluorescent and photoemissive surfaces may be an exceedingly thin transparent film of mica, $ZnF_2$, silicon or of a suitable plastic.

The photoelectron image obtained and stored in the photoemissive layer 8 is now projected on the first screen 10 of the amplifying section 9 having one screen 10 or a few successively arranged amplifying screens 10*a* by means of focusing magnetic and/or electromagnetic fields 15 which are not indicated in detail since they are well known in the art.

The amplifying screen 10 consists of electron pervious light reflecting layer 11, an electron fluorescent layer 12, a light transparent barrier layer 13 and photoemissive layer 14. Fluorescent substances that may be used for amplifying screens 10 and 10*a* are zinc silicates, zinc sulphide, barium sulphate or calcium tungstate with or without activators. The satisfactory photoemissive materials will be caesium oxide activated by silver, caesium with antimony, or antimony with lithium or potassium. The barrier layer 13 between the fluorescent and photoemissive surfaces can be an exceedingly thin light



transparent film of mica, $ZnF_2$ or ZnS, silicon or of a suitable plastic. The electrons emitted from the amplifying screen 10 are accelerated and electron-optically diminished by means of magnetic or electromagnetic fields 15*a* and projected on the next amplifying screen 10*a*. Next the electron images are focused by means of magnetic or electromagnetic fields 15*b* on the target 16 where they are intensified by secondary emissions and are stored. The target 16 is scanned by slow electron beam 17. The latter is modulated by the electron pattern on the target so that returning electron beam 18 brings the charges corresponding to the electron point images on the target to the multiplier section 19. They are intensified there by secondary emission and then sent in the form of video signals 20 by coaxial cable 21 or by high frequency transmission to the amplifier 22. The X-ray intensifying pick-up tube used in this invention can be of intensity modulation type, of deflection modulation type, of velocity moludation type, of photo-emissive type and it is obvious that various types of pick-up tubes can be used without affecting the basic idea of this invention. The synchronizing and deflecting circuits 23 are not indicated in detail as they are well known in the art.

In the amplifiers 22 said video signals are intensified. The relative amplitudes of video signals depend essentially on the strength of transmitted X-rays because, as explained above, they are produced by them. In the X-ray examination of human body the energy of transmitted X-rays, when using conventional X-ray equipment varies from 0.001 r up to 1 r.—0.001 r corresponds to radiopaque parts of the body such as e. g. abdomen, while higher X-ray values correspond to radiolucent parts such as lungs. In order to obtain colorimetric representation of various transmitted X-ray intensities, I arbitrarily assign different colors to X-ray signals of different energy. In particular the range of X-ray energy between 0.001–0.015 r has assigned red color, the range of X-ray energy from 0.015 to 0.03 r has orange color, from 0.03 to 0.45 to yellow color, from 0.45 to 0.60 r green, from 0.60 to 0.75 r blue, from 0.75 to 0.90 r violet and above 0.90 r white color. In industrial X-ray work the assignment of colors will be different depending on the examined object. In general the number of colors used and significance of each color in terms of transmitted X-ray energy will vary in different types of X-ray examinations. Each of these groups of X-ray energies will produce as its counterpart corresponding group of video signals. The video signals after amplification activate the discrimination circuit. There are as many discrimating circuits as there are groups of video signals and as many colors we want to have in final X-ray image. In this case I am making use of seven discriminating circuits 24, 25, 26, 27, 28, 29, and 30. Each group of video signals has assigned only one discriminating circuit, which it is able to activate. The discriminating circuits are so designed that each of them responds to signals only of certain amplitude range. This can be accomplished by electronic tubes which are biased at different cut-off voltages. Such circuits are described in detail in the article by H. F. Freundlich, E. P. Hincks, and W. I. Ozeroff, "A Pulse Analyzer for Nuclear Research" published in the Review of Scientific Instruments, volume 18, page 19, 1947. An article by Kenneth Raulston entitled "A Simple

Differential Pulse Height Analyzer" in the publication Nucleonics, volume 7, page 27, October 1950, also describes such discriminating circuits. It is obvious that there are many forms of discriminating circuits such as e. g. using thermionic tubes instead of vacuum tubes and it is understood that any of these alternative forms may be used in this invention without departing from the scope thereof.

Each discriminating circuit fed into its proper receiver tube and there are as many receiver tubes **31**, **32**, **33**, **34**, **35**, **36** and **37**, as there are discriminating circuits. Each receiver tube produces a different color. The color may be obtained by selecting special phosphors for the screen of each kinescope, which have fluorescence sharply limited to one spectral region, or by placing various color filters in front of conventional kinescopes producing white fluorescence. All kinescopes are identical except for their phosphors. As each kinescope tube has various color phosphors, equalizing circuits are incorporated in the amplifiers **22** in order to compensate for different persistence of said phosphors. Each kinescope has an associated projecting lens and deflection yoke. The scanning rasters theoretically should be identical and properly positioned within a fraction of the width of a scanning line. It is possible however in practice to have a considerable inaccuracy in registration without any detrimental results. The scanning rasters are made uniform by using identical yokes in all kinescopes, connecting them in parallel instead of in series and supplying them with power from the same deflecting circuits.

Video signals from the amplifiers are segregated by discriminating circuits into seven groups according to their energy and are distributed to respective kinescopes. Each kinescope produces therefore only a fragment of the original X-ray image and in one color only.

The partial images produced by all kinescopes are projected simultaneously by the optical lenses **38**, **39**, **40**, **41**, **42**, **43** and **44**, associated with each kinescope on the viewing screen **45**. The partial images projected by the optical means must not differ from one another in geometric distortion. Superimposition of all these partial images creates a complete multicolor images due persistence of vision of the observer. In this way multicolor X-ray images are obtained.

The multicolor X-ray images on the viewing screen may be photographed or cinematographed. A modification of this invention is shown in Fig. 2. In this embodiment the invisible X-ray picture is first converted into fluorescent X-ray picture in the fluoroscopic screen and only then projected by the optical system onto X-ray image pick-up tube for conversion into electric signals necessary for color reproduction.

Referring now to Fig. 2, there is shown an X-ray source **46**, the examined body **47**, the fluoroscopic screen **48**, the fluorescent X-ray image **49**, the optical system **50** and the X-ray image intensifying tube **51**. The X-rays after the passage through the examined body from an invisible X-ray image which is converted in the fluoroscopic screen **48** into fluorescent X-ray image **49**. The fluorescent image is projected by the reflective optical system **50** on the photocathode **52** of the X-ray image intensifying tube **51**. The optical system **50** in this form of invention must have the greatest possible speed as



the fluorescent X-ray image **49** is of weak luminosity. The reflective optical system of Schmidt type requires precise workmanship, as the aspheric correcting plate is of a shape which is described mathematically as a curve of the fourth degree. Such a plate cannot be produced by machine with precision necessary for high speed and good resolution. Therefore I am making the use in this invention of the optical system belonging to the family of so-called "wide field fast cameras" described by L. C. Henyey and Jesse L. Greenstein in OSRD Report No. 4504 which optical system can be manufactured in quantity with necessary precision. This optical system does not require an aspherical correction plate and consists essentially of a meniscus lens and of a concave spherical mirror. All optical surfaces have a common center of curvature located at diaphragm which limits the entering light. I modified this optical system for purposes of my invention by using in addition a plane or convex spherical mirror located approximately at the focal plane of the concave spherical mirror. The operation of this optical system is shown in Fig. 2. The fluorescent X-ray image is produced by invisible X-ray image on the fluoroscopic screen **48** which has curved surface in order to eliminate spherical aberration. The fluorescent light rays pass through the correction meniscus lens **53** and are reflected by aluminized concave spherical mirror **54** onto the plane reflecting mirror **55** placed at the focal point of the concave mirror. The light rays are reflected from the mirror **55** onto the photocathode **52** of the X-ray image intensifying tube **51** which is disposed outside of the axis of the optical system **50** so that it does not obstruct the path of the fluorescent rays from the fluoroscopic screen through the optical system. The fluoroscopic screen **48**, the optical system **50** and X-ray image intensifying tube **51** are enclosed in lightproof box **57** in fixed position to each other in order to avoid need for focusing at each examination. In case of maladjustment focusing can be accomplished by means of lock screw mechanism and micrometer adjustment screw **56** which shifts the meniscus lens along the optical axis. For proper positioning of the box **57** in relation to the examined part of the body a separate fluoroscopic screen **48***a* attached outside of the box **57** and monitor receiver tube **58** are utilized. The fluorescent X-ray image produces in the photoemissive photocathode **52** photoelectron image, which is projected on the first composite screen **10** of the amplifying section **9** by means of focusing magnetic or electromagnetic fields **15** which are not indicated in detail since they are well known in the art. The amplifying composite screen **10** consists of electron pervious light reflecting layer **11**, of fluorescent layer **12**, of light transparent barrier layer **13** and of photoemissive layer **14**. The photoelectron image after intensification by cascade amplification in screens **10** and **10***a*, electron-optical diminution and by secondary emission is stored in the target **16** and is scanned by electron beam **17**, is multiplied and converted into video signals **20**, as was explained above. Video signals are transmitted to amplifiers **22** and operate discriminating circuits **24**, **25**, **26**, **27**, **28**, **29** and **30** and color reproducing receiver tubes **31**, **32**, **33**, **34**, **35**, **36** and **37** producing multi-colored X-ray images, as was described above.

Fig. 3 shows another modification of this inven-

tion in which electromechanical color means are used. The X-ray source 62 produces invisible X-ray image of the examined body 2. The invisible X-ray image is projected on the X-ray image intensifying tube as described and illustrated above and is converted into video signals 64 which are transmitted to amplifiers 63, as was explained above. All video signals are arbitrarily segregated in number of groups according to their strength. Each group of video signals has one color assigned to it. The strongest signals may be characterized by blue color, weaker signal by green color, still weaker by orange color and the weakest signals e. g. by red color. Each of these groups of video signals is associated with one discriminating circuit which it can activate without affecting the remaining circuits. The discriminating circuits 65, 66, 67, 68, 69 and 70 are connected with receiver tube 72 producing white and black images on the fluorescent screen 77. The color wheel or disc 71 is disposed in cooperative relation with the receiver tube 72 and the viewing screen 73. The color wheel has a red filter 78, orange filter 79, yellow filter 80, green 81, blue 82 and white 83. The synchronizing circuit 74 controls the 6-way connector 75 in such a way that video signals from successive frames reach the discriminating circuits in predetermined order. It means video signals from the first frame of the pick-up tube can reach only the discriminating circuits 65 and only the weakest video signals can activate it. The video signals from the next frame can reach only the discriminating circuit 66 and only the next group of video signals of predetermined strength can activate it. This process is repeated in succession until all discriminating circuits have been used and then this cycle repeats itself.

Each discriminating circuit allows the passage of video signals of a certain predetermined amplitude. The video signals which passed the discriminating circuit are transmitted to the receiver tube and are transformed there into fluorescent white and black partial images by the action of electron beam 76 on the screen 77. The color wheel 71 is rotating also under the control of synchronizing circuit 74, so that the red filter 78 is positioned in front of the receiver tube 72 at the same time when connector 75 is making connection with the discriminating circuit 65 which serves to transmit only the group of video signals of an amplitude, which has been predetermined, is to be represented by the red color. In the same way the orange filter is synchronized with the discriminating circuit 66, yellow filter 80 with discriminator circuit 67 and so forth. It is apparent that in order to produce 6-color X-ray image, six X-ray images must be transmitted in a rapid succession from the X-ray image intensifying tube 3 to the receiver tube 72. If these six X-ray images are projected by the optical system 97, on the viewing screen 73 in fast succession they will blend in one multicolor image due to observer's persistence of vision. In order to avoid the flicker the complete multicolor image must be repeated at the rate 30–40 times a second. As each complete multicolor image consists in this case of six partial single color images, it means that each partial image cannot last longer than approximately $\frac{1}{200}$ second. The partial single color image represents one frame of the X-ray image intensifying tube. The X-rays are usually generated by sixty cycles per second current. In this case however X-ray impulses of about $\frac{1}{200}$ second are necessary. This can be accomplished by operating the X-ray source 62 by means of a radar pulse generator. The shorter time of X-ray exposure obviously necessitates proportionally stronger X-ray beam. In this way, multicolored X-ray images are produced without the need of several receiver tubes, with a disadvantage however of using much greater amount of X-ray energy for each examination.

Fig. 4 illustrates the operation of this invention in case as a source of depicting radiation invisible light such as e. g. infra-red or ultra-violet is used. The infra-red rays from the infra-red lamp 84 are focused by optical system 96, pass through the filter 85 transmitting only infra-red, are refracted by the prism 86 of material transparent to infra-red on the examined body 87. The infra-red rays reflected from the examined body are focused by the optical system 88 on the photocathode of the infra-red intensifying pick-up tube 89. The photocathode of said tube may be of caesium silver oxide if short infra-red rays are used. In case the source of radiation is infra-red of longer wave length, it is preferable to use a composite photocathode 90 consisting of infra-red transparent, fluorescent light reflecting layer 91, of phosphor layer 92 fluorescent under excitation by the long infra-red rays and of the photoemissive layer 94 sensitive to fluorescent light emitted by said phosphor; layers 92 and 94 being separated by barrier layer 93 transparent to said fluorescent light. The infra-red image is converted in the composite photocathode 90 into photoelectron image. The photoelectron image after intensification is converted into video signals 20 and transmitted to the amplifier system 22 as was described above.

Video signals after amplification operate discriminating circuits 24, 25, 26, 28, 29 and 30 and color producing receiver tubes 31, 32, 33, 34, 35, 36, and 37 and create multicolored visible images as was explained above, having the pattern of original infra-red images.

In case ultra-violet rays are used the photocathode of the pick-up tube should be preferably of caesium on antimony or of K—Cs—Sb and the optical system and the face of the intensifying pickup tube should be of quartz or of other U—V transparent material. The remaining parts of the system are the same as described above.

It is obvious that this invention can be used in the same manner to produce colored microscopic images without staining the examined objects and irrespectively whether the source of depicting radiation is visible light, invisible light or the electron beam of an electron microscope. In case this invention should be used in electron-microscopy, the electron beam of the electron microscope after passage through the examined body is converted into fluorescent image. The latter is projected by optical system on the photocathode of pick-up tube and is converted thereby into video signals. The video signals after assigning them chromatic values, as was explained above, are reconverted into multicolor images for inspection or photographic recording. Instead of using the optical projection of said fluorescent electron image, the electron image may be converted into photoelectron image by means of composite screen having light reflecting layer, electron fluorescent layer, light transparent separating layer and photoemissive layer, which screen is disposed in the vacuum tube in the path of electron beam carrying the invisible image of the examined body. The photoelectron image obtained

in this way is converted by usual television means into video signals. Video signals after passage through discriminating circuits have assigned to them various chromatic value, as was explained above, and are reconverted into multicolor images for inspection or recording. When strong electron source is available, the electron beam carrying the invisible electron image may be projected on the photoemissive photocathode of the pick-up tube, without prior conversion into fluorescent image, and is transformed thereby into secondary electron image. The latter is converted by television means into video signals. Said video signals after passage through discriminating circuits have assigned to them chromatic values, as was explained above, and are subsequently reconverted by electro-mechanical or by all-electronic means into multicolor images for inspection or recording.

The scanning electron beam carrying the invisible electron image of the examined body may be also projected directly on the cathode of the electron-sensitive multiplier tube without its prior conversion into fluorescent image, and is transformed thereby into video signals. Said video signals after passage through the discriminator circuits, as was explained above, have assigned to them chromatic values according to their energies and are subsequently converted by receivers into multicolor image.

Another modification for producing colored U—V or other light images is shown in the Figure 5. In this form of invention, the ultra-violet radiation is produced by the kinescope **99** operated by independent signal generator **98** and having screen **100** of ZnSAg. This screen when excited by electron beam **101** is emitting besides the visible fluorescence also the invisible ultraviolet fluorescence of a very short persistence. The visible fluorescence is removed by the filter **102**, so that only ultra-violet light is reaching the examined body **103**. The scanning action of the electron beam **101** in the kinescope produces scanning illumination of the examined body with ultra-violet light point after point until all said body has been illuminated. The ultraviolet rays which pass through examined body and which represent separate image points of said body are projected in succession by the optical system **104** on the ultra-violet sensitive phototube **105**. Each ultra-violet light image point is converted in the phototube **105** into electron discharge which after intensification by electron multiplication produces electrical signals **106**. These signals represent the pattern of the ultra-violet image and are transmitted in succession from the phototube to the amplifiers **107**. The signals from the amplifier are sent by coaxial cable **108** to the discriminating circuits **109**, **110**, **111**, **112**, **113** and **114**. Each discriminating circuit is in cooperative relationship with one receiver. Therefore, there are as many receivers **115**, **116**, **117**, **118**, **119** and **120** as there are discriminating circuits. Each receiver has different color producing phosphor screen. As was explained above, each of the discriminating circuits, passes to the receiver which is connected with it, signals only of certain predetermined range of amplitude and rejects all other signals. In this way we may arbitrarily assign various colors to different groups of signals. By distributing said video signals according to their amplitude to various receivers, we produce in each receiver a fragment of the original ultra-violet image in one color characteristic for the particular receiver. All these fragments of the image are projected simultaneously on the viewing screen **121** by lenses **115***a*, **116***a*, **117***a*, **118***a*, **119***a* and **120***a*, whereby we receive a complete multicolor image having the pattern of the original ultra-violet image.

In case the examined body is immovable we may make the use as a source of the ultra-violet radiation of the mercury arc. In order to produce scanning type of illumination by means of mercury arc we have to resort to a mechanical system such as, oscillating mirror or revolving wheel provided with multiple mirror or lenses.

This invention may also be applied to images produced by reflected ultra-violet radiation. It is obvious that this method will have its principal field of application in U—V microscopy. It is also evident that this modification may be also used for X-ray examination, as well as electron microscopy. In the latter case, the scanning electron beam will replace ultra-violet light as a depicting radiation. The scanning electron beam after passage through the examined body is producing fluorescent scanning image of said body of short persistence. Said fluorescent image is projected on the phototube and is converted thereby into video signals which after assigning to them chromatic values, as was explained above, are reconverted into multicolored image for inspection or recording.

Although the particular embodiments of this invention have been demonstrated, it is understood that modifications may be made by those skilled in the art without departing from the true scope and spirit of the foregoing disclosure.

What I claim is:

1. A device for producing colored X-ray images comprising in combination, X-ray means for irradiation of the examined body, X-ray sensitive means for receiving X-ray images of said body, means for converting said X-ray images into electrical signals, means for segregating said signals according to their amplitude, means for assigning different chromatic values to said segregated signals and means for reconverting said electrical signals into multicolor visible images.

2. The device for producing colored X-ray images comprising in combination, X-ray means for irradiation of the examined body, X-ray sensitive means for receiving X-ray images of said body and transforming said images into photoelectron images, means for converting said photoelectron images into electrical signals, means for segregating said signals according to their amplitude, means for assigning different chromatic values to said segregated signals and means for reconverting said electrical signals into multicolor images.

3. The device for producing colored X-ray images comprising in combination, X-ray means for irradiation of the examined body, X-ray sensitive means for receiving X-ray image of said body and transforming said images into fluorescent images, means for converting said images into electrical signals, means for segregating said signals according to their amplitude, means for assigning different chromatic values to said segregated signals and means for reconverting said electrical signals into multicolor images.

4. A device for producing colored X-ray images comprising in combination, X-ray means for irradiation of the examined body, fluorescent means for converting the X-ray image into a fluorescent image, means for transforming said image into a photoelectron image, means for transforming said photoelectron image into elec-

trical signals, means for segregating said signals according to their amplitude, means for assigning different chromatic values to said segregated signals and means for reconverting said electrical signals into a multicolor image.

5. A device for producing color X-ray images comprising in combination X-ray means for irradiation of the examined body and X-ray image sensitive pick-up tube, having photocathode consisting of a fluorescent layer and a photoemissive layer for receiving said X-ray image and converting said X-ray image into electrons, and means for converting said electrons into electrical signals, means for segregating said signals according to their amplitude, means for assigning different chromatic values to said segregated signals, and means for reconverting said signals into multicolor images.

6. A device for producing color X-ray images comprising in combination X-ray means for irradiation of the examined body, an X-ray sensitive pick-up tube having a photocathode consisting of a fluorescent layer, a light transparent separating layer and a photoemissive layer, said tube for receiving X-ray images of said body and converting said X-ray images into electrical signals, means for segregating said signals according to their amplitude, means for assigning different chromatic values to said segregated signals,



and means for reconverting said signals into multicolor images.

EDWARD EMANUEL SHELDON.


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UNITED STATES PATENTS

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