

[54] HEAD-UP DISPLAY APPARATUS

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[51] Int. Cl. G03b 21/00

[58] Field of Search.....353/14, 13, 12, 11, 28, 94,
353/82

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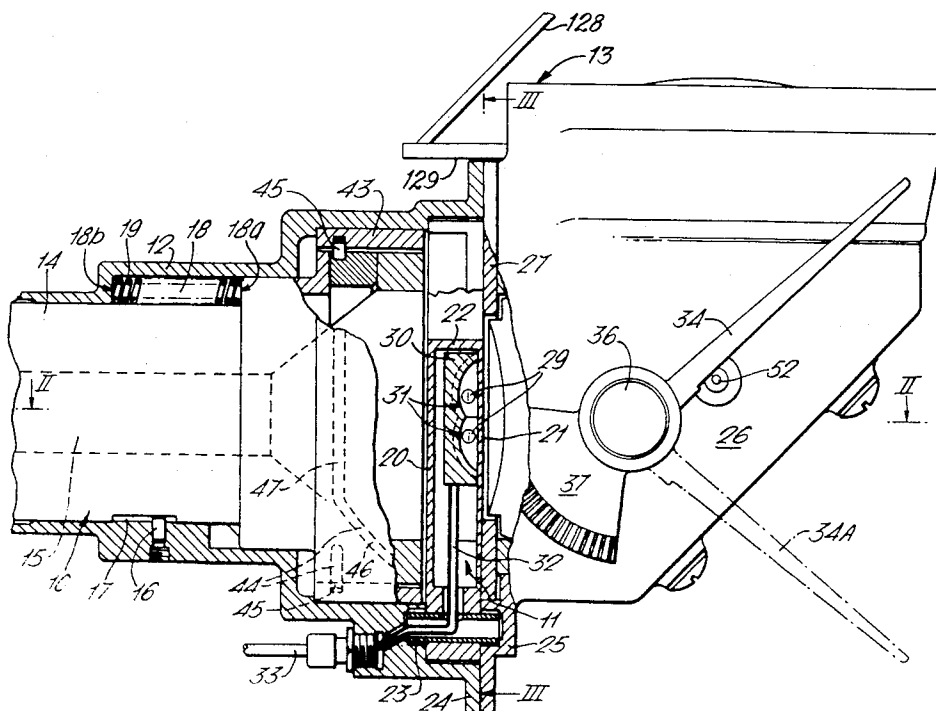
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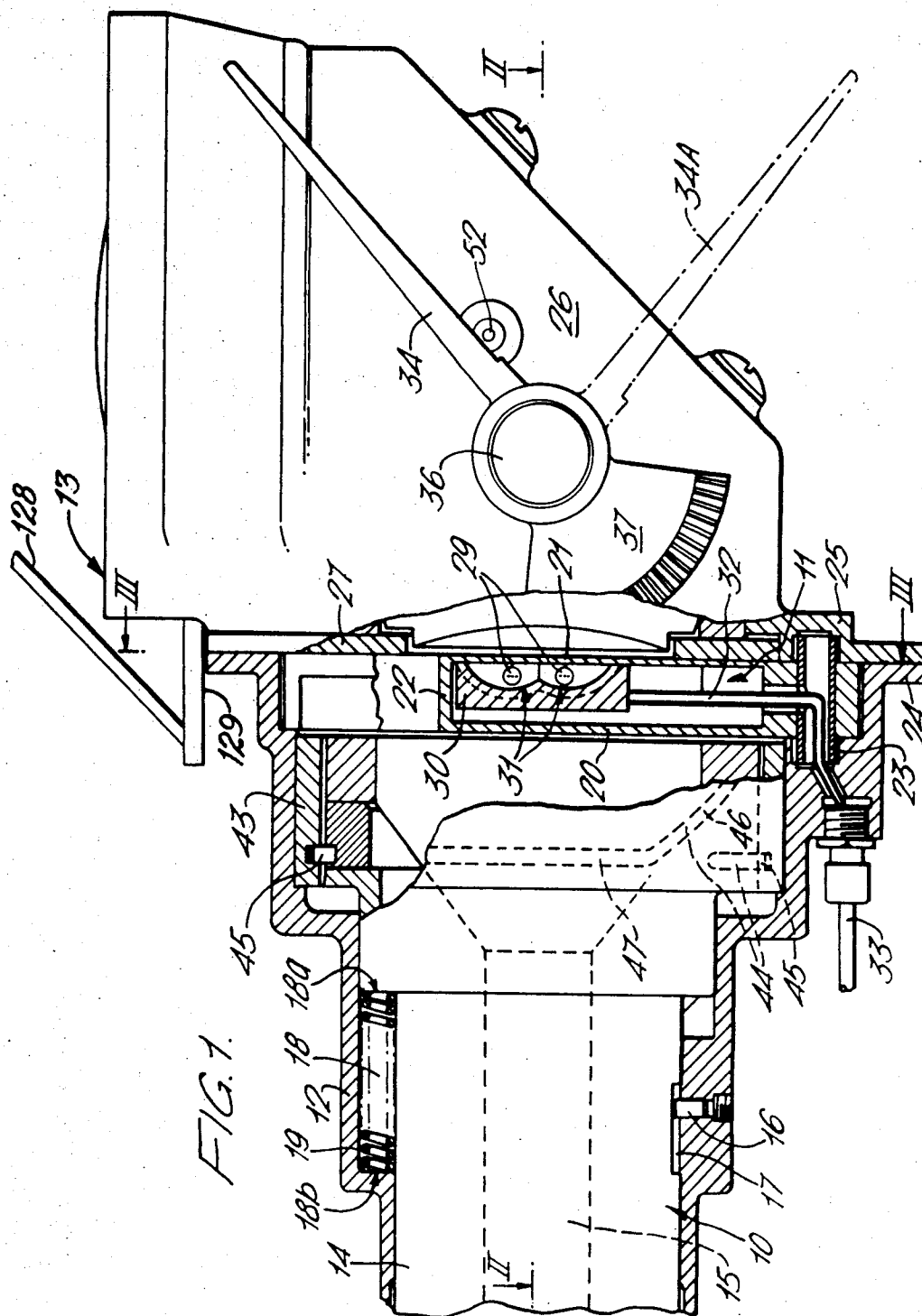
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ABSTRACT

Head-up display apparatus that includes a collimator for projecting a display on to a partially-transparent reflector, also includes first and second display-producing means for providing respectively main and auxiliary displays of information, and means for selecting which of the displays is projected on to the reflector. Selection of which of the two display-producing means acts as the source of the projected display is effected by a handle that is movable between first and second positions to control rotation of a sleeve that is coupled to both display-producing means. Movement of the handle in one direction moves the first display-producing means longitudinally away from the collimator means so as to provide a space between this display-producing means and the collimator means, and also pivots the second display-producing means into the said space along an arcuate path substantially normal to the direction of movement of the first display-producing means. The first display-producing means is a cathode-ray tube, and the second display-producing means, for use in the event that the cathode-ray-tube display fails, is an illuminated graticule or a device in which an incandescent filament is strung into a desired display-pattern.

11 Claims, 13 Drawing Figures





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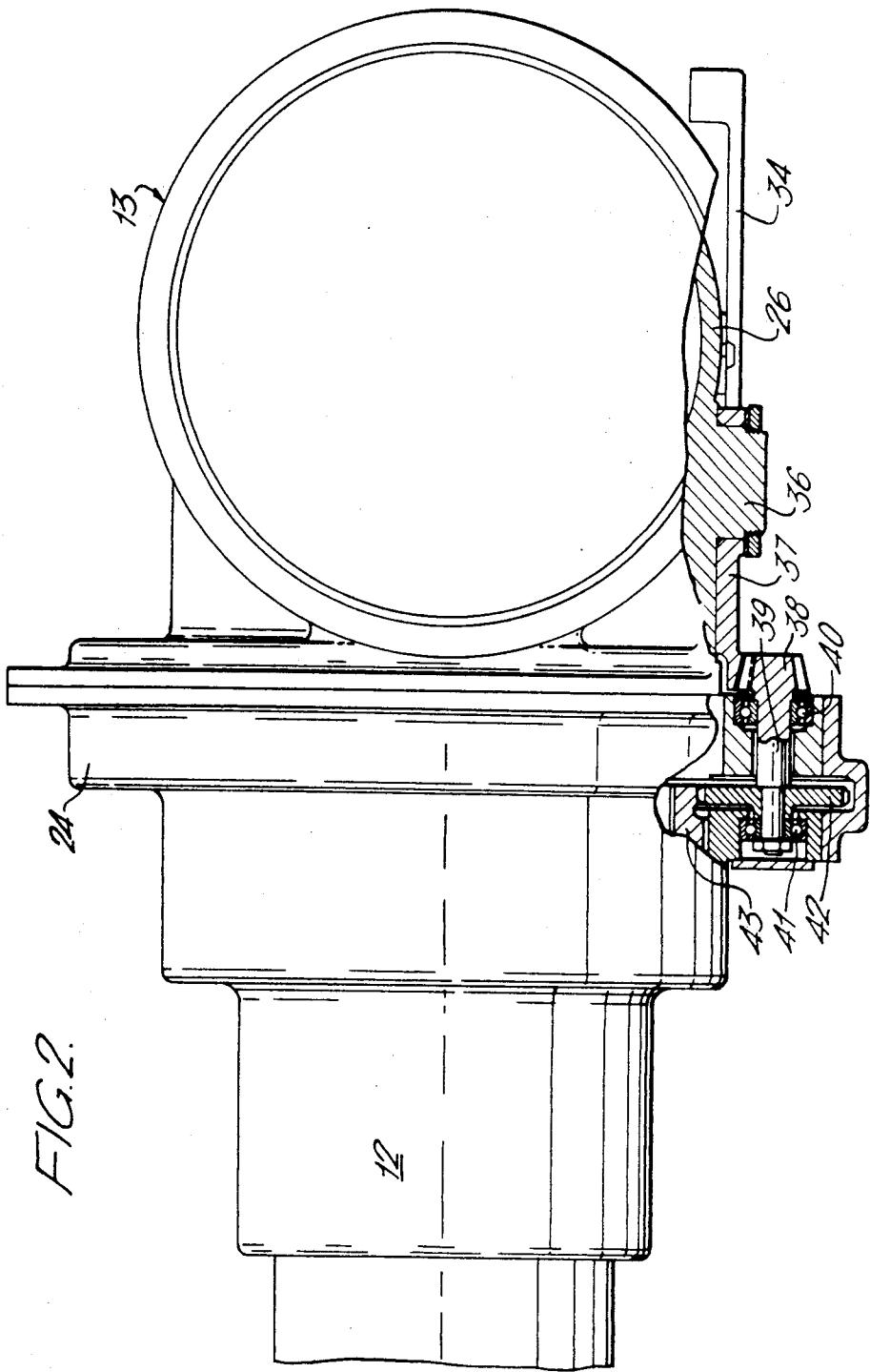
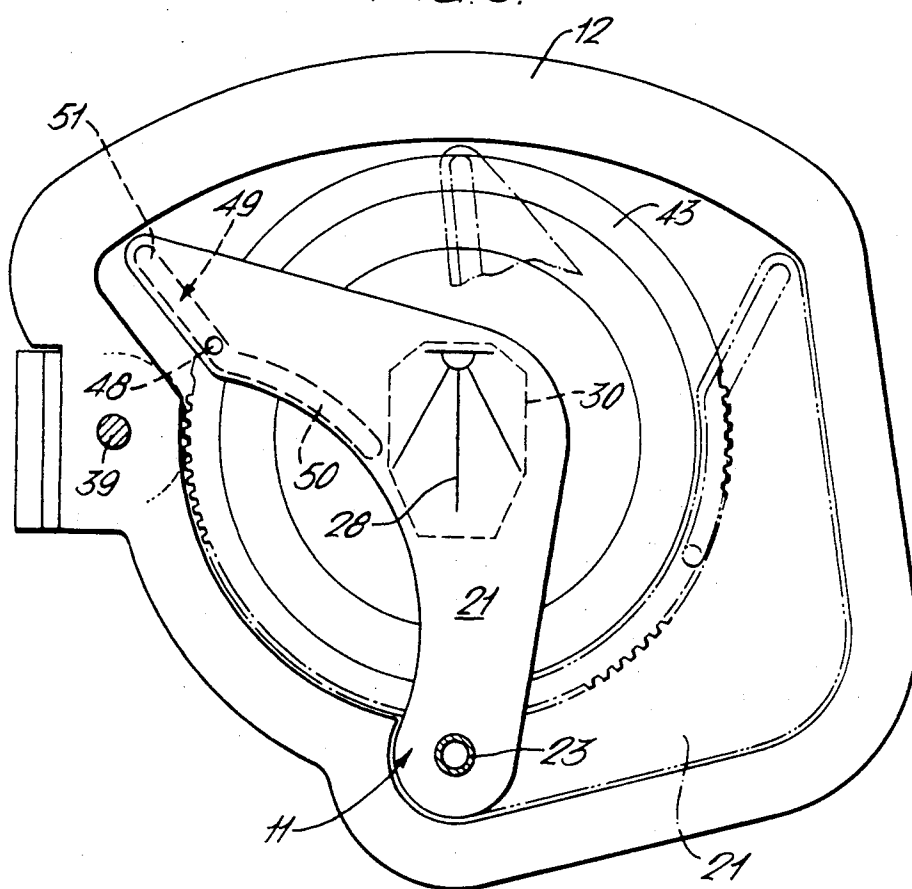


FIG. 2.

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FIG. 3.



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FIG. 4.

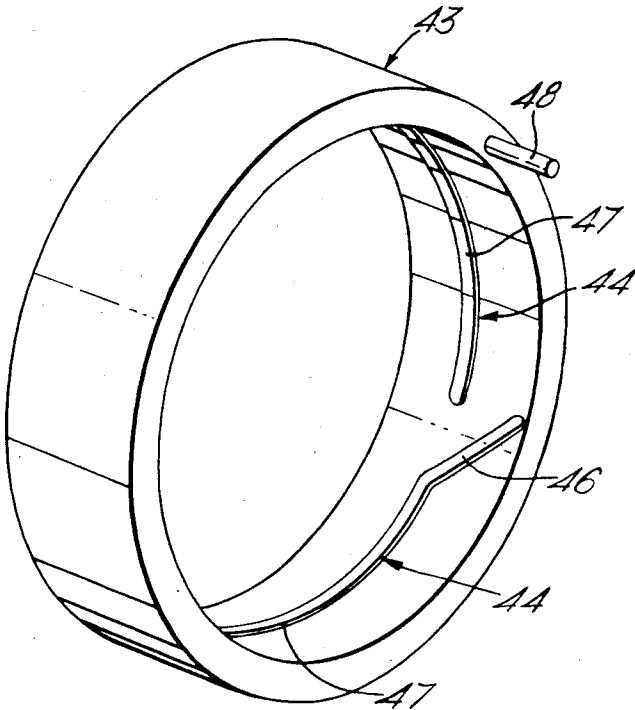
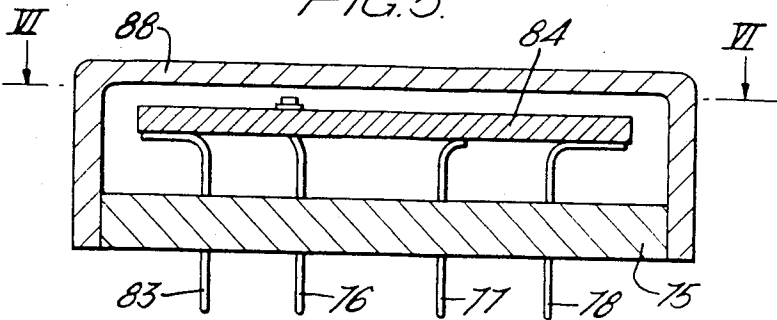
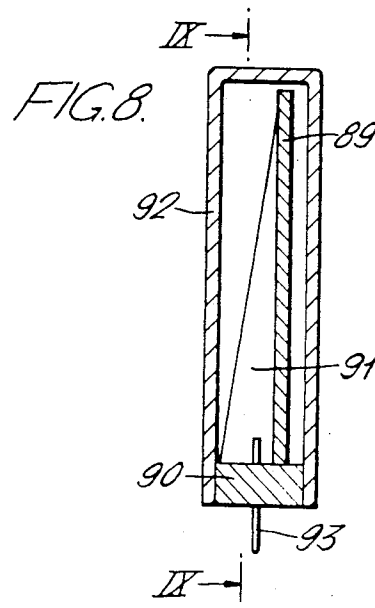
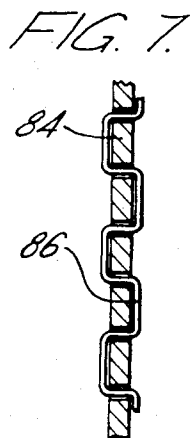
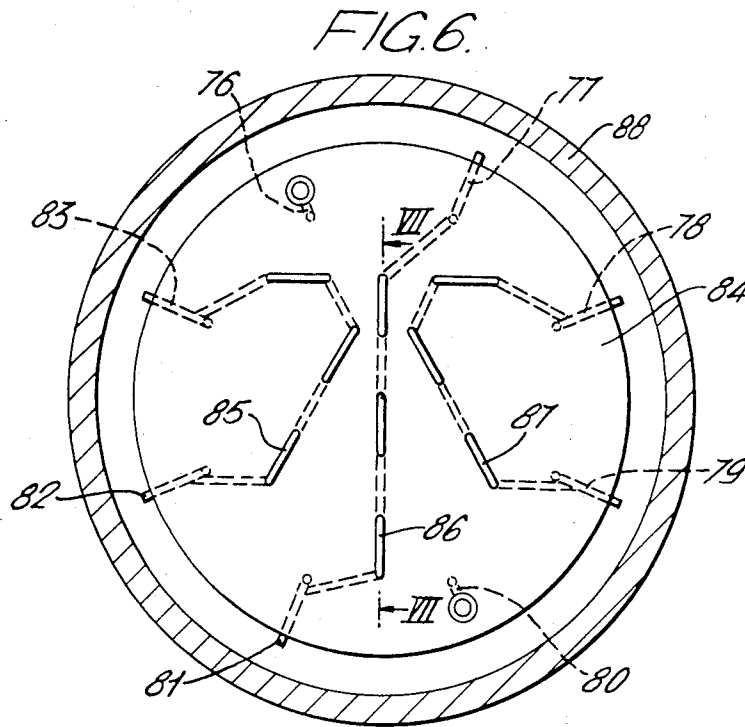


FIG. 5.



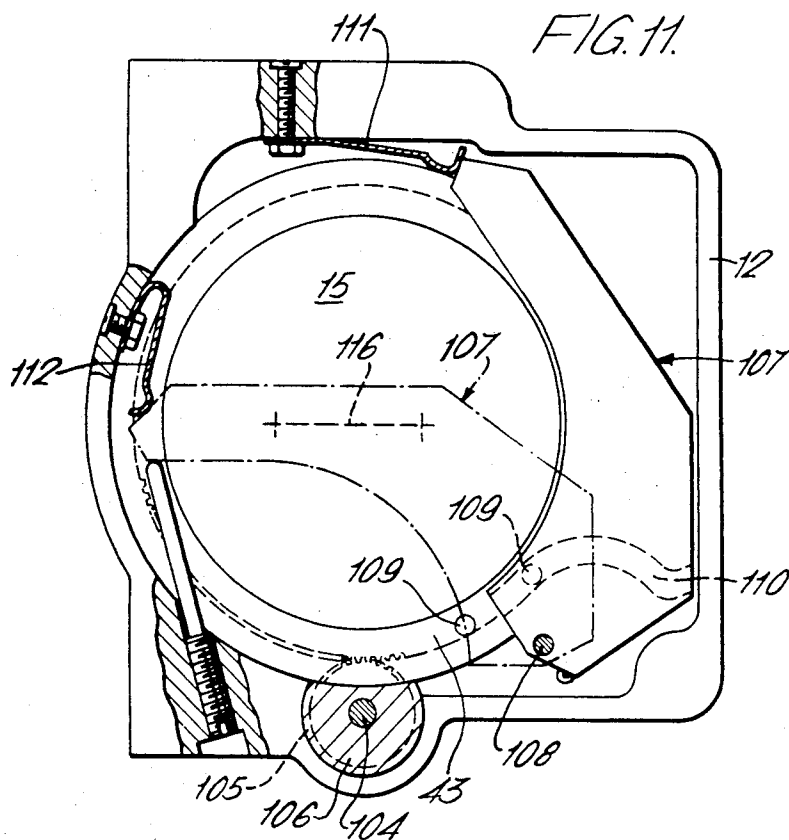
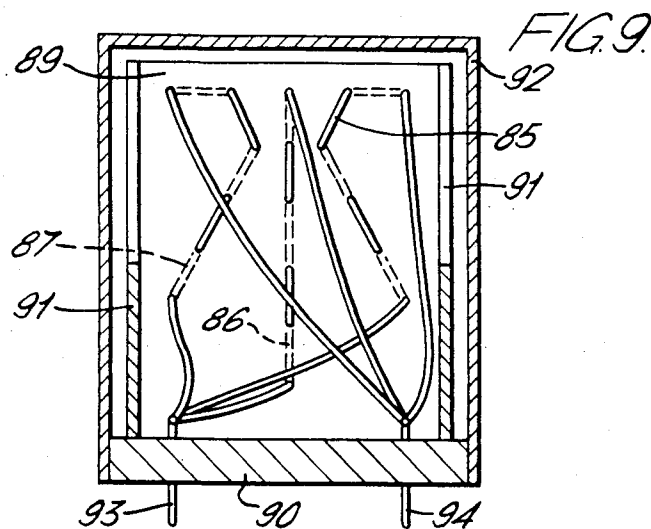
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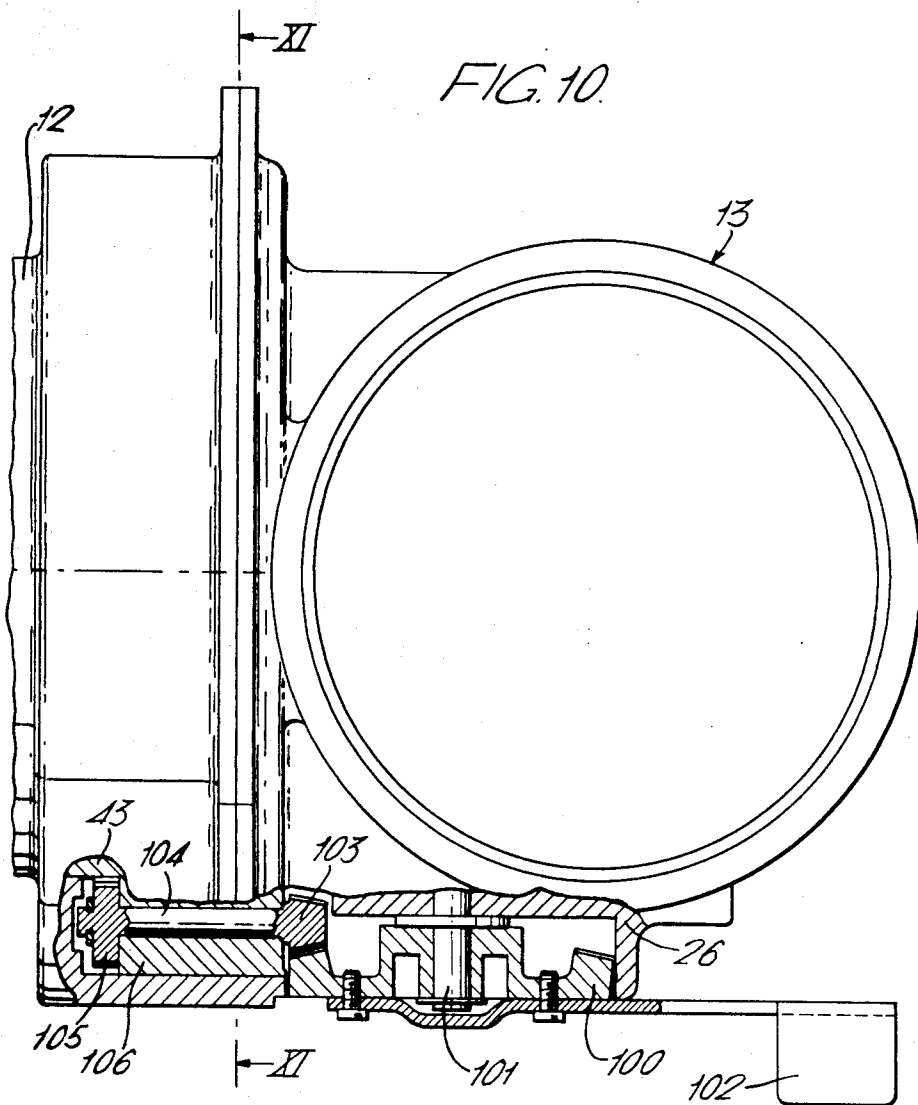


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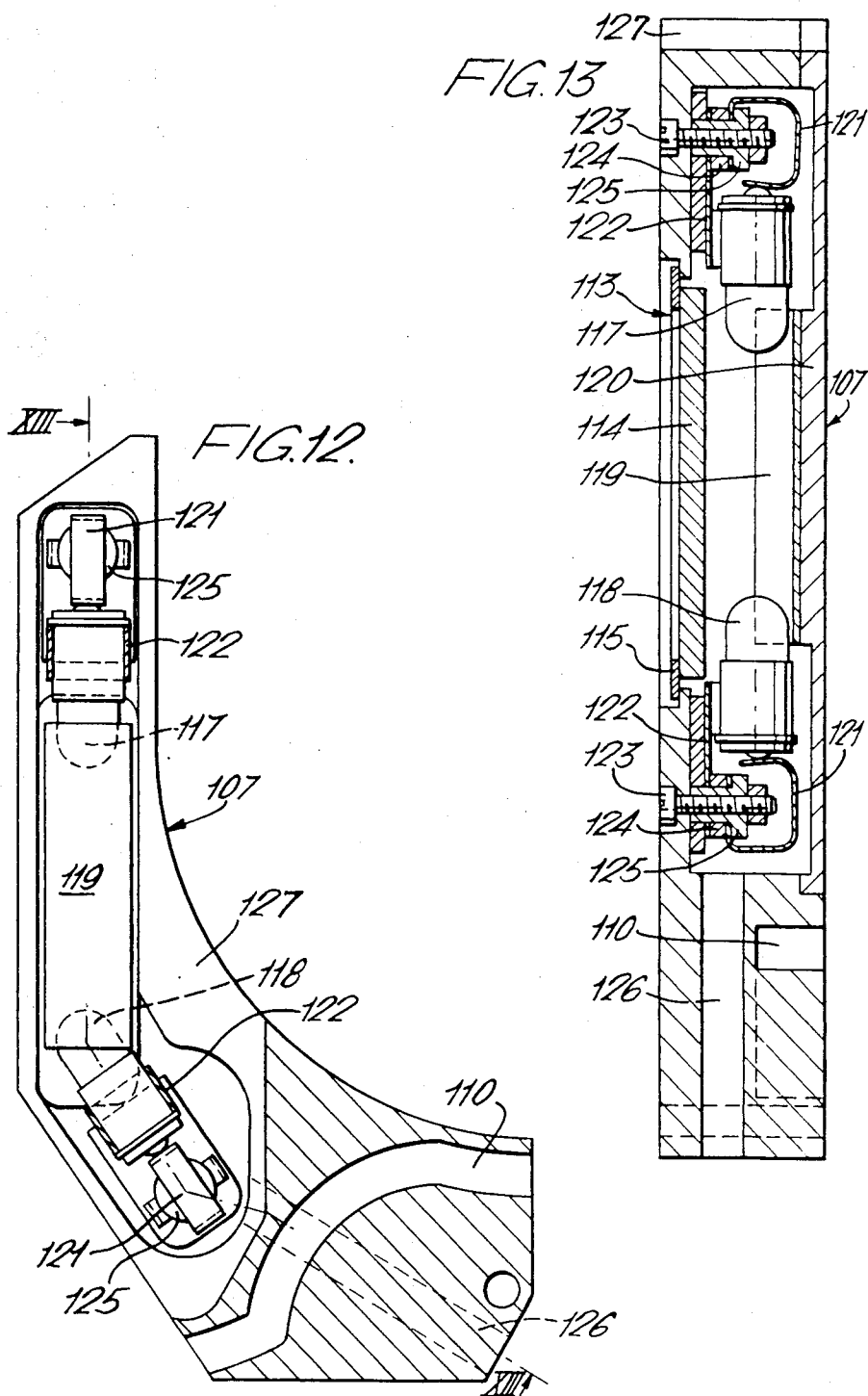


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HEAD-UP DISPLAY APPARATUS

This invention relates to head-up display apparatus.

According to the present invention there is provided a head-up display apparatus for a craft (for example, an aircraft), wherein collimator means is arranged to project on to a partially-transparent reflector the display provided by a selected one of two display-producing means so that the display projected is visible to an observer in the craft viewing a distant scene through the reflector, and wherein the selection of the particular display-producing means involved is effected by selection means that is operable to move the selected display-producing means to the collimator means and the other display-producing means from the collimator means.

Preferably the movement of the two display-producing means is effected sequentially.

A first of the display-producing means may be mounted for movement longitudinally from the collimator means so as thereby to provide a space between this display-producing means and the collimator means, and, in such a case, a second of the display-producing means may be mounted for movement into the said space along a path substantially normal to the direction of said movement of the first display-producing means.

One of the display-producing means may comprise an electrically-operated display device including a gas-tight housing which has a transparent wall portion and which encloses a substantially planar panel that faces the wall portion, the panel carrying an electric filament which at least along a part of its length extends across the panel intermediate the panel and the wall portion in the form of a symbol to be displayed, and which is adapted to be energized from outside the housing to provide an illuminated display of said symbol through the wall portion.

Various forms of head-up display apparatus for an aircraft in accordance with the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a side elevation, partly in section, of part of one form of head-up display apparatus;

FIG. 2 is a plan view of FIG. 1 partly in section on the line II—II;

FIG. 3 is an end elevation on the line III—III of FIG. 1;

FIG. 4 is a perspective view of a sleeve shown in FIGS. 1 to 3;

FIG. 5 is a sectional side view of one form of electrically-operated display device which may be used to provide a stand-by display of information for head-up display apparatus;

FIG. 6 is a sectional plan view on the line VI—VI of FIG. 5;

FIG. 7 is a fragmentary sectional view on the line VII—VII of FIG. 6;

FIG. 8 is a sectional side view of an alternative form of electrically-operated display device which may be used to provide a stand-by display of information for head-up display apparatus;

FIG. 9 is a sectional view on the line IX—IX of FIG. 8;

FIG. 10 is a plan view, partly in section, of part of a modified form of head-up display apparatus;

FIG. 11 is a view on the line XI—XI of FIG. 10;

FIG. 12 is a sectional end view of a display device in the head-up display apparatus of FIGS. 10 and 11; and FIG. 13 is a view on the line XIII—XIII of FIG. 12.

Referring to FIGS. 1 to 4, the head-up display apparatus includes a unit 10 for producing a main display of information and a unit 11 for producing a stand-by display of information for use in the event of failure of the main display. The units 10 and 11 are housed in a generally tubular elongated housing 12 of aluminum.

The housing 12 is mounted, by means not shown, immediately above the instrument panel of the aircraft and in front of the pilot with the longitudinal axis of the housing 12 extending lengthwise of the aircraft. The housing 12 has secured to one end thereof a collimator 13 for projecting the display of information produced by either of the units 10 and 11 on to an inclined partially-transparent reflector 128 (only part of which is shown) mounted above the collimator 13 on a frame 129 carried by the housing 12. The reflector 128 is disposed in the line-of-sight of the pilot through the windscreen of the aircraft and is inclined so that the display of information projected on to the reflector appears in the line-of-sight of the pilot. Thus, the pilot views the collimated image of the display of information projected on to the reflector against a background of the scene through the windscreen of the aircraft, and does so without any need for refocussing of his eyes.

The unit 10 includes a generally tubular elongated casing 14 in which a cathode-ray tube 15 is mounted with the face of the tube 15 in alignment with the end of the casing 14 adjacent the collimator 13. The casing 14 is slidably mounted within the housing 12 to vary the spacing between the face of the tube 15 and the collimator 13. Rotational movement of the casing 14 relative to the housing 12 is prevented by a pin 16 that is carried by the housing 12 and projects into a groove 17 formed in the casing 14 and extending longitudinally thereof. The housing 12 and the casing 14 are shaped to provide therebetween an annular space 18 which is centered on the longitudinal axis of the housing 12, the annular space 18 being bounded at the end nearest to the collimator 13 by a peripheral shoulder 18a on the casing 14 and being bounded at the other end by a peripheral shoulder 18b on the housing 12. The annular space 18 houses a plurality of springs 19 which are spaced apart around the casing 14 and are mounted to urge the face of the tube 15 towards the collimator 13.

The unit 11 includes a pair of generally arcuate-shaped plates 20 and 21 which are spaced apart and are joined at their edges by a side wall 22 that extends completely round the periphery of the plates 20 and 21. The plate 20 is of metal while the plate 21 is of glass. The unit 11 is pivotally mounted on a tubular pivot-pin 23 which extends through holes formed in one end of the plates 20 and 21, the ends of the pin 23 extending outwardly from the unit 11 and being rotatably mounted in holes formed in flanges 24 and 25 on respectively the housing 12 and a housing 26 of the collimator 13. The unit 11 is movable about its pivot between the position shown in FIGS. 1 and 3 where the unit 11 is disposed between the collimator 13 and the face of the tube 15 and a position, shown in dashed outline in FIG. 3, which allows the unit 10 to be advanced to bring the face of the tube 15 into abutment with a washer 27 carried by the collimator 13.

The plate 21 has formed thereon a graticule 28 (FIG. 3) which is positioned so that the center of the graticule 28 lies on the longitudinal axis of the unit 10 when the unit 11 is in the position shown. The part of the plate 21 on which the graticule 28 is formed is illuminated by a pair of electric lamps 29 (FIG. 1) carried on a body 30 of metal which is secured to the side wall 22, the surface of the body 30 adjacent the plate 21 being shaped to define a pair of parabolic reflectors 31. The lamps 29 are disposed at the focal points of respective reflectors 31 so that the rays of light passing through the plate 21 are parallel with one another. Electrical connections to the lamps 29 are provided by electric cables which extend through the pin 23 and are connected to respective electric connector pins mounted on the flange 24. One of the electric cables is shown in FIG. 1 and referenced 32, the electric cable 32 being connected to an electric connector pin 33.

During normal operation of the head-up display apparatus the unit 11 is disposed in the position shown in dashed outline in FIG. 3 and the unit 10 is positioned so that the face of the tube 15 abuts the washer 27. In the event of failure of the display of information on the screen of the tube 15, the unit 10 is moved to the position shown in FIG. 1 and thereafter the unit 11 is moved into the position shown in FIGS. 1 and 3 so that the stand-by display of information provided by the graticule 28 is projected on to the partially-transparent reflector 128. The movement of the units 10 and 11 is effected in accordance with the invention by selection means.

The selection means includes an arm 34 rotatably mounted on a boss 36 carried by the housing 26 so as to enable the arm 34 to be moved between the position shown in full outline in FIG. 1 and the position shown in dashed outline in FIG. 1 and reference 34A. The arm 34 carries a gear segment 37 whose teeth engage a bevel gear-wheel 38 (FIG. 2) carried by a shaft 39 which is rotatably mounted in bearings 40 and 41 disposed in the flange 24. The shaft 39 also carries a spur gear-wheel 42 for transferring rotational movement of the bevel gear-wheel 38 to a sleeve 43 which has teeth formed in its outer circumferential surface for engaging the teeth on the spur gear-wheel 42 and which is mounted for rotational movement in the housing 12 about the longitudinal axis thereof. Thus, movement of the arm 34 between the positions shown in FIG. 1 causes the sleeve 43 to be angularly displaced about the longitudinal axis of the housing 12. The sleeve 43 is mounted in the housing 12 to prevent relative axial displacement of the sleeve 43 and the housing 12.

The sleeve 43, which is shown in more detail in FIG. 4, has a pair of diametrically-opposed slots 44 formed in its inner circumferential surface which are engaged by respective pins 45 carried by the casing 14. Each slot 44 has a curved portion 46 which forms part of a helical spiral centered on the longitudinal axis of the housing 12 and a portion 47 which lies in a plane normal to the longitudinal axis. The sleeve 43 carries a pin 48 (FIG. 4) which extends outwardly from the end of the sleeve 43 adjacent to the collimator 13 and engages a slot 49 formed in the plate 20 of the unit 11. The slot 49 is provided at the end of the plate 20 remote from the pin 23 and has a curved portion 50, and a straight portion 51 disposed at the end of the curved portion 50

remote from the pin 23. The curved portion 50 is in the form of an arc which, when the unit 11 is disposed in the position shown in dashed outline in FIG. 3, is centered on the longitudinal axis of the housing 12, while the straight portion 51 diverges outwardly from the end of the curved portion 50 remote from the pin 23 and subtends an angle of approximately 40° thereto.

When the units 10 and 11 are in their normal positions, that is with the face of the tube 15 abutting the washer 27 and the unit 11 in the position shown in dashed outline in FIG. 3, the arm 34 is in the position referenced 34A, the pin 48 is disposed at the end of the curved portion 50 of the slot 49 remote from the straight portion 51, and the pins 45 are disposed at the ends of the curved portions 46 of the respective slots 44 remote from their straight portions 47. In the event of failure of the display of information provided by the cathode-ray tube 15 it is required to use the collimator 13 to project the stand-by display of information provided by the unit 11 on to the partially-transparent reflector 128. This is effected by moving the arm 34 towards the position shown in full outline in FIG. 1.

This movement of the arm 34 causes the sleeve 43 to rotate about the longitudinal axis of the tube 15 and thereby causes the pins 45 to move along the slots 44 and the pin 48 to move along the slot 49. During the first part of the movement of the arm 34 the pins 45 move in the curved portions 46 of the respective slots 44 and thereby cause the unit 10 to move away from the washer 27. At the same time the pin 48 moves along the curved portion 50 of the slot 49 but since the arcuate path through which the pin 48 is moved is also centered on the longitudinal axis of the tube 15 the unit 11 remains stationary. This action continues until the pins 45 reach the ends of the curved portions 46 of the slots 44 when it is arranged that the pin 48 reaches the end of the curved portion 50 of the slot 49.

During the remainder of the movement of the arm 34, the pins 45 move in the straight portions 47 of the slots 44 and, since the portions 47 lie in a plane extending normally to the longitudinal axis of the tube 15, the pins 45 serve merely to maintain the unit 10 in the selected position. However, during this part of the movement of the arm 34, the pin 48 moves in the straight portion 51 of the slot 49 and causes the unit 11 to be angularly displaced about the pin 23 and moved into the space between unit 10 and the washer 27. The pin 48 moves in one direction along the straight portion 51 to effect the first half of the movement of the unit 11, the second half of this movement being effected by the pin 48 moving in the opposite direction along the straight portion 51.

Accidental displacement of the arm 34 from the position shown in the drawings is prevented by a spring catch 52 mounted on the housing 26.

It is visualized that more than two parabolic reflectors 31 may be provided in the unit 11, and, in such a case, individual lamps 29 are disposed at the focal points of each of the reflectors 31.

The portion of the unit 11 for providing the stand-by display of information, that is the lamps 29, the body 30 and the portion of the plate 21 on which the graticule 28 is formed, may be replaced by an electrically-operated display device as shown in FIGS. 5 to 7 or FIGS. 8 and 9.

Referring to FIGS. 5 and 6, the electrically-operated display device includes a base 75 of insulating material which is in the form of a disc and through which extends a plurality of circumferentially-spaced electrical conducting pins 76-83. The upper ends of the pins 76-83 are bent outwardly to provide a support for a disc 84 of ceramics which carries three filaments 85 to 87 of, for example, nichrome wire. The ends of the pins 76 and 80 extend through diametrically opposed holes in the disc 84 and the ends of these pins projecting above the disc 84 are flattened to secure the disc 84 in position. The disc 84 has formed therein a plurality of holes which are disposed to form, on the upper face of the disc 84, an outline similar to that of the stand-by display of information provided by the graticule 28 of FIG. 3. The filaments 85 to 87 are threaded through respective groups of these holes so that the filaments 85, 86 and 87 are disposed to provide respectively a left-hand portion, a center portion, and a right-hand portion of the display of information. FIG. 7 shows the filament 86 threaded through holes in the disc 84. The ends of the filaments 85 to 87 are electrically connected to respective pairs of the pins 77 to 79, and 81 to 83 as indicated in FIG. 6. The disc 84 is housed within a glass envelope 88 which is sealingly connected to the circumferential edge of the base 75. The glass envelope 88 has a flat top which is disposed near to the disc 84 and extends parallel therewith. The electrically-operated display device is either evacuated or gas filled. When the filaments 85 to 87 are heated to incandescence by a low voltage electric current, the stand-by display of information provided by the filaments 85 to 87 is in dashed outline and is visible through the flat top of the envelope.

The electrically-operated display device is mounted within the unit 11 with the flat top of the envelope 88 extending into an aperture in the plate 21 so that the external surface of the flat top and the external surface of the plate 21 lie in the same plane. In such an arrangement the plate 21 is conveniently of metal.

An alternative form of electrically-operated display device for providing the stand-by display of information is shown in FIGS. 8 and 9. Referring to FIGS. 8 and 9, the electrically-operated display device includes a rectangular panel 89 of ceramics having holes through which the filaments 85 to 87 are threaded to form an outline identical to that provided by the filaments 85 to 87 in the electrically-operated display device of FIGS. 5 and 6. The panel 89 is vertically mounted on a base 90 and is supported at its ends by supports 91. The panel 89 is housed within a glass envelope 92 of rectangular cross-section which is sealingly connected to the peripheral edge of the base 90. The panel 89 is disposed near to a side wall of the envelope 92 and extends parallel therewith. The base 90 carries a pair of electrical conducting pins 93 and 94 to which the ends of the filaments 85 to 87 are appropriately connected to enable the filaments 85 to 87 to be heated to incandescence by a low voltage electric current.

The filaments 85 to 87 may be constituted by a printed circuit formed on the disc 84 or the panel 89.

A modified form of head-up display apparatus is shown in FIGS. 10 to 13. Referring to FIGS. 10 to 13, the head-up display apparatus includes an annular gear 100 which is rotatably mounted on a spindle 101 car-

ried by the housing 26 of the collimator 13. The rotation of the gear 100 is effected by an arm 102 mounted on the gear 100. The gear 100 has teeth which engage teeth on a bevel gear-wheel 103 mounted on one end of a shaft 104. A spur gear-wheel 105, having teeth which engage the teeth formed on the outer circumferential surface of the sleeve 43, is mounted on the other end of the shaft 104. The shaft 104 is rotatably mounted in a sleeve 106.

The stand-by display of information is produced by a unit 107 mounted for angular displacement about a pivot pin 108. This displacement is effected by rotating the sleeve 43 to bring a pin 109 on the sleeve 43 into engagement with a groove 110 in the unit 107. When it is required to move the unit 107 into the position shown in dotted outline in FIG. 11, the sleeve 43 is rotated by the arm 102 to move the pin 109 towards the groove 110. During an initial part of the movement of the sleeve 43, the cathode-ray tube unit 10 (FIG. 1) is moved away from the input face of the collimator 13, and, thereafter, when the pin 109 attains the position shown in dotted outline in FIG. 11, the pin 109 commences to bear against a side wall of the groove 110 to initiate the displacement of the unit 11.

The housing 12 carries a pair of resilient arms 111 and 112 for retaining the unit 107 in respective ones of its two positions.

The unit 107 is shown in detail in FIGS. 12 and 13 and includes a housing 127 of aluminum having an aperture 113 in which is disposed a glass plate 114. The plate 114 is carried by a frame 115 mounted on the housing 127. The plate 114 has formed thereon a graticule 116 (shown in dashed outline in FIG. 11) which is positioned on the plate 114 so that, when the unit 11 is in the position shown in dashed outline in FIG. 11, the center of the graticule 116 lies on the longitudinal axis of the cathode-ray tube 15. The plate 114 is illuminated by a pair of electric lamps 117 and 118, the light-rays from which are directed towards the plate 114 by a reflector 119. The reflector 119 is carried by a plate 120 which is mounted on the housing 127 by means of screws (not shown) so that the plate 120 may be readily removed to allow access to the interior of the housing 127 for replacement of the electric lamps 117 and 118.

The unit 11 includes identical mountings for the electric lamps 117 and 118. Each such mounting comprises a pair of electric connectors 121 and 122 which are mounted on a metal screw 123. The electrical connectors 121 and 122 are isolated from one another by a washer 124 of insulating material carried by the screw 123, and this screw also carries a sleeve 125 of insulating material which isolates the screw 123 from the connectors 121 and 122. The electrical connectors 122 include clips which constitute supports for the respective lamps 117 and 118 and which establish electrical connections to circumferential terminals of the lamps 117 and 118. The electrical connectors 121 resiliently bear against end terminals of the respective lamps 117 and 118. An electric supply is connected to the electric connectors 121 and 122 by electric cables (not shown) which extend through a hole 126 in the housing 127.

We claim:

1. A head-up display apparatus for a craft, comprising two display-producing means, collimator means

having an optical axis, means defining a display position substantially in a focal plane of said collimator means, means mounting a first of said display-producing means in said display position, a partially-transparent reflector mounted in the image field of the collimator means, said collimator means projecting onto the reflector the display provided at said display position so that the display projected is visible to an observer in the craft viewing a distant scene through the reflector, and display-changing means operable selectively to replace the said first display-producing means at said display position by the second display-producing means, said display-changing means comprising means operable selectively to withdraw said first display-producing means from said display position along a path substantially parallel to said optical axis at said position, and means for moving said second display-producing means into said display position in place of said first display-producing means.

2. An apparatus according to claim 1, wherein one of the display-producing means comprises an electrically-operated display device including a substantially planar panel, a gas-tight housing having a transparent wall portion, means mounting said panel within the housing with said panel facing said wall portion, an electric filament carried by said panel with at least part of the filament extending across said panel intermediate said panel and said wall portion in the form of a symbol to be displayed, and means for electrically connecting said filament to an energizing source whereby to enable said filament to be energized from outside the housing to provide an illuminated display of said symbol through said wall portion.

3. An apparatus according to claim 2, wherein said electric filament is constituted by electrical resistance wire, and said panel defines holes through which the wire is threaded.

4. An apparatus according to claim 2, wherein said electric filament is constituted by a printed circuit formed on the surface of said panel facing said wall portion.

5. An apparatus according to claim 1, wherein one of the display-producing means comprises a window, a graticule on the window in the form of a symbol to be displayed, an electric lamp for illuminating the window, and a light-reflecting surface for directing light-rays from the electric lamp towards the window.

6. An apparatus according to claim 1, wherein one of the display-producing means is a cathode-ray tube for providing a main display of information, and the other of the display-producing means is an auxiliary-display means for providing a static display of information that can be used in the event of failure of the main display.

7. Apparatus for providing a head-up display in the line of sight of an observer, comprising two display-producing means, selection means operable to select one of the two display-producing means as the source of said head-up display, collimator means for optical projection of the display provided by the said selected display-producing means, and a partially-transparent reflector mounted to reflect the projected display into the line of sight of the observer, said selection means comprising first transport means operable to move a first of said display-producing means along a straight-line path from said collimator to a withdrawn position

spaced therefrom, second transport means operable when said first display-producing means is moved from said collimator to move the second display-producing means transversely of said straight-line path into the space between the said withdrawn position and the collimator, and a selector movable from a first position to a second position to operate said first and second transport means to select the second display-producing means in place of said first display-producing means as the source of said head-up display.

8. Apparatus according to claim 7 wherein the said second transport means is means operable to move the said second display-producing means along an arcuate path transverse to said straight-line path.

9. An apparatus according to claim 7, wherein said first display-producing means is a cathode-ray tube for providing a main display of information, and said second display-producing means is an auxiliary-display means for providing a display of information that can be used as an alternative to said main display in the event of failure of the said cathode-ray tube.

10. An apparatus according to claim 7 wherein the selection means includes a rotatably-mounted sleeve, drive means coupled between the said selector and the sleeve to rotate the sleeve in response to movement of the said selector between said first and second positions, the direction of rotation of the sleeve being dependent on whether the movement of the said selector is toward said first position or toward said second position, first coupling means coupling the sleeve to the said first display-producing means to move the first display-producing means away from the collimator means when the sleeve is rotated in one direction and to move the first display-producing means toward the collimator means when the sleeve is rotated in the opposite direction, and second coupling means coupling the sleeve to the said second display-producing means to move the second display-producing means toward the collimator means when the sleeve is rotated in said one direction and to move the second display-producing means away from the collimator means when the sleeve is rotated in said opposite direction.

11. A head-up display apparatus for a craft, comprising two display-producing means, collimator means having an optical axis, means defining a display position substantially in a focal plane of said collimator means, means mounting a first of said display-producing means in said display position, a partially-transparent reflector mounted in the image field of the collimator means, said collimator means projecting onto the reflector the display provided at said display position so that the display projected is visible to an observer in the craft viewing a distant scene through the reflector, and display-changing means operable selectively to replace the said first display-producing means at said display position by the second display-producing means, said display-changing means comprising means operable selectively to move said first display-producing means from said display position, means mounting said second display-producing means for pivotal movement into said display position, and means for effecting said pivotal movement of said second display-producing means into said display position in place of said first display-producing means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,709,589

Dated January 9, 1973

Inventor(s) EDWARD LAWRENCE LAMB, KENNETH GORDON MCAINSH, and
RALPH DAVID SMITH

It is certified that error appears in the above-identified patent
and that said Letters Patent are hereby corrected as shown below:

Foreign Application Priority Data

January 2, 1970 Great Britain. 204/70

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,709,589 Dated January 9, 1973

Inventor(s) EDWARD LAWRENCE LAMB, KENNETH GORDON MCAINSH, and
RALPH DAVID SMITH

It is certified that error appears in the above-identified patent
and that said Letters Patent are hereby corrected as shown below:

Foreign Application Priority Data

January 2, 1970 Great Britain. 204/70

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

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Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents