THE General Radio EXPERIMENTER

VOLUME XXV No. 1 JUNE, 1950

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

35 YEARS OF INSTRUMENT MANUFACTURE

Also
IN THIS ISSUE

● **JUNE, 1950,** marks a significant anniversary for the General Radio Company. Founded in June, 1915, the Company completes this month its 35th year in the manufacture of precision electronic test equipment, and also sees the retirement from Company affairs of its founder, former President and Chief Engineer, Melville Eastham. Another retirement, earlier this year, was that of Henry S. Shaw, former Treasurer and later Chairman of the Board, who became associated with the Company in 1917.

These two men are largely responsible for today's General Radio Company, for one was its founder and the other did much to assure its continued existence during its formative years.

Instrument companies were few in 1915, and it took an unusual combination of courage and vision to start one of a different kind, to serve

Melville Eastham

Henry S. Shaw

an industry still in its infancy. Proof of the soundness of Melville Eastham's judgment is found in the electronics industry of today, providing a continuing market for not only one but many test-equipment makers.

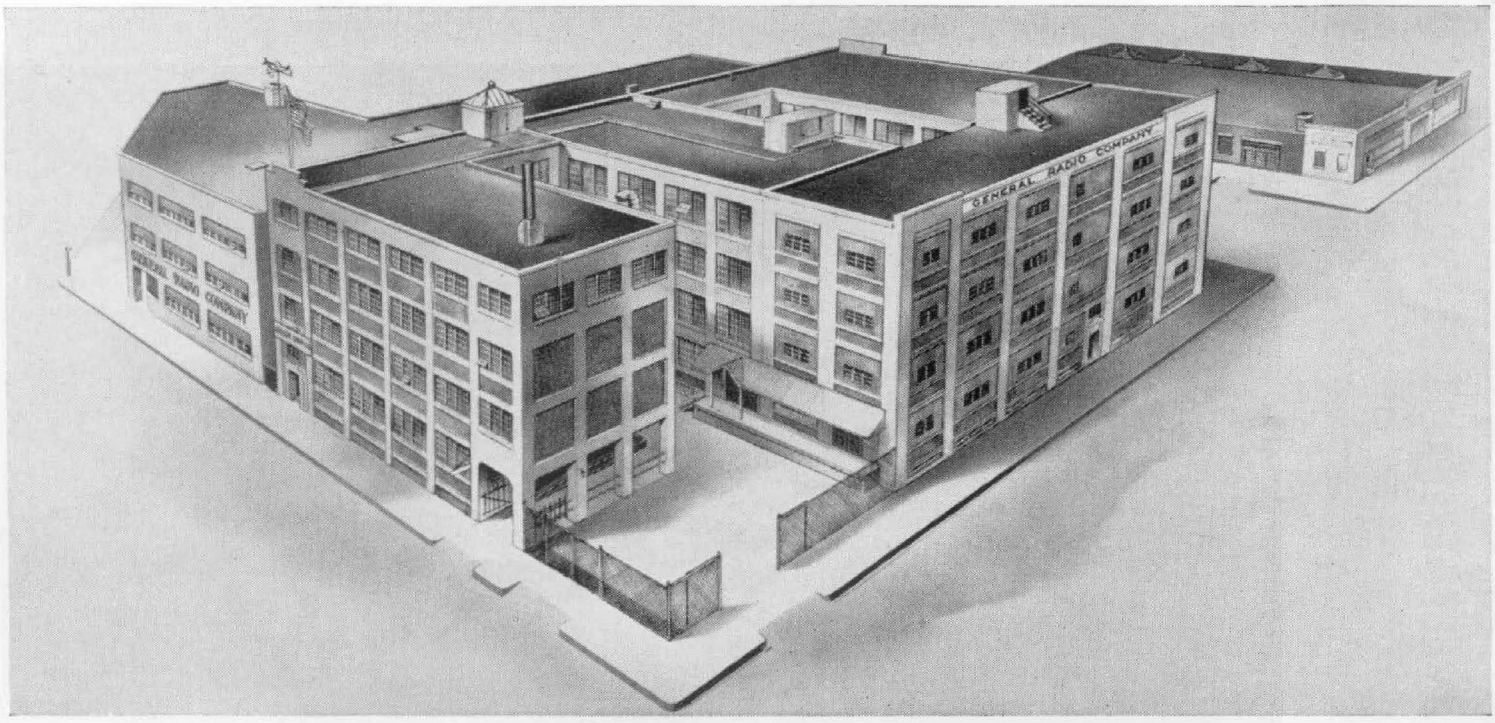
Mr. Eastham held the office of President from 1915 to 1944, and during most of this period, as well as the years from 1944 to 1950, also functioned as Chief Engineer. For these thirty-five years, his wise counsel has guided the Company's technical developments, its employee relations, and its business and management philosophy.

In 1917, Henry S. Shaw joined the Company, becoming Treasurer the following year and Chairman of the Board in 1926, holding that post until 1944. Through his help, the Company weathered both the violent expansion necessitated by World War I and the equally serious deflation that followed. His keen interest in employee welfare and business management have contributed immeasurably to the Company's success.

Retirement is mandatory at sixty-five in the General Radio Company. Messrs. Eastham and Shaw have chosen also to retire as directors, thus severing all active connection with Company affairs. "Retirement," however, is hardly a valid description of the future activities of these men, for the freedom from routine duties will give even greater scope to their wide-ranging scientific and business interests.

At the annual meeting of the General Radio Company, held on February 15, 1950, Charles C. Carey, Vice-President for Production, and Arthur E. Thiessen, Vice-President for Sales, were elected directors to replace Mr. Eastham and Mr. Shaw. Subsequently, at their meeting on the same date, action was taken by the Board of Directors, as indicated by the following extract from the minutes of the meeting:

". . . The signal service rendered this Company by Messrs. Eastham and Shaw can never be duplicated by any other officer. . . . It was felt that appropriate recognition should be given to the services of these two gentlemen. It was, therefore, on motion duly made and seconded, VOTED: That Melville Eastham be designated Honorary President of the Company and that Henry S. Shaw be designated Honorary Chairman of the Board of Directors."



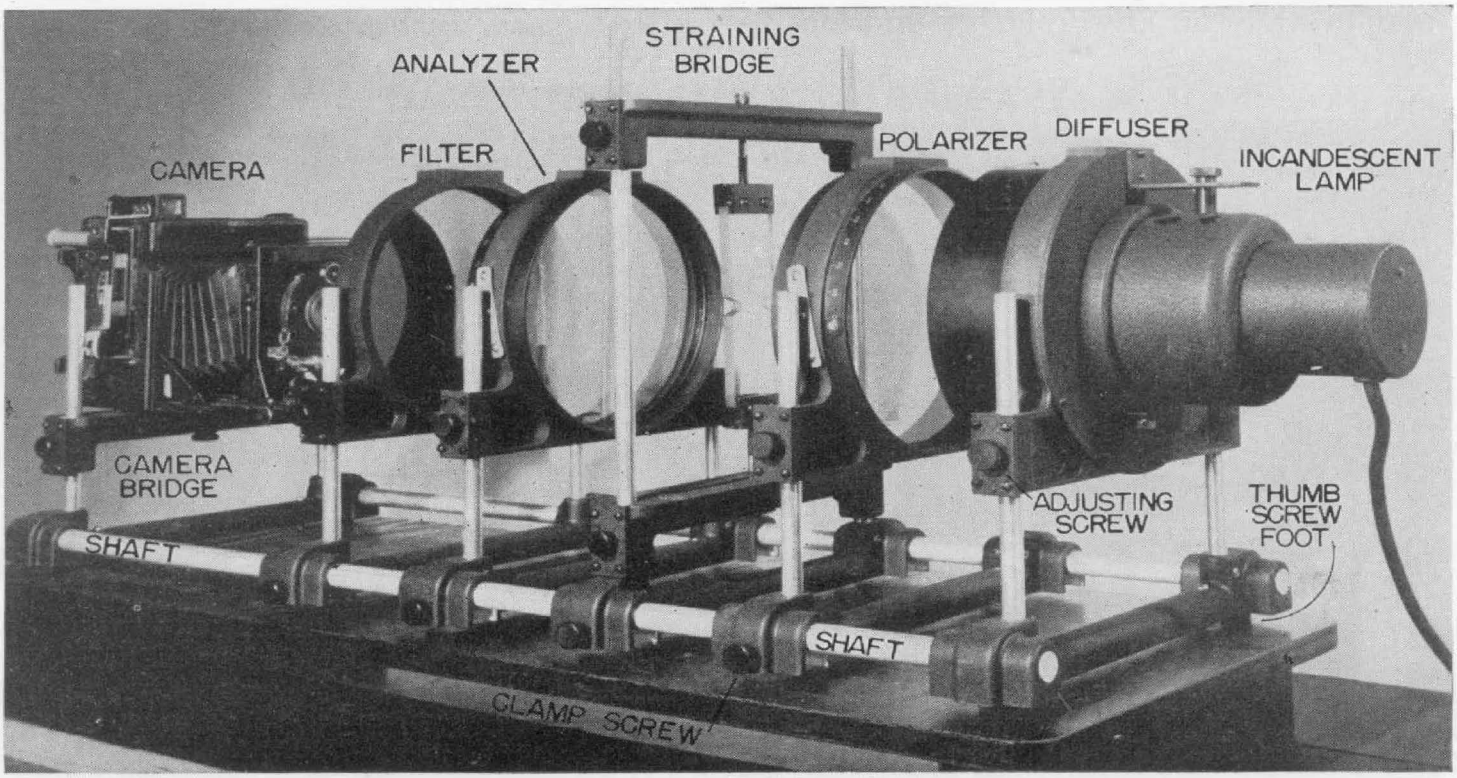
A POLARISCOPE FOR DYNAMIC STRESS ANALYSIS

One of the more useful tools in mechanical research is the photoelastic polariscope for stress analysis. The science of photoelastic stress analysis is based on the property of certain transparent materials which causes them to exhibit, when strained, a degree of optical double-refraction exactly proportional to the net stress. Such materials, under stress, are no longer isotropic to light, a ray of which, entering such a stressed material, will travel faster in one plane than in the plane at right angles to it. Further, the retardation in the "slow" plane is a direct function of the causative stress.

Monochromatic polarized light traversing such a stressed material is resolved into two vector components, fast and slow respectively, the effect of which, through cancellation and reinforcement depending upon the relative delay, is visible as a pattern of light and dark bands when the model under stress is viewed through a polarizing analyzer. Since the relative delay is a function of the net stress, the number of bands or "fringes" at a given point indicates net stress at that point. Furthermore, stresses parallel to the direction of plane polarization produce no effect under plane polarized light, so that unaffected areas represent the locus of all stresses parallel to the plane of polarization. Such clear areas are called isoclynics and may be used to determine the direction of the principal stresses. Under circularly polarized light the isoclynics disappear, since circularly polarized light represents a plane polarized light, whose plane of polarization is rotating at the frequency of the monochromatic light employed, thus blurring out the isoclynics. Thus both the magnitude (under circular polarization) and direction (under plane polarization) of the net stresses can be derived from observation of a photoelastic model in the polariscope.*

*M. M. Frocht, "Photo-Elasticity," John Wiley and Sons, N. Y.

Figure 1. View of complete polariscope with incandescent light source and camera.



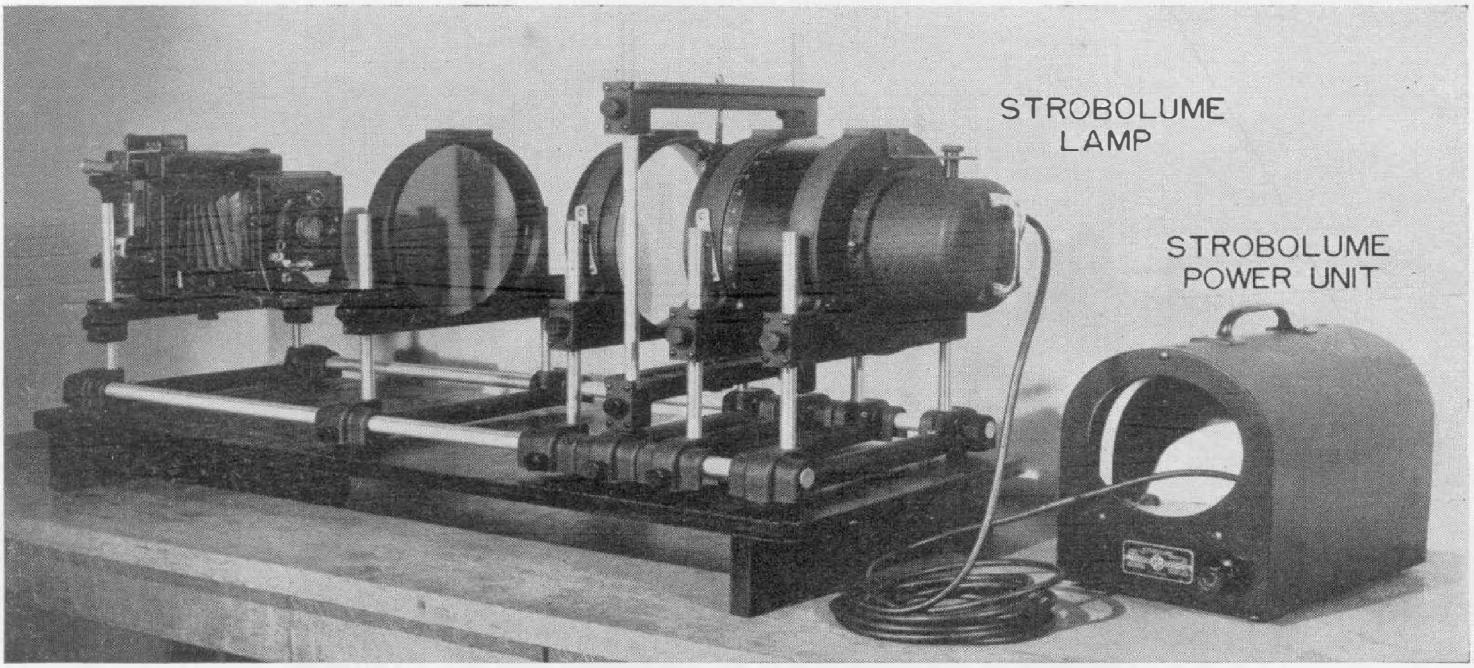
A polariscope, basically, requires a source of monochromatic light, or a light source and means for effectively securing monochromatism; a polarizer and analyzer, both capable of plane and circular polarization with means for determining the inclination of the axis of plane polarization; and a means of visual or photographic observation of the stress patterns exhibited by a strained photoelastic model interposed in the light beam between polarizer and analyzer.

The fullest employment of photoelastic methods of stress analysis has, in the past, been hampered by the cumbersome and costly nature of the equipment required for visual or photographic observation. If a sizable field for easily manipulated models was required, the optical requirements imposed by the use of available monochromatic light sources, natural polarizing media, and model substances of relatively low photoelastic sensitivity could only be met by expensive, bulky apparatus with relatively weak illumination. Photographic exposures ran into minutes, so that the "bench," as such a setup is termed, had to be carefully designed to minimize vibration or any relative motion between its multiple parts. Bench assemblies weighing many tons are commonplace in photoelastic laboratories. Sensitivity of model materials was still further reduced by the choice of monochromatic light of long wavelength, due to the low radiation of blue-violet by most artificial light sources adaptable to the purpose.

Many of the earlier limitations were removed by the appearance of synthetic polarizing materials in sheet form. These relatively inexpensive materials replaced costly natural media and simultaneously reduced the optical problem by removing the narrow dimensional limits imposed by natural polarizers. Nevertheless, photographic exposure times were still sufficiently long to require stability, attained through bulk; and the cost reduction, while appreciable, was not great enough to bring equipment into more general use.

The General Radio TYPE 1534-A Polariscope removes most of the remaining obstacles to wider use of photoelastic techniques, through the use of the TYPE 1532-A Strobolume as a light source. The intense, short flash of the Strobolume reduces the exposure time

Figure 2. View of polariscope with Strobolume flash source.



to 40 microseconds, which effectively "stops" motion in a dynamic stress pattern as well as pattern motion originating in vibration. As a result, the TYPE 1534-A Polariscope is much lighter in weight and lower in cost than polariscopes designed for longer exposures, where vibration effects must be minimized.

The blue-green monochromatic light band used in the TYPE 1534-A Polariscope is peaked at 4800 Ångstrom units. This is a much shorter wavelength than is ordinarily used in polariscopes. The blue-richness of the Strobolume spectrum is the secret. Since photoelastic sensitivity (expressed as bands or "fringes" per unit stress per unit thickness) varies inversely with the wavelength of the incident light, the 4800 Å. monochrome materially increases sensitivity as compared with conventional practice.

The TYPE 1534-A Polariscope is made up of several subassemblies all tied together horizontally by two TYPE 1534-P7 Shafts to form an optical "bench." The light beam traverses, in order, a TYPE 1534-P2 Diffuser, a TYPE 1534-P1 Polarizer, the model mounted in a TYPE 1534-P3 Straining Bridge, a TYPE 1534-P1 Analyzer, a TYPE 1534-P5 Filter, and terminates in the camera, mounted on a TYPE 1534-P4 Camera Bridge. The TYPE 1534-P2 Diffuser accepts either the TYPE 1532-A Strobolume lamp housing (Figure 2) or the TYPE 1534-P6 Incandescent Light Source (Figure 3) for steady visual observation. The TYPE 1534-P1 Polarizer-Analyzer assemblies are identical. Both mount a plane polarizer and quarter-wave retardation plate, removable without tools, mutually rotat-

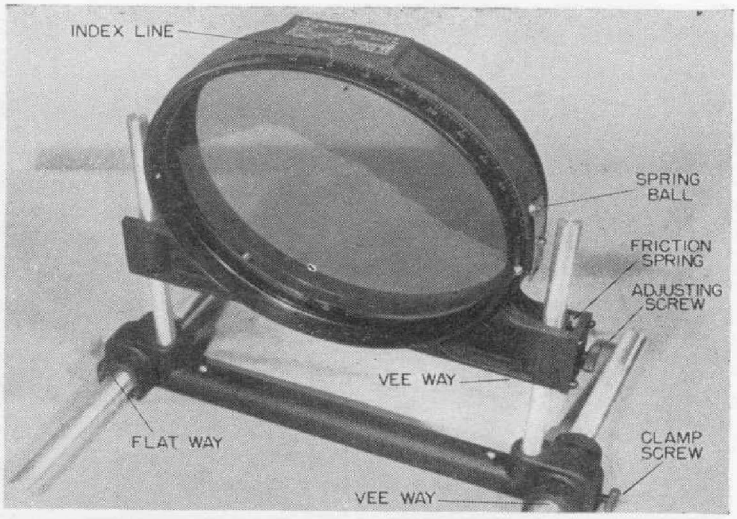


Figure 3. View of Type 1534-P1 Polarizer-Analyzer Assembly.

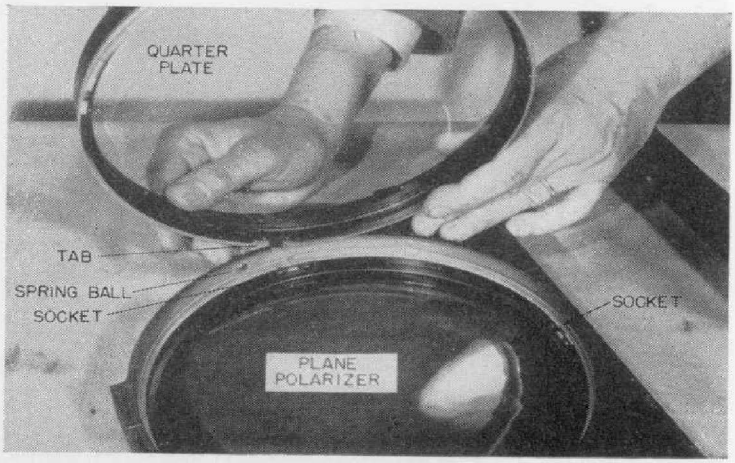


Figure 4. Quarter plate can be installed or removed without tools as shown here.

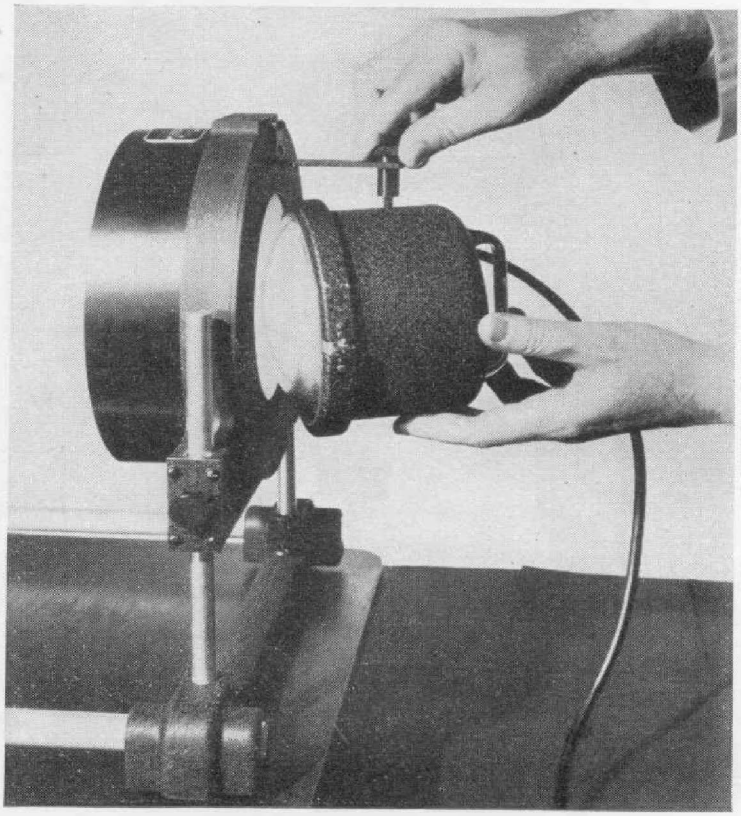


Figure 5. Either Strobolume or incandescent light source can readily be mounted on the diffuser.

able, and registering for right- or left-hand circular polarization. Plane polarizers carry a degree scale calibrated from zero to both plus and minus ninety degrees for isoclinic (loci of equi-directional stresses) determination. The TYPE 1534-P4 Camera Bridge has a captive ¼" x 20 thumbscrew for mounting the user's camera by means of its tripod socket.

All elements are horizontally adjustable along the TYPE 1534-P7 Shafts and vertically adjustable over some nine inches. Vee and flat ways insure optical alignment. Thumbscrews hold desired settings.

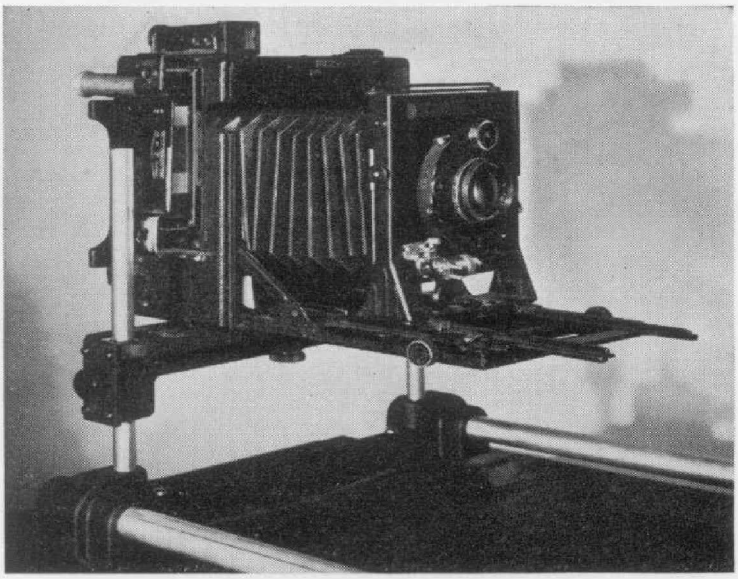


Figure 6. View of camera mounted on camera bridge.

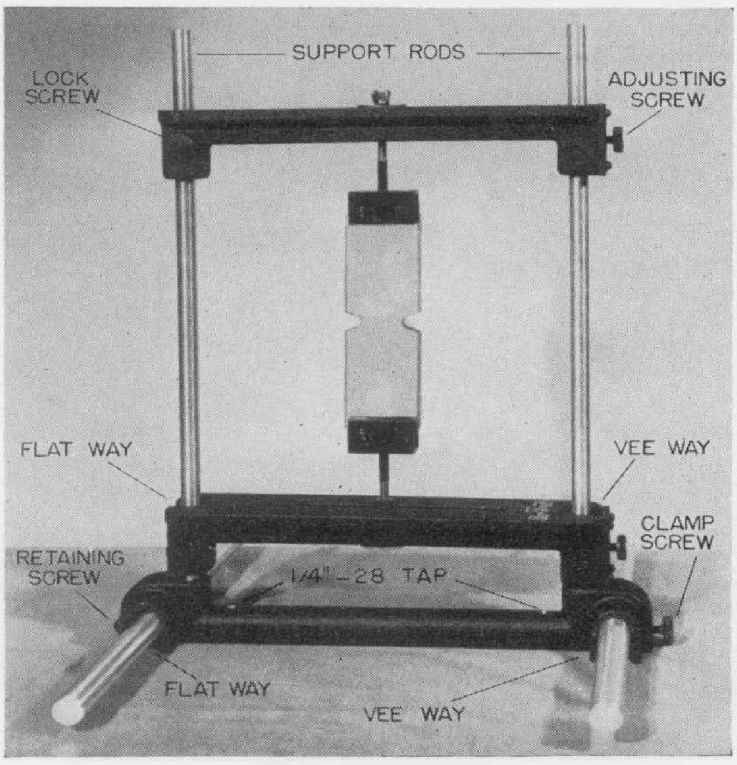


Figure 7. View of notched specimen mounted in straining frame.

The bases of all components are provided with mounting holes for use when the TYPE 1534-P7 Shafts are not required. Note, please, that TYPE 1534-P7 Shafts are supplied 36" long unless specifically ordered in other lengths.

Necessary accessories not furnished as a part of the polariscope include the TYPE 1532-A Strobolume and a camera, the choice of which latter is left to the user. A ground glass focusing system and a lens speed of not less than f/4.5 are essential requirements. Flash synchronizing contacts are a convenience, though a simple bulb or time shutter will be perfectly satisfactory.

Dynamic stress analysis problems call for a certain amount of ingenuity. We can but suggest the use of contacts that close, or circuits that break at some predetermined deflection of the model. Our TYPE 1535-A Contactor is available for synchronizing the TYPE 1532-A Flash with rotary devices such as might be used in cyclical straining, and is continuously adjustable for proper phasing.

The TYPE 1534-P3 Straining Bridge will serve for certain simple setups, but is in no way intended as an accurately calibrated straining frame. Such latter equipment may be obtained from a number of reliable suppliers or may be devised by the user to fit his particular problem.

Models of water-white Catalin are most satisfactory. High sensitivity and transparency to the 4800 Å. monochrome are definitely in its favor. It is strong and relatively inexpensive. Models contour-cut from sheets cast between

plate glass surfaces require no further finishing for proper optical properties.

For photographic use, a Wratten No. 75 front-of-lens filter may be substituted for the TYPE 1534-P5 Filter, though the latter is preferable for visual observation. The Wratten 75 filter prevents most of the normal room illumination from reaching the film, so that the camera shutter can be opened for some time without danger of fogging.

Process film is recommended for optimum results, although other film may be used. The process film spectral response yields the narrowest monochromatic band for sharp resolution in regions of steep stress gradient. Process film is easily handled, being relatively fog-free to incandescent light. It has a fine grain and a bright contrast for clear enlargement and projection.

Despite the severe requirements imposed by the large, eight-inch diameter field and diffuse illuminating system of the TYPE 1534-A Polariscope, a single Strobolume flash is adequate for full exposure at a relative aperture of f/4.5. While diffuse illumination is theoretically inferior to a collimated beam, its use in the TYPE 1534-A is justified by its far greater simplicity and the excellent results obtained in practice.

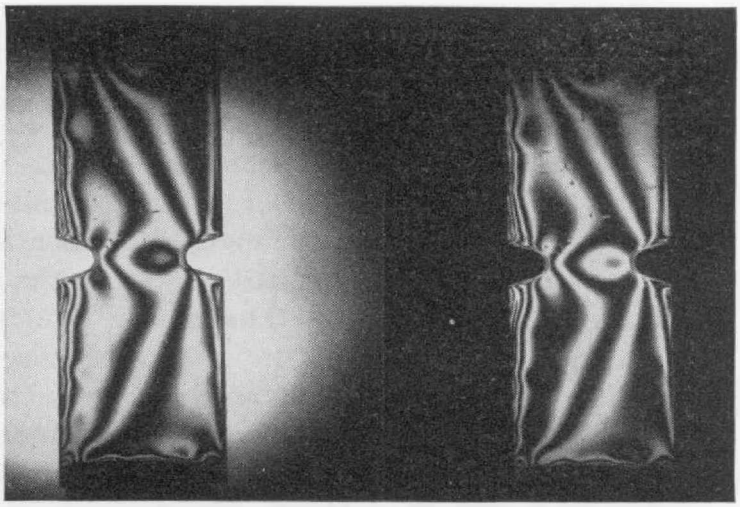


Figure 8. Light- and dark-field photographs of specimen shown in Figure 7, illustrating fringe patterns shown under circular polarization.

The simplicity of operation and the low price of the TYPE 1534-A Polariscope bring photoelastic measurements within the reach of the small laboratory with a modest budget and limited space, and should greatly extend the field of application of photoelasticity in mechanical research and design.

— GILBERT SMILEY

SPECIFICATIONS

Components Supplied:

1 TYPE 1534-P1 Polarizer
1 TYPE 1534-P1 Analyzer
1 TYPE 1534-P2 Diffuser
1 TYPE 1534-P3 Strain Bridge
1 TYPE 1534-P4 Camera Bridge
1 TYPE 1534-P5 Filter
1 TYPE 1534-P6 Incandescent Light Source
2 TYPE 1534-P7 Shafts (furnished 36 inches unless otherwise specified)

Optical Field: 8-inch diameter.

Vertical Adjustment: 12 inches.

Accessories Required: TYPE 1532-A Strobolume, camera with ground glass and lens of f/4.5 or faster.

Other Accessories Recommended: Wratten No. 75 front-of-lens filter.

Dimensions: 36 x 14¼ x 16½ inches, overall.

Net Weight: 32 pounds.

Type		*Code Word*	*Price*
1534-A	**Polariscope**	FOCUS	**$490.00**

Strobolume

The TYPE 1532-A Strobolume was described in the May, 1949, issue of the *Experimenter*. Complete description will be supplied on request.

Type		*Code Word*	*Price*
1532-A	**Strobolume**	TITLE	**$225.00**

MISCELLANY

DECADE ATTENUATORS

ERRATA: It has been called to our attention that the low frequency (d-c) errors of the TYPE 829 Decade Attenuator Units and the TYPE 1450 Decade Attenuators are substantially less than were quoted in the December, 1949, *Experimenter*. Since the individual resistor elements are all calibrated within ±¼% of their theoretical values, Mr. Lamson's analysis shows that, for any switch setting, the actual d-c attenuation will be correct within 0.001 db ±¼% (indicated db value). The 0.001 db term is due to switch resistance.

Mr. P. K. McElroy was responsible for the excellent mechanical design of these units.

SUMMER CLOSING

VACATION — During the weeks of July 24 and July 31 most of our employees will be vacationing. Manufacturing departments will be closed and other departments will be manned by a skeleton staff. Every effort will be made to take care of urgent business, but repairs cannot be made, except in hardship cases. Our Service Department requests that shipments of material to be repaired be either scheduled to reach us well before this vacation period or delayed until afterward.

INSTRUMENT EXHIBITS

At the annual meeting of the American Society for Testing Materials, to be held in Atlantic City June 26 to 30, 1950, General Radio instruments for the materials testing field will be exhibited, including the TYPE 1534-A Polariscope described in this issue of the *Experimenter*.

General Radio products will be on display at two important meetings next September, the Pacific Electronics Exhibit at Long Beach, California, and the National Electronics Conference in Chicago.

THE General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in communication-frequency measurement and control problems. When sending requests for subscriptions and address-change notices, please supply the following information: name, company address, type of business company is engaged in, and title or position of individual.

GENERAL RADIO COMPANY
275 MASSACHUSETTS AVENUE
CAMBRIDGE 39 MASSACHUSETTS
TELEPHONE: TRowbridge 6-4400

BRANCH ENGINEERING OFFICES

NEW YORK 6, NEW YORK
90 WEST STREET
TEL.—WOrth 2-5837

LOS ANGELES 38, CALIFORNIA
1000 NORTH SEWARD STREET
TEL.—HOllywood 9-6201

CHICAGO 5, ILLINOIS
920 SOUTH MICHIGAN AVENUE
TEL.—WAbash 2-3820

PRINTED IN U.S.A.