July 29, 1958 E. E. SHELDON 2,845,561

TUBE FOR STORAGE OF IMAGES

Filed April 5, 1952

Fig. 1

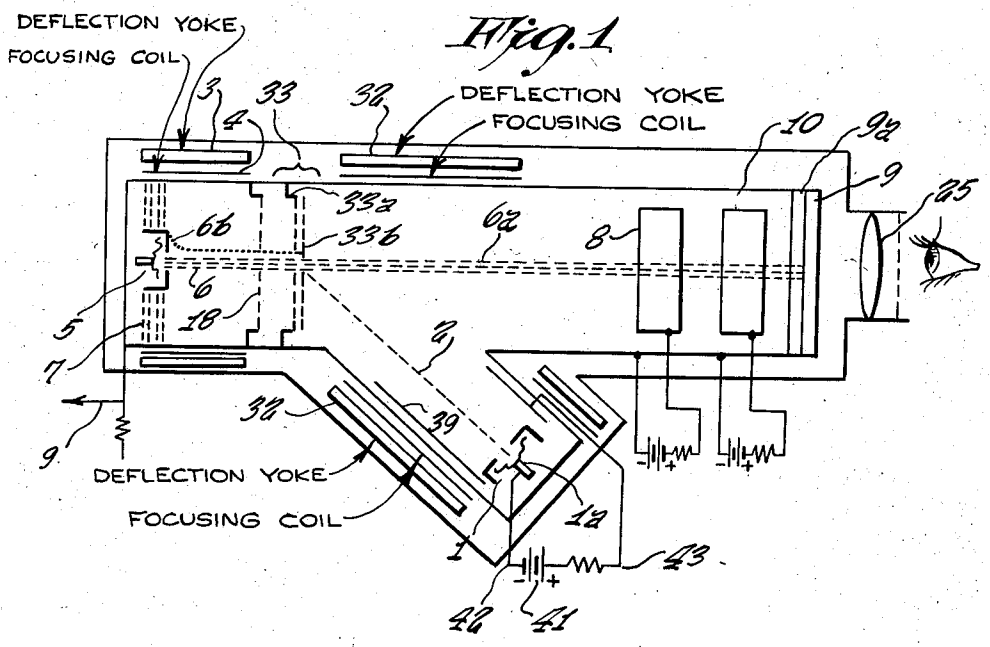


Fig. 2

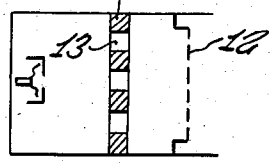


Fig. 3

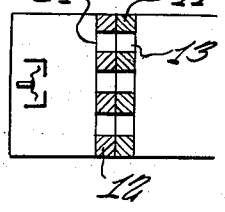


Fig. 5

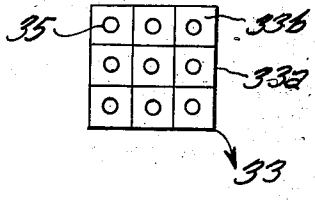
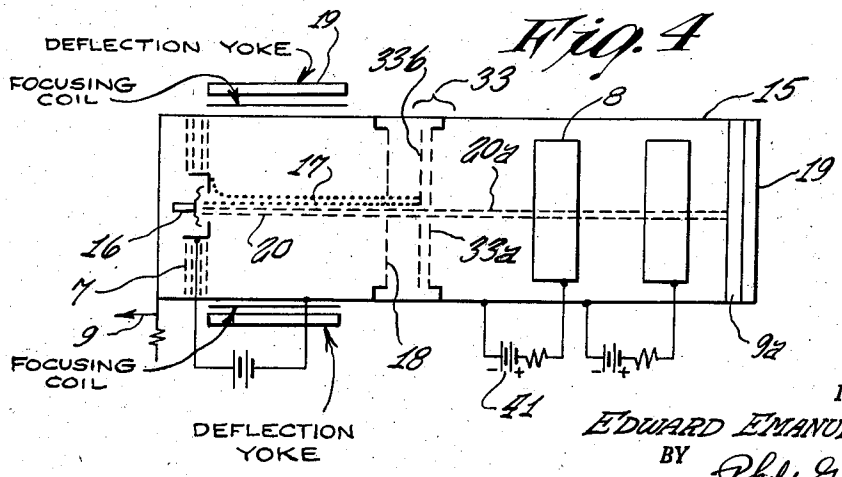


Fig. 4



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TUBE FOR STORAGE OF IMAGES

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9 Claims. (Cl. 313—65)

This invention relates to the storage of images formed by electromagnetic radiations and represents a continuation in part of my co-pending patent application Serial No. 265,463, filed January 8, 1952.

The primary object of the present invention is to provide a method and device for the storage of radar or other invisible images and inspecting them for a desired length of time, when wanted.

Another object of this invention is to provide a method and device to produce intensified radar or other electromagnetic images. This intensification will enable the overcoming of the inefficiency of the present examinations of radar images of a long persistence. At the present level of illumination of the fluorescent radar image of a long persistence, the human eye has to rely exclusively on scotopic (dark adaptation) vision, which is characterized by a tremendous loss of normal visual acuity in reference both to detail to the contrast and to the speed of vision. The purpose of this invention is to enable the observer to use his photopic vision, in order to inspect radar or other images in daylight.

Another object of this invention is to make it possible to obtain enlarged radar images for examination by many persons simultaneously.

Another object of this invention is to increase the sensitivity of radar image receivers to radar or other signals.

Still another object is to provide more contrasting radar or other electromagnetic images than was possible until now, in particular, to obtain the reproduction of half-tones. To obtain the objects of this invention, a special storage tube had to be designed. The novel storage tube has an electron gun for providing a scanning electron beam, which is modulated by signals carrying the information to be reproduced. The modulated electron beam scans a dielectric perforated storage target and produces secondary electron emission therefrom, which may be higher or lower than unity, depending on potentials applied. The secondary electrons are drawn away. As a result, a positive or negative charge image is stored on dielectric storage surface and may remain thereon for a long time.

Another electron gun serves to produce a source of a broad electron beam. The latter electron beam is projected on the perforated storage target. The passage of said broad electron beam through the perforated target is controlled by charges stored in said target. Therefore, transmitted electron beam will have the pattern of the stored charge image, which has the pattern of the invisible original image. The broad beam of electrons is focused on the fluorescent screen and reproduces a visible image thereon. Because of dielectric properties of the storage target, the charge image will persist thereon for a very long time, dependent on the type of storage material used. During all this time, the invisible image can be reproduced in a visible form as a fluorescent image, as was explained above. In this way, the primary object of the present invention, a storage of images, was accomplished. Because the energies of electrons of the

broad electron beam and of the stored charges can be matched closely and because the broad electron beam does not discharge stored charges, it will be possible also to reproduce half-tones, which will improve the contrast of reproduced pictures, and which was another object of my invention.

Due to the fact that fluorescent screen is excited by a broad electron beam covering substantially the whole image area, instead of a scanning electron beam covering only one image point, as in other radar receivers or kinescopes, a markedly intensified image can be obtained, which was another purpose of this invention.

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

In the drawings:

Figure 1 represents a diagrammatic cross-sectional view of the novel image tube.

Figure 2 represents a modification of the storage target.

Figure 3 represents another form of the storage target.

Figure 4 represents a cross-sectional view of a modification of the storage tube.

Figure 5 represents a plan view of the storage target.

Reference will now be made to Fig. 1, which illustrates the new tube **10** to accomplish the purposes outlined above.

The radar or other signals activate and modulate cathode ray beam **2** from the electron gun **1**. The cathode **1***a* of the electron gun **1** is provided with a negative potential. The second anode **39** may be in the from of a conducting coating on the inside surface of the tube envelope, and is supplied with a positive potential in relation to the potential of the cathode of the electron gun. The proper operating potentials may be applied to the electrode of the electron gun from potential source **41**. Between its terminals **42** and **43**, a potentiometer or a bleeder resistance may be connected in order that the relative potentials of the various electrodes may be properly selected. The horizontal and vertical scanning motion of the electron beam **2** across the storage target **33** is provided by the deflection yoke **32** having horizontal and vertical deflection coils. The deflection coils are energized by a cyclically varying current of a suitable wave form, which may be obtained from a horizontal deflection generator and from a vertical deflection generator. Deflection generators are well known in the art and are therefore not shown in the drawings. The cathode ray beam transforms the radar or other signals into a stored charge image in the storage target **33**. The storage target **33**, shown also in Fig. 5, consists of a thin perforated sheet of metal or other conducting material, or of a woven conducting wire mesh **33***a*. On the side of the target facing the electron gun **5**, there is deposited by evaporation a thin coating to prevent leakage of charges. On the opposite side is deposited dielectric layer **33***b*, such as of precipitated silica, silicon dioxide and titanium dioxide, so that perforations **35** remain unobstructed. The scanning electron beam **2** is produced in the storage tube **10** by the electron gun **1**, and is modulated by incoming video signals carrying the invisible information. This scanning electron beam **2** should have the finest spot compatible with the required intensity of beam. In some cases, between the electron gun **1** and the storage target **33** in close spacing to the target, there is mounted a fine mesh conducting screen, for collecting secondary electrons emitted from the dielectric layer **33***b*, when scanned by electron beam **2**.

As a result of the impingement of the scanning beam **2** on the storage target **33**, there are deposited on the storage target varying charges at successive points according to the amplitude of modulating input signals. The best way of operating my system is to have the storage surface at zero potential or at cathode potential

and then to write on it "positive," which means to deposit positive charges. This can be accomplished by adjusting the potential of the surface of the storage target, so that its secondary emission is greater than unity. The secondary electrons will be collected by the collecting anode or by an additional conducting mesh screen disposed in proximity of the storage target and positive charges will be left on the storage surface. These positive charges deposited on the storing surface of the target may be stored thereon for many hours depending on the type of the storage material 33*b* which was used. Whereas BaF_2 has a time constant of 0.1 second, CaF_2 has the time constant of 50 hours. Also, precipitated silica, silicon dioxide and titanium dioxide may be used for this purpose. The storage target must prevent fading of the stored image, which would cause its disappearance. It must also be free from lateral leakage of stored charges, which would impair resolution of the image.

These conditions are satisfied by equation:

$$\frac{R_0AC}{B}=T$$

in which

R_0 is equal to resistivity of the target in ohm-cm.
A=picture area in square centimeters.
C=capacitance of the storage target.
T=storage time for one image in seconds.
B=thickness of storage target in centimeters.

In case the storage time of three seconds is desired, the electrical resistivity of 5×10^{12} ohm-cm. will be suitable, if the thickness of target is 10^{-3} cm. and picture element is 10^{-4} square centimeter.

When the stored image is to be read, the electron gun **1** is inactivated and instead, electron gun **5** is activated. The electron gun **5** produces a broad electron beam **6**. The electron beam **6** is slowed down in front of the storage **33** by decelerating electrode **18**, which may be in the form of ring electrode or a fine mesh screen. The passage of the broad electron beam **6** through the perforations **35** in the target **33** is modulated by the pattern of deposited charges of said storage target. The greater the positive charge, the more electrons will pass through the openings **35** in the target. The less positive the stored charge, the fewer electrons will be transmitted through these openings. In this way, the electron beam **6** irradiating the storage target will be modulated by the stored image. The transmitted electron beam **6***a*, therefore, will carry an image. This electron image is accelerated. The accelerating electrode **8** serves to accelerate transmitted electrons **6***a* to the fluorescent screen **9**. The accelerating electrode may be in the form of a ring electrode or in the form of a conducting coating on the inside surface of the glass envelope. The accelerating electrode is provided with a positive potential from an external source of power, as described above.

Next, the electron image may be demagnified if its additional intensification is desired. The electron diminution of the image, in order to gain its intensification, is well konwn in the art and therefore does not have to be described in detail. The diminished electron image is projected on the fluorescent screen **9** at the end of the tube **10**, where it can be viewed by the observer directly or by means of an optical magnifying eye-piece **25** or may be photographed. The use of an optical eye-piece to magnify optically the electronically diminished image appearing on the fluorescent screen, is also well known in the art and therefore does not need further description. The fluorescent screen **9** is provided with an electron-transparent conducting backing, such as of aluminum **9***a*, which improves its efficiency. On the other hand, if magnification of the radar or other radiation image is needed, it can also be accomplished by electron-optical means. The available energy of the electron image will allow 20–30 times magnification of the image with sufficient luminosity of the fluorescent image. After the stored image has been read and no further storage is desired, it may be erased by the use of the scanning electron beam **2** by adjusting the potential of the storage target to the value at which the secondary electron emission of its storing surface is below unity. In such case, the target will charge negatively to the potential of the electron gun cathode, and will neutralize the stored positive charges. The same results may also be obtained by changing velocity of the scanning electron beam **2**.

It is obvious that the image stored in the target **33** may be converted into video signals instead of a fluorescent image. In such case, the electron beam **6** must be focused and must be of a scanning type. Deflection yoke **3** serves to provide the scanning motion of the electron beam **6**. Focusing coil **4** serves to produce a fine spot electron beam. The returning nontransmitted electrons **6***b* are diercted to multiplier **7** for intensification and then are converted into video signals **9** in the usual manner.

A modification of the storage target is shown in Fig. 2. In this embodiment of my invention, the storage target **11** is made of a perforated screen of dielectric material, such as glass, silicon, dioxide or titanium dioxide. The dielectirc material should have, preferably, electrical resistance to satisfy the equation discussed above. The holes **13** in said screen can be produced by photo-engraving methods. The preferred method is to use ionic or electronic etching. The openings must be uniform in size and spacing and should be, preferably, not larger than 100 microns, in diameter. The dielectric storage target may be attached to the walls of the tube by means of metallic rings, or it may be deposited on the mesh screen, as shown in Fig. 1. The supporting mesh screen in some cases may be made of insulating material instead of a conductive material. In some cases, a metallic fine mesh screen **12** connected to the source of potential can be placed in very close proximity to the storage target and then serves to collect secondary electrons emitted from the storage target under impingement of the scanning electron beam **2**. Obviously, screen **12** must be disconnected from source of potential in the reading phase of operation when electron gun **5** is activated.

In another modification of my invention, the storage target **11** has a metallic backing **14** deposited on it in such a manner that the openings **13** remain unobstructed, see Fig. 3.

A simplified modification of my invention is shown in Fig. 4. The storage tube **15** has only one electron gun **16**. The radar or other signals modulate the electron beam **17**. The perforated storage target may be the same as described above and illustrated in Figs. 1, 2 and 3. The electron beam **17** modulated by incoming signals scans the storage target **33** in the usual television raster. The scanning motion of the electron beam is provided by deflecting yoke **19**, which has coils in two, perpendicular to each other, planes and which are energized by a sawtooth signal producing generator. The impingement of the electron beam **17** of the target **33** produces secondary electron emission therefrom. The secondary electrons are drawn away either by an adjacent mesh screen or by a conductive coating on the wall of the tube. As a result, a positive charge image remains on the storing layer **33***b*.

In the second phase of operation, which is the reading phase, the electron gun **16** produces a broad, uncontrolled electron beam **20** covering substantially the whole area of the stored image. The broad electron beam is slowed down in front of the storage target **33** by decelerating electrode, which may be in the form of a ring electrode or in the form of a fine mesh screen **18**. The screen **18** is connected to the source of an outside potential, and

it is activated only in the reading phase of the operation. The passage of said broad electron beam through the perforated target is controlled by charges stored in said target. Therefore, transmitted electron beam **20***a* will have the pattern of the stored charge image, which has the pattern of the invisible original image. The broad beam of electrons is accelerated and is focused on the fluorescent screen **19** and reproduces a visible image thereon. Because of dielectric properties of the storage target, the charge image will persist thereon for a very long time, dependent on the type of storage material used. During all this time, the invisible image can be reproduced in a visible form, as a fluorescent image, as was explained above.

Although particular embodiments and forms of this invention have been illustrated, 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.

I claim:

1. A storage tube comprising in combination a source of electrons, a perforated light-stable storage target for receiving and storing electrons emitted from said source, said target consisting only of a self-supporting perforated dielectric screen, means for irradiating said dielectric screen with a beam of electrons and a luminescent screen for receiving electrons of said beam transmitted through said perforated screen.

2. A storage tube comprising in combination a source of electrons, a perforated storage target for receiving and storing electrons emitted from said source, said target consisting of a perforated light-stable dielectric layer on a perforated dielectric supporting screen, means for irradiating said dielectric screen with a beam of electrons and electron reactive means for receiving electrons of said beam transmitted through said perforated screen.

3. A storage tube comprising in combination a source of electrons, a perforated light-stable storage target for receiving and storing electrons emitted from said source, said target consisting only of a perforated self-supporting dielectric screen, means for irradiating said dielectric screen with a beam of electrons, the source of said beam of electrons being disposed in said tube on the side of said perforated storage target opposite to the side on which said emitted electrons are stored, and luminescent screen for receiving electrons of said beam transmitted through said perforated target.

4. A device as defined in claim 3, wherein said perforated storage target consists of a perforated dielectric layer on a perforated dielectric supporting screen.

5. A storage tube comprising in combination a source of electrons, a perforated storage target for receiving and storing electrons emitted from said source, said target consisting only of a perforated dielectric screen, means for irradiating said dielectric screen with a beam of electrons, the source of said beam of electrons being disposed in said tube on the side of said perforated storage target opposite to the side on which said emitted electrons are stored, means for decelerating electrons from said source, and an electron reactive luminescent screen for receiving electrons of said beam transmitted through said perforated screen.

6. A storage tube comprising in combination an electron gun for producing an electron beam, a perforated storage target consisting only of a perforated self-supporting screen of dielectric material, means for scanning with said electron beam said storage target for producing a stored image in said target, means for producing a second electron beam, means for projecting said second electron beam on said target to modulate passage of said beam through said perforated target with said stored image, and an image reproducing luminescent screen for receiving said transmitted electrons.

7. A device as defined in claim 6, wherein said storage target consists of a perforated dielectric layer and a perforated dielectric supporting screen.

8. A storage tube comprising in combination an electron gun for producing an electron beam, a perforated target consisting only of a perforated self-supporting screen of dielectric material, means for scanning with said electron beam said storage target for producing a stored image in said target, means for producing a second electron beam, said means being disposed in said tube on the side of said perforated storage target opposite to the side of the said electron gun, means for projecting said second electron beam on said target to modulate passage of said beam through said perforated target with said stored image, and an electron reactive image producing screen for receiving said transmitted electrons.

9. A storage tube comprising in combination an electron gun for producing an electron beam, a perforated target consisting of a perforated self-supporting screen of dielectric material, means for scanning with said electron beam said storage target for producing a stored image in said target, means for producing a second electron beam, said means being disposed in said tube on the side of said perforated storage target opposite to the side of the said electron gun, means for decelerating said second electron beam, means for projecting said second electron beam on said target to modulate passage of said beam through said perforated target with said stored image and electron reactive means for receiving said transmitted electrons.

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