

Schüller Attila
schuller.a@gmail.com

COMPARATIVE ANALYSIS OF PATENTS FOR VISUAL FIRE ALARMS

Abstract

Tűzeset miatti épületkiürítéskor fontos szerepe van annak, hogy a menekülők gyorsan felismerjék a helyes menekülési útvonalat. Ennek elősegítésére léteznek szabályozások, de folyamatosan adnak be szabadalmakat az előírásokhoz képest hatékonyabb vizuális tűzjelző eszközökre. A szerző néhány amerikai szabadalomban szereplő megoldás előnyeit mutatja be, amelyek csökkenthetik a kiürítés során jelentkező negatív emberi tényezőket.

During evacuation due to fire it is important that the people who are trying to escape should quickly recognize the escape route. To facilitate this, there are regulations, but patents are being lodged continuously for visual fire alarm devices that are more efficient than the requirements. The author presents the advantages of some solutions offered by several U.S. patents.

Keywords: vizuális tűzjelzés, szabadalom, emberi tényező, tűzriadó, evakuálás, épületkiürítés ~ visual fire alarm, patent, human factor, fire drill, fire alarm, evacuation

INTRODUCTION

The types of alarm and signs laid down in the fire safety regulations only ensure a certain level of safety and rely on people's awareness, attention and discipline. However, experience has shown that many people act inappropriately in emergency situations even when they have been informed what to do in case of fire and have taken part in fire drills. Although this training reduces the occurrence of human errors, technical solutions could also be used to help the people fleeing to choose the right escape route.

In the 2/2012 issue of *Hadmérnök* I discussed the negative human factors that occur during a fire alarm. [1] I pointed out, among other things, that people do not pay attention to the routes during evacuation. A Swedish study shows that most people prefer to use the main entrance, even when an emergency exit is closer. This is especially true when the emergency exit door is closed. [2]. In many cases not only does finding the right escape route pose a problem but also people do not realise that they have to escape. [1]

Provided sufficient resources are available for the use of modern visual tools, people are able to recognize quickly that there is an emergency and to choose the right escape route.¹

There are a lot of patents on the subject of this article and their number continues to grow. Due to lack of space, the list of the solutions I have presented is not exhaustive. I have tried to present the most interesting ones and those which are relatively easy to implement. In some cases, the patents describe a more complex system, but I have only dealt with the visual signalling part of the system.

REGULATIONS

The National Fire Protection Association (NFPA) defines the general requirements in the U.S. The escape route is designated by simple, easy to understand pictograms. Figure 1 allows the American pictograms to be compared with their Hungarian equivalents, the appearance of the latter is in accordance with the prescriptions contained in the decree 2/1998. (I. 16.) MüM.



Figure 1: U.S. (left) and Hungarian (right) escape route signs²

The fundamental imagery for symbols, as well as their background colour³ and shape, are designated in Standard NFPA 170. However, although strobe lighting is commonly used to indicate the escape route, only these static symbols are used to provide information about the direction of escape, but experience shows, escaping people often do not pay attention to these pictograms.

¹ This article deals only with visual tools, but there are other tools such as directional sound, which was described in a previous issue of *Hadmérnök*. [3]

² This figure has been compiled by the author using sources [4] and [5].

³ The colour of the symbol must meet the requirements of ANSI Z535.1, Safety Color Code.

With regard to lights, we should draw a distinction between emergency lighting that enhances the environment and the visibility of the emergency exits in the case of an emergency, and the visual cues that draw attention to the evacuation. From the standpoint of this article, regulation of visible signalling is more important than emergency lighting, so I have emphasized some factors that relate to the patents I have examined with regard to the fire safety regulations.

According to the Hungarian National Fire Protection Regulations (Országos Tűzvédelmi Szabályzat – OTSZ), visual signalling devices for fire alarms should not be used independently, only to supplement the audio alarm systems. The visual devices used for fire alarms should be clearly visible and should be clearly distinguishable from other lights used in the area. [6]

The parameters of strobe lights are regulated in detail by the NFPA. The flash rate shall not exceed two flashes per second (2 Hz) nor be less than one flash every second (1 Hz) throughout the listed voltage range of the appliance. The maximum pulse duration shall be 0.2 seconds with a maximum duty cycle of 40 percent. The pulse duration shall be defined as the time interval between initial and final points of 10 percent of the maximum signal. Lights used for fire alarm signalling only or to signal the intent to completely evacuate shall be clear or nominal white and shall not exceed 1000 cd (effective intensity). Lights used to signal to occupants that they should seek information or instructions shall be clear, nominal white or another colour as required by the emergency plan and the authority having jurisdiction for the area or building. [7] The regulations only refer to strobe lights. As I shall show, several patents propose sequential signal lights, for which there are currently no standards. However, the current rules can be regarded as providing a basic standard, so that in the case of sequential lights, I recommend that the parameters of the entire section should be adjusted to the characteristics of strobe lights. The OTSZ prescribes, among other things: the circuits of fire alarm systems shall be designed so that in the case of a single wire break or short circuit no more than 32 units may become inoperable and these devices must be in the same area and serve the same function.[6] So, in the case of sequential lights, the system should be divided into sections of 32 indicator lights. If more lights are required for a particular section of the route, they will have to be synchronised.

In the USA strobes used in combination systems where the same strobe is used for both mass notification and fire notification shall comply with the following:[7]

1. Be clear or nominal white, meeting the listing requirements of ANSI/UL 1971, Standard for Signalling Devices for the Hearing Impaired
2. Have no marking or be marked with the word "ALERT" stamped or imprinted on the appliance
3. Be visible to the public

It is worth noting that the regulations permit the use of colour signals, the conditions for such use are described in a separate section.

Lights used for fire alarm signalling only or to signal the intent to completely evacuate shall not exceed 1000 cd (effective intensity). [7] This regulation is significant for those patents I have examined in which a laser beam is employed.

The OTSZ permits solutions to be employed that improve safety⁴: establishment of a fixed fire extinguishing and fire alarm device (design and construction), operation, inspection and maintenance shall comply with the law and the relevant technical requirements, or should at least ensure an equivalent safety level. [6]

⁴ In this case, permission has to be obtained from the fire authority for installation and use.

SOLUTIONS OF PATENT

The title of the first patent that I examined is "Dynamic Emergency Escape Indicator". [8] The design of this device is similar to that of a normal exit sign, however, there are several silhouettes that flash sequentially. (Figure 2) Lighting devices located on the edge of the device increase its effectiveness in attracting people's attention. Because the direction of these can be adjusted independently, this means that, according to the author of the patent, the device can be also used to help to designate the direction of escape by illuminating nearby objects one after the other.



Figure 2: dynamic emergency escape indicator [8]

The advantage of this device is that it attracts one's attention to the figures flashing sequentially and the devices emitting flashing lights attract the eye. However there is a hidden danger in that the silhouettes flashing sequentially indicate a kind of a direction of escape, which may mislead the people escaping. For example the positioning in figure 2 may lead the person escaping to believe that he should turn left, rather than go out of the door (because the three human figures flash from right to left suggesting that you have to go left). The brightness of the lamps is not sufficient to illuminate distant objects, so these lights may only be a distraction. If the lighting devices are adjusted incorrectly, they may also shine in the eyes of people escaping, which may cause the direction of escape indicated by the sign to be more difficult to recognise. It should be noted that, in contrast to what is shown in figure 2, the smoke generated by the fire is not on the floor, but spreads almost to the ceiling.

The following patent helps for orientation in the dark with LED light strips built into the floor. [9] The lines shown in figure 3 indicate clearly and visibly the sections of the corridor, and the strip passes the doors that cannot be used for escape, it leads people escaping to the emergency exit with a clearly visible arc. The escape route is thereby easy to see, but the direction is not, therefore, the use of conventional supplements is absolute essential. (A similar solution is where the sign is also located in the middle of the corridor, but arrows indicate the direction and in some places texts provide information on the distance of the exit. [10]) This patent also includes an alternative solution for the case where mounting the LED strip in the middle of the corridor is not possible. In this case, the emergency exit would not be clearly marked, therefore the patent proposes a modification, as a result of which, the light signal can be seen only in one direction. Using this solution, apparently, the emergency exit door can be easily distinguished from the rest.

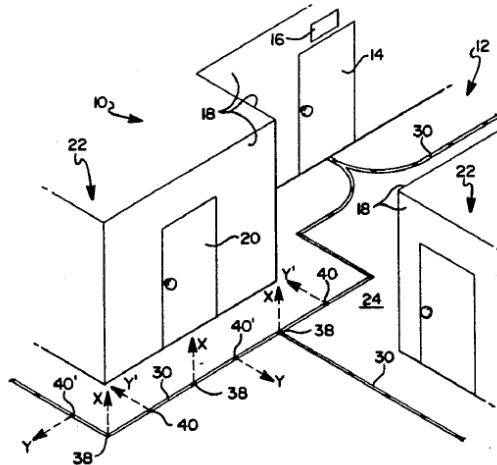


Figure 3: Emergency lighting strip [9]

Positioning the signs in the middle of the floor is preferable to prevent objects placed temporarily in the corridor (cupboards, flowers, boxes, etc.) from hiding the signs (in the case of a low positioning of the signs). However, the implementation is difficult and costly, especially where there is a carpeted floor. It should be noted that the material of the cover should be strong enough to avoid cracking and breaking, and such that transmission of the light is not reduced due to wear and tear, cleaning and other stress. The alternative solution of [9] makes the visual signal more difficult to see from a relatively narrow angle, making it difficult to interpret. In patent [10] the signal occupies a wide band and in many cases (e.g. the luxurious floor covering of hotels) can damage the overall effect of the design. This is offset by the easily recognizable arrows, which make the direction of evacuation absolutely clear and the distance marker inscriptions provide additional information for the people escaping. These information signals are shown in green and the red flashing “DONT USE!! GO TO EXIT” signal is to call attention to the predetermined danger-zones (the entrances to elevators).

The solution shown in figure 4 is different in that it facilitates the evacuation with photoluminescent signs. [11] Predetermined arrows, silhouettes or a series of geometric shapes (e.g. circles) of increasing or decreasing size designate the direction of escape (the arrow version is shown in the figure) and the EXIT signs show the exits. There are also patents in which arrows are also used, but in both directions, so in an emergency they light up, so that in a given situation – according to certain criteria – they mark out the optimal route. [12]

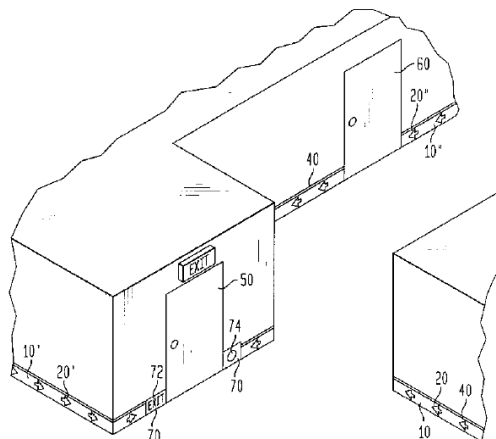


Figure 4: Evacuation route with photoluminescent indicators [11]

The arrows are easily recognizable from a distance, but different sized geometric symbols only provide information for those who know that the diameter of the signs increases or decreases towards the emergency exit.

A multifunctional signalling system is illustrated in figure 5. [13] The white or clear static lights provide ambient lighting, the coloured lights located among them indicate the direction of escape with sequential flashing. In one version of the invention, heat sensors located at each exit will trigger a reversal of the tracer lights to direct evacuees away from the exit in the event that the temperature at that exit reaches an unsafe level.

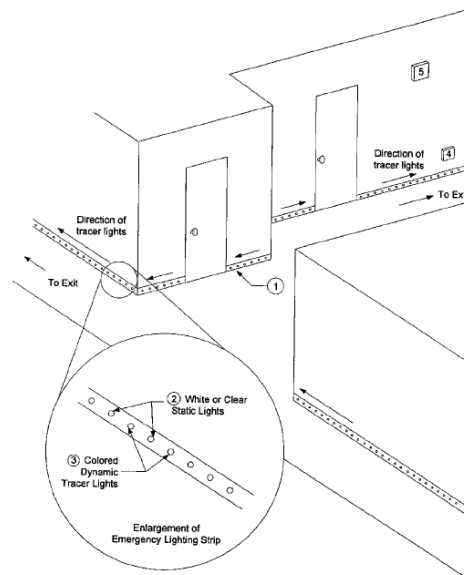


Figure 5: Emergency lighting system [13]

The ambient lighting feature is most effective close to the ground, so it is much easier to see things which might possibly prevent escape. The coloured lights flashing one after another clearly indicate the right direction of escape. The determination of the direction on the basis of the exit temperature may only be used if the direction of all route segments is defined by a main control circuit. The possibility of employing coloured lights in non-fire emergency situations (e.g. tornado, terrorist emergency) is also included in the patent, as well as for decorative purposes (e.g. pulsing lights controlled by music in a disco). According to the U.S. standards the fire alarm signal should be distinct from other types [7], the OTSZ states the following: the lights used for signalling fires should be clearly visible and should be clearly distinguishable from other light signals used in the area at risk. [6] The decorative use of the visual fire alarm and the fire alarm operation cannot be distinguished from one another, so in an emergency situation the people evacuating may think that the usual disco lighting is being operated. As a result they do not understand the meaning of the light strip, so do not pay any particular attention to it. In a previous part of this article (see Regulations) I pointed out that the NFPA allows the fire alarm to be used in other emergency situations, provided certain conditions are met. In this case, however, each mode of the system clearly draws attention to the danger.

The system in the following patent can only signal in one direction, but it is unique in that it provides information about how many doors there are to the exit. [14] This information can be recovered from the number of devices placed one above the other, and from the number of the contact points of these devices, as shown in figure 6. Another advantage is that because the devices stand out from the wall, their number can be counted and shape can be felt, which is very useful for the visually impaired.

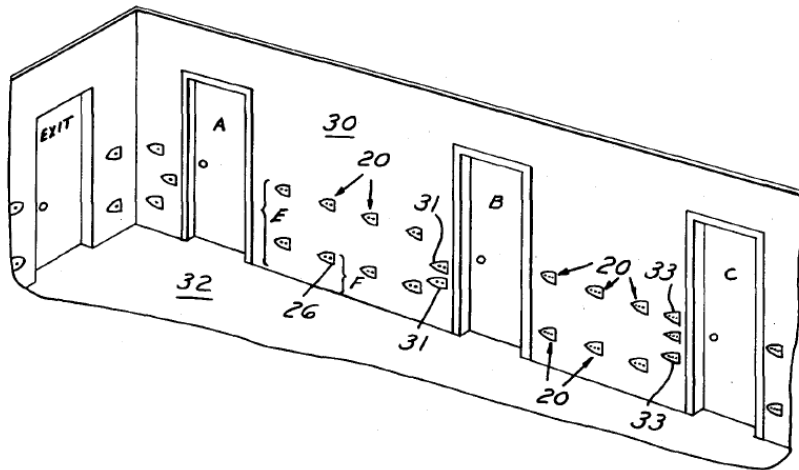


Figure 6: Escape/rescue system [14]

Although it is a good idea to provide information about the number of doors to the exit, this solution should only be used for short corridors. Otherwise, too many devices would have to be installed to indicate the distance of the exit. This would increase the construction cost and interpreting the information necessary for escape would be more difficult.

Finally, I introduce two solutions with lasers. Equipment that may be mounted to the wall is described in the patent [15], and which uses laser beams to project arrows, graphic or alphanumeric symbols onto the floor in the direction of escape. In the basic configuration there are three laser diodes adjusted at different angles, but the number of lasers may be more or less than this figure. The housing for the system can be moved horizontally and vertically to orient the projection within certain limits.

Although the position of the equipment is adjustable, it can only project signals over a short range. In a long corridor several devices should be used to ensure continuous projection of the escape route. To build a complete system would be very costly due to the many diodes that would be needed. One disturbing feature is that the size of the projected signals varies depending on the distance between the device and the point where the signal strikes the floor. A further problem could be if the equipment placed above the exit shines into the eyes of people escaping. As I have already pointed out, the NFPA allow 1000 mc maximum brightness, however, even a low-powered laser greatly exceeds this value and can dazzle a person. There has been a case when a laser used in a disco caused permanent damage to the eyes of the dancers. [16] The patent states that after the fire alarm has been activated the signs are projected continuously, but the signs flashing one after another would be more efficient. Implementing this, however, is difficult if the designation of a section of the escape route can only be achieved using several devices, because then they would have to be synchronised.

The last system employed is built into a false ceiling and can designate the escape route with vertical laser beams. [17] The patent describes three possible solutions. In the first case the laser beam is transmitted through a distribution unit to different glass fibres that transmit light to different points in the corridor. The second possibility is that the beam is transmitted through a mirror to additional mirrors sequentially; the latter direct the beams vertically. The third option is that each beam is created by independent laser diodes. For each option, the order in which the signs are indicated can be changed, so that the direction of escape can also be changed. In the systems contained in the patent the laser does not shine into the eyes (unless someone looks up at the ceiling), but the inventor recommends a very high-powered laser, which can cause damage to the eyes even if a person looks at it accidentally. The patent recommends using a 120 volt laser, which could also be dangerous if water is used to extinguish a fire, as it could cause electrocution.

All three solutions appearing in the above patent are imaginative, but their implementation is costly. In the first case the glass fibre distribution unit makes the system expensive, while in the second case positioning the mirrors exactly would be a costly process. In the third case the system would need a large number of laser diodes, which would demand a lot of financial resources. In the case of long corridors the solution with rotating mirrors would be very difficult to implement, because it would take too much space from the ceiling. Another disadvantage of this method is that coordination of the signs of separate sections of the escape route is difficult.

CONCLUSION

As the article has shown, there are several available solutions to designate and clarify the escape routes. In addition to the patents described several other options are available, but these must satisfy the regulations of the given country.

In choosing one of the many possible solutions, there are other important considerations, among which are the following:

- the material of the cover of the lights on the floor should be strong enough to avoid cracking and breaking, and such that transmission of the light is not reduced due to wear and tear, cleaning and other stress,
- care should be taken so that the light signs do not prevent people from seeing other signs when they are escaping,
- dynamic, not static lights attract peoples' attention more effectively,
- in the case of dynamic signs it is important to ensure that the direction of the light is the same as that of the escape route,
- if the indicator light is static, then arrows should indicate the direction of escape,
- when the direction of the light signs can be changed, this allows the escape route to be designated taking account of the location of the fire, but at present the legislation in force does not permit such a solution,
- the light signs must be synchronized with each other at the junction of the different sections so that the direction of the escape route is clear.

I have pointed out the problem of the compliance with existing standards and controls not being checked when the patent is accepted. This is supported by the fact that patent [13] recommends the decorative use of visual fire alarm devices.

The signalling of escape routes and directions is prescribed by the current regulations. By using visual warning devices that indicate the right direction of escape, it would be possible to determine an escape route which depends on the location of the danger, so it can be adjusted to the situation. The current technical level of development permits such a system to be implemented allowing people in danger to leave a building more easily and faster, where easily understandable light signals are used, which are able to designate the escape route taking into account the location of the fire. As I mentioned, the current law does not allow the implementation of such a system, but I am convinced that if the system I have described were implemented, it would be possible to demonstrate its superiority over the systems presently in operation, which would then require a change in the relevant legislation.

THIS ARTICLE IS SUPPORTED BY TENDER TÁMOP 4.2.2./B-10/1 (RISKS AND ANSWERS IN THE FIELD OF TALENT MAINTENANCE: "KOVÁSZ")

References

- [1] Schüller, Attila: Az emberi tényező és a technikai megvalósítások vizsgálata tűzriadók során. In: *Hadmérnök*, 2/2012, p. 37-46.
- [2] Benthorn, L., Frantzich, H.: Fire Alarm in a Public Building: How Do People Evaluate Information and Choose Evacuation Exit? *Fire and Materials*, 6/1999, p. 311-315.
- [3] Miskey, Tamás: Az emberi tényezők és egy új kiürítéstámogató rendszer bemutatása. In: *Hadmérnök*, 2/2009, p. 57.66.
- [4] NFPA 170: Standard for Fire Safety and Emergency Symbols, 2012 Edition. National Fire Protection Association, Quincy, Massachusetts, 2012.
- [5] 2/1998. (I. 16.) MüM rendelet – a munkahelyen alkalmazandó biztonsági és egészségvédelmi jelzésekről
- [6] 28/2011. (IX. 6.) BM rendelet – az Országos Tűzvédelmi Szabályzatról
- [7] NFPA 72: National Fire Alarm and Signaling Code, 2013 Edition. National Fire Protection Association, Quincy, Massachusetts, 2012.
- [8] Juei-Chao Chen: Dynamic Emergency Escape Indicator. U.S. Patent 2010/0013658 A1, Jan. 21, 2010.
- [9] H. Gerald Gross: Emergency Lighting Strip. U.S. Patent 5 130 909, Jul. 14, 1992.
- [10] Maurice Bligh: Color-coded Evacuation Signaling System. U.S. Patent 6 646 545 B2, Nov. 11, 2003.
- [11] Daniel J. Tassej, Kenneth F. Newbold: Evacuation Route Having Photoluminescent Indicators. U.S. Patent 6 237 266 B1, May. 29, 2001.
- [12] Steve B. LaCasse: Intelligent Directional Fire Alarm System. U.S. Patent 7 626 507 B2, Dec. 1, 2009.
- [13] John W. Peterson: Emergency Lighting System and Method. U.S. Patent 7 255 454 B2, Aug. 14, 2007.
- [14] Frederick G Schriever: Escape/Rescue System. U.S. Patent 4 385 586, May. 31, 1983.
- [15] Mark R. Lehman, Dan Gechtman, Jerome Keith Fuller, Michael A. Hreha: Laser Director for Fire Evacuation Path. U.S. Patent 6 150 943, Nov. 21, 2000.
- [16] Reuters and New Scientist staff: Party laser 'blinds' Russian ravers. *New Scientist*, 2008. <http://www.newscientist.com/article/dn14310-party-laser-blinds-russian-ravers.html> (18.05.2013)
- [17] Gary L. Sweeney: Laser Light Fire Evacuation System. U.S. Patent 5 572 183, Nov. 5, 1996.