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(54) **Illumination for electromagnetic display panel**

(57) A new concept of illumination of the electromagnetic display panels is described using invisible UV light illumination (11, 16) of the display panel to extend the operation of said display panels into low ambient light conditions. Such a solution is possible, if one uses UV fluorescent dyes in the paints or plastic material for the reflective surface (13p) of the selected pixel element instead of the regular reflective ones. The said dyes absorb the invisible near-UV light and upon absorbing it reemit the light in the visible range. The described display panel illumination concept results in excellent contrast, as there is no visible light scattering from the background or protective display panel top covers, which in turn result in haze and glare. Furthermore unlike with the electromagnetic display panels, using built-in light sources imbedded in each pixel element (i.e.: LED,...), the appearance / perception of the displayed characters (shape, geometry) as well as the angular visibility remain unchanged in the high as well as in the low or "dark" ambient light conditions.

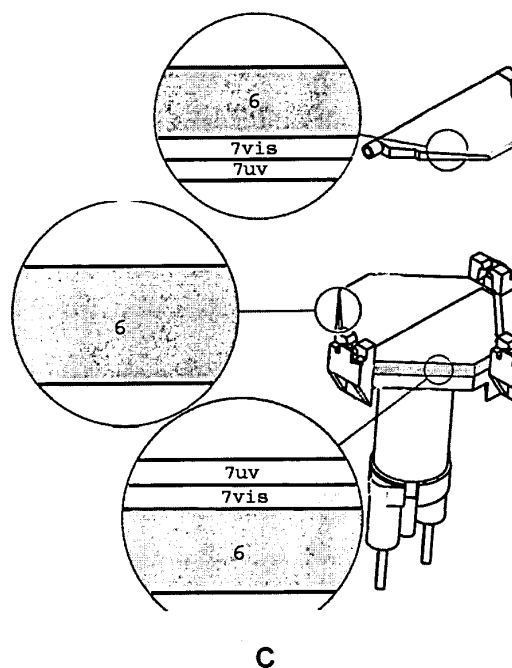


Fig. 3

Description

OBJECTIVE OF THE INVENTION

[0001] The objective of the present invention is the concept of illumination of electromagnetic display panels, which minimizes the light reflection from the dark background, as well as the reflections from the outer transparent protective cover and emphasizes only the light emerging from the bright luminescent surface layer on the activated display pixels. The proposed illumination of electromagnetic display panels is based on the use of the luminescent dyes in absorbing light in the near-UV light range and upon absorbing the UV light reemitting the light in the visible spectral range. The advantage of the new concept is that the reflected light, used for the display panel illumination, is hardly visible to the human eye and so the direct reflections from the dark, nonactivated background as well as from the outer transparent display panel protective cover is extremely low. This in turn results in extremely high display panel contrast in poor lighting conditions. As the light emitted from the display pixels is emitted in random directions, the angular visibility of such a display is excellent.

TECHNICAL FIELD OF THE INVENTION

[0002] The technical field of the invention is the illumination of the large, bistable electromagnetic display panels, used for traffic signs, buses' and trains' destination displays, large information display panels in airports, train and bus stations and sporting events in poor lighting conditions. According to the international patent classification, the patent application is classified in the groups G09F 3/4 and G09F 9/37. As the visibility of these display panels is of prime importance, excellent angular visibility, visual perception and high contrast are necessary.

TECHNICAL PROBLEM

[0003] The technical problem solved by the present invention is to provide a novel, low production cost concept of illumination of the electromagnetic displays, which should provide excellent angular visibility in poor or no ambient light conditions, reduce the haze and glare caused by light scattering from the protective cover as well as light reflections from the background and display casing, which adversely affect the display contrast.

BACKGROUND OF THE INVENTION

[0004] The electromagnetic display panels have been known for over two decades and are playing an important role in niche applications, where relatively large size, medium information content display panels, with high contrast and excellent visibility even at oblique an-

gles in rather high ambient lighting conditions are required. The bistable electromagnetic display panels (US 3,871,945, US 4,577,427, US 4,860,470, EP 0 084 959, EP 0 731 435 A1,...), used for traffic signs, buses' and trains' destination displays, large information display panels in airports, bus and railway stations and sporting events seem to comply very well with the above requirements. Using bright reflective paints on the selected picture elements ("ON" state) and mate black on the non-selected areas ("OFF" state), these displays feature good contrast and excellent angular visibility in high ambient light conditions.

[0005] Due to their excellent performance in the above-mentioned niche applications, extending their operation in the situations, where the ambient light is rather poor or not present at all (night), seems to become more and more important. The existent solutions however do not seem to be very adequate:

- The straightforward illumination of the whole display panel with additional regular light sources such as standard fluorescent lights represents a cheap, efficient and widely used solution. Its major deficiency however is that such an illumination concept results in excessive haze and glare of the display panels. The fact is that the light incoming from the light sources used for display illumination is scattered on the protective transparent covers (bus and train destination displays,...) as well as on the background surfaces and nonselected display pixels resulting in rather poor display panel contrast.
- In most cases the technical solutions are based on the use of additional light sources in each of the display picture elements. A number of technical solutions of this kind have been developed so far. Most of these solutions use LED diodes (US 5,050,325, WO 00/62274, DE 189 02 218 A1, EP 0 731 435 A1,...) or other light sources (US 4,914,427, GB 2,297,185 A, US 5,642,130,...) built into every pixel element directly or via optical fibers (US 5,055,832).

The general problem with all these solutions is that the light source has to be embedded in the display pixel surface in order to allow for the electromagnetic element to function properly, allowing one (US 6,603,458) or another type (US 5,771,616) of rotation of the pixel flaps in order to display reflective color (selected element - "ON") or mate black background surface (nonselected element - "OFF"). Because of this the visibility of the display panel, when using its own active light sources, is noticeably degraded at slant viewing angles compared to the same display using only normal ambient light. Yet another problem is that the light source, built-in each pixel, can cover only a very limited area of the pixel to allow the electromagnetic display panel to operate in the regular (high) ambient light conditions. This means that the perception of the characters on such a display in dark ambient light conditions is strongly degraded.

Finally one has to mention that the use of the LEDs or any other additional light emitting element for the individual display pixels illumination is a very expensive and energy consuming solution.

[0006] According to the invention the patent solves the above-specified technical problems using external UV rather than standard visible light illumination of the electromagnetic display panels. In order to make advantage of the UV illumination, the use of color dyes absorbing light in the near-UV light range and reemitting it in the visible spectral range is necessary on the selected picture elements either in the form of UV luminescent paint or plastic material used for display pixels having the said dyes directly imbedded/dissolved in them. The UV light illuminated paints with luminescent dyes are quite commonly used in various light shows (entertainment, advertisement,...). No use of this display illumination concept has however been reported, where the above concept is used to reduce the haze and glare of the electromagnetic display panels resulting in increased contrast of these devices.

SUMMARY OF THE INVENTION

[0007] The electromagnetic displays are typically made as large matrix arrays of preferably square display pixels with movable flaps and built-in solenoids. The "ON" and "OFF" state of the flaps is indicated by visually highly contrasting colors. By rotating the flap around the axis by means of the magnetic field one can display arbitrary patterns. The magnetic driving of the pixels provides for the inherent memory, which is essential for keeping the power consumption within the required limits.

[0008] The goal of the invention is achieved by using invisible UV light illumination of the display panel, which is possible, if one uses UV fluorescent dyes in the paints or plastic material for the reflective surface of the selected pixel element instead of the regular visible light reflective ones. The said dyes absorb the invisible near-UV light and upon absorbing it reemit the light in the visible range - see Fig. 1. Such a display panel illumination concept results in excellent contrast, as there is no visible light scattering from the background or protective top covers resulting in haze and glare. Furthermore unlike with the electromagnetic display panels using built-in light sources on each pixel element (i.e.: LED,...), the appearance / perception of the displayed characters (shape, geometry) remains unchanged in the high as well as in the low or "dark" ambient light conditions.

[0009] The major advantage resulting from the use of the said near-UV light illumination is not so much the bright color under UV light illumination (- any bright, properly illuminated reflective paint can do the same) but rather the lack of illumination light scattering from the background surface and display protective covers, which normally significantly degrade the standard elec-

tromagnetic display panel contrast. The effect is evident even in regular illumination conditions (additional UV light increases the brightness) and is especially present in the dark ambient situations, where the electromagnetic displays according to the invention exhibit extremely high contrast without any haze due to the scattered illumination light.

[0010] The technical solution, proposed in this patent application, simultaneously solving the problem of haze and glare due to the scattered illumination light (-visible!) as well as angular dependence and visual perception of the illuminated display pixel, seems to be a very simple, cheap and at the same time highly efficient solution for the overall technical problem of the visibility of electromagnetic display panels in "dark ambient" conditions.

[0011] The use of the proposed illumination concept is not limited to any particular design and can be used with anyone of the already existing electromagnetic display concepts.

[0012] As emphasized before in order to be able to make advantage of the invisible UV illumination, the use of color dyes absorbing light in the near-UV light range and reemitting it in the visible spectral range is necessary in the top layer of the selected ("ON") display pixel surface either in the form of UV luminescent paint or by imbedding/dissolving the said UV luminescent dyes in plastic material used for display pixels. In order to avoid the need for the additional UV illumination also in high ambient light conditions the selected ("ON") display pixel surfaces have to reflect the visible light as well. There are several possibilities to achieve this goal, which however vary to some extent with the display pixel operation principle (see Fig. 2a, 2b and the corresponding "Detailed description" to follow).

[0013] In the normal lighting conditions the electromagnetic display panel using the display pixels made according to the above described concept behaves just like any present state-of-the-art reflective electromagnetic display panels, however if additionally illuminated with near-UV light, its brightness can be improved. It is the dark ambient condition, where the possibility of using the invisible near-UV light illumination brings the most profit, since the electromagnetic displays according to the invention exhibit extremely high contrast without any haze and glare due to the scattered visible illumination light as opposed to the present state-of-the-art solutions using illumination with standard fluorescent lights.

[0014] The realization of the active illumination of the electromagnetic display according to the invention is very similar to the standard concept of illumination with regular fluorescent lights. If the latter are replaced for example by the "black ray" fluorescent lights used in entertainment, advertisement etc. (See Fig. 4) or any other near-UV light source (UV LED,...), an important increase of contrast as well as important reduction of haze and glare is achieved as a result of the lack of illumina-

tion light scattering from the background surface and display protective covers, which normally significantly degrade the standard electromagnetic display panel contrast..

DESCRIPTION OF DRAWINGS

[0015] This invention may be better understood and its objectives and advantages will become apparent to those skilled in the art by reference to the annexed drawings as follows:

Fig. 1 - Light spectra of the UV luminescent dye: trace a - light absorption spectrum; trace b - light emission spectrum

Fig. 2 - Standard design concepts of the electromagnetic display pixels:

a - concept #1 - display pixel movable flap represents the complete display pixel

b - Concept #2 - display pixel is composed of the static part and the movable flap, which covers only one half of the display pixel surface

Fig. 3 - Cross-sections through the "ON" sections of the display pixels showing relative positions of the layers containing UV luminescent dyes for different manufacturing concepts:

a) layers of paint containing UV luminescent dyes and visible light reflective dyes covering the "ON" side of the display pixel flap according to the operational concept #1

b) UV luminescent dyes imbedded/dissolved in the basic plastic material (7) used for manufacturing the display pixel flaps according to the operational concept #1 covered on the "OFF" side with the layers containing visible light reflective dyes (7_{VIS}) and dark (typically mate black) dye (7_b) respectively,

c) layers of paint containing UV luminescent dyes and visible light reflective dyes covering the "ON" side of the display pixel flaps and the "ON" sections of the display pixel surface (operational concept #2),

d) UV luminescent dyes imbedded/dissolved in the basic plastic material (7) used for manufacturing the display pixel flaps and display pixel surface layers according to the operational concept #2 - The display pixel flap as well as the corresponding static surface of the display pixel are covered with additional layers containing color dyes reflecting visible light (7_{VIS}) and with the layers containing light absorbing dyes (7_b) respectively: with the pixel flaps the "OFF" side the flap plastic material (7) is first covered with the layer (7_{VIS}) reflect-

ing visible light and finally with the light absorbing typically black mate layer (7_b); with the static display pixel surface the "OFF" section is covered with the layer including light absorbing dyes (7_b), while the "ON" pixel section is on its bottom side covered with the layer containing visible light reflecting dyes (7_{VIS}).

Fig. 4 - UV illumination principle - the "ON" side of the display pixels surfaces are covered with UV luminescent paint; display panel is illuminated with the near-UV "black ray" light source and the light intensity equalizing filters can be optionally added to equalize the overall display panel illumination,

Fig. 5 - UV illumination principle for large electromagnetic display panels.

DETAILED DESCRIPTION OF THE INVENTION

[0016] As pointed out above, the proposed technical solution of illumination of the electromagnetic display panels by means of the invisible near-UV rather than visible light according to the invention solves the problem of extending the operation of electromagnetic display panels in low and/or dark ambient light conditions in a simple, cheap and yet very efficient way. The said solution strongly reduces the haze and glare of the display panel and therefore increases its contrast.

[0017] The proposed illumination concept can be applied generally irrespectively of the operational concept of the electromagnetic display pixels. The details of the implementation however vary to some extent with the display pixel operation principle. There are basically two substantially different state-of-the-art "electromagnetic display pixel operating concepts" as shown on the Figs. 2a and 2b:

1. Solutions (as described in EP 0327250, US 6,272,778, US 6,025,825, US 5,898,418,...) based on the movable pixel flap **2**, rotating around the pivoting axis **5** through the center of the flap **2** for typically $\leq 180^\circ$ just inward the mechanical limiting positions **9** and having the size of the entire display pixel (see Fig. 2a):

The flap **2** is painted on its front **2a** and rear side **2b** with visually highly contrasting colors.). For switching between the "ON" and "OFF" state of the display pixel these solutions typically use a fixed permanent magnet inserted in the center of gravity of the movable pixel flap **2** plane and oriented perpendicularly to the flap pivoting axis **5**, as well as an electromagnet (3+8) with the U-shaped magnetic core **8** built-in the display pixel body **6** and oriented perpendicularly to the pivoting axis **5** of the display pixel movable flap **2**. The magnetic poles

of the U-shaped magnetic core **8** are positioned at the sides of each display pixel flap **2** at the closest proximity of the poles of the permanent magnets built-in the movable display pixel flaps **2**. The short intense driving electric pulse determines the direction of magnetization in the magnetic core **8** made of the magnetically semi-hard material, which keeps the magnetization even after the driving electric pulse is gone. The remnant magnetization of the electromagnet core plays the role of the memory element - inherent memory. Through the magnetic force, exerted by the magnetic field of the "semi-hard" magnetic core of the driving electromagnet, the latter determines the orientation of the permanent magnet built-in the display pixel movable flap **2** forcing it to display either highly contrasting bright colored "ON" side **2a** or dark (typically mate black) "OFF" side **2b** of the display pixel.

2. Solutions (as described in US 6,603,458, DE 3501912C2, DE 3601018A1,...) based on display pixels, which are divided into two parts - the static display pixel surface **1a**, **1b** and the movable flap **2** covering only one half of the display pixel (see Fig. 2b):

Each pixel is provided with a rotatably mounted, bistable tilting flap **2**, which is asymmetrical in relation to its rotational axis **5**. The tilting flap **2** covers one of the two portions of the panel surface in the pixel zone, when the flap **2** lies in each of its two stable positions. The side **2a** of the tilting flap **2** facing the front side of the panel and the portion of the panel **1a** in the pixel zone covered by it are painted in one and the opposite side of the flap **2b** and the remaining part of the pixel zone **1b** are printed with different, highly contrasting color to the first one. In order to switch between the "ON" and "OFF" state of the display pixel these solutions use a permanent magnet inserted in each tilting flap in close proximity to the rotational axis. The permanent magnet is oriented perpendicularly to the display pixel flap surface. The tilting flap **2** is rotated from the first bistable position into the second bistable position by an electromagnet with a straight magnetic core, which is located on the reverse side of each display pixel. The mechanism for switching between the "ON" and "OFF" state of the display pixel is very similar as in the case #1. Such a construction has a certain advantage over the other state-of-the-art solutions, as the entire construction can be noticeable thinner (only one half of the pixel surface rotates around the pivoting axis!) than with the technical solutions as described before

(concept #1).

[0018] In order to be able to make advantage of the invisible UV illumination, the use of color dyes absorbing light in the near-UV light range and reemitting it in the visible spectral range is necessary in the top layer of the selected ("ON") display pixel surface either in the form of UV luminescent paint or by imbedding/dissolving the said UV luminescent dyes in plastic material used for display pixel surface layer manufacturing. In order to avoid the need for the additional UV illumination also in high ambient light conditions, the selected ("ON") display pixel surfaces have to reflect the visible light as well. There are several possibilities to achieve this goal, which however vary to some extent with the display pixel operation principle and are discussed in more detail in "Examples" to follow:

- The display pixel flap is made of the dark (typically mate black) plastic **6p**, which is typically the same as the one used for display pixel body **6**. The ("ON") side of the pixel is covered with the paint having both UV absorbing dyes (reemitting light in the visible range) as well as visible light reflecting color dyes.
- The display pixel is made of the dark (typically mate black) plastic **6p**, which is typically the same as the one used for display pixel body **6**. The ("ON") side of the pixel is covered first with the layer of paint reflecting visible light 7_{VIS} and then with the layer 7_{UV} of paint having UV absorbing dyes, which is typically transparent in the visible spectrum.
- The display pixel is made of the transparent plastic **7** having UV absorbing dyes imbedded/dissolved in it. The "OFF" and "ON" states of the display pixels are in these cases achieved by additional layers of paints containing visible light reflective (7_{VIS}) and light absorbing ($7b$) dyes (typically mate black) - see examples for details.

[0019] The realization of the active illumination of the electromagnetic display panel **13** (Fig 4, 5) according to the invention is very similar to the standard concept of illumination with regular fluorescent lights. If the latter are replaced for example by the "black ray" fluorescent lights **11** used in entertainment, advertisement etc. (See Fig. 4) or any other near-UV light source (UV LED,...), an important increase of contrast is achieved. In order to focus as much light on the display panel **13** an additional light reflector **10** is typically used. Irrespective of the optimization of the form of such a reflector the near-UV illumination of the UV luminescent paint covering the "ON" sections of the display pixels **13p** (Fig. 4), strongly depends on the distance between the "black ray" fluorescent light **11** and a particular section of the display panel **13**. The intensity of the visible light emitted by the fluorescent dyes varies accordingly since it is proportional to the near-UV illumination. As the increase of

the distance between the "black ray" fluorescent light source **11** and the display panel **13** is usually very limited by the overall constraints of the display panel **13** dimensions, the uniformity of the UV light illumination is obtained by the addition of the adequately variable gray filter **12** (see Fig 4).

[0020] In case of larger display panels **13** the above described technical solution using standard "black ray" fluorescent light sources is not very practical, since large areas cannot be illuminated only from the sides. Spot-light near-UV light sources **16** would be a lot more appropriate (see Fig. 5). In case that higher UV illumination is required than provided with commercial "black-ray" spot-lights **16**, standard low pressure Hg-vapor light sources like Philips HPR 150 spot-lights can be used instead. In order to eliminate the visible light generated by the said sources, additional color glass visible light absorbing filters **14** can be added (e.g. Schott EG3 glass). In order to reduce the heat dissipated by these filters, optimize the peak light emission with the peak light absorption of the fluorescent dye (Fig. 1) and finally to efficiently eliminate the deeper UV light, an additional thin-film Fabry-Perot reflective filter **15** can be added (Fig. 5).

[0021] The use of the proposed technical solution can be best demonstrated by its application in medium large display panels typically used for bus or train destination displays. In this case the electromagnetic display panel is made as NxM matrix array (N-number of rows; M-number of columns) of display pixel elements, where the number of columns is typically significantly larger than the number of rows (few lines of α -numeric characters). As pointed out before, the embodiments of the proposed invention mainly depend on the choice of the method of inducing the UV luminescent properties to the display pixel surface **13p**, when the display pixel is in the "ON" state, as well as on the operational principle of the electromagnetic display pixels, used in a particular application. Typical working embodiments are described in the four Examples and illustrated in the Fig. 3a, b, c and d as follows:

EXAMPLE 1

[0022] The basic operational principle of the display pixels used in this embodiment of the said "bus or train destination" electromagnetic display panel is based on the movable pixel flap **2** rotating around the pivoting axis **5** through the center of the flap **2**, which actually represents the display pixel element - the operational concept #1, as described above (see page 7 and Fig. 2a). In order to display either "ON" or "OFF" position of the display pixel, the flap **2** has to rotate for $\sim 180^\circ$ around its pivoting axis so both sides of the flap must exhibit highly contrasting colors.

[0023] In order to be able to use the display panel in high as well as low ambient light conditions an additional illumination is required. When implementing the use of

the invisible UV-light illumination principle according to the invention, the flap is in this embodiment manufactured using black mate material **6p** (typically black pigmented ABS) preferably the same as used in the main body **6** of the display pixel element. So the "OFF" side **2b** of the flap exhibits black mate appearance without any further processing. In order to obtain a highly contrasting appearance, the "ON" side **2a** of the flap **2** is painted first with the layer (typically 10 μ m thick) of paint **7vis** containing visible light reflecting dye and finally covered with the layer of paint **7uv** containing high concentration of UV luminescent dye (for example: HOS Y3G). The latter absorbs light in the near-UV spectral range and upon absorbing reemits the light in the visible spectral range (see Fig. 1) that preferably matches the reflection spectrum of the first layer paint **7vis** - see Fig. 3a.

[0024] The realization of the active illumination of the electromagnetic display panel **13** (Fig 4, 5) according to the invention is achieved by using the "black ray" fluorescent lights **11** positioned along one or both long sides of the electromagnetic display panel **13** (See Fig. 4). In order to focus as much light on the electromagnetic display panel **13** surface, a light reflector **10** shaped to illuminate the display panel surface as evenly as possible, is added. However, irrespective of the optimization of the form of such a reflector, the near-UV illumination of the UV luminescent paint covering the display pixels **13p**, as shown in the Fig. 4, strongly depends on the distance between the "black ray" fluorescent light **11** and a particular section of the display panel **13**. As a result of this the intensity of the visible light emitted by the fluorescent dyes varies accordingly. Uniformity of the electromagnetic display panel **13** illumination can be in principle improved by displacing the light sources away from the display panel surface, however the increase of the distance between the "black ray" fluorescent light source **11** and the display panel **13** is usually very limited by the overall constraints of the display panel **13** dimensions and mounting options. Therefore the uniformity of the UV light illumination cannot be obtained by optimizing the form of the light reflector **10** alone. In order to optimize the results optionally an adequately variable gray filter **12** is added (see Fig 4).

EXAMPLE 2

[0025] Alternatively to the embodiment of the "bus or train destination" electromagnetic display panel as described in the Example 1, the said display panel can be manufactured so that the rotatable display pixel flaps are manufactured from a plastic material **7** having UV luminescent dyes according to the invention imbedded/dissolved in it rather than using the same material **6p**, as used for the manufacturing of the body **6** of the display pixel. In order that the plastic "body" of the flap **2**, made of the said material **7**, reflects bright visible light, when illuminated either by visible or near-UV light, the plastic material **7** has to be more or less transparent in

the visible light spectrum and the surface of this flap opposite to the incoming light being painted with a layer 7_{VIS} fully reflecting the light in the visible spectrum, while the UV luminescent dyes imbedded/dissolved in the material **7** have to emit the absorbed light in preferably the same visible spectral range as the layer 7_{VIS} . If the same side is finally painted with a layer of mate black paint 7_B (fully absorbing the incoming light) then rotating the flap for $\sim 180^\circ$ results in switching between the "ON" (bright) and "OFF" (dark) state of the display pixel (see Fig. 3b).

[0026] The realization of the active illumination of the said electromagnetic display panel **13**, as well as all other considerations related to the visibility of such an embodiment, remain the same as discussed in the Example 1.

EXAMPLE 3

[0027] The basic operational principle of the display pixels used in this embodiment of the said "bus or train destination" electromagnetic display panel is based on display pixels, which are divided into two parts - the static display pixel surface **1a**, **1b** and the movable flap **2** covering only one half of the display pixel - the operational concept #2, as described above (see page 7 and Fig. 2b). In order to display either "ON" or "OFF" state of the display pixel, the asymmetric tilting flap **2** has to rotate for $\sim 180^\circ$ around its pivoting axis. So both sides of the flap **2a** and **2b** as well as the sections of the static display pixel surface **1a** and **1b** covered by the flap **2** must exhibit highly contrasting colors in either one of its bistable positions.

[0028] In order to be able to use the display panel in high as well as low ambient light conditions an additional illumination is required. When implementing the use of the invisible UV-light illumination principle according to the invention in this embodiment of the said "bus or train destination" electromagnetic display panel, the flap is manufactured using black mate material **6p** preferably the same as used in the main body **6** of the display pixel element. So the "OFF" side of the flap **2b** and the "OFF" section of the static display pixel surface **1b** exhibit black mate appearance without any further processing. In order to obtain a highly contrasting appearance of the "ON" state of the display pixel, the "ON" side of the flap **2a** and the "ON" side the static display pixel surface **1a** are painted first with the layer (typically $10\ \mu\text{m}$ thick) of paint 7_{VIS} containing visible light reflecting dye and covered with the layer of paint 7_{UV} containing high concentration of UV luminescent dye, which absorbs light in the near-UV spectral range and upon absorbing reemits the light in the visible spectral range (see Fig. 1). The spectrum of the light emitted by the UV-luminescent dyes preferably matches the reflection spectrum of the first layer paint 7_{VIS} - see Fig. 3c. Tilting the flap **2** from one to another bistable position results in switching between the "ON" (bright) and "OFF" (dark) state of the display pixel.

[0029] The realization of the active illumination of the said electromagnetic display panel **13**, as well as all other considerations related to the visibility of such an embodiment, remain the same as discussed in the Example 1.

EXAMPLE 4

[0030] Alternatively to the embodiment of the "bus or train destination" electromagnetic display panel as described in the Example 3, the said display panel can be manufactured so that the rotatable display pixel flaps **2** as well as the static display pixel surface plate **1** (see Fig. 2b and Fig 3d) are manufactured from a plastic material **7** having UV luminescent dyes according to the invention imbedded/dissolved in it rather than using the same material **6p**, as used for the manufacturing of the body **6** of the display pixel.

[0031] In order to assure the operation of the said electromagnetic display panel, when illuminated either by visible or near-UV light, it is necessary that the plastic "body" of the flap **2** (side **2a** on Fig. 2b) and the section **1a** of the static display pixel surface plate **1**, made of the said material **7**, reflect bright visible light when the display pixel **13p** is in the "ON" state.

[0032] Therefore the plastic material **7** has to be more or less transparent in the visible light spectrum and the surface of the flap **2b** has to be covered by the layer of paint 7_{VIS} , which fully reflects the light in the visible spectrum. Since in this embodiment the display pixel surface is composed of the flap surface **2a** and the section **1a** of the static display pixel surface plate **1**, the latter also has to be covered on the side opposite to the incoming light by the layer of paint 7_{VIS} , which fully reflects the light in the visible spectrum. As the UV luminescent dyes imbedded/dissolved in the material **7** emit the absorbed near-UV light in preferably the same visible spectral range as the layer 7_{VIS} , the said display pixel exhibits intense bright state ("ON" state) under UV or visible light. If the same side **2b** of the flap **2** as well as the section of the static display pixel surface layer **1b**, covered by the tilting flap **2**, is finally painted with a layer of mate black paint 7_B (fully absorbing the incoming light) then rotating the flap for $\sim 180^\circ$ results in switching between the "ON" (bright) and "OFF" (dark) state of the display pixel (see Fig. 3b).

[0033] The realization of the active illumination of the said electromagnetic display panel **13**, as well as all other considerations related to the visibility of such an embodiment, remain the same as discussed in the Example 1.

[0034] It should however be emphasized, that the above described Examples represent only four feasible working embodiment of the electromagnetic display panel according to the invention. Various modifications and variations can be made within the scope of this invention in order to adapt to a particular electromagnetic display pixel construction/manufacturing and/or opera-

tion principle. Typical modifications of the above Examples are related to the use of paints using both UV luminescent color dyes as well as the visible light reflecting color dyes instead of two distinctively different layers of paints using one or another type of color dyes as described in the above Examples. Another typical variation to the above examples are larger display panels (for example: Airport information panels), where the above described technical solutions using standard "black ray" fluorescent light sources is not very practical, since large areas cannot be illuminated only from the sides. Spot-light near-UV light sources would be a lot more appropriate (see Fig. 5). In case that higher UV illumination is required than provided with commercial "black-ray spot-lights 16, standard low pressure Hg-vapor light sources like Philips HPR 150 spot-lights can be used instead. In order to eliminate the visible light generated by the said sources, additional color glass visible light absorbing filters 14 can be added (e.g. Schott EG3 glass). In order to reduce the heat dissipated by these filters, match the peak light emission with the peak light absorption of the fluorescent dye (Fig. 1) and finally to efficiently eliminate the unwanted deeper UV light, an additional thin-film Fabri-Perot reflective filter 15 can be added (Fig. 5).

Claims

1. The electromagnetic display panel, consisting of a matrix array of typically quadratic display pixels with electromagnetically movable flaps (2) having two bistable positions and means for illumination (11, 16) to allow for the operation in low ambient light conditions, the "ON" and "OFF" state of the display pixels (13_p) being determined by the two bistable positions of the movable flaps (2) and indicated by visually highly contrasting colors on the displayed pixel surfaces (13_p) each of the flaps (2) having a built-in permanent magnet and each of the pixels having a built-in solenoid (3) with the semi-hard magnetic core (8) allowing moving the flap (2) from one bistable position to the other by means of the electric current pulses, **characterized in that** the means for illumination (11, 16) emit the light in the near-UV spectrum and that the display pixel surface (13_p) displayed in one of the two bistable positions corresponding to either "ON" or "OFF" state of the display pixel contains fluorescent dyes absorbing the near-UV light and emitting the light in the visible spectral range.
2. The electromagnetic display according to the claim one, **characterized in that** the fluorescent color dyes absorbing the near-UV light and emitting the light in the visible spectral range are incorporated in the display pixel surface layer (13_p) displayed in

one of the two bistable positions of the movable flap (2), corresponding to either "ON" or "OFF" state of the display pixel, and

that said UV-fluorescent dyes are incorporated by painting the said display pixel surface layer (13_p) with a layer of paint (7_{vis}) containing color dyes reflecting light in the visible spectral range, which is covered by the layer (7_{uv}) of paint doped with the near-UV light fluorescent dyes.

3. The electromagnetic display according to the claim one, **characterized in that** the fluorescent color dyes absorbing the near-UV light and emitting the light in the visible spectral range are incorporated in the display pixel surface layer (13) displayed in one of the two bistable positions of the movable flap (2), corresponding to either "ON" or "OFF" state of the display pixel and

that said UV-fluorescent dyes are incorporated by painting the said display pixel surface layer (13_p) with a layer of paint containing color dyes reflecting light in the visible spectral range as well as near-UV light fluorescent dyes.

4. The electromagnetic display according to the claim one, **characterized in that** the UV-fluorescent color dyes absorbing the near-UV light and emitting the light in the visible spectral range are incorporated in the display pixel surface (13_p) layer by imbedding/dissolving the said dyes in the plastic material that the said display pixel surface (13_p) layer is made of.

5. The electromagnetic display according to the claims 1 and 2 or 3 or 4, **characterized in that** the means for illumination (11, 16) are standard "black-ray" fluorescent lamps emitting the light in the near-UV light range of the spectrum.

6. The electromagnetic display according to the claims 1 and 2 or 3 or 4 and 5, **characterized in that** it uses additional gray level filter (12) as well as the adequately formed light reflector (10) to homogenize the UV light intensity on the display surface.

7. The electromagnetic display illuminated by the near-UV light according to the claim 1 and 2 or 3 or 4, **characterized in that** it uses standard "spot-light" UV A light sources (16) and additional visible light absorbing glass filter (14) preferably combined with the thin film reflector (15), the spectral dependence of which is optimized so that the effective spectral dependence of both filters is centered to the peak absorption of the fluorescent dye (Fig. 1).

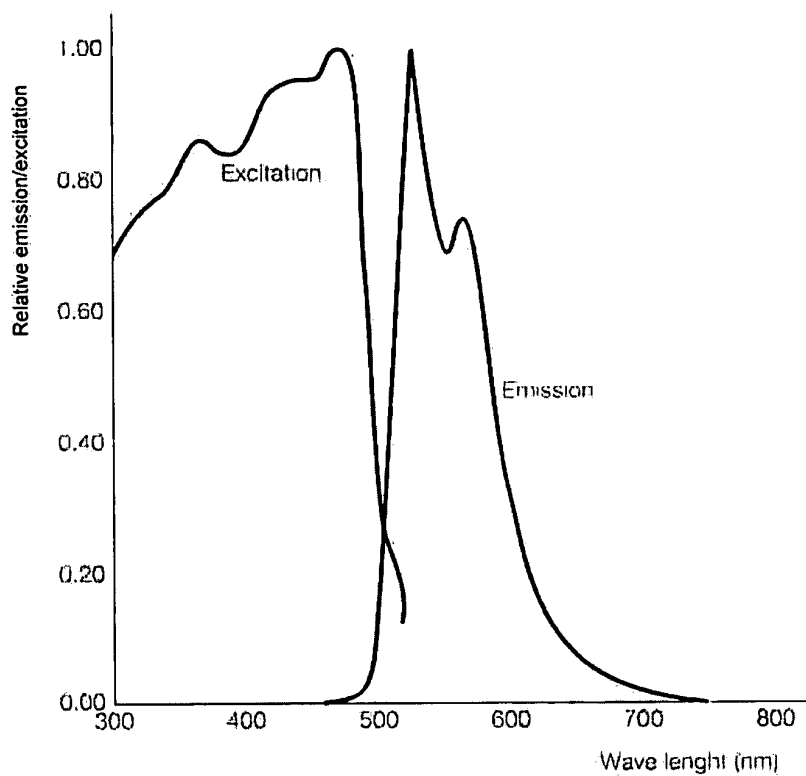


Fig. 1

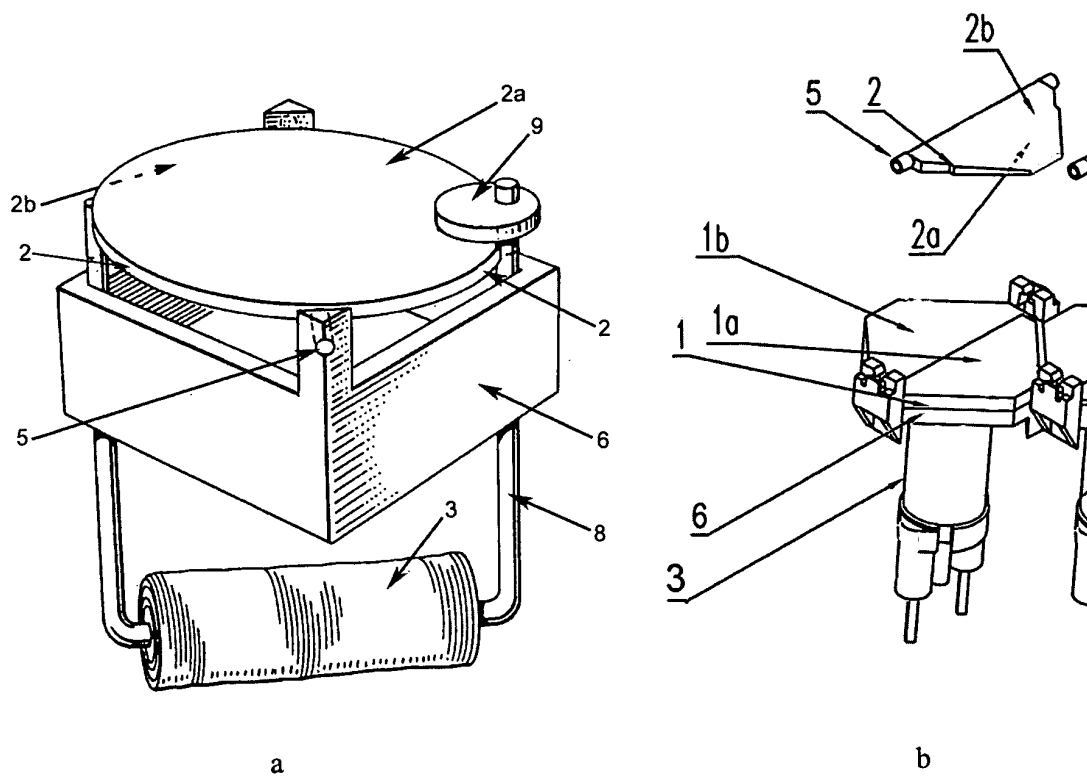


Fig.2

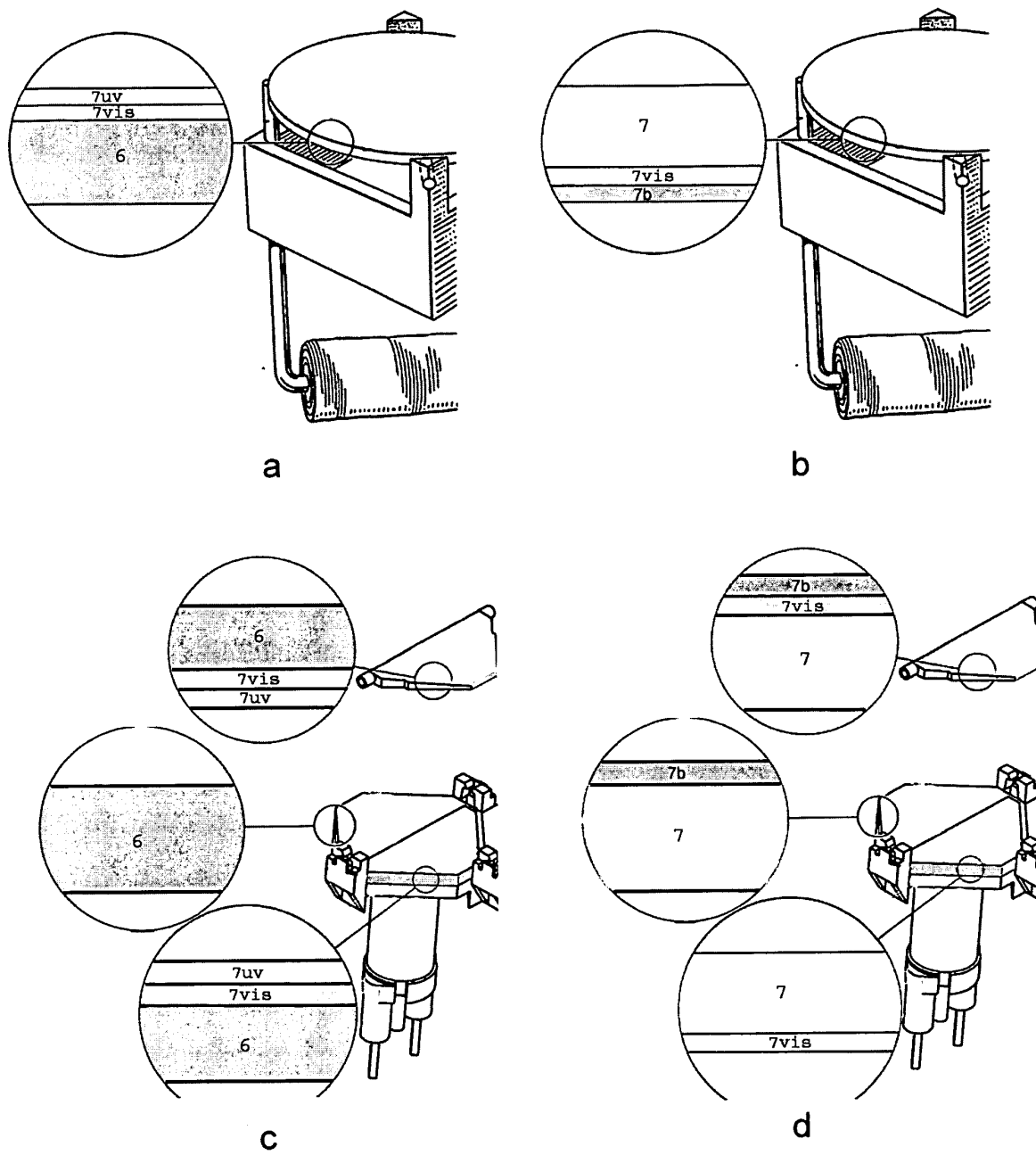


Fig. 3

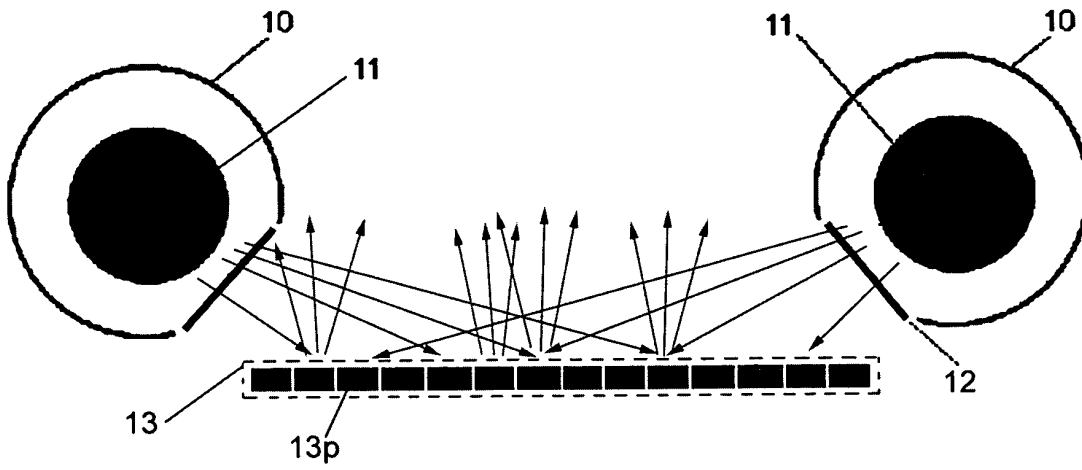


Fig. 4

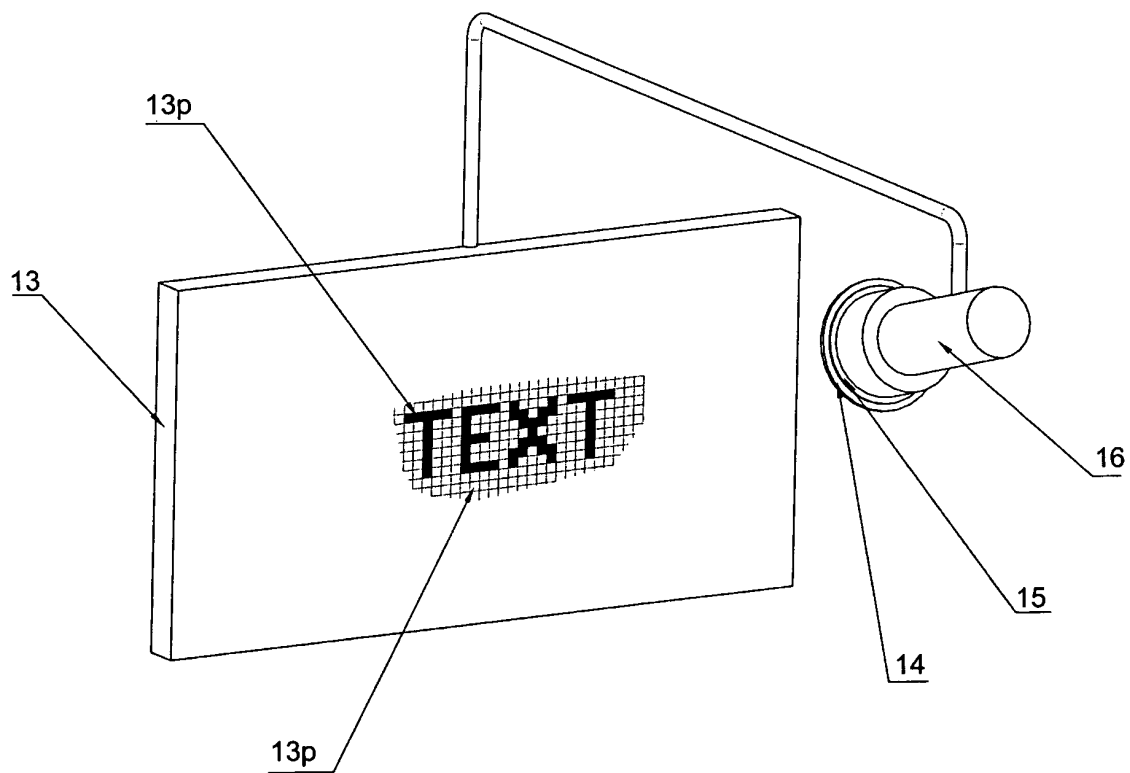


Fig. 5