

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO RADAR APPARATUS

(71) We, SMITHS INDUSTRIES LIMITED, a British Company of Cricklewood Works, London, N.W.2., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relate to radar apparatus.

According to the present invention there is provided radar apparatus wherein a display arrangement for displaying echoes received from targets within a repeatedly-scanned area of radar surveillance includes an image-retaining device that comprises a pair of electrodes with an intervening layer containing electroluminescent material, the said device having the characteristic that while voltage is applied between its electrodes emission of light from any area of the layer is stimulated by irradiation thereof and continues for a substantial period after the stimulation has ceased, and the arrangement being such that the layer is irradiated in accordance with echoes received from successive radar scans of said area to provide thereby a sustained cumulative display of those echoes.

The apparatus may include a cathode-ray tube for providing a display representation of received echoes, and in these circumstances it may be arranged that the image-retaining device is exposed to the display representation provided by the cathode-ray tube through successive scans so as thereby to irradiate the said layer in accordance with the echoes received during those scans. The display representation provided by the cathode-ray tube may be a conventional plan-position display of targets within the area of radar surveillance.

The apparatus may include means for combining the display representation provided by the cathode-ray tube with the display representation provided by the image-retaining device to provide a composite display of echoes as displayed both currently and previously by the cathode-ray tube. The combining means may, for example, include a photographic arrangement for photographing the display re-

presentations provided by the cathode-ray tube and the image-retaining device, the composite display being provided by superimposition of the photographic records of the two display representations. The composite display may be presented for viewing in these circumstances by projection of the superimposed photographic records.

A radar system that includes apparatus in accordance with the present invention, will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a schematic representation of the radar system;

Figure 2 is a sectional side elevation of an image-retaining panel used in the system of Figure 1;

Figure 3 is a perspective view illustrative of a mechanical arrangement that contains the image-retaining panel in the system of Figure 1; and

Figures 4A, 4B and 4C serve to illustrate the relative positioning of elements of the arrangement of Figure 3 at different stages during operation of the system of Figure 1.

The radar system shown in Figure 1 is for use on a ship to provide a display that is of assistance in navigation.

Referring to Figure 1, a radar transmitter-receiver 1 supplies to a cathode-ray display-tube 2 video signals corresponding to radio-frequency echo-signals that are received by an aerial 3 of the system. The aerial 3 rotates to receive echo-signals from all directions in azimuth, and the tube 2, in accordance with the video signals supplied to it sequentially by the transmitter-receiver 1, provides on its screen 4 a plan-position display representation of the received echo-signals. A timing unit 5 associated with the transmitter-receiver 1 supplies to the tube 2 signals that produce at the screen 4 the rotating, and appropriately-synchronised, radial time-base as required to produce such display of the sequentially-applied video signals.

The screen 4 is exposed within a light-tight

box 6, and within the box 6 is associated with a mirror 7 and an electroluminescent image-retaining panel 8. The mirror 7 and image-retaining panel 8 are both pivotally mounted, the mirror 7 such that it may be pivoted from a position (as shown) in which it reflects light from the screen 4 to a camera 9, to a position in which it does not obstruct exposure of the image-retaining panel 8 to the camera 9. The panel 8, on the other hand, is mounted such that it may be pivoted from the position (as shown) in which it is exposed directly to the camera 9 to a position in which it is in face-to-face contact with the screen 4 of the cathode-ray tube 2.

The image-retaining panel 8 is of a form sold by Thorn Electrical Industries Limited and described in a paper entitled "The Image Retaining Panel", by A. S. Henderson, published in the journal "New Scientist", Volume 16, pages 686 to 688. As shown in Figure 2 of the drawings accompanying the present specification, the panel 8 has a metal substrate 10 that carries two superimposed vitreous-enamel layers 11 and 12. The uppermost layer 12 is embedded with an electroluminescent phosphor (basically zinc cadmium sulphide) and is coated with an electrically-conductive transparent film 13. Unidirectional voltage is applied between the substrate 10 and film 13 (film 13 positive with respect to substrate 10), and under these conditions irradiation of any area of the layer 12 with light, causes a yellowish glow to build up in that area in proportion to the intensity and duration of the irradiation. The emission of light is sustained after irradiation ceases, so the panel 8 has an effective memory by which it retains any image to which it is exposed. The image is retained in this way, without any serious deterioration in sharpness and contrast, for a period of some twenty minutes provided that the application of the unidirectional voltage is uninterrupted; if there is interruption of the applied voltage for even a few seconds, the image is no longer retained. Except where otherwise stated in the following description, it is assumed that unidirectional voltage is approximately applied to the panel 8 without interruption.

Referring again to Figure 1, the pivoting of the panel 8 into face-to-face contact with the screen 4 exposes the panel 8 to the plan-position display thereon. An image of this display representation is accordingly retained by the panel 8, and is photographed by the camera 9 when the panel 8 is pivoted back to its former position. The image is photographed on a film-strip 15 that extends through the camera 9 from a reel 16 storing the unused length of film, to a reel 17 that stores the used length.

The portion, or frame, of the film-strip 15 within the camera 9 is exposed successively to the panel 8 and, via the mirror 7, to the screen

4, so as to provide on the relevant frame superimposed photographic records of the plan-position display as currently appearing on the screen 4, and as it appeared earlier during the exposure of the panel 8 to the screen 4. The film-strip 15 is then advanced so as to move the exposed frame from the camera 9 into a processing station 18, and replace it in the camera 9 by another, second, unexposed frame of the film-strip 15. The exposed first frame is processed in the station 18 (so as to produce a transparency of the superimposed records) while the panel 8 is again exposed to the screen 4 and the second frame in the camera 9 is exposed successively to the panel 8 and screen 4. After the second frame has been doubly exposed in this way, the film-strip 15 is again advanced to bring a third, unexposed frame into the camera 9, and this moves the second frame into the processing station 18 and the first, processed frame into a projector 19 for projection. Following exposure of the panel 8 to the screen 4 again, and successive exposures of the third frame in the camera 9 to the panel 8 and screen 4, the film-strip 15 is again advanced, moving the third frame into the processing station 18 and the now-processed second frame into the projector 19 in place of the first frame.

The film-strip 15 is advanced in this manner frame-by-frame from the reel 16, and thence to the reel 17, throughout operation. Each frame exposed within the camera 9 records the display representation currently on the screen 4 superimposed upon a record of the image retained by the panel 8, and is advanced in one step into the processing station 18 and then in the next step into the projector 19 for projection of the composite record during a subsequent sweep cycle. Reference is directed to British Patent Specification No. 814,079 for details of the arrangement (not shown in the present drawing) by which the film-strip 15 is advanced step-by-step in synchronism with the time-base sweep-cycle, and to British Patent Specification No. 814,080 for details of the arrangement associated with the processing station 18.

The projector 19 directs light through the film-strip 15 so that the image of the composite record on the frame located within the projector 19, is projected on the under-surface 20 of a translucent screen 21. The projected display, as this appears on the upper-surface 22 of the screen 21, is viewed by the radar operator who is thereby presented with a composite display of the video information that appeared on the screen 4 a predetermined, but short, time earlier, superimposed upon the video information retained by the panel 8 during repeated exposures to the screen 4.

The video information retained by the panel 8 results from superimposition of successive display representations presented on the screen

4 throughout a period of some twenty minutes beforehand, and accordingly provides a cumulative historical record of any movements of targets within the area under radar-surveillance. Movement of a target appears in this record as a succession of dots that in general merge to form a line in the composite display. The latest-recorded position of the target appears in the composite display as a dot at one end of the line, this dot (since it results from exposure of the film-strip 15 to the screen 4 via the mirror 7) being readily distinguishable from the others by its greater intensity. The direction along the line towards this particular dot is indicative of the direction of movement of the target, and the length of the line is indicative of the relevant speed of movement (or at least, of the distance travelled in the relevant period). A new, up-dated display representation is presented to the operator with each advance of the film-strip 15.

The historical record can be erased and restarted simply by interrupting the application of the unidirectional voltage to the panel 8. It may be arranged simply that the process of erasure and restarting is effected automatically, and in particular, that it is effected repeatedly at any selected one of a number of frequencies, for example, every three, six or twelve minutes.

In the present example the display provided by the cathode-ray tube 2 is selectively either a relative- or true-motion display, and a bearing scale 23 in the box 6 is illuminated periodically so as to superimpose a record of the scale 23 upon each frame of the film-strip 15. The scale 23 lies beneath the panel 8 so as to be exposed to the camera 9 while the panel 8 is in face-to-face contact with the screen 4; it is at this time that the illumination of the scale 23 takes place. A heading line and a series of calibration rings are displayed on the screen 4 only while the frame in the camera 9 is being exposed to the screen 4 via the mirror 7. The heading line is a line that in the display representation on the screen 4 extends outwardly from the dot representing the ship carrying the radar system, and this as recorded on the frame provides against the bearing scale earlier recorded, an indication of the heading of the ship.

The cycle of operations performed repeatedly in the box 6, and the coordination of this cycle with the operation of the system as a whole, is controlled by the timing unit 5. The operations within the box 6 are carried out by means of a motorized cam unit 24, the unit 24 including a series of cams that are driven by an electric motor to operate pneumatic actuators successively. The unit 24, in addition to controlling movement of the mirror 7 and panel 8 in the box 6 during the cycle, operates the shutter 25 of the camera 9 and moves two lenses (not shown) into and out of position before the screen

4 and panel 8 respectively, at appropriate times in this cycle. Figure 3 provides a more-detailed indication of the construction of the box 6 and the manner in which the mirror 7, the panel 8, and the two lenses are mounted therein.

Referring to Figure 3, the mirror 7 is carried by a flap 30 that also carries a plano-convex lens 31. The flap 30 is pivoted about an axis 32 for movement round to a position as shown in Figure 4A, in which the plane face of the lens 31 is in direct contact with the flat screen 4 of the cathode-ray tube 2. The lens 31 corrects in the image of the display reflected from the mirror 7, distortion that would otherwise arise from use of the flat screen 4.

The image-retaining panel 8 is carried by a flap 33 that is pivoted about an axis 34 for movement from the position in which it obscures the bearing scale 23 to a position as shown in Figure 4B, in which the panel 8 is in face-to-face contact with the screen 4. In order that the image retained on the panel 8 shall be in good focus, it is preferable to use a cathode-ray tube 2 having a glass-fibre optical face-plate.

A third flap 35 that carries a plano-convex lens 36 is pivoted about an axis 37 for movement to a position as shown in Figure 4C, in which the plane face of the lens 36 is in face-to-face contact with the panel 8. The lens 36 corresponds to the lens 31 and corrects for distortion that otherwise would result during exposure of the flat panel 8 to the film-strip 15.

The cycle of operations performed repeatedly within box 6 has a period of twenty seconds, this being the time taken for the radial time-base of the cathode-ray tube 2 to make some six to seven complete sweeps of the screen 4. At the commencement of the cycle, the flap 30 is in the position shown in Figure 4A with the lens 31 against the screen 4, and the first period of one half-second in the cycle is occupied with pivoting the flap 30 back to its position away from the screen 4. At the same time transport of the film-strip 15 takes place to bring an unexposed frame into the camera 9.

During the second period of one half-second of the cycle, the flap 33 is pivoted up about the axis 34 to bring it into the position shown in Figure 4B in which the panel 8 is in face-to-face contact with the screen 4. Throughout this movement, and from the commencement of the cycle, the unit 24 keeps the shutter 25 of the camera 9 closed, and the unit 5 is operative to effect blanking of the video signals applied to the tube 2. At the end of the first period of one second in the cycle, the blanking ceases and the shutter 25 is opened.

For the period of six seconds from the first to seventh seconds of the cycle, the image-

retaining panel 8 is in contact with the screen 4 to retain an image if the display produced throughout two sweeps of the radial time-base. During this six-second period the unit 5 24 effects illumination of the bearing scale 23 for a period of one second so that this scale is thereby recorded on the frame within the camera 9. At the end of the six-second period the unit 5 again effects blanking of the video 10 signals applied to the tube 2, the shutter 25 is again closed, and the flap 33 is pivoted back to its position away from the screen 4. This latter action occupies a period of one 15 half-second and is followed during the next half-second by pivotal movement of the flap 35 bringing the lens 36 down on the panel 8 into the position shown in Figure 4C. Following this the shutter 25 is again opened and remains open for some six seconds to expose 20 the image retained by the panel 8 to the frame in the camera 9.

After the shutter 25 is closed following the six-second exposure, the flap 35 is pivoted back away from the panel 8, and the flap 30 25 is pivoted round to bring the lens 31 against the screen 4. These two operations occupy successive periods of one half-second, and are followed by reopening of the shutter 25. The blanking of the video signals, brought into 30 effect at the end of exposure of the panel 8 to the screen 4, at the same time ceases, and the display representation on the screen 4, as reflected via the mirror 7, is recorded on the frame in the camera 9 during the remaining 35 period of five seconds of the cycle. The heading line and calibration rings are displayed on the screen 4 at this time. At the recommencement of the cycle the shutter 25 is closed and a new, unexposed frame is brought 40 into the camera 9, the exposed frame accordingly moving on into the processing station 18 for subsequent projection.

It has been found that the image retained by the panel 8 can be markedly improved in 45 sharpness and contrast by exposing the panel 8 to a flash of high-intensity light following its exposure to the display on the screen 4. In this respect, an electric lamp (not shown) is mounted in the box 6 and is energized to produce a short-duration high-intensity flash towards 50 the end of the movement of the flap 35 back away from the screen 4; this movement occurs during the period of one half-second following exposure of the panel 8 to the screen 4, and at the time of the flash the 55 shutter 25 has already closed.

Attention is directed to co-pending Patent Application No. 46816/67 (Serial No. 125591) which includes description of the same radar system as described above and claims relevant thereto.

WHAT WE CLAIM IS:—

1. Radar apparatus wherein a display arrangement for displaying echoes received from targets within a repeatedly-scanned area of radar surveillance includes an image-retaining device that comprises a pair of electrodes with an intervening layer containing electroluminescent material, the said device having the characteristic that while voltage is applied between its electrodes emission of light from any area of the layer is stimulated by irradiation thereof and continues for a substantial period after the stimulation has ceased, and the arrangement being such that the layer is irradiated in accordance with echoes received from successive radar scans of said area to provide thereby a sustained cumulative display of those echoes. 65 70 75

2. Radar apparatus according to Claim 1 including a cathode-ray tube for providing a display representation of received echoes, and wherein it is arranged that the image-retaining device is exposed to the display representations provided by the cathode-ray tube through successive scans so as thereby to irradiate the said layer in accordance with the echoes received during those scans. 80 85

3. Radar apparatus according to Claim 2 wherein the display representation provided by the cathode-ray tube is a plan-position display of targets within the area of surveillance. 90

4. Radar apparatus according to any one of the preceding claims wherein said electroluminescent material is embedded within one of two layers of vitreous enamel interposed between the two electrodes. 95

5. Radar apparatus according to any one of the preceding claims wherein said electroluminescent material includes zinc cadmium sulphide. 100

6. Radar apparatus according to any one of the preceding claims including an image-retaining device substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

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retaining panel 8 is in contact with the screen 4 to retain an image if the display produced throughout two sweeps of the radial time-base. During this six-second period the unit 5 effects illumination of the bearing scale 23 for a period of one second so that this scale is thereby recorded on the frame within the camera 9. At the end of the six-second period the unit 5 again effects blanking of the video signals applied to the tube 2, the shutter 25 is again closed, and the flap 33 is pivoted back to its position away from the screen 4. This latter action occupies a period of one half-second and is followed during the next half-second by pivotal movement of the flap 35 bringing the lens 36 down on the panel 8 into the position shown in Figure 4C. Following this the shutter 25 is again opened and remains open for some six seconds to expose the image retained by the panel 8 to the frame in the camera 9.

After the shutter 25 is closed following the six-second exposure, the flap 35 is pivoted back away from the panel 8, and the flap 30 is pivoted round to bring the lens 31 against the screen 4. These two operations occupy successive periods of one half-second, and are followed by reopening of the shutter 25. The blanking of the video signals, brought into effect at the end of exposure of the panel 8 to the screen 4, at the same time ceases, and the display representation on the screen 4, as reflected via the mirror 7, is recorded on the frame in the camera 9 during the remaining period of five seconds of the cycle. The heading line and calibration rings are displayed on the screen 4 at this time. At the recommencement of the cycle the shutter 25 is closed and a new, unexposed frame is brought into the camera 9, the exposed frame accordingly moving on into the processing station 18 for subsequent projection.

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2. Radar apparatus according to Claim 1 including a cathode-ray tube for providing a display representation of received echoes, and wherein it is arranged that the image-retaining device is exposed to the display representations provided by the cathode-ray tube through successive scans so as thereby to irradiate the said layer in accordance with the echoes received during those scans.

3. Radar apparatus according to Claim 2 wherein the display representation provided by the cathode-ray tube is a plan-position display of targets within the area of surveillance.

4. Radar apparatus according to any one of the preceding claims wherein said electroluminescent material is embedded within one of two layers of vitreous enamel interposed between the two electrodes.

5. Radar apparatus according to any one of the preceding claims wherein said electroluminescent material includes zinc cadmium sulphide.

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