

Aug. 23, 1966

B. G. OLESEN ETAL

3,267,598

INTERNALLY ILLUMINATED MATRIX

Original Filed April 12, 1960

2 Sheets-Sheet 1

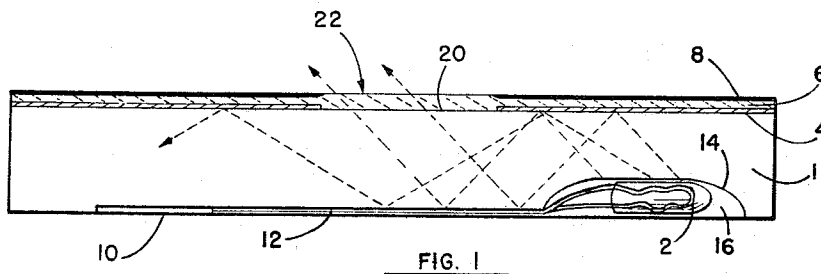


FIG. 1

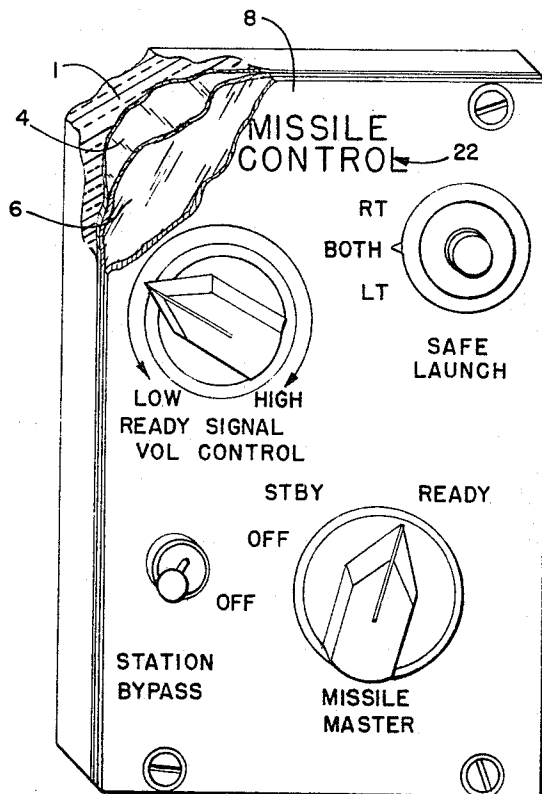


FIG. 2

INVENTORS
BOBBY G. OLESEN
BARBERO DIMARTINO
RICHARD T. HEAP
NORMAN G. HADDAD
BY *[Signature]*
ATTORNEY

Aug. 23, 1966

B. G. OLESEN ET AL

3,267,598

INTERNALLY ILLUMINATED MATRIX

Original Filed April 12, 1960

2 Sheets-Sheet 2

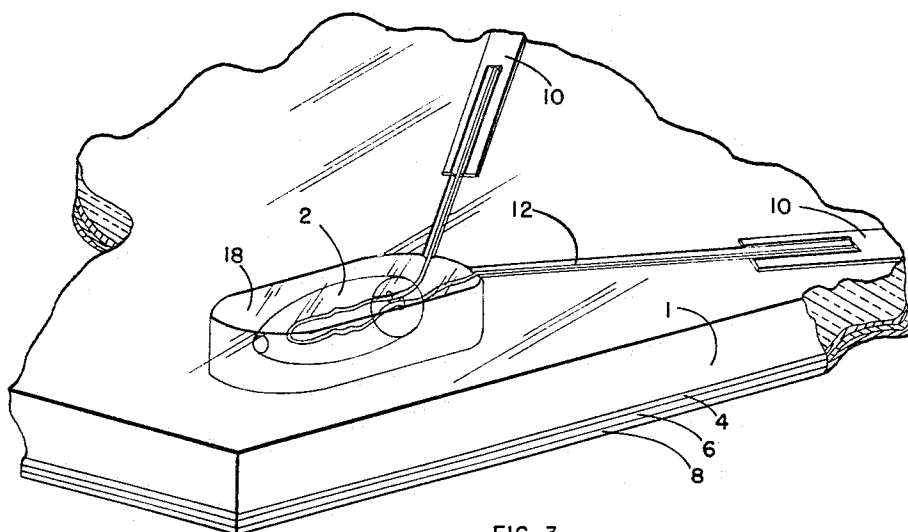


FIG. 3

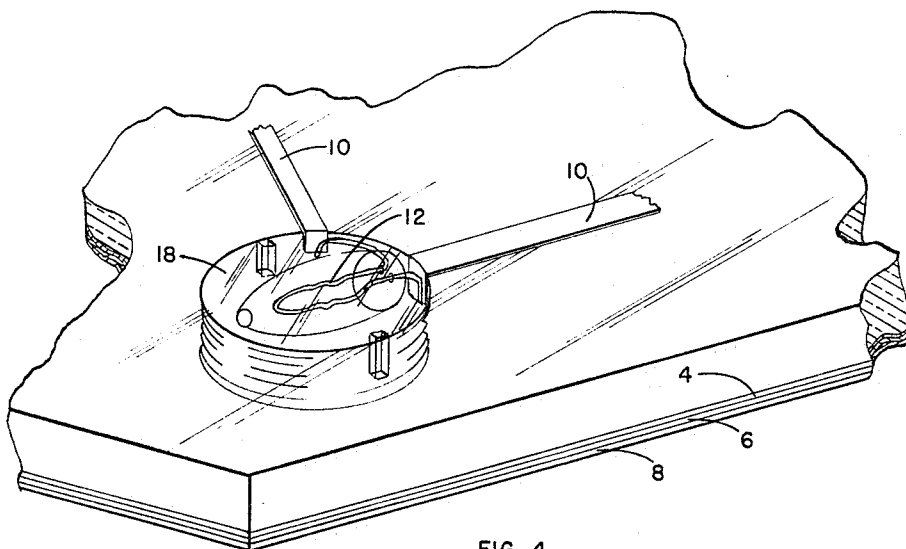


FIG. 4

INVENTORS
BOBBY G. OLESEN
BARBERO DIMARTINO
RICHARD T. HEAP
NORMAN G. HADDAD
BY *Richard T. Heap*
ATTORNEY

1

3,267,598

INTERNALLY ILLUMINATED MATRIX

Bobby G. Olesen, Inglewood, Barbero Di Martino, Rolling Hills, Richard T. Heap, Los Alamitos, and Norman G. Haddad, Long Beach, Calif., assignors to North American Aviation, Inc.

Continuation of application Ser. No. 21,825, Apr. 12, 1960. This application June 5, 1963, Ser. No. 285,840
8 Claims. (Cl. 40—130)

This is a continuation of application Serial No. 21,825, filed April 12, 1960, now abandoned.

This invention concerns improved means for illuminating panels upon which written matter or characters appear, and has particular application to instrument or switch consoles such as may be used in aircraft.

The invention disclosed herein is applicable to any panel or console involving written characters, letters or symbols which are read or interpreted by an observer. However, a particular need for this invention arose in connection with cockpit panel illumination in advanced high speed type aerial vehicles, wherein the greater complexities of the control systems and increased penalties of size and weight impose greater restrictions in the design of cockpit components than in conventional aircraft.

The panel illumination system disclosed herein is within that class of systems which broadly comprise a light transmitting panel with a dark surface coating which is etched to expose light from within the panel in the form of letters, symbols or other indicia, and a source of light to illuminate the panel from within. A common type of conventional control panel within the stated class is that comprising a sheet of acrylic resin or methylmethacrylate plastic material such as known to the trade as Lucite or Plexiglas. With this type of material which has light-conducting properties, it is possible to illuminate the matrix of the panel which then conducts light to any desired location where the indicia occurs. A source of light is provided at one or more selected points within the periphery of the panel, and light from the stated source or sources is diffused through the matrix. A dark coating is applied over the outer surface of the panel so that light within the panel matrix is not visible. Then portions of the covering material are cut, shaved, or otherwise removed from such coating to form letters or other indicia. Where the coating is removed, light from within the panel matrix is emitted therefrom so that the stated indicia glows in contrast with the dark coating which forms the panel outer surface covering.

Among the principal advantages of the stated panel illumination technique is the improved flexibility of design permitted by the fact that the sources of light used to illuminate the panel matrix may be interspersed throughout the panel between the various knobs, switches, dials or other such items located on the panel. Since the entire panel glows internally, lettering or indicia of any type may be placed anywhere on the panel outer surface where space permits, without the need for placing a light source directly in back of such indicia.

The advantage stated above is of particular importance in the fabrication of control panels for use in vehicles within the broad class including supersonic aircraft and space vehicles. In such vehicles, efficient use of available space is of greater importance than with conventional high-performance aircraft, since the penalties of size, weight, and drag are greatly multiplied during space travel at extremely high speed. Use of space at maximum efficiency requires that component structural parts fit together as closely as possible, with a minimum of voids or unused areas throughout the vehicle, including

2

the cockpit area. Therefore, it is a basic requirement in vehicles of the stated class that the cockpit control panels be as thin and smooth as possible, permitting the closest possible relationship between such panels and adjacent structure.

Also, vehicles of the stated class are characterized by highly complex electronic systems for performing many of the guidance and control functions. Due to the increased criticality of the size and weight limitations in supersonic vehicles as mentioned above, the compactness and crowded internal conditions resulting from such equipment severely limits the accessibility of items requiring adjustment or maintenance which may be situated out of reach within the vehicle. Therefore, it is a further requirement in vehicles of the stated class that the cockpit panel illumination means be adapted to function without any need for adjustment or maintenance throughout the entire service life of the panel.

In addition to the above, the increased complexity of problems incident to operation by the pilot of vehicles within the stated class results in the need for many additional control items in the cockpit. The switch and instrument panels in such vehicles consequently tend to be more crowded than generally similar panels known to the prior art. This factor results in less space being available for light sources, circuits, etc., used for panel illumination. Therefore, it is a further requirement in such control panels that the illumination means occupy a minimum of surface area of the panel, permitting the maximum availability of space for the controls and instruments, together with their identifying indicia, essential in the operation of the vehicle.

Also, due to the increased need for rapid and accurate pilot response to every demand on his attention imposed by extremely high speed flight in vehicles of the stated class, it is essential that the maximum of visual clarity and acuity be achieved by every possible means within the pilot's field of vision. Thus, the crowding of essential controls and dials within the limited area of the cockpit requires careful arrangement of the panel so that the least possible confusion of the pilot in directing his attention generally over the panels or selectively toward any particular item on a panel will result. Therefore, it is a further requirement that the illumination means in panels for use in vehicles of the stated class be as unobtrusive as possible and preferably completely invisible to the pilot so that the continuity of the control or instrument panels will not be interrupted by distractions such as bulbs, knobs, holes, or protuberances interspersed between the essential items.

Accordingly, it is a general object of the invention disclosed herein to provide improved control panel illumination means resulting in maximum visual clarity and acuity within the limited available panel area.

More particularly, it is a principal object of the instant invention to provide complete illumination of a light-transmitting panel from within by light sources which are totally invisible when the panel is viewed as during normal use.

It is a further object of the instant invention to provide complete illumination of a panel by internal means which permit substantially planar surfaces on both the front and back of the panel.

It is an additional object in this case to provide illumination of a translucent matrix in the form of a body from within by light sources which neither protrude nor are recessed below the surfaces of the body, but are integrally united to the body by encapsulation within the matrix.

Also, it is an object of the instant invention to provide improved illumination means in a control panel requir-

3

ing no adjustment after installation, and no maintenance or replacement of light source or circuitry during the entire service life of the panel.

It is a further object in this case to accomplish the above stated objects by compact means having minimum weight and occupying a minimum of space.

Other objects and advantages of the instant invention will become apparent upon a close reading of the following detailed description of an illustrative embodiment of the invention, reference being had to the accompanying drawings wherein:

FIGURE 1 shows an end view of a panel constructed in accordance with the inventive principles disclosed herein,

FIGURE 2 shows a general view of a panel embodying the inventive concept,

FIGURE 3 shows in detailed and fragmentary form an alternative means for installing a light source in the panel of FIGURE 1, and

FIGURE 4 shows a view generally similar to FIGURE 3 of another alternative embodiment for installation of a light source.

Referring to FIGURE 1 which shows an illustrative embodiment of the inventive concept, the lighting system to be described includes a panel 1 of light-transmitting matrix such as acrylic material. Embedded therein is a light source 2 which, for example, may comprise a miniaturized bulb such as known to the trade as a "grain-of-wheat" bulb commercially available from the Chicago Miniature Lamp Works, Chicago, Illinois. These bulbs are less than $\frac{1}{4}$ inch in length and $\frac{1}{8}$ inch in diameter, and have a service life in excess of 10,000 hours, often exceeding 60,000 hours. Hence, such bulbs would never have to be replaced during the life of the control panel which incorporates them. As indicated by lines, light rays from source 2 illuminate matrix 1 interiorly, and are reflected between the surfaces thereof except where light is emitted at the exposed surface of the indicia 22.

It is axiomatic in the field of optics that the amount of light reflected by a surface in relation to the amount which penetrates the surface varies with changes in the angle at which light impinges upon the surface. Each material which is capable of transmitting light has a particular angle of incidence, called the critical angle, which is one of the inherent light-transmitting properties of that material. All of the light impinging on a surface at an angle greater than the critical angle is reflected by that surface, whereas at less angles of incidence, some of the impinging light penetrates the surface. The value of the critical angle for each material depends upon its index of refraction and in the case of acrylic resin, the critical angle is about 45° .

Because the placement of light sources 2 in a particular panel need not depend upon the location of the indicia 22, it follows that the angle of incidence of light rays in any particular area of the panel will vary considerably depending upon the relative location of such area with respect to the light source or sources which illuminate it. Accordingly, in order to insure that a substantial portion of the light in the area of indicia 22 will impinge at an angle less than the critical angle for the panel material used, the panel 1 is surface treated to create a grainy or finely ground texture at the location of indicia 22, such as surface 20 in FIGURE 1. This may be accomplished by a variety of means, one of which is to mask the panel surface by a template which exposes only the area of the indicia, such as area 20 in FIGURE 1, and vapor-blasting such area in accordance with accepted vapor-blasting technique. This is done by impinging a stream of air and liquid mixed with fine abrasive particles against the exposed area of the plastic panel. The resulting surface roughness in the vapor-blasted area causes light from within the panel matrix 1 to impinge on surface 20 at numerous and diverse angles, so that a substantial portion of such light is refracted. Thus, more light is emitted

4

ted through letters or characters comprising the indicia, causing the same to glow with improved brilliance in sharp contrast with the surrounding panel area.

In fabricating a control panel incorporating the improved illumination means disclosed herein, after vapor-blasting is accomplished as set forth above, a layer 4 of brilliant light-reflecting material is applied to the surface of panel matrix 1 as shown in FIGURE 1. Layer 4 may comprise any white or silver substance, such as white enamel, or aluminum film, and which may be applied as a pre-cut sheet adhesively joined to the acrylic material or may be applied by spraying, painting, dipping or other known technique. During the application of layer 4, care is required to prevent the substance of layer 4 from covering the surface of matrix 1 where indicia such as 22 occur. Thus, surface 20 as shown in FIGURE 1 may be masked by a template, and the remaining surface of matrix 1 may then be coated with layer 4. Although in the drawings only the front surface of matrix 1 is coated with layer 4, it is obvious that both front and back surfaces of matrix may be similarly coated.

Upon completion of the above step, layers 6 and 8 may be applied, either simultaneously or in sequence. Layer 6 may be a lightly colored or white plastic or white paint, applied either in sheet form with an adhesive bond or painted on by spraying, brushing or dipping. The purpose of layer 6 is to render the indicia white or an otherwise light color, and to heighten the clarity of the indicia in contrast to the surrounding panel surface when light from within panel matrix 1 shines through layer 6. Therefore, the substance used for layer 6 should have light-transmitting properties.

Layer 8 is a black or otherwise dark covering which may be plastic or paint and preferably does not transfer light. Layer 8, which may be applied as in the manner of layer 6, is allowed to become permanently secured to layer 6, by drying or curing, if necessary. Then those portions of layer 8 which lie over surfaces such as 22 in FIGURE 1 wherein indicia are located are cut, shaved or otherwise removed from layer 8 so that layer 6 will be exposed. Thus, the indicia formed by the exposed portions of layer 6 will glow brilliantly when illuminated from within panel matrix 1, while those portions of the matrix covered by layer 8 will appear black or otherwise dark in color.

If applied simultaneously, layers 6 and 8 may be pre-formed plastic sheets which are placed together with a sheet of acrylic material in the desired relationship in a mold. The face of the mold may form a die which will leave an impression upon the top surface of the laminae thus formed, this impression corresponding to the lettering or other indicia desired for the finished panel. Upon the application of heat and pressure, the panel structure may be formed completely in one operation, and the black layer then cut away as described above to expose the white indicia beneath.

Since a panel embodying the inventive principles disclosed herein may include any number of light sources 2 depending upon the particular requirements in a given design problem, and each source is constructed in the same manner, only one need be described. As shown in FIGURE 1, the light source consists of a miniature or "grain-of-wheat" bulb such as heretofore described. Bulb 2 is situated within a cavity 14 which is cut or molded into the back surface of panel 1. In the structure shown by FIGURE 1, bulb 2 is embedded into cavity 14 by initially placing the bulb in the hollow of the cavity and thereafter filling the remaining volume of the cavity with potting material or an appropriate adhesive such as, for example, acrylic resin, or water white epoxy resin preferably having the same index of refraction as panel matrix 1.

With bulb 2 thus secured as set forth above, with its two wire leads 12 emerging from cavity 14, a connection

5

between the two stated leads and an energizing circuit may be accomplished by appropriate means. Although the inventive principles herein disclosed are obviously adaptable for use with conventional wire circuits, the use of printed circuits on the back side of panel 1 results in an advantageous saving of space and weight. Accordingly, leads 12 from bulb 2 may be joined to the printed circuit 10 as shown in FIGURE 1.

Where metallic mirrorizing material is used for layer 4 as set forth above, a layer of insulating material may be layed over layer 4 on the back surface of panel 1 to insulate layer 4 from the printed circuit, if necessary.

An alternative method of installing light bulb 2 in panel matrix 1 is shown in FIGURE 3. In this embodiment, bulb 2 is first embedded in a small plug or cube 18 of the same material as matrix 1. A recess or cavity of shape corresponding to cube 18 is created in the back surface of matrix 1, and the cube with bulb 2 embedded therein may be adhesively secured within the stated cavity, as shown in FIGURE 3. Leads 12 from bulb 2 are soldered or otherwise joined to appropriate portions of printed circuit 10 as in connection with FIGURE 1 described above. Leads 12 may be adhesively secured to panel matrix 1 within V-shape grooves as shown in FIGURE 3, to insure that leads 12 do not protrude above the surface of the panel.

Instead of adhesively securing cube 18 within a corresponding recess in matrix 1, cube 18 may be cylindrically shaped as shown in FIGURE 4 with one or more shallow helical screw threads engaging in similar threads in cylindrical cavity, so that tube or plug 18, with bulb 2 embedded therein, may be screwed into place. At the periphery of plug 18, two narrow spaced strips of silver conductive paint may be placed, with leads 12 from bulb 2 connected thereto. The matching recess into which plug 18 is threadably secured may have two similarly spaced strips of corresponding material connected to printed circuit 10. When plug 18 is properly positioned as shown in FIGURE 4, the two sets of tabs are in electrical contact, avoiding the necessity for soldered connection between leads 12 and circuit 10. The alternative embodiment of FIGURE 4 thus provides a means by which light sources in a panel using this arrangement could be easily changed or replaced.

In all of the embodiments discussed above, after the installation of illumination means disclosed herein, the panel is perfectly smooth on both the front and back surfaces, with nothing to break the continuity of the surface. In other words, in the case of a flat panel, both the front and the back surfaces thereof would be perfectly planar and parallel to each other. In addition, in all of the stated embodiments, one or more sources of colored light may be used in any panel incorporating the system herein disclosed by including a colored filter in the laminae forming the front surface of the finished panel. Alternatively, in the case of FIGURES 3 and 4, for example, colored or tinted plastic can be used in forming cubes or plugs 18 in which bulbs 2 are embedded before the cubes are secured within matrix 1.

From the description and drawings contained herein, it may be seen that applicants have provided an improved panel illumination system which achieves all the objectives hereinabove set forth with new and novel results. FIGURE 2 shows a general view of panel constructed in accordance with the inventive principles disclosed herein. For purposes of illustration, the indicia are shown black in FIGURE 2 and the panel surface white, whereas in actual appearance the panel is black or dark in tone and the indicia white. Since there are no protrusions caused by the illumination system on the front of the panel, considerable unnecessary cluttering has been avoided and the controls are commensurately easier to identify and operate. Removal of the protrusions from the back of the panel increases flexibility in selecting lo-

6

cations for the light sources, which in turn permits more even panel lighting and avoidance of glare.

The structural details set forth above may obviously be varied without departing from the scope of the inventive concept as disclosed herein and defined by the appended claims.

We claim:

1. The combination of:

a panel of transparent material in relatively thin sheet form having indicia on an outer surface of said panel, a light source comprising at least one electric light bulb integrally united to said material by encapsulation therewithin so that the outer surface of said bulb is in substantially uniform contact with said material over substantially the entire surface of said bulb, and

means for energizing said light source to illuminate said material from within.

2. The combination set forth in claim 1 above, wherein:

said panel comprises generally smooth and uninterrupted front and back surfaces, and

said light source comprises a miniaturized bulb of a size adapted to fit between said surfaces whereby said surfaces are free of protrusions.

3. The combination set forth in claim 2 above, wherein:

a portion of said surface of said panel is relatively coarsely textured so that light from within said material is diffused and refracted through said portion at a multitude of different refraction angles.

4. The combination set forth in claim 3 above, having in addition thereto:

a coating of opaque material completely covering said panel except where portions of said opaque material are lacking in areas which form said indicia through which light from within said matrix passing through said relatively coarse surface portion also passes.

5. The method of installing a source of light in a relatively thin-walled panel of transparent material comprising the steps of:

providing a hollow cavity in one surface of said panel, placing a relatively small light bulb in said cavity, filling said cavity with a fluid capable of hardening into a transparent solid material, and

hardening said fluid whereby said bulb is integrally joined to said transparent material and securely supported in stationary relationship in relation to said panel.

6. The combination set forth in claim 1 above, wherein:

said panel has a back surface having a cavity located therein,

said material in which said electric lightbulb is encapsulated is a cube being of a shape corresponding with the shape of said cavity so as to completely fill the same,

said cube being secured within said cavity so that the exposed surface of said cube is flush with said back surface of said panel, presenting a smooth, uninterrupted surface throughout said panel, and means for securing said cube within said cavity.

7. The combination set forth in claim 6 above, wherein:

said cube of said material is tinted with color so that the illumination originating from said light source assumes the color of said tinting.

8. The combination set forth in claim 1 above, wherein:

said panel has a back surface having a generally cylindrical shaped cavity located therein,

said material in which said electric lightbulb is encapsulated is a generally cylindrical plug of said material,

7

said plug being of a shape corresponding with the shape
of said cavity so as to completely fill the same,
said plug further having a helical thread on the gen-
erally cylindrical surface of said plug,
said cavity having a helical thread on its generally
cylindrical surface, and
said plug being adapted to fit within said cavity by in-
terengagement of said two helical threads on said
plug and said cavity, respectively.

2,808,528
2,821,800
2,824,399
2,838,865
2,852,877
2,864,057
2,906,048
2,945,313
3,018,614
3,059,134
3,120,350

10/1957
2/1958
2/1958
7/1958
9/1958
12/1958
9/1959
7/1960
1/1962
10/1962
2/1964

8

Martin ----- 40—130 X
Hardesty ----- 40—130
Neugass ----- 40—130
Hardesty ----- 40—130
Goebel ----- 40—130
Connelly ----- 240—2.1 X
Kraus ----- 40—130
Hardesty ----- 40—130
Brien ----- 40—130 X
Tedrick ----- 40—130 X
Nuenz ----- 40—130 X

References Cited by the Examiner

UNITED STATES PATENTS

1,995,863 3/1935 Prideaux ----- 40—130 X
2,170,600 8/1939 Voll ----- 40—130 X
2,337,744 12/1943 Garstang ----- 40—130 X
2,651,864 9/1953 Howenstine ----- 40—130
2,795,069 7/1957 Hardesty ----- 40—130

FOREIGN PATENTS

336,764 4/1959 Switzerland.

EUGENE R. CAPOZIO, *Primary Examiner.*

JEROME SCHNALL, *Examiner.*

H. ROSS, *Assistant Examiner.*