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A Dual-Layer, Switchable, Transparent Projection Screen

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ABSTRACT

Projection displays with transparent screens are a fresh approach that offers enhanced user experiences. However, projection displays suffer from low brightness of reflected light and undesired leakage of transmitted light. This disclosure describes a switchable, dual-layer projection screen that is transparent when off. When turned on, the screen displays a bright, sharp, reflection of the projected image devoid of noisy or background images arising from light leakage.

KEYWORDS

- Projection display
- Liquid crystal display (LCD)
- Transparent projection screen
- Switchable LCD
- Light leakage
- Background image

BACKGROUND

Smart devices, e.g., smartphones, smart speakers, smartwatches, etc., typically use regular, direct-view displays such as liquid-crystal displays (LCD). Projection displays with transparent screens are a fresh approach that offers enhanced user experiences. However, projection displays suffer from low brightness of reflected light and undesired leakage of transmitted light.

DESCRIPTION

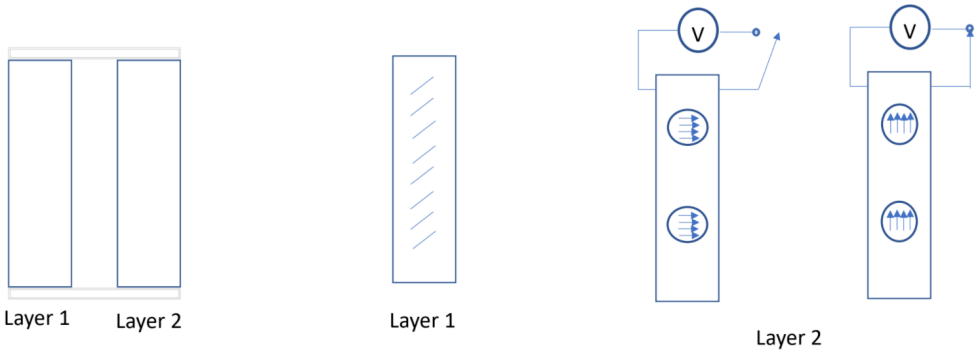

Fig. 1: Dual-layer, switchable, transparent projection screen

Fig. 1 illustrates an example of a dual-layer, switchable, transparent projection screen, per the techniques of this disclosure. The screen comprises two layers, of which a first layer (layer-1) is a film that can selectively reflect light in one direction and is highly transparent (e.g., transmittance greater than ninety percent) in the other direction, and a second layer (layer-2) is a film that includes liquid crystal droplets in polymer form. As illustrated, the second layer can be switched between transparent and opaque by applying an electric voltage. The second layer is transparent when no voltage is applied and opaque when sufficient voltage is applied. Effectively, the second layer works as a reverse-mode polymer dispersed liquid crystal.

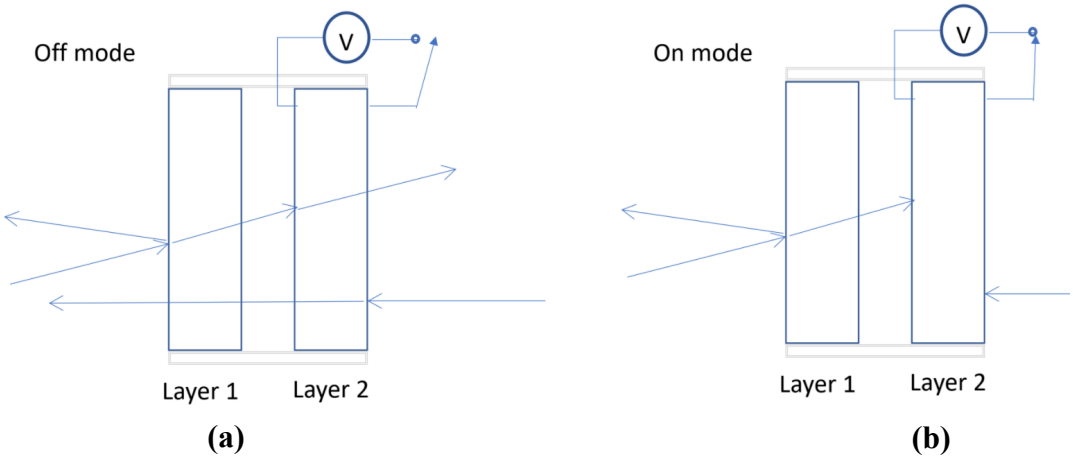

Fig. 2: Working of the dual-layer, switchable, transparent projection screen

Fig. 2 illustrates the working of the dual-layer, switchable, transparent projection screen, per the techniques of this disclosure. Fig. 2(a) illustrates the projection screen in off mode, e.g., with no applied voltage across the second layer. In off mode, the second layer is nearly fully transparent. Light incident from the layer-1 side is partially reflected off layer-1 and mostly transmitted through both layers. Light incident from the layer-2 side is almost fully transmitted through both layers.

Fig. 2(b) illustrates the projection screen in on mode, e.g., with sufficient voltage applied across the second layer. As mentioned before, the applied voltage causes the second layer to become opaque, such that light incident on layer-2 from either side is not transmitted through the screen, while light incident from the layer-1 side is mainly reflected. The fraction of light that passes through layer-1 undergoes diffuse reflection at layer-2 (but no transmission). The diffused light emanating from layer-2 serves to enhance brightness at normal and wide angles.

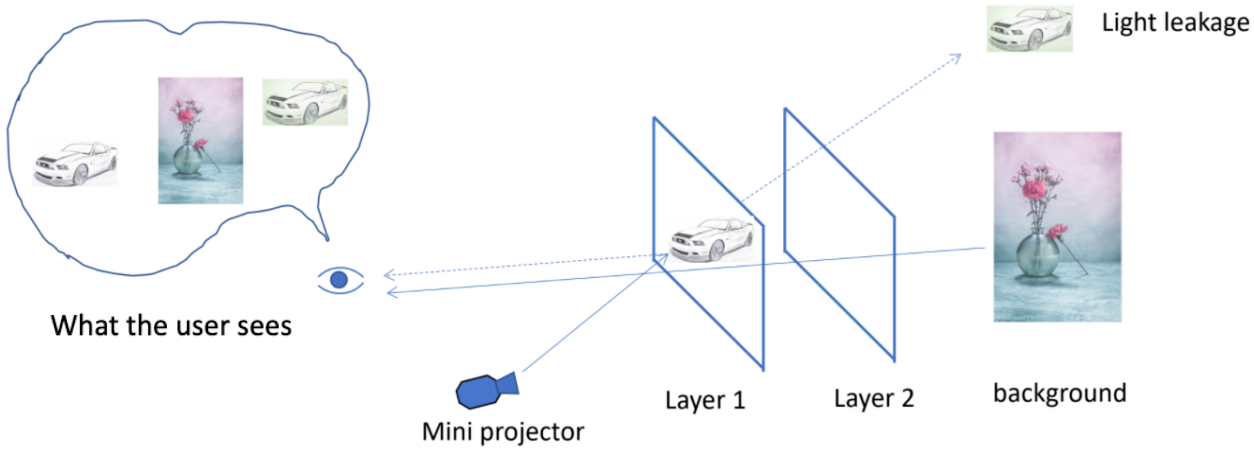

Fig. 3: Operation of the dual-layer, switchable, transparent projection screen in off mode

Fig. 3 illustrates the operation of the dual-layer, switchable, transparent projection screen in off mode. As explained earlier, in off mode, the second layer is transparent, such that when a (mini) projector projects an image (the car) on the screen, the viewer sees not only the reflection

of the car off the first layer, but also a second reflection (termed as noise or light leakage) of the car off the second layer, as well as the background behind the second layer. As such, in off mode, the projection screen is effectively invisible, passively transmitting the background behind layer-2, and, when illuminated, presenting additionally a mildly reflective view of the illuminating image.

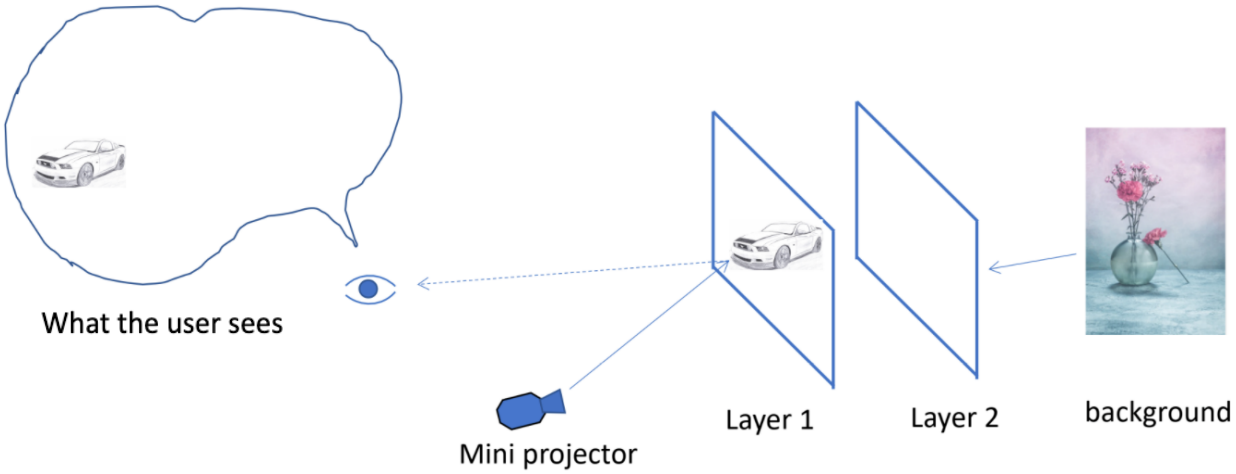

Fig. 4: Operation of the dual-layer, switchable, transparent projection screen in on mode

On the other hand, in on mode, illustrated in Fig. 4, layer-2 is opaque, thereby inhibiting the view of the background, while enabling the viewer to see a single, sharp, bright image of the image (car) being projected by the projector. In the viewer's optic field, neither is the noise image present nor is the background behind layer-2. Also, as mentioned before, the diffused light emanating from layer-2 serves to enhance brightness at normal and wide angles.

CONCLUSION

This disclosure describes a switchable, dual-layer projection screen that is transparent when off, but when turned on, displays a bright, sharp, reflection of the projected image devoid of noisy or background images arising from light leakage.