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# United States Patent [19]

**Farchmin et al.**

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[54] **REFLECTOR FOR FLAT PANEL DISPLAY BACKLIGHT UNIT**

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[73] Assignee: **Allen-Bradley Company, Inc.**, Milwaukee, Wis.

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[51] **Int. Cl.**[6] ..... **F21V 7/09**

[52] **U.S. Cl.** ..... **362/241**; 362/29; 362/224; 362/225; 362/297; 362/346

[58] **Field of Search** ..... 362/224, 225, 362/237, 241, 245, 247, 260, 297, 346, 347, 348, 217, 29

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[57] **ABSTRACT**

Backlighting for an LCD display is provided by a direct backlight unit which is hinged to the front panel in which the display is mounted. When closed, the backlight unit lamps and reflector transmit light directly against the back of the display. The reflector surfaces are made by a combination of constant radius, hyperbolic, parabolic and flat surfaces which maximize the emitted light transmitted to the display and help fill in for any failed or dimmed light sources.

**20 Claims, 3 Drawing Sheets**

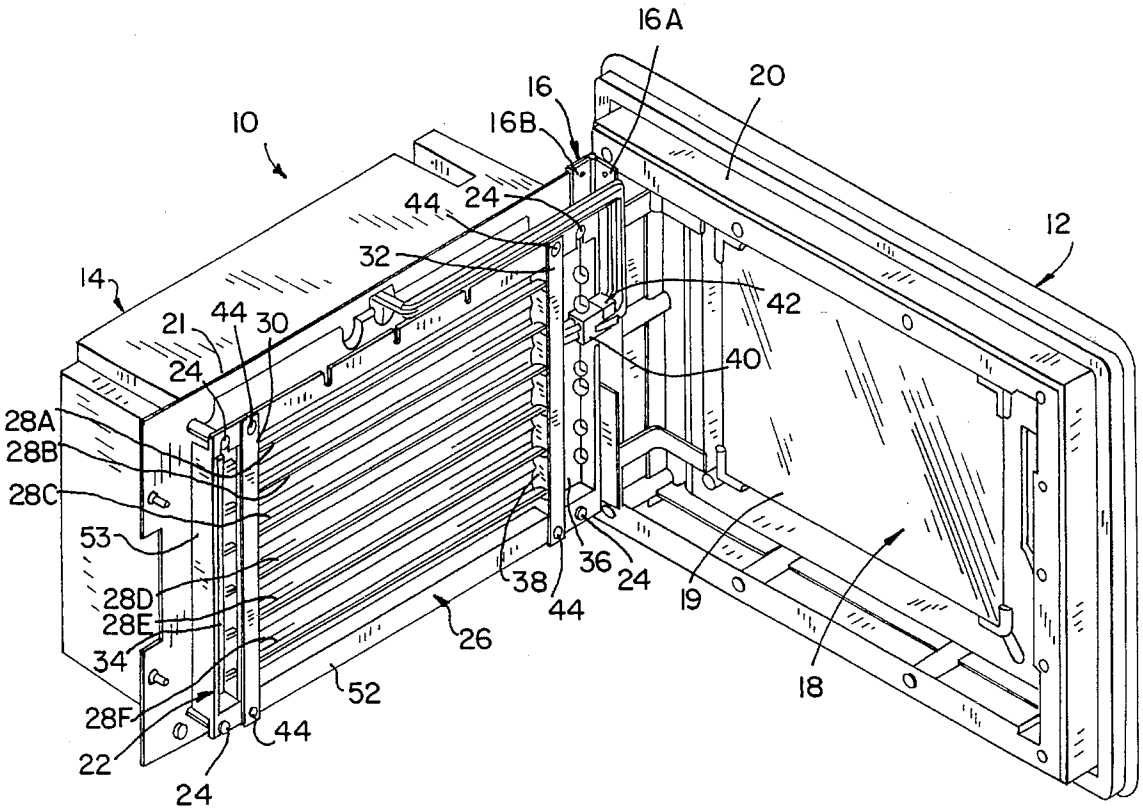


FIG. 1

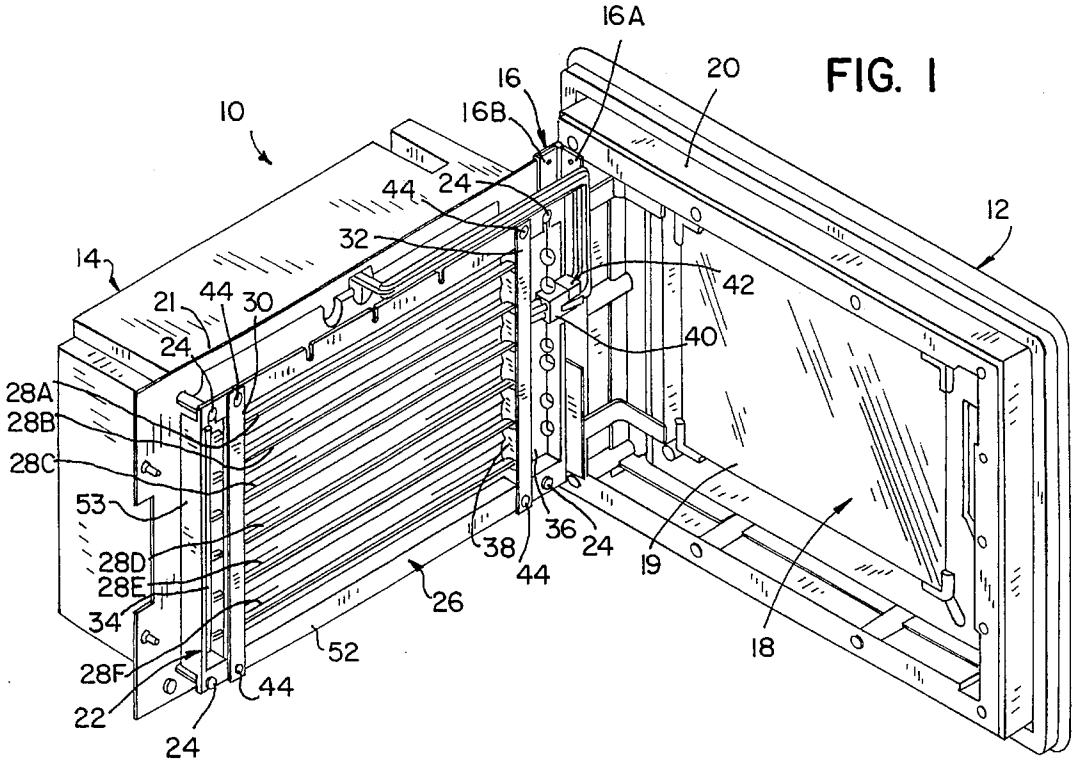



FIG. 2

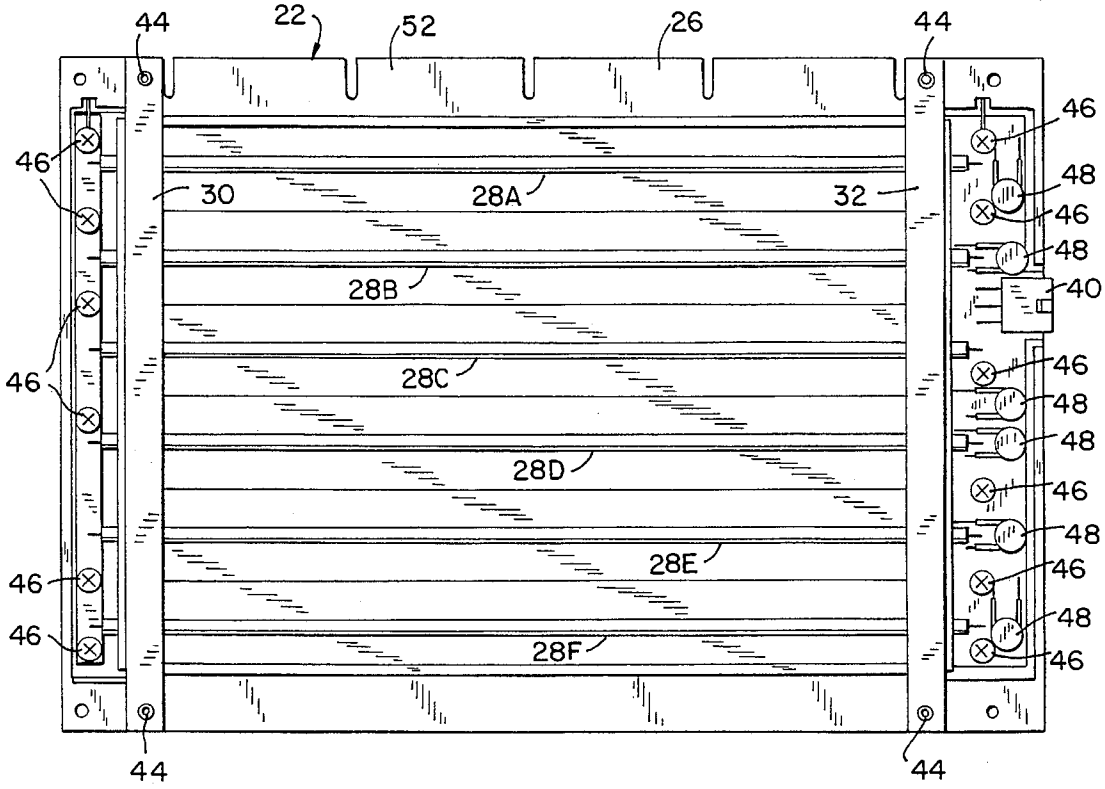


FIG. 3

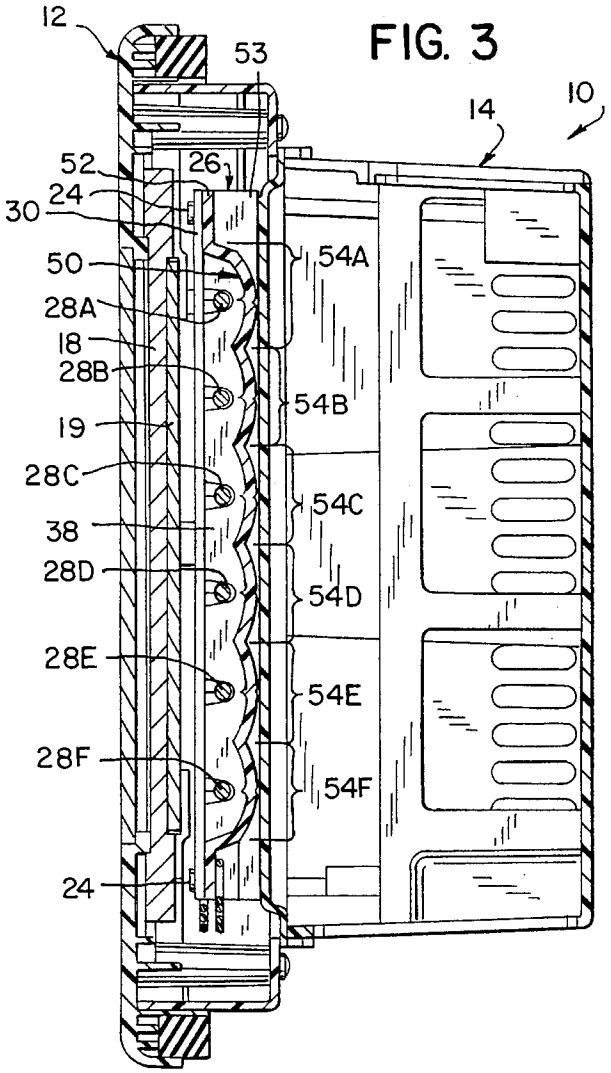



FIG. 4

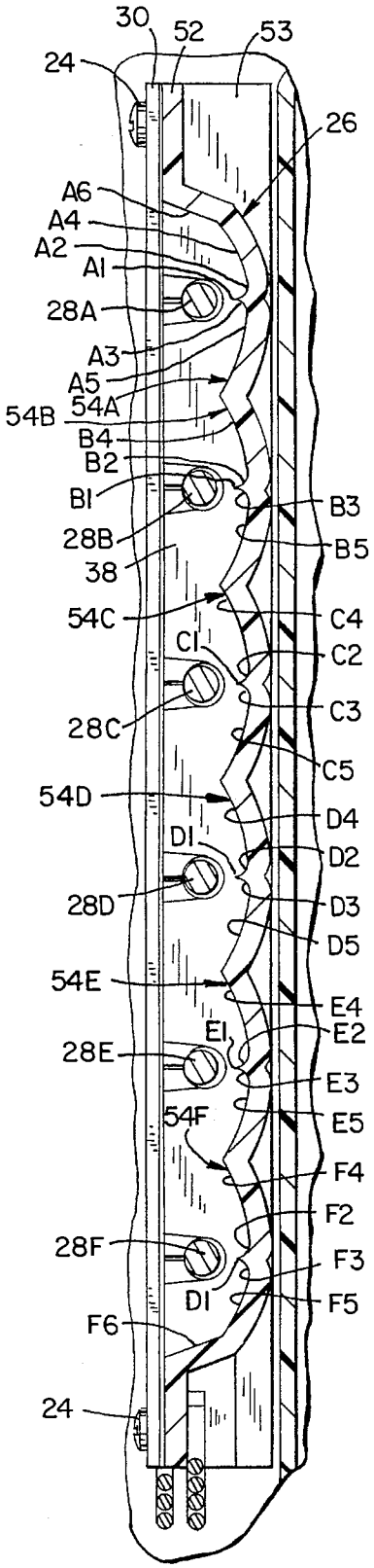
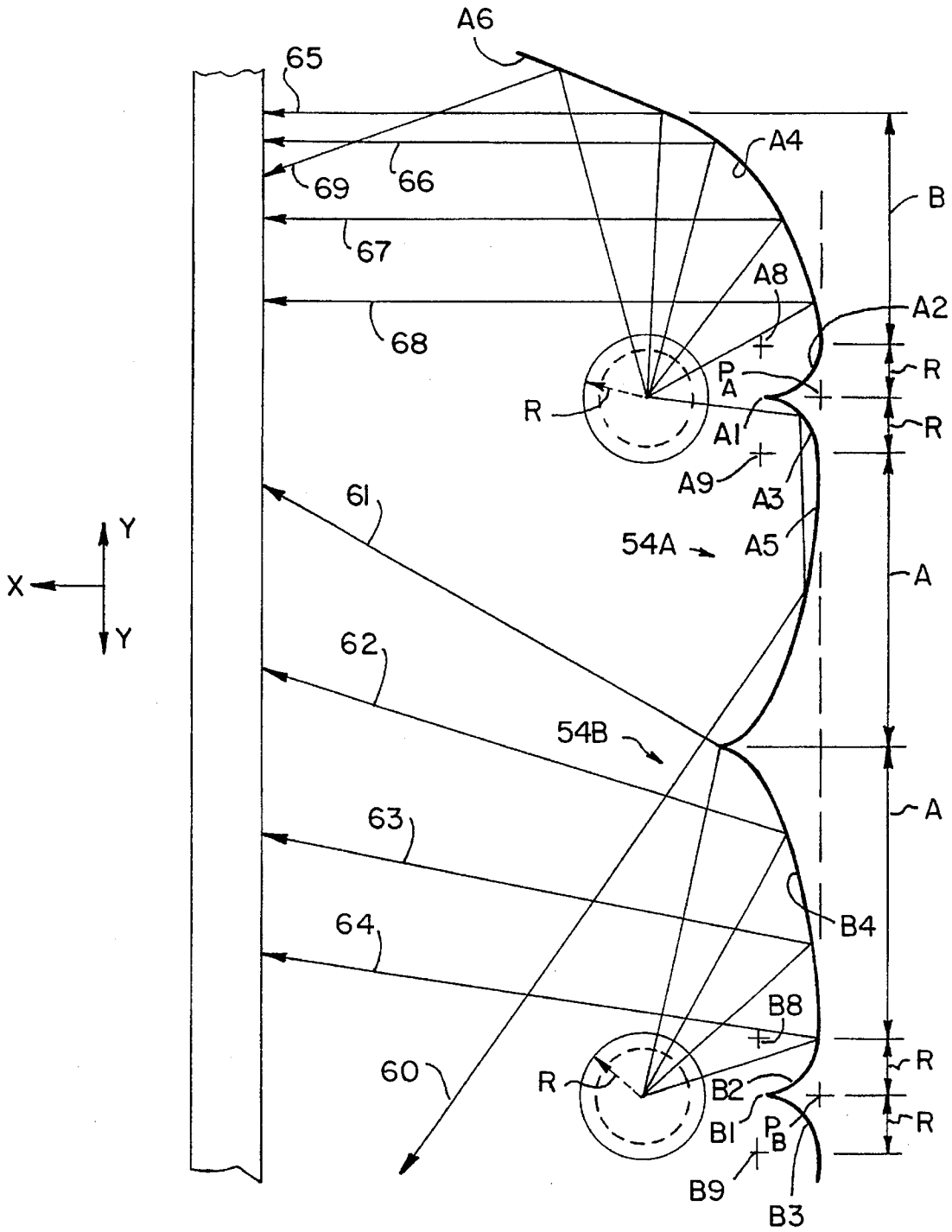


FIG. 5



# REFLECTOR FOR FLAT PANEL DISPLAY BACKLIGHT UNIT

## FIELD OF THE INVENTION

This invention relates to flat panel display backlight units and in particular to reflectors for direct backlighting units.

Direct backlighting of liquid crystal displays is well known and reflectors for such backlighting units have been developed. For example, U.S. Pat. No. 5,253,151 which issued Oct. 12, 1993 discloses such reflectors.

It is desirable in backlighting units for flat panel displays that the light produced by the backlight unit be uniform and capable of a high intensity over the entire viewing area of the display. In addition, especially for industrial computer displays where failure of the display can result in a costly loss of production, it is desirable that these backlight displays be durable and reliable, and that they do not fail disastrously.

## SUMMARY OF THE INVENTION

The invention provides a reflector for multiple parallel cylindrical light sources of the type having an arcuate reflective surface section for each parallel source. Each surface section defines an apex ridge directly behind the corresponding source and the surface section extending from both sides of the apex ridge in arcuate surfaces. An improvement of the invention is that the arcuate surfaces extending from the apex ridge are defined by constant radius surfaces. Thereby, light being transmitted directly rearward from the source is redirected by the constant radius surface to be reflected by another reflector surface back toward the display. The result is to increase the diffusion of the light reflected from the sources, use more of the light to illuminate the display, and reduce the effect of an adjacent lamp dimming or failing completely, all of which contributes to the effectiveness of a reflector of the invention.

In one useful aspect, at least one of the constant radius surfaces is joined at its edge opposite from the apex ridge by a hyperbolic surface. This is desired in areas of the reflector where dispersion and diffusion of the light from the corresponding bulb is desired, such as for the interior surface sections of the reflector. Thereby, when one lamp burns out, light from the adjacent lamps will be reflected into the area of the burned out lamp to fill in for it and largely preserve the visibility of the display until the backlight unit can be replaced.

For interior surface sections, hyperbolic surfaces are preferably provided on both sides of the apex ridge, whereas for the end surface sections, a parabolic surface is preferable provided on the outer side of the apex ridge. The parabolic surface in this location is useful to collimate the light reflected from the corresponding lamp, so as to direct it toward the display and prevent it from escaping past the edge of the display. A further improvement is that a flat reflector surface may be provided outside from each parabolic surface, to direct redirect light toward the display.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a cabinet which incorporates the invention illustrated in an open position:

FIG. **2** is a front plan view of a backlight unit of the invention;

FIG. **3** is a vertical sectional view through the cabinet shown in FIG. **1** illustrated in a closed position;

FIG. 4 is a detail view of a portion of FIG. **3**; and



FIG. **5** is a schematic ray tracing of the backlight unit illustrated in FIGS. **1–4**.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a cabinet **10** incorporating the invention includes a front panel **12** and a cover **14**. The cover **14** is secured to the front panel **12** by a hinge **16** secured along corresponding vertical edges of the panel **12** and cover **14** so as to allow pivoting of the cover **14** relative to the panel **12** between the open position shown in FIG. **1** and the closed position shown in FIG. **3**.

As best shown in FIGS. **1** and **3**, the front panel **12** includes a flat panel display **18** which may be, for example, a thin film transistor (TFT) or metal insulator metal (MIM) type display. However, any flat panel liquid crystal display which is backlit in operation may be used to practice the invention. Preferably, a diffuser plate **19**, which may be for example a sheet of white opaque acrylic to diffuse light transmitted against the back of the display **18**, directly overlies the back of the display so as to enhance the uniformity of the light transmitted by a backlight unit **22**.

The front panel **12** also includes a bezel **20** which frames the display **18** and to which the hinge plate **16**A of the hinge **16** is directly connected. Hinge plate **16**B of hinge **16** is directly connected to a vertical panel of flange **21** of the cover **14**. The cover **14** is made generally in the form of a box so as to house most of the electronic components of the enclosure **10**, such as the computer which controls the display **18**.

The backlight unit **22** is releasably secured with screws **24** to the front of the cover **14** so that when the cover **14** is pivoted to the open position shown in FIG. **1**, the front of the backlight unit **22** is exposed as are the heads of the screws **24**. The backlight unit **22** is shown by itself in FIG. **2**. When the cover **14** is closed as shown in FIG. **3**, the backlight unit **22** is moved to within close proximity of the rear of the display **18** and to being parallel to the display **18** so as to transmit light against the rear of the display **18**, through the diffuser plate **19**. This provides backlighting to the display **18** which is necessary for a user to view the indicia generated by the display **18**. In order to ensure adequate cooling of the display **18**, it is preferable to maintain an air gap of ¼ to ⅜ inches between the closest surface of the backlight unit **22** and the rear of the diffuser panel **19** in the closed position.

The backlight unit **22** includes a molded plastic reflector **26** which doubles as the structural foundation to which the other components of the backlight unit **22** are secured. These other components include **6** straight cylindrical cold cathode fluorescent lamps (CCFL's) **28**A–F, metal strips **30** and **32** along the respective left and right ends of the lamps **28**A–F to hold the lamps in position, a left connector strip **34** for making contact with the left electrodes of the lamps **28**A–F and a right connector strip **36** for making a electrical contact with the right electrodes of the lamps **28**A–F. Elastomeric material **38** is preferably placed between the strips **30** and **32** and the reflector **26** so as to hold the lamps **28**A–F securely in position.

In addition, the right connector strip **36** preferably includes a plug half **40** to mate with a mating plug half **42** which is wired to the electronics in the cover **14** so that the backlight unit **22** may be releasably electrically connected to the enclosure **10**. Screws **44** secure the strips **30** and **32** to the reflector **26**, and screws **46** secure the connector strips **34**

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