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COLOR PATTERNS FOR FLAGMEN'S VESTS

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COLOR PATTERNS FOR FLAGMEN'S VESTS

SYNOPSIS

Laboratory and field tests were performed on flagmen's vests of four different color patterns to determine the most effective two-color combination and pattern for visibility.

The study was limited to the following four specimens:

1. Red and white stripes 1/2 in. wide.
2. Red and white stripes 2-1/2 in. wide.
3. Black and yellow stripes 3 in. wide.
4. Black and yellow diamonds 4-1/2 in. square.

The tests showed that: 1) the 1/2 in. red and white stripes were too narrow for resolution by the human eye at 500 ft.; 2) the yellow and black diamond pattern of the Air Force jacket had the best target value and delineating characteristics at all distances; and 3) all but the 1/2 in. red and white striped specimen had target and delineation values in excess of minimum requirements and would provide satisfactory protection.

The yellow diamond of the Air Force jacket was quite orange in color and it is recommended that a lemon yellow be tried in place of it for Department jackets to still further enhance target value, especially at dusk and under conditions of poor visibility.

COLOR PATTERNS FOR FLAGMEN'S VESTS

In response to a request last fall from Mr. D. F. Haley, Safety Supervisor, Maintenance Division, the Research Laboratory undertook a study of color patterns for vests to be used by flagmen directing traffic during various construction and maintenance operations. The object of the study was to determine two things: 1) the most effective combination of two contrasting colors; and 2) the most effective geometric pattern of these two colors for visibility to the drivers of oncoming vehicles. It was Mr. Haley's intention that the vest be effective at a distance of 500 ft., and further if possible. The study was limited to the following four specimen patterns furnished by Mr. Haley:

1. Red and white stripes 1/2 in. wide.
2. Red and white stripes 2-1/2 in. wide.
3. Black and yellow stripes 3 in. wide.
4. Black and yellow diamonds 4-1/2 in. square.

The first three of the above specimens were in the form of loose fitting slip-on vests and the fourth was a nylon jacket of the type used by the United States Air Force.

Tests

The four specimens were tested both in the laboratory and by visual observation in the field. The laboratory tests consisted in measuring the brightness, hue and saturation of the various colors, and the values of these properties are given in Table 1. These values will be discussed later in connection with the results of the field tests.

On November 15, 1956 all four garments were evaluated in a field test by four observers to determine: 1) the greatest distance at which the wearer could be first noticed; and 2) the greatest distance at which the pattern of the garment could be distinguished. Observations were made at the sign test course near the Lansing Airport, where roadside markers were available for establishing distances to the target. In addition to visual observation, photographs of the wearer were taken at 600 ft. with an Argus C 3 camera using a telephoto lens. The results of these tests are given in Table 2 and the photographs in Figure 1. Preliminary tests showed that the pattern of the red and white 1/2 in. stripes could not be resolved at 500 ft., so this vest was not tested further.

Discussion

The results of the field tests given in Table 2 show that the Air Force jacket was the most effective of the three types both in long range visibility and resolution. The photographs in Figure 1 taken at 600 ft. do not bear out this observation--in fact they indicate just the reverse. These pictures were taken without filters on black and white panchromatic film, the chromatic sensitivity of which is shown superposed on the visual response curves in Figure 2. From these curves it can be seen that the film response to color is higher than the visual at both ends of the visible spectrum (blue and red bands), and lower at the middle (yellow-green region). These effects make the reds and blues appear lighter and the yellows darker in the photographs than by normal visual observation, which would tend to lower the contrast in both the red-white and yellow-black stripe patterns in the pictures. The observed superior resolution of the yellow-black diamond pattern is probably due primarily to the size (4-1/2 in.) of the color blocks. This pattern also produces better silhouette delineation by breaking vertical color lines.

It is difficult to explain why the Air Force jacket gave better long range visibility than the others, especially the red-white stripes. Actually the difference is not great and a larger number of observations might bring the two even closer together in this respect. Apparently the greater amount of light energy reflected from the white (Table 1) just about compensated for the higher visual response to color in the yellow region of the spectrum. The curves in Figure 2 labeled "rods" and "cones" give the responses of the average normal human eye to the various spectrum colors. The cones of the retina work at high levels of illumination (photopic vision) and the rods at night (scotopic vision). These curves show the visual response to an equal energy spectrum, that is, one in which equal amounts of energy are emitted at all wavelengths. In other words, a given amount of energy emitted or reflected in the yellow-green region appears much brighter to the human eye than the same amount of energy emitted or reflected in the other color regions. Colors are not perceived by scotopic vision (night) and all objects appear as a series of indistinct grays. However, this does not contradict the fact that colors in the green-yellow region will appear brighter and more distinct than the others at twilight and night. It also will be seen in Figure 2 that the response curve for the rods is shifted to the left of that for the cones, which means that maximum response is in a greener portion of the spectrum at night than by day.

The spectral characteristics of the various pattern colors given in Table 1 show that the yellow of the Air Force jacket is definitely on the orange or red side but is considerably less saturated than the spectrum

color of the same wavelength. The yellow of the striped vest is much yellower, or less red, than that of the diamond pattern, but it is considerably more saturated, that is, it approaches more nearly the depth of the corresponding spectrum color.

From all of the above considerations, it would be reasonable to expect that a greener yellow, or one more nearly a lemon shade, would produce even better visibility and contrast than the particular shade now used in the Air Force jacket, especially at twilight and under conditions of generally poor visibility. Probably the selection of a cloth with some luster or sheen also would be beneficial.

Summary and Recommendations

In retrospect, the salient points of this study may be summarized as follows:

1. The 1/2 in. stripes of the red-white vest were too narrow for pattern resolution at 500 ft., and this vest is not considered suitable.

2. The yellow-black diamond pattern of the Air Force jacket had the best target and delineation values at all distances.

3. All but the 1/2 in. red-white vest satisfied the original requirement of visibility and pattern resolution at distances greater than 500 ft.

4. Black-and-white photographs on panchromatic film cannot be depended on to give true contrasts unless the effects of the spectral sensitivity of the film are corrected by the use of suitable lens filters to match visual response.

5. It is recommended that the Highway Department vests or jackets be made of a semi-lustrous material patterned after the Air Force jacket but with a greener yellow diamond, say a lemon yellow.

TABLE 1

SPECTRAL CHARACTERISTICS OF PATTERN COLORS

Color and Pattern	Reflectivity, percent (Brightness)	Dominant Wavelength, mu (Hue)	Excitation Purity, percent (Saturation)
Black Stripe	2.5	----	----
Red Stripe	13.8	610.5	78.2
Yellow Diamond (Jacket)	41.0	596.0	20.5
Yellow Stripe (Vest)	46.8	579.4	79.6
White Stripe	67.5	581.0	0.8

TABLE 2

VISIBILITY OF FLAGMEN'S VESTS

Observer	Visibility Distance, feet					
	Red and White Stripes		Black and Yellow Stripes		Black and Yellow Diamonds	
	First Noticed	Pattern Distinguished	First Noticed	Pattern Distinguished	First Noticed	Pattern Distinguished
1	1900	650	1600	600	1800	600
2	2100	450	1500	600	2300	900
3	1750	600	1700	800	2100	700
4	2000	800	1800	750	2000	650
Average	1938	625	1650	688	2050	713

Notes: Date - November 15, 1956, 2:00 p. m.
Weather - Heavy overcast, light sprinkle.

A. Red and White Stripe, 2-1/2 in. Wide.

B. Black and Yellow Stripe, 3 in. Wide.

C. Black and Yellow Diamond, 4-1/2 in. Square.

Figure 1. Flagmen's Vests at 600 ft. Argus C 3 with Telephoto Lens. November 15, 1956

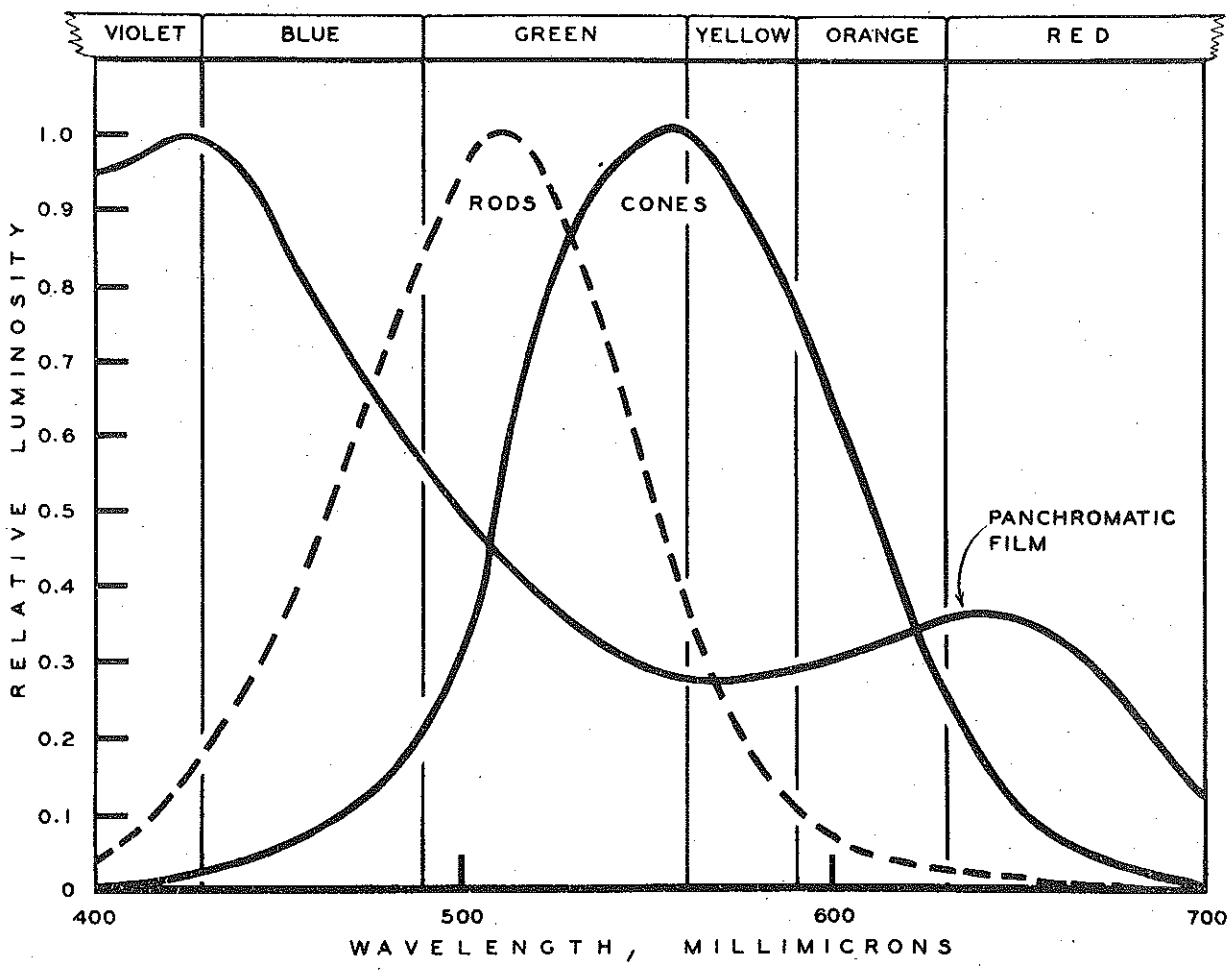

Figure 2. Relative spectral sensitivites of the rods and cones. Rod vision (dotted curve) serves us in very dim light such as starlight; cone vision (solid curve), in daylight. The solid curve refers only to the light-dark aspect of daylight vision and is called the relative luminosity curve.