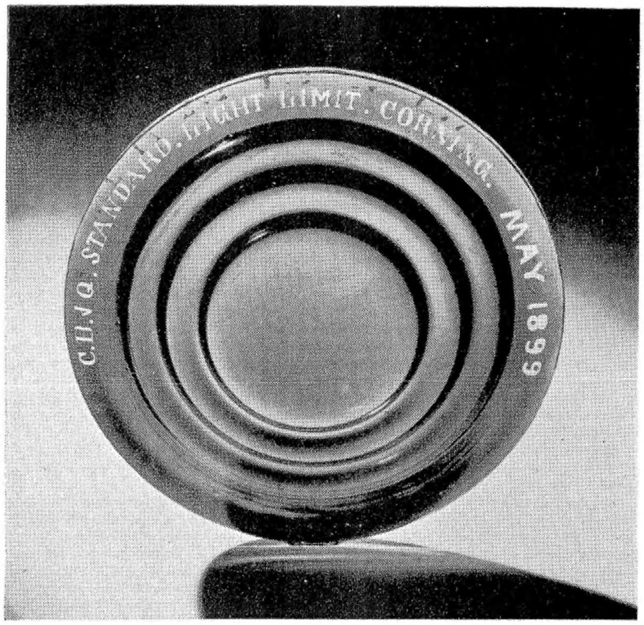
A Century of

A story of the research in the period 1841 to 1947, to design lenses to concentrate the light and to develop colors with distinctive difference and of standard values



The Chicago, Burlington & Quincy standard red lens of 1899 made by the flash method

TODAY the red, yellow and green color lights in signals are of maximum distinctiveness, and are of equal color values on all parts of each railroad and on all railroads on the North American continent. These results, which contribute to safety of railroad operations, were attained by perseverance and hard work on the part of several serious-minded men who visualized the need for standardization of color glasses used in signaling. Of interest especially to the new men in the field, the following discussion is a brief history of some of the research and developments in signal glass.

While the exact beginning of railroad signaling is not known, it is recorded that some standards for signal colors were established at a convention of railroad signalmen in Birmingham, England, in 1841. This group established the following color guides: White for safety, red for danger and green for caution. (See page 47 Railway Signal Association Proceedings, Volume 2.) This system for night aspects for semaphore signals was followed by all railroads up to 1900, and by a few until 1910 or a little later.

Early Consideration of Color

In 1894 the committee on interlockings and block signals of the American Railway Association gave consideration to the subject of color aspects. They recommended red for danger, violet for caution and green for clear. A month later this committee revised its opinion and recommended continuing green for caution and white for clear. Later in the same year, this group reported the use of blue or orange for caution did not seem practical.

The use of white as a clear indication had objectionable features. For example, the breakage of either a red or green glass left a white light or a clear indication. In the event that the red or green light was extinguished there was the ever present danger that some wayside light might be mistaken for a clear indication. (This circumstance is said to have been the cause of an accident at Whitenton Junction on the New Haven in 1898.)

In order to eliminate white as a clear aspect, there was need of a third color such as yellow. Furthermore, the third color must be distinctive to avoid any possible confusion with either the red or green.

Early Bulls-eye Lenses

Since its organization in 1868, Corning Glass Works had been manufacturing railroad glassware such as bullseye lenses and lime glass lantern globes. Colored lenses and globes were made by first making a clear glass article and covering it with a thin film of colored glass. A picture of this type of lens, made in 1899, is shown on one of the accompanying illustrations. Solid color glassware did not come into the picture until after the turn of the century.

The first lenses were of the plain convex type called bullseyes and they were followed by the flat corrugated lenses which were used with the smooth surface toward the light source. Snow, sleet and dirt lodged in the outside steps or corrugations reducing the effectiveness of the lens. In 1877, Charles F. Houghton, one of the founders of Corning Glass Works and its sales manager, conceived the idea of a convex lens with steps on the inner surface, toward the light source, and smooth on the outer surface exposed to the elements. This revolutionary change in lens design was accepted and the principle involved is still in use today.

Each Road Had Its Colors

As signaling developed in America during the 19th century, each railroad had its own signal colors. Reds varied from orange to a very dark red, while greens ranged from a blue green to yellow chrome green. As yellow came into use, difficulty was experienced either from a reddish-yellow easily confused with red or a greenish yellow easily mistaken for green. The New York, New Haven & Hartford was the first road to use red for stop, yellow for proceed with caution, and green for clear.

In 1899, Prof. E. W. Scripture, head of Yale Psychological Laboratory, delivered a lecture on color blindness at a meeting of the New York Railroad Club. Alanson B. Houghton, a son of one of the founders of Corning Glass Works and at that time sales manager, was in the audience. Impressed and intrigued by the statement that correct signal colors could be determined by a careful study of the physical and color conditions involved, Mr. Houghton asked the professor to undertake a laboratory investigation to establish correct values for each of the possible signal

Signal Glass Developments

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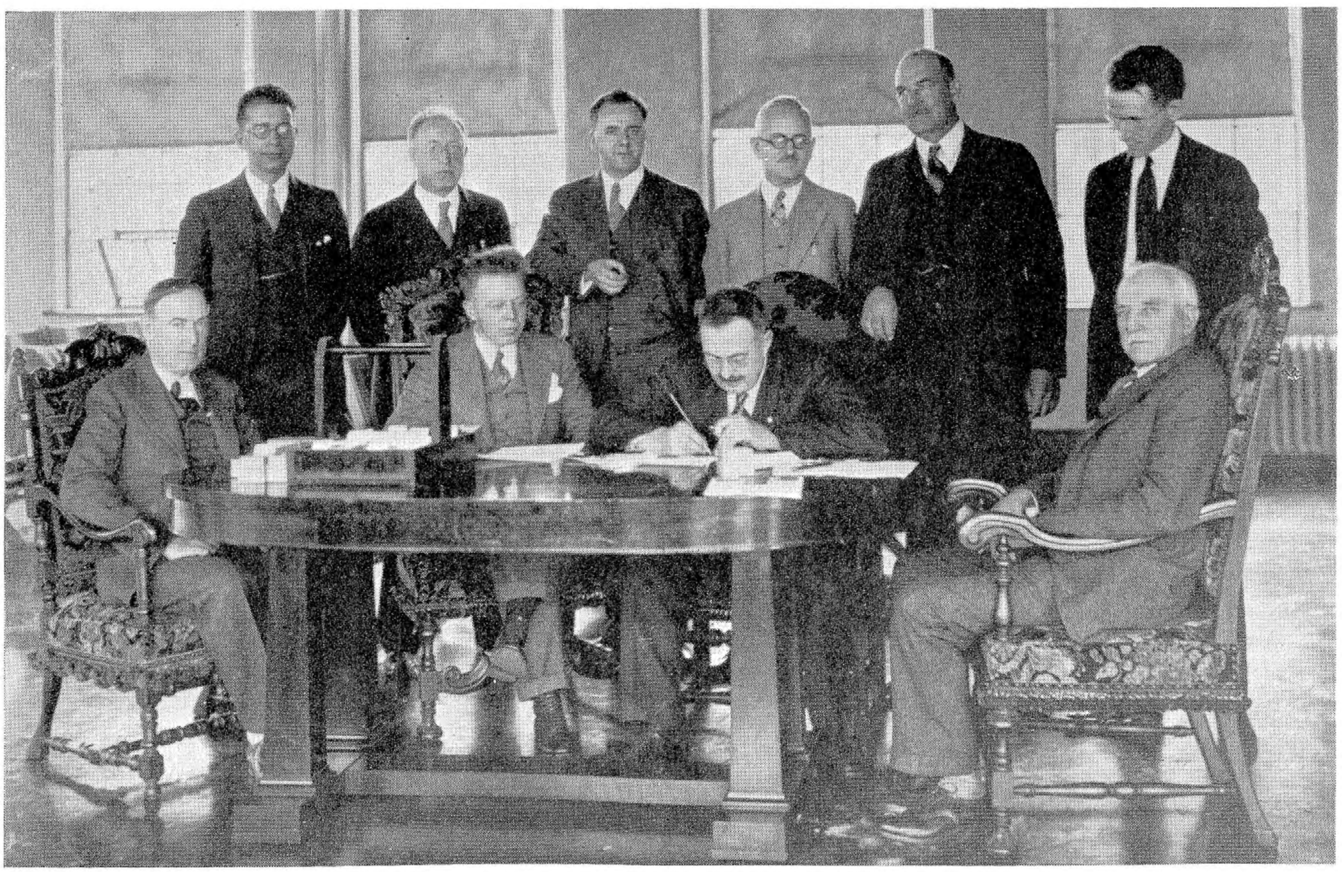
colors. Preliminary research was done at Yale by Prof. E. W. Scripture and Dr. William Churchill. In 1904, Dr. Churchill was employed by Corning Glass Works and established an optical laboratory for the specific study of signal lenses and color.

The Roundel Problem

By October 1905, Dr. Churchill had considerable progress to report in his paper, "The Roundel Problem," at the Ninth Annual Meeting of the Railway Signal Association. This organization of railroad engineers was founded in 1895 as the Railway Signal Club, adopted the name Railway Signal Association in 1903, and changed to Signal Section, Association of American Railroads in 1920. In this paper Dr. Churchill proposed the fundamental principles and methods of testing for the colorimetric specification of colored signal ware that were necessary for the standardization of signal colors. He announced the development of new glasses with a satisfactory manufacturing range between light and dark limits to provide a three-color signal system. The new red was of a nature that even with high transmission it did not appear orange. The new green was of slightly bluish tint and having nearly 50% higher transmission than the average for previous greens. The yellow or amber glass had a hue distinct from red or green and a density providing balanced transmission. Dr. Churchill



Committee VI—Designs of the Signal Section, Association of American Railroads, as assembled at Corning, N.Y., in June, 1931, for purpose of identifying a series of colored glasses. Left to right seated: H. G. Morgan, signal engineer, Illinois Central, chairman; I. G. Priest, Bureau of Standards; H. P. Gage, chief of optical laboratory, Corning Glass Works; and J. C. Mock, signal engineer, Michigan Central, now retired. Standing: G. K. Thomas, signal engineer, Santa Fe, vice-chairman; A. J. Patterson (deceased), signal engineer Advisory Committee, Chesapeake & Ohio; O. S. Field, General Railway Signal Company; A. W. Fisher, Union Switch & Signal Company; C. J. Kelloway, superintendent signals, Atlantic Coast Line (deceased); and A. S. Haigh, now signal engineer, New York Central, Lines East.

also proposed lunar white, a new blue and a new purple for certain kinds of signals.

Optical Laboratory

The period 1905 to 1908 marked great activity in the new optical laboratory in Corning. In addition to glass research many new types of lenses were created. The optical lens gave a concentrated beam of light with a maximum of candle power and a minimum of spread and the wide angle lens had less candle power because the light was diffused to cover a wider area. Later the wide angle lens became obsolete with the development of the more efficient spredlite lens with bars or flutes on the smooth surface to spread the light in a fan shaped beam. The spredlite lens saved the top and bottom portion of the beam that was wasted by the wide angle lens. Another development was the inverted lens with a cover glass having characteristics similar to the optical lens. The combination of a lens and cover glass would permit the use of a clear glass lens and a colored cover glass. At that time the variation in thickness of corrugated lenses caused considerable color variation. The cover glass was plain and of uniform thickness which would eliminate the lens color problem. Later developments in color control and design caused the combination to be discarded in favor of the optical lens. Some of this work was covered in Dr. Churchill's paper, "The Optics of the Signal Lens," presented at the Railway Signal Association meeting in October 1906.

A Railway Signal Association Committee followed developments at Corning and participated in laboratory and field demonstrations. Sample colored roundels were selected as representative of the committee's opinion as the ideal color. These were arbitrarily called 100 per cent standards. Based on these standards a specification was written and presented to and adopted by the association at its meeting in October, 1908. This specification defined photometric limits for the various colors and required that each piece of colored signal glass be photometrically measured and marked with a sticker indication that it was within the R.S.A. limits. During the following ten years, the railroads abandoned individual color requirements and replaced them with glasses to R.S.A. specifications.

Heat-Resistant Glass

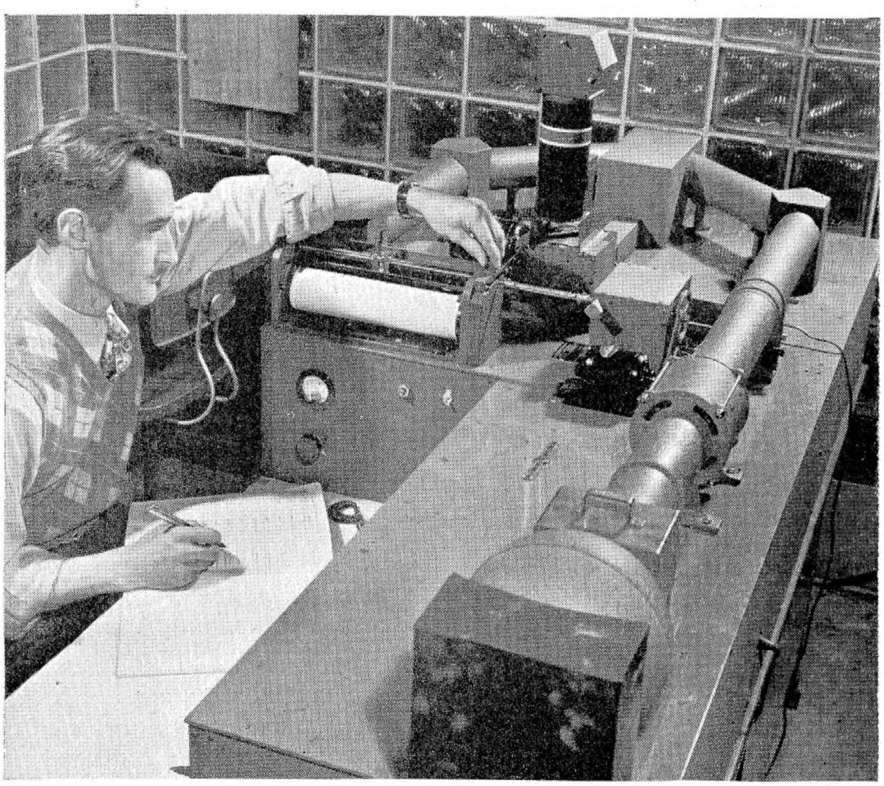
The year 1908 marked another important glass development for railway signal work. This was a new low expansion borosilicate glass that would withstand sudden temperature change without breakage. It was an ideal glass for lantern globes and reduced service breakage of globes an estimated 60 per cent. The railroads were reluctant to pay a higher price for heat-resisting globes and much effort was expended in demonstrating to them that globes made from the new glass not only saved them money but added to the safety of operation. The first R.S.A. specification for heat-resisting lantern globes was adopted in 1927.

Another application of the new heat resisting glass was for primary battery jars. An R.S.A. specification covering battery jars was adopted in 1921. The story is told that a young Corning physicist cut the bottom out of a heat-resisting battery jar and had his wife bake a cake in it. This is alleged to have been the start of the now famous Pyrex baking ware.

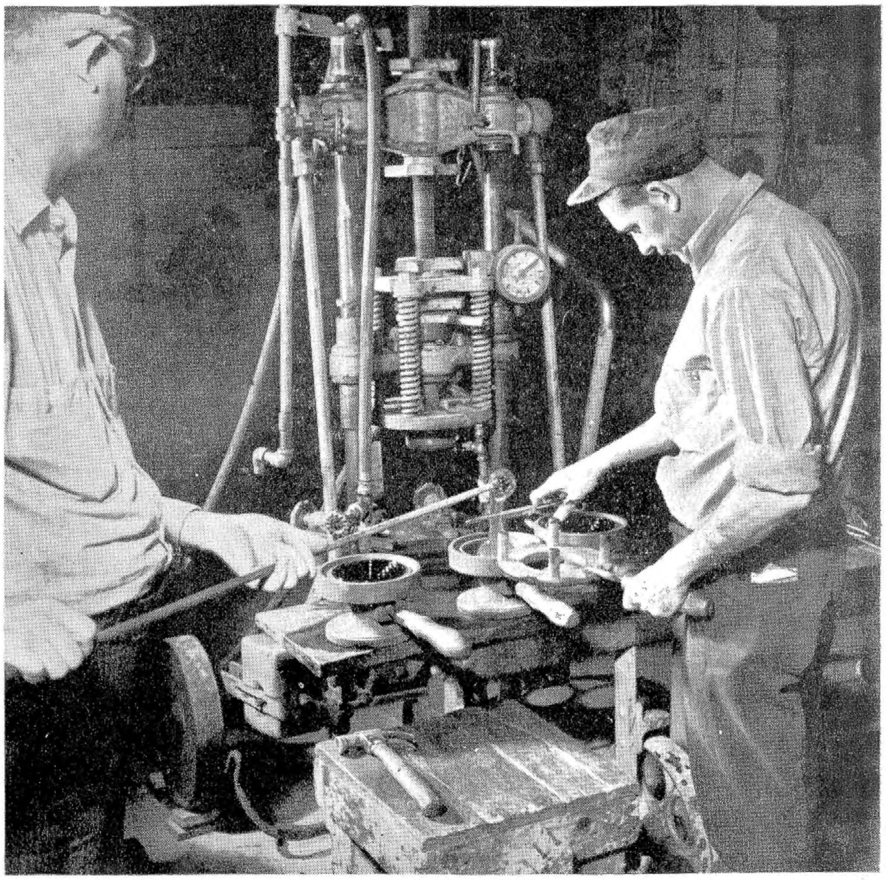
Dr. Gage to Corning

The adoption of the R.S.A. specification did not end development work in the Corning laboratory. In 1911, Dr. H. P. Gage, a Cornell physicist, came to Corning and later succeeded Dr. Churchill as head of the optical laboratory. Day after day experimental melts were made in small crucibles that looked like flower pots. True, certain colors were available. Was it possible to obtain additional distinctive colors in glass? Whereas the experiments which still continue did not produce additional signal colors, they did produce improved colors. Higher transmission was desirable since no matter how good a color is, its effectiveness is limited by the maximum range of the signal. The years 1917 and 1918 again witnessed an R.S.A. committee visiting Corning to examine the improved signal glass that was available. A revised specification for lenses, roundels and glass slides was adopted at the 1918 meeting of the association. For many years glasses furnished to the specification were known as high transmission glasses. The year 1913 marked the development of the doublet lens combination for color-light signals visible for a distance of 4,000 ft. The first color-light signal was installed in the New York subway in 1915. The doublet lens combination is still used in railway signaling and is also used in the 36-in. airway beacons.

Many usual and unique designs of lenses and roundels have been de-



This equipment in Corning laboratory used when making a spectrometric test on colored glass made for railroads



Man at left is pouring molten glass into mold and man at right uses his scissors to cut off just the correct amount which is then pressed into final form of lens

veloped in the Corning laboratory in cooperation with equipment manufacturers. Among these are toric lenses, various types of deflecting roundels as well as special devices for searchlight signals. During the dark days in the early thirties a reflex lens was developed for switch lamps. These lenses eliminate oil and maintenance, and in the course of years have saved the railroads thousands of dollars.

The color standards established by the 1918 specification were in the form of 8⅜-in. flat roundels. It was not until October 30, 1930, that J. C. Mock, signal engineer of the Michigan Central, and A.A.R. sub-committee chairman, visited Corning and engraved a set of standards. J. C. Mock 10-3-30. The 8⅜-in. pressed roundels were not suitable for spectro-photometric analysis and therefore could not be exactly duplicated. With the cooperation of the United States Bureau of Standards, limit glasses in the form of two-inch polished squares were prepared. This work extended over a period of years during which hundreds of squares were prepared and examined by means of a spectrophotometer.

Signal Section, A.A.R., Committee VI

In June 1931 a meeting of Committee VI designs of the Signal Section was held in Corning. This group seems to have the distinction of being the only such group photographed in Corning. It consisted of H. G. Morgan of the Illinois Central, G. K. Thomas of the Santa Fe, vice-chairman, A. J. Patterson, Chesapeake & Ohio, A. S. Haigh, New York Central, and C. J. Kelloway, Atlantic Coast Line. Also in attendance by invitation were Dr. K. S. Gibson and F. G. Priest of the U.S. Bureau of Standards, Oscar Fields, General Railway Signal Co., and A. W. Fischer of the Union Switch & Signal Co. Dr. H. P. Gage of Corning Glass Works was host and technical adviser. After reviewing spectro-photometric data and making field observations, the two-inch polished square limit glasses were approved and endorsed as accepted standards. One set was entrusted to the Bureau of Standards for file in Washington, a second set was held by the Signal Section and the third set was held on file at Corning Glass Works. It is now possible to obtain certified duplicates of these limit glasses through the Bureau of Standards.

Revisions In 1935

The year 1935 witnessed a revision of the specifications for lenses, roundels and glass slides. Experience gained in manufacture and test at Corning, combined with research at the Bureau of Standards and experience in the field, permitted the specification to be rewritten permitting use of higher transmission glasses. The 1935 specifications define color values in a manner that with proper test equipment any doubtful glass will be eliminated. This specification also covers heat resisting discs for searchlight signals. The year 1939 saw the selection of limit glasses for highway crossing signal red.

The Journal of Research of the National Bureau of Standards, Volume 36, January 1946, covers the extensive research work done by K. S. Gibson, G. W. Haupt and H. J. Keegan of the Bureau of Standards. In this paper the authors state, "Success in carrying through the program of Railway Signal Glass standardization has resulted in a large measure from the generous cooperation of Corning Glass Works. Special acknowledgment is due in this connection to Dr. H. P. Gage."

Still More Research

As of today, American railroads are equipped with best designed lenses and colors that modern glass manufacturers are capable of producing. That behind this opinion lies more research and production knowledge than is generally known is evidenced by the preceding historical survey. The Corning optical laboratory has supplemented its research in the railroad signal field with designs and colors for traffic, aviation and marine signals as well as glass color filters for scientific purposes. Production knowledge for railway signal glassware has benefited from the experience and facilities acquired in producing other signal ware and thousands of other technical products. The search for new and better glasses continues in the Corning laboratory.

In conclusion, tribute should be made to the progressive spirit of the railway signal engineers which has kept them among the leaders in the use of the best technique in the selection of signal colors and in the formulation of purchase specifications based on scientific data.