The Scientific Shop

ALBERT B. PORTER

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CIRCULAR 325—Fourth Edition — MAY 1907

PALERMO - OSSERVATORIO ASTRONOMICO

Frederic E. Ives' Optical Novelties and Specialties

The prices given below are not subject to discount. *No charge is made for boxing an order amounting to ten dollars or more.*

Ives' New Process Replicas of Rowland's Diffraction Gratings

Patented April 24, 1906

Awarded the John Scott Legacy Medal and Premium by the Franklin Institute

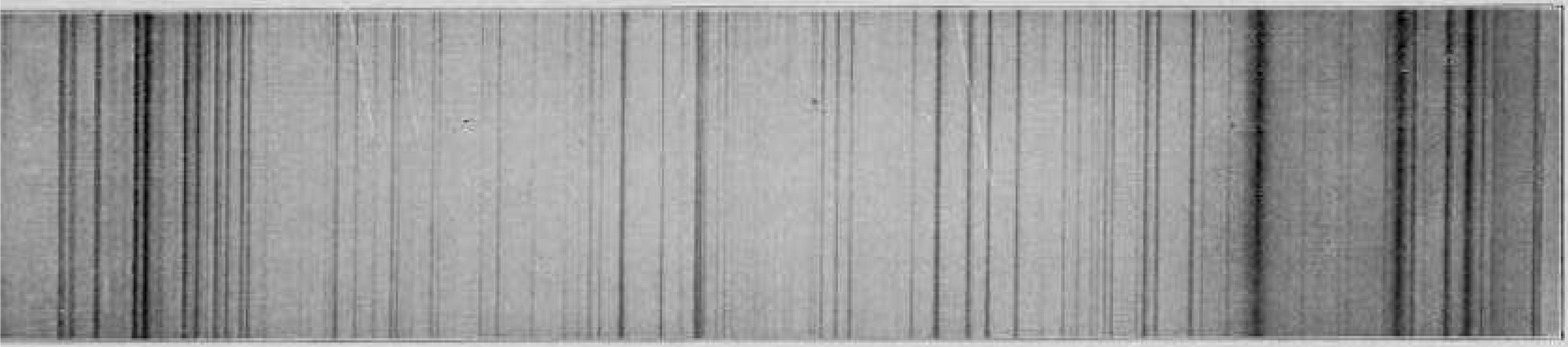
Thorp's method of reproducing Rowland's Diffraction Gratings by making a celluloid cast and mounting it face upward on glass has produced copies good enough for some purposes, but the celluloid film always distorts sufficiently to mar the definition more or less, so that even the best of them define better over some limited portion of their area than over all. They give the best results only when the rays entering the spectroscope are practically parallel, as with direct sunlight without a condenser, and are transmitted through a selected limited portion of the grating. Even then, owing to the scattering of the light, which manifests itself as a pale fringe or halo about the lines in bright-line spectra, the lines of the solar spectrum do not appear as black as with the original Rowland grating. Aside from the stretching of the film, the manner of putting it down and attaching it to the glass causes a slight unevenness of thickness which, by refraction, destroys the perfect parallelism of the emerging rays, and distorts the plane of the diffracting surface, while the difference in refractive index of the celluloid and glass produces disturbing reflections between the two surfaces of the replica. The defects introduced by any one of these sources of error may be slight, but that altogether they are of material importance the result always shows, especially when the grating is used in spectra of the higher orders.

By a remarkable improvement upon this method, Mr. Ives has succeeded in making replicas which give entirely satisfactory definition even when used with high eyepieces in the second order spectrum, and these gratings are so finished that they are no more easily injured than glass prisms.

This improvement, which was described at the Franklin Institute in January, 1905, and in The Journal of the Institute in June, 1905, and which has since been protected in all essential details by letters patent, is effected (1) by making the cast in a harder and less elastic material than celluloid, (2) by putting it face down upon the glass and forcing it into optical contact therewith, so that the perfect plane of the diffracting surface is preserved, and (3) by sealing it up under another plane glass, with a balsam mixture having the same refractive index as the casting material, so that the perfect parallelism of the transmitted rays is insured, and at the same time the grating is protected from injury.

The Ives Replicas are made from selected, quality A, Rowland Gratings, and will be found equal for most purposes to average originals, besides being more convenient to use in the spectroscope, less liable to injury, and comparatively very low priced. They are sold for less than one-fifth the cost of quality A orginals.

A photograph of the E b region of the solar spectrum made with a C 140 replica will be forwarded on application. The b-group lines are well defined, and the print shows more than one hundred lines between E_1 and b_1, i. e., more than two-thirds of the lines shown in the same region on Rowland's map made with a six-inch concave grating. A half-tone reproduction of an enlargement of this photograph is given on page 2.



tograph of the E-b region of the solar spectrum, taken with Ives Grating C 140.

ndicate the scale of this photograph it may be mentioned that it includes only about one thirty-sixth part sible spectrum.

To indicate the scale of this photograph it may be mentioned that it includes only about one thirty-sixth part of the visible spectrum.

Much detail has, of course, been lost in reproduction, but the line marked **x**, midway between E and b at wave length 5227, is shown clearly resolved into a triplet. In testing the gratings all are rejected which do not resolve this line in the second order spectrum. As the D lines are about 20 times as far apart as the adjacent lines in this triplet, it will be seen that these replicas have a resolving power in the second order spectrum 20 times as great as that needed to resolve the D line and ten times that required to show the nickel line between the D's. This is the guaranteed minimum resolving power of the smallest of these gratings. To secure full advantage of this resolving power it is of course necessary to use a good slit, a high eyepiece, and to focus the image of the sun on the slit.

It should be noted that as the price of the replicas precludes the use of glass with surfaces worked with telescopic accuracy, there is usually a right side up and right way around for placing them in the spectroscope in order to obtain the finest definition. Let the label be right side up and facing the eyepiece, and telescope turned to left.

There is a very slight but even shrinkage of the cast replicas, increasing the number of lines to the inch as compared with the originals, which are ruled 15,000 lines to the inch. Conditions have been established which insure a very close approximation to 15,050 lines to the inch, which number may be assumed to be about correct.

Ives' new process replicas of Rowland's diffraction gratings were first offered for sale in December, 1904, and their remarkable quality, freedom from liability to injury and low price, met with an immediate and gratifying appreciation. Practical experience has developed a still more precise and economical system of manufacture, and more rigid methods of testing have been applied, with the result that a new rating and price list is now given, as follows:

C 140-C141

C 142

C 140. **Ives Grating,** with one inch ruled surface, passed on clear resolution of the triplet at wave length 5227 at full aperture in the second order spectrum **$5.00**

C 141. **Ives Grating,** same size as C 140, but made from a different and unique original, and remarkable for the brilliancy of the first order spectra. The second order spectra are practically the same as with C 140, and the grating is passed on the same resolution test............ **6.50**

C 145. **Ives Grating,** ruled surface 1⅜ by 1⅞ inches, giving excellent definition with moderate powers **9.00**

C 146. **Ives Grating,** same dimensions as C 145, but bearing highest eyepiecing at full aperture **12.00**

C 147. **Ives Direct Vision Brilliant Grating.** This is a one inch Ives replica grating mounted between prisms so as to give direct vision in the brilliant first order spectrum. The grating is "passed" on good definition of D_1 D_2 and the nickel line in the first order **10.00**

These gratings all have approximately 15050 lines to the

New 20,000 Line Grating Replicas

C 481. **Ives Grating Replica** 1 inch, 20,000 line ruling. This grating gives a brilliant first order spectrum, but is weak in the second order. It is, however, capable of just distinctly resolving the test triplet 5.227 in the first order spectrum, by using sunlight, condenser, full aperture, and a power of 30 diameters,—a really marvellous performance for a cast replica.................. $5.00

Cheap Grating Replicas

Owing to the fact that there is a large demand for low priced gratings for purposes which do not call for the high quality which is represented by Mr. Ives' tested standards, and because a percentage of those turned out in the regular course of manufacture have heretofore been destroyed, it has been decided to mark all such which are not used up in the Simplex Spectroscopes "Second Class," and to offer them at half the price of the cheapest standard Ives Replicas. The only guarantee given with these second class replicas is that they can be made to show the nickel line between D_1 and D_2 with direct sunlight without a condenser, and the only advantage claimed for them over average Thorp process replicas is that they are protected from injury by careless handling. The supply is limited.

C 150. **Second Class Grating Replica** with about one square inch of ruled surface $2.50

C 151. **Second Class Grating Replica** with ruled surface 1⅛x1⅞ inches 4.50

C 148. **Second Class Prism Grating Replica** mounted after the style of C 142 .... 5.00

These gratings both have approximately 15050 lines to the inch.

C 482. **Second Class Grating Replica** 1 inch, 20,000 line ruling.... 3.00

Photographic Diffraction Gratings for Use in the Spectroscope

Mr. Ives has perfected a process for making photographic gratings which yields, with rulings up to 7,000 or 8,000 lines to the inch, by far the most brilliant transmission grating replicas which have ever been made. These are now supplied for use in the spectroscope in two spacings, viz., 3,610 and 7,219 lines to the inch. They are made from originals ruled on Rowland's engine, and are recommended for use where brilliant normal spectra are desired with less dispersion than is given by the Ives patented gratings.

The 3,610 line gratings handsomely resolve the D line in the first order spectra, and clearly show the nickel line in the second order, with one-inch aperture. Everyone owning a 15,050 line grating will find one of these 3,610 line gratings a desirable addition to his spectroscopic outfit.

The 7,219 line gratings are the most inexpensive gratings made which will show the nickel line in the first order spectra and also give fine definition in the second order. The spectra are not as brilliant as those given by the 3,610 line gratings.

C 485. **Ives Photospectroscopic Grating**, 1x1 inch, 3,610 lines to the inch $1.75

C 486. **Same**, 1¾x1¾ inch, 3,610 lines to the inch.................. 2.50

C 487. **Same**, 1 3-16x1 3-16 inch, 7,219 lines to the inch.......... 2.00

Photographic Diffraction Gratings

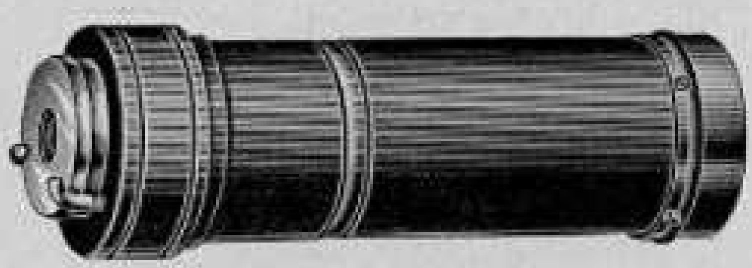
The following photographic diffraction gratings are mounted between plate glasses and sealed after the fashion of lantern slides. They possess great brilliancy and are sufficiently accurate for rough spectroscopic use.

measurement of wave lengths by Kelvin's simple method, etc. They are also excellent for projection of spectra with the lantern.

C 153. **Photographic Diffraction Grating,** ruled surface 2½x2½ inches, 2,888 lines to the inch $1.50

C 154. **Photographic Diffraction Grating,** ruled surface 1x1 inches, 2,888 lines to the inch .... .75

Freak Diffraction Gratings



C 500

The text-books are partly to blame for some current misconceptions in regard to diffraction gratings, for the discussion is usually confined to an elementary explanation of the behavior of black-line (or opacity) gratings, and little or nothing is said about the special properties of transparent retardation gratings, or of reflection gratings which belong to the same general class. The student is hence often left with the belief that the distribution of energy or illumination is always the same in the grating spectrum, whereas nothing could be farther from the truth, and many experimenters have doubtless in consequence wasted time in making energy measurements in the grating spectrum only to discover that supposed anomalies in the source were really anomalies in the grating.

Gelatine-bichromate process photographic gratings may give colored central images because of a half wave-length retardation in the raised lines on the gelatine film. It is evident that the elevation of the lines may be such as to give this retardation for light passing in the direction of one of the spectra. When this happens, a portion of this spectrum is entirely missing, and the spectrum is intersected by a dark band whose position varies with the angle of incidence of the light upon the grating. Such extreme effects are seldom obtained with the gelatine-bichromate photographic process as heretofore practiced, but Mr. F. E. Ives has so modified and perfected it that either perfectly normal or extremely anomalous gratings can be produced at will.

In order most readily to show the characteristics of the anomalous gratings, Mr. Ives makes a tube 1⅕ inches in diameter and 4½ inches long, with a slit and circular aperture at one end, and at the other end a screw focussing cap with lens and viewing aperture, against which the freak gratings, put up in separate metal mounts, may be held. One viewing device therefore serves for any number of freak gratings, and may be used much like a pocket spectroscope, or for projection by the electric lantern to a size sufficient for class demonstration, by substituting the viewing device and grating for the lantern objective. The circular aperture is seen as disks of complementary color, similar to those obtained with a double-image prism and mica film in the polariscope, and the slit is spread out into spectra showing dark bands or other anomalous effects.

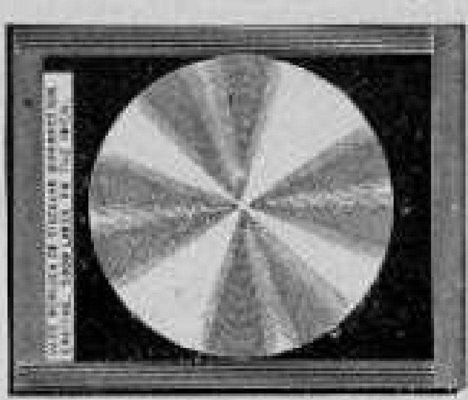
Set No. 1 includes the viewing device and one normal and two freak gratings. One of the freak gratings belonging to this set shows a deep blue or purple central image, throwing all or nearly all of the sodium light into the spectra; the other shows an intense dark band in the orange, yellow or green of the first order spectra. Set No. 2 is like set No. 1 with the addition of two curious asymmetrical freaks.

C 500. **Freak Diffractor Set No. 1** $5.00

C 501. **Freak Diffractor Set No. 2** 8.00

Circular Diffraction Grating for Lantern Projection

These photographic gratings have a ruled surface three inches in diameter, with five thousand lines to the inch. By projecting an image of the electric arc upon the screen and then placing the circular grating centrally over the objective a circular rainbow is obtained. These circular gratings are mounted between selected plate glasses and finished like lantern slides; they show considerable periodic error, which does not, however, injure them for demonstrations with the optical lantern.



C 152

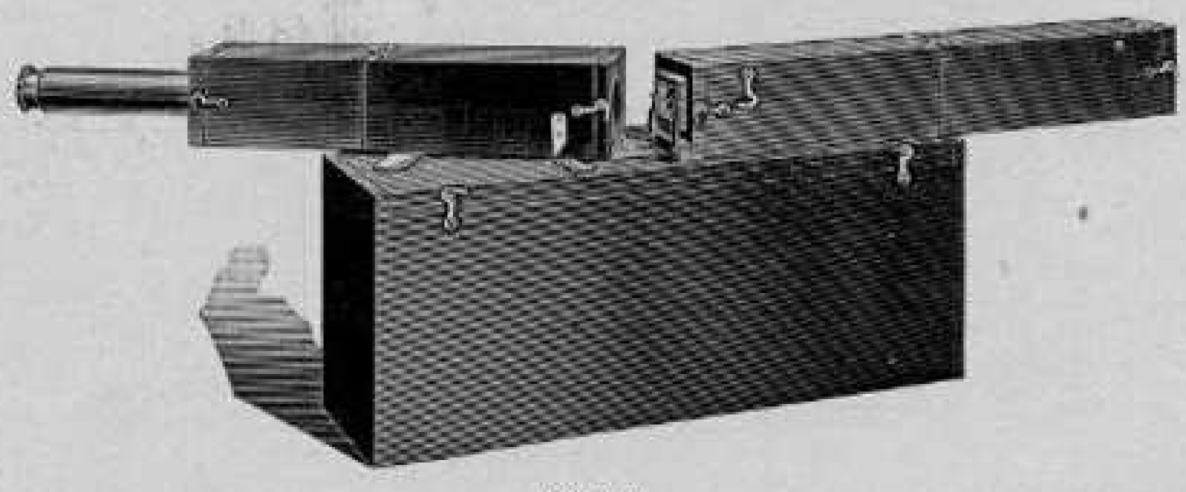
C 152. **Circular Diffraction Grating,** 3 inches diameter, 5,000 lines to the inch $3.00

Small Circular Gratings

C 458. **Circular Diffraction Grating,** 11/16 inch diameter, 1,800 lines to the inch........................ $1.00

C 459. **Circular Diffraction Grating,** 1⅛ inches diameter, 900 lines to the inch 1.00

Ives' "Innovation" Diffraction Spectroscopes



C 137

Mr. Ives' revolutionary improvements in the production of replicas of Rowland Gratings have outstripped the optical capacity of moderate priced spectroscopes to utilize their remarkable resolving power.

A first class spectroscope of 1¼ or 2 in. aperture is a very beautiful and desirable piece of apparatus, but it is a very costly combination of "brass and glass" and quite beyond the reach of many who would like to be able to obtain visually the results shown in Mr. Ives' photograph of the E b region of the solar spectrum.

The multiplicity of parts and adjustments, and the display of finely finished brass work, to be found in a spectroscope costing several hundred dollars, are undeniably attractive, and have their uses, but they are not necessary to secure the dispersion, magnification and definition which are the most important functions of a spectroscope. For nearly every purpose a simple form of high power spectroscope would be far more desirable than a more elaborate instrument with comparatively small optical capacity. Mr. Ives has therefore, in order to meet an expressed demand based upon a recognition of these facts, extended the idea which is the basis of his simplex and duplex spectroscopes to include spectroscopes which at a comparatively small cost will yield substantially the same resolution and definition as could formerly be obtained only with original Rowland gratings used in large laboratory spectroscopes.

Ives' Innovation Spectroscopes have an aperture of 1¼ inches and are fitted with 15,050 line and 3,610 line gratings which utilize the full ape.ture, but are not supplied with prisms or prism tables.

Used with the photographic gratings these spectroscopes give brilliant spectra showing about the same dispersion and definition that would be obtained with one 60 degree prism, but second and third order spectra are also available with corresponding increase of resolution. Used with the Ives' New Process Grating Replicas, they are guaranteed to readily show with sunlight properly focused on the slit, everything which appears in Mr. Ives' photograph of the E b region of the solar spectrum, i. e., more than two-thirds of the lines photographed by Rowland with a 6-inch concave grating worth $350.00 and a spectroscope costing as much more.

These spectroscopes, although of quite novel construction, are extremely simple and convenient. It is necessary to use long tubes in order to obtain the requisite optical capacity, and in order to close the instrument up in a comparatively small space when not in use, but yet to make it rigid and not awkwardly cumbersome when in use, the tubes are jointed in the middle, and the box which holds them when packed is made to serve as stand and base. An 8½ inch circle is provided, divided to half degrees, the telescope turns only to the left, the slit is adjusted by a lever, and the focusing is by a sliding tube; in short, while all necessary adjustments are provided for the purpose for which the spectroscopes are designed, every adjustment which is not necessary is sacrificed in order to secure optical efficiency at low cost. They are sold only with the Ives gratings fitted, and are tested and passed as a whole.

Photographs of limited regions of the spectrum can be made with these spectroscopes by aid of the Simplex Spectrograph described below. For very high power work in the second order spectrum it is necessary to have everything very rigid, to take sunlight from a heliostat, to focus with great precision (a matter of some difficulty because the light is greatly reduced), and to give long exposures on plates sensitive to the light of the region exposed. Photographs in the first order spectrum, with lower magnification, are much easier to obtain satisfactorily.

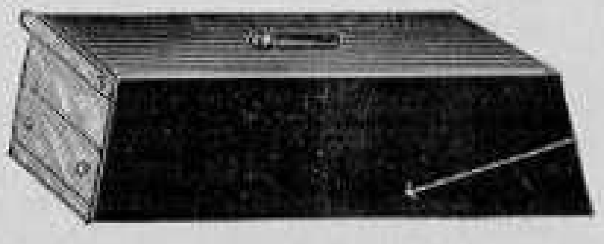
C 137.	**Ives' Innovation Spectroscope, No. 1**.....................	$50.00
C 138.	**Ives' Innovation Spectroscope, No. 2**, larger size, 1⅞ inch aperture, fitted with C 146 and C 486 gratings.........	75.00

Extra eyepieces, each..$2.00
Cross line eyepieces....$6.00

The Simplex Spectroscope No. 1

A Small Diffraction Spectroscope of Original Design and Construction. Cheaper and much more efficient than the commonly used prismatic pocket spectroscopes.

C 133



C 133

The Simplex Spectroscope measures 2x2x8 inches, and weighs eight ounces. It has a sliding focus, an adjustable slit, and is fitted with a small Ives grating replica having 15,050 lines to the inch. It is designed to use as a hand spectroscope, with the spectrum spread out vertically instead of horizontally, and the spectra are viewed at an indicated angle from the axis of the tube—about 15° to 25° with the first order spectrum, and 30° to 50° for the second order. The spectrum may also be viewed in the horizontal position if preferred.

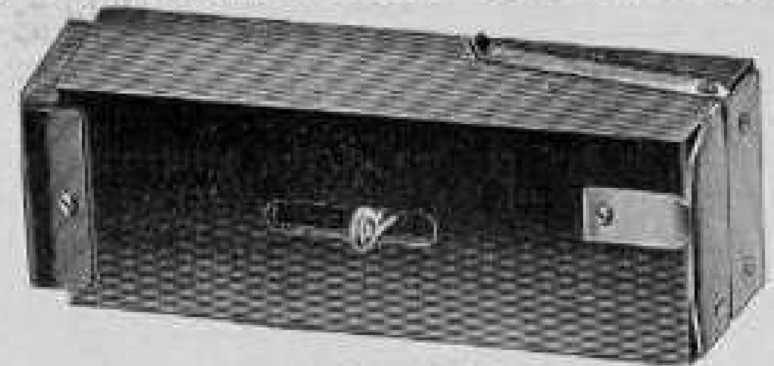
With the slit closed enough to show the D, E, b, and F Frauenhofer lines, it gives a brilliant first order spectrum in diffused daylight, suitable for testing the absorption of colored glasses, liquids, photographic color screens, etc. The slit is long enough to permit of covering one-half only with colored glasses, etc., when testing their absorption.

With direct sunlight or electric arc the second order spectrum is equally brilliant when the slit is sufficiently closed to resolve the D line.

The Simplex Spectroscope is sold at a remarkable low price because it utilizes grating replicas which, while entirely satisfactory for this purpose, are for one reason or another not up to the standard for use in more powerful spectroscopes. It is believed that many teachers in the smaller schools, and many students and experimenters, who might not wish to pay the price of a more costly spectroscope, will appreciate the opportunity thus afforded to obtain a serviceable spectroscope at a very low price. It will also be found to be a very "handy" accessory instrument for those who have large spectroscopes.

C 133. **Ives Simplex Spectroscope** as illustrated and described.... **$5.00**

Ives Simplex Petite Spectroscopes



C 488—C 485

C 488. **Ives' Simplex Petite Spectroscope,** 1⅝x1⅝x5½ inches, weight 5 ounces, same power as Simplex No. 1...... **5.00**

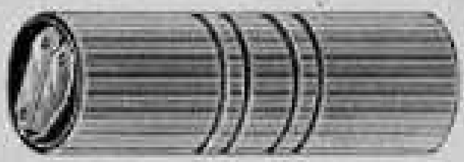
C 885. **Direct Vision Petite Spectroscope**...................... **7.50**

Ives' Simplex Spectroscope No. 2

A modified Simplex Petite Spectroscope with a full-sized grating, so disposed as to nearly double the dispersion, and make it possible, with careful adjustment, to clearly see the resolution of the sodium line in the bright first order spectrum, either with sunlight or the sodium flame. The second order spectrum is practically eliminated. The grating can be instantly removed for use in a stand spectroscope, in which it will handsomely show the nickel line in the first order spectrum.

C 490. **Simplex Spectroscope No. 2**.............................. **$8.00**

Ives' Pocket Diffraction Spectroscope

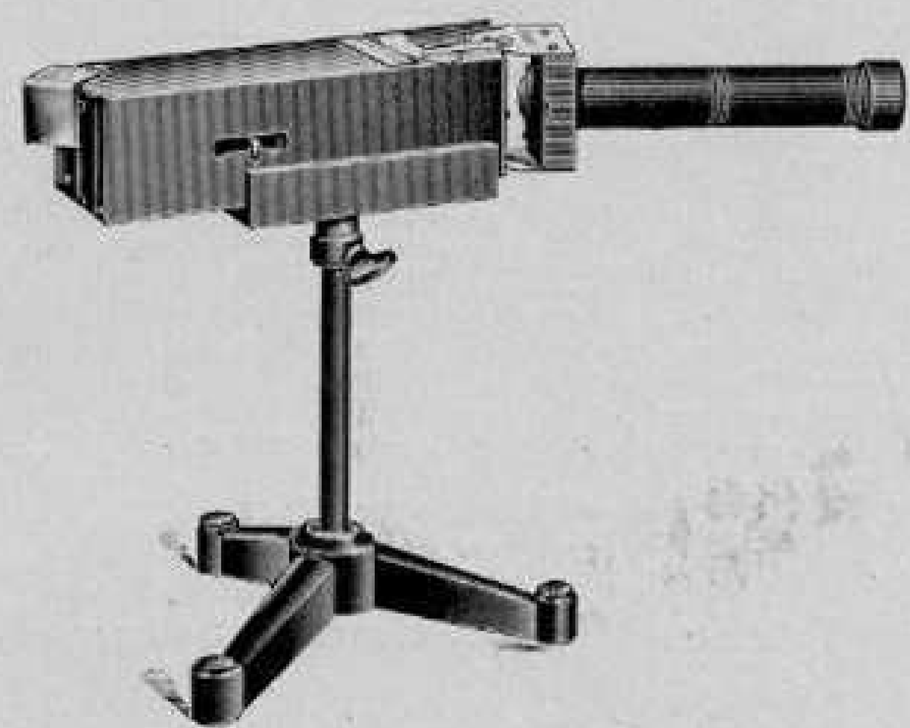


C 491

The cheapest spectroscope made. Polished wood tube one inch in diameter and three inches long, with screw caps. Slit adjustment is crude but practical, and focusing is done by screwing out one of the caps, one or more half turns. Direct vision shows the slit centrally, with a spectrum about 20° to either side. By choosing position for the eye, one spectrum only is seen.

C 491. Pocket Diffraction Spectroscope $2.50

Ives' Duplex Diffraction Spectroscope No. 0



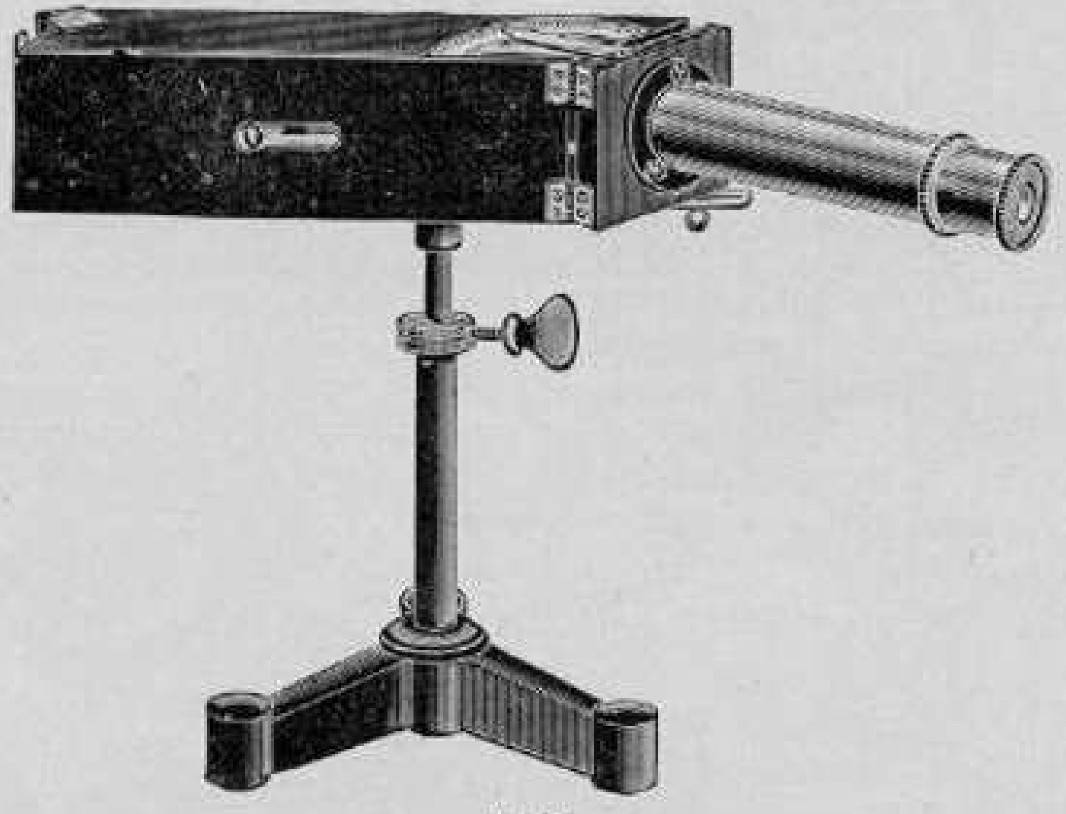
C 130

This is essentially a Simplex Spectroscope with the addition of a wooden tube telescope with fixed eyepiece, and focusing by movement of the collimating lens. The stand is made with a spring cradle top, and the telescope is detachable, so that the Simplex Spectroscope can be used as a hand spectroscope with or without the telescope, and without the telescope can be used with the Simplex Spectrograph. The first order spectrum is all shown at once across the large field of the eyepiece, and with narrow slit and direct sunlight the D line is shown handsomely resolved. This spectroscope is therefore more efficient for many purposes than one of the Bunsen pattern costing from $25 to $50.

The Duplex Spectroscope No. 0 is supplied with an iron tripod stand, and a small adjustable mirror for comparison of spectra.

C 130. Ives' Duplex Diffraction Spectroscope, No. 0............ $13.00

Ives' Duplex Diffraction Spectroscope No. 1



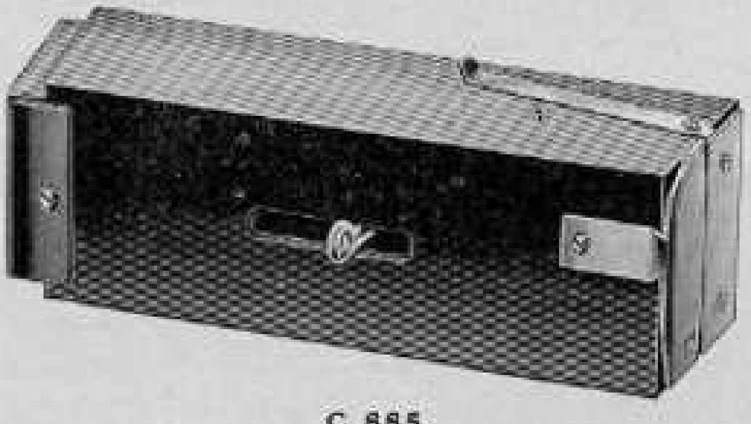
C 135

This spectroscope is similar to the Duplex No. 0, but with a brass telescope tube and well made Huygenian eyepiece. The second order spectrum can be made to show the nickel line between D_1 and D_2 although a higher power eyepiece should be used for this purpose. The stand is now made with a spring clamp top so that the spectroscope can be instantly removed to use as a hand spectroscope. The telescope can also be taken off to permit the instrument to be used with the Simplex Spectrograph. The Duplex No. 1 is made either with the body of Simplex No. 1, or Simplex Petite, at the same price.

C 135. Ives' Duplex Diffraction Spectroscope, No. 1 .... $16.00

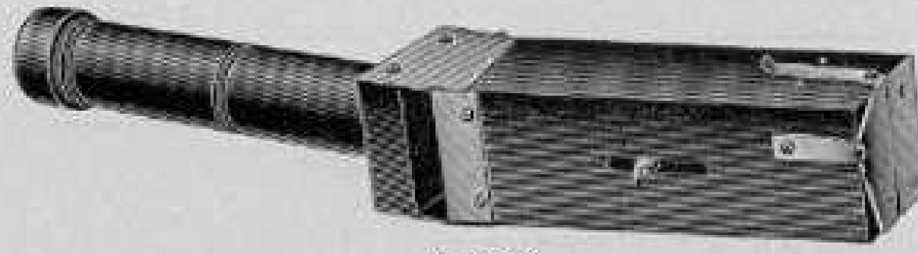
Extra Eyepieces $2.00 each.

Ives' Direct Vision Spectroscopes



C 885

These C 885 spectroscopes are of the direct vision pattern. The dispersive element is an Ives Patented Grating of 15,050 lines to the inch, mounted under a prism so that the brilliant first order spectrum is swung round into the direction of the incident beam of light. Each instrument is supplied with an adjustable slit and with a focusing slide, and the two larger sizes have telescopes to give greater magnification of the spectrum.

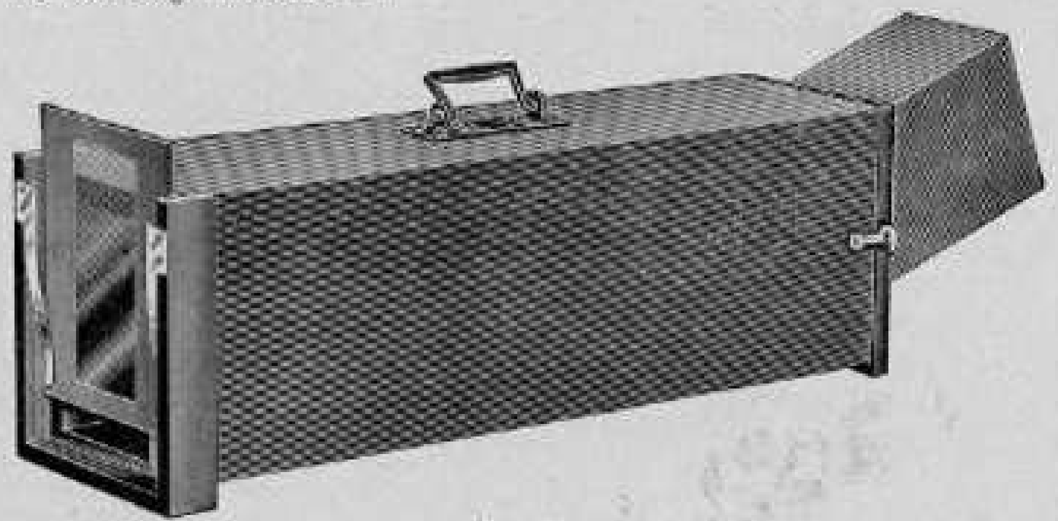


C 886

C 885.	Ives' Direct Vision Hand Spectroscope, No. 1, without telescope, Simplex Petite size........................	$ 7.50
C 886.	Same, No. 2, with pivoted wooden tube telescope, handsomely resolving the sodium line..................	10.50
C 887.	Same, No. 3, with brass telescope and well-made Huygenian eyepiece	13.50

Ives' Simplex Spectrograph

A substantial fixed focus camera to which a Simplex Spectroscope can be instantly attached for the purpose of making photographs of the spectrum to test photographic sensitive plates and color screens, make records of absorption experiments, etc. Comparison spectra can be readily photographed by covering one-half of the slit during the first exposure, and the other half during the second.



C 134

The half-tone cut below was made from a photograph taken in this manner with the Simplex Spectrograph. One-half of the slit was covered by a cell containing a solution of didymium chloride and the exposure was made in diffused daylight. The lower half of the cut shows the solar spectrum while the upper half gives the absorption bands of the salt.

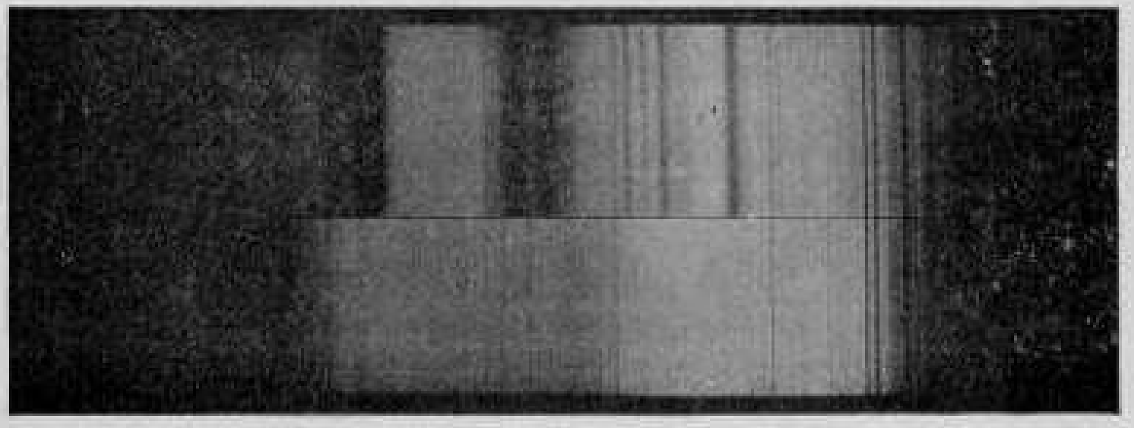


Fig. 134a. Solar spectrum and absorption spectrum of didymium chloride. Photograph taken with a Simplex Spectrograph.

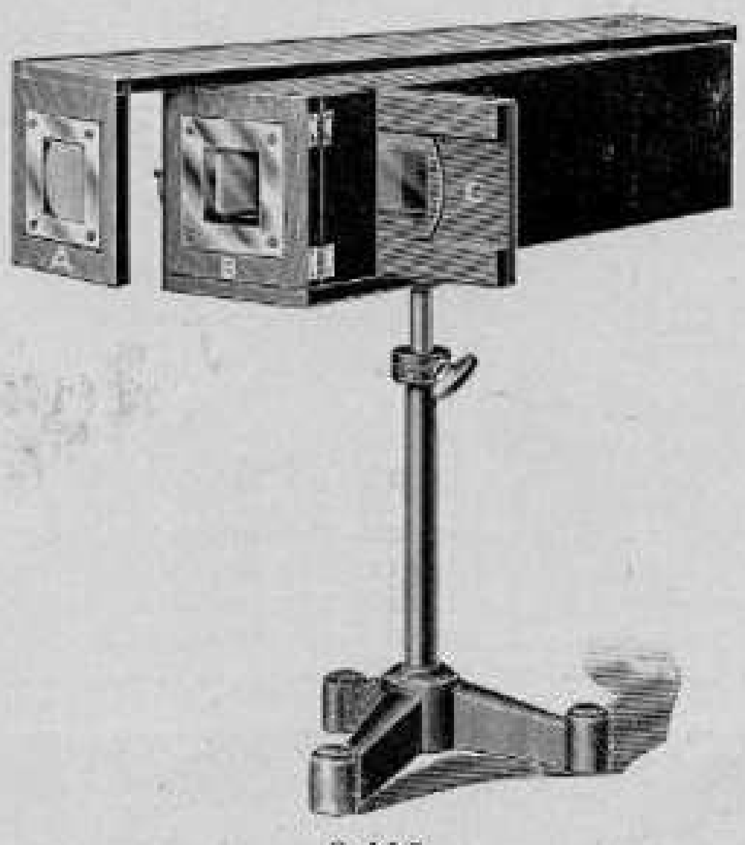
This spectrograph is now made to receive interchangeable fronts adapted to different uses. It is supplied with one vertically adjustable front with lens for either Simplex No. 1, Simplex Petite, or Simplex Direct Vision Spectroscopes, as desired, and another front to permit of using the camera with a stand spectroscope, for making photographs of limited regions of the spectrum, or with a horizontal microscope for photomicrography. It is so diaphragmed as to permit of bringing it close to the eyepiece of spectroscope or microscope so as to practically shut out all light except that coming through the eyepiece, but as an additional precaution, a cloth may be thrown over it when making exposures.

The magnification depends upon the focal length of spectroscope and eyepiece, and can be altered only by change of eyepiece power. The camera may be supported in any convenient manner, as rigidly as possible, to bring its axis into line with the axis of the telescope. Mr. Ives' photograph of the Eb region of the solar spectrum was made with exactly such an arrangement as this, except that a weak cylindrical lens was introduced and carefully adjusted to smooth out the horizontal lines due to dust on the jaws of the slit.

Made in hardwood, ebonized, with achromatic lens, double plate holder, and ground glass screen.

C 134. Simplex Spectrograph, the camera with plate holder, focusing screen, and two fronts, but without spectroscope.. **$10.00**

Ives' Straight Line Monochromatic Illuminator



C 307

There are so many occasions when it becomes necessary in laboratory work to illuminate the slit of a spectroscope, etc., with monochromatic light that this new monochromatic illuminator will doubtless be welcomed by all who have heretofore been compelled to use makeshift appliances. The instrument consists of a collimator with an adjustable slit and 10-inch focus lens, a direct vision double prism Ives' Grating replica having an aperture of ¾x1 inch and a 10 inch focus lens on swinging arm to focus parallel rays on the slit of another instrument, all mounted on an adjustable iron stand.

This apparatus is of quite novel construction, making it not only simpler and cheaper than anything of the kind heretofore produced, but incomparably more convenient to use, and at the same time capable with sunlight of projecting upon the slit of another spectroscope a large amount of light which is confined to wave-lengths less separated than D_1 D_2.

The replicas used are Ives' second class specials, giving remarkably brilliant first order spectra, with resolution and definition quite good enough for this purpose. They are cemented between 16° prisms, thus giving direct vision without lateral displacement of the spot of light, and with straight line adjustments the part of the spectrum utilized is changed by sliding the mount of the collimating lens, which is made of large diameter for this purpose. The convenience and efficiency of this novel method of shifting along the spectrum must be seen to be appreciated. The condensing lens, which swings into and out of position, comes automatically to the exact position necessary to focus parallel rays axially upon the slit, and the focusing lens may be swung out when a broad parallel beam is required for filling the condenser of a microscope or other similar purpose.

A most interesting experiment with this apparatus consists in projecting the parallel rays (preferably of sunlight from a heliostat) through the condenser of a microscope and then observing the comparative resolving power with rays from different parts of the spectrum by slowly sliding the collimating lens in its mount. A 1-5 in. objective, with central light, very handsomely resolves a dry pleurosigma with the blue rays, focusing black and white dots with great crispness, but as the spectrum is shifted, the resolution becomes first woolly, in the yellow green, and finally, in the orange, altogether absent.

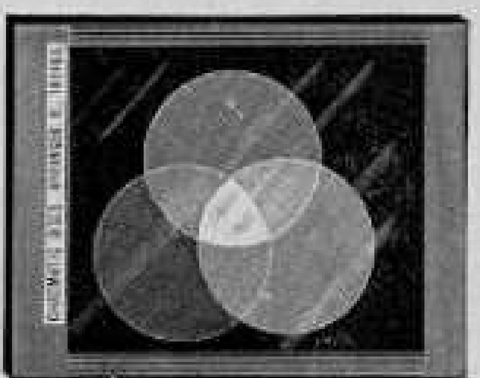
C 123. Ives Straight Line Monochromatic Light Apparatus with non-achromatic lenses **$20.00**

C 124. Same, with two achromatic lenses........................ **25.00**

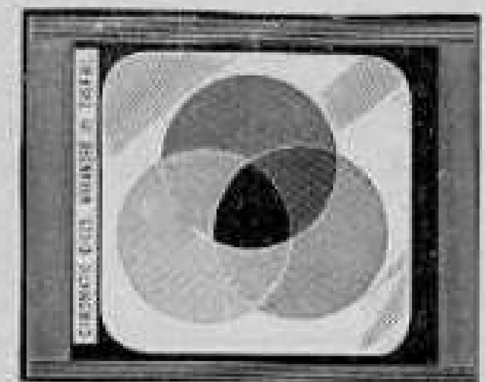
In Preparation: Ives' Color Patch Apparatus. Special circular will be issued.

Ives' Color Preparations

C 118



C 120 No. 1



C 120 No. 1

C 118. Set of Coal-Tar Dyes for Absorption Experiments. Eight selected colors in gelatine, in rectangles separated by white spaces, on a 3¼x4-inch plate, mounted like a lantern slide. Each rectangle of color is divided into two parts, showing different depths of color. The arrangement is such that with a 1¼-inch slit in the optical lantern, divided spectra can be projected, showing at one time two shades of the same color and white, or either shade of two adjacent colors and white. In most ordinary spectroscopes spectra of any one color and white, or of two shades of any one color, can be seen at one time........................ $2.50

C 120. Chromatic Discs, arranged in Trefoil. In form of lantern slides. No. 1, illustrating mixture of colored lights, red, green and blue-violet on a black ground, overlapping to make white and the minus colors, peacock-blue, crimson pink, and yellow. No. 2, illustrating superposition of films of transparent color. Minus red (peacock-blue), minus green (crimson pink), and minus blue (yellow) overlapping to make black and the plus colors, red, green, and blue-violet. Per pair...... 5.00

C 122. Colored Crystals of Potassium Chlorate. Occasionally in crystallizing potassium chlorate a few crystals are obtained which show interference colors due to laminary structure of the crystal. The phenomenon is described on page 134 of Wood's "Physical Optics." These colors are ordinarily not very brilliant because of mixture with white light reflected from the surface of the crystal, but, when mounted in balsam between narrow angled prisms and viewed against a black background, the crystals show colors of more than gem-like brilliancy. Attractive "spreads" of these colored crystals, prism mounted, (like Fig. C 142) and enclosed in small boxes with black velvet bottoms are being made by Mr. Ives. Each........................ 5.00

Ives' Special Color Screens

Mr. Ives found some years ago that achromatic microscope objectives and huyghenian eyepieces which projected well-defined visual images gave very poor results in photomicrography by daylight owing to the large amount of action by ultra violet rays, for which they are not corrected, and further that, even with ordinary photographic plates, they gave excellent results if the ultra violet rays only were suppressed. For this purpose he devised a dry sealed esculin screen which is much more efficient and convenient than tanks of esculin or quinine solution. The same screens are useful in photo-spectrography for cutting off the ultra violet overlap of the second order spectrum upon the red and orange of the first order, and in landscape photography for notably improving the rendering of sky, clouds, and distance, without recourse to the use of color-sensitive plates, yellow screens, and time exposures.

These screens are now made up with plate glass, in rectangular form, about ¼ inch thick, and balsam-sealed. Esculin-tartrazine screens, the most efficient possible light yellow screens, and methyl-violet-uranine screens photographically complementary to the esculin screens, are made in the same style. The latter permits action upon ordinary photographic plates only by the ultra violet rays of ordinary daylight and the deepest visible violet near H but, as even these rays are somewhat damped, comparatively long exposures are necessary.

These screens are uniform in their absorption, and therefore all equally good for photomicrographic and photospectrographic work but, for use with photographic objectives of large aperture, those are selected which are optically most perfect and are placed in a class by themselves at a higher price.

C 530.	**Ives' Dry Sealed Esculin Screen,** 2x2 inches	$1.50
C 531.	**Same,** 3¼x4 inches	2.00
C 532.	**Ives' Esculin-Tartrazine Screen,** 2x2 inches	1.50
C 533.	**Same,** 3¼x4 inches	2.00
C 534.	**Ives' Methyl-Violet-Uranine Screen,** 2x2 inches	1.00
C 535.	**Same,** 3¼x4 inches	1.25

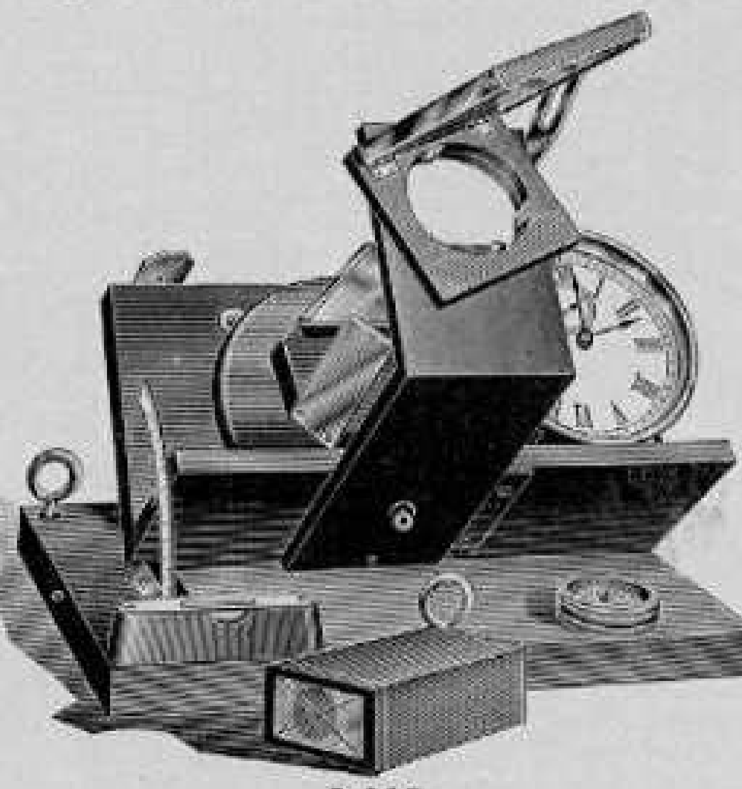
Selected Screens

For Use With Photographic Lenses of Large Aperture.

C 536.	**Esculin Screen,** 2x2 inches	$2.00
C 537.	**Same,** 3¼x4 inches	3.00
C 538.	**Esculin-Tartrazine Screen,** 2x2 inches	2.00
C 539.	**Same,** 3¼x4 inches	3.00

Color screens for other special purposes made to order.

Ives' Simplex Clockwork Heliostat No. 1



C 307

There are a great many optical experiments requiring a beam of sunlight to be projected upon the instrument in order to secure sufficient illumination. Many such experiments would naturally form a part of a student's laboratory course, were it not for the expense and difficulty of providing each student with his own steady beam of sunlight. Various heliostats have been put upon the market, but these have all been too expensive to permit of much duplication, and hence the choice of optical experiments in the students' laboratory has often been governed more by the absence of heliostats than by the teaching value of the experiments chosen.

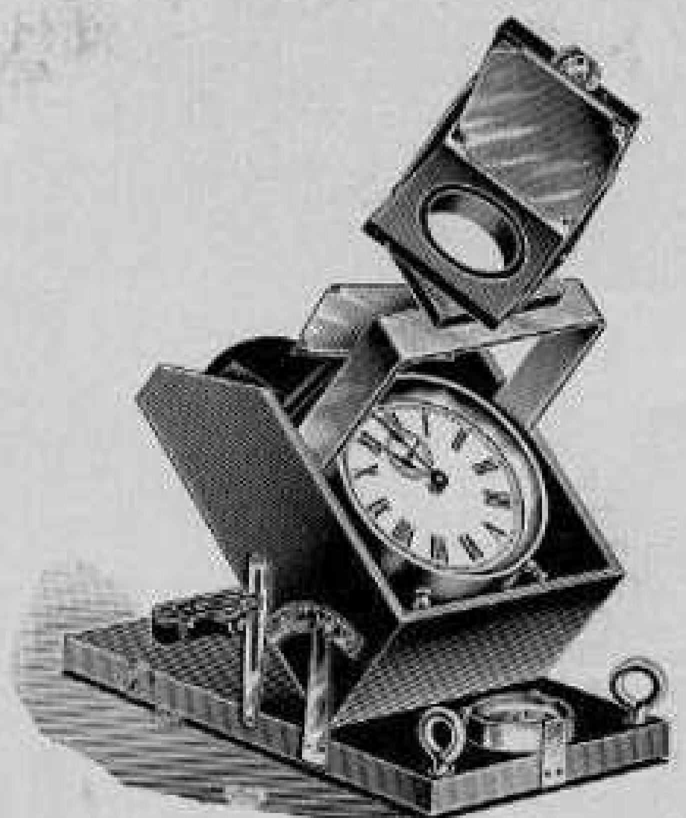
Mr. Ives has recently designed a new clockwork heliostat which is sold at such a low price that there is no longer reason why each student should not be provided with his own beam of sunlight for experimental purposes. Two or three of these heliostats can be placed in every sunlit window in the laboratory and the steady beams of light thus obtained may be utilized anywhere in the room. Mr. Ives' Simplex Clockwork Heliostat consists of a base with levelling screws, with detachable clock, magnetic compass, and spirit level, combined with a suitably inclined revolving mirror which projects a beam of sunlight parallel to the earth's polar axis, and a second adjustable mirror which reflects this beam of light in any desired direction, upward, downward, or horizontally to either side. Although it is the cheapest clockwork heliostat on the market, it has points of merit altogether peculiar to itself. The clock is a good time-piece, used without any alterations or attachments, except a small brass wheel fitting the key post and serving both as winding key and as a friction drive for the revolving mirror, which it turns smoothly at the rate of one revolution in 24 hours. The clock can be instantly detached from the heliostat to wind or set, and as instantly replaced, and it may be used as a time-piece placed on a shelf when the heliostat is not in use. All unessential details have been eliminated in order to meet a recognized demand for a serviceable and low-priced heliostat, and the finish of the instrument is, for the same reason, made simple and plain. For the use, however, of those who prefer more finely finished instruments, a second pattern is made with polished mahogany woodwork and more elaborate and ornamental fittings at an advanced price.

The mirrors used on the Simplex Heliostats are 2x3 inches, giving a two-inch circular beam of light.

The instruments have been somewhat modified in detail since the cut was made.

C 307.	**Ives' Simplex Clockwork Heliostat No.** 1, ebonized cherry with simple, plain fittings..............................	**$15.00**
C 307a.	**Same,** improved construction, made of varnished cherry..	**18.00**
C 308.	**Ives' Simplex Clockwork Heliostat No. 2,** polished mahogany and more elaborate and superior fittings, and all improvements	**25.00**

Ives' Simplex Clockwork Heliostat No. 0



C 495

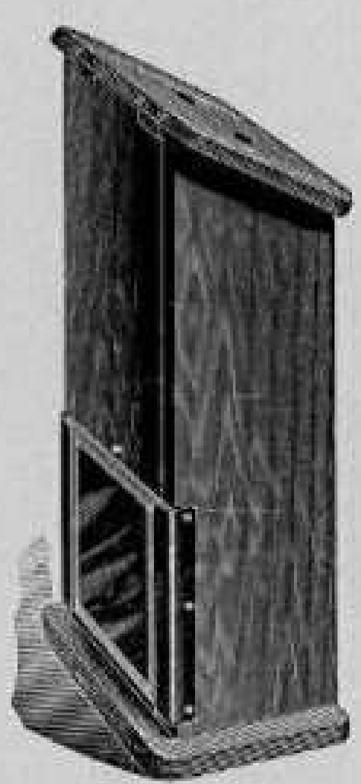
C 495. **Ives' No. 0 Clockwork Heliostat,** different and more compact form than No. 1, and giving only a 1½-in. beam of light, ebony finish $12.00

C 496. **Same,** natural cherry varnish finish, lacquered brass fittings, etc. 14.00

C 497. **Same as C 496,** but giving a two-inch beam of light 16.00

The Ives Fluoroscope

This is a specially designed dark box with a deep blue glass window, and having viewing apertures faced with pale yellow glass.



C 116

Placed near a window in daylight, objects enclosed in the box are almost invisible unless they show green, yellow, orange, or red fluorescence, in which case they appear beautifully self luminous. If direct sunlight is allowed to fall through the blue window, the effect is gorgeous.

The bottom is hinged so that it can be readily opened to receive the objects. With each Fluoroscope is included a fluorescent photograph, a "jewel" of uranium glass, and three corked tubes of fluorescent dyes.

With some objects, the beauty of the display is enhanced by removing the yellow glass, thus making the objects appear dichroic.

C 116. **Ives' Fluoroscope,** with fluorescent photograph, jewel of uranium glass, and three tubes of fluorescent dyes. . $5.00

Ives' Parallax Stereogram

A Most Remarkable and Beautiful Optical Novelty

Awarded the only medal in the scientific section of the Royal Photographic Society's annual exhibition.

Fig. 454 a

The Parallax Stereogram is a photographic transparency which, without the use of a stereoscope or any other optical aid, shows the objects photographed in perfect stereoscopic relief, apparently as solid objects seen through and beyond the glass, or standing in the air in front of the glass. It is an admirable demonstration of the principles of stereoscopic vision.

The parallax Stereogram consists of (1) a photographic transparency, which is a line composite of the two images of an ordinary stereoscopic photograph, as shown in Fig. 454a, and on a larger scale, in Fig. 454b, and (2) a cover screen, ruled with opaque lines, mounted over the photograph at a suitable distance.

The Photographs are made through a screen ruled with one hundred lines to the inch, the opaque lines being broader than the clear spaces, and a similar screen is used for the cover. The photograph itself has two hundred lines to the inch, the alternate lines belonging respectively to the images intended for the right and left eye. It will be seen that if the cover screen is placed in contact with the photograph, it can be so disposed as to cover all the lines belonging to one eye, and a single image, like one-half of an ordinary stereoscopic photograph will then be seen; and that if the screen is slightly raised above the photograph, either set of lines may be seen at will by looking through the screen at different angles from the perpendicular. In order to obtain stereoscopic vision, the screen is so disposed that from one point of view, owing to parallax of vision, the lines forming the right eye image are seen only by the right eye, and the lines forming the left eye image are seen only by the left eye, as is indicated in Fig. 454c. Under these conditions the flat photograph appears to vanish and to be replaced by a solid object, which may appear to be situated at some distance on the other side of the frame, or suspended between the frame and the eyes. Photographs of large size can be made in this way and, owing to the angle of vision subtended and the absence of any visible optical aid, the results are far more realistic and impressive than by any other means of stereoscopic representation.

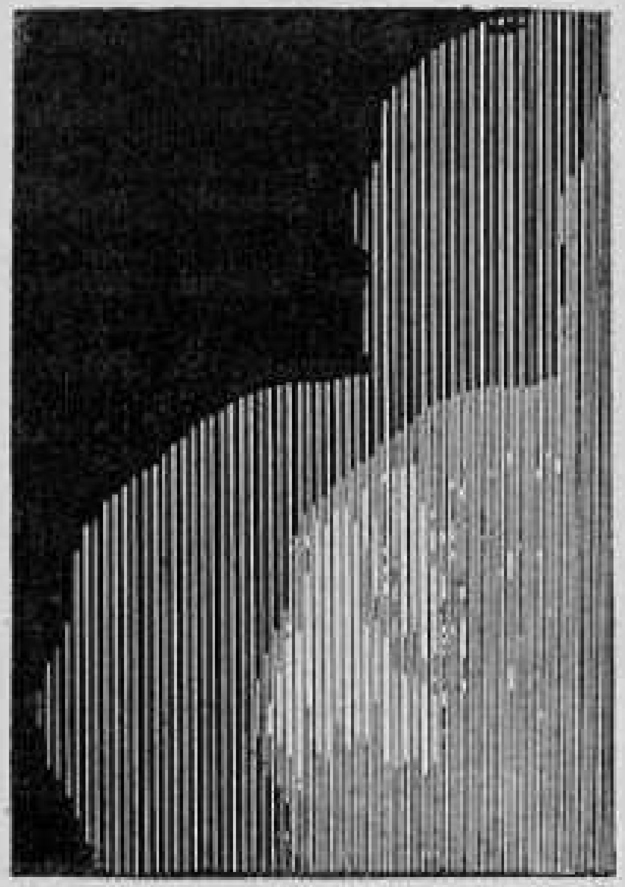


Fig. 454b

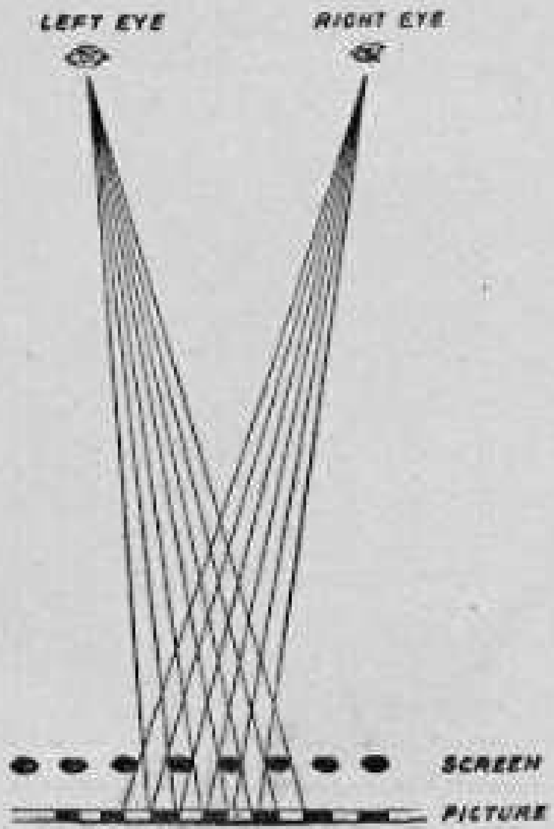


Fig. 454c

The following selections from our list of stock subjects are of a popular character and are particularly well adapted to illustrate the invention.

Those marked * are "retreating" effects; those marked ** "advancing." The view of the moon is not only a striking and interesting subject, but beautifully illustrates pseudoscopic vision by appearing as a hollow hemisphere when the right eye occupies the correct position for the left eye, and vice versa.

Stock Subjects, 6½x8½ inches, in oak frame, packed in grooved lid wooden box.

C 450.	**President Roosevelt***	$5.00
C 451.	**Girl with Violin***	5.00
C 452.	**The Moon*** and **	5.00
C 453.	**The Brigand** (man holding pistol), head,* pistol**	5.00
C 454.	**Statuette of Girl's Head***	5.00
C 455.	**Statuette of Girl's Head****	5.00
C 456.	**Statuette of Man's Figure** with Camera*	5.00

Where Ives' Gratings and Spectroscopes may be Seen

Ives' New Process Gratings were first offered for sale about three years ago on a market in which other grating replicas had been largely exploited. The Ives Spectroscopes have been on the market less than two years. The following partial list of American and Foreign Institutions where these instruments have already come into use indicates to some extent the favor with which Mr. Ives' products have been received.

Adelbert College, O.
Adelphi College, N. Y.
Agricultural School, Wagenin, Holland.
Albion College, Mich.
Amherst College, Mass.
Astronomical Observatory, Shanghai, China.
Bates College, Me.
Boston University, Mass.
Bowdoin College, Me.
Bradley Polytechnic Institute, Ill.
Brown University, R. I.
Bryn Mawr College, Pa.
Carleton College, Minn.
Case School of Applied Sciences, O.
Clark University, Mass.
Collegiate Institute, Ingersoll, Ontario.
College of the City of New York, N. Y.
Cooper Union, N. Y.
Columbia University, N. Y.
College of St. Hyacinthe, Canada.
Colorado College, Colo.
Cornell College, Ia.
Cornell University, N. Y.
Cumberland University, Tenn.
Dartmouth College, N. H.
De Pauw University, Ind.
Dickinson College, Pa.
Earlham College, Ind.
Ecola Polytechnica, Rio de Janiero, Brazil.
Foochow Mission, China.
Georgetown University, D. C.
George Washington University, D. C.
Harvard Observatory, Mass.
Harvard University, Mass.
High Burghal School, Breda, Holland
High Burghal School, Middlebury, Holland.
High Burghal School, Delft, Holland.
High Burghal School, Deventer, Holland.
High Burghal School, Gonda, Holland.
High Burghal School, Hilversum, Holland.
High Burghal School, The Hague, Holland.
High Burghal School, Rotterdam, Holland.
Imperial University, St. Petersburg, Russia.
Indiana University, Ind.
Iowa College, Ia.
Johns Hopkins University, Md.
Kalamazoo College, Mich.
Koeniglichen Archigymnasium, Soest, Germany.
Kaiser Wilhelm University, Strassburg, Germany.
Kgl. Gymnasium, Schweinfurt, Germany.
K. K. deutches medic.-chemisches Institut, Prague, Austria.
Lake Forest University, Ill.
Leland Stanford, Jr. University, Calif.
Lincoln University, Pa.
Marietta College, O.
Massachusetts Institute of Technology, Mass.
Miami University, O.
Middlebury College, Vt.
Mount Holyoke College, Mass.
Meteorological Observatory, Pilar, Argentina.
Michael Artillery School, St. Petersburg, Russia.
Mississippi Agricultural College, Miss.
Northwestern University, Ill.
Ohio State University, O.

Ontario Agricultural College, Ont.
Ohio Wesleyan University, O.
Olivet College, Mich.
Penn College, Ia.
Pomona College, Calif.
Rensselaer Polytechnic Institute, N. Y.
Rose Polytechnic Institute, Ind.
Royal Naval Institute, den Helder, Holland.
Royal University, Naples, Italy.
Rutgers College, N. J.
School of Mines, Rolla, Mo.
School of Mining, Kingston, Canada.
State Normal School, Westchester, Pa.
St. John's College, O.
St. Joseph's College, Pa.
Technological Institute, Kharkov, Russia.
Simmons College, Mass.
Smithsonian Institution, D. C.
South Kensington Board, London, England.
Solar Observatory, Pasadena, Calif.
St. Johns University, Minn.
St. Lawrence University, N. Y.
St. Mary's Institute, O.
State Normal College, Ypsilanti, Mich.
State Normal School, San Diego, Calif.
State Normal School, Stevens Pt., Wis.
State Normal University, Normal, Ill.
St. Xavier's College, Calcutta, India.
St. Xavier's College, Cincinnati, O.
Techn. Hochschule, Charlottenburg, Germany.
Techn. Hochschule, Danzig-Langfuhr, Germany.
Technical High School, Delft, Holland.
Techn. Hochschule, Stuttgart, Germany.
Trinity College, Ct.
Trinity College, D. C.
University of Arizona.
University of Aberdeen, Scotland.
University of Alabama.
University of Amsterdam, Holland.
University of Barcelona, Spain.
University of Berne, Switzerland.
University of Bologna, Italy.
University of Breslau, Germany.
University of South Carolina.
University of Chicago, Ill.
University of Christiania, Norway.
University of Cracow, Austria.
University College of Wales.
University of Edinburgh, Scotland.
University of Erlangen, Germany.
University of Freiburg, Germany.
University of Goettingen, Germany.
University of Grenoble, France.
University of Halle, Germany.
University of Idaho.
University of Illinois.
University of Iowa.
University of Kansas.
University of Leipzig, Germany.
University of Lyons, France.
University of Manitoba.
University of Michigan.
University of Minnesota.
University of Missouri.
University of Montana.
University of Montpellier, France.
University of Muenster, Germany.
University of Naples, Italy.
University of Nevada.
University of Oregon.
University of Parma, Italy.
University of Pennsylvania.
University of Rostock, Germany.
U. S. Signal School, Kas.
University of Upsala, Sweden.
University of Utah.
University of Washington.
University of Wyoming.
Ursinus College, Pa.
U. S. Military Academy, N. Y.
Vassar College, N. Y.
Virginia Military Institute, Va.
Washburn College, Kas.
Washington and Lee University, Va.
Wellesley College, Mass.
Wesleyan University, Ct.
Western Reserve University, O.
West Virginia University, W. Va.
Williams College, Mass.
Wittenburg College, O.
Worcester Polytechnic Institute, Mass.

Lippmann Color Photographs

These photographs of the prismatic spectrum, by Mr. Herbert E. Ives, are the first examples of Lippmann's interesting interference process of color photography offered on the American market.

It will be remembered that Lippmann's process consists in backing the sensitive film with mercury, so as to secure a reflecting surface, and then making the exposure through the glass side of the plate. In this way the incident and reflected beams set up a series of stationary waves in the film which act on the silver salts at the antinodes in such manner that, when the plate is developed, the silver is deposited in thin sheets parallel to the surface of the film. The distance separating these sheets at any point in the film is exactly equal to the half wave-length of the light to which that point was exposed and, as the sheets act as reflecting surfaces, the developed plate reflects interference colors similar to, but much purer than those given by ordinary thin films, because of the multiple reflections at the various silver sheets. At perpendicular incidence, the color reflected from each point of the film is the same as that to which that point was exposed.

These spectrum photographs, which are about 1⅝x⅝ inches in size, are mounted under narrow angled prisms to avoid dilntion of the interference colors by surface reflection. The photographs are viewed by reflected light at nearly perpendicular incidence. The best lighting is obtained by standing near a single window facing the light, and holding the photograph at arm's length below the eyes. When so viewed, the colors are in the main remarkably true. By changing the incidence, which is readily done by looking endwise along the picture, the colors all shift in the direction of the longer wave-lengths, and the red end of the spectrum can thus be made to disappear and to be replaced by green or blue.

The pictures are especially valuable to the teacher as offering a crucial demonstration of the truth of the wave theory of light.

C 890. **Lippmann Color Photograph** of the Prismatic Spectrum.. $3.50

Wood's Optical Novelties

The following novelties, devised by Professor R. W. Wood of Johns Hopkins University, afford inexpensive and striking illustrations of some of the most fundamental, and of some of the most recondite phenomena of light.

C 391

C 392

C 394

C 391. **Phase-Reversal Zone Plates.** These are small glass plates on which are photographed concentric circles in transparent gelatine whose radii are proportional to the square roots of the natural numbers. By the combined effects of diffraction and phase-reversal, due to the retardation in the gelatine film, they act somewhat like convex lenses, bringing a parallel beam of light to a real focus. (Phil. Mag. 45, p. 511.) Focus 180, 80, or 10 cm. as desired. The zone plates of 180 cm. focus are intended for lantern demonstrations; those of 80 cm. focus are for hand use and laboratory experiments; those of 10 cm. focus may be used as eyepieces in zone plate telescopes, or for experiments in zone plate photography. Each........................ $1.50

C 392. **Dichromatic Prisms.** These are wedges of Canada balsam colored with an aniline dye and enclosed between glass plates. A gas flame or incandescent light seen through the prism shows two images, one red and the other green. As the prism is moved across the eye, both images decrease in brightness, but at different rates, so that when the thick edge of the prism is reached the red alone shows. These phenomena may also be shown with the lantern, using a slit as in projecting ordinary spectra. (Physical Review, 15, p. 121.) Each.......................... 3.00

C 394. **Cyanine Prisms with Attached Gratings.** These consist of two small glass plates enclosing a thin wedge-shaped film of fused cyanine, forming a prism. To one of the plates is attached a fragment of a photographed diffraction grating, so placed that it disperses the light passing through it in a line at right angles to the direction of the dispersion of the prism. Holding the prism with its refracting edge horizontal and looking through it at an arc lamp, one sees vertical spectrum

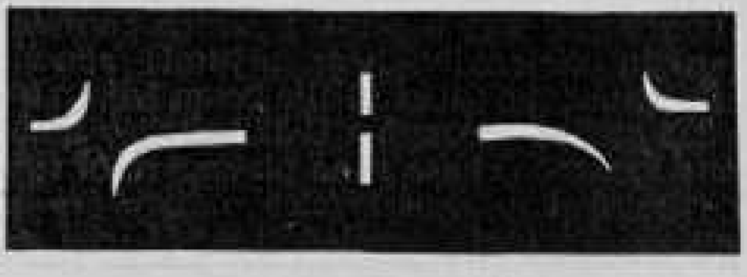


Fig. 394 a

showing colors the following anomalous order—red, green, blue, yellow. On each side of this spectrum are seen curved spectra, of the shape indicated in fig. 394 a, due to the combined dispersions of prism and grating. These curves clearly show the relation between the refractive index of cyanine and the wave-length of the refracted light; for the deviation given by the grating is approximately proportional to the wave-length of the light, while that given by the prism is nearly proportional to the refractive index of the cyanine for the corresponding color. Hence, in the curves, the abscissae represent wave-lengths, and the ordinates represent refractive indices. (Phil. Mag. 46, p. 380. Phil. Mag. 1, p. 624, June, 1901.) Each.. $4.00

C 395. **Cyanine Prisms, plain.** These are similar to C 394 but without the attached gratings. They show the anomalous spectrum, but do not give the dispersion curves. Each.......................... 3.25

C 396

C 398

C 396. **Nitroso Screens.** These are films of gelatine stained with nitroso dimethylaniline and mounted between glass plates about three inches square.

violet light. They are useful in spectrum photography in the ultra-violet for the purpose of eliminating the visible portions of overlapping spectra. Used as color screens in landscape photography, they give negatives in which the shadows cast by the direct rays of the sun are largely suppressed, since they absorb the visible rays which would affect the plate while transmitting the ultra-violet light from the sky which illuminates the shadows. (Phil. Mag. 5, p. 257, Feb., 1903.) Each $3.00

C 397. **Nitroso Screens, Double Stained.** These are films similar to C 396, but are also stained with a second dye which cuts out the yellow and red rays. Visually they are almost opaque, but they still transmit ultra-violet light. If the beam from an arc lamp is brought to a focus by means of a lens, and one of these screens is interposed, one obtains an invisible pencil of ultra-violet light in the focus of which uranium nitrate shows brilliant fluorescence. (Phil. Mag. 5, p. 257, Feb., 1903.) Each 4.00

C 398. **Uranium Nitrate Cells.** These consist of cells, made of glass plates and watch glasses, which contain crystals of uranium nitrate. These crystals show brilliant fluorescence at the focus of the beam from an arc lamp which has passed through a C 397 nitroso screen. Each 1.50

C 399. **Soret Zone Plates.** These zone plates are of the original Soret type with opaque circles. They are useful for illustrating Fresnel's explanation of the rectilinear propagation of light. They have the same focal properties as the phase-reversal plates C 391, but give only about one-fourth the intensity at the focus. Focal length about 80 cm. Each 1.00

Abbes' Diffraction Apparatus

This diffraction apparatus, as perfected by Professor Abbe in 1876, serves to demonstrate the effects of diffraction in the formation of images in the microscope. It consists of a diffraction plate and a set of stops, with an arrangement for fitting the stops and rotating them above the objective. The dimensions of the stops are such as to adapt them for Zeiss' objective "a a."

The diffraction plate consists of a glass slip with three cover-glasses cemented side by side. The lower surfaces of the latter are silvered and have groups of lines ruled upon them so as to form simple and crossed gratings.

C 891 **Abbe's Diffraction Apparatus,** from stock .... $ 7.60

C 892 **Diffraction Plate,** separately, in case. From stock 3.40

C 893 **Iris Diaphragm** to place above objective for studying effect of aperture on resolving power, from stock 4.75

C 894 **Zeiss Objective "a a,"** 26 mm. focal length. From stock.... 10.25

Abbes' Test Plate

This test plate, for testing microscopic objectives with respect to spherical and chromatic aberrations and for estimating that thickness of cover glass which corresponds to the most perfect correction, was designed by Professor Abbe in 1873. Used in conjunction with the Abbe illuminating apparatus, and by establishing the so-called sensitive rays, it gives the greatest prominence to any existing faults of correction.

This test plate consists of a glass slip with six cover-glasses of accurately determined thicknes (0.09 mm. to 0.24 mm.) cemented side by side. These cover-glasses are silvered on their lower surfaces and engraved with lines, the serrated edges of which form the test object proper.

C 157 **Abbe's Test Plate,** in case. From stock $3.80

OSSERVATORIO ASTRONOMICO
inv. m. 13559/