Study on Improvement of Visibility of Road Traffic Signal

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Abstract

Road traffic signals of LED type and filament bulb type are now available. Especially, LED road traffic signal is beginning to be officially available everywhere, though the initial investment of LED road traffic signal is more expensive compared to a conventional signal using filament bulbs. However, there are some problems to be solved, respectively. In the road traffic signal using filament bulb, the pseudo-lighting phenomenon occurs when in the morning and evening sun altitude is low. On the other hand, the LED road traffic signal is difficult to reduce problems such as washout phenomenon.

In this paper, by inserting the multi-eye lens unit and a light-shielding film in between the colored filter and reflector, we proposed a traffic signal which has no risk of pseudo-lighting and we have proposed reduction of washout phenomenon of LED signal head by using the LED element 192 and low-reflection black plate on a blank area between the elements. We report the development of a road traffic signals reducing the pseudo lighting phenomenon occurring in the bulb type and reducing the washout occurring in the LED type.

Keywords: Road traffic signal head, pseudo-lighting phenomenon, washout phenomenon.

1. Introduction

The world's first high-brightness blue LED was produced in 1989. Practical technique for manufacturing it has been established in 1993. In this way, the application to the traffic signal has become possible by RGB LED are aligned. In Japan, the experimental operation of road traffic signal LED was started in Aichi Prefecture and Tokushima

Prefecture in 1994. Especially, LED road traffic signal is beginning to be officially available everywhere, though the initial investment of LED road traffic signal is more expensive compared to a conventional signal using filament bulbs.

In North America, the evaluation of some LED for using to traffic signal, heat and on cost and efficiency issues have been reported, and also the solution to problems that lose of the difference between yellow and red LED traffic signal for color-deficient drivers ⁽¹⁻³⁾.

In addition to these problems, the evaluation method for determining the turn on and off in the case with regard to pseudo lighting phenomenon caused when the sun is irradiated on the surface of a light, the light of high intensity is irradiated to a traffic light during daytime such as has been shown ⁽⁴⁾. In this paper, we have proposed a

Fig. 1. Pseudo-lighting phenomenon

Fig. 2. Traffic signal head for anti-“pseudo-lighting”

road traffic signal lights that are designed to reduce the wash-out phenomenon occurring in the LED road traffic signal system.

2. Road traffic signal head

2.1 Signal head using filament bulbs

A road traffic signal head using a filament bulb is to turn on the signal light unit, by reflected the light of the source by the reflector and through the colored filter lens. Therefore, in the morning and evening sun altitude low, pseudo-lighting phenomenon looks to be lighting state as if it were had occurred, because sunlight is irradiated to the reflector through the colored filters and reflected light is emitted. A pseudo-lighting phenomenon state and its principle are shown in Fig. 1 and 3, respectively.

However, we have solved this problem by inserting the two multi-eye lens units between the colored filter and the filament bulb unit ⁽⁵⁾. Figure 4 shows the structure of the bulb type signal head of anti-pseudo lighting we proposed. The light-shielding film is attached to the rear surface of the first sheet of a multi-eye lens. The sunlight from Oblique above is focused by the first sheet of the multi-eye lens, however, the light-shielding film on the back surface of the lens blocks the focused sunlight, so pseudo-lighting phenomenon does not occur. On the other hand, the light from the filament bulb are focused in the same manner by the multi-eye lens is emitted to the outside without being blocked by the light-shielding film. Figure 1 shows pseudo-lighting phenomenon, although the bulb is not lighting, all bulbs look lit. Figure 2 shows the road traffic signal using the light-shielding film type lens unit, It can be seen that the blue is only lit, and other colors are off state.

2.2 Signal head using LED

Blue LED is now mass-produced, and now available for a lot of road traffic signal head. The road traffic signal head using LED have a high visibility, since a light source of LED elements emit light directly, resulting in uniform light compared to the filament bulb and using no reflector. In addition, in morning and evening sun of low-altitude, unlike bulb type, pseudo-lighting phenomenon does not occur since no reflection mirror is used. Furthermore, the power consumption of LED system is 9.5 [VA] against that of bulb system using TS-70R (70W) traffic signal light bulb. The life of the LED system is considered to be

Fig. 3. Principle of pseudo-lighting phenomenon

Fig. 4. Structure of the bulb type signal head of anti-pseudo lighting

Fig. 5. Structure of the LED traffic signal head for reducing- "washout phenomenon"

approximately six to eight years, though bulbs have been replaced for about a year, and It is also excellent from the viewpoint of cost savings and inhibiting the flow of traffic due to bulb replacement. However, as shown in Fig. 6, in the morning and evening low solar altitude, and in the type having an uneven small front lens, the color of signal can not be identified due to occurring washout phenomenon. As a solution, we have proposed reduction of washout phenomenon of LED signal head by using the LED element 192 and low-reflection black board on a blank area between the LED elements. Figure 5 shows the structure of the LED type signal head of reducing-“washout phenomenon” we proposed. The low reflectance plate we called "phantom board" is inserted between the front lens and the LED substrate. Diffused reflection of incident sunlight that occurs at front lens and the blank area between LED elements can be suppressed by the phantom board. Therefore, the washout phenomenon is reduced, and the color of the traffic signal lights can be recognized clearly. Figure 7 shows LED traffic signal head we proposed, as apparent from this figure, we can recognize that only green light is lit and other colors are not lit.

2.3 Luminance uniformity and intensity distribution characteristics of road traffic signal head

A characteristic of the light intensity distribution was measured by using a digital illuminance meter TOPCON IM-5, according to the traffic signal lighting specification by the National Police Agency. The luminosity standards prescribed by the National Police Agency is shown in Fig. 8.. The measurement conditions is as follows ; 0° is the optical axis direction; Input voltage AC 100 [V]; at room temperature 25°C ; Humidity 65 Rh. The measurement results are shown in Fig. 9-11. Figure 9 shows the characteristics of the light intensity distribution in the case of green light at 10° [deg]. Both of the bulb type and the LED type satisfy the conditions described in the traffic signal lighting specification by the National Police Agency, however the LED method is found to be higher than the light intensity of bulb type.

The measurement of luminance uniformity was carried out by using a Luminance colorimeter TOPCON BM-7, according to the procedure described in the traffic signal lighting specification by the National Police Agency. Measurement point of the luminance uniformity is shown in Fig. 12. The measurement conditions are the same as those described above. A luminance ratio from the measurements

Fig. 6. Washout phenomenon of LED traffic signal head

Fig. 7. LED traffic signal head for reducing-“washout phenomenon”

Fig. 8. Standard luminosity

Fig. 9. Characteristics of the light intensity distribution (Green 10° [deg])

is 1.97:1, and are satisfied the condition described in the traffic signal lighting specification by the National Police Agency.

3. Conclusions

We developed filament bulb type traffic signal head which has no risk of pseudo-lighting by inserting multi-eye lens unit wearing a light-shielding film in between the color filter and bulb unit. In addition, we have succeeded in reducing the washout phenomenon of LED type signal head by using "phantom board", which is low-reflection black board to prevent diffused reflection of incident sunlight at small lens. In the measurement of light intensity distribution and luminance uniformity, it was confirmed that both of the bulb type and the LED type satisfy the conditions described in the traffic signal lighting specification by the National Police Agency.

As a result, even in the early morning or evening when the sun altitude is low, the driver and pedestrians are easily to recognize the color of signal lights

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Fig. 10. Characteristics of the light intensity distribution (Green 0[deg])

Fig. 11. Characteristics of the light intensity distribution (Red 10[deg])

Figure 12. Measurement point of the luminance uniformity