

C681.2085

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1913

ADAM HILGER, LTD.

SEPTEMBER 1913.

WAVELENGTH SPECTROMETERS.

FIRST MADE IN 1904.

Hilger Wavelength Spectrometers, Constant Deviation Type, have been supplied to the following, amongst others:—

UNIVERSITIES.

Cambridge (2 instruments)— Cavendish Laboratory. Pembroke College.	Berlin. Montpellier (2 instruments). Grenoble. Lyons.	Minnesota, U.S.A. Princeton, U.S.A. Illinois, U.S.A.
Liverpool (4 instruments)— Hartley Botanical Laboratory. George Holt Physics Laboratory. Chemical Laboratory.	Moscow (5 instruments)— Mineralogical Cabinet. Cabinet de Physique. Laboratoire de Physique. Institut de Physique.	Howard University, Washington, U.S.A. Wisconsin, U.S.A. (2 instruments).
Birmingham.	Kharkow.	Boston, U.S.A.
Leeds.	Dorpat.	Cornell, U.S.A.
Sheffield.	Cracow.	South Dakota, U.S.A.
London.	Tomsk, West Siberia.	Pittsburg, U.S.A.
Manchester.	Helsingfors.	Chicago, North-western, U.S.A.
Nottingham.	Louvain.	Harvard, U.S.A.
Glasgow.	Utrecht (2 instruments).	New Mexico, U.S.A.
St Andrews.	Amsterdam (2 instruments).	Toronto—
Aberdeen.	Naples.	Dept. of Physics.
Edinburgh.	Rome (2 instruments).	Dept. of Applied Chemistry.
Jena.	Palermo.	Tohoku, Japan.
Konigsberg i. Pr.	Neuchatel.	Tokyo, Japan (2 instruments).
Strassburg.	Zaragoza, Spain.	Adelaide, S. Australia.
Heidelberg.	Jassy, Roumania.	Queensland.
Bonn.	Vienna.	Sydney, N.S.W.
Leipzig.	Prague, Bohemian University (3 instruments)— Chemisches Institut. Physikalisches Institut.	
Munich.		
Tübingen.		

OTHER EDUCATIONAL ESTABLISHMENTS.

Imperial College of Science and Technology, London (2 instruments).	Bedford College, London.
Central Technical College, London.	Institute of Chemistry, London.
Northampton Institute, London.	Armstrong College, Newcastle-on-Tyne.
University College, London (2 instruments).	Technical College, Bradford (Dept. of Chemistry and Dyeing).
Wesleyan Training College, London.	Oundle School, Northants.
King's College, London.	University College, Dundee.
East London Technical College.	Royal College of Science, Dublin.

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OTHER EDUCATIONAL ESTABLISHMENTS--*continued.*

Albert Agricultural College, Dublin.
 University College of S. Wales, Cardiff.
 University College of N. Wales, Bangor.
 University College, Aberystwyth.
 Technische Hochschule, Danzig.
 Faculté des Sciences, Nancy.
 Faculté des Sciences, Dijon.
 Académie de Médecine, Paris.
 Faculté des Sciences, Rennes.
 Faculté des Sciences, Lille.
 Technical College, Delft.
 Polytechnic School, Zurich.
 Technical Institute, Bari, Italy.
 Lab. de Investigaciones Fisicas, Madrid.
 School of Pharmacy, Lisbon.
 Technische Hochschule, Moscow.
 Landwirtschaftliches Institut, Moscow.
 Académie des Sciences, St Petersburg.
 Electro-Technical Institute, St Petersburg.

Comité Geologique, St Petersburg.
 Polytechnic School, Warsaw.
 Mount Wilson Observatory, California,
 U.S.A.
 Dartmouth College, New Hampshire,
 U.S.A.
 Girard College, U.S.A.
 Bowdoin College, U.S.A.
 Polytechnic, Rio de Janeiro.
 Central College, Bangalore.
 Presidency College, Calcutta.
 Government College, Lahore.
 Engineering College, Sibpur.
 Medical College, Madras.
 Muir Central College, Allahabad.
 Royal Observatory, Cape of Good Hope.
 Transvaal University College.
 Government of New South Wales.

INDUSTRIAL LABORATORIES.

Royal Arsenal, Woolwich (3 instruments).
 British Home Office Laboratory.
 Borough of Southwark (London) Analytical Laboratory.
 Messrs Curtis's & Harvey, Cliffe at Hoo.
 Messrs Kynoch, Ltd.
 Messrs Nobels' Explosives Co., Ltd.,
 Stevenston.
 The E.C. Powder Co., Ltd., Dartford.
 Elton Paper Mills, Bury, Lancs.
 The Cotton Powder Co., Ltd., Faversham.
 The United Alkali Co., Widnes.
 Messrs Brunner, Mond & Co., Northwich.
 Jandus Arc Lamp Co., London.

The Eastman Kodak Co., Rochester, U.S.A.
 The L. E. Knott Apparatus Co., Boston,
 U.S.A.
 The National Electric Lamp Co., Ohio,
 U.S.A.
 The Bureau of Standards, Washington,
 U.S.A.
 The Bureau of Soils, Washington, U.S.A.
 La Société de l'Air Liquide, Boulogne s.
 Seine.
 Geological Survey Office, Pretoria.
 Agricultural Chemist of the Punjab.
 Ordnance Laboratory at Naini Tal.
 Forest Department, Government of India.

PRIVATE LABORATORIES.

The late Lord Blythwood, C.B.
 Thomas M. Campbell, Esq.
 Señor J. Munrōz del Castillo.
 A. A. C. Campbell Swinton, Esq.,
 M.Inst.C.E.
 Professor A. Cotton, Paris.
 The late Dr F. H. Dupré.
 W. Foster Brown, Esq., Newport, Mon.
 J. W. Gifford, Esq.

Rear-Admiral Chas. E. Gissing.
 Rev. J. M. Gordon.
 The late Sir William Huggins, F.R.S., etc.
 Professor H. Jackson, F.R.S.
 T. R. Merton, Esq.
 H. F. Parshall, Esq., M.Inst.C.E.
 Dr H. A. Roome.
 C. H. Stearn, Esq.

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QUARTZ SPECTROGRAPHS.

FIRST MADE IN 1908.

Quartz Spectrographs, Size C, have been supplied to the following, amongst others:—

UNIVERSITIES.

Cambridge.	Kharkow—
Birmingham.	Magneto-Meteorological Cabinet.
Sheffield.	Pharmaceutical Laboratory.
Liverpool.	Naples.
Leipzig—	Stockholm.
Theoret. Physikalisches Institut.	Ghent.
Physikalisches Chemisches Institut.	Leiden.
Chemisches Institut.	Copenhagen.
Bonn.	Columbia University, New York, U.S.A.
Göttingen.	Vanderbilt University, Nashville, Tenn.,
Paris, Laboratoire des Recherches Physiques	U.S.A.
à la Sorbonne.	Illinois, U.S.A.
Montpellier.	Yale, U.S.A.
St Petersburg.	Cornell, U.S.A.
Moscow—	Missouri, U.S.A.
Analytical and Organic Chemistry	Indiana, U.S.A.
Laboratory.	Clark University, Worcester, Mass., U.S.A.
Laboratoire de Physique.	Toronto.
	Tohoku.

OTHER EDUCATIONAL ESTABLISHMENTS.

Imperial College of Science and Technology,	Institut Oceanographique, Paris.
London.	Faculté des Sciences, Fribourg.
University College, London.	Technisches Institut, K. Nicholas II., St
East London Technical College.	Petersburg.
Royal Holloway College, Surrey.	Polytechnic du Don, Nowotscherkassk.
Royal Scottish Museum, Edinburgh.	Polyteknisk Laeraenstalt, Copenhagen.
Glasgow and West of Scotland Technical	Instituto Superior Tecnico, Lisbon.
College.	Bates College, U.S.A.
Queen's College, Belfast.	College of Agriculture and Mechanic Arts,
Physikalischer Verein, Frankfurt, A.M.	New Hampshire, U.S.A.
Königl. Technische Hochschule, Stuttgart.	Bureau of Science, Manila, Philippine
Technische Hochschule, Brunswick.	Islands.
Technische Hochschule, Aachen.	

INDUSTRIAL LABORATORIES.

The Cotton Powder Co., Ltd., Faversham.
Geo. Bray & Co., Leeds.
Bureau of Chemistry, Washington.
Government Laboratory, Perth, Western
Australia.
Inst. für Angew. Elektrizität Göttingen.
Badische Anilin and Soda-Fabrik, Ludwigs-
hafen a Rh.
Chem. Zentral. Lab. der Finanz-Ministerium,
St Petersburg.

PRIVATE LABORATORIES.

Sir James Dewar, F.R.S., etc.
H. F. Parshall, Esq., M.Inst.C.E.
C. A. Schunck, Esq.
Dr C. E. Kenneth Mees.
Mons. A. de la Bruère, Nantes.

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General catalogue.

The prices at which our apparatus is sold in the United States are now at the uniform rate of \$5.40 to the £ sterling, calculated on our catalog prices, which are strictly net.

This rate is for delivery f.o.b. New York, Philadelphia, or Boston, and includes all charges excepting only transportation from either of these cities to final destination, and duty.

F.O.B. Washington, D.C. \$5.50.

When duty must be paid, the corresponding prices should be calculated at the rate of \$8.00 per £, f.o.b. New York, Philadelphia, or Boston; and \$8.10 per £, f.o.b. Washington, D.C.

ADAM HILGER, Ltd.

July 1912.

75a, Camden Road, London, England.



INDEX OF SECTIONS

*All wavelengths are expressed in microns (μ) or in micromillimetres ($\mu\mu$)
one micron = ten Ångström units.*

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*The following Sections are not included in this Volume, but will
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SECTION D.*

WAVELENGTH SPECTROMETERS.

INTRODUCTION.

THE Wavelength Spectrometer introduced by us in 1904, and described in its most recent form on pp. D 1 to D 3, has been found useful for a large variety of purposes. A number of additions greatly extending the range of work which can be undertaken are fully described in Sections D and F of the Catalogue.

The selection of any such accessories must be determined by the work in view, but we give below a list which may assist such selection. In each case the Spectrometer given in the list is the *Hilger Wavelength Spectrometer*, with dense prism, on *Universal Base* (pp. D 4 to D 6).

LIST SUITABLE FOR A CHEMICAL LABORATORY.

	See pages.	Price.	Purposes for which useful.
		£ s. d.	
Spectrometer	D 1 to 4	29 5 0	General spectrum analysis.
Camera	D 3	6 13 0	
„ if with mirror and telescope	D 4	16 13 0	
Sliding diaphragm, to slit with three apertures instead of wedge	F 5	0 1 0	
Etalon for use in photography	F 10	3 10 0	
Shutter eyepiece and slide, with light filters	D 3	5 5 0	
Extra high power eyepiece.	D 3	1 10 0	
Slit rod and Carrier, with sphero-cylindrical glass condenser	F 2	2 17 6	
Combined Vacuum tube holder and spark apparatus	F 1	3 10 0	
Arc lamp, for metals	F 1	3 5 0	

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LIST SUITABLE FOR A CHEMICAL LABORATORY—continued.

	See Pages.	Price.	Purposes for which useful.
<i>Nutting Photometer</i> , with 2 tubes for liquids and stand for same.	F 4	£ s. d. 36 15 0	All kinds of Spectrophotometry; quantitative estimation of coloured salts, dyes, and organic substances possessing suitable absorption bands when in solution.
<i>Infra-red accessories.</i>			
<i>Thermopile</i> , etc. . . .	F 12	16 0 0	Measurement of light absorption in the infra-red.
<i>Wavelength drum</i> calibrated from W.L. 3900 to W.L. 20,000 . . .	F 12	4 10 0	
<i>Galvanometer</i> , and scale on stand	F 12	11 9 3	

For a Physical Laboratory the following are useful in addition to the above:—

<i>Additions to convert spectrometer into form for high resolving power accessories described in Section O</i>	D 5 to D 6	8 10 0	Zeeman effect, and other work requiring high resolving power.
¹ <i>Michelson Echelon</i> . . .	O 1 and O 2	12 10 0	
<i>Lummer-Gehrcke plate</i> . .	O 2	11 10 0	
<i>Fabry & Perot etalon</i> . .	O 3	10 10 0	
<i>Small electromagnet</i> for showing the Zeeman effect	O 7	5 10 0	
² <i>Shutter eyepiece</i> with polarising prism for observing the Zeeman effect	O 7	6 10 0	

¹ If the larger echelon described on p. O 2 be selected, an extra extension of the spectrometer base is necessary (p. O 5), price extra, £2, 5s.

² If this shutter eyepiece be ordered, it is unnecessary to purchase the one described above.

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THE HILGER WAVELENGTH SPECTROMETER, Constant Deviation Type.

THE design of this instrument (Fig. D 1) is based on the use of the well-known "constant deviation prism." There are a number of different forms of this prism, of which the one used on the Hilger Wavelength Spectrometer is shown in Fig. D 2. It may be considered as built up of two 30° prisms and one right-angled prism from the hypotenuse of which the light is internally reflected as shown.

The telescope and collimator are both rigidly fixed, since to pass through the spectrum it is only necessary to rotate the prism; and as a result a construction is arrived at which is at once extremely convenient and mechanically sound.

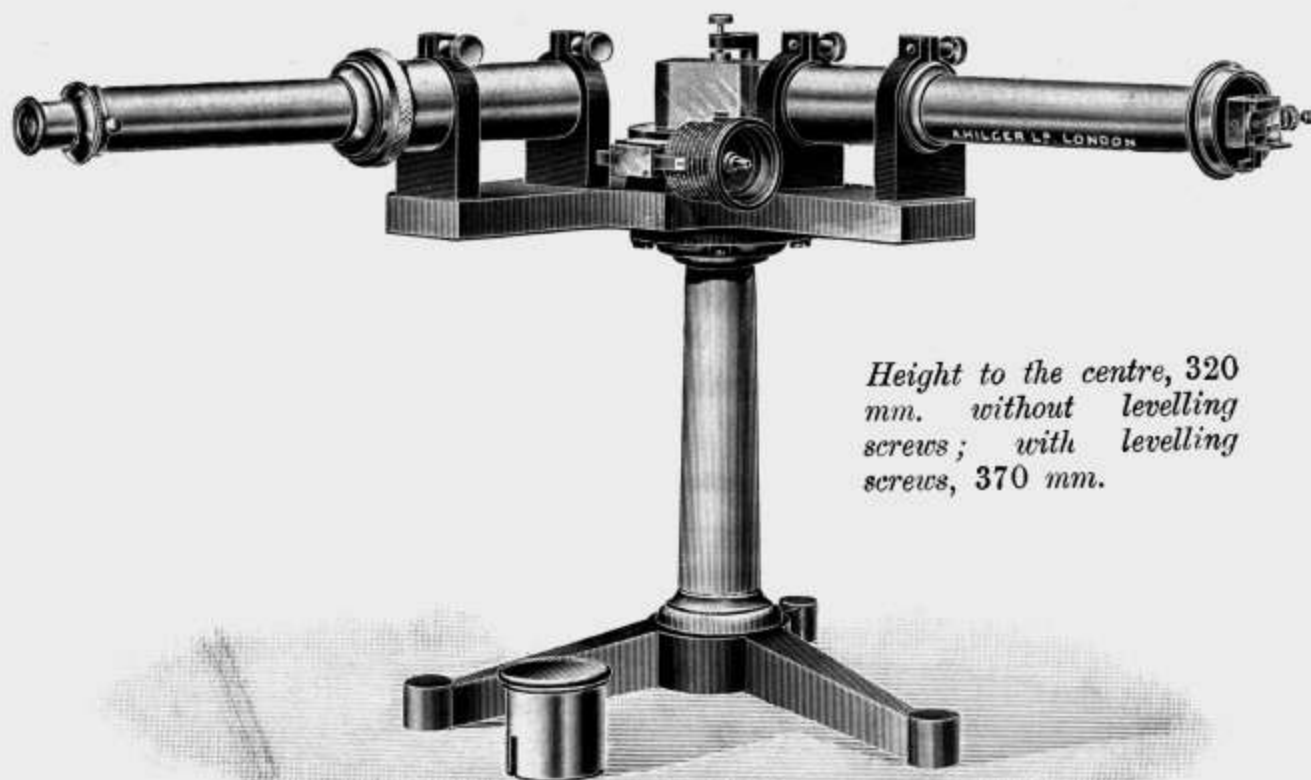


Fig. D 1.

The table on which the prism stands is rotated by means of a fine steel screw, the point of which pushes against a projecting arm on the prism table. To the screw is fixed a drum (*see* Fig. D 3) on which the wavelengths of the line under observation are read off direct as indicated by the index which runs in a helical slot. In the most recent instruments this index is on the side of the drum towards the eye; so that the wavelengths of lines can be read off without quitting the eyepiece (*see* Fig. D 1). The point of the micrometer screw is of hardened steel, and is permanently fixed before the screw thread is cut, to avoid the risk of periodic errors, the point forming one of the centres whilst the screw thread is being cut. This hardened steel

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point presses against a steel plug in the above-mentioned projecting arm of the prism table, itself flint-hard and *optically polished*.

The telescope and collimator are both rigidly fixed to the cast-iron base, and the whole is screwed to a strong cast-iron tripod. The object glasses of both telescope and collimator are of $11\frac{1}{4}$ inches (285 mm.) focal length, and $1\frac{1}{4}$ inches ($31\frac{1}{2}$ mm.) clear aperture.

It will be seen that the design is extremely strong and simple; and the accuracy is as great as that obtainable by the use of the very highest class of divided circle spectrometer (unless recourse is had to careful line-to-line measurements with a micrometer eyepiece or some similarly laborious process), whilst in point of ease, speed, and convenience the "Wavelength" form is vastly superior.

The focussing of the telescope is obtained by the milled ring, which can be seen in the figure on the body of the telescope. By the turning of this ring the object glass is made to move by a carefully protected helical mechanism, the eyepiece remaining always fixed. By this means a more accurate focussing adjustment is obtained, without the liability to a sideways shift of the lines due to the focussing, which it is impossible entirely to avoid in the older form.

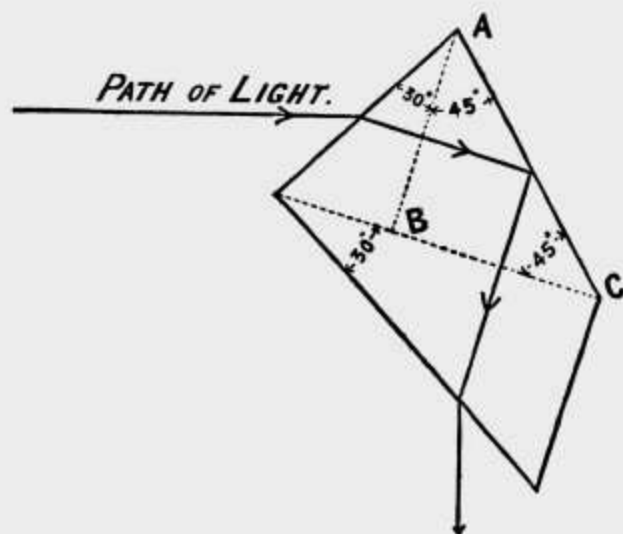


Fig. D 2.



Fig. D 3.

Prices :—

Wavelength Spectrometer, prism of 1.65 refractive index for D, accurately calibrated from 385 $\mu\mu$ to 800 $\mu\mu$ ¹	£25 0 0
With denser prism, 1.74 refractive index for D, and correspondingly increased accuracy of calibration, the calibration being from 390 $\mu\mu$ to 800 $\mu\mu$ ¹	27 15 0

¹ With the prism of 1.65 refractive index for D, the Helium line 3888.8 and the Lithium line 8127 can both be seen. With the prism of 1.74 refractive index for D, the Helium line is not visible, but the Calcium lines 3968.6 and 3933.8, and the Aluminium lines 3961.7 and 3944.2 are visible in the light of a carbon arc fed with lime and alumina; while at the red end the Lithium line is easily visible.

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"Universal" base to either of the above (for full description of this modification and its applications <i>see</i> p. D 4)	£1 17 0
Protective cover to prism table	0 10 6
Levelling screws	0 18 6
Well-made case with lock and key, for either of the above ...	1 8 6
Extra high-power eyepiece, with its own zero adjusting cross-webs	1 10 0
Shutter eyepiece with lateral adjustment to bright pointer (<i>see</i> Fig. D 5, and description below)	4 0 0
Slide with light filters to the shutter eyepiece for giving the pointer any desired colour, by means of which an increase of accuracy and comfort in reading can be secured, especially in the violet part of the spectrum	1 5 0

NOTE.—This eyepiece has two shutters, which can be shifted from either side in the focal plane so as to cover any desired part of the field, thereby obscuring any bright lines which by their proximity prevent the observation of feebler lines. The metal pointer, whose extremity is ground exceedingly fine and polished bright with the greatest care, is illuminated from above by a mirror. This bright pointer is adjustable laterally by the two milled head screws below, so that one can always return to the standard reading by setting the bright pointer on a reference line.

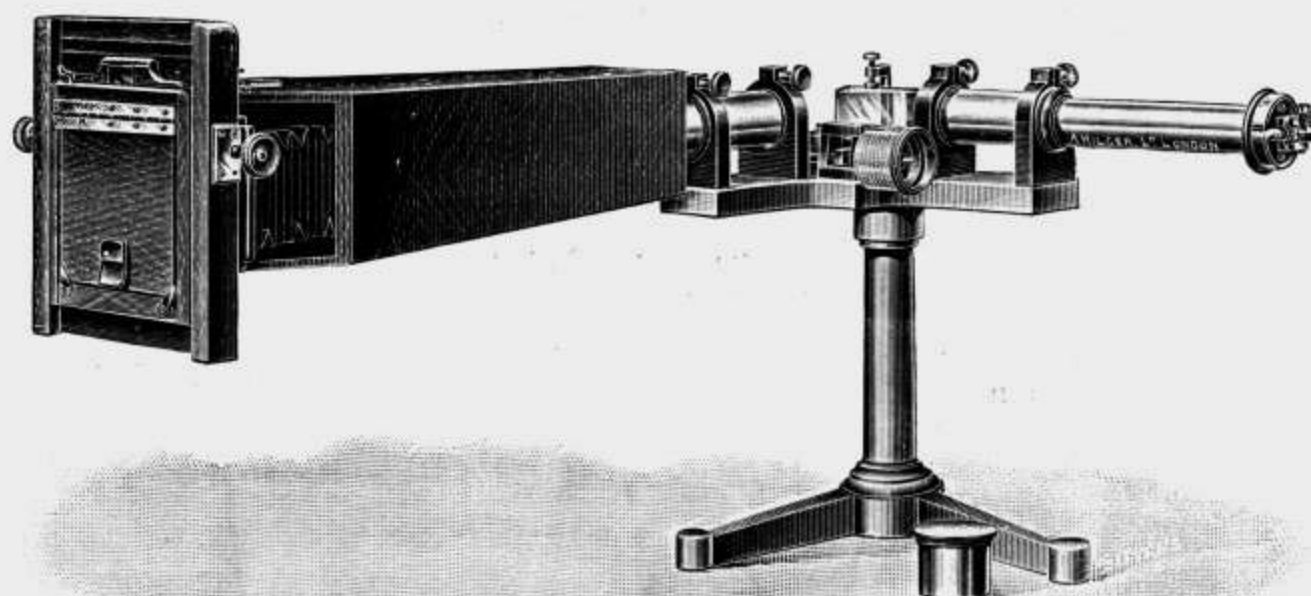


Fig. D 4.

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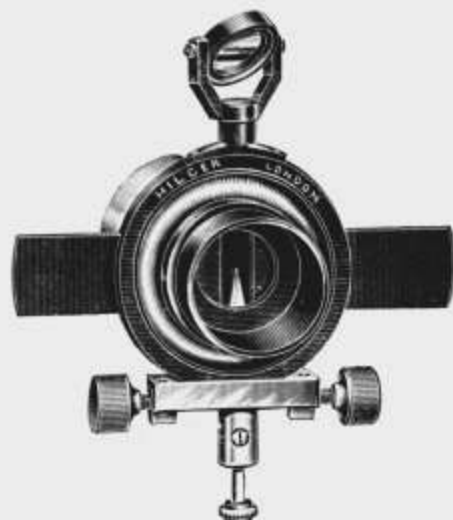


Fig. D 5.

Camera, with 21-inch focus lens, tilting adjustment for accurately focussing the whole spectrum, and shutter for exposure (shown in position in Fig. D 4) ... £6 13 0

Telescope fixed to side of the camera, and internal mirror with external milled head by means of which the spectrum can be reflected into the telescope at will. In this way the spectrum can be observed immediately before photography. The telescope is on the collimator side of the camera, so that the slit, wavelength drum, and light source are all within reach of the observer. Price ... 10 0 0

Replica of Rowland diffraction grating, as described on p. D 8, interchangeable with the prism.

Price, including calibration in wavelengths for both prism and grating 11 0 6

NOTE.—This can only be supplied if ordered at the same time as the Spectrometer.

We can now supply for these Spectrometers apochromatic triple object glasses. The calculations for these lenses and the measurements of the refractive indices of the glasses used have been made by J. W. Gifford, Esq.

Clear Aperture	...	32 mm. ($1\frac{1}{4}$ ")
Equivalent Focal Length	..	280 mm. ($11\frac{1}{4}$ ")

Price adapted to the Wavelength Spectrometer in place of the usual achromatic doublet object glasses, extra. ... £6 10 0

For other accessories, see Section F, "Accessories for Spectrometers and Spectrographs."

HILGER WAVELENGTH SPECTROMETER, with Universal Base.

The Hilger Wavelength Spectrometer (Constant Deviation Type) described on pp. D 1 *et seq.* can now be supplied with a slightly altered base-plate which permits of the immediate adaptation of the additions described below, over and above all the usual accessories. To this form of base-plate we have given the name "Universal" for convenience of reference. The alterations are as follows:—

- (1) The base-plate and tripod are of the form shown in Fig. D 6, the tripod being heavier and larger than in the ordinary wavelength spectrometer and the base-plate having an extended arm.

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(2) The base-plate is drilled with all necessary holes for the addition of the following parts:—

(i.) Nutting Photometer (*see* p. F 4), converting the spectrometer into an efficient and accurate spectrophotometer. In this case the uprights supporting the collimator are screwed on by means of the holes provided for the purpose near the prism table. The four holes thus left vacant towards the end of the extended arm are then utilised to attach the Nutting photometer.

(ii.) The complete accessories for high resolving power (Michelson echelon, Lummer-Gehrcke plate, and Fabry-Perot etalon) described in Section O.

The four holes left vacant towards the extremity of the extended arm when the collimator is in the first position will also be found of considerable use in many investigations where it is desired to fix something very rigidly in front of the slit of the spectrometer.

Prices:—

Wavelength Spectrometer, prism of 1.65 refractive index for D, as described on pp. D 1 to D 4, but with Universal base-plate...	£26 10 0
With denser prism, 1.74 refractive index for D	29 5 0
Well-made case, with lock and key	1 17 6

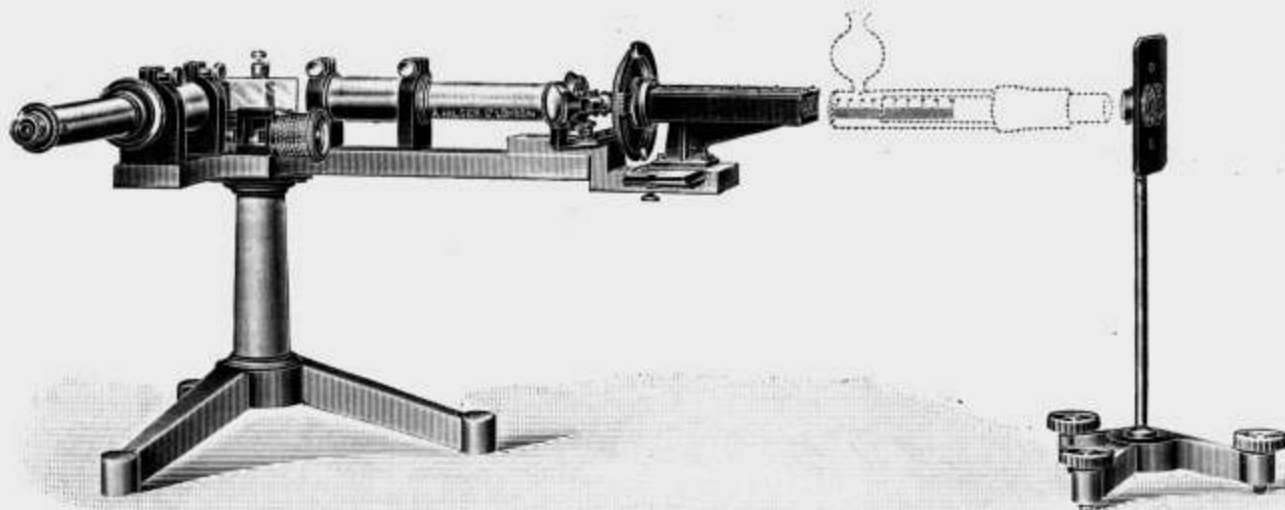


Fig. D 6.

The above figure shows the Hilger Wavelength Spectrometer on Universal Base, with Nutting Photometer. The change over from this arrangement to the one immediately below can be easily effected in ten minutes.

Nutting photometer for attachment to above (as described on p. F 4 and shown attached in Fig. D 6), extra £33 0 0

Complete additions, as described on pp. O 4 and O 5 to convert the Spectrometer into the form modified for use with the Michelson echelon, Lummer-Gehrcke parallel plate, or Fabry-Perot etalon described in Section O. (Shown in Fig. D 7 with Lummer-Gehrcke parallel plate in position as set up for observation of the Zeeman effect.)

(If these additions be ordered at the same time as the Spectrometer, the ordinary slit may be omitted, and £2, 10s. deducted from the above price. We recommend, however, that the ordinary slit be retained for general spectroscopic work.)

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Wavelength Spectrometers

D 6

Well-made case, with lock and key to take the Nutting photometer, Michelson echelon, Lummer-Gehrcke parallel plate, Fabry-Perot etalon, and the other parts required for use with these accessories. Price £8 10 0

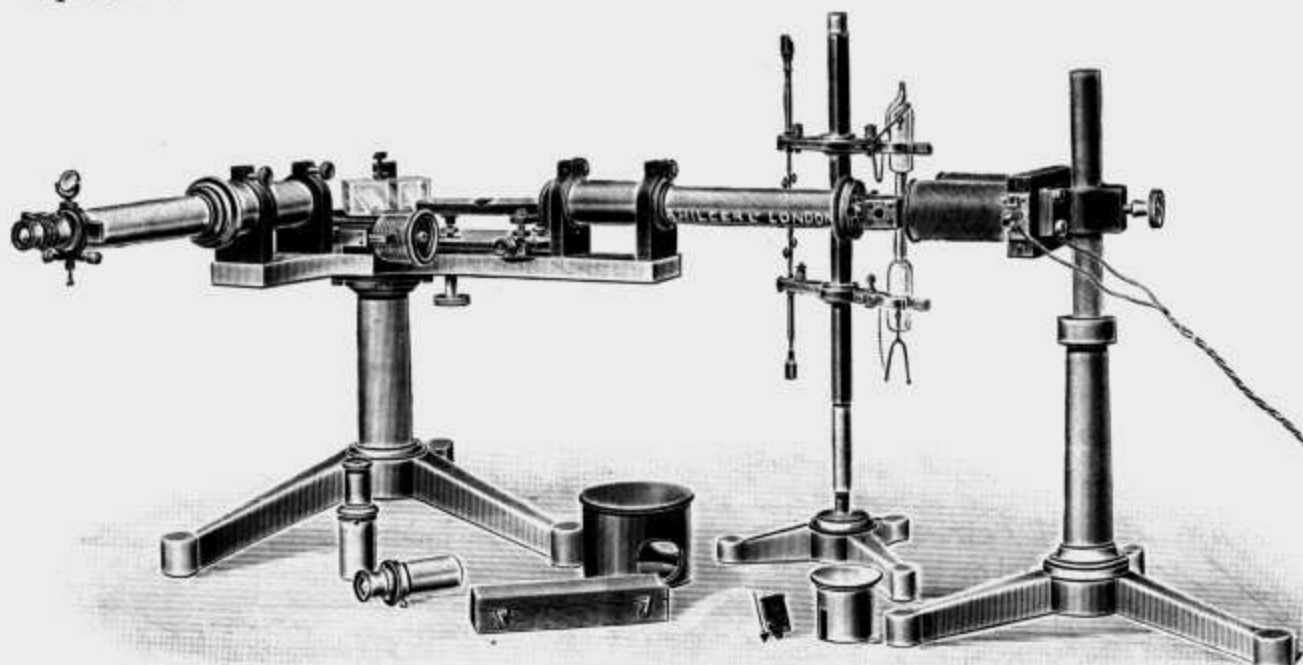


Fig. D. 7.

The above figure shows the Hilger Wavelength Spectrometer on Universal Base, arranged for use with Fabry-Perot etalon, etc. (see Section O); with Lummer-Gehrcke parallel plate in position as set up for observing the Zeeman effect.

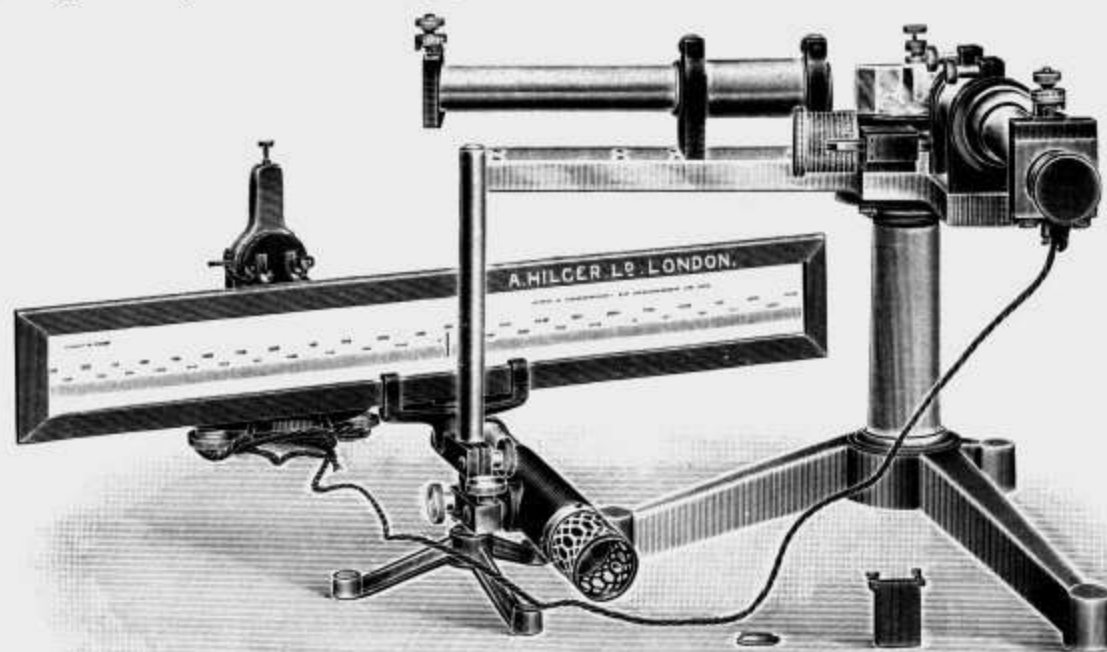
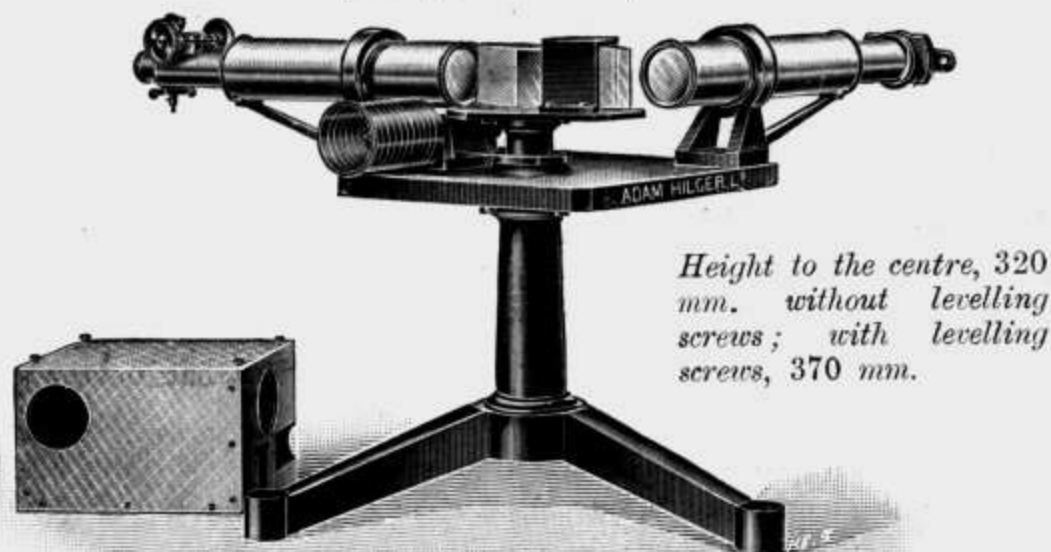


Fig. D 8.

The above figure shows the Hilger Wavelength Spectrometer on Universal Base, with Infra-red Accessories described on p. F 12.

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WAVELENGTH SPECTROMETER, Constant Deviation Type (Large Model).



Height to the centre, 320 mm. without levelling screws; with levelling screws, 370 mm.

Fig. D 9.

Wavelength Spectrometer, Constant Deviation type, large Model.—This instrument (Fig. D 9) reads with an average accuracy of about 1 Ångström unit, from 388.8 to 795.0 $\mu\mu$ in wavelengths direct. The principles of its construction are the same as that of the smaller model, but it is larger and more powerful in every way. The object-glasses are of 1½-inch (41½ mm.) clear aperture, and of 14½ inches (368 mm.) focal length. The divided scale of wavelengths is engraved on a helical drum, the length of scale division being about 81 inches (205 cm.) The eyepiece has a bright pointer for measuring the wavelengths of bright spectrum lines on a dark field. The instrument is of the Constant Deviation Type—i.e., the telescope and collimator are both rigidly fixed, the spectrum being traversed by the fine micrometer screw to which the helical drum is attached. The index is on the side of the drum towards the eye, so that the wavelengths of lines can be read off without quitting the eyepiece.

Price, including shutter eyepiece with bright pointer and lateral adjustment (see Fig. D 5), and calibrated complete ... £80 0 0

NOTE.—We can also supply this instrument with a smaller screw motion, and less extended wavelength scale engraved on a drum identical with that on the Wavelength Spectrometer with Diffraction Grating (Fig. D 10). The accuracy is then the same as that of the small instrument with dense prism, but the intensity of illumination is nearly double.

Price ...	£68 0 0
Levelling screws to either of the above ...	1 2 0
Well-made mahogany case, with lock and key to either of the above ...	3 7 6
Camera to go in place of the telescope, with 21½-inch focus lens, extra to either of above ...	9 10 0
Apochromatic triple object glasses, instead of the doublets usually supplied, extra to either of the above ...	10 10 0

For further accessories, see Section F, "Accessories for Spectrometers and Spectrographs."

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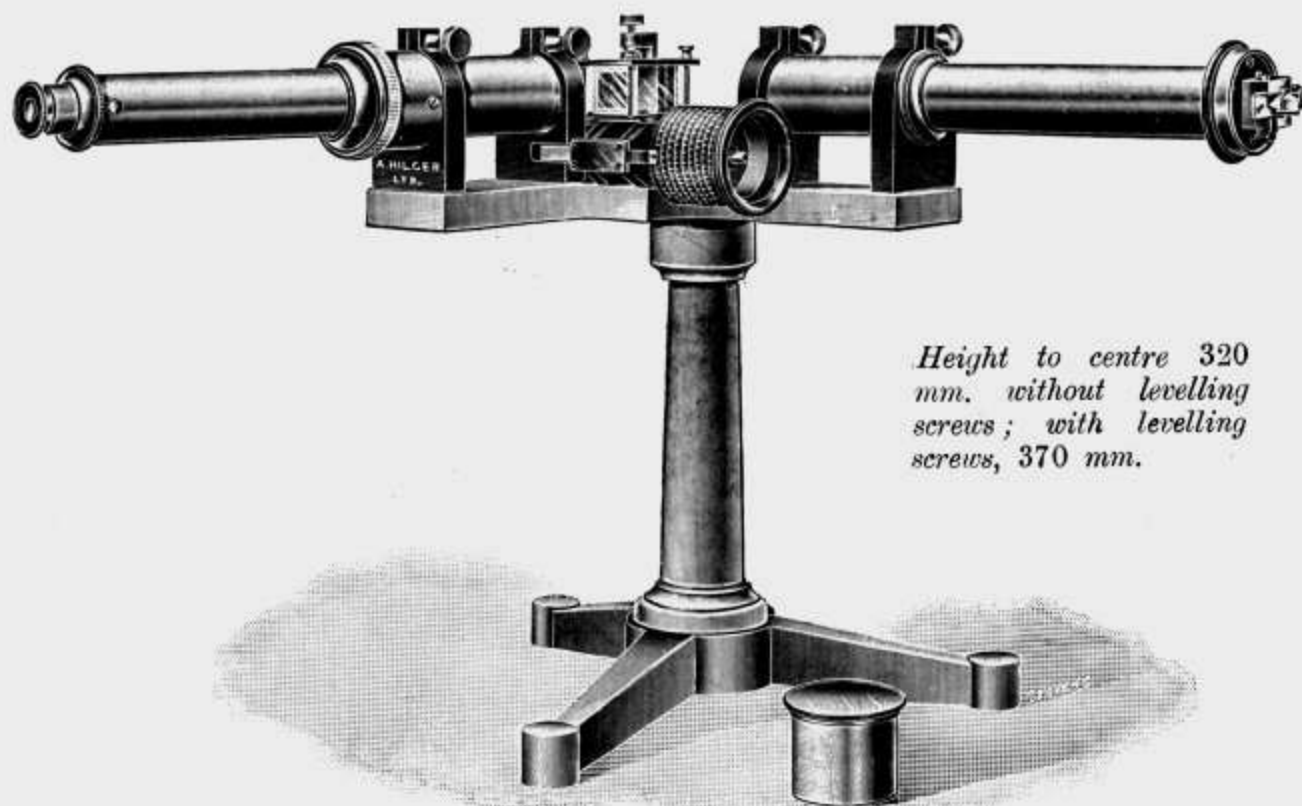
HILGER WAVELENGTH SPECTROMETER, with Diffraction Grating.

(Resolves the 4 doublets of the E Group, and measures wavelengths to 1 Ångström Unit.)

THIS Spectrometer (Fig. D 10) has been designed with a view to supplying the demand for an instrument giving a greater accuracy of wavelength measurement than does our well-known Wavelength Spectrometer, Constant Deviation type with prism, to which it is similar in construction; and is suitable for use in all cases where the amount of light available is sufficient.

The accuracy of the instrument is about $2\frac{1}{2}$ times that of the dense prism instrument, the readings being accurate to 1 Ångström unit throughout the spectrum.

Of this instrument and the prism instrument each has its peculiar advantages, the former on account of its higher accuracy, and the latter on account of the brightness of the spectrum making it suitable for the examination of the very faintest lines.



*Height to centre 320
mm. without levelling
screws; with levelling
screws, 370 mm.*

Fig. D 10.

The diffraction grating, which is a carefully selected film replica of one of Rowland's metal diffraction gratings, is mounted on a right-angle prism from the hypotenuse of which the light is totally reflected. By this means one can pass through the spectrum by rotation of the table on which the prism stands, as in the case of the instrument described on p. D 1. The telescope and collimator and general

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build are also similar to those of that instrument. The wavelength drum and index are shown in Fig. D 11.

Price of this Spectrometer, accurately calibrated in wavelengths throughout the whole visible spectrum from $380 \mu\mu$ to $800 \mu\mu$ (including cover to prism table) ... **£32 15 0**

Additions to convert into the prism instrument described on p. D 1, with wavelength graduations for both grating and prism scales, and wooden case for keeping prism and grating when not in use. ... **£6 0 6**

NOTE.—*These can only be supplied if ordered at the same time as the Spectrometer.*

The following additions can be supplied with this instrument:—

Levelling screws, case with lock and key, extra high power eyepieces, shutter eyepiece, and camera. For prices and descriptions, see under the prism instrument, pp. D 4 and D 5.

For further accessories, see Section F, "Accessories for Spectrometers and Spectrographs."

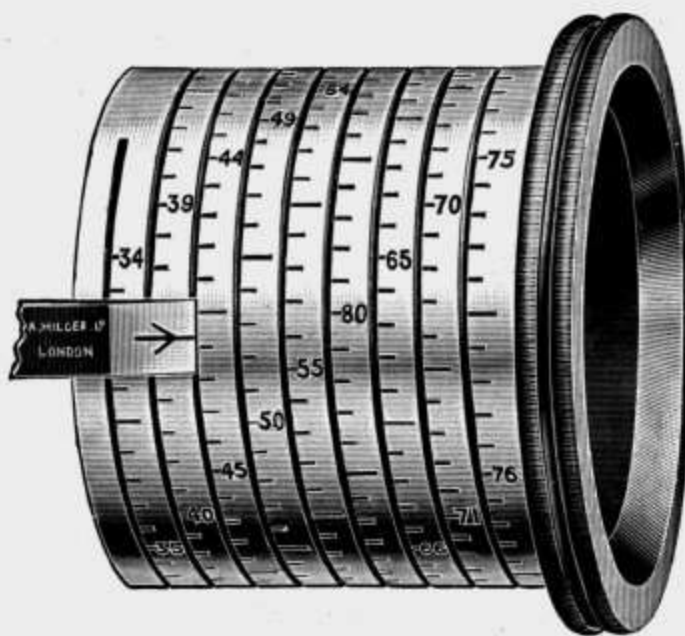


Fig. D 11.

WAVELENGTH SPECTROMETER, Photographic Scale Type.

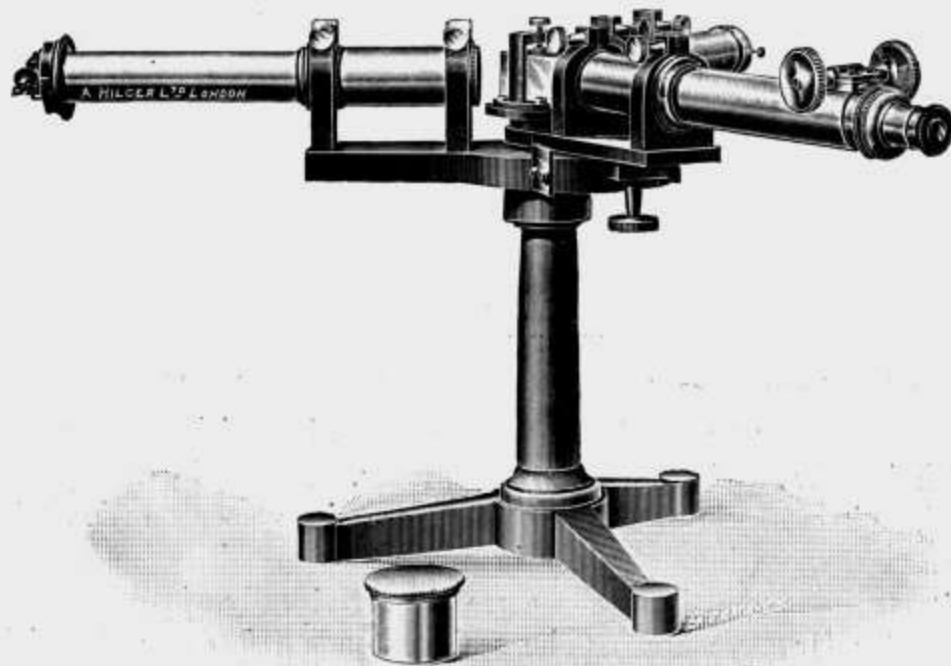


Fig. D 12.

This Spectrometer (Fig. D. 12) affords the most ready means of determining wavelengths where great accuracy is not required, as readings can be taken at a glance in wavelengths direct to an accuracy of about 10 Angström units from $390 \mu\mu$ to $800 \mu\mu$.

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The photographic scale is mounted on a tube (with collimating lens), and the light from the scale is reflected from the surface of the prism. A reflected image of the scale is thus seen in the telescope in juxtaposition to the spectrum as shown in the woodcut in Fig. D 13. The print must only be taken as representing the size of the real image formed by the telescope object-glass. To get an idea of the size of field in the instrument, the print should be looked at with an eyepiece.

The collimator, prism, and photographic scale mount are fixed to a rigid cast-iron base, the telescope alone rotating to pass through the spectrum.

A leaflet of instructions is issued with each instrument.

The greatest care is taken in the standardisation of the prisms and lenses, and in the preparation of the scales, and the highest attainable accuracy and best definition is guaranteed.

Price, complete	...	...	...	...	...	£14 10 0
Levelling screws to the above	...	...	...	...	...	0 18 6
Screw adjustment to photographic scale (extra)	...	...	...	...	...	0 16 0
Well-made case, with lock and key	...	...	...	...	...	1 10 0

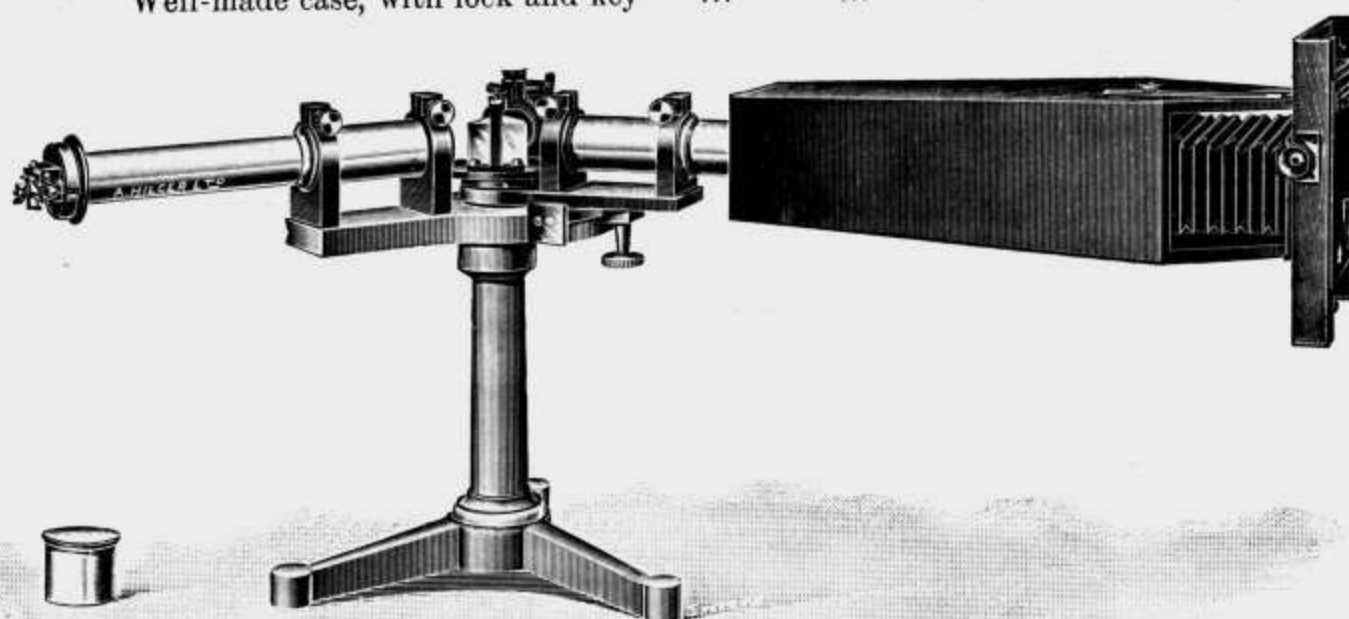


Fig. D 14.

Wavelength Spectrometer, Photographic Scale Type, with Camera attached.—The above figure (D 14) shows the camera in position. The camera has its own lens, which is achromatic and of 21-inch focus. It goes in place of the telescope, and the interchanging of telescope and camera occasions no alteration of adjustment whatever, the scale appearing correctly in juxtaposition with the spectrum on the photograph if the instrument has been correctly set visually with the telescope. The camera has shutter for exposure. (The scale extends only over the visible portion of the spectrum.)

A leaflet of instructions is issued with each camera.

Price of camera, extra	...	...	...	...	...	£6 13 0
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For other accessories see Section F, "Accessories for Spectrometers and Spectrographs."

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DR TUTTON'S SPECTROSCOPIC MONOCHROMATIC ILLUMINATOR.

Aperture ratio $f/6$.

This instrument (Fig. D 15) is described and illustrated in Dr Tutton's "Crystallography" (Macmillan & Co., 1911), and performs very efficiently the same functions as the Spectroscopic Monochromatic Illuminator described by Dr Tutton to the Royal Society in 1895 (*Phil. Trans. A*, 185, 913), an illustrated account of which is also given in his "Crystalline Structure and Chemical Constitution"

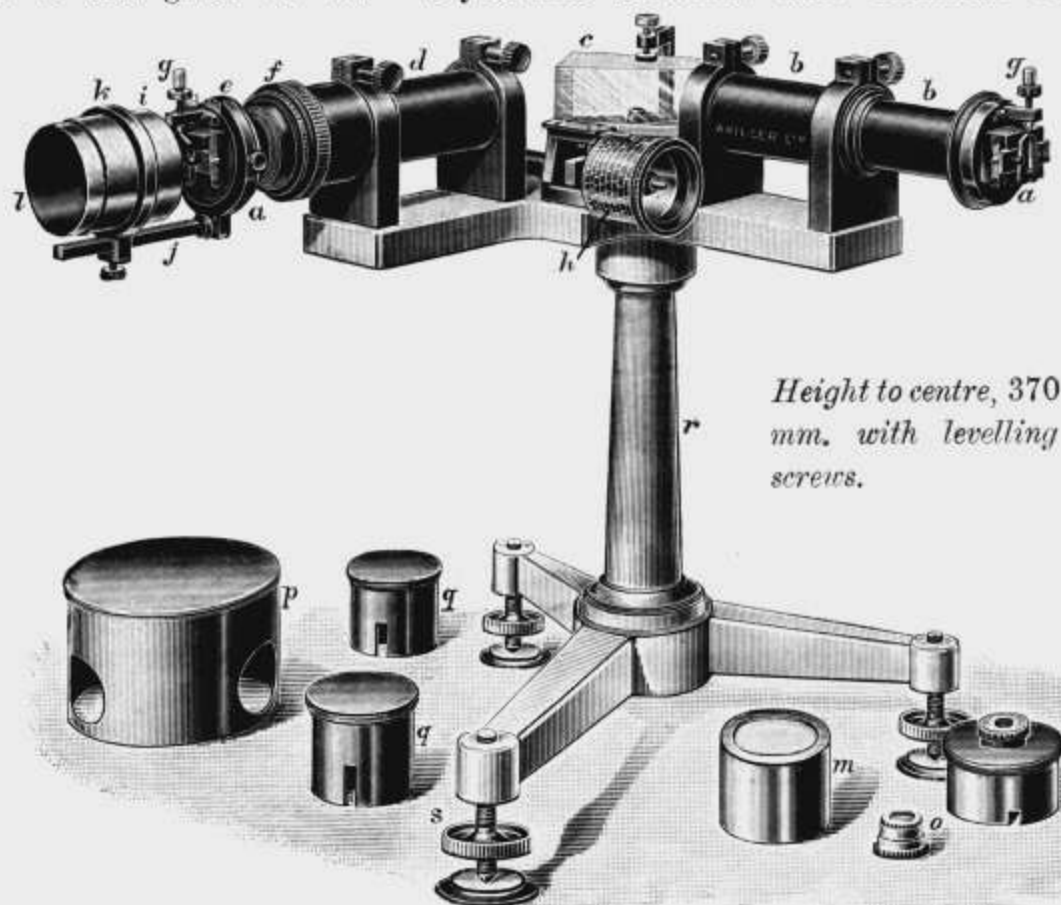


Fig. D 15.

(Macmillan & Co., 1910). It is similar in construction to the Hilger Wavelength Spectrometer (prism form) described on p. D 1 to D 4, with the following modifications:—

- (1) The addition of a second adjustable and *symmetrically opening* slit which can be put in the place of the eyepiece, thus converting the instrument into a Monochromatic Illuminator. The first slit is also made *symmetrically opening*.
- (2) The prism (of 1.62 refractive index for D) is of larger size, giving an effective beam of light 30 mm. wide for 589 $\mu\mu$.
- (3) The object glasses are 31.5 mm. clear aperture; but to increase the intensity of the light the focal length is reduced to 185 mm.
- (4) The eyepiece may be attached in front of the second slit, for observation of the spectrum lines and regulation of the opening of the slit.
- (5) One of two alternative ground-glass diffusing screens is mounted on an

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adjustable tubular fitting in front of the second slit, adequately to diffuse the issuing monochromatic light so as to fill the field of any observing instrument brought in front of it.

The wavelength drum is engraved from λ 385 $\mu\mu$ to λ 800 $\mu\mu$.

Price, including the usual accurate wavelength calibration and protective cover for the prism table **£36 0 0**

In the case of certain classes of work for which this instrument may be used requiring greater intensity of light, a suitable lens may be mounted in place of the ground glass screen; but for convenience and efficiency in crystallographic observations Dr Tutton has found the diffusing screens greatly superior.

**MONOCHROMATIC ILLUMINATOR FOR THE ULTRA-VIOLET
AND VISIBLE, reading from 200 $\mu\mu$ to 700 $\mu\mu$ direct in
Wavelengths**

(Can be calibrated with a Frequency or Frequency² Scale if desired.)

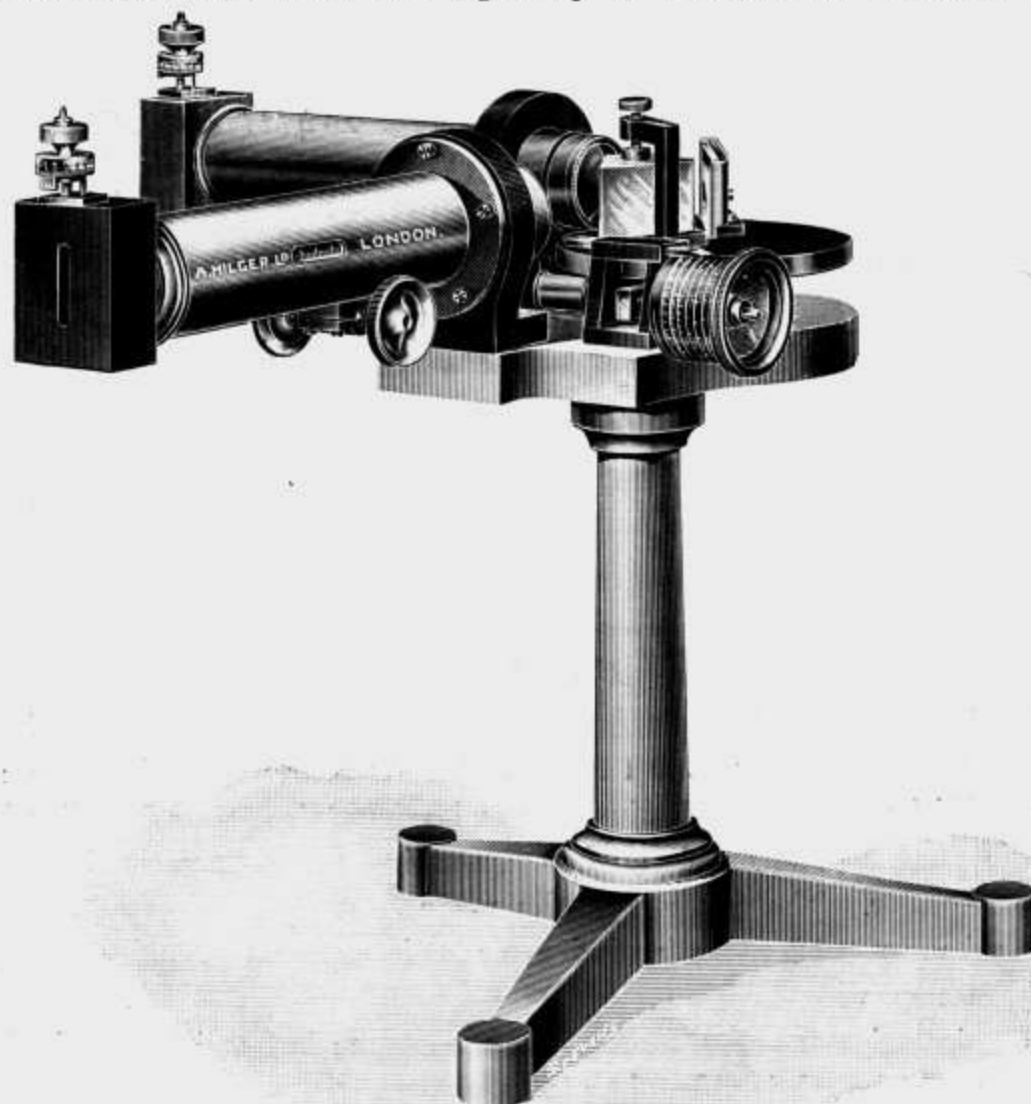


Fig. D 16.

This instrument (Fig. D 16), which is particularly suitable for experiments on

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the photo-electric effect, etc., is shown in the above illustration. Levelling screws are always supplied, although not shown in the figure.

The lenses are of 31 mm. aperture and 210 mm. focal length for $\lambda = 300 \mu\mu$.

The beam of light from the collimator passes at minimum angle through a Cornu prism of quartz (height 32 mm., length of face 42 mm.), and is then reflected from a plane mirror into the telescope. The prism and mirror stand on one table, which is rotated by means of a fine steel screw in the same way as the prism table of the Wavelength Spectrometer, Constant Deviation type (*see pp. D 1 to D 4*), the wavelength of the portion of the spectrum under observation being read off direct on a helical drum. The average accuracy of reading throughout the range is about $1 \mu\mu$. The collimator and telescope are rigidly fixed to the cast-iron base. If desired, a quartz prism on the constant deviation principle can be supplied, but owing to the greater thickness of quartz traversed with such a prism, and the fact that the absorption of quartz begins to be important even at wavelength $202 \mu\mu$, this form is not recommended.

Price (a) with ordinary non-symmetrical slits (our No. 1, with
14 mm. long aperture, described on p. F 5) £47 0 0

Price (b) with symmetrical slits suitable for use with the infra-
red arrangements mentioned below, as shown in Fig. D 16 52 0 0

For quartz-condensing lenses, fluorescent eyepiece, etc., *see* Section F.

The dimensions of the optical parts of this instrument have been adopted as having been found suitable for work on the photo-electric effect; we are, however, prepared to quote, if required, for instruments of similar construction but with larger prisms and larger diameter lenses up to $f/4.5$ in quartz, or if purity of spectrum can be sacrificed, lenses of the standard diameter but of focal aperture $f/4.5$ can be supplied. For such large focal apertures it is desirable to use in front of the slit a special quartz condenser figured to remove spherical aberration.

Additions for converting the above Instrument (b) into the Infra-red Spectrometer, described on p. D 14, consisting of:—

Rocksalt prism, nickel-steel concave mirrors, plane mirror of nickel steel to replace that used for the ultra-violet, thermopile with mounting for attaching it to one of the symmetrical slits above, extra helical drum calibrated for the infra-red, cast-iron base and mounting for the symmetrical slits and mirrors, and case to take the ultra-violet or infra-red portions of the apparatus when not in use.

When it is desired to use the apparatus for infra-red work, it is only necessary to remove the telescope and collimator, to replace the quartz prism by that of rocksalt, and to attach the cast-iron frame on which the mirrors are mounted with the symmetrical slits in position thereon.

Price of the complete infra-red attachments £36 15 0

For suitable galvanometer for use with the above infra-red attachments, see p. F 12 of our Catalogue.

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INFRA-RED SPECTROMETER.

Calibrated in Wavelengths from 500 $\mu\mu$ to 5000 $\mu\mu$.

(The wavelength drum is long enough to enable the spectrum to be examined up to 9000 $\mu\mu$, and marks are made on the drum to indicate the positions of W.L.s 6000, 7000, 8000 and 9000 $\mu\mu$.)

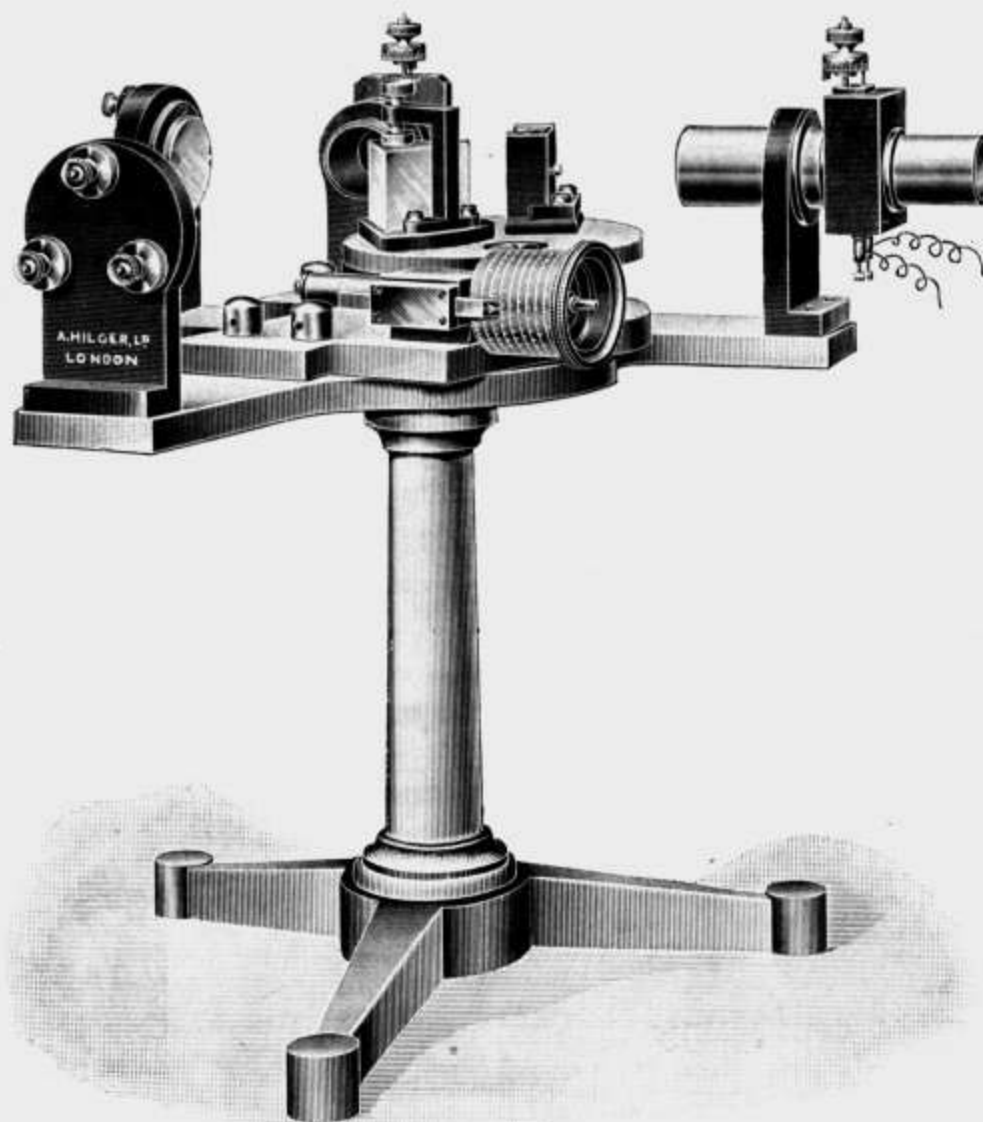


Fig. D 17.

The optical elements of the Infra-red Spectrometer shown in Fig. D 17 are as follows :—

Two symmetrical slits, each having an effective length of jaws of 20 mm. In the second of these slits is mounted a Hilger Bismuth-silver thermopile (fully described on pp. F 14 and 15).

Two concave mirrors of nickel steel (which in the case of the alloy selected is practically non-tarnishable), both of 27 cms. focal length and 38 mm. diameter.

Rocksalt prism 32 mm. high, 42 mm. length of face.

Plane mirror of nickel steel.

The light entering from the first slit is collimated by the first mirror, and passes

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through the rocksalt prism to the plane mirror. It is reflected thence to the second concave mirror, by which an image of the spectrum is formed on the second slit.

The rocksalt prism and plane mirror are mounted on a table which is capable of rotation by a fine screw. To this screw is attached a drum on which the wavelengths of the line under observation are read off direct by means of an index running in a helical slot in the same way as in the case of the Wavelength Spectrometer described on p. D 1.

The entire thermopile case is protected from external radiations by a large nickel plated case.

The thermopile will be supplied with a sensitive area 10 mm. long $\times$ 1 mm. wide unless otherwise ordered. If desired the 20 mm. long $\times$ 1.5 mm. wide size can be supplied, the price being the same. The larger size gives, of course, larger galvanometer deflections (provided the whole length of the slit be filled with light), but owing to the curvature of the spectrum lines a less accurate reading of the wavelength is obtainable.

The rocksalt prism is varnished with a solution of pyroxylin in amyl acetate unless special instructions are given to the contrary. This varnish, while protecting the prism, allows most of the infra-red rays in the region over which this spectrometer is calibrated to pass almost unabsorbed. It has one strongly-marked absorption band, but if necessary it can easily be washed off with amyl acetate.

Price of the Infra-red Instrument complete, as described, with					
levelling screws	...	...	...	...	£60 0 0
Price of additions necessary to convert the Infra-red Spectrometer into the Monochromatic Illuminator described on					
p. D 12, including case for the parts not in use	...	..	..	..	£28 15 0

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Telegraphic Address—"Sphericity, Camroad, London."

Telephone—1687 North.

Cable Code—Western Union.

September 1913.

SECTION E.*

SPECTROGRAPHS.

Specimen photographs taken on any of the Spectrographs mentioned in this Section will be sent post free on application.

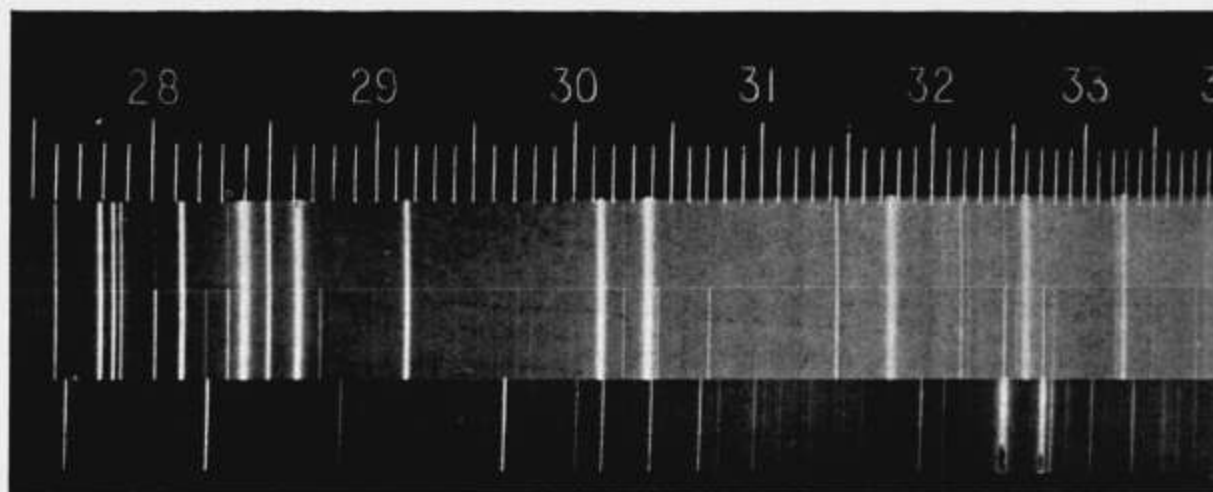


Fig. E 1 (*enlarged three times*).

UNLESS a special desire is expressed to the contrary, we now supply on the slits of all spectrographs described on pp. E 2 to E 5 and the Uviol Glass Spectrograph on p. E 7, in place of the usual comparison prism, a sliding diaphragm, interchangeable with the wedge of the slit, this diaphragm having three apertures giving three comparison spectra in close juxtaposition.

The above print is a process reproduction, enlarged three times, of a portion of a photograph of three comparison spectra taken in this manner on our quartz spectrograph, size (c), with wavelength scale (*see* p. E 3).

In addition to those described in this Section, other forms of spectrograph made by us are the "Littrow" spectrographs (either with plane diffraction gratings or with prism systems) of 8 feet (Section G) and of 10 feet focal length; and quartz spectrographs of large aperture ratio (up to $f/5$); while for work in the visual spectrum not requiring great resolving power, the wavelength spectrometers with cameras described in Section D, and the efficient and inexpensive little direct vision grating addition described on p. J 1, should also be taken into consideration. Prices, and specimen photographs taken on any of these, will be sent post free on application.

Photographs of Samples.—We are prepared to take photographs of the spectra of samples on one of our quartz (c) spectrographs, with wavelength scale, at a charge of 7s. 6d. for each photograph. The spectra of three samples, together with the wavelength scale, as shown above, can be taken for this price.

For micrometers for use with these spectrographs, see Section L.

For other accessories for spectrographs, including photographic plates, see Section F.

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QUARTZ SPECTROGRAPHS.

Quartz Spectrograph, size (d) Fig. E 2.—This spectrograph has a dispersion three times that of size (c), being designed for work with complex spectra, such as that of iron. It takes the entire spectrum from $210\ \mu\mu$ to $800\ \mu\mu$ in three exposures, on 10×4 inch photographic plates.

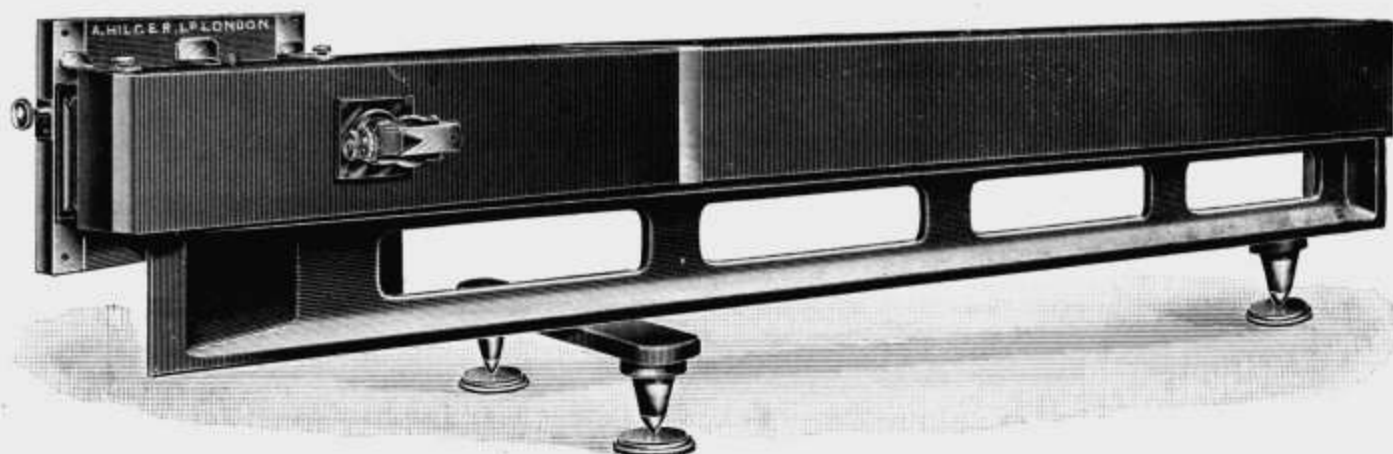


Fig. E 2.

It is of the "Littrow" form, which in so large an instrument presents great advantages owing to its compactness.

The optical train consists of one quartz lens of 70 mm. clear aperture, and 170 cms. focal length; and a 30° prism of quartz 98 mm. length of refracting face $\times 57$ mm. high, the second face being coated with tin mercury amalgam, which is a good reflector throughout both the visual and ultra-violet regions.

The slit is our No. 2 (*see* p. F 5).

The light enters by the slit, is reflected along the camera tube by a right-angled prism of quartz, is collimated by the lens, enters and is reflected back by the quartz prism, and retraces its path through the lens, an image of the spectrum being formed on the photographic plate.

The prism and lens are mounted on a carriage which moves along a slide, its position being definitely determined by two stops with screw adjustment. The prism can also be rotated to one of three definite positions. These alternative positions correspond with the three portions of the spectrum; the camera being provided with means of varying the inclination of the plate necessary to obtain good definition throughout the spectrum.

The whole is mounted on a substantial cast-iron base.

Overall length of spectrograph 78.7 inches (2000 mm.).

Overall width of spectrograph 13.75 inches (350 mm.).

Price ~~£350 0 0~~

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The following two spectrographs, with quartz prisms and lenses, have been very carefully designed with the following objects in view:—

- (1) To be in permanent adjustment.
- (2) To give the whole spectrum from 200 $\mu\mu$ to 800 $\mu\mu$ on one plate.
- (3) To give good definition over the whole spectrum on the ordinary photographic plate.
- (4) To give as large an amount of light as is consistent with the above conditions, thus enabling spectrograms to be taken with relatively short exposures.

The instruments are sent out completely adjusted, ready for photographs to be taken.

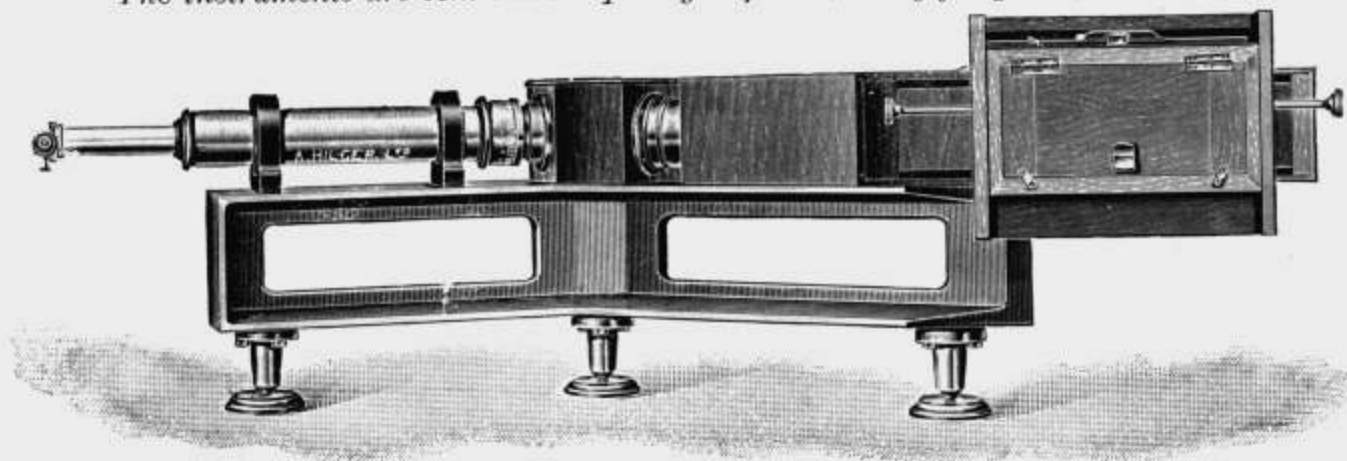


Fig. E 3.

Quartz Spectrograph, size (c) (see Fig. E 3).—Lenses of 24 inches (610 mm.) focus, the instrument giving a spectrum from 210 $\mu\mu$ to 800 $\mu\mu$ of about 200 mm. long. Prism, 41 mm. high $\times$ 65 mm. long face. Size of plate, 10 $\times$ 4 inches. The slit is our No. 2 (see Spectroscope slits, Section F). The dispersing system consists of one Cornu prism. There is a vertical motion by rack and pinion to the dark slide, with scale, whereby a number of exposures can be taken one below the other.

Price

£58 15 0

(Specimen photographs will be sent post free on application.)

Quartz Spectrograph, size (c), with wavelength scale.

In the case of the size (c) instrument, an accurate scale of wavelengths can be mounted internally in such a manner as to be brought at will in contact with the photographic plate. Illumination is provided by means of a small electric lamp, and a contact print of the wavelength scale can thus be obtained on the same plate as, and in juxtaposition to, the photograph of the spectrum (as in Fig. E 1).

Price, if ordered at the same time as the spectrograph, including small battery in case, with push key for illuminating lamp; the whole being attached to the spectrograph in a convenient position for use ... £13 0 0

The accuracy with which wavelengths can be read on these scales is approximately as follows:—

WAVELENGTH.	ERROR OF READING. (In Ångström units.)
7000	100
4000	20
3000	5
2500	2
2200	1

If desired, the scales can be divided to read frequencies instead of wavelengths, the price being the same.

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Metal Slides for Plate-holder.—The size (c) spectrograph can also be supplied with metal slide for the plate-holder, the said slide being attached to the base of the instrument by a rigid metal bracket. In this construction the wooden cone and bellows of the camera are still retained, but play no part in the support of any essential portions of the apparatus.

Price, extra £17 10 0

Wavelength Scales on glass for size (c) similar to those described below in connection with size (a). Price each 1 10 0

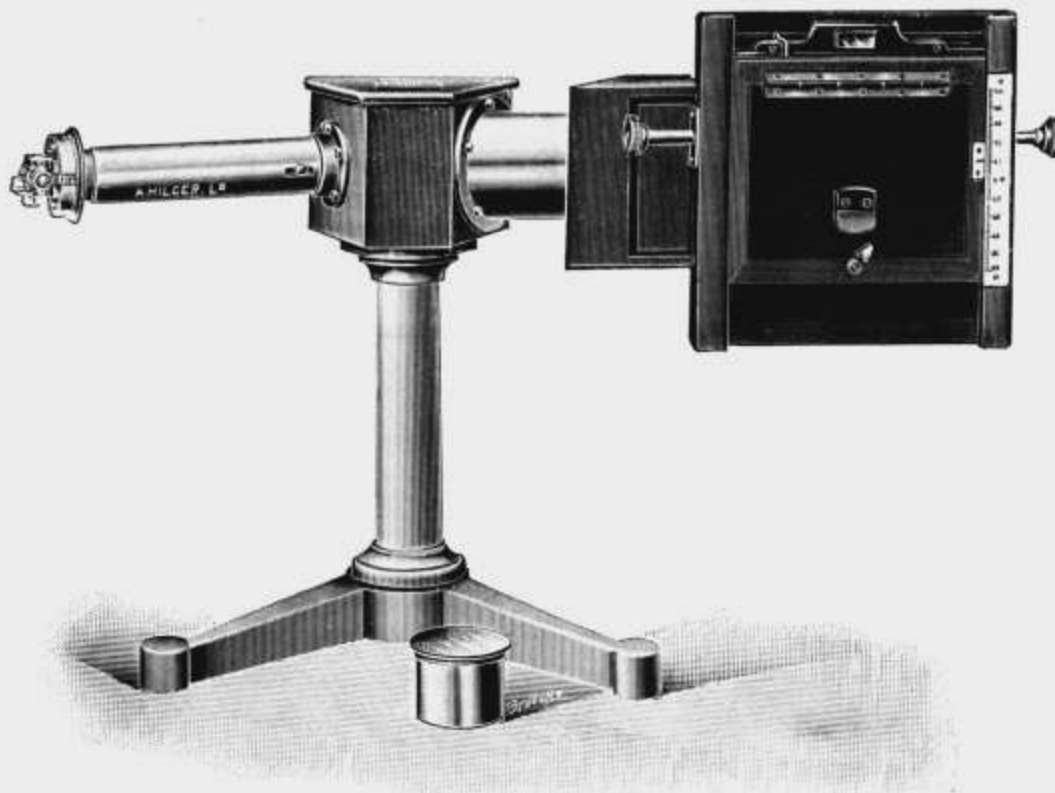


Fig. E 4.

Quartz Spectrograph, size (a).—Lenses of 8 inches (203 mm.) focus, the instrument (see Fig. E 4) giving a spectrum from 200 $\mu\mu$ to 800 $\mu\mu$ of about 65 mm. long. Size of plate, $4\frac{1}{4} \times 3\frac{1}{4}$ inches. The slit is our No. 1 (see list of Spectroscope slits). The dispersing system consists of one Cornu prism.

Price £21 10 0

(Specimen photographs will be sent post free on application.)

Accurate scales of wavelengths have been prepared in connection with this spectrograph. These scales are photographed on glass, and can be laid direct on the spectrograms to read off the wavelengths. They are prepared to suit each individual instrument, and are sufficiently accurate to determine the identity of most lines.

Price £1 5 6

The quartz spectrograph size (a) can also be supplied, if desired, with shorter focus lenses, and taking the whole spectrum from W.L. 1850 to W.L. 8000. Price, the same as the above.

Eyepiece mounted for the examination of the visible spectrum.

Price £1 10 0

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Large Quartz Spectrograph, "Arc" Form (Fig. E 5), has a high quality slit with non-tarnishable jaws and fine steel adjusting screw with large divided drumhead.

The collimator and telescope lenses are of quartz, $1\frac{3}{4}$ inch clear diameter, 35.7 inches focus for D. Focussing by accurate slides and rackwork to both collimator and telescope, and division for setting focus.

Right and left rotation quartz prism each of 30° (Cornu system), 41 mm. high $\times$ 65 mm. long face. The camera arm is a light but extremely rigid casting of aluminium alloy. The camera is mounted on a rotating table with clamp and division, so that the plate can be tilted to any angle to get the spectrum in focus throughout its entire length.

The camera has double rack and metal slide with division, taking seven exposures on a quarter plate, the spectrum running the long way of the plate.

Mounted on massive cast-iron stand with the camera arm supported by a solid arc with divisions for setting. The camera arm has a clamp for fixing it in position. Levelling screws to cast-iron stand.

The prism table stands on three levelling screws on a rotating table, which has a rack and pinion for rotating, and a division for setting.

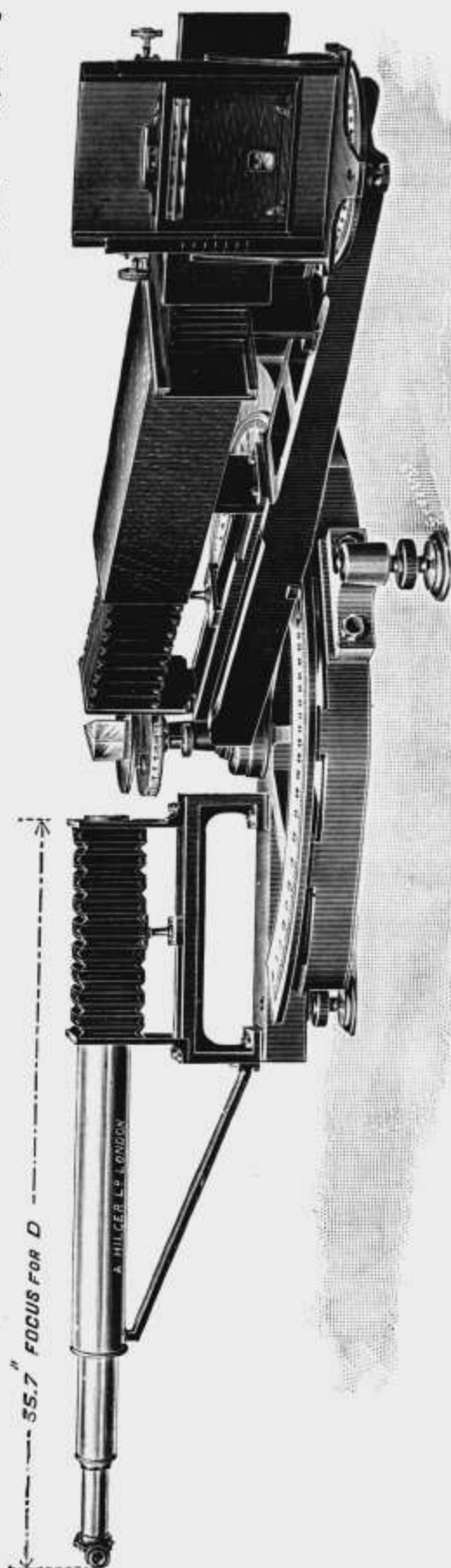
The instrument is suitable for use with a diffraction grating, although when using a plane grating and quartz lenses there is considerable curvature of the focal surface.

The mounting is thoroughly rigid, and the whole instrument is of high quality work throughout.

Price, complete ... £105 10 0

Same as above, but camera to take half plate.

Price, extra ... £7 0 0



LARGE QUARTZ SPECTROGRAPH ("Arc" Form), Fig. E 5.

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THE FÉRY SPECTROGRAPH.

(For full description see separate leaflet.)

The Féry Prism and Instruments embodying the same are protected by the following patents—viz., Germany 228589, Austria 48972, France 411862, Great Britain 10330/10, and United States of America 1007346.

In this instrument (Fig. E 6,) the collimator and camera lenses are entirely suppressed, the only optical work being the prism itself. It is usually supplied with a quartz prism, but a glass prism can be used *on the same instrument* if desired.

The employment of the principle of auto-collimation with a 30° prism simultaneously shortens the apparatus, simplifies the lens system, and avoids trouble due to the rotatory properties of the quartz, since the prism is traversed twice in opposite directions.

The general condition for producing a pure spectrum is that all the incident or refracted rays should make the same angle with the refracting surface. By giving suitable spherical curvature to the front and back surfaces of the prism this condition is very closely realised, and a sharp spectrum is obtained on a cylindrical surface exactly as with a curved reflecting grating.

Dimensions :—

Size of prism, 58 mm. ; length of face, 50 mm. high.

Distance from face of prism to centre of photographic plate, 1080 mm.

Size of photographic plate, 10 inches $\times$ 2 inches (or if desired 24 cm. $\times$ 5 cm.), taking 4 spectra one below the other.

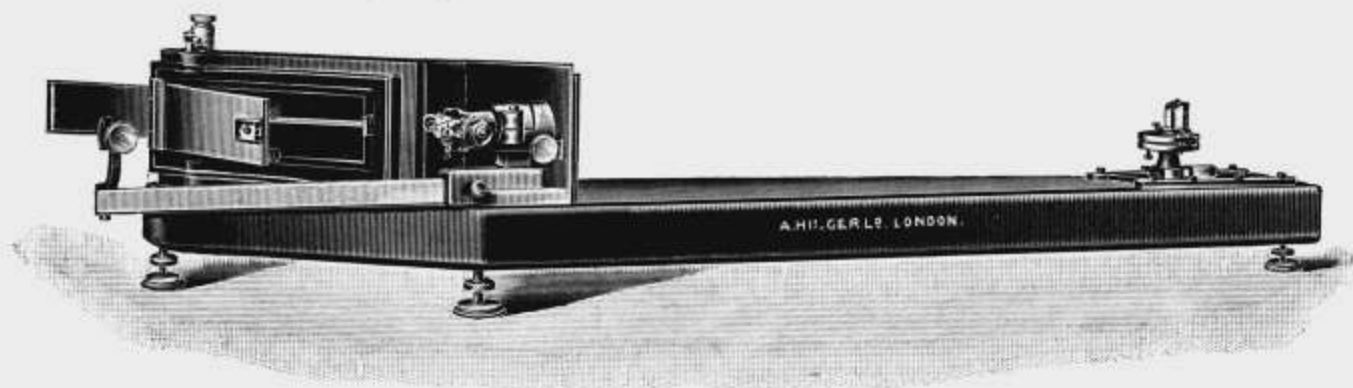


Fig. E 6.

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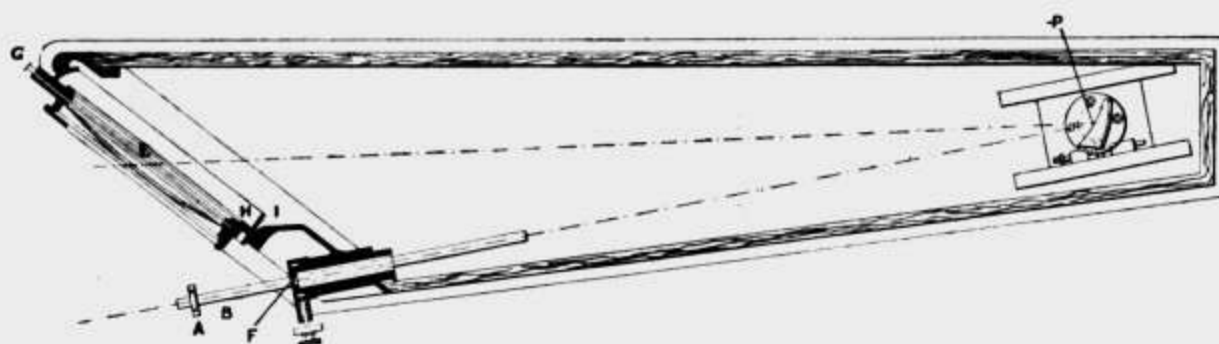


Fig. E 7.

The spectrum extends from $210 \mu\mu$ to $800 \mu\mu$, the length of spectrum between these limits being 224 mm.

The spectrograph is shown in Fig. E 6 and in diagram in Fig. E 7.

Price, complete with quartz prism and quartz spherocylindrical condensing lens	£68 10 0
Simpler mounting constructed in wood, but with similar quartz prism and giving similar spectra to the above, price ...	27 0 0

Quotations can also be given for these instruments with prisms of glass.

(Specimen photographs taken on the instrument, and complete description of its construction, will be sent post free on application.)

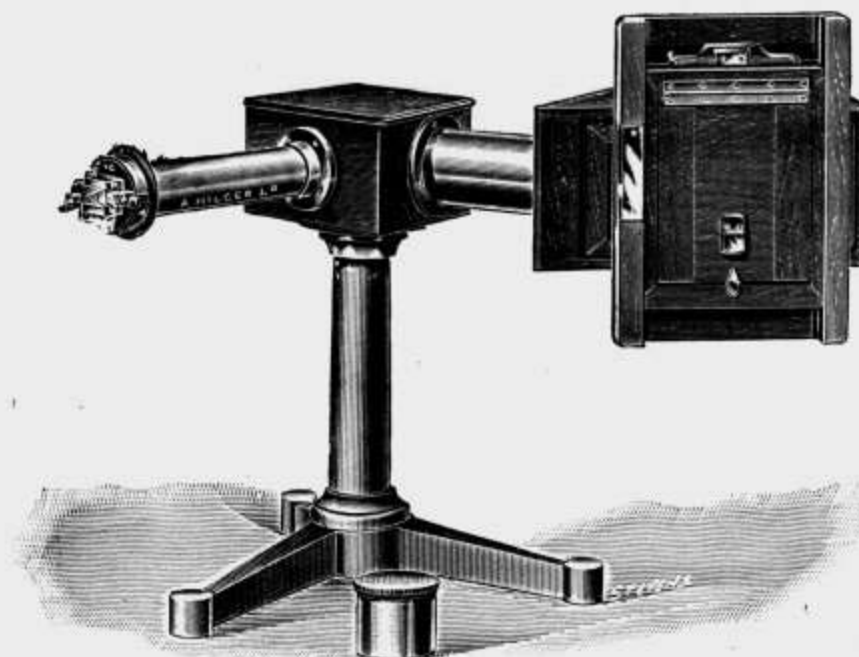


Fig. E 8.

Ultra-Violet Glass Spectrograph for the spectrum from $300 \mu\mu$ to $800 \mu\mu$.

(a) With two prisms and lenses of the most transparent ultra-violet glass (see Fig. E 8), the lenses of 8 inches (203 mm.) focus, the spectrum from $300 \mu\mu$ to $800 \mu\mu$, occupying about 40 mm. long. Size of plate, $4\frac{1}{4} \times 3\frac{1}{4}$ inches. The slit is our No. 1 (see Section F).

Price	£16 10 0
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CONCAVE GRATING SPECTROGRAPHS.

(EAGLE MOUNTING.)

(See Paper by A. Eagle "On a New Mounting for a Concave Grating")
Astrophys. Jour., 31, page 120 (March 1910).

In comparison with the classical Rowland mounting, the Eagle mounting has the following advantages:—

- (1) It occupies very little space.
- (2) No darkened room is necessary.
- (3) Spectra on either side of the normal may be used with equal facility; a point of some value, as it may happen that the best third-order spectrum is on the opposite side to the best first-order spectrum.
- (4) Everything being on the same axis, great rigidity is obtained.
- (5) It is much easier to ensure uniformity of temperature. This is of capital importance in making long exposures with the larger models.
- (6) Higher orders are obtained.

Mr Eagle has developed in detail in the above-mentioned paper the comparison between the two methods of arranging the diffraction grating. We are of opinion that for the great majority of work the Eagle mounting is much to be preferred. We are, however, prepared to quote, if desired, for spectrographs constructed on the Rowland system.

SIZE (a).

(see Fig. E 9.)

(Suitable for a Grating of 90 c/m. radius and 1.4" diameter;
 20,000 lines per inch.)

The instrument consists of a cast-iron girder on which are mounted the camera, and the slide for the grating carriage. The grating carriage is movable longitudinally by a screw of $\frac{1}{4}$ " pitch, the motion being sufficient to give the following ranges of spectra, if the grating be of 20,000 lines per inch.

1st order,	from the extreme violet to 1,900 $\mu\mu$
2nd	" " " 950 "
3rd	" " " 640 "
4th	" " " 480 "
5th	" " " 385 "

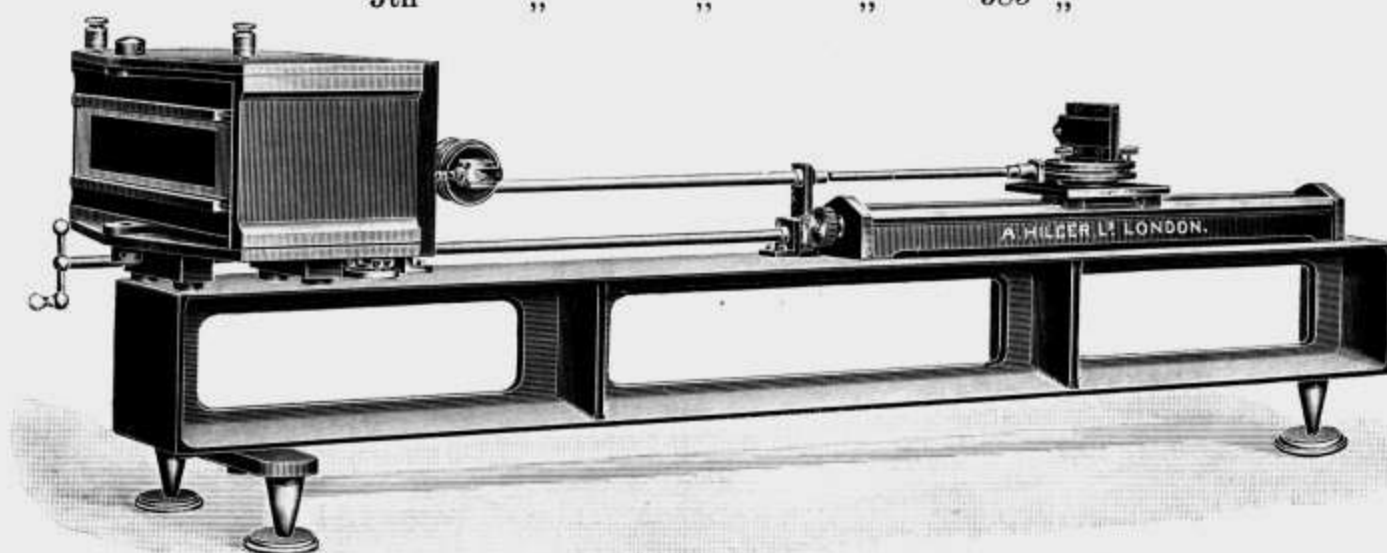


Fig. E 9.

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The frame of the camera is of metal, the dark slide of mahogany. Comparison photographs are obtained by means of a sliding diaphragm in front of the plate actuated by screw motion. The slit is our No. 1 size (*see* Section F). The size of the film is 10" x 2", of which 9½" x 1" are exposed.

We recommend that with this and the next size of instrument films be used. Stiff films are now easily obtainable from photographic plate makers (*see* p. F 16), and this will bend to the full curvature and give perfect definition from end to end. For the use of plates, however, a second dark slide is provided, which has only half the correct curvature, that being the greatest amount of bending to which one can safely submit even the specially thin plates now obtainable.

The grating mount is provided with means of levelling the grating, and of setting the lines of its ruling parallel to its axis of rotation. The slit can also be adjusted to be parallel to the lines of the grating. The instrument is provided with a well made light-tight cover.

Price, including best quality Rowland grating of dimensions mentioned above	...	...	...	...	£82 0 0
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Rods from camera ends of the instrument to actuate the screw motion and rotate the grating; also counting mechanism to both for accurately setting the grating to any desired position.

Price, extra	...	...	...	...	£9 0 0
--------------	-----	-----	-----	-----	--------

SIZE (b).

(Suitable for a Grating of 120 c/m radius and 1.4" diameter.)

This instrument is of the same design as size (a), but of increased length.

Price	...	...	...	...	£86 0 0
-------	-----	-----	-----	-----	---------

The price of the rods and counters is the same as for the size (a) instrument.

SIZE (c).

(Suitable for a Grating of 305 c/m radius and 4" diameter.)

With gratings of this radius it is usually preferable to mount the camera and the slides with screw motion, etc., on separate concrete or brickwork supports instead of both on one girder, and the camera and slides are designed for this purpose. A drawing of the necessary brickwork is sent in receipt of every order for one of these instruments. The wooden cover is provided as for the smaller size of grating mounting, but in this and in the following case a second inner cover is provided further to retard the temperature variations which with all large grating spectrographs are a source of great inconvenience if not provided against. The camera is arranged to take plates 40 x 4 c/m, and all

Concave Grating Spectrograph

E 10

adjustments, as given under specification for size (a), are provided, together with rods from the camera to actuate the screw motion and rotation of the grating. The slit is our No. 2 size (see Section F).

Price, including best quality Rowland grating £190 0 0

SIZE (d).

(Suitable for a Grating of 650 c/m radius and 6" diameter.)

This size is of exactly the same design as size (c) described above, with the exceptions that it is longer to suit the longer radius of curvature, and that the grating mount and carriage are suitably modified.

Price, including best quality Rowland grating £230 0 0

Small Wooden Camera for adaptation to any spectroscope, with dark slide and fine ground grey plate, taking four exposures on half a quarter plate.

Price £2 0 0

The above camera can be supplied with achromatic enlarging lens, enlarging three times. (If preferred, the arrangement can also be supplied enlarging either twice or four times.)

Price, extra £1 10 0

Small Wooden Camera, same size as the above, having tilting motion with bellows to enable the whole spectrum to be focussed. (The nature of the optical system must be stated when ordering this camera; the woodwork is then constructed to give approximately the tilt required, a sufficient amount of motion for exact adjustment being provided in addition.)

Price £2 15 0

Wooden Camera, with 21 inches (530 mm.) focal length achromatic lens of $1\frac{1}{4}$ inch (31 mm.) aperture, tilting motion with bellows (up to an angle of 35° with the axis in either direction), and dark slide arranged to take six exposures on a quarter plate, the slide being moved by rackwork. A shutter is provided for exposure.

This camera is designed for use with a No. 1 or No. 2 table spectrometer (Section C), or with our wavelength spectrometers (Section D), but it can be adapted to almost any instrument.

Price £6 13 0

ADAM HILGER, Ltd., 75a Camden Road, London, N.W.

Telegraphic Address "Sphericity, Camroad, London."

Telephone—1687 North.

Cable Code—Western Union.

September 1913.

SECTION F.*

ACCESSORIES FOR SPECTROMETERS AND SPECTROGRAPHS.

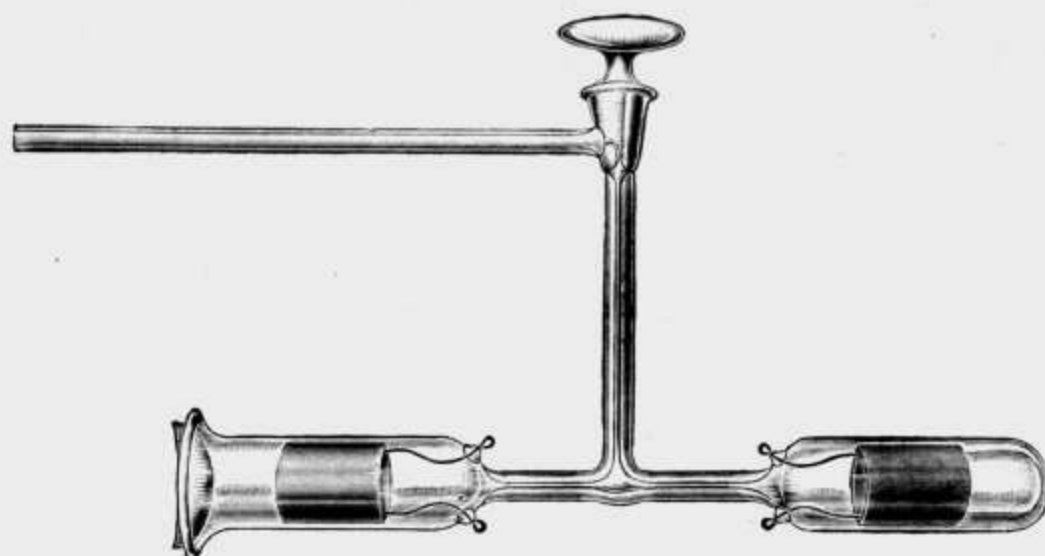


Fig. F 1.

Vacuum Tube for Experimental Work.—The tube is, as will be seen

from the sketch (Fig. F 1), of the end on type. It is supplied with a tap, and the light is concentrated into a line focus by a sphero-cylindrical condenser, of which the spherical portion fits accurately the ground and polished cup at the end of the vacuum tube.

Price, with glass
condenser ... £2 5 6

Price, with quartz
condenser ... 3 15 6

Combined Vacuum Tube Holder and Spark Apparatus, readily interchangeable (Fig. F 2).

Price ... £3 15 0

Arc Lamp (Fig. F 3) suitable for the arc spectra of metals. Rods of the metal (of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. diameter) are held in the spring clips. A direct current is employed, which should be off a circuit of 100 volts or more, with suitable resistance to give about 3 amps.

Price ... £3 5 0

Attachment for using
the arc horizontal.

Extra ... 0 10 0

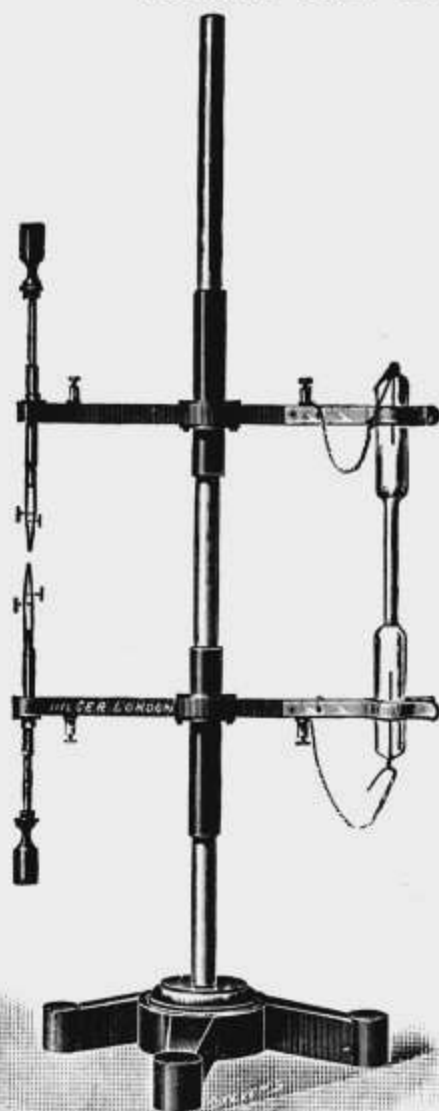


Fig. F 2.

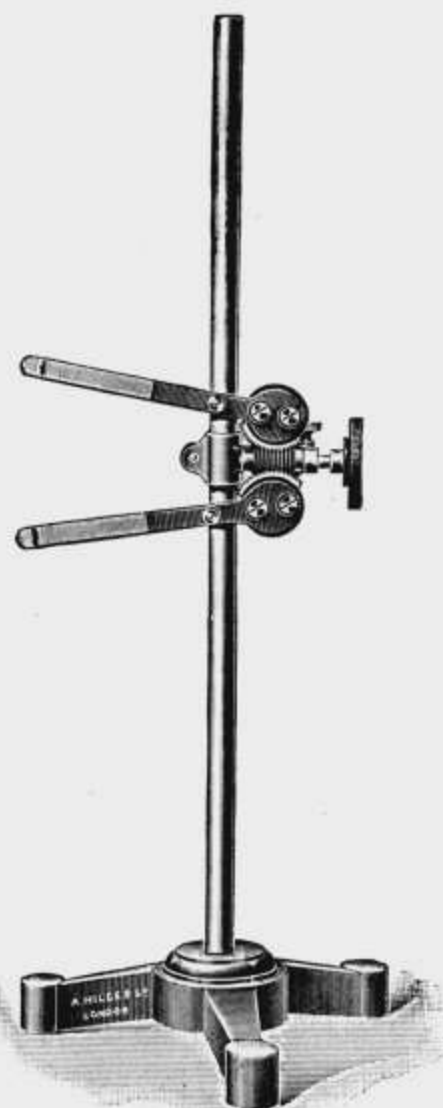


Fig. F 3.

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Slit Rod for attachment to any Collimator.—This simple device can be quickly and easily attached to the collimator of any spectroscope without in any way interfering with the adjustments. Figs. 4 and 5 show the slit rod in position clamped to a collimator, in Fig. F 4 a condensing lens being carried, and in Fig. F 5 a Baly adjustable absorption tube. The absorption tube, condenser, etc., are readily interchangeable and are adjustable for height. A very considerable gain in convenience results from being able to attach such accessories to the collimator in this way.

The following parts are supplied :—

1. **Rod Carrier** for attachment to any collimator tube, with rod and clamp for same.
 Price £1 5 0
 Price, with two clamps, suitable for use with mirror and condenser simultaneously 1 7 6
2. **Condensing Lens** of glass, with spherical surfaces in mount with stem for the above rod carrier. Price 0 11 6
3. **Condensing Lens** of quartz, do., do. Price 1 12 6

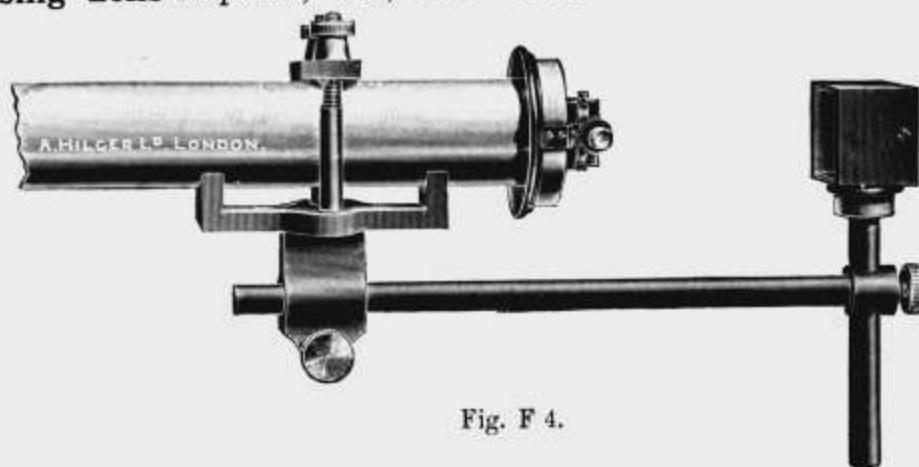


Fig. F 4.

4. **Sphero-cylindrical Condenser** of glass (as in Fig. F 4) similarly mounted for the above rod carrier. Price £1 12 6
5. **Sphero-cylindrical Condenser** of quartz. Price 2 14 0

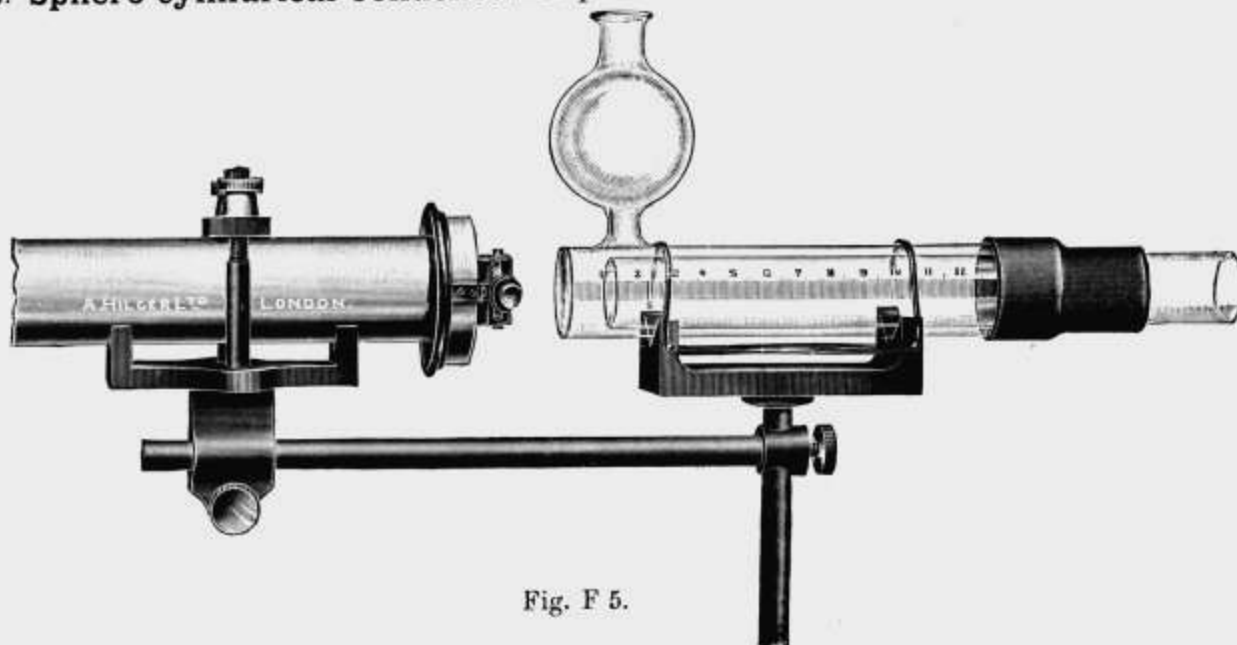


Fig. F 5.

6. **Carrier** for Baly absorption tube, described on the next page, with stem for the above rod carrier (as in Fig. F 5). Price £0 7 6
 (The absorption tube is held securely in place on its mount by means of a rubber band which passes under four projecting pins, the ends being looped over the tube.)
7. **Mirror** in tilting mount, with stem for the above rod carrier. Price £0 11 6

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Sphero-cylindrical condensers on raising and lowering stand, giving a line of light on the slit from a point source.



Fig. F 6.

Price, glass	£2 15 0
„ quartz	3 10 0

Condenser (spherical surfaces) (Fig. F 6) on raising and lowering stand.

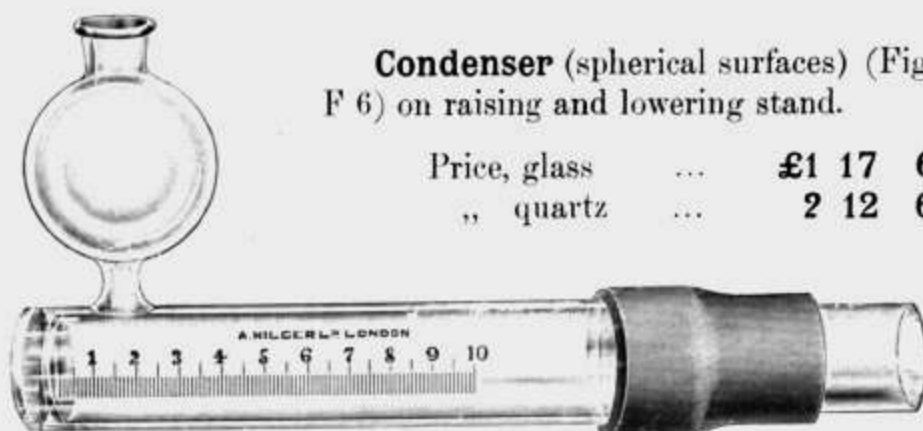


Fig. F 7.

Adjustable absorption tube for examination of the light absorption of liquids (see Baly's "Spectroscopy," First Edition, p. 414). The thickness of liquid can be read off on the scale in millimetres. With quartz end plates, 19 mm. clear aperture, as shown in Fig. F 7.

Price	£1 5 6
Engraved with logarithmic scale in addition to millimetre scale, extra	0 5 0

THERMOSTAT.

Designed by Dr T. M. Lowry for maintaining a steady flow of water at a constant temperature.

The thermostat (Fig. F 8) is constructed of teak and is lined with lead.

The water is kept of uniform temperature through vigorous circulation by the stirrer S, while the temperature is controlled by the Toluene thermo-regulator R, which automatically governs the amount of gas consumed by the heating burner. A well-made circulating pump is supplied, and the amount of water passed can be easily regulated.

The stirrer and pump are driven by a well-made 1/6 H.P. motor, which can be arranged for 110 or 220 volts.

Price, complete with motor	£16 10 0
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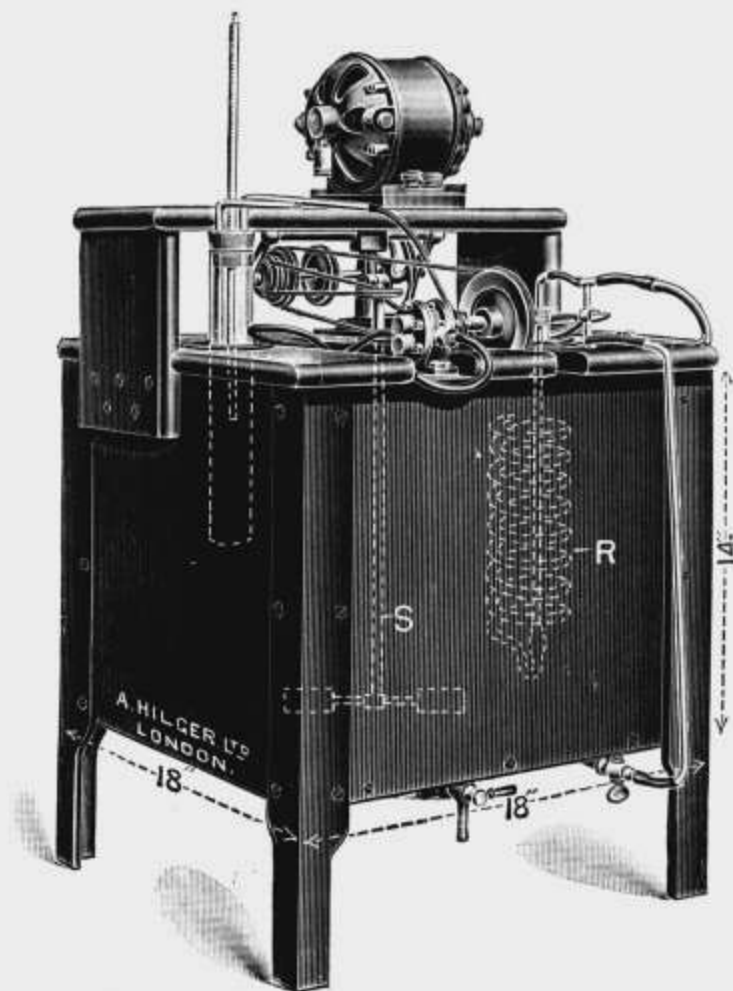


Fig. F 8.

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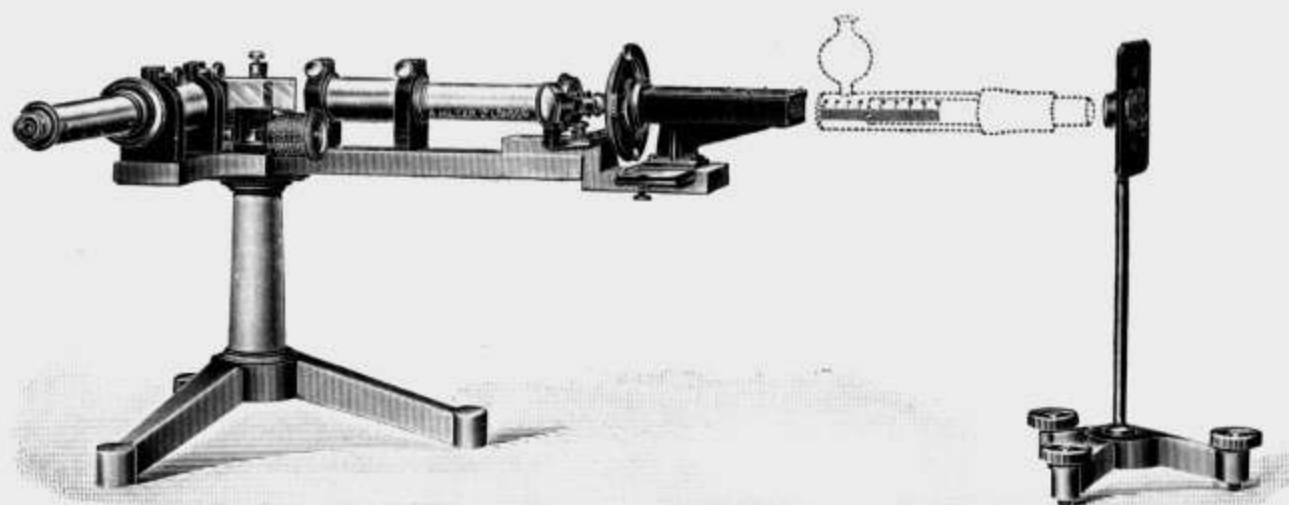


Fig. F 9.

NUTTING POLARISATION PHOTOMETER ATTACHMENT.

This is a form of polarisation photometer attachment for spectroscopes described by P. G. Nutting (*see* reprint No. 155, *Bulletin of the Bureau of Standards*), modified in one or two particulars. It can be used for all classes of spectrophotometry in the visible spectrum; and when supplied mounted on a tripod stand can be used with any ordinary spectroscope. It is also supplied mounted suitably for immediate attachment to the "Universal" form of the Hilger Wavelength Spectrometer described on p. D 4.

The combination of the Nutting Photometer with a Hilger Wavelength Spectrometer results in a spectrophotometer which is accurate as regards both the wavelength and the photometric measurements, gives a great amount of light, and is extremely rapid to use. Great care has been taken to work out thoroughly the correct conditions of illumination (a point of the utmost importance in accurate spectrophotometry), and the instrument can be thoroughly recommended for all visual spectrophotometry.

The circle is divided both in "densities" and in degrees.

The prices given below include the supply of an arrangement on separate stand for producing two parallel beams of light, by which means, together with an adjustment provided on the photometer itself, the correct conditions of illumination referred to above can be obtained with columns of liquid of any desired length. The distance between the centres of the two beams is 38 mm. This arrangement is shown in Fig. F 9.

Nutting Photometer Attachment described above, and including small electric lamp for illumination of the scale.

Price, ready for immediate attachment to the "Universal" form of Hilger Wavelength Spectrometer (*see* Fig. F 9, which shows the photometer attached in position) **£33 0 0**

Price, on separate stand with levelling screws, suitable for use with any ordinary spectroscope **£33 5 0**

Raising and lowering stand for holding tubes of absorbing liquids, taking tubes 100 mm. long and upwards, or the Baly tubes described on p. F 3; with two carriers, each with stem, similar to the carrier for Baly tube on p. F 2, the correct beam distance apart for the Nutting Photometer.

Price **£2 15 0**

100 mm. tubes with screwed end caps, for the above, each ... **0 10 0**

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SPECTROSCOPIC ACCESSORIES.

SPECTROSCOPE SLITS.

Note.—All Spectroscope Slits made by us have jaws of untarnishable metal.

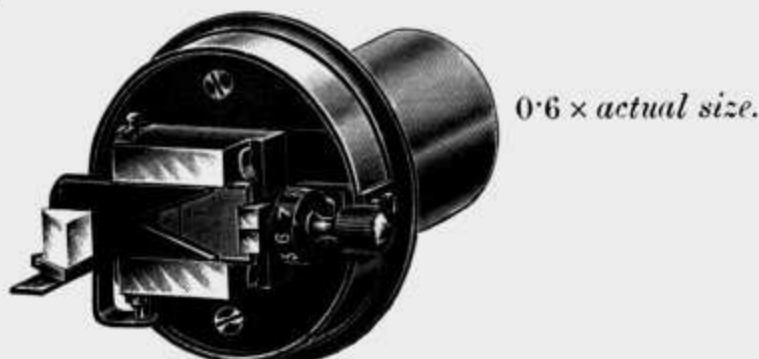


Fig. F 10.

1. Slit (Fig. F 10) with fine screw adjustment; having divided drumhead, comparison prism, wedge for reducing the aperture, screws for correcting want of parallelism of the jaws, should this become at any time necessary, and protective cap.

Price £2 12 0

Instead of the wedge a sliding diaphragm with three apertures for spectrum photography, giving the spectra in close juxtaposition, can be supplied with this slit.

Price, extra, if supplied instead of wedge £0 1 0

in addition to " 0 3 6

Price of slit No. 1, opening symmetrically (without wedge or diaphragm) 4 10 0

Maximum length of slit which can be utilised in either of the above = 7 mm.

The above slits can also be supplied giving a length of slit = 14 mm. (without reducing wedge) as follows:—

Ordinary form £2 17 6

Opening symmetrically 4 18 6

Glass window to protective cap in any of the above, extra 0 2 6

The wedges and sliding diaphragms for reducing the aperture, and the screws for correcting the parallelism of the jaws are not supplied on the above symmetrical slits.

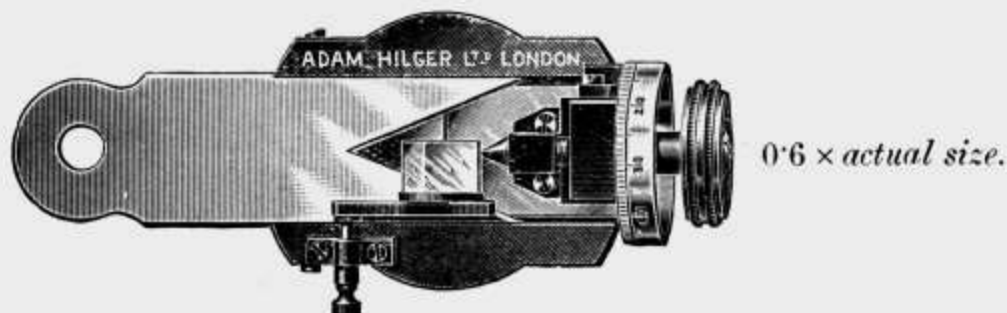


Fig. F 11.

2. Slit (Fig. F 11), with adjustment by fine steel micrometer screw, and large divided drumhead, comparison prism, wedge for reducing the aperture, and screws for correcting want of parallelism of the jaws. (Maximum length of slit which can be utilised = 18 mm.)

Price £5 10 0

Instead of the wedge a sliding diaphragm with three apertures for spectrum photography giving three comparison spectra in close juxtaposition can be supplied with this slit.

Price, extra, if supplied instead of the wedge £0 5 0

in addition to " 0 18 6

Morocco case for No. 2. 0 10 6

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CROSSED SLITS.

For many purposes it is desirable to have two slits superposed at right angles, both adjustable (*see*, for instance, our Wavelength Spectrometer modified for use with high resolving power accessories, Section O, for one use of such slits). We make these in two sizes.

(a) Main slit of the same size as slit No. 1, Fig. F 10.	
Price	£3 15 0
(b) Main slit of the same size as slit No. 2, Fig. F 11.	
Price	9 10 0

In both the above the secondary slits can be readily rotated out of the field, or entirely removed if desired. No comparison prism or wedge is supplied in either case.

Symmetrical Slit, with fine differential steel micrometer screw, $\frac{1}{50}$ and $\frac{1}{100}$ of an inch pitch, large divided drumhead, comparison prism, and wedge for reducing the aperture.

Price	£12 10 0
--------------	----------

Double and Symmetrical Slit for percentage measurements of solutions by the absorption method, with fine differential screws, each having threads of $\frac{1}{50}$ and $\frac{1}{100}$ of an inch pitch, and large divided drumhead.

Price	£21 0 0
--------------	---------

NOTE.—*This form of Symmetrical Slit can be confidently recommended where a very accurate measurement of the slit width, together with symmetrical opening, is desired.*

Note.—Vierordt's double slit method still remains the most economical of light for spectrophotometry, and with the above high-class slit a high accuracy is attainable.

For Schulz's cells for use with the double slit, see list of Optical Work, Section P.

EYEPIECES, ETC.

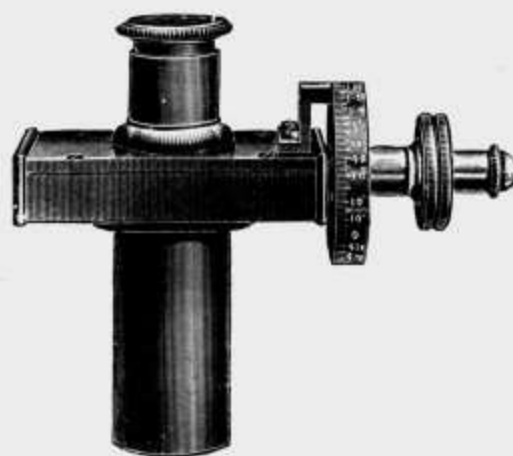


Fig. F 12.

Micrometer Eyepiece, pitch of screw = $\frac{1}{2}$ mm.

Price	£6 7 6
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Shutter Eyepiece (Fig. F 13), including one positive eyepiece, bright pointer with lateral adjustment and mirror with universal motion for illumination of the same to render it visible in a dark field, and two sliding shutters in the focal plane.

Price £4 0 0

Note.—This eyepiece has two shutters, which can be shifted in from either side at will in the focal plane to cover any desired part of the field, thereby obscuring any bright spectral lines which by their proximity hinder the observation of feebler lines. The metal pointer, whose point is ground exceedingly fine and polished bright with the greatest care, is illuminated from above by a mirror. This bright pointer is adjustable laterally by the two milled head screws below, so that one can always return to the standard reading by setting the bright pointer on a reference line.

Slide with light filters to the shutter eyepiece for giving the pointer any desired colour, by means of which an increase of accuracy and comfort in reading can be secured—especially in the violet part of the spectrum £1 5 0



Fig. F 13.

Helical Focussing Eyepiece to the Shutter Eyepiece (see Fig. F 14) of 1" (25 mm.) equivalent focal length.

Extra ... £0 13 6

Fluorescent Eyepiece, as designed by Prof. Liveing for visual work in the ultra-violet.

Price ... £2 10 0

Illumination of the pointer in above by mirror with universal motion.

Price (extra) £0 18 6



Fig. F 14.

Gauss Eyepieces.—This is a positive, or Ramsden, eyepiece with a plane glass inclined at 45° to the optical axis, placed between the two lenses. Light entering through an aperture in the side of the tube is thrown by the mirror on to the webs. A clear space is left in the middle of the mirror through which the webs can be observed. This forms a very useful accessory to a spectrometer for the accurate adjustment of the optical axis, etc.

Price £1 10 0

Autocollimating Eyepiece. having slit with adjusting screw with divided drumhead (the jaws being in the focal plane of the eyepiece), and reflecting prism.

Price £4 18 6

ADAM HILGER, Ltd., 75a Camden Road, London, N.W.

VACUUM TUBES, Etc.

(Best quality only stocked.)

Tubes of Hydrogen or other common gases.

Price, each, ordinary form **£0 7 6**

Mercury Tubes.

Price, each, ordinary form **0 8 6**

"End-on" Tubes can be supplied if desired.

Price, each, hydrogen or other common gases **0 9 6**

Price, each, mercury or cadmium **0 11 6**

Vacuum Tubes of ARGON, HELIUM, NEON, KRYPTON, XENON.

Vacuum Tubes of Krypton, or Xenon of guaranteed purity.

Price, each **£3 3 0**

Vacuum Tubes of Neon, Helium, or Argon of guaranteed purity.

Price, each **1 1 0**

Vacuum Tubes of Helium or Argon, good tubes, but purity not guaranteed.

Price, each **0 15 0**

**Vacuum Tubes of FUSED SILICA, for Ultra-Violet Work,
with secure mercury seals.**

	Ordinary Form.	End-on Form.
Filled with Hydrogen, Oxygen, Nitrogen, etc.		
Price, each	£3 4 6	£3 4 6
Filled with Helium, Argon, or Neon of guaranteed purity.		
Price, each	3 16 6	3 16 6
Filled with Krypton or Xenon of guaranteed purity		
Price, each	5 4 6	5 4 6
Unfilled, with tube for exhaust, for experimental purposes.		
Price, each	2 12 6	2 12 6

ADAM HILGER, Ltd., 75a Camden Road, London, N.W.

Vacuum Tubes of FUSED SILICA, with External Electrodes.

(Prints of vacuum tube spectra taken with these tubes will be sent on request.)

Although these tubes do not give so brilliant a discharge as the usual form, they have the advantage of absolute permanence.

Price, unsealed, for experimental purposes, with tube for exhaust	...	£0 18 0
Price, with Hydrogen, Oxygen, Nitrogen, or other common gas	...	1 10 0
Price, with Helium, Argon, or Neon of guaranteed purity	...	2 2 0
Price, with Krypton or Xenon of guaranteed purity	...	3 10 0

Sparkling Tubes with gold electrodes and platinum conducting wires for the spark spectra of metals in solutions (as used by Dr. James H. Pollok in his researches on the quantitative spectra of metals in solution; see Sci. Proc. Royal Dublin Society, vol. xi., Nos. 16, 17, 18).

Price, each ...	...	£0 16 0
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Tubes for Dr. Dupré's test for mercury in gun-cotton, etc. (see Fig. F 15).

Price, each ...	...	0 12 6
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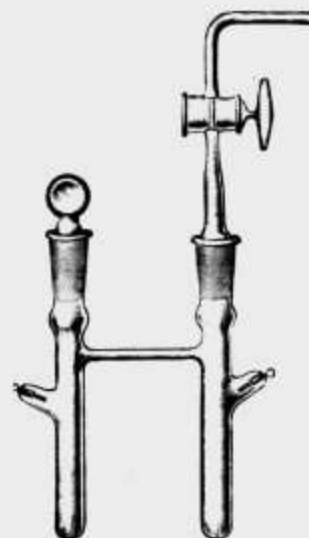


Fig. F 15.

PLANO-CONVEX LENSES OF QUARTZ (SECOND QUALITY), SUITABLE FOR CONDENSING LENSES.

<i>Diameter.</i>		<i>Focal Length.</i>		<i>Price.</i>
in.	mm.	in.	mm.	
1	25.4	3	76	£0 15 0
1 1/4	32	3 3/4	95	0 19 6
1 1/2	38	4 1/2	114	1 4 0
1 3/4	44	5 1/4	133	1 10 0
2	51	6	152	2 4 0
2 1/4	57	6 3/4	174	3 3 0

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FURTHER SPECTROSCOPIC ACCESSORIES.

The Accessories on pp. F 10-13 are particularly suitable for use with the HILGER WAVELENGTH SPECTROMETER (Constant Deviation Type), and the price in each case includes adaptation to that instrument. They can, however, be adapted at a small extra charge to almost any other form of Spectroscope.

INTERFERENCE ETALON ATTACHMENT FOR SPECTROSCOPES, for Measuring Wavelengths.

(See Paper by EDSER and BUTLER, Phil. Mag. 46, pp. 207-216, 1898.)

This device utilises the rectilinear system of interference bands formed when a beam of light from a continuous light source, after passing through a thin air film contained between two highly reflective surfaces is afterwards analysed by a prismatic spectroscope.

It consists of two plates of glass, each with one silvered surface suitably mounted with the silvered surfaces towards each other. The silvered surfaces are separated by a small distance d , which is selected according to the purpose for which it is intended to use the device.

Then if the arrangement be placed in front of the slit of a spectroscope, the plates being normal to the axis of the collimator, and the slit illuminated through the plates by a source of light giving a continuous spectrum, the spectrum will be crossed by interference bands.

If the silvered surfaces are accurately parallel to one another, the bands will be perpendicular to the spectrum; and the number of bands between any two wavelengths λ_1 and λ_2 (of which λ_2 is the greater) will be given by the relation

$$n = 2d \left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2} \right).$$

Thus by counting the bands between any two lines of known wavelengths d can be found. This being done, the wavelength of any other line can be at once determined by counting the bands between it and either of the lines of known wavelength.

The arrangement as usually supplied by us is particularly useful in photography of the spectrum with the camera attached to the Hilger Wavelength Spectrometer,

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shown on p. D 2. It is so mounted as to utilise the means of attachment to the slit normally occupied by the comparison prism, and is shown thus attached in Fig. F 16.

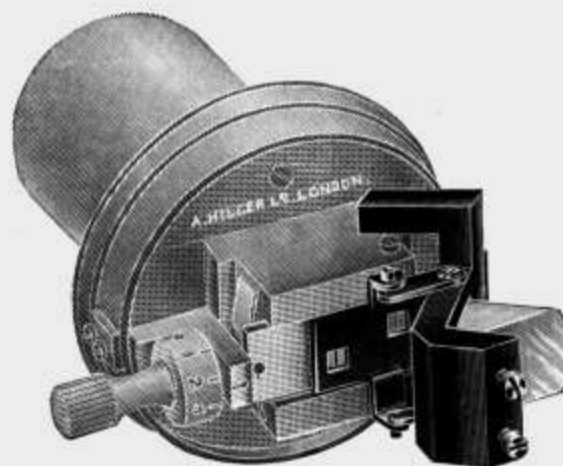


Fig. F 16.

The light enters from the side, as with an ordinary comparison prism, being reflected along the axis of the collimator by a right-angled prism.

Immediately in front of the slit is a diaphragm pierced with two apertures. It is so attached to the etalon mount as to move sideways when the latter is rotated in or out of position, in such a manner as to illuminate the lower half of the slit when the etalon is out of the field and the spectrum of the source under test is being examined, and the upper half when the etalon is in position. The kind of photograph obtained is shown on an enlarged scale in Fig. F 17, which is a reproduction of an actual photograph.

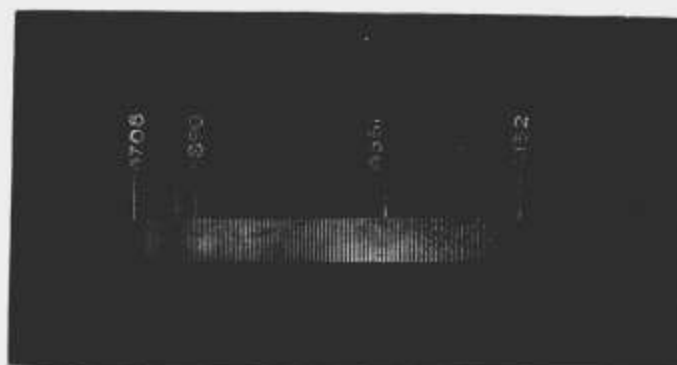


Fig. F 17.

Price, complete, ready for mounting on any Hilger Wavelength

Spectroscope	...	...	...	...	...	...	£3 10 0
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Same as above (Comparison Prism Form), but without the sliding diaphragm.

Price	...	...	...	...	...	...	£2 14 0
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Simpler Form, consisting only of two suitably silvered discs mounted in a cell which must be held in front of the spectroscope. (This form can be used with any spectroscope.)

Price	...	...	...	...	...	...	£1 2 0
-------	-----	-----	-----	-----	-----	-----	--------

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INFRA-RED ACCESSORIES

The Hilger Wavelength Spectrometers, in common with other spectrometers in which the lenses and prisms are of glass, although not suitable for the extreme infra-red, are nevertheless capable of use considerably beyond the visible spectrum. With the additions described below they can, moreover, be calibrated interferometrically down to W.L. 2.0μ (the visible spectrum extends from about 0.38μ to 0.8μ). This is as far as water transmits, thus the instrument is quite suitable for measurements of the absorption of aqueous solutions in the infra-red.

The Additions required are as follows:—

Hilger Thermopile (*see* p. F. 14) sensitive area 20×1.5 mm., suitably mounted on tube to fit in place of eyepiece of Hilger Wavelength Spectrometer, with symmetrical slit; symmetrical slit to replace that usually supplied for the collimator, with 20 mm. effective length of jaw; simple shutter attachment clamping to the Spectrometer for exposing and cutting off light; helical drum divided into 100 parts per revolution to replace the wavelength drum for infra-red work.

Price £16 0 0

If the additions be ordered at the same time as the Wavelength Spectrometer, then instead of an additional wavelength drum for infra-red work one extended drum alone will be supplied calibrated in wavelengths up to W.L. 8000, and beyond that point divided into 100 parts per revolution; or the said extended drum can be supplied calibrated in wavelengths throughout both the visible and infra-red regions, as far as W.L. 2.0μ , at an extra charge of £4 10 0

The following table gives the average error of wavelength reading for various regions of the spectrum in the case of the Hilger Wavelength Spectrometer (constant deviation type) with dense prism. The figures have been obtained by readings on actual instruments:—

	VISIBLE.					INFRA-RED.		
Wavelength in $\mu\mu$	400	500	600	700	800	1000	1700	2000
Average error in $\mu\mu$	0.1	0.1	0.16	0.3	0.5	3.0	7.0	8.0

Galvanometer (Cambridge Scientific Instrument Co.'s Make) specially selected for use with the above.

Price £8 13 3

Scale, on stand, with Nernst lamp for use with this Galvanometer (strongly recommended). In ordering, the voltage of the electrical supply should be stated

Price, with flexible lead, holder, and plug adapter £2 16 0

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Further Spectroscopic Accessories

F 13

Interference Etalon Attachment, on raising and lowering stand, on the same principle as that described on p. F 10, but of suitable dimensions for use with the above apparatus in the infra-red up to W.L. $2.0\ \mu$.

Price £4 0 0

A portion of the curve obtained using this etalon with the other infra-red accessories on a Hilger Wavelength Spectrometer is shown in Fig. F 18. The source of light was a Nernst lamp.

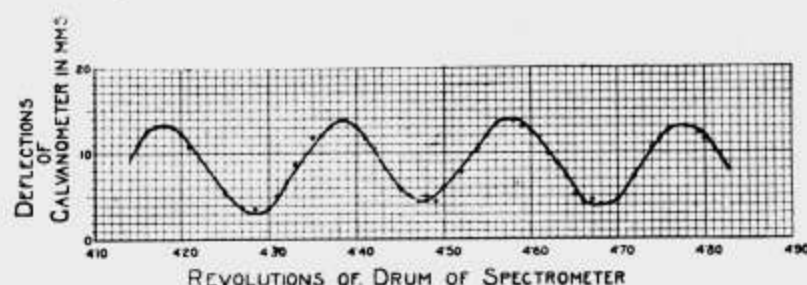


Fig. F 18.

The etalon was placed immediately in front of the slit, so that the light from the Nernst lamp passed through it before being submitted to the analysis of the spectrometer. An image of the filament of the lamp was concentrated on the slit by means of a condensing lens. The helical drum actuating the prism of the Wavelength Spectrometer was set to a position well in the red, and a reading taken of the galvanometer deflection when the light was allowed to pass by opening the shutter.

The helical drum was then moved two divisions, and a similar reading taken. The process was repeated in the direction of the infra-red, and the curve shown in Fig. F 18 obtained by plotting the results. From the positions of the maxima, combined with readings on two known wavelengths in the visual part of the spectrum, the calibration of the Spectrometer can be carried out.

Price, with plates of quartz £5 0 0

HILGER THERMOPILES.

(LINEAR THERMOPILES OF GREAT SENSITIVENESS.)

The Design for this Thermopile is registered in the United Kingdom, and is protected by Design Patents in France, Germany, and U.S.A.

THE following thermopiles are the result of experiments in our laboratories, undertaken with a view to putting on the market a thermopile of great sensitiveness for spectrum work. Our experiments during 1912 convinced us of the soundness of the principles of construction laid down by Johansen in his very valuable paper in the *Annalen der Physik*, (4) **33**, p. 517; 1910, and it is on the general principles enunciated in that paper that our thermopiles are constructed. The distinctive design is our own.

We have supplemented the work of Johansen by experiments in our own laboratory on the distribution by convection, conduction, and radiation of the energy received by the thermopile; and from the data thus obtained we are able to calculate very closely for each size of thermopile the number of elements, dimensions of lead wires, etc., which will produce the maximum sensitiveness. It should be noted that there is in each case a particular number of elements giving maximum sensitiveness, and thermopiles having more than this number are *less* sensitive.

To obtain greatest sensitiveness the galvanometer should have a resistance not greatly different from that of the thermopile.

The couple chosen is Bismuth-Silver, a combination which produces a thermopile superior in sensitiveness to any other couple which has yet been tried for this purpose, with the exception of Bismuth-Iron.¹ Although the latter is somewhat more sensitive, the iron is very subject under ordinary working conditions to rust, which may render the thermopile useless in a few weeks. The receiving-plates are of silver foil.

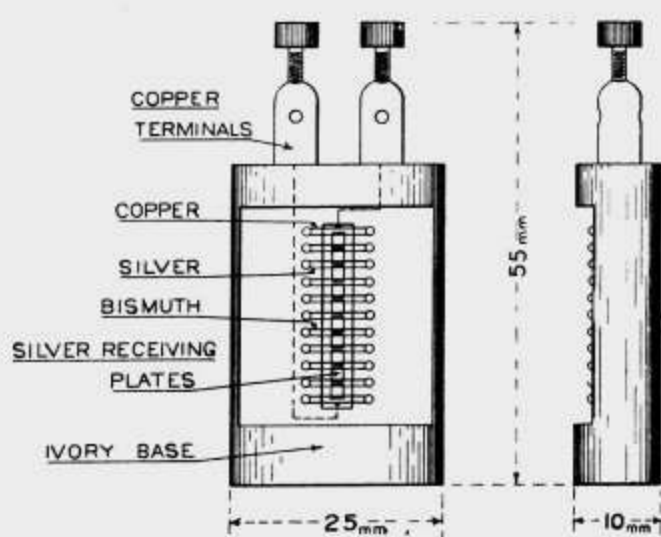


Fig. F 19.

The thermopile for use in air is shown in diagram in the Figure. It can be supplied either in a simple mount or in a symmetrical slit.

The simple mount (Fig. F 20) has a tube with eyepiece and a protecting tube which can be screwed on over this eyepiece tube without disarranging the eyepiece. It also has a tube with the standard fitting for the telescopes of our spectrometers.

The symmetrical slit mount is also provided with these same tubes.

Both the above mounts are

arranged for attachment to a raising and lowering stand.

¹ A further exception is Bismuth-Tellurium. We have made thermopiles of Bismuth-Tellurium, a couple which gives, for equal rise of temperature, an E.M.F. about eight times as great as Bismuth-Silver; but have not yet been able to produce them of sufficient permanence, mechanical soundness, or rapidity of action to justify our placing them on the market.

ADAM HILGER, Ltd., 75a Camden Road, London, N.W.

The following thermopile, designed for use in air, can be delivered from stock :—

Dimensions of sensitive area—20 mm. long; 1.5 mm. wide. Number of junctions, 10.

Resistance (approximate)—2.8 ohms



Fig. F 20.

Price of thermopile described above, mounted in simple mount ...	£7	0	0
" " " symmetrical slit	10	3	0
Raising and lowering stand to take either of the above, extra ..	1	5	0
Sensitive portion of above thermopile alone, in brass case ...	4	10	0

We can also supply thermopiles having sensitive areas as follows :—

<i>Length.</i>	<i>Width.</i>	<i>Price Simple Mount.</i>	<i>Symmetrical Slit.</i>
10 mm.	1 mm.	£7 12 6	£10 15 6
10 mm.	0.5 mm.	7 12 6	10 15 6

which are interchangeable in the mounts described above; and we can further supply thermopiles designed to have maximum sensitiveness when used in vacuo.

Broca Galvanometer (made by the Scientific Instrument Co., Cambridge), selected as being suitable for general work with the thermopile.

[illegible]

Paschen Galvanometer (made by the Scientific Instrument Co., Cambridge).—This is a modified form of the Thomson Galvanometer, and was specially designed by Professor Paschen for radiometric measurements. The magnet system consists of two groups of thirteen magnets arranged alternately on opposite sides of a fine glass stem. The coils are elliptical in shape, and are wound with six different sizes of wire, with the object of producing a maximum field for a given resistance of copper. The sensitivity is about forty times as great as that of the Broca Galvanometer. The period can be varied by means of a control magnet.

Price of the galvanometer having a resistance of about 3 ohms. ...	£34 13 0
--	----------

Scale, on stand, with Nernst lamp for use with the above galvanometers.

Price, extra	...	...	...	...	...	...	...	£2 16 6
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ADAM HILGER, Ltd., 75a Camden Road, London, N.W.

SENSITIVE PLATES FOR SPECTROGRAPHIC WORK.

THE following plates, manufactured by Messrs WRATTEN & WAINWRIGHT, Ltd., are those which we have found the best for general Spectrographic work. The sizes indicated by larger type are those which are used for all our stock Spectrographs, and may be had by return of post.

- PANCHROMATIC "A" . . . Sensitive from the Ultra-violet up to 6800 Å.U.
 PANCHROMATIC "B" . . . Rather less green sensitive than Panchromatic "A," but sensitive to about 7800 Å.U.
 WRATTEN "M" . . . Of similar sensitiveness to Panchromatic "A," but of much finer grain and about one-third the speed.
 ALLOCHROME . . . Evenly sensitive to about 5600 Å.U.
 DOUBLE INSTANTANEOUS . . . A fast "ordinary" plate of fine grain suitable for Ultra-violet work.

Not only are these plates extremely sensitive, but they keep good for a long time.

SIZE.	PRICE PER DOZEN.		SIZE.	PRICE PER DOZEN.	
	Panchromatic A or B, or M.	Allochrome or D. Instant.		Panchromatic A or B, or M.	Allochrome or D. Instant.
Inches.			Centimetres.		
$4\frac{1}{4} \times 1$. . .	1/6	1/-	2.5×10 . . .	1/-	/8
$4\frac{1}{4} \times 3\frac{1}{4}$ } . . .	2/-	1/6	3×9 . . .	1/6	1/-
$6\frac{1}{2} \times 1\frac{1}{2}$ } . . .			6×9 . . .	1/6	1/-
$6\frac{1}{2} \times 2$ } . . .			6.5×9 . . .	1/6	1/-
$6\frac{1}{2} \times 2\frac{3}{8}$. . .	2/2	1/8	4.3×18 . . .	2/-	1/6
$6\frac{1}{2} \times 4\frac{3}{4}$. . .	4/3	3/3	9×12 . . .	2/4	1/9
$9\frac{3}{4} \times 4\frac{1}{4}$. . .	6/-	4/6	* 4×24 } . . .	3/4	2/6
* 10×2 . . .	3/-	2/3	* 4×30 } . . .		
* 10×4 . . .	6/-	4/6	* 6×24 } . . .		
* 12×2 . . .	5/-	3/9	13×18 . . .	5/4	4/-
* $12 \times 2\frac{1}{2}$. . .	5/6	4/3	5.5×50 . . .	10/6	8/6
12×3 . . .	7/-	5/4			

Other sizes at corresponding prices.

* We can supply plates of these sizes coated on extra thin glass to bend to a radius of about 30 inches (75 centimetres) at an increase of 25 per cent. on the above prices. For greater curvature than this we recommend the use of celluloid film. This (about 0.5 mm. in thickness) can be made to order at an advance of 50 per cent. on plate prices. All plates may be had backed at a slight extra charge.

Messrs WRATTEN & WAINWRIGHT, Ltd., also make LIGHT FILTERS, of which upwards of eighty varieties are now stocked, either transmitting narrow bands, or cutting out a specified region of the spectrum. Price Lists on application.

ADAM HILGER, Ltd., 75a Camden Road, London, N.W.

Index of Spectra, by W. MARSHALL WATTS, D.Sc. (Lond.), B.Sc.

(Vict.), F.I.C. Revised Edition, greatly enlarged. Will be sent post free at the following price:—Bound volume, including Appendix A, £1, 5s. (Specially recommended.)

And the following Appendices, in paper covers:—

- Appendix B (Table of corrections to reduce to Rowland's standard, ultra-violet Spectra of Co and Ni, etc.), 3s. 6d.
- Appendix C (Spectrum of Iron, telluric lines of solar spectrum, spectrum of Hydrogen), 7s. 6d.
- Appendix D (Arc-spectra of Ga, Li, Na, K, Rb, Cs, Mg, Ca, Zn, Sr, Cd, Ba, Hg, absorption spectrum of Bromine, Arc-spectrum of Alumina), 5s. 6d.
- Appendix E (Spectra of Air, Cu, Ag, Au, Al, In, Tl, C, CN, N, Si, Ammonia, and the Table of reductions to vacuum), 4s. 6d.
- Appendix F (The Arc-spectra of Cr, Sn, Pb, Sb, Bi, flame-spectra of K, Na, Li, Ca, Sr, Ba, etc.), 3s. 6d.
- Appendix G (Rowland's Standard Wavelengths, Spectra of Hg, He, Cd, etc., and oxyhydrogen spectra), 5s. 6d.
- Appendix H (The three spectra of Argon, the arc-spectrum of Ti, the spark-spectra of Cu, Ag, and Au), 5s. 6d.
- Appendix I (The arc- and spark-spectra of Co and Ni, and "Index Indicis"), 5s.
- Appendix J (The spark-spectra of Fe and W, and the arc- and spark-spectra of Pt), 8s.
- Appendix K (Spectrum of Chlorine, and the spark-spectrum of Mo), 5s.
- Appendix L (Spectra of Bromine, Gallium and Radium, and the spark-spectrum of Uranium), 7s. 6d.
- Appendix M (The arc-spectra of Mn and V, the spark-spectra of V, Au and Si, and the spectrum of Argon), 6s.
- Appendix N (Flame-spectrum of Radium, infra-red spectra of Alkalies, ultra-violet spectrum of Thorium), 4s.
- Appendix O (Arc-spectrum of Mo, spark-spectra of Ca, Sc, In, Be, Li, Tl, K, Cs, Sb, As, Ra), 4s.

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Appendix P (Arc- and spark-spectra of Ruthenium, Yttrium: Line- and Band-spectra of Sulphur), 7s. 6d.

Appendix Q (Spectra of Neon, Xenon, and Krypton; and a second "Index Indicis"), 4s. 6d.

Appendix R (Spark-spectrum of Cr, arc- and spark-spectra of Pa, and the spectra of Polonium and Ex-radio), 5s. 6d.

Appendix S (Arc- and spark-spectra of Ir, Os, and Rh), 10s. 6d.

Appendix T (Arc- and spark-spectra of Tantalum, Zirconium, and Lanthanum), 8s.

Appendix U (Table of Stronger Lines of the Elements, arranged according to Wavelength), 10s. 6d.

Note.—(Specially recommended).—Appendices B to I inclusive are also supplied bound in one volume, price £2, 3s.

Appendices J to Q inclusive, bound in one volume, price £2, 8s.

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Cable Code—Western Union.

September 1913.

SECTION J.*

POCKET AND OTHER DIRECT VISION SPECTROSCOPES.

DIRECT VISION SPECTROSCOPIC ATTACHMENT for use with any ordinary Stand or Hand Camera.

The attachment consists of a tube carrying a short focus achromatic object glass, slit with sliding diaphragm for obtaining comparison photographs, and a film diffraction grating of 14,000 lines per inch.

It is shown in Fig. J 1 screwed in front of an ordinary hand camera.

Fig. J 2a is a process reproduction (actual size) of a photograph of the arc spectra of copper and brass¹ taken with the attachment mounted on a camera with a $7\frac{1}{2}$ " focus lens, use being made of the sliding diaphragm for obtaining comparison photographs. The definition of the spectrum lines is unfavourably represented in the reproduction, but in the actual photograph is quite good, the optical work of the attachment itself being made with such precision as not to impair the definition of the finest photographic lenses.

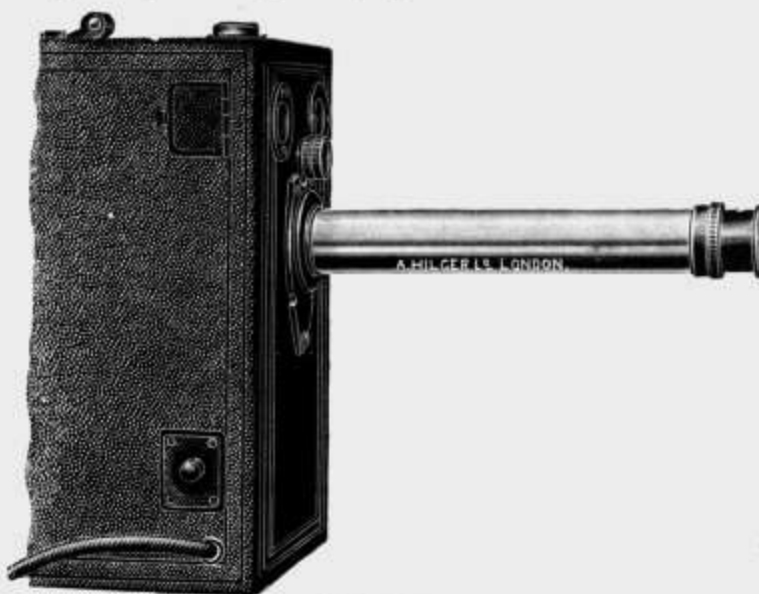


Fig. J 1.

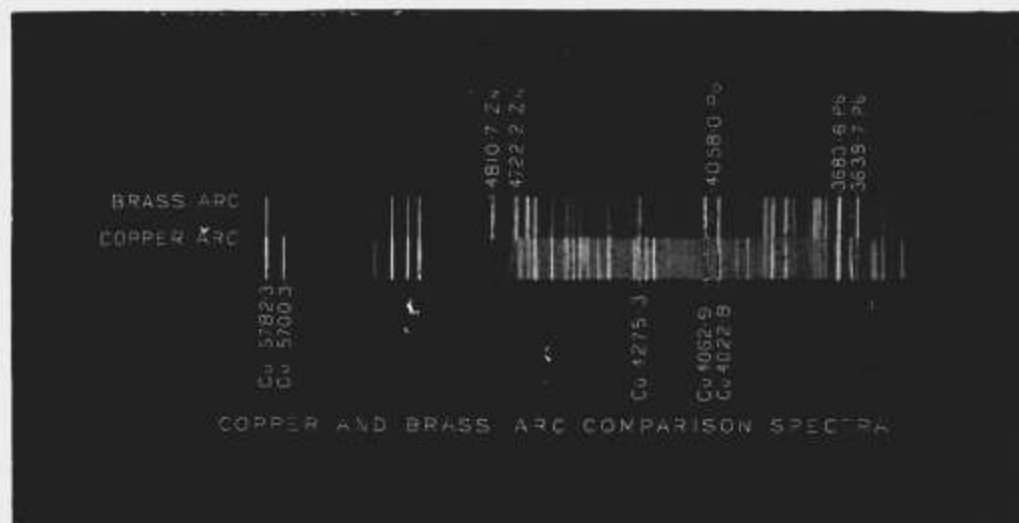


Fig. J 2a.

¹ Note the presence of copper in the brass, indicated by the more persistent copper lines being present in the brass spectrum; and of lead in both specimens.

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Fig. J 2b is from photographs taken on an Ordinary and on a Panchromatic plate using the wedge method of Dr C. E. Kenneth Mees (see *Brit. Jour. of Phot.*, 1907, p. 384). The curves represent the sensitiveness of the respective plates for light of various wavelength.

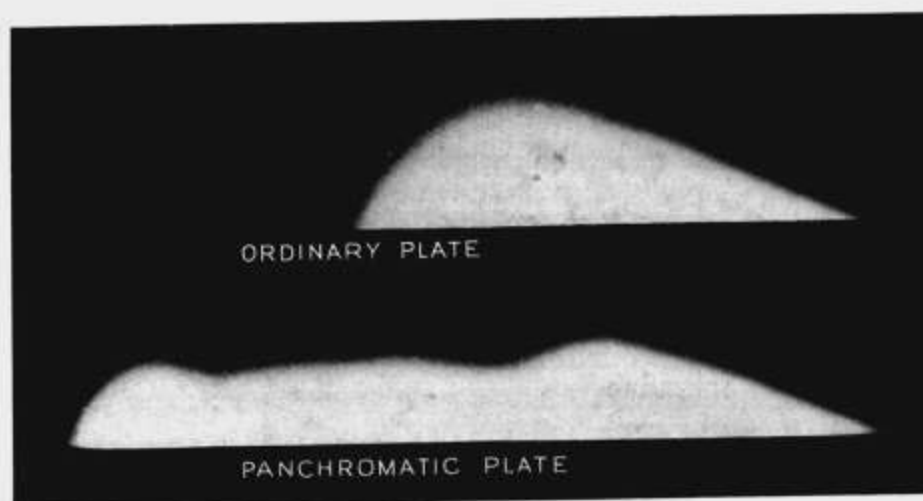


Fig. J 2b.

In spite of the simplicity of this attachment, it will perform in an entirely satisfactory manner a wide range of work, including—

Spectrum analysis of metals, alloys, salts, etc.

Comparison of colour sensitiveness of different photographic plates, by means of the wedge method.

Comparison of dyes and of light filters.

Sun spectrum photographs, and comparison of the Fraunhofer lines with those of the metals from which they originate.

Absorption spectra of blood, and other organic substances.

Price, including adaptation to camera £4 5 0

Accurate Wedge of neutral tint glass adapted to fit on in front of the slit; for testing colour sensitiveness of different photographic plates, price 2 2 0

In ordering, give particulars of the camera lens mount, or of the camera front in the case of hand cameras of the box form.

1. **Ramsay Spectroscope**, for use in the rapid examination of vacuum tubes, small prism.

Price £0 15 0

2. **Ramsay Spectroscope**, large prism.

Price 1 0 0

Brass case for either of the above 0 1 6

3. **Direct Vision Pocket Spectroscope with fixed slit**, $3\frac{1}{2}$ inches long.

Price with protective cap with glass window and brass case ... £1 5 0

(The above instrument is specially suitable for the observation of absorption bands, etc.)

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Fig. J 3.

4. **Direct Vision Pocket Spectroscope**, 2 inches or $3\frac{1}{2}$ inches long, with adjustable slit, prism of high dispersion and protective cap over the slit with glass window, in brass case (Fig. J 3). Suitable for Rainband observations.

Price £2 0 0

5. **Direct Vision Pocket Spectroscope**, $5\frac{1}{2}$ inches long, with adjustable slit and large compound prism of high dispersion, in brass case.

Price £2 10 0



Fig. J 4.

6. **Direct Vision Pocket Spectroscope, with photographic scale**, and with rotating mirror for illumination of the same (Fig. J 4). The scale is reflected in the prism face so as to be seen in juxtaposition to the spectrum. These scales are exceptionally fine, and very good readings can be obtained with this instrument.

Price, in morocco case £3 10 0

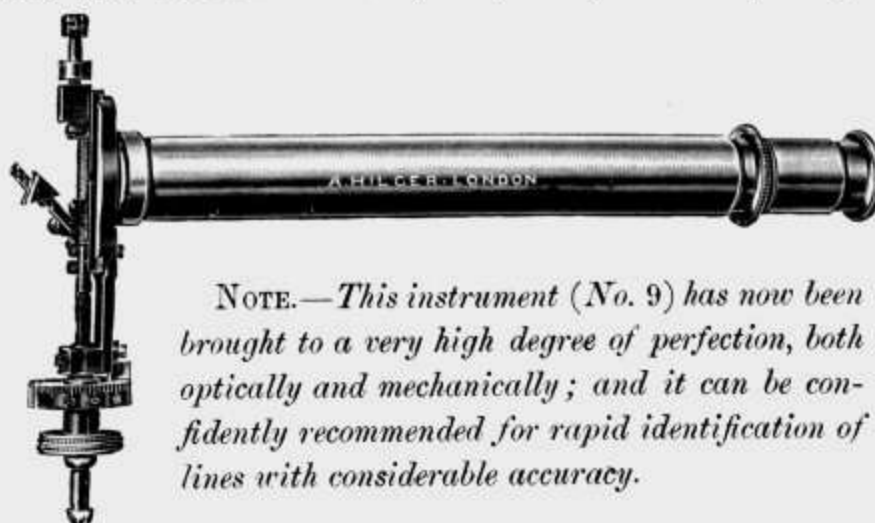
7. **Direct Vision Pocket Spectroscope**, $5\frac{1}{2}$ inches long, with adjustable slit, compound prism of high dispersion, and condensing lens in front of the slit, for examination of rays proceeding from a particular part of any source of light, an image of the source being formed on the slit, in brass case.

Price £3 0 0

Comparison prism, Nos. 3 to 7, price (extra) 0 10 6

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9. **Direct Vision Spectroscope** (Fig. J 5), $8\frac{1}{2}$ inches long, having adjustable slit, with divided drumhead, compound prism of high dispersion, and positive eyepiece,



NOTE.—*This instrument (No. 9) has now been brought to a very high degree of perfection, both optically and mechanically; and it can be confidently recommended for rapid identification of lines with considerable accuracy.*

separating the yellow sodium lines distinctly. Fine micrometer screw motion for passing through the spectrum and pointer, enabling wavelength determinations to be made with considerable accuracy.

Price ... £9 10 0

Comparison prism to No. 9, price (extra)

£0 12 6

Fig. J 5.

10. **Direct Vision Pocket Spectroscope**, mounted with **Film Replicas of Rowland's Diffraction Gratings**, 14,438 lines per inch, **Visible spectrum over 20°** .

$5\frac{1}{2}$ inches long, with adjustable slit, in brass case £3 0 0

Comparison Prism to No. 10, price (extra) 0 10 6

Morocco case for No. 9.

Price (extra) 0 15 6

Bright pointer for No. 9, with reflecting mirror having universal motion to illuminate the pointer in any position of the spectroscope.

Price (extra) £1 6 0

Table stand for Nos. 3 or 4, with universal tilting motion.

Price 0 18 6

Table stand for Nos. 5, 6, 7, or 10, with hinge clamp for the spectroscope, universal tilting motion, and clamp for raising and lowering.

Price £1 12 6

Table stand for No. 9, on cast-iron tripod, with hinge clamp, universal tilting motion, and clamp for raising and lowering.

Price £2 2 0

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DIRECT VISION POCKET SPECTROSCOPE WITH INTERFERENCE ETALON.

GLASS INTERFERENCE ETALON for use with Direct Vision Pocket Spectroscope, showing the Fabry & Perot Ring System.

With this accessory, which is designed to fit our No. 5 Direct Vision Pocket Spectroscope (*see p. J 3*), the individual lines of a spectrum are subjected to a resolving power¹ of about 100,000. The Zeeman effect can be detected on suitable radiations (such as the yellow helium line), a distinct tripling of the line being visible.

The addition consists of an Interference Etalon of glass, that is, an accurately plane-parallel disc of glass, the polished surfaces of which are silvered to such a degree that only a small part of the light is transmitted, the majority being reflected. Light entering by the slit is then subjected to interference by multiple reflection within the plate in a manner analogous with that in the case of the Fabry & Perot Interferometers and Etalons.² The silver films on the surface are deposited with the greatest care in the manner recommended by Professor Fabry so as to obtain the most sharply-defined and bright intensity maxima in the ring system, and a cover is provided for the protection of the silvered film when the Etalon is not in use.

The Etalon, E, is carried in a mount (as shown in Fig. J 6) which screws in

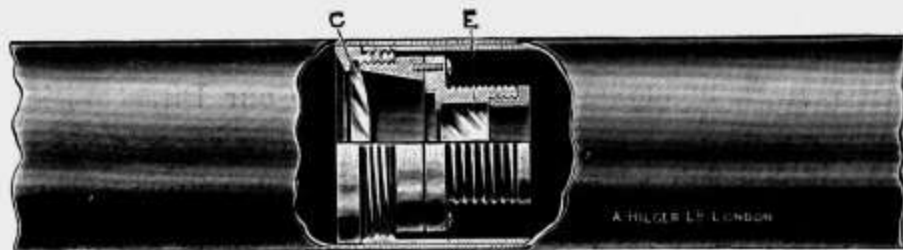


Fig. J 6.

place of the cell carrying the collimating lens of the Spectroscope. The mount carries its own collimating lens, C, and is provided with screws whereby the Etalon is set perpendicular to the axis of the Spectroscope. The position of the mount M in the Spectroscope is indicated in Fig. J 7.



Fig. J 7.

¹ Resolving power = $\frac{\lambda}{\Delta\lambda}$ where λ and $(\lambda + \Delta\lambda)$ are in the wavelength of two radiations which can just be detected as separate.

² For bibliography concerning Fabry & Perot Interferometers, *see p. N 6*.

The instrument is suitable for use with any light source which emits radiations sufficiently intense and pure, such, for example, as a copper arc, a mercury vapour lamp, or a helium vacuum tube. When such radiations are examined, the following appearance is seen in the eyepiece:—

- (1) The lines of the spectrum are visible in the same positions as they would occupy were the Etalon removed, but of course far less bright.
- (2) Each spectrum line is a diametrical strip of the interference ring system produced by the light of that wavelength. This appearance on one of the spectrum lines is shown in Fig. J 8; while Fig. J 9 shows the same

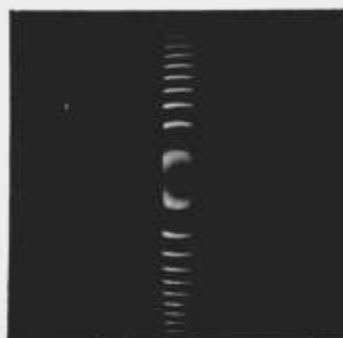


Fig. J 8.



Fig. J 9.

line submitted to the Zeeman effect, the magnet used having a field strength of 6,000 Gauss and a Nicol prism being interposed between the Spectroscope and the light source.

Price of No. 5 Direct Vision Pocket Spectroscope, 5½" long, with high dispersion compound prism	...	...	...	£2 10 0
Price of Etalon, including the adaptation to our Direct Vision Pocket Spectroscope No. 5	...	...	...	1 3 0
Similar Etalons can be supplied adapted to any other Pocket Spectroscope. Price	...	...	...	1 7 6

DIRECT VISION SPECTROSCOPE for Rapid Spectroscopic Observation of Spark, Arc, or other light sources which, when viewed from any distance exceeding a yard or two, are approximately point sources.

This instrument has no slit, being similar in principle to the Ramsay Spectroscopes mentioned on p. J 2; but with the addition of a combination of a fixed cylindrical with a movable spherical lens which extends the points of light into spectrum lines and enables one to focus them as in the ordinary Direct Vision Spectroscope.

Thus light sources at any distance can be examined and sharp lines obtained even by observers having imperfect power of eye accommodation.

Price in brass case	..	..	..	..	..	£1 2 6
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September 1913.

SECTION K.*

DIFFRACTION GRATINGS.

Rowland Diffraction Gratings.—A stock of diffraction gratings, ruled at the Johns Hopkins University, both plane and concave, is always kept. The best quality only are stocked. Price lists and particulars of gratings in our stock will be sent post free on application.

For Concave Grating Spectrographs, see Section E.

For Wavelength Spectrometer, Constant Deviation Type, with Diffraction Grating, see Section D, "Wavelength Spectrometers."

Film Replicas of Rowland's Diffraction Gratings. (14,438 lines per inch.)

1. Mounted on worked plate glass, for use with table spectroscopes.
Price, in morocco case £0 18 6
2. Mounted on best plane parallel worked glass, for use with table spectroscope, specially selected gratings.
Price, in morocco case £1 17 6
Mounting with three levelling screws for either of above gratings.
Price 1 2 6
3. Mounted in 5½ inch long direct vision pocket spectroscope, with fixed slit, in brass case. *Visible spectrum over 20°.*
Price £1 17 6
4. Mounted in 5½ inch long direct vision pocket spectroscope, with adjustable slit in brass case. *Visible spectrum over 20°.*
Price £3 0 0
5. Mounted on field glasses (adapted to customers' own instruments) for eclipse observations.
Price £2 10 0
6. Dr Marshall Watts' Binocular Spectroscope or spectroscopic opera-glass.
Price 3 3 0
7. Photographed Gratings, 3,610 lines per inch, for demonstration purposes.
Price 0 7 6

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For Michelson Echelon Diffraction Gratings, see our separate Illustrated List B.

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SECTION L.*

MICROMETERS, Etc.

NOTE.—The term "Micrometer" is often applied indiscriminately to any screws of fine pitch, sometimes even to screws cut with dies. We wish it to be noted that we invariably imply by it a screw well cut between dead centres on a special lathe with tested screw, and fitted and ground into its nut with due care and skill.

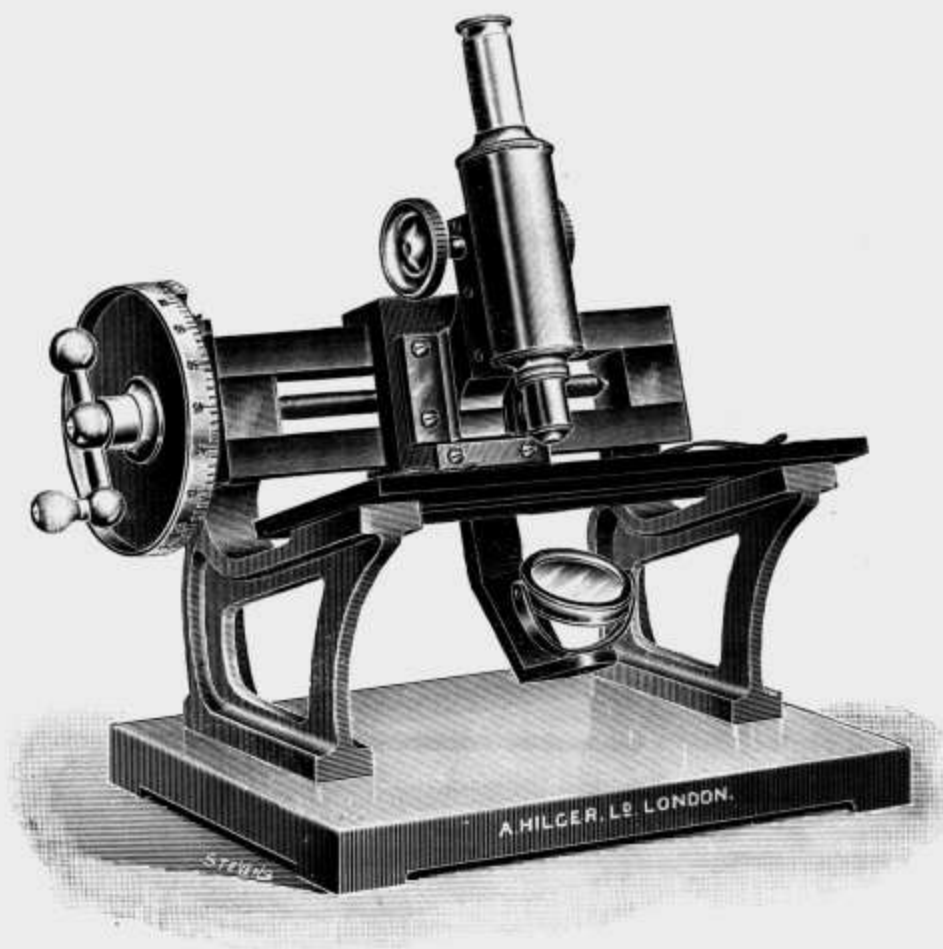


Fig. L 1.

Photomeasuring Micrometer, 1913 MODEL (Fig. L 1).—The latest model of this instrument has the following modifications, which experience has shown to be of very great value in facilitating readings:—

The mirror moves with the travelling microscope.

The milled head for turning the screw has been replaced by a handle.

The standards which support the slide and substage are so designed that the axis of the microscope is sloped towards the observer.

A vernier has been added, reading to 0.001 mm.

Though specially designed for accurate and rapid measurements of spectrum photographs, this instrument can be used with equal advantage for any of the accurate length measurements the need for which so often arises in a laboratory.

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The objects aimed at in its construction are:—

- i. Accuracy.
- ii. Long life under frequent use.
- iii. Rapidity and convenience of working.

I. Is attained by the greatest care being exercised in the manufacture of the steel screw, its nut, the gunmetal slide which bears the microscope, and the shoulder fitting of the screw.

II. Is attained by strict simplicity of design, and by the provision of adequate bearing surfaces in screw and microscope slide. The deep thread of the screw and its substantial diameter are the main points to be noted in this respect.

III. Is attained by making the screw of fairly large pitch, *i.e.*, 1 mm., and putting on a specially large divided drumhead and vernier. With the aid of the handle now provided, one can pass rapidly over the whole range of motion, while at the same time the large drumhead enables measurements to be taken to 0.001 mm.

The base is of cast-iron, and the microscope slide is mounted on two cast-iron standards, of such a shape as to form convenient handles for moving the instrument.

Price, with 6-inch (152 mm.) travel	...	...	...	£36 10 0
Price, with 3-inch (76 mm.) travel ...	...	...	...	30 10 0

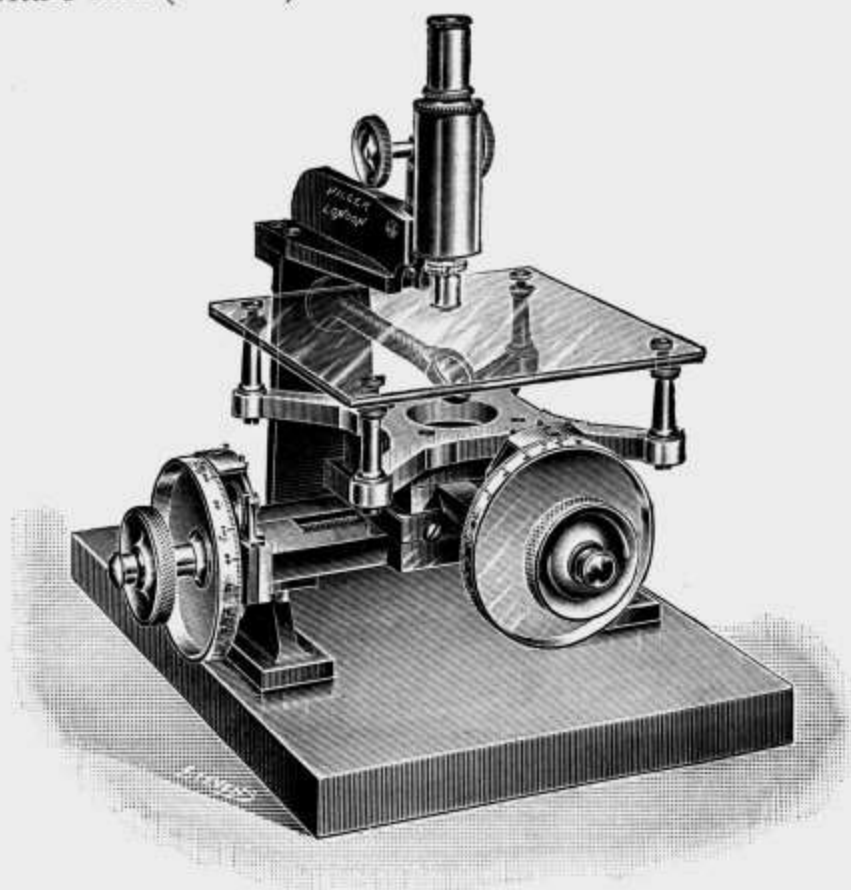


Fig. L 2.

NEW MODEL CROSS-SLIDE PHOTOMEASURING MICROMETER. Fig. L 2.

In this instrument the photographic plate moves, the microscope being rigidly fixed. Six inches (152 mm.) of motion is provided in two directions at right angles to each

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Micrometers

L 3

other, the distance being measured by accurate screws similar to those of the instrument described above, massively and rigidly mounted, and of the highest accuracy.

Price (6-inch travel in two directions at right angles to each other) £67 10 0

High Quality Spherometers with $\frac{1}{100}$ inch micrometer screws, and radius of 1 inch.

Price, in morocco case £5 10 0

High Quality Spherometers, radius of 2 inches.

Price, in morocco case 25 0 0

Smaller, larger, or intermediate sizes to order. The screws can be in the metric system if desired.

"Standard" Spherometer (Ring Form). Fig. L 3.

This form of spherometer has a ring instead of the usual three legs. The ring is optically ground so as to have two truly circular edges, one of which makes contact with concave surfaces, and the other with convex surfaces. The inside and outside diameter are accurately measured. With this instrument readings can be obtained as reliable as those of the most elaborate instruments obtainable.



Fig. L 3.

Price £8 10 0

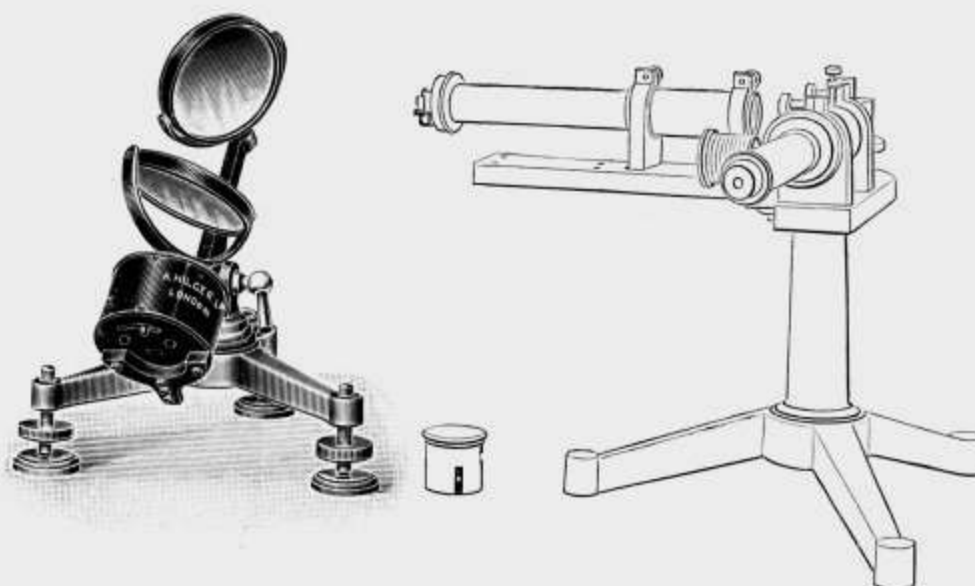


Fig. L 4.

Heliostat for use with Table Spectrometers, see Fig. L 4; which shows the heliostat in position before a Wavelength Spectrometer.

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Micrometers

L 4

These heliostats have mirrors which are optically polished, but are not of first quality. The mirrors are silvered on the back.

The clock motion is sufficiently good to ensure light from the sun being reflected on to the slit of a spectrometer for many hours without readjustment.

Price £15 0 0

Larger sizes with optically plane silvered glass or speculum metal mirrors quoted for on application.

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SECTION M.*

POLARIMETERS AND REFRACTOMETERS.

We strongly recommend that where feasible the light of the Mercury Vapour lamp should be used in place of the Sodium flame. Greater accuracy and far greater comfort and convenience of reading are thus obtained (see Lowry, "The Rotatory Dispersive Power of Organic Compounds," Trans. Chem. Soc., 1913, vol. 103, p. 1064), Commercial Mercury Vapour lamps are now easily to be purchased from various sources.

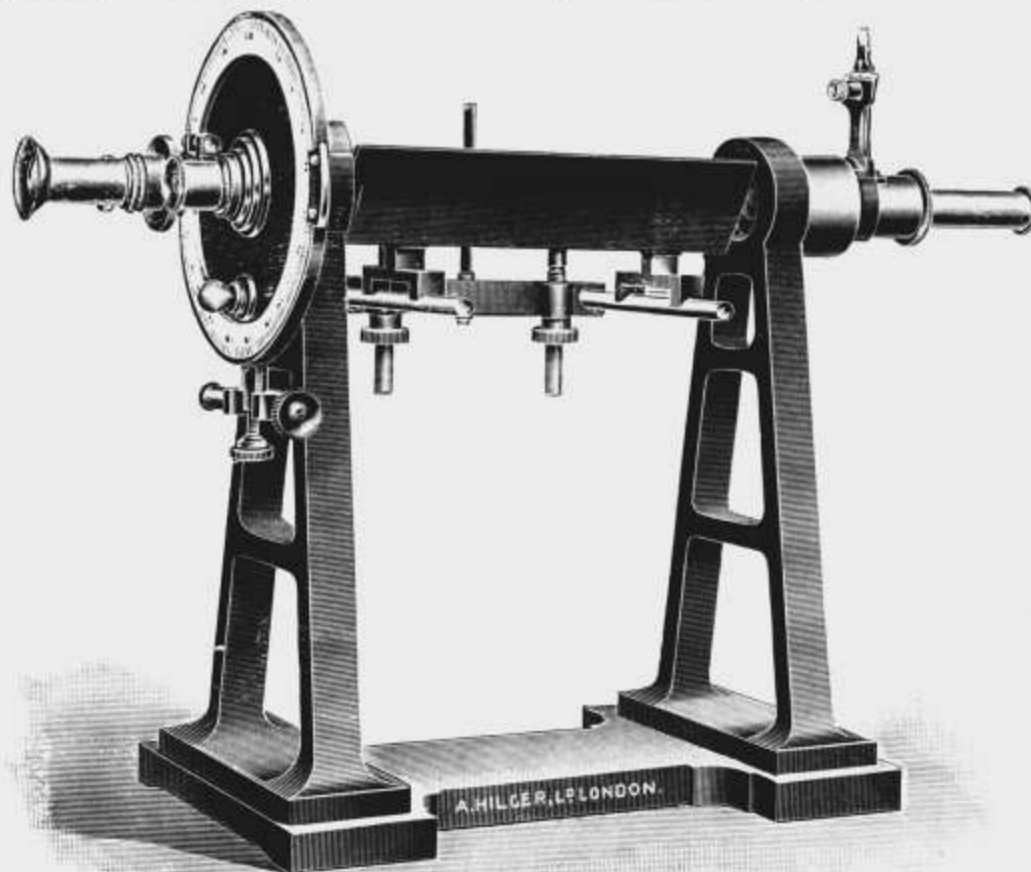


Fig. M 1.

The more recent model of our Polarimeter, as shown in Fig. M 1, has been greatly improved in design. By removal of the trough and its support a clear space can be left in between polariser and analyser for such accessories as heating apparatus, electro-magnet, etc.

Further improvements are the following:—

The slow motion adjusting screw is of almost non-tarnishable metal. All parts of the instrument are well protected against chemical corrosion, either by extremely refractory enamel, or by special lacquer very carefully selected for its power of resistance to chemical action. Thus the instrument is very suitable for use in a chemical laboratory.

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The verniers are illuminated by 4 volt metal filament lamps, and a small dry battery in metal case and key for actuating the same are also provided, and are attached to the base of the instrument. The battery will light a 4 volt lamp for five hours continuously, and the cost of extra batteries for replacement is 6d. each.

Polarimeter (Fig. M 1).—Taking tubes for liquids 200 mm. long; with screws for raising and lowering and levelling, and slides for sideways adjustment for centring the tube.

The polarising system is of the Lippich form, in which the field of view is as shown in Fig. M 2.



Fig. M 2.

The illumination of the middle strip decreases in intensity when the outer increases, and *vice versa*. The brightness of the illumination can be varied by rotation of the polarising prism; and an index and clamp are provided for the setting of this adjustment.

The divided circle is 7 in. diameter, and the division is on platinoid, which does not readily tarnish. There are double verniers, reading to 0.01 degree, and readers and illuminating lamps for the same. There is a good screw slow motion with clamp for fine adjustment of the analyser.

The work throughout is of the highest quality.

Price, with tube for liquids	...	...	...	...	£39 10 0
With Ventske scale in addition to the ordinary division, extra	...				3 10 0
Well made case, with lock and key	...	...	...	...	1 14 0

Polarimeter, as above, but taking tubes 400 mm. long, the construction being otherwise identical.

Price, extra	...	...	...	...	...	£7 10 0
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Addition of Direct Vision Spectroscope attachments to either of the above, consisting of slit at polariser end (formed by shutters pushing in by hand in front of Lippich polariser), and one high dispersion direct vision prism in mount screwing on in front of the eyepiece.

Price	...	...	...	...	...	£4 10 0
-------	-----	-----	-----	-----	-----	---------

The above direct vision prism can be supplied direct for the red, green, or violet, as desired.

Extra prisms mounted, price each	...	...	...	...	£2 0 0
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SPECTRO-POLARIMETER.

For measurements on the rotatory power for radiations of any desired wavelength.

This instrument (Fig. M 3) consists of a wavelength spectrometer, as described on pp. D 1 to D 4, reading in wavelengths direct, a polariser, and an analyser—all mounted on an accurate cast-iron bed. An image of the spectrum is projected on to the plane of the dividing lines of the Lippich triple field Polariser, which dividing lines are in this instrument set horizontal.

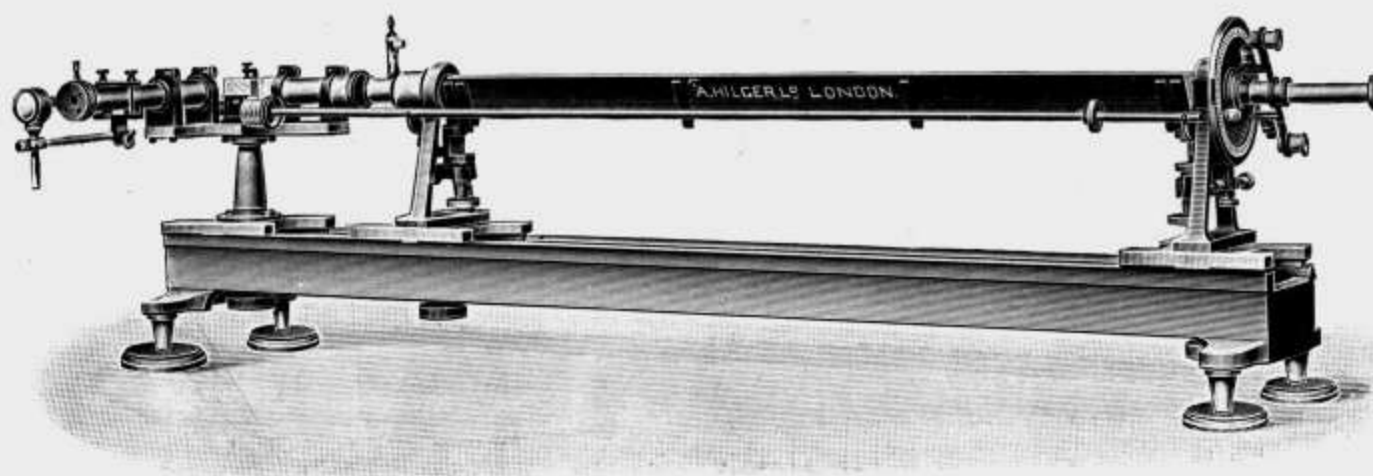


Fig. M 3.

Close to these dividing lines, and between them and the eye, are two shutters pushing in by hand, which limit the field observed to a strip of monochromatic light. The slit of the spectrometer opens symmetrically.

The three standards carrying the spectrometer, polariser, and analyser can be clamped in any desired position on the bed.

A suitable condensing lens is mounted on the collimator of the spectrometer, and a rod with milled head is provided for passing through the spectrum without quitting the eye end of the apparatus. The polariser and analyser are identical with those in the instruments described on pp. M 1 and M 2.

Price, taking tubes up to 200 mm. long	...	...	£89	5	0
Price, taking tubes up to 400 mm. long	...	...	96	15	0
Price, taking tubes up to 1000 mm. long	...	...	105	0	0

PRICES OF POLARIMETER TUBES.

Length of Tube.	Glass tube with screwed end caps.	Tubes with water circulation.
100 mm.	8/- each.	16/- each.
200 mm.	8/- "	18/- "
400 mm.	9/- "	21/- "
600 mm.	10/6 "	27/- "
1000 mm.	14/- "	37/- "

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THE HILGER SPECTROSCOPE—REFRACTOMETER.

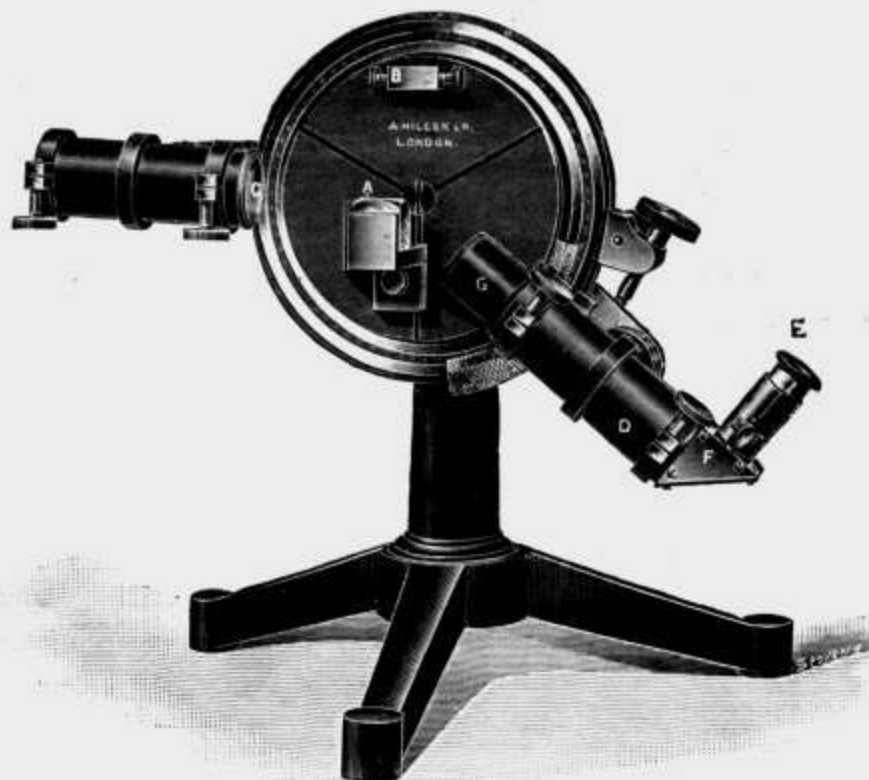


Fig. M 4.

This instrument (Fig. M 4) consists of our No. 2 Spectrometer (*see* Section C, "Spectrometers and Goniometers"), with the following additions:—

- (1) A cast-iron bracket by the aid of which the axis of rotation of the prism table can be set horizontal as in the figure.
- (2) A Pulfrich Prism, A, in a mount which can be readily screwed to the prism table.
- (3) A fine adjustment, B, for setting the prism table.
- (4) A condensing lens, C, which takes the place of the collimator.
- (5) A telescope, D, with the eyepiece set at right angles to its axis, the light being reflected by means of a right-angled prism at F.

In the focus of the object glass, G, is a polished steel pointer which is illuminated by the mirror which is visible in the eyepiece E.

The use of the instrument as a Refractometer is as follows (the parts being in position as in the figure):—

(1) Raise the telescope so that its vernier reads 0 on the circle. In this position its axis is horizontal. The vertical face of the Pulfrich Prism, A, should now be set so as to reflect the light from the steel pointer at E back along the axis of the telescope to form a real image, which is seen in the eyepiece with its point seeming exactly to touch the pointer itself. This is done by means of the slow motion at B.

(2) Place the prism of material under test on the top of the prism, A, with a drop of Monobromonaphthaline in the usual way, and focus the light from a vacuum tube of, say, hydrogen, on to the interface between the two prisms. The telescope, D, is now lowered until the light for which it is desired to test the refractive index of the material is seen.

It will be seen in the eyepiece as a band stretching horizontally through the field, with the upper edge (as seen in the eyepiece) blurred, but the lower edge sharp. The pointer should be adjusted exactly to the lower edge, and the reading of the vernier will then give, by the usual simple calculation, the refractive index of the prism under test.

Price of No. 2 Spectroscope, with the above additions, ... £37 10 0

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THE FÉRY REFRACTOMETER.

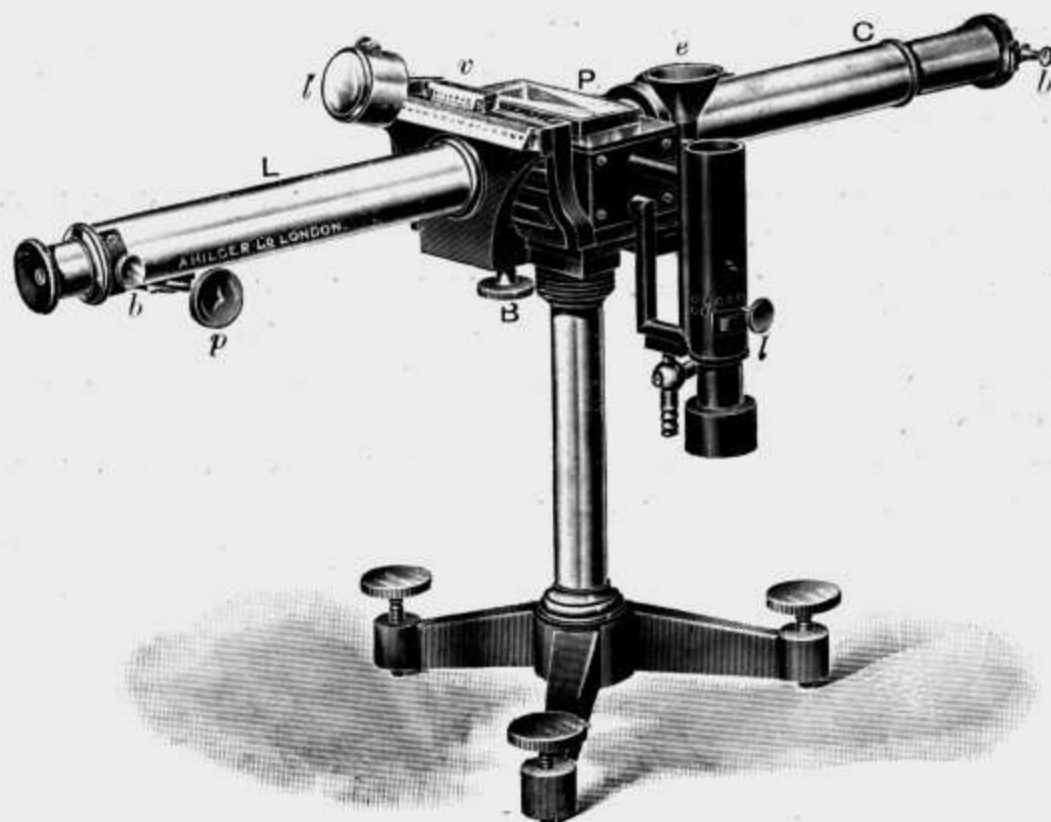


Fig. M 5.

A *direct reading* refractometer for taking the refractive index for sodium light of oils; solutions of acids; mixtures of glycerine, alcohols, etc., with water; sugar solutions; and other liquids of interest to the industrial chemist.

Advantages of the Instrument :—

- (1) It reads *direct* the refractive index of any transparent liquid with a uniform accuracy of nearly 0.0001, from 1.3300 to 1.6726.
- (2) The glass with which the liquid comes into contact is a crown glass, which resists to an exceptional degree the action of chemical reagents.
- (3) The temperature control is extremely simple and effective, and forms an integral part of the apparatus.
- (4) The manipulation of the apparatus is extremely simple and convenient.

Price, complete, as in Fig. M 5 £29 10 0

(Complete description, and references to tables of refractive indices,
post free on application.)

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JAMIN REFRACTOMETER.

(Full description, abstracted from Jamin's original paper in the "*Ann. de Chim. et de Phys.*," 3rd series, tome lii. p. 163, 1858, sent out with each instrument or post free on application.)

The JAMIN REFRACTOMETER, as supplied by us (for price, see below), is shown in Fig. M 6 and in diagram in Fig. M 7.

Light from any convenient source S is divided by the mirror M_1 (silvered on the back) into two beams; the first is reflected from the exterior face and passes along the tube B_1 , the second is reflected from the interior silvered face and passes along the tube B_2 .

After traversing the two tubes (which contain, the one the gas or liquid under test and the other that with which it is to be compared), the two beams pass through the plates of the compensator C (see Fig. M 7). Falling on the mirror M_2 , which is identically the same as M_1 , and parallel to it, the beams experience reflections inverse to those to which they were primarily subjected, with the result that they are superimposed under conditions suitable for interference.

PRICES.

Jamin Refractometer (see Fig. M 6) giving a separation between the centres of the beams of 18 mm., and taking tubes 250 mm. long. The observation telescope has rack and pinion for focussing and cross-webs in the eyepiece. Two tubes for gases are provided. Means are provided for altering the angle between the compensator plates, and the rotation of the plates is read by vernier to 0.1° . All optical work is of the highest quality.

Price	£26 10 0
--------------	----------

If the tubes are to be sufficiently accurate for work on liquids,	
price extra for the pair of tubes	3 0 0

Jamin Refractometer with worm-wheel motion for rotating the compensator plates and accurately divided circle for same, reading by vernier to 0.02° . Screw motion for altering the sensitiveness by rotation of one compensation plate relative to the other. Separation of beams of 30 mm., and taking tubes 500 mm. long.

Price	£41 10 0
--------------	----------

If the tubes are to be sufficiently accurate for work on liquids,	
price extra for a pair of tubes 250 mm. long	3 0 0
(We do not supply tubes for liquids 500 mm. long.)	

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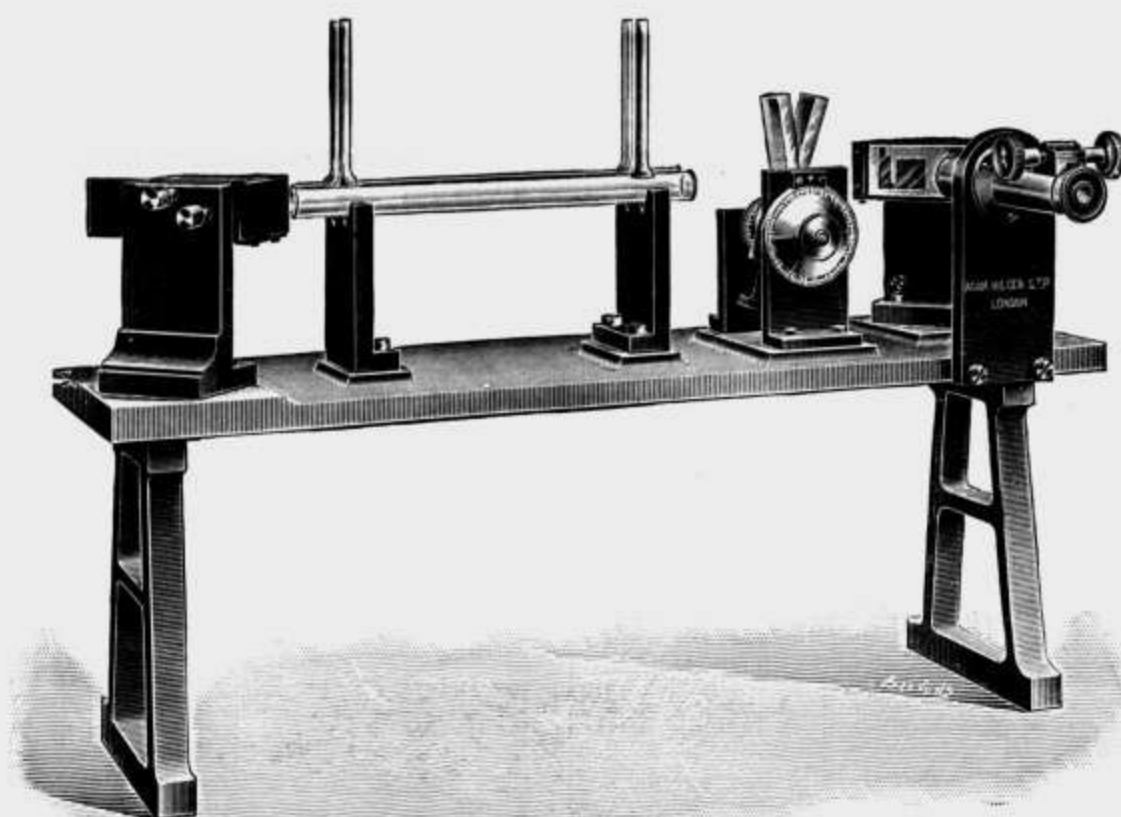


Fig. M 6.

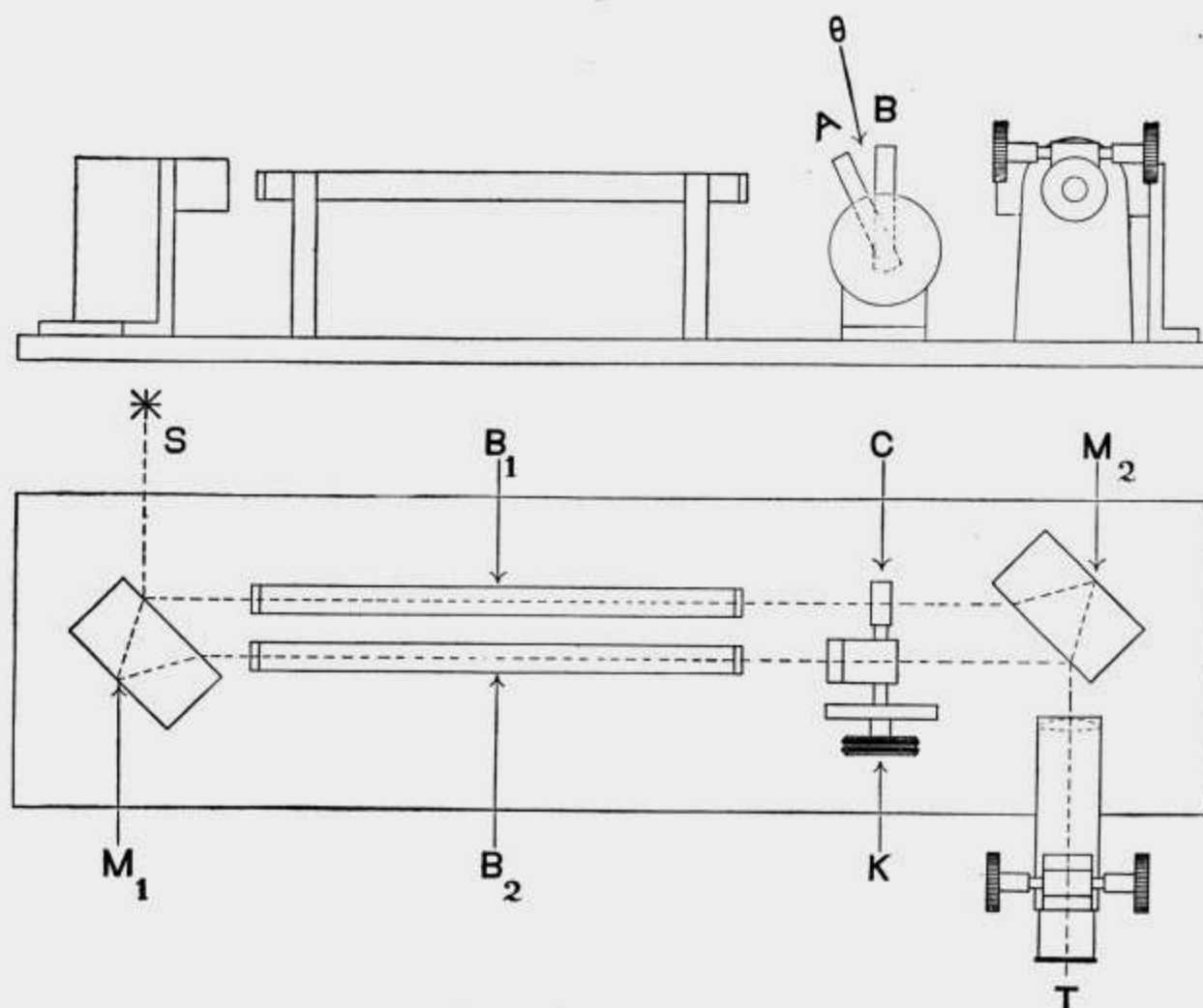


Fig. M 7.

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SECTION N.*

MICHELSON AND FABRY & PEROT
INTERFEROMETERS.

See also for Fabry & Perot Etalons—

p. O 3, Fabry & Perot Etalon ;

p. O 6, Mount for taking the above in front of any ordinary Spectroscope ;

p. J. 5, Direct Vision Pocket Spectroscope, with Interference Etalon.

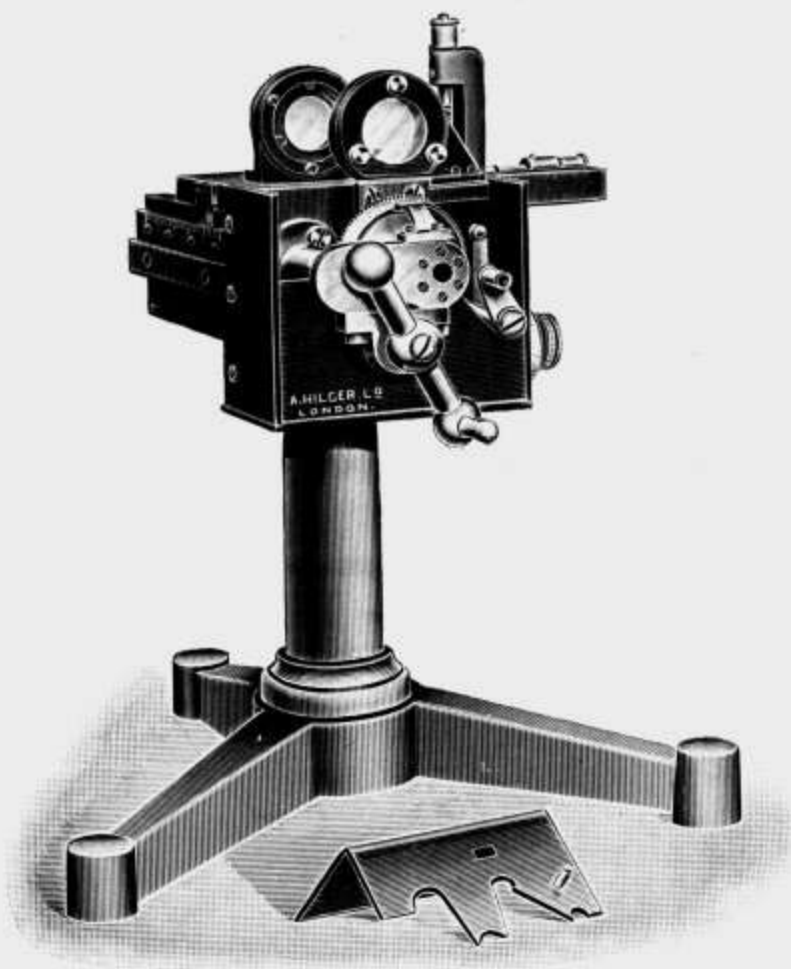


Fig. N 1.

The transmission plates in the following interferometers are silvered by cathodic deposition from fresh electrolytically deposited silver. With silver films deposited in this manner the loss of light is less than by any other known method, and the necessary condition for sharply defined and bright intensity maxima is thus fulfilled. In the case of the Fabry & Perot Interferometers the plates are made slightly wedge-shaped in the usual manner to avoid the secondary interference systems caused by reflection at the unsilvered outer surfaces.

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Our latest models of **Michelson and Fabry & Perot Interferometers**—those, namely, sent out during or after August 1912—are in every case so arranged that either the Fabry & Perot or the Michelson system of mirrors can be supplied at any subsequent time and attached without any alteration of the apparatus.

Three sizes are made, having respectively 75 mm., 120 mm., and 200 mm. travel of the movable mirror. The 200 mm. size is supported on a tripod of special form (see Fig. N 3). Otherwise, except as regards the lengths of the slides and of the micrometer screws, all three sizes are of identically the same construction, both as to accuracy of workmanship and dimensions. Thus a set of mirrors suitable for any one size is also suitable for any other.

The micrometer screws have 1 mm. pitch. The divided head attached to the screw has 100 divisions, and one turn of the slow motion screw, whose head is also divided into 100 parts, corresponds to one division on the main drumhead. Thus one division on the drumhead of the slow motion screw corresponds to $\frac{1}{10,000}$ mm. (one ten thousandth of a millimetre).

The slides are massive, and of steel,* and the sliding surfaces are worked *optically flat*. The slides are heavily protected by hard enamel, with the exception of the actual sliding surfaces. Only these sliding surfaces, therefore, require care to avoid rust. A bottle of suitable oil is provided, which it is well to use freely on the slides, and occasionally on the screw. The most recent construction of the slides is the result of many experiments, and is such that we are able to make them flat to a high optical precision, thus securing the desired accuracy in maintaining the parallelism of the movable mirror in its progress from one end of the slide to the other.

The slow motion mechanism has a carefully made cover, which can be readily removed, if desired, for inspection.

The micrometer screws are cut between dead centres and ground at constant temperature, and are made throughout with the very greatest care. Their position is determined longitudinally by a plate of polished quartz at the end towards the observer, which end takes the thrust when the mirror is moving in the direction of increasing optical path. A system of opposing screws enables this plate to be set up perpendicular to the axis of rotation of the micrometer screw, whose end is polished to an approximately flat surface. Thus by reflecting light in the direction of the axis of the screw through the thickness of the quartz block (which is polished on both surfaces to enable the end of the screw to be thus observed), one can observe the interference fringes produced between the light reflected from the thrust-taking surface of the quartz and the polished end of the micrometer screw. Observation in this manner enables the adjustment of the plate of quartz perpendicular to the axis

* The slides are made from forgings of specially-selected steel, the preparation and treatment of which to avoid subsequent deformations are carried out for us by Sir W. G. Armstrong, Whitworth & Co., whose experience in the construction of standard screw gauges has enabled them to supply us with a material excellently well adapted for the purpose in view.

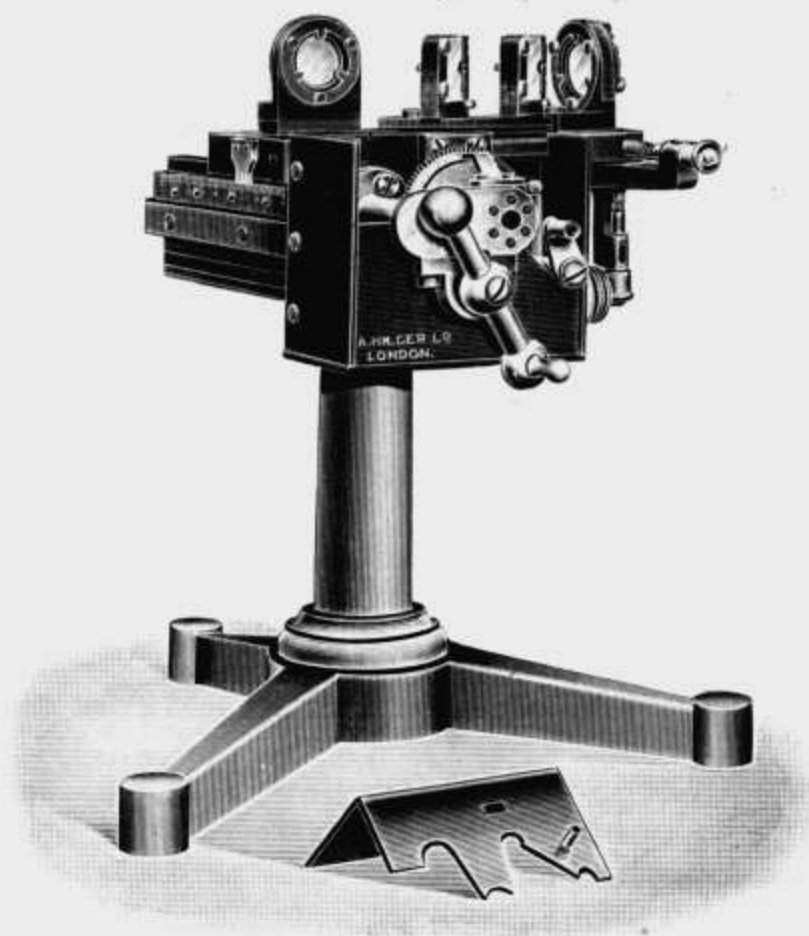


Fig. N 2.

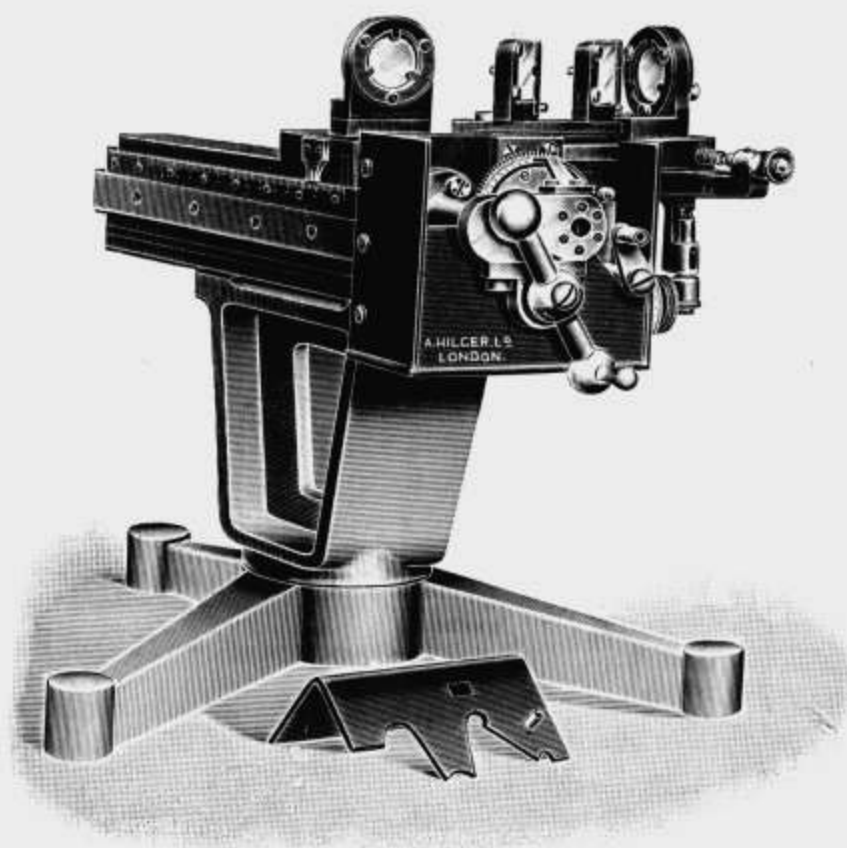


Fig. N 3.

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of rotation of the screw to be made with great and ascertainable precision. The other end of the micrometer screw thrusts against the polished end of a fixed screw, by means of which one is enabled to reduce the longitudinal play of the micrometer screw to a minimum, without introducing any longitudinal compression. The carriage can be removed by lifting it off its slide, and can be as easily replaced. The two thrust blocks under the carriage, which engage with the nut of the micrometer screw, are so adjusted as to allow a small amount of lost time. A convenient spring adjustment is provided for one mirror, which, while enabling the delicate final adjustment for parallelism to be made with great precision, is nevertheless so substantial as to introduce no trouble from vibration.

Fabry & Perot Interferometer. latest design as described above—

Price, with 75 mm. motion of the carriage (Fig. N 1)...	...	£50	5	0
Price, „ 120 mm. „ „ „	...	56	0	0
Price, „ 200 mm. „ „ „	...	70	5	0

Set of Michelson mirrors, with mounts and spring adjustments complete, as shown in Fig. N 2, suitable for immediate attachment to any of the above instruments—

Price ...	...	...	...	...	...	...	£8 10 0
Case to take both sets of mirrors, with their mounts.	Price	...					0 10 6

Michelson Interferometer—

Price, with 75 mm. motion of the carriage	£53 0 0
Price, „ 120 mm. „ „ „ „ „ „	58 15 0
Price, „ 200 mm. „ „ „ „ „ „ (Fig. N 3)	73 0 0

Set of Fabry & Perot mirrors suitable for immediate attachment to any of the above instruments—

Price ...	...	...	...	...	...	...	£5 15 0
Case to take both sets of mirrors, with their mounts,	Price	...					0 10 6

Levelling Screws to either Fabry & Perot or Michelson Interferometers—

Price, 75 mm. or 120 mm. sizes	...	...	...	...	£0 18 6
Price, 200 mm. size	...	...	...	...	1 5 0

Well made case, with lock and key, for either Fabry & Perot or Michelson Interferometer—

Price, 75 mm. size	...	...	...	...	...	£1	2	0
Price, 120 mm. size	...	...	...	...	...	1	3	0
Price, 200 mm. size	...	...	...	...	...	1	5	0

The instruments with levelling screws are of suitable height for use in front of the slit of the Hilger Wavelength Spectrometers (Constant Deviation Type).

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Achromatic Lens 6" (150 mm.) focal length in mount for attachment to the Fabry & Perot Interferometer, with focussing adjustment. This lens enables an image of the diffraction pattern to be thrown on the slit of a spectrometer, the dispersion of which then gives the necessary separation of the overlapping monochromatic fringes. The screw-holes for attachment of this lens are provided on all interferometers sent out subsequent to 30th August 1912. £2 3 6

Special Mercury Green Line Filters cemented in optically-worked glass—

(a) Transmitting only $\frac{1}{2}$ per cent. of the yellow lines and 72 per cent. of λ 5461; 2" (51 mm.) square—

Price £1 5 0

(b) Transmitting 0.0025 per cent. of the yellow lines and 50 per cent. of λ 5461, 2" (51 mm.) square—

Price £2 0 0

The (b) filters above can also be supplied 16 mm. clear aperture, mounted in brass tube, 30 mm. long—

Price £1 16 0

(These screens are made for us by Messrs Wratten & Wainwright from glass prepared by ourselves.)

Plates for Interferometers.

Circular mirrors for Michelson Interferometers, 25 mm. dia., each ... £0 11 6

Transmission and compensation plates for Michelson Interferometers, 40 mm. long $\times$ 25 mm. high, each £1 2 6

Complete set of Michelson Interferometer mirrors and plates as above—the set £3 8 0

Circular plates, silvered by cathodic deposition (*see* p. N 1), for Fabry & Perot Interferometers, of special construction, as used on our Fabry & Perot Interferometers (*see* Fig. N 4), permitting the interior surfaces to be brought close together. The diameter of the silvered surfaces is 25 mm.

Price per pair £1 16 0

Price, if of quartz, the plates being coated with nickel by cathodic deposition, for ultra-violet work, per pair

4 13 0



Fig. N 4.

Small Observation Telescope, with cross webs for viewing the fringes, on raising and lowering stand.

Price £3 10 0

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The bibliography has been chosen from the most important literature on the principles and methods involved in these instruments.

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September 1913.

SECTION O.*

SPECTROSCOPIC APPARATUS FOR HIGH
RESOLVING POWER.

(See also our separate Lists of larger Echelons, of Lummer-Gehrcke Parallel Plates, and of Interferometers, and p. J 5 for small etalon attachment in Pocket Spectroscope.)

THE instruments described on this and the six following pages are

- (a) A Michelson Echelon Diffraction Grating,
- (b) A Lummer-Gehrcke Parallel Plate,
- (c) A Fabry & Perot Etalon,

together with apparatus specially designed for use with the above.

Although designed primarily for demonstration work, they are all optically as perfect as our larger apparatus of the same kinds (for which see the lists cited above).

They are of a size and design suitable for use on most ordinary Spectroscopes, but are especially useful in conjunction with the modified form of Hilger Wavelength Spectrometer (Constant Deviation Type) described below. Thus applied, the Fabry & Perot Etalon affords a means of determining wavelengths to a very high accuracy; while either the Echelon or the Lummer-Gehrcke Plate will demonstrate the Zeeman effect, the effect of pressure on the lines of the spectrum, or the minute structure of



Fig. O 1.

any desired lines with a minimum of trouble and with the great intensity of light which distinguishes these powerful devices for high resolving power. At the same time the approximate wavelengths of the lines under observation can be read off direct from the drum of the Wavelength Spectrometer (see descriptive leaflet of the Hilger Wavelength Spectrometer, Constant Deviation Type).

The mode of application to the Wavelength Spectrometer has the further great advantage that a large number of lines of the spectrum can be examined at one and the same time, all the lines which are visible in the eyepiece being simultaneously subjected to the analysis of the Echelon, or of the Lummer Plate, or of the Fabry & Perot Etalon, as the case may be.

(a) **Echelon** (see Fig. O 1) of highest quality, in mount complete. Suitable for use on any ordinary Spectroscope (in which case an auxiliary analysis of the light

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Spectroscopic Apparatus for High Resolving Power

O 2

is necessary) or on the modified form of wavelength spectrometer described below, in which case the combined apparatus is complete in itself.

Number of plates, 12.	Length overall of Echelon and mount,
Thickness of plates, about $4\frac{1}{2}$ mm.	105 mm.
Width of step, 1 mm.	Resolving power, 45,000, for W.L.
Effective aperture, 13 mm. square.	5461.
Price, in mount complete	£12 10 0

Larger Echelon, mounted in the same way. (*This is the size of Echelon we recommend; it requires an extra extension of the base, see below under The Hilger Wavelength Spectroscope, Constant Deviation Type, modified for use with these accessories.*)

Number of plates, 12.	Effective aperture, 29 mm. $\times$ 13 mm.
Thickness of plates, 10 mm.	Resolving power, 100,000, for W.L.
Width of step, 1 mm.	5461.
Price, in mount complete	£16 10 0

The accurate thickness of the plates and the optical properties of the glass are in every case engraved on the mount.

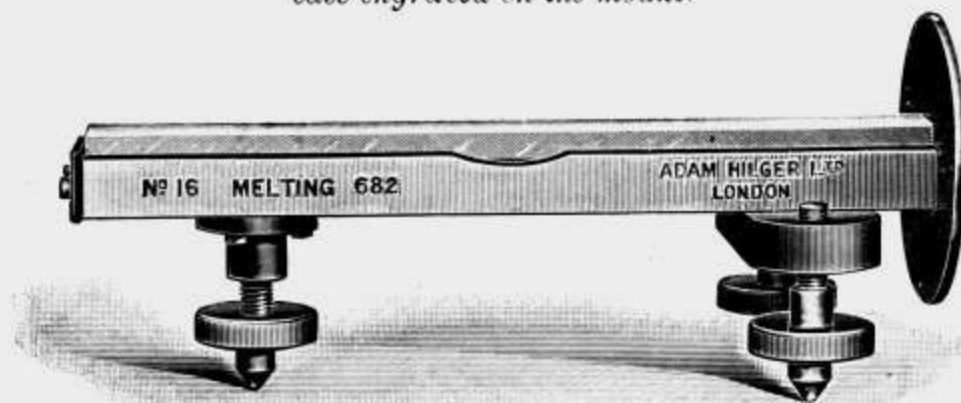


Fig. O 2.

(b) **Lummer-Gehrcke Plate** (see Fig. O 2), in mount complete. Like the Echelon above, this can be used on any ordinary Spectroscope, or preferably on the modified form of Spectrometer described below.

Length of plate, 130 mm.	Length overall of mount, 135 mm.
Width of plate, 15 mm.	Resolving power, about 200,000.
Thickness of plate, $4\frac{1}{2}$ mm.	
Price, in mount complete	£11 10 0

The thickness of the plate and optical properties of the glass of which it is made are engraved on the mount.

We can also supply Lummer-Gehrcke Parallel Plates, of the same size, in quartz, for work in the ultra-violet.

Price in mount (Fig. O 2)	£19 0 0
---------------------------	---------

These can be used in front of a quartz spectrograph on the mount described below (Fig. O 6) which is then supplied with a quartz-rocksalt triple or quartz-fluorspar double achromatic lens at an extra charge of 5 10 0

As quartz-fluorspar makes a better achromatic combination than quartz-rocksalt, the former will always be supplied whenever fluorspar of suitable quality is obtainable.

(For the theory of the Lummer-Gehrcke parallel plate, see *Annalen der Physik*, Band 10, 1903, p. 457.)

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Fabry & Perot Etalon (see Fig. O 3). The Etalon is constructed with a distance piece consisting of a hollow cylinder of fused silica between the plates (as described by H. C. Rentschler, *Astrophysical Journal*, December 1908).

The co-efficient expansion of fused silica being less than that of any other known material (0.000,000,59 per 1°C —about one-seventeenth part of that of platinum) temperature alterations can be entirely avoided quite easily.

The plates are silvered by cathodic deposition from freshly electrolytically deposited silver. With silver films deposited in this manner the loss of light is less than by any other known method, and the necessary condition for sharply defined and bright



Fig. O 3.

intensity maxima is thus fulfilled. The plates are made slightly wedge-shaped in the usual manner to avoid the secondary interference systems caused by reflection at the unsilvered outer surfaces; but the angles of the wedges are the same in each plate, and they are so mounted that the total deviation caused by the Etalon is zero.

The appearance seen in the eyepiece when the Etalon is in position and correctly adjusted is as follows :—

- (a) The lines of the spectrum are visible in the same positions as they would occupy were the Etalon removed; but of course far less bright.
- (b) Each spectrum line is a diametrical strip of the ring system which would be produced by the Etalon if the field of view were filled with light of the wavelength of the line in question. The diameter of the ring system for each line can then be measured with a micrometer eyepiece.

The distance between the plates is about 10 mm., this distance producing a convenient ring system for measurement.

The thickness of the Etalon correct to 0.005 mm. is in each case engraved on the mount.

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Spectroscopic Apparatus for High Resolving Power

O 4

Length overall of Etalon and mount, 105 mm.

Price complete, with mount £10 10 0

Price, with plates of quartz, nickelled by cathodic discharge, for
ultra-violet work 11 10 0

For the method of working to obtain standard wavelengths by comparison with lines of accurately known wavelengths, see papers by Lord Rayleigh, Phil. Mag. [6], May 1906, p. 685; and [15] April 1908, p. 548.

NOTE.—The height to the centre of the aperture in each of the above accessories is 35 mm.

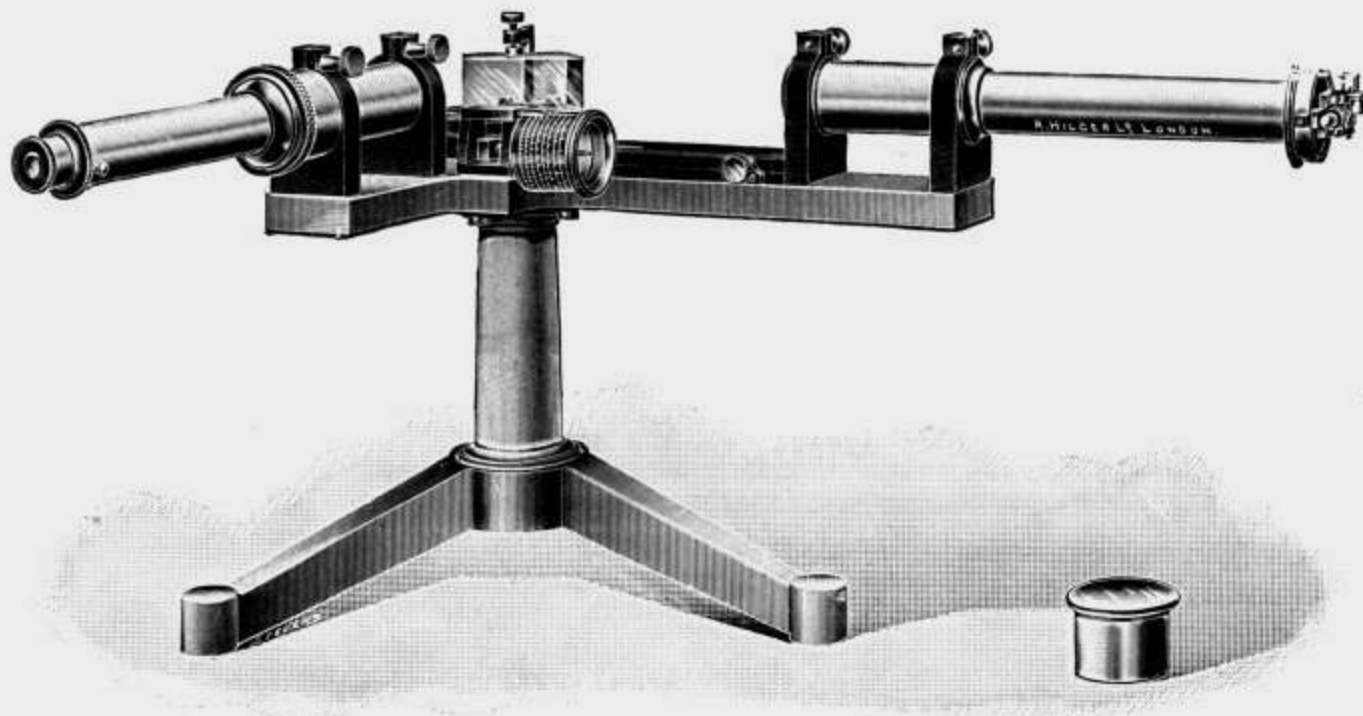


Fig. O 4.

THE HILGER WAVELENGTH SPECTROMETER (CONSTANT DEVIATION TYPE) MODIFIED FOR USE WITH THE ABOVE ACCESSORIES.
(See Fig. O 4.)

(See also separate leaflet describing the normal form.)

The modifications are as follows :—

- (1) The arm carrying the collimator is extended to make room for any one of the above accessories to be placed in position between the collimator and prism. A protective cover for the prism table is also supplied.
- (2) The accessories stand on a brass plate capable of slight rotation by means of a milled head screw. This, together with a readily accessible levelling screw, provides the necessary adjustment for each of the accessories. Each of the accessories is in addition provided with screws for the levelling adjustment if it be desired to use them on the table of an ordinary Spectrometer.

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(3) The aperture of the slit of the collimator is longer than that of the slit generally supplied with the W.L. Spectrometer, this being desirable for use with the Etalon. A second slit is attached to the main slit, the jaws running at right angles to it. This second slit can be rotated into or out of position as desired, and is necessary for use with the Echelon. The Echelon is mounted with the edges horizontal in the manner employed by Professor Michelson.

(4) An extra low-power eyepiece is supplied for use with the Etalon or Lummer-Gehrcke Plate.

(5) The base plate is of the "Universal" form described on p. D 4.

Price of Modified Wavelength Spectrometer, with extra dense prism,
refractive index for D = 1.74. £35 5 0

Well-made case with lock and key 1 17 6

Price, if extended to suit larger Echelon of 12 plates, the plates
being 10 mm. thick, and the effective aperture 29 mm. $\times$ 13 mm. ... 37 10 0

(The price of these larger Echelons, suitably mounted for this
form of Spectroscope, is £16, 10s.)

Accurate micrometer eyepiece for measurement of the diameter of
the ring system produced by the Etalon, or for employment with the
Echelon and Lummer-Gehrcke Plate, with adapter for low-power eyepiece
interchangeable with that for the usual eyepiece supplied.

Price 6 12 6

(For sundry other accessories for the Wavelength Spectrometer, see
Sections D and F.)

MOUNT TO TAKE THE ABOVE FABRY & PEROT ETALON, OR LUMMER-GEHRCKE PARALLEL PLATE, IN FRONT OF AN ORDINARY SPECTROSCOPE.

This mount (Fig. O 5 and O 6) is made to suit the Fabry & Perot Etalons and Lummer-Gehrcke Parallel Plates described above.

The Etalon (as in Fig. O 5) or the Lummer-Gehrcke Parallel Plate (as in Fig. O 6) stands on a brass plate which is capable of slight rotation about a vertical axis by means of a milled head screw. This, together with a readily accessible levelling screw, provides the necessary adjustment for either of the accessories.

The rays from the source of light should be approximately collimated by a condensing lens. They then traverse the Lummer-Gehrcke Parallel Plate or Etalon, as the case may be; and an image of the resulting diffraction pattern is formed by an achromatic lens of about 5" (130 mm.) focal length. This image consists, of course, of a number of superposed images produced by the various monochromatic radiations emanating from the source.

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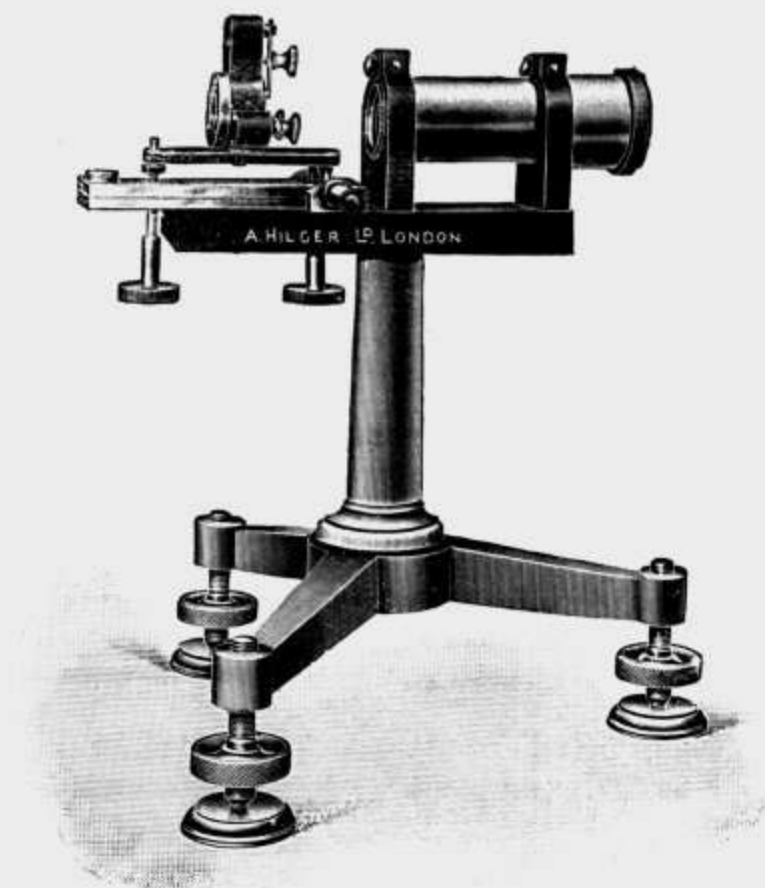


Fig. O 5.

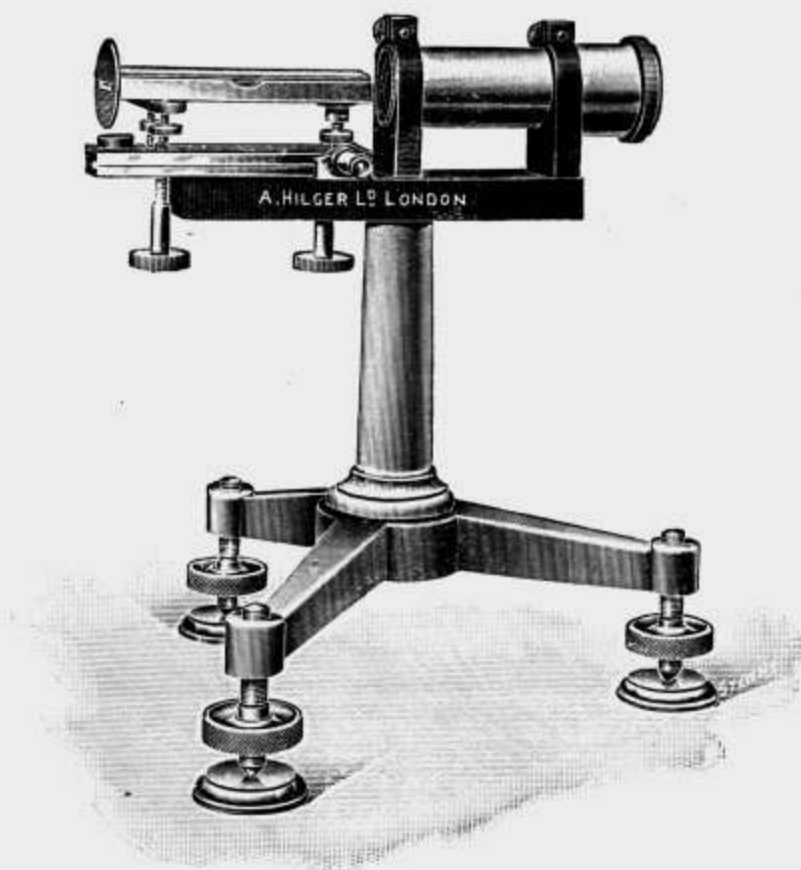


Fig. O 6.

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The spectroscope to be used in conjunction with this arrangement is then placed in train with the above apparatus so that the diffraction image falls on the slit. The jaws of the slit should be set vertical; and the dispersion of the spectroscope will then give the necessary separation of the overlapping diffraction images.

The apparatus is mounted on a substantial cast-iron tripod, with three levelling screws, and is suitable for use with any ordinary spectroscope.

Price £11 15 0

Besides its use with the Lummer-Gehrcke Parallel Plate and Etalon, this piece of apparatus can also be employed, with the addition of a special collimator, to utilise the Echelon, described above, in combination with any ordinary spectroscope. The short tube with achromatic lens shown in Figs. O 5 and O 6 must then be replaced by the special collimator in question, and the collimator of the ordinary spectroscope removed. The light from the source first passes through the special collimator, then through the Echelon, and then on to the prism of the spectroscope.

Price of this special collimator (which is identical with that of the
Modified Wavelength Spectrometer described above) ... £4 15 0

USEFUL ACCESSORIES FOR THE DEMONSTRATION OF THE ZEEMAN EFFECT BY MEANS OF THE LUMMER-GEHRCKE PARALLEL PLATE.

Small electro-magnet on raising and lowering stand, pole pieces adjustable from contact to $\frac{1}{2}$ " ($12\frac{1}{2}$ mm.) apart; suitable for demonstrating the Zeeman effect with these Lummer-Gehrcke Parallel Plates. The current required is about 3 amperes when using an ordinary vacuum tube as the source of light. The lines are distinctly separated with these plates into triplets, etc.

Price £5 10 0

Shutter eyepiece with bright pointer and double image prism, for Zeeman effect observations with the Lummer-Gehrcke Parallel Plate. By means of the shutter eyepiece the line under observation can be isolated, and the double image prism being turned into position, the components of the rays polarised in vertical and horizontal planes can then be observed side by side simultaneously.

The surfaces of the double image prism are protected by glass plates.

Price £6 10 0

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September 1913.

SECTION P.*

OPTICAL WORK.

Prisms for Spectroscopic Work.

The following expressions give the prices of single prisms of 60° angle made to order:—

h is the height of the prism in centimetres.

l is the length of the refracting face in centimetres.

Refractive Index for D.	Price in Shillings.	The Expressions may be used up to (centimetres)		Glass always in stock to cut Prisms of (centimetres)	
1.58 to 1.62	$0.33hl^2 + 17$	h	l	h	l
1.65	$0.36hl^2 + 17$	13	18.5	10	13
1.74	$0.62hl^2 + 17$	10.5	16	8	11
		8	10.5	6	8

The above prisms have rectangular refracting surfaces.

Prisms of refractive indices below 1.58 are supplied at the same price as those of 1.58. Higher refractive indices than 1.74 are not recommended except for special purposes. The expressions may be employed up to the sizes given in the third column, and prisms exceeding the dimensions there given will be quoted for on application.

Glass is *always* kept in stock to cut prisms of about the sizes given in the fourth column, and *usually* to cut prisms of the sizes given in the third column.

The prices are for prisms of the highest quality. The angles are made accurate to within 10'. If a greater accuracy be required, for an accuracy of $\pm 15''$ add 25 per cent., with a minimum charge for the increased accuracy of 10s.; for an accuracy of $\pm 5''$ add 75 per cent., with a minimum charge for the increased accuracy of 25s.

The following sizes are stocked in refractive indices from 1.58 to 1.65, and are supplied, as will be seen, at a considerable reduction on the above scale of prices. They are in all respects equal in quality to the above prisms, but are only supplied in the sizes and of the refractive indices as stated. The surfaces are rectangular.

Light Flint.			Dense Flint.		
ref. ind. for D=1.58 to 1.62 about.			ref. ind. for D=1.63 to 1.65 about.		
Length of Face.	Height of Prism.	Price.	Length of Face.	Height of Prism.	Price.
in. mm.	in. mm.	£ s. d.	in. mm.	in. mm.	£ s. d.
1½ 32	1 25	1 2 0	1½ 35	1 25	1 10 0
1¾ 42	1¼ 32	1 10 0	1¾ 44	1¼ 32	1 14 0
2 51	1½ 38	2 2 6	2½ 54	1½ 38	2 8 0
2¾ 60	1¾ 44	3 0 0	2¾ 64	1¾ 44	3 7 0

It will be noted that the lengths of the surfaces in the above prisms are greater than the heights, and that the ratio of length of surface to height becomes greater with the refractive index. By this means a more satisfactory effective aperture is obtained.

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Right-Angled Prisms.

Length of Square Cathetus Surface.	Price.
10 mm.	£0 16 0
15 "	1 5 0
20 "	1 15 0
25 "	2 5 0
30 "	2 15 0
35 "	3 7 0
40 "	4 0 0
45 "	4 12 0
50 "	5 6 0
55 "	6 0 0
60 "	7 0 0

Larger sizes quoted on application.

The above right-angled prisms are of the very finest quality; of white, clear, and thoroughly annealed crown. The definition is guaranteed, and all the angles are accurate to within 5'. If a greater accuracy of angles be required, for an accuracy of $\pm 10''$ add 25 per cent., for an accuracy of $\pm 5''$ add 75 per cent. to the above prices.

Diagonal Planes, of guaranteed quality, silvered. (These planes are so edged as to reflect a circular beam of light when set at an angle of 45° .)

Diameter of minor axis of surface.	Price.	Diameter of minor axis of surface.	Price.
$1\frac{1}{8}$ inches.	£1 5 0	2 inches.	£2 18 0
$1\frac{1}{4}$ "	1 8 0	$2\frac{1}{2}$ "	4 13 0
$1\frac{1}{2}$ "	1 14 6	3 "	6 10 6
$1\frac{3}{4}$ "	2 10 0	$3\frac{1}{2}$ "	8 10 0

Diagonal planes can be made to fit existing mounts at the same scale of prices, or existing planes up to $2\frac{1}{2}$ inches minor axis Palladinised.

Plane Mirrors, of guaranteed quality, for Siderostats, Heliostats, and general purposes. The price includes silvering. The price for speculum metal mirrors is 50 per cent. higher.

Diameter in inches.	Price.	Diameter in inches.	Price.
1	£0 16 0	8	£20 0 0
$1\frac{1}{2}$	1 3 6	9	24 15 0
2	1 14 0	10	30 10 0
3	3 4 0	11	37 0 0
4	5 6 0	12	44 0 0
5	8 0 0	13	51 0 0
6	11 6 0	14	64 5 0
7	15 10 0	15	78 0 0

Concave mirrors of radius not less than 20 times the diameter, add 25 per cent. to the above prices. Larger sizes quoted for on application.

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Galvanometer Mirrors, of the highest optical perfection, to the following dimensions :—

Diameter.	Thickness.	Radius of Curvature.
10 mm. (or anything smaller)	0.5 mm.	36 inches, or 1,000 mm.

(1) Of glass, palladinised on the front. Price, each £0 6 9

(2) Of fused silica, platinised on the front. (These can be soldered without damage.) Price, each 0 8 6

Plane Mirrors, up to 10 mm. dia., at the same prices as above.

Concave Mirrors, up to 10 mm. dia., of other radii than those given, can be supplied at double the above prices.

Larger sizes quoted for if required.

Cornu Prisms of Quartz.

Refracting Angle 60°.

These prisms are accurately cut with respect to the axis. They are composed of two prisms of right and left rotation quartz respectively, each of 30° angle.

We have recently introduced an important improvement in the construction of these prisms, viz., the setting of the two component prisms into optical contact at the interface. This procedure results in

- (1) Greater optical perfection.
- (2) Removal of double image caused by reflection between the two inside surfaces, without the necessity of any liquid between the two surfaces.
- (3) A gain in light transmitted.
- (4) Greater convenience of handling.

Following our usual procedure with 60° prisms we quote for a length of face greater than the height of prisms. We cannot, however, in the case of quartz prisms always adhere quite rigidly to the sizes stated.

Length of external faces.		Height of prism.		Price.
mm.	in.	mm.	in.	
25	1	19	$\frac{3}{4}$	£3 10 0
32	$1\frac{1}{4}$	25	1	4 16 0
42	$1\frac{3}{8}$	32	$1\frac{1}{4}$	8 2 0
50	2	38	$1\frac{1}{2}$	12 0 0
57	$2\frac{1}{4}$	44	$1\frac{3}{4}$	17 0 0
65	$2\frac{5}{8}$	41	$1\frac{5}{8}$	17 10 0
65	$2\frac{5}{8}$	50	2	21 0 0
82	$3\frac{1}{4}$	52	$2\frac{1}{8}$	32 0 0
98	4	59	$2\frac{3}{8}$	45 0 0
110	$4\frac{3}{8}$	70	$2\frac{3}{4}$	78 0 0

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QUARTZ LENSES.

Price of Quartz Lenses, unmounted, accurately cut with the crystallographic and optical axes coincident.

CLEAR APERTURE.								PRICE.
IN.	MM.							
1	25.4	...	...	...	...	...	...	£2 0 0
1 $\frac{1}{4}$	32	...	...	...	...	...	...	2 5 0
1 $\frac{1}{2}$	38	...	...	...	...	...	...	2 12 0
1 $\frac{3}{4}$	44	...	...	...	...	...	...	3 0 0
2	51	...	...	...	...	...	...	3 14 0
2 $\frac{1}{4}$	57	...	...	...	...	...	...	5 0 0
2 $\frac{1}{2}$	64	...	...	...	...	...	...	6 15 0

The above prices are for Lenses of the finest definition, with carefully-selected curves, the focal length for W.L. 400 μ being not less than 10 times the diameter.

Lenses of larger angular aperture up to F/4.5 can be supplied figured to correct the spherical aberration for points on the axis at the prices obtained by multiplying the prices in the above table by the factor

$$1 + \left(\frac{10 - N}{N - 2} \right)$$

where N is the focal length divided by the aperture.

Condensing Lenses of Quartz, see Section F.

Plane Parallel Glass.

(First quality surfaces only supplied.)

This is stocked in the following thicknesses:—

1 mm., 2 mm., 3 mm., 4 $\frac{3}{4}$ mm., 7 $\frac{1}{2}$ mm., 10 mm.

1 mm. thick Plane Parallel Glass, accuracy of parallelism about 10 seconds.

Price in shillings = $2.00 \times \text{area in square cms.} + 3.5$.

up to 25 mm. in the longest dimension.

2 mm. thick Plane Parallel Glass, accuracy of parallelism about 6 seconds.

Price in shillings = $1.75 \times \text{area in square cms.} + 3.5$,

up to 40 mm. in the longest dimension.

3 mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.

Price in shillings = $1.75 \times \text{area in square cms.} + 3.5$.

up to 50 mm. in the longest dimension.

4 $\frac{3}{4}$ mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.

Price in shillings = $1.75 \times \text{area in square cms.} + 3.5$.

up to 65 mm. in the longest dimension.

7 $\frac{1}{2}$ mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.

Price in shillings = $1.75 \times \text{area in square cms.} + 3.5$.

up to 100 mm. in the longest dimension.

10 mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.

Price in shillings = $1.75 \times \text{area in square cms.} + 3.5$.

up to 150 mm. in the longest dimension.

Crystalline Quartz of like accuracy cut perpendicular to the axis.

Prices, 2 $\frac{1}{2}$ times the above.

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CONSTANT DEVIATION PRISMS (Fig. P 1), as used in the Hilger Constant Deviation Spectrometer (see p. D 1).

Refractive Index for D.	Size of Equivalent 60° prism face.		Price.
	Length of Face.	Height.	
	in. mm.	in. mm.	
1.65	1 ⁵ / ₈ 42	1 ⁵ / ₈ 34	£3 15 0
1.74	1 ⁵ / ₈ 42	1 ⁵ / ₈ 34	5 10 0
1.65	2 ⁵ / ₈ 65	1 ³ / ₄ 44	15 0 0

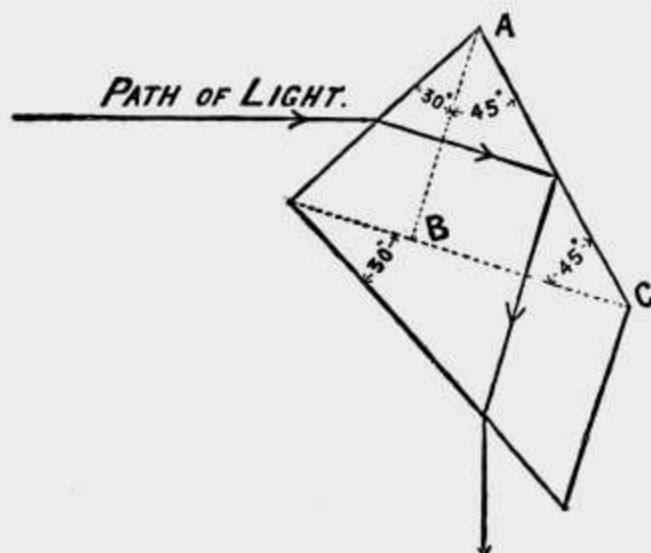


Fig. P 1.

Schulz's Cell, with body, for Spectrophotometry, closed or open. Diameter of hole, $\frac{7}{8}$ " (22 mm.) ... Price, **£1 12 6**

Prisms of Rocksalt, up to 6 cm. long face. Can be priced from the following formula:—Price in Shillings = $0.8 hl^2 + 17$ (h and l being the height and the length of face in centimetres).

60° Prisms of Fluorspar (these are subject to fluctuations in price, but can usually be supplied somewhat as follows):—

Length of Face.	Height.	Prices.
mm.	mm.	
20	15	£3 0 0
30	20	6 0 0
35	25	9 10 0
40	35	17 10 0

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Lenses of Rocksalt.

Focal length for D not less than five times the diameter, second quality surfaces.

DIAMETER.		PRICE.
inches.	mm.	
1	25	£0 19 0
1 $\frac{1}{4}$	31	1 1 0
1 $\frac{1}{2}$	38	1 4 0
1 $\frac{3}{4}$	44	1 8 0
2	51	1 14 0
2 $\frac{1}{4}$	57	1 19 0
2 $\frac{1}{2}$	63	2 5 0
2 $\frac{3}{4}$	70	2 17 0
3	76	3 9 0

First quality lenses of Rock Salt, focal length for D not less than $\frac{1}{7}$ the diameter, curves such as to give minimum spherical aberration for W.L. 10 μ , price 2 $\frac{1}{2}$ times the above.

Quartz-Fluorspar combination achromatic object glasses, achromatised to give the best results for the region from the red to W.L. 1850 (made to curves computed by J. W. Gifford, Esq., from his measurements of the refractive indices of quartz and fluorspar).

Spherical aberration corrected for W.L. 320 $\mu\mu$ (see note below).

Clear Aperture.	Focal Length.		Price (in cell).
mm.	cms.	ins.	
17 (f/12.3)	21.0	8.27	Variable according to the price of fluorspar.
17 (f/9)	15.3	6	
28 (f/11.5)	32.3	12.72	
28 (f/7.5)	21.0	8.27	
36 (f/9)	32.3	12.72	

Any longer focus than any of the above at the same price as the longer focus of the same aperture.

NOTE.—The Spherical Aberration of the above Quartz-Fluorspar lenses is corrected for W.L. 3200. There is therefore considerable spherical aberration in the visible spectrum and extreme ultra-violet (2100) even with the f/12.3 lenses, while with the f/7 lenses it is, of course, greater in these regions. The purposes for which it is intended to use the apparatus must in each case determine which focal length should be selected.

Fresnel biprisms $1\frac{1}{4} \times \frac{3}{4}$ inch, 179° angle, £1 5 6

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The very greatest care is exercised in packing, which is charged at cost price, and ADAM HILGER, LTD., cannot hold themselves responsible for injuries, which should be claimed for from the carrier. Cases should always be examined on arrival in presence of the carman for any external signs of damage, and his recognition of any such damage obtained.

Cases returned carriage paid and in good condition will be credited at two-thirds.

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