The Optics of a Railway Signal Lamp*

Why is the Lens Made of Corrugated Glass?

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SPHERICAL ABERRATION.

THE forms of lenses in common use in signal lamps are shown in Figs. 1, 2, 3, 4, 5 and 6. Fig. 1 is a lens now seldom seen in railway practice, being supplanted by others more perfect in form and lighter in material. The law for the survival of the fittest here prevails, as in the animal or vegetable kingdoms.

Fig. 1 is deficient in this particular: Parallel rays of light nearest the axis of the lens are refracted to a focus more remote from the lens than those which are incident at a distance from the axis of the lens.

In this lens, either by experiment or projection of the rays of light, the ray *a* will meet the axis at *b*, and the ray *a* at *d*. The distance *b d* is called the spherical aberration, and in this form will amount 117/100 of the thickness of the lens. As the central parts of the lens refract the light too little and the outer parts too much, it is clear, if we should increase the convexity at *e*, and decrease it at *f*, we should remove the spherical aberration. The ellipse and hyperbola are curves of this kind in which the curvature decreases from *e* to *f*, but while a lens of this form is perfect, yet the great difficulty of making these curves has prevented its introduction. Corrugated lenses, invented by Fresnel, are the forms in general use, and in comparison with the plano-convex, can be made much lighter, and the spherical aberration corrected by making the foci of each zone coincide, as in Fig. 3, in which the rays of light coming from the focus are refracted into parallel lines; and by the law of conjugate foci, the reverse holds true, namely, light falling on the lens in parallel lines is refracted to a focus. To determine experimentally if a light falling on a certain lens was refracted to a focus free from spherical aberration, a series of opaque diaphragms were used, so arranged that zones 1, 2, 3, 4,

Fig. 3, could be tested separately. The diaphragms were made from a thick piece of drawing paper, on the plan shown in Figs. 7, 8, 9 and 10.

For measuring the aberration of the lenses, an instrument was devised, shown in Fig. 12. This was made very simply, and the material was pine wood. The face *A* is covered with white paper, *B* is a sliding piece carrying the lens to be tested. The method of testing is this: The lens is held on *B* by three wooden clamps, and a diaphragm, Fig. 7, placed on the lens, stopping off all the light except the central ring 1. The instrument

manipulate, and at the same time accurate, led to its adoption over other forms of photometers in use. My photometer was made of pine wood. See Fig. 13. The strip *A* is ten feet long. *B* is a paper screen on a sliding piece of wood. *C* is a lamp so arranged that lenses can be introduced quickly. *d* is a sperm candle used in these experiments as a standard of comparison. The paper screen is glued upon the sliding piece while wet; when dry, it becomes tight like a drumhead. The aperture in *E*, over which the paper screen is placed, is 8 inches in diameter; in the center of the screen a grease spot is made about 1/2 inch in diameter.

This is best made with spermaceti dissolved in naph-

Fig. 11.

tha. The theory of the spot is this: The spot allows more light to pass through it, and consequently reflects less than the unstained part of the paper: if, therefore, the paper be illuminated more strongly from behind, it appears bright on a dark ground. On the other hand, it appears dark on a white ground if it be more strongly illuminated on the front surface; while with equal illumination the spot becomes invisible, since it cannot then appear either darker or lighter than the adjoining paper. The lenses are tested by moving the candle until the grease spot disappears. The distance *e* is noted for each lens under consideration. They are to be compared with each other inversely as the square of the distance *e*.

The apparatus used by me in testing did not cost over \$3, being made principally from pine wood, utilizing an old switch target lamp to hold the lenses in the photometric tests. While the cost is but small, the satisfaction is great. Where uncertainty before existed, no obstinate doubt remains after such tests.

RESULTS.

1. It has been found by means of these tests that lenses from the same makers often vary 7 per cent in their transmitting power, although to the eye they appear apparently similar.
 2. Lenses by different makers vary as much as 50 per cent in light transmission.
 3. Certain lenses were so deficient that the outer zone could be stopped out, and the quantity of parallel light transmitted would not be affected thereby.
 4. A removal of the flame 1/2 inch from the focus reduced the light in one instance 20 per cent.
- Always have the flame in the focus, if the best results are wished for.

PURITY OF THE GLASS.

The comparative purity can be tested by observing the appearance of a black line upon white paper, when the lenses to be compared are laid upon it. The lens that shows the darkest line is the one made from the purest glass. Care should be used in this test, that the edge of lenses only be used, as they have parallel sides for a short distance. This can be done, and any error arising from the different curvatures be avoided. Fig. 11 shows the position of the lenses in regard to the black line.

PHOTOMETRIC TESTS.

In my first photometric experiment, the method of comparative shadows was used as devised by Rumford, but was finally abandoned in favor of a photometer invented by Bunsen. Rumford's photometer on account of the different sizes of shadows, makes it difficult to decide when they are of equal intensity. Bunsen's being used on a different theory, practically easy to

Fig. 12.

Fig. 13.

The Use of Sulphur Dioxide in the Manufacture of Wines

The justification of the use of sulphur dioxide (sulphurous acid) in preparing wines is one of the subjects which was brought before the recent Congress of Applied Chemistry. P. C. Rossi quotes the following expert opinion given to him by Frederick T. Violetti in regard to this subject: "The judicious use of sulphurous acid, whether in the form of sulphur fumes, potassium meta bisulphite or the liquified gas during acid before fermentation, has resulted in great improvements in the quality of all wines and has greatly diminished the amount of spilt and unwholesome wine which was formerly made. On this point, all expert wine-makers and all competent enological investigators agree. While there is less danger of the complete spoiling of sweet wines by injurious fermentation than there is of that of dry wines, imperfect fermentations often much deteriorate their quality. Volatile acids, persistent cloudiness, unpleasant flavors and odors, are caused principally by the development of bacteria, molds and wild yeasts. Much of this damage may occur during

the first stages of fermentation in sweet as in dry wine. There is no method known to practice or science of effectively preventing these defects without introducing others except the accurate and careful use of sulphurous acid. Much of the opposition to the use of sulphurous acid on the part of those unfamiliar with the theory and practice of wine-making comes apparently from a misconception as to its object. Sulphurous acid is not used by the wine-maker as a preservative. The amount necessary for this purpose would be sufficient to completely spoil his wine and to render it unmarketable.

Used properly, it is no more a preservative than the steam he uses to clean and sterilize his barrels. Wines properly fermented by the use of minute but accurately measured amounts of sulphurous acid have superior keeping qualities but not because of the presence of sulphurous acid. This, in the finished wine, has in great part disappeared and what remains has entered into innocuous combinations and lost its antiseptic properties. Such wines keep better because the yeast has done its work better, and has utilized the sugar, albuminoids and other matters acted upon by micro-

organisms to produce substances of value, and not deleterious to the wine, as are those produced by the other organisms which would have developed had no sulphurous acid been used."

Preservation of Rubber Articles.—Rubber articles that have become hard recover their elasticity in a short time if placed in 3 per cent carbolic water or 3 per cent aniline solution. In the case of the carbolic solution it must not be forgotten that black goods exposed to it become grey. If it is desired to preserve the black or red color of the goods, that, too, can be done. A one per cent solution of pentasulphate of potash is employed. It is true that this smells dreadfully but the restoration of elasticity is quite considerable. Experiments with glycerine and water, in equal parts, as regards simple preservation, gave excellent results, says *Das Rezept*. The goods remain perfect for a long time but old goods are not restored to usefulness. Least satisfactory was the proposition by Berg. to preserve the rubber goods in lime water; if effective the vessels would have to be closed air-tight. In open vessels the lime settles and the solution molds.