No. 28.

CARL ZEISS

OPTISCHE WERKSTÄTTE

JENA.

MICROSCOPES

AND

MICROSCOPICAL ACCESSORIES.

1889.

History of Carl Zeiss

· 1846	November 17.th- Carl Zeiss (11 Sept.1816 -3 Dez.1888) establishes a small workshop in Jena.
· Since 1847	Selling his first microscpes
· 1866	First cooperation of Zeiss and Ernst Abbe (23 Jan.1840 -.14 Jan.1904). 200 employees . The 1000th microscope is delivered.
· 1872	A Breakthrough : in the price list No.19 the first microscopes, designed by mathematical modeling --Abbe Sine Condition-- are presented to the public.Three of the 17 offered objectives are of the immersion type.
· 1875	Abbe becomes partner in business
· 1881	Zeiss son Roderich becomes partner; first meeting of Abbe and Schott.
· 1882	Otto Schott (17 Dec. 1851 - 27 Aug. 1935) opens his laboratory in Jena.
· 1883	O. Schott , E.Abbe ,Carl and Roderich Zeiss found th Schott & Genossen Glaswerk.
	Result of the successful cooperation of Zeiss, Abbe and Schotte was a leading position of Zeiss products since the late 19th century.
· 1889	After the death of Carl Zeiss Ernst Abbe creates the Carl-Zeiss-Stiftung (foundation)
· Ca.1900	more than 1000 employees; the employment benefits at Zeiss are at an uncommonly high level Cooperation with other companies like Bausch & Lomb ,N.Y.
· 1923	5000 employees
· 1945	Partial destruction of the works in Jena
· 1946	Founding of "Optische Werke Oberkochen" later "Carl Zeiss" in Western Germany
· 1947	Founding of "VEB Carl Zeiss Jena" and "VEB Jenaer Glaswerk" in Eastern Germany
· 1995	After the reunification of Germany carl Zeiss, Oberkochen takes over Jenaoptik GmbH and Carl Zeiss Jena GmbH.
· 1996	150 Years Carl Zeiss

Every article specified in this Catalogue will be supplied singly or otherwise at the prices subjoined.

The price of completely fitted Microscopes is in all cases the sum-total of the individual items.

Payment must be made in ready money without discount, either in cash or bills drawn upon a chief town in Germany, cheques drawn upon English banks also accepted.

Goods are forwarded, value declared, at the risk and cost of the receiver — foreign orders are despatched by the shortest route and with every precaution.

It is requested that the name and destination be plainly written in all orders and, to prevent any mistakes, please quote the number or date of this Catalogue.

Jena, 1889.

Carl Zeiss,
Optische Werkstätte.

A selection of completely fitted Microscopes for the most varied requirements will be found at the end of this list.

Contents.

Those pieces of apparatus indicated by an asterisk are such as have originated in our factories, i. e. either introduced by us as absolutely new or, at any rate, first made by us in the manner here described.

Objectives and Eye-pieces.

Since the publication of our last catalogue in 1885 a considerable advance has been made in the optical equipment of the microscopes constructed in our factories. The technical glass factory established here with our cooperation, after years of experiment and research by Dr. SCHOTT and Prof. ABBE, has produced a series of *new glasses* (borate and phosphate glass in particular) for optical purposes, which in refractive power and colour dispersion greatly excel the ordinary crowns and flints. By the use of this material and the application of new formulæ in the construction of the lenses, since the year 1886 we have produced *microscope objectives* which possess a considerably *more perfect correction both of chromatic and spherical aberration*, and therefore a much greater concentration of light in the image, than has hitherto been attained. For special use with these objectives we have likewise introduced eye-pieces of new construction which, in addition to other advantages, give almost perfect achromatism and sharpness of image over the whole visual field.

These new productions, first brought out in August 1886 under the designations *Apochromatic Objectives* and *Compensating* or *Projection Eye-pieces*, have since become widely known and universally accepted. During the last few years they have been the subjects of numerous comments in the various technical journals and are now included in our catalogue among the ordinary articles of manufacture.

The present catalogue includes, in addition to this new series, most of our older achromatic objectives and ordinary eye-pieces. For although it may confidently be predicted that before very long the apochromatics must entirely supplant the older objectives in the more difficult departments of microscopical research, there are problems enough in microscopy which do not demand the highest attainable perfection of apparatus and in which the ordinary achromatic microscope will render as good and sufficient service as it has done in the past, provided it is good of its kind, and is made with care and understanding.

The older type of objectives and eye-pieces again from their simple construction can be supplied at a considerably lower price than the much more complicated systems of the new series, the production of which will probably be limited for a long time yet on account of the extraordinary demand they make on the skill of the optician.

With deference to these considerations, only those numbers are erased from the list of our former achromatic objectives, whose special purpose is undoubtedly better fulfilled by the apochromatics — namely a few of the weaker dry lenses of relatively large aperture and the very short and very long focus lenses in the series of water and homogeneous immersions. The older kind of objectives moreover have been considerably improved in detail by the use of the new varieties of glass and such other alterations as their type of construction permitted.

In the special catalogue of 1886 we made an attempt to introduce a rational system of designation to specify the objectives and eye-pieces of the new series in place of the prevailing purposeless and arbitrary method.

Although we consider this system more practical than any of the usual ones of names and numbers and a step in advance if it could be universally adopted, we have thought it better for the present to exclude therefrom our older series of objectives and eye-pieces.

Great alteration in the focal lengths of both objectives and eye-pieces would have been necessary in order to designate these by the same convenient round numbers as in the new series. Our microscopes moreover being in such extensive use, so many microscopists have become accustomed to the focal-lengths hitherto adopted and to the usual denotation of the various items, that a radical alteration in this direction would no doubt give rise to considerable confusion. On these grounds the former designation of the objectives by letters and the arbitrary numeration of the eye-pieces has been retained in the older series.

Our **Objectives** are all constructed on the formulae of Prof. ABBE of Jena and subject to his constant supervision.

Every detail of their construction being mathematically computed, combined with perfect technical methods of working and a systematic control of each phase of their manufacture, obviates all testing and guarantees an extraordinary uniformity of our glasses from the highest to the lowest, at the same time altogether excluding specimens of inferior quality. All objectives are uniformly free from spherical aberration up to the marginal zone (proper thickness of cover with the higher powers being understood) and as far as possible perfectly corrected for colour. Special consideration is also given to the removal of aberrations outside the axis and to flatness of field.

Working Distance. Owing to the importance of a good working distance for the convenient and safe employment of the higher powers, particular attention is given to this factor in calculating the formulae of the various glasses. Our stronger objectives possess therefore an unusually large amount of working distance in comparison with their focal length and aperture. All, even the very highest, may be used with cover-glasses of 0.2 mm or more in thickness.

Body Length. The whole of the objectives in this catalogue are adjusted to a body length of 160 mm. or of 250 mm., according to order. The length is reckoned from the contact surface of the objective thread to the upper end of the body on which the eye-piece rests. This may be read off directly on stands of our make by the divisions on the draw tube. The objectives a, aa, A, B, C, F and J even if adjusted for the short (continental) tube, may be used on stands of English model with 10 inch bodies without appreciable loss. All the rest, particularly the apochromatic series and also the homogenous immersions, perform more or less deficiently as ordinarily adjusted for continental microscopes on stands of English model.

In foreign orders it should always be stated whether the objectives are to be adjusted for the short (continental) or for the long (English) body.

Thickness of Cover. All objectives in fixed mounts are, unless otherwise ordered, corrected for a medium thickness of cover between 0.15 and 0.20 mm. In the higher series from D upwards the thickness of cover consistent with the most perfect correction is indicated on the side of the mount by small figures (mm). It is as a rule sufficient for ordinary work, with such objectives as we supply only with non-correcting mounts, to use covers of an estimated medium thickness.

Homogeneous immersion objectives are, within wide limits, independent of the thickness of cover.

Correction Adjustment. The graduation and numbering on the correction collar, read off on the fixed index, indicates directly at each position of the collar the corresponding thickness of cover in hundreths of a millimeter coincident with the best correction at this point. The correction for cover must be carefully adjusted, particularly in the apochromatics 4.0 and 2.5 mm and the achromatics F and J, in order to ensure the best possible performance of these objectives.

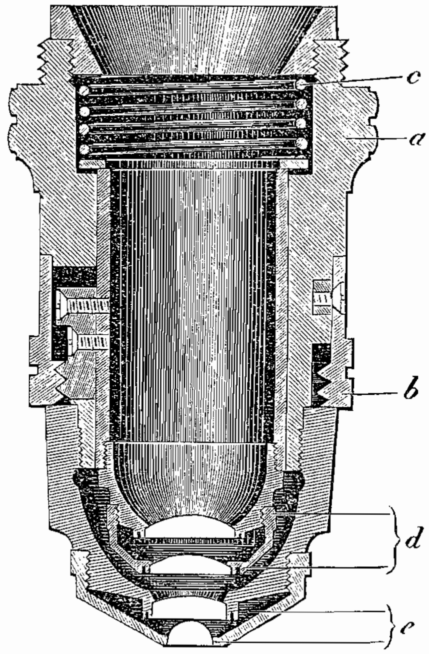

Fig. 1.

The homogeneous immersion objectives are only supplied in fixed mounts, for as already stated, they are independent of thickness of cover between rather wide limits, and also because any alteration in the distance of their lenses interferes with the perfection of their correction. Considerable variations in thickness of cover are best compensated for

by slightly lengthening the body-tube for thinner covers
" " shortening " " " " thicker ones.

The immersion fluid recommended for the homogeneous objectives is Cedarwood oil (from Juniperus virginiana) which we have used from the first. Latterly we supply the same in a thickened condition, which not only does away with its inconvenient fluidity but at the same time obtains almost perfect identity of refractive index with that of the cover-glass. A bottle of this oil is given with each objective and supplied subsequently when required. We expressly request therefore, that no immersion fluids from other sources be used with our objectives, or at least until these have been carefully tested as to their proper refractive power, because considerable loss in the performance of the objective may be expected if unsuitable fluids are employed.

The mounts of all objectives are provided with the English **standard thread.** In the series from A to J however, and also in DD when not fitted with correction adjustment, the mount containing the lenses is made to unscrew from the adapter and if required used with the narrow-gauge thread.

The name of the firm is engraved on the adapters of all objectives; on the apochromatics also the aperture, focal-length and body-length for which they are adjusted, and on the ordinary glasses the letter by which they are designated.

*Apochromatic Objectives.

We can only briefly state here the essential features of these glasses and must refer to the paper of our colleague Prof. ABBE „Ueber Verbesserungeu des Mikroskops mit Hilfe neuer Arten optischen Glases“ (Sitzungsberichte der med.-naturw. Gesellschaft zu Jena. Sitzung vom 9. Juli 1886)[1]) for a detailed statement of the scientific aims towards which the onstruction of this series is directed and to the well known work of DIPPEL „Das Mikroskop“ (2. Aufl., Braunschweig 1882) in regard to the general principles.

These objectives are distinguished from all other systems of lenses hitherto used with the microscope, by fulfilling simultaneously two conditions which have not otherwise been attained by any kind of optical construction — viz. 1) the union of three different colours of the spectrum in one point of the axis, that is to say, the removal of the so-called secondary spectrum of the older achromatics, and 2) the correction of spherical aberration for two different colours, in place of one in the brightest part of the spectrum.

All optical systems hitherto constructed, microscopes included, project a sharp image with one kind of light only (with yellow-green in such as are used with eye-pieces and blue-violet in photographic lenses), the other rays give more and more confused pictures, appearing partly as colour fringes and partly as a general blur. In the apochromatics however the projected images are nearly equally sharp with all the colours of the spectrum and the picture consequently is always of the same perfection, whether white or compound light is employed, or monochromatic illumination with any section of the spectrum.

1) Sent gratis on application.

In the older series again the colour correction is really good for one zone of the objective only, becoming imperfect towards both the margin and the centre of the aperture, whilst in the apochromatics it is corrected equally for all zones. Consequently in using Abbe's test-plate scarcely more colour is perceived with the most oblique illumination than with central light.

Finally even in the zone of most perfect colour correction of the ordinary achromatics only two colours can be combined in one point. The various coloured images therefore can only fall on the same spot in pairs between which is a considerable difference in focus. In the new series however three colours are combined in one point, whereby the amount of focal difference for the various sections of the spectrum, from the visible to far into the chemically active portion, is diminished to such an extent as to be practically non-existent, and this, as before stated, equally for each zone of the objective. The individual images of each single colour are therefore made to combine and cooperate most accurately in one spot[1]).

The practical advantage of these novelties is at once apparent. A considerably increased concentration of light with ordinary eye-piece observation as for every other purpose — and this by any kind of illumination, central or oblique, white or monochromatic — confers on these glasses an acknowledged superiority both in the power of their performance as in the diversity of their application.

It may be stated in reply to numerous inquiries and occasionally expressed doubts, that objectives of this kind are entirely constructed from glass which affords the best guarantee for their durability. Whenever any mistake has been proved in this direction the questionable glass has been always at once replaced by one of greater resistence. But obviously it cannot be expected that the lens surfaces will remain intact if the setting is unscrewed and they are exposed to the action of fluids and vapours.

The natural colours of objects, even in the more delicate tints, are reproduced unaltered by these objectives. Close to the margin of the field, the images are nearly as sharp as in the centre, though the high aperture and the relatively great working distance render a moderate degree of curvature of the image unavoidable in these objectives just as in the older ones.

As a result of the great concentration of light afforded by these objectives they permit the use of very high eye-pieces without detriment to the ac-

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1) This higher order of achromatism is theoretically and practically quite a different thing from a mere improvement of the ordinary kind of achromatism, by which the secondary spectrum could be diminished, but two colours only were made to combine. The word „apochromatic“ was introduced by Prof. Abbe as a technical term for this other kind of achromatism, long familiar to opticians as an idea but only just lately practically realised.

curacy or brightness of the image, thus giving high magnifying power with relatively long focal length, and enabling a series of very varying amplifications to be obtained with the same objective.

In the annexed list beside the apertures and foci the corresponding objective magnification is stated, i. e. the magnification which the objective alone would give at the distance of distinct vision if used as a simple lens. This is simply 250 (distance for distinct vision) divided by the focal length of the objective in mm. For instance, the objective magnification of a 3^{mm} is

$$\frac{250}{3} = 83.3.$$

The apertures given are the guaranteed minimum values; the stated focal lengths are adhered to as closely as possible.

List of the Apochromatic Objectives.

	Numerical aperture	Equivalent focus in mm	Initial magnification	Price *Marks*
Dry Series	0.30	24.0 16.0	10.5 15.5	**140.—** **100.—**
	0.65	12.0 8.0	21 31	**170.—** **130.—**
	0.95	6.0 4.0	42 63	**220.—** with corr. adjust. **180.—** with corr. adjust.
Water Immersion	1.25	2.5	100	**300.—** with corr. adjust.
Homogeneous Immersion	1.30	3.0 2.0	83 125	**400.—** **400.—**
	1.40	3.0 2.0	83 125	**500.—** **500.—**

The three objectives 24 mm, 12 mm and 6 mm of the dry series are constructed exclusively for the 10 inch-tube; all the others for both short and long tubes.

*Compensating Eye-pieces.

All objectives of considerable aperture, from their peculiar construction (hemispherical fronts), display certain colour defects in the extra-axial portion of the visual field (chromatic difference of the magnification), even if perfectly achromatic in the centre. The various coloured images which when combined form the final picture (Dippel, l. c. p. 225) are of different dimensions, the blue greater than the red. Whether an image be directly projected by such an objective or whether it be examined with an eye-piece (even of the achromatic or so-called aplanatic form) colour fringes will be observed, increasing towards the margin of the field.

This peculiarity is also possessed by the apochromatic objectives, and in the weaker ones it has been purposely introduced in about an equal degree because the error is nearly perfectly eliminated by means of suitable eye-pieces. These are so constructed as to possess the same amount of error of the opposite kind, that is, they magnify the red more than the blue. Such eye-pieces therefore compensate the different magnification of the objective and the images appear free from colour up to the margin of the field.

This compensatory action of the eye-pieces is manifested, particularly in the higher numbers where the limiting diaphragm is placed outside the lenses, by the fact that the edge of this diaphragm, shows a red border, whilst the image quite close at the edge is colourless.

The setting of the eye-pieces is so arranged, that the lower focal point of all numbers in each series lies in the same plane when inserted in the body-tube. No alteration of focus is therefore required on changing the eye-piece, and the optical tube-length (i. e. the distance between the upper focal point of the objective and the lower one of the eye-piece), which is the standard factor for the magnifying power, remains constant. This optical tube-length in the continental microscopes (excluding small differences between the various objectives) equals 180 mm, provided that the length of the body, from the contact surface of the objective to the upper end of the tube on which the eye-pieces rest, is 160 mm.

The eye-pieces of extremely low power designated **Searchers** serve the purpose of reducing to its lowest limits the available magnification with each objective,

List of Compensating Eye-pieces.

	Searcher Eye-pieces		Working Eye-pieces					
Eye-piece No:	1	2	4	6	8	12	18	27
	For the continental body:							
Equivalent focal length in mm	180	90	45	30	22.5	15	10	—
Price: Marks	20.—	20.—	20.—	20.—	30.—	30.—	25.—	—
	For the English body:							
Equivalent focal length in mm		135	67		34	22.5	15	10
Price: Marks		25.—	25.—		35.—	30.—	30.—	25.—

Table of Magnifications of the Apochromatic Objectives with the Compensating Eye-pieces

for an image distance of 250 mm.

Focus of the objective	Searcher Eye-pieces		Working Eye-pieces					
	1	2	4	6	8	12	18	27
24.0		21	42		83	125	187	281
16.0	15.5	31	62	94	125	187	281	
12.0		42	83		167	250	375	562
8.0	31	62	125	187	250	375	562	
6.0		83	167		333	500	750	1125
4.0	62	125	250	375	500	750	1125	
3.0	83	167	333	500	667	1000	1500	
2.5	100	200	400	600	800	1200	1800	
2.0	125	250	500	750	1000	1500	2250	

Carl Zeiss, Optische Werkstätte, Jena.

thus facilitating the preliminary examination of specimens and the labour of searching for particular points with high powers. Thus No. 1 of this series enables an objective to be employed with its own initial magnifying power, i. e. as if it were used as a simple lens without an eye-piece. They will be found of special service with immersion objectives, where great inconvenience is caused by having to change a lens already adjusted for another of lower power.

The working eye-pieces for regular observation are likewise of entirely new construction. They begin in both series with a magnifying power of 4 and are easy to work with even in the highest numbers. The eye-point in all lies so high above the eye-lens and the diameter of the lens itself is so large, that the usual inconveniences attending the use of eye-pieces of short focus are entirely obviated.

The ordinary drawing prisms and particularly the Abbe Camera may be used without difficulty on all the compensating eye-pieces from the even distance of their eye-points. The most appropriate for the purpose however are the weaker powers 4 and 6.

The numeration of these eye-pieces is carried out on the principle suggested by Prof. Abbe. The number which denotes how many times an eye-piece increases the magnifying power of the objective when used on a body of given length, affords the proper measure of the eye-piece magnification and at the same time the figures for rational numeration. On this basis the following series is arranged according to their magnifying power 1, 2, 4, 6, 8, 12, 18, 27, and these figures likewise serve as their designation.

The magnification obtained by combining a compensating eye-piece with any apochromatic objective is arrived at directly by multiplying its number by the initial power of the objective as given in the preceding list. An objective of 3.0 mm focus for example gives from itself a magnification of 83.3 (at the conventional distance of vision of 250 mm); eye-piece 12 therefore gives with this objective $12 \times 83.3 = 1000$ for the same distance.

For the continental and the English model microscopes two distinct series of compensating eye-pieces are made. The corresponding numbers in both series are of a different focal length according to the different length of the tubes.

The eye-pieces 1 and 6 are only made for the continental tube and 27 only for the English.

*Projection Eye-pieces.

These are used for projecting an image on a screen for demonstration or upon a photographic plate. They consist of a convex lens and a compound system, which is most carefully corrected both spherically and chromatically and is entirely free from secondary chromatic aberration and from difference of focus between the visual and chemical rays. A diaphragm is placed between the lenses for limiting the field, and the compound lens can be made to approach or recede from this diaphragm. The cap of the projection eye-piece forms a diaphragm by which any reflex from the body-tube is entirely cut off. The aperture of this diaphragm is made to correspond with the greatest aperture of the apochromatics.

They are specially corrected for our apochromatics on the principle of the compensating series, but may nevertheless be advantageously employed with ordinary achromatics of large aperture.

The designation of these eye-pieces corresponds to that of the compensating series according to their magnification, which for the 160^{mm} body equals 2 and 4, and for the 250^{mm} body 3 and 6.

The magnification for any distance of image from the eye-piece is obtained, by dividing this distance, expressed in millimeters, by the focal length of the objective in use and multiplying the result by the number of the projection eye-piece employed. Thus the objective of 3 mm gives with the projection eye-piece 2 an image magnified 1000 times at a distance of 150 cm $\left(\frac{1500}{3} \times 2 = 1000\right)$. This rule holds good strictly speaking for long distances only; for short distances it gives too high a reading.

The image distance may be reduced in the case of 2 and 3 to about 400 mm and with 4 and 6 to about 250 mm (reckoning from the eye-piece); it may be increased to any desired amount.

For further details see special Photo-micrographic catalogue.

Price of the Projection Eye-pieces 40 Marks each.

Achromatic Objectives.

For the general character of these objectives see the remarks on pages 4—6.

The **objectives a** are simple achromatic lenses, so mounted that, notwithstanding their great focal length, the body of the microscope remains at its ordinary elevation during observation. In $\mathbf{a}_1$ the thread is so placed that when screwed home the lens is inside the body. They are only intended for use with the lower eye-pieces.

Objective a* consists of two achromatic lenses, a concave front lens and a convex posterior system. By means of a ring rotating like a correction collar the two lenses can be approximated or withdrawn, whereby, using one of the lower eye-pieces, the magnification is changeable in the proportion from about 1 to 2. This graduation of the magnifying power is obviously useful for many purposes.

Besides the $^1/_{12}$ homogeneous immersion of 1.30 to 1.35 aperture we construct one of 1.20 at a correspondingly lower price.

We no longer supply the objectives BB, CC; G, K, L (Water immersions) and $^1/_8$ and $^1/_{18}$ (hom. immers.) of our former catalogues, because the special design of these is now, in our opinion, better fulfilled by the apochromatics.

All objectives are also supplied adjusted for the 10 inch body and in the English form of mount.

List of Achromatic Objectives.

	Designation	Numerical aperture	Equivalent focal length	Price without Correction	Price with Correction
				Marks	
Dry Series	a_1	—	40mm	12.—	
" "	a_2	—	35mm	12.—	
" "	a_3	—	30mm	12.—	
" "	a*	—	38—26mm	40.—	
" "	aa	0.17	26mm	27.—	
" "	A	0.20	18mm	24.—	
" "	AA	0.30	18mm	30.—	
" "	B	0.35	12mm	30.—	
" "	C	0.40	7mm	36.—	
" "	D	0.65	4.3mm	42.—	
" "	DD	0.85	4.3mm	54.—	74.—
" "	E	0.85	2.7mm	66.—	86.—
" "	F	0.85—0.90	1.85mm	84.—	104.—
Water Immersion	H	1.15—1.20	2.4mm	110.—	130.—
	J	1.15—1.20	1.8mm	144.—	164.—
* Homog. Immersion	$\frac{1}{12}$	1.20	2.0mm	160.—	
	$\frac{1}{12}$	1.30—1.35	2.0mm	300.—	

Magnification

of the Achromatic Objectives with the several Huyghenian Eye-pieces

with a body-length of 160 mm and an image distance of 250 mm.

Eye-piece:	1	2	3	4	5	
a_1	7	10	15	20		a_1
a_2	11	16	23	30		a_2
a_3	20	30	40	50		a_3
a*	4—8	7—14	10—20	15—30		a*
aa	25	35	47	60	77	aa
A, AA	37	50	70	90	115	A, AA
B	60	85	115	145	185	B
C	105	145	200	265	325	C
D, DD	175	240	325	420	540	D, DD
E	280	390	535	680	865	E
F	415	585	790	1000	1277	F
H	320	440	610	770	985	H
J	340	585	810	1030	1314	J
$\frac{1}{12}$	385	530	730	925	1180	$\frac{1}{12}$
	1	2	3	4	5	

Huyghenian Eye-pieces.

We supply these for use with the ordinary achromatic objectives. Their focal lengths and magnifications are shown in the following table.

Eye-piece No:	**1**	**2**	**3**	**4**	**5**
Focus in mm	50	40	30	25	20
(Eye-piece) magnification	3	4	5,5	7	9

Price 7 Marks each.

The magnification is computed by the same rule as in the compensating series (see page 12), but having regard to the various positions of their lower focal planes.

With regard to the choice of eye-pieces for a microscope we would remark, that all our higher objectives are capable of giving effective magnifications for regular observation even with No. 4.

With the higher power achromatics, from DD upwards, the compensating eye-pieces give an image free from colour, particularly at the edge of the field.

We no longer supply the „orthoscopic" eye-pieces of former catalogues, their place being taken by the compensating or projection series.

Accessory Apparatus for testing the fundamental properties of Microscopical Objectives.

No. | | *Marks*

1 *__Apertometer__ after Abbe, for estimating the numerical and angular aperture of objectives (Journ. of the R. Micr. Soc. Jany. 1878, p. 19). Semi-circular disc of thick plate glass 90 mm in diameter, with reflecting prism for throwing horizontally-incident light in the axis of the microscope; to lie on the stage of the microscope. The objective to be tested is adjusted to a central spot on the surface of the disc. The limits of the aperture are indicated by moveable indices on the periphery of the disc; a special auxiliary objective is used for observation, which screws into the draw tube and is adjusted by it to the image of the indices. The reading is given by two series of divisions on the glass disc, one of which shows the angle of aperture in air and the other the numerical aperture. For use on either of the larger stands with draw-tubes. Including the auxiliary objective, in case (fig. 2) . . . . . . 60.—

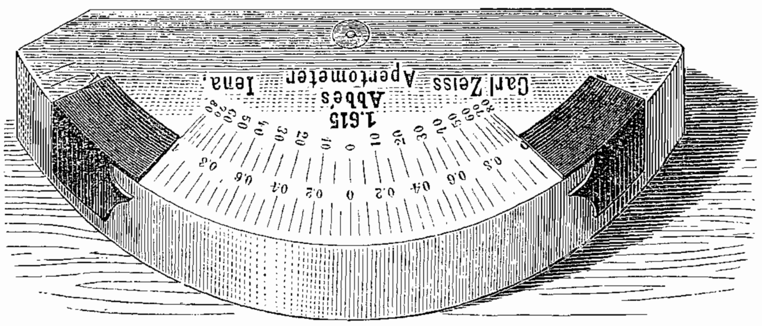


Fig. 2.
Apertometer.

2 *__The same apparatus,__ the glass disc being provided with a metal foot on which the indices move in a groove and are therefore more easily adjusted . . . . 80.—

No.		Marks
3	***Test-plate** after ABBE — for testing the spherical and chromatic aberration of objectives, and for estimating the thickness of cover compatible with the most perfect correction. Six cover glasses, having the exact thickness marked	

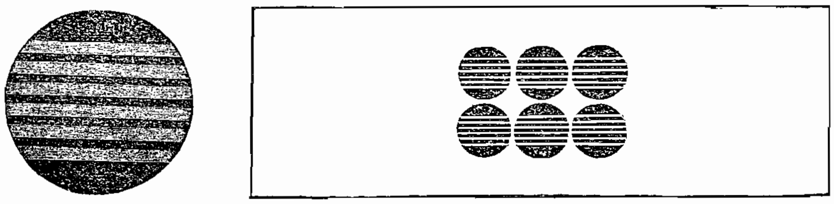


Fig. 3.
Test-plate No. 3.

	on each (0.09 to 0.24 mm), cemented in order on a slip, their lower surface silvered and engraved with parallel lines, the contours of which form the test. For use with the ABBE Condenser. (See Instruction for use.) In case	7.—

Stands.

The general form of our stands, like most others of continental design, is modelled on the type first introduced by OBERHÄUSER and developed by HARTNACK. It is more or less universally acknowledged that the size and general arrangement of this kind of stand best corresponds to the requirements of scientific research. The extensive employment of the continental forms even in English and American science schools, as well as the testimony of numerous competent investigators, shows that, for scientific work at least, they are preferred even there to the more elaborate of the so-called English stands.

Latterly we have endeavoured to perfect the mechanical details of the microscope, and have made several improvements in the three main factors which essentially constitute the stand viz. the stage arrangements, the focussing and the illumination.

A. The Stage.

The dimensions of the stage in all our stands (except in the Laboratory stands VI and VII) are sufficiently large to allow the use of any size slip or culture plate.

The diameter of the stage opening in stands I to V is 33 mm, in consequence of the large field of the longer focus objectives (especially the projection objective of 75 mm focus). It may be reduced to the diameter of the upper lens of the condenser, by slipping in a diaphragm provided for the purpose, when very small slips are employed.

The height of the stage above the table is reduced to the lowest limits which will permit the application of the ABBE condenser in stands II[a] to V, in order that the hands may be supported by the table when manipulating on the stage. In the larger stands (I, I^a, photographic and mineralogical stands) the stage is made higher, to facilitate the employment of various methods of illumination other than the ABBE condenser, which are occasionally required.

Stands IV, V^a and stand „BABUCHIN" are made with **fixed stages.**

Mechanism for moving the object is provided in N$^{os.}$ I, I^a, II^a, the photographic and mineralogical stands. This consists of the following arrangements:

a) Revolution of the stage and body round the optic axis (stand I).

b) Revolving stage-plate with arrangement for centering (N$^{os.}$ I^a, II^a, mineralogical stand). (Fig. 4.)

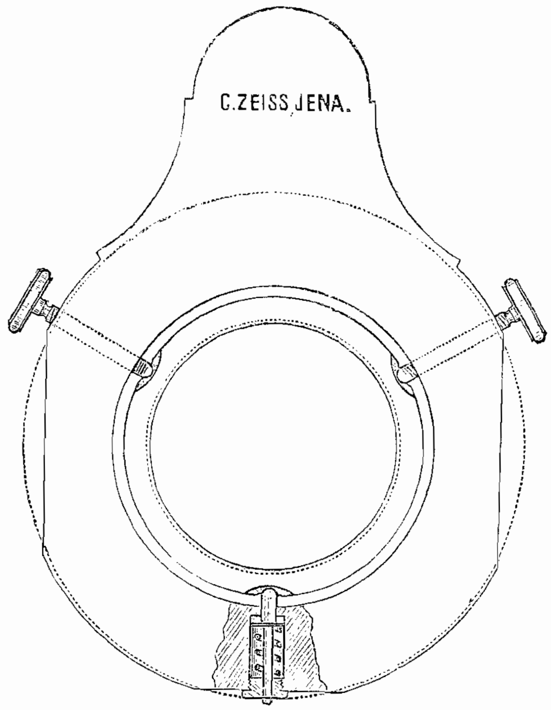


Fig. 4.
Revolving stage-plate with arrangement for centering.

c) Mechanical stage (stand I^a and „for photo-micrography"). This, which possesses the general arrangement of the English form of moveable stage, is substituted in place of the rotating vulcanite stage-plate in stand I^a. (Fig. 5.) The micrometer stage in the photo-micrographic stand is made for delicate adjustments of the object. (Fig. 6.)

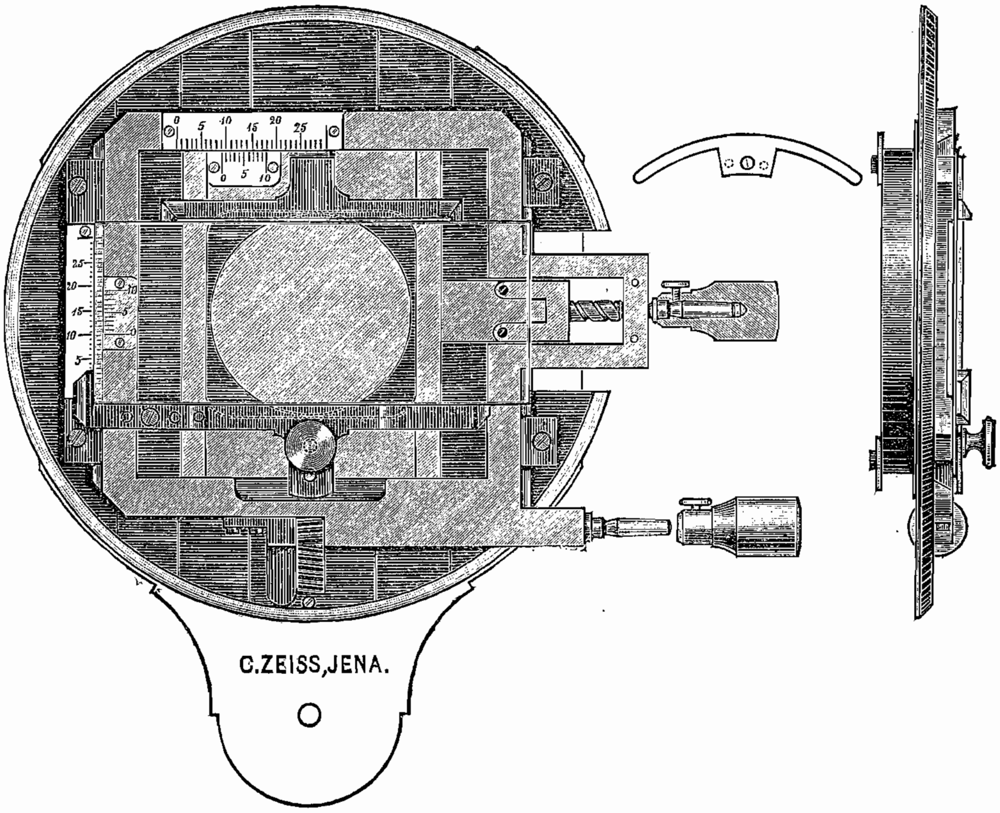
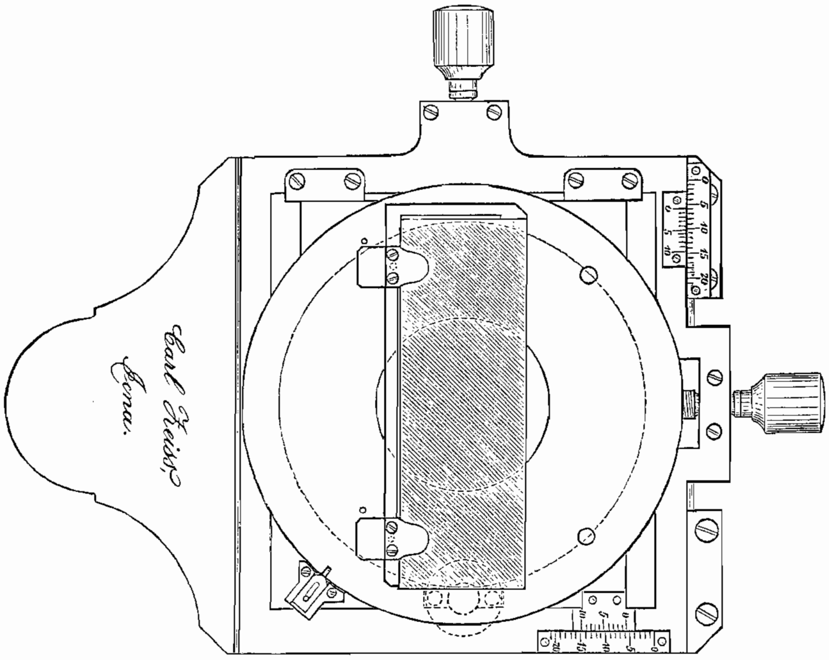


Fig. 5.
Mechanical stage of stand I a.



¡Fig. 6.
¡Mechanical stage of photographic stand.

Mechanical stage movements were formerly peculiar to English microscopes and absent in the great majority of continental instruments. It is only lately that they have received much attention on the continent but for some years they have been experimented with in our factories. We have become convinced that mechanical movement of the object is of advantage in the following cases:

1. In the employment of high power lenses, when it is required to bring a point seen at the margin into the middle of the field. This, as is well known, when done by hand, is often a sore trial of patience. The small amount of movement necessary to accomplish this is provided for, in a limited way, by the centering arrangement of the revolving stages in stands I^a^ and II^a^ (see above b).

2. For the systematic examination of specimens.

3. For counting particles within a certain field of the object.

4. For registering certain spots in specimens in order to find them again readily.

5. For the projection of real images.

In cases 2 and 5 a mechanical stage must be chosen more or less according to the requirements; for the former like that of stand I^a^, for the latter that of the photo-micrographic stand. These are both so constructed as not to interfere in the least degree with any other manipulative process, and they may be retained in situ even when using pure-cultivation plates. We consider this to be a great improvement on the ordinary form of mechanical motion, which must be removed from the stand during certain investigations with the instrument. For this reason we have ceased to manufacture the so-called pendulum and the Reichert stages.

B. The Adjustments.

The coarse adjustment. Whilst the sliding form of coarse adjustment, retained in the cheaper stands V, VI and VII, has undergone scarcely any alteration since its introduction, the rack and pinion motion in N^os.^ I—IV, IX and the mineralogical, photographic and „Babuchin model" stands has recently been very considerably improved by us. We have constructed special machinery for the accurate production of the (diagonal) gearing, and this motion is now made so perfect that objectives of medium power can be focussed by it alone without having recourse to the micrometer screw.

The fine adjustment. This has also lately received our special attention. The result is a micrometer movement of new construction now fitted to all our stands except N^o.^ IX. (For detailed description see Zeitschrift für wissenschaftliche Mikroskopie III, 2, p. 207.) As will be seen from the annexed illustration (fig. 7) the advantage of this new arrangement is that the force exercised by the micrometer screw, is transferred to the moveable limb by a single contact between hardened steel surfaces. This ensures an extremely delicate and equable motion of the limb carrying the body.

The divisions on the milled head of the micrometer screw in stands I—IV are for registering the vertical movements of the body. In the new stands each division corresponds to 0.01 mm elevation or depression of the body-tube in the optic axis.

By this means measurements of thickness may be made with some degree of accuracy. The upper and lower surfaces of the object are successively focussed and the amount read off on the milled head by the fixed index. In doing this it must be remembered to make both adjustments by an equable rotation of the screw. The depth of the layers of air is then proximately equal to the difference between the two readings.

The thickness of layers of any other substance may also be measured by the same arrangement. **Estimation of the thickness of cover-glass** for instance is best done as follows: With a high-power dry lens (D or E) N° 3 or 4 eye-piece and central illumination, take covers of known thickness — such as those on the Abbe Test plate — focus their upper and lower surfaces and note the apparent thickness so obtained. A comparison of this with the known true value gives, once for all, the amount of reduction which must be made, on measuring any other covers with the same objective under precisely similar conditions of illumination. Roughly speaking this equals 3/2 (the refractive exponent of glass). The thickness of specimens is estimated in a similar manner.

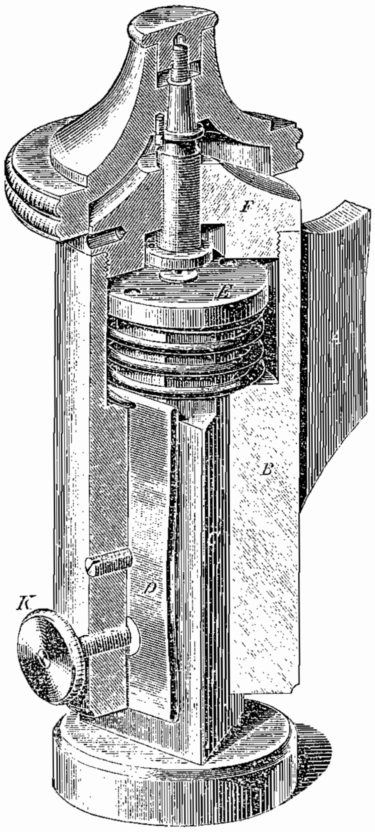


Fig. 7.
New form of fine adjustment.

The medium body length of our stands is 160 mm from the attachment of the objective to the upper end.

The draw tubes for lengthening or shortening the body are furnished with a millimeter scale to show the amount of withdrawal. The lower end is tapped with the standard thread to take the auxiliary objective used with the apertometer.

C. The Illumination of the Object.

The modern microscope is essentially constructed for illumination with transmitted light. Ordinary microscopic observation solely requires an illumination by white (day or lamp) light without limitation of the field, but the incident pencil should be capable of wide variation as regards its angular aperture (wide or narrow illuminating cone) and its direction (central or oblique light). These requirements are fulfilled by the **ABBE Condenser**, first introduced by us in 1873. It is now so generally employed and so universally acknowledged as an indispensable accessory in the finer kinds of microscopic work, that it properly forms an essential adjunct to all stands intended for scientific research.

To facilitate the **employment of the cylinder diaphragms**, which formerly were only applicable after removal of the entire illuminating apparatus, we have lately made certain alterations in the mechanical part of the ABBE Condenser. Other special forms of illuminator described in N^os^ 20—23 can also be applied to the same fitting, so the sub-stage formerly required to adapt them has been done away with even in stand I.

The cases for all the large and medium stands are of solid mahogany. The cupboard form has been substituted for the ordinary box, as the instrument is certainly more easily taken out and replaced in them without the least derangement of its fittings. The size is reduced as much as possible for the sake of compactness, but they are sufficiently roomy to permit of the instrument being replaced with the objective (on the nose-piece even) and eye-piece in situ, and to contain an extensive assortment of objectives, eye-pieces and the ordinary accessory apparatus.

If desired they can be furnished with:

Metal name plates, including engraving, to screw on the door, Mk 5.—

Leather travelling cases according to size . . . . Mk 10—20.—

The ordinary cases are included in the price of the stand. Cases of particular design, in walnut or ebony, can be made if desired at an extra charge.

Specification and Price of the various Stands.

A. Large Stands.

No.		Marks
4	**Stand I.** Stage and body revolving round the optic axis.	
	Coarse adjustment by rack and pinion, fine adjustment by micrometer screw with divided head.	
	Draw-tube with millimeter divisions.	
	ABBE Condenser (see p. 46) with rack and pinion adjustment. Iris diaphragm of the newest construction with full aperture. Condenser system of 1.40 mm. aper. interchangeable with cylinder diaphragm. (Fig. 8.)	300.—
	Centering arrangement to the diaphragms or sub-stage condenser (see p. 47) is only supplied if specially ordered. Price M. 20.—	
	The sub-stage formerly supplied with this stand for holding a centering diaphragm or other apparatus and also the extra mirror, is done away with, the new arrangement of the ABBE Condenser permitting the use of these accessories.	

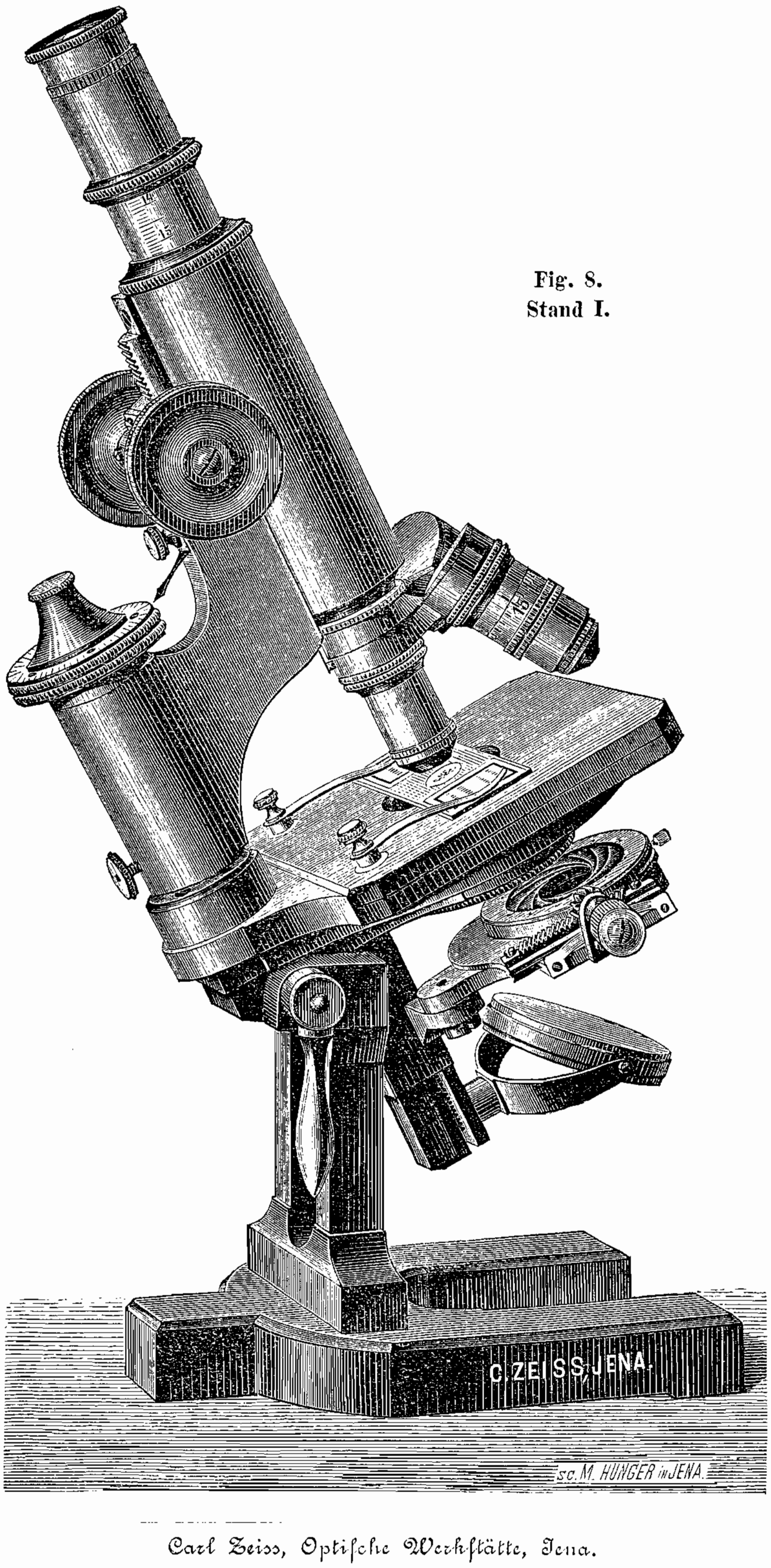


Fig. 8.
Stand I.

Carl Zeiss, Optische Werkstätte, Jena.

No.		Marks
5	**Stand I^a.** Stage with rotating vulcanite disk, which is removable and can at any time be replaced by the mechanical stage described below. The rotating disk is centered by means of two milled-head screws (fig. 4). This adjustment also serves to give slight motion to the object.	
	Otherwise exactly as stand I. (Fig. 9.)	
	Without mechanical stage	300.—
	With „ „	400.—

The mechanical stage is shown in Fig. 5. It is an improvement on the English form. The improvements are as follows:

1. It permits the use of any sized slips. Culture plates may be put upon the stage by removing the clips and milled heads, which is very easily done.

2. It is divided to serve as a finder, the divisions with the vernier reading to $^1/_{10}$ mm. To use this arrangement the slip must always be pushed against the projection at the left hand of the object holder, so that it always occupies the same position relative to the rectangular movements of the stage. The divisions can also be used for measurement, if the accuracy required does not exceed 0.10 mm.

3. The stage is available with every method of illumination.

Attachment of the mechanical stage is effected in the simplest manner on removing the rotating disk, which also involves no complicated manipulation.

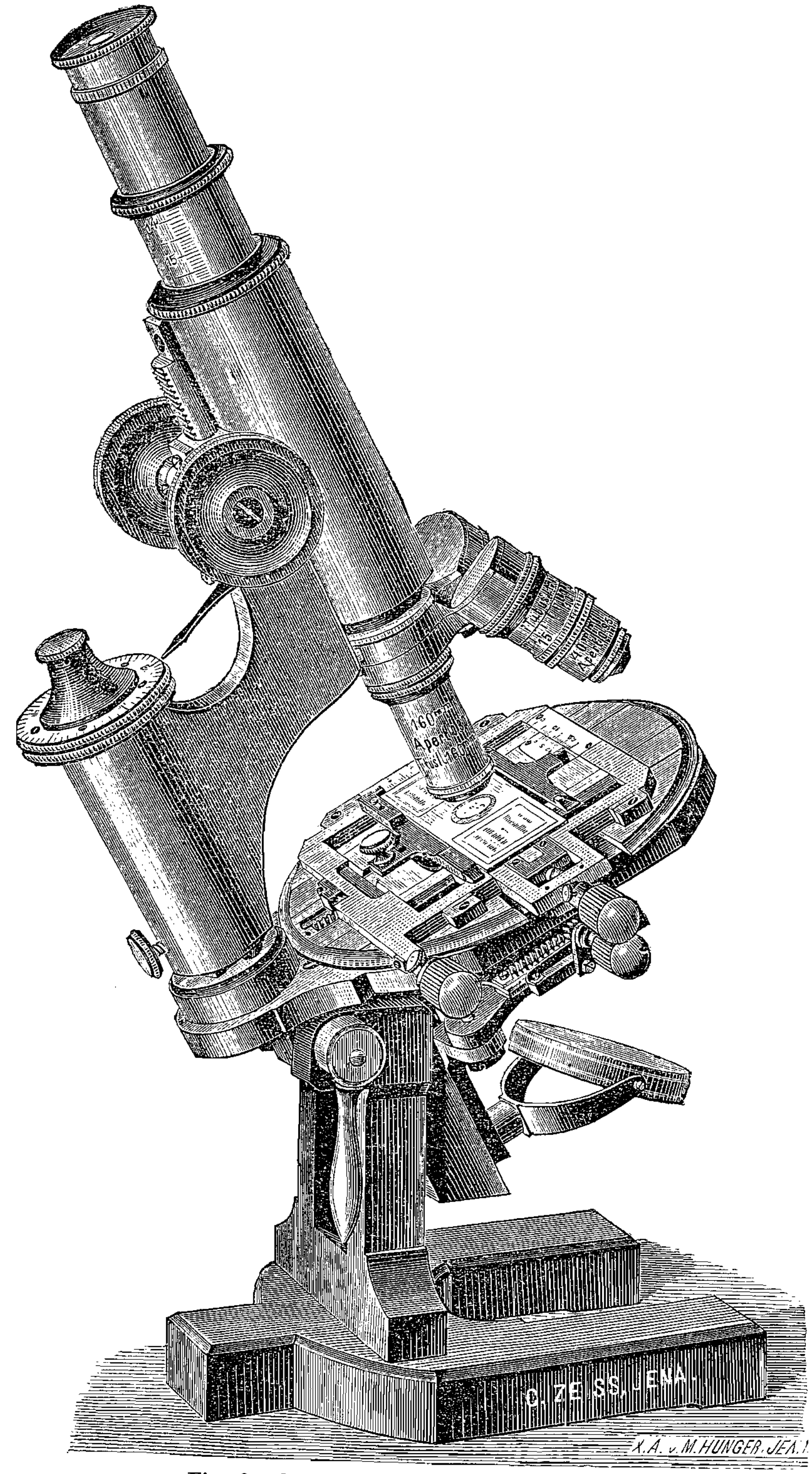


Fig. 9. Stand Ia with mechanical stage.

No.		Marks
6	**Stand for Photo-micrography.** Extra large stage, with arrangement for delicate motion of the object as described below, and which also permits the use of any sized slips (including culture-plates).	

Body very short and of great diameter, so that photographic objectives of very long focus may be used within it. Draw-tube with millimeter divisions.

Coarse adjustment by rack and pinion, fine adjustment by micrometer screw of new construction with divided head. The edge of this head is geared for working the fine adjustment by a HOOKE's joint.

ABBE Condenser (see p. 47) with iris diaphragm and ordinary lens system of 1.20 num. apert. which is fitted to the apparatus by a sliding jacket. For projecting a sharp image of the flame in the plane of the object, an achromatic centering condenser of 1.0 num. apert. with iris diaphragm between the lenses, is made to fit the sliding jacket in place of the condenser of 1.20 num. apert. **(See special catalogue of apparatus for photo-micrography and projection.)** The achromatic condenser is of course available for ordinary purposes, except when oblique illumination is required. (Fig. 10.)

The mechanical stage of the above stand is constructed for imparting a very slow motion to the object, which the projection of a magnified image at a great distance necessitates. Whilst the revolution of the object is effected in the ordinary way by rack and pinion, the cross motions are attained by fixing the rotating disk on slides at right angles to each other, which are acted upon by micrometer screws. Finder arrangement (reading to 0.10 mm) as in stand I^a^. (Fig. 6.)

		Marks
	Without achromatic Condenser	350.—
	With " "	425.—

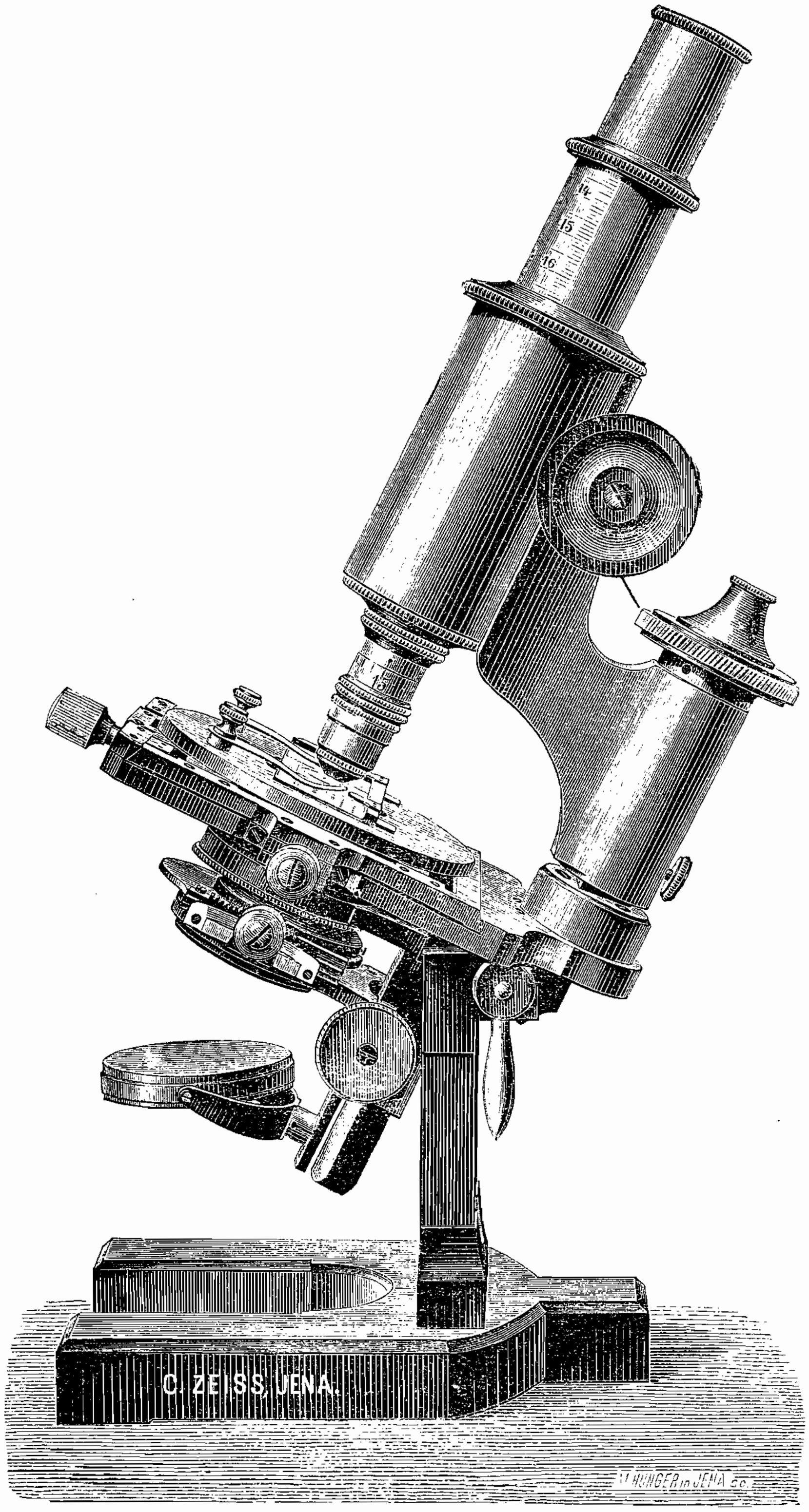


Fig. 10. Stand for Photo-micrography.

B. Stands of Medium Size.

No.		Marks
7	**Stand II^a^.** Stage with revolving vulcanite disk, which is centered by two milled-head screws acting against a spring in front; within small limits this can be used as a fine stage movement.	

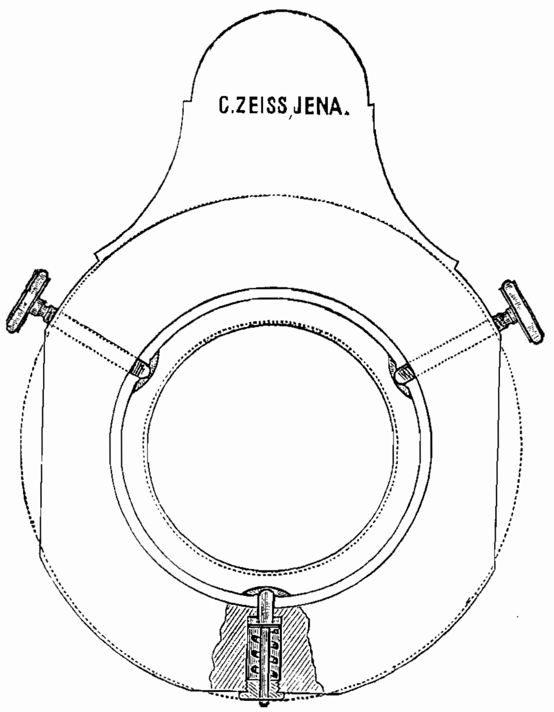


Fig. 11.
Stage with revolving disk and centering arrangements.

Coarse and fine adjustments as in the former instruments.

Abbe Condenser of new construction with iris diaphragm. Condenser 1.40 num. aper. Cylinder diaphragm to fit in place of the lens of the condenser. (Fig. 12.) . . . . 290.—

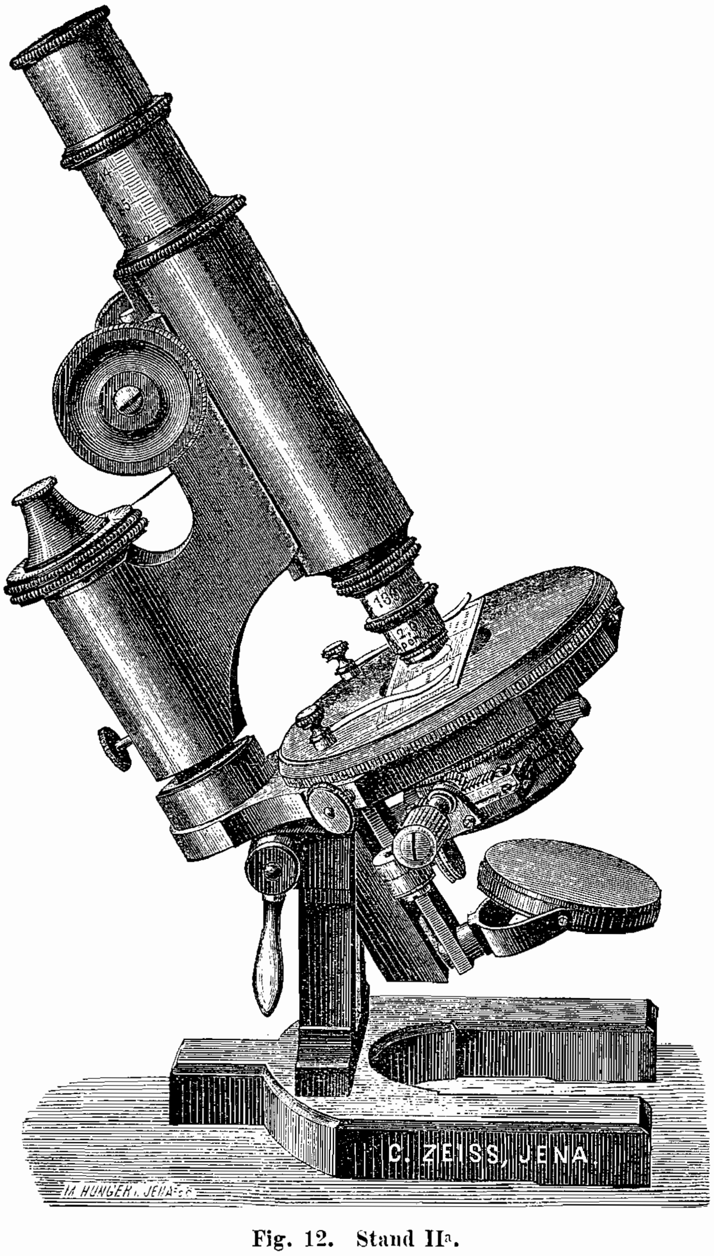


Fig. 12. Stand IIa.

No.		Marks
8	**Stand IV¹.** Fixed stage. Coarse and fine adjustments as above. ABBE Condenser of 1.20 num. aper. Cylinder diaphragm to fit in place of the lens of the condenser. Without iris diaphragm, which however can be added at an extra charge of 15.— Mk., either on ordering or subsequently	**200.—**
9	**Stand IV².** Without condenser; this is replaced by the ordinary plane and concave mirror with universal motions and the ordinary cylinder diaphragm, which is connected with the under surface of the stage by a bayonet catch. This arrangement permits a rapid interchange of the diaphragm for the simplified ABBE condenser (condenser of 1.20 num. aper., with fixed iris diaphragm; page 49)	150.—
	With this illuminating apparatus No. 18 . .	**190.—**

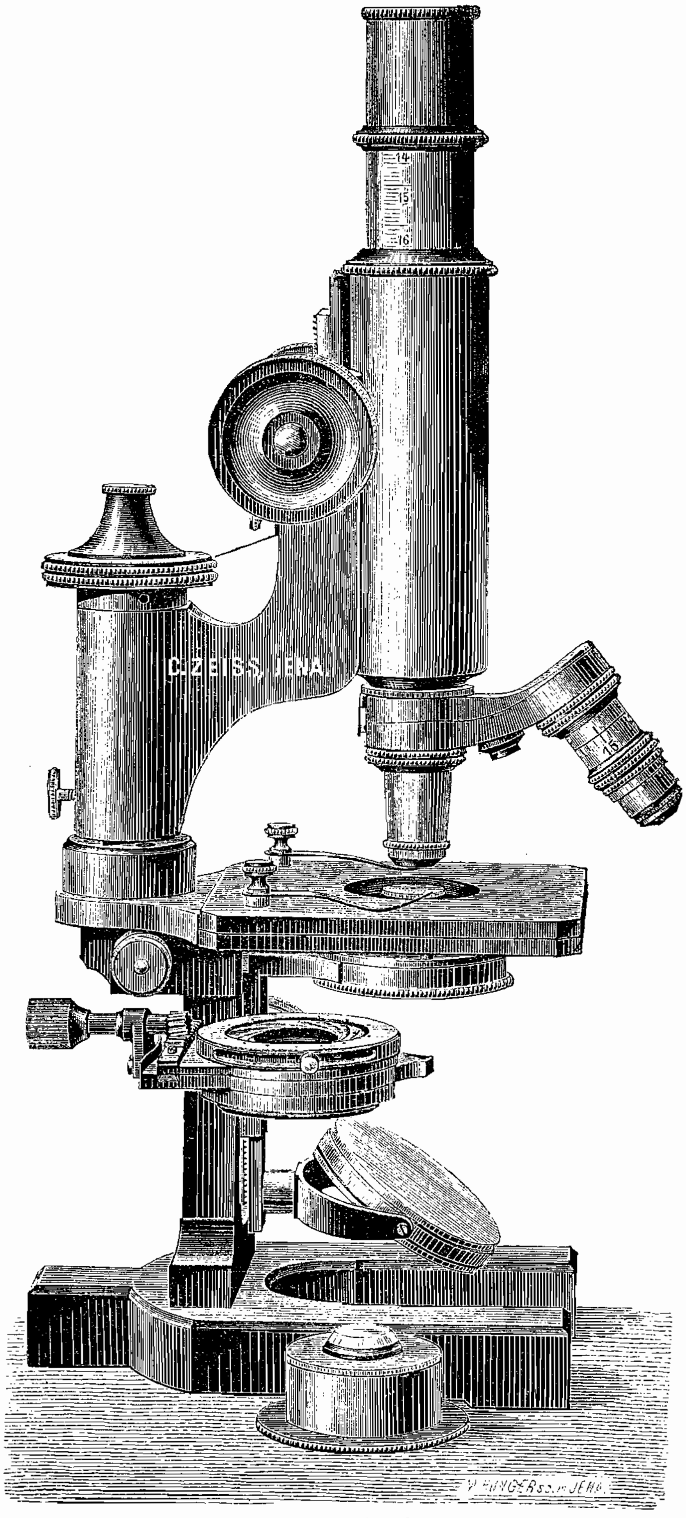


Fig. 13. Stand IV[1].

No.		Marks
10	**Stand V¹.** Fixed stage. Coarse adjustment by sliding tube. Fine ditto by micrometer movement of new construction. ABBE Condenser as in stand IV. (Fig. 14.)	120.—
11	**Stand V².** As the above but without the ABBE condenser. Other arrangements as in stand IV²	95.—
	The new form of ABBE Condenser for stands IV² and V² is supplied at any subsequent time at the ordinary price; as now constructed it can be fitted to these instruments by any optician.	
12	**Babuchin Model Stand.** This instrument, made after the design of Prof. BABUCHIN of Moscow, is included in our own series as it possesses several novel features of practical value which cannot be combined in the ordinary form of stand. These are substantially as follows: 1. The ABBE Condenser is constructed in a manner resembling that adopted by NACHET. The lens system, mounted in a holder, is inserted from above into the carrier which can be screwed downwards and swung out to the left. It is also made to centre. By these means the lens is easily changed for another of different aperture, or for a cylinder diaphragm or polariser.	

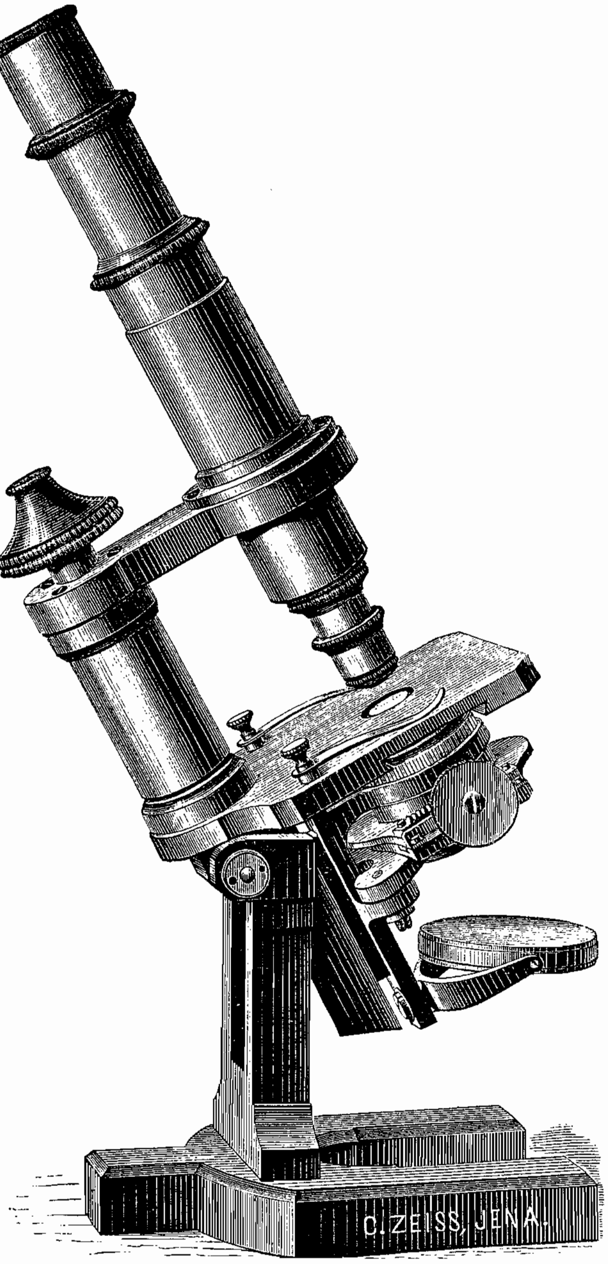


Fig. 14. Stand V[1].

No.		Marks

2. Below the condenser is a slot rotating about the optic axis, in which the iris diaphragm worked by rack and pinion is inserted; for oblique illumination this can be adjusted excentrically.

3. The condenser is moved in the optic axis, not, as is generally the case, by rack and pinion, but by a screw fitted to the under side of the stage on the left hand, which gives a slower and more delicate motion. When the screw has been turned until the condenser has reached the lowest point, a further turn of the screw causes it to turn out automatically to the left, in which position the system can be changed, centered and so forth.

A specially large mirror fixed to a sliding holder allows plenty of up and down movement, and, when the condenser is swung outward, can be placed in any oblique position.

The stage, which is not made to rotate or move, is sufficiently large to take cultivation plates.

The upper part of the stand is attached by a hinge joint to a prism-shaped pillar sliding in an outer tube, so that it can be withdrawn and fixed by a clamping screw. This arrangement permits: 1. to give a compact form to the instrument, 2. to increase the height of the stage and stand generally, should this be required for the application of a photographic camera, or a larger substage &c.

The height of the stand may be thus varied from a minimum of about 200 mm, with a body-length of 150 mm, to a maximum of 230 mm; that of the stage from 105 to 135 mm. — This stand is fitted with the new micrometer fine adjustment. (Fig. 15.) 285.—

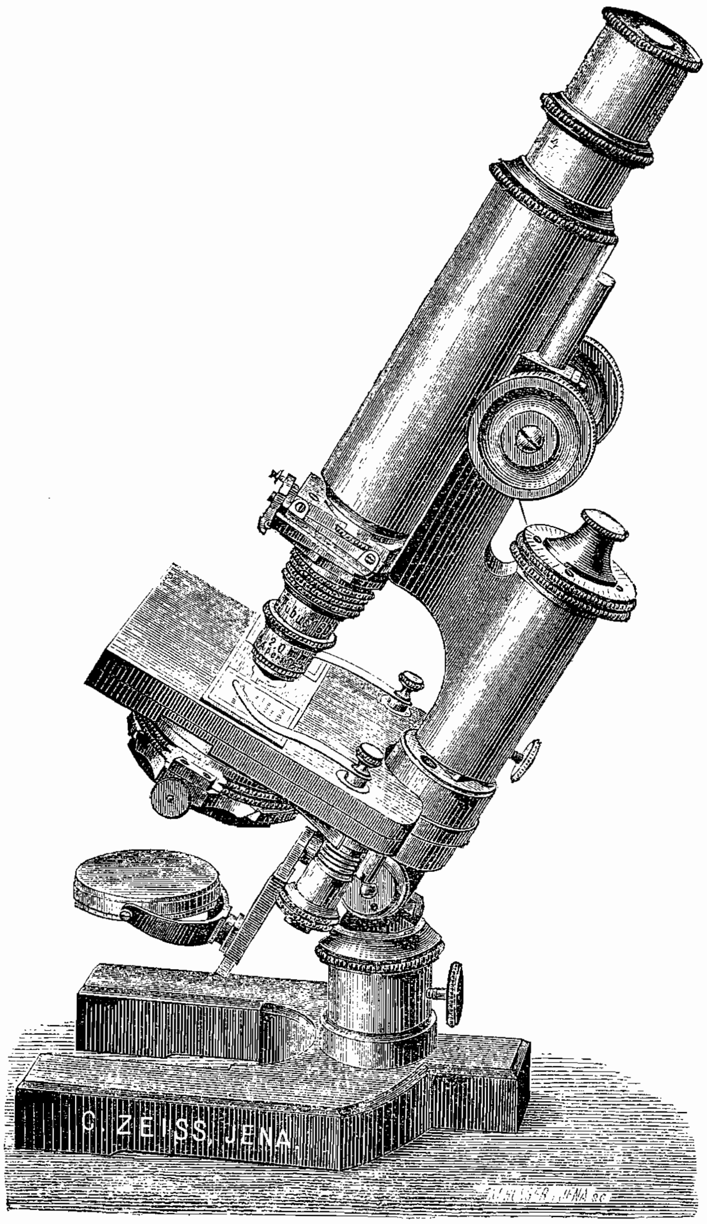


Fig. 15.
Babuchin model stand.

C. Small Stands.

Stands V^b, VII^b and VIII of former catologues will only be supplied to special order and provided also that not less than 10 be taken.

No.		Marks
13	**Stand VI.** Fixed stage. Illumination by plane and concave mirrors with universal motion in and out of the optic axis. Cylinder diaphragm with jacket fitted to the under surface of the stage by a bayonet catch, easily removed when very oblique light is required. This arrangement also permits the application of the illuminator No. 19 (of about 1.10 num. aper.) in place of the diaphragm, when objectives of larger aperture are in use. Coarse adjustment by sliding tube. Body provided with draw-tube. Fine adjustment by micrometer screw of new construction. This stand is made to incline. (Fig. 16.)	**65.—**
14	**Stand VII.** In all respects as stand VI but non inclinable. Rather stoutly built for laboratory use, but the strongest objectives are available on account of the fine quality of the micrometer movement (Illuminator No. 19 as in stand VI). (Fig. 17.)	**60.—**

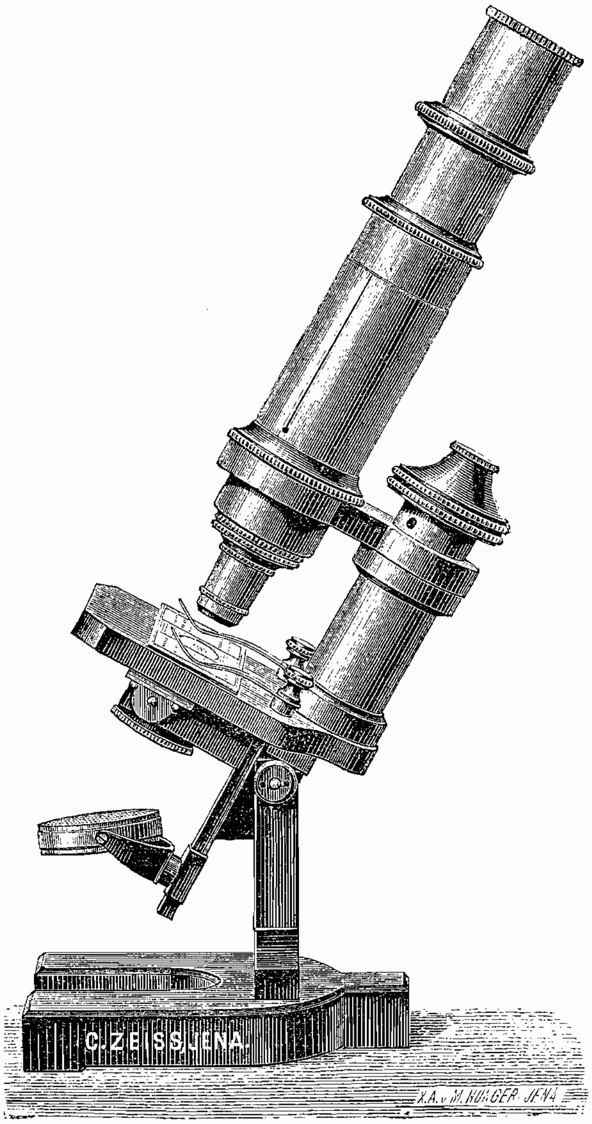


Fig. 16. Stand VI.

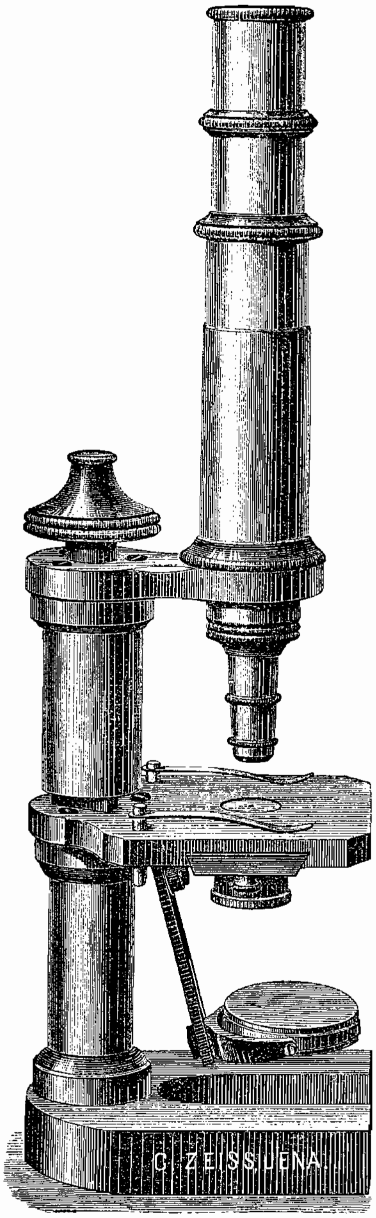


Fig. 17. Stand VII.

No.		Marks
15	**Stand IX.** Simple stand for laboratory and technical purposes. Large plain stage with large aperture, which may be decreased if required by dropping in a diaphragm. Large plane and concave mirrors. Adjustment by rack and pinion, the construction of which permits the use of medium powers (C, D). (Fig. 19.)	30.—
	Recommended by Prof. JOHNE (Veterinary school, Dresden) for the detection of Trichina.	
16	**Hand or Demonstration Microscope.** Stage with clips to hold the specimen; sliding body, which after adjustment is securely fixed by a clamping ring. Fine adjustment if required	

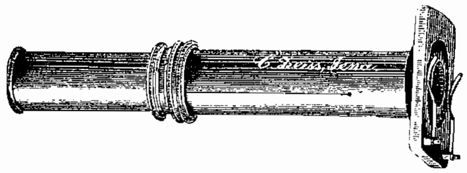


Fig. 18.
Hand or demonstration microscope.

to made by the tube carrying the eye-piece. In use it is directed by hand towards a window or lamp. Available even with objective D. Without objective, eye-piece and case. (Fig. 18.) . . 15.—

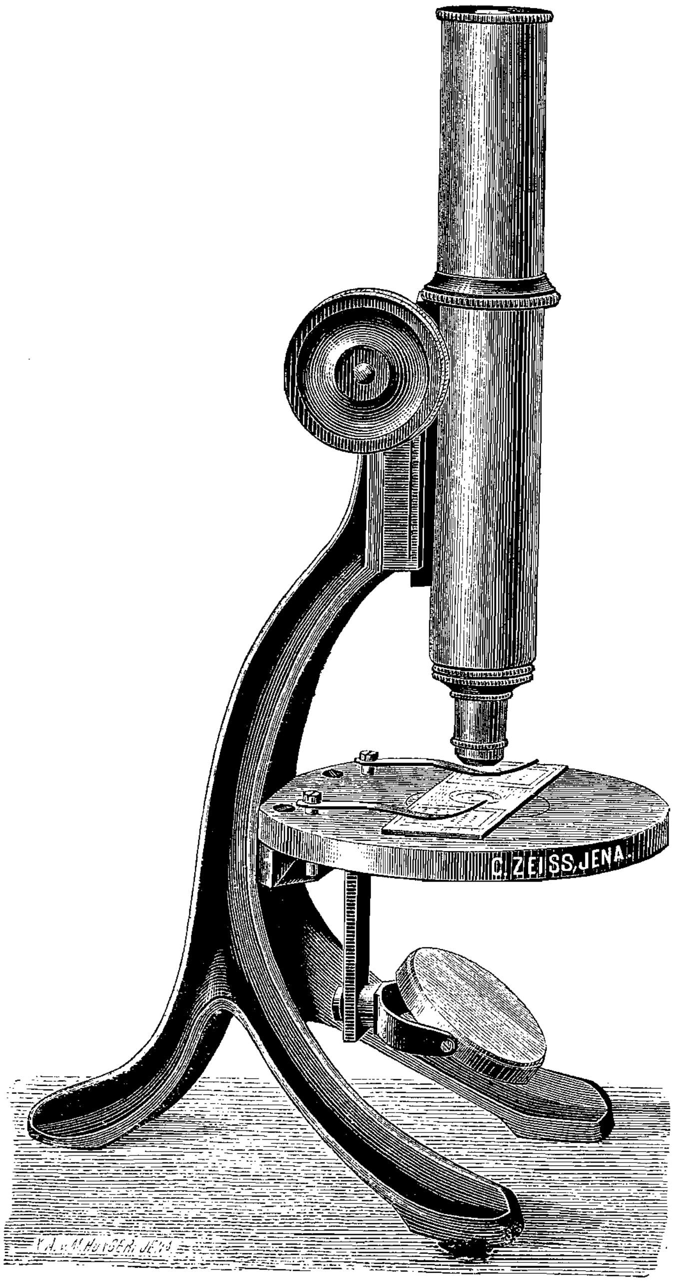


Fig. 19. Stand IX.

Illuminating Apparatus.

A. For white light.

No. | Marks

17 ***Illuminating Apparatus after ABBE** (new arrangement). The essential feature of this is a condenser system of very short focus, which collects the light reflected by the mirror into a cone of rays of very large aperture and projects it on the object.

The full aperture of the illuminating cone is only used when observing finely granular and deeply stained particles (bacteria) with objectives of large aperture. In every other case the cone must be reduced to suitable dimensions either by an iris diaphragm (see below) or common diaphragm (central illumination). On placing the diaphragm excentrically, by means of the rack work attached to the carrier, the central rays are excluded and a certain portion of the extra-axial cone falls upon the object (oblique light). When the diaphragm is thus excentrically placed this oblique pencil can be directed from all azimuths by rotating the carrier round the optic axis.

The central stop diaphragm shuts off all the axial and transmits only the marginal rays (dark-ground illumination).

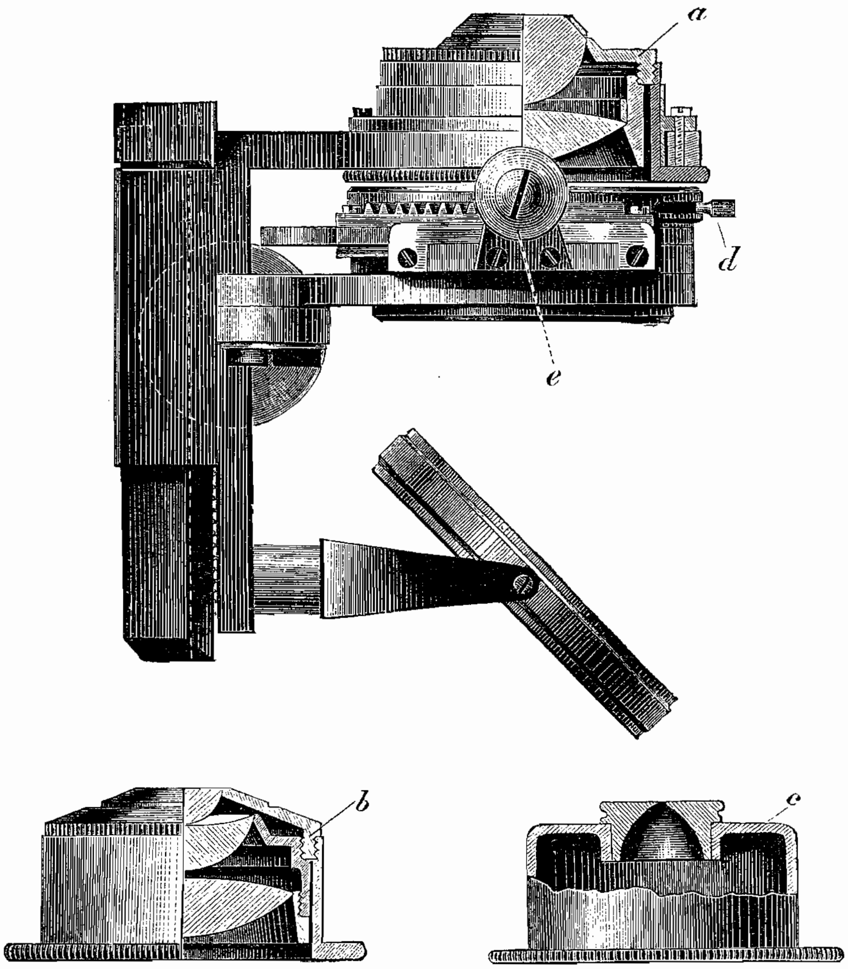


Fig. 20.

Illuminating apparatus after Abbe.

a) Condenser system of 1.2 num. aper., *b*) condenser system of 1.4 num. aper., *c*) cylinder diaphragm, *d*) iris diaphragm, *e*) adjustment for throwing the diaphragms out of centre.

No.		*Marks*

The *Condenser system — made as before in two forms, a double combination of 1.20 num. aper., price Mk. 20.—, and a triple ditto of 1.40 num. aper., price Mk. 25.—, — is mounted in a holder which fits a sprung jacket on the apparatus. This arrangement facilitates an interchange of the two condenser systems, and also serves to carry the following apparatus when the lens is removed:

a) the ordinary cylinder diaphragm; this is included with every condenser;

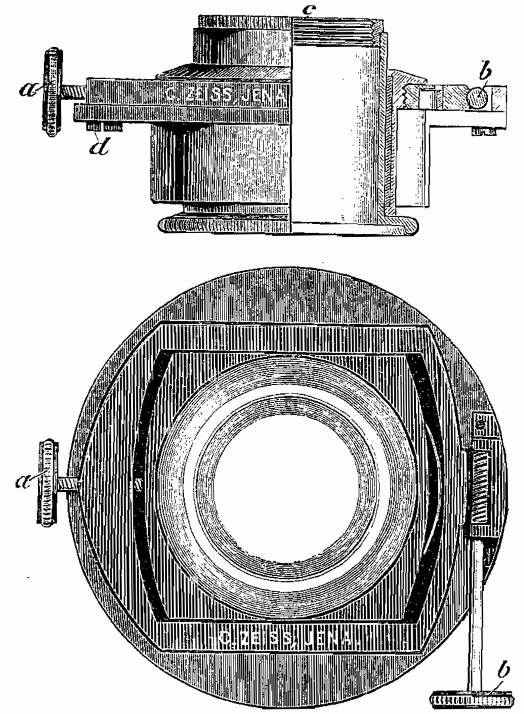


Fig. 21.
Arrangement for centering.

b) the illuminating appliances described under No. 20—23.

c) centering arrangement for accurately adjusting the above. (Fig. 21.) (Price Mk. 20.—.)

As most of these appliances require adjustment to the plane of the object a rack and pinion motion in the optic axis has now been fitted to the Abbe Condenser, so that every microscope provided with this accessory is capable of taking any other form of illuminator which may be required.

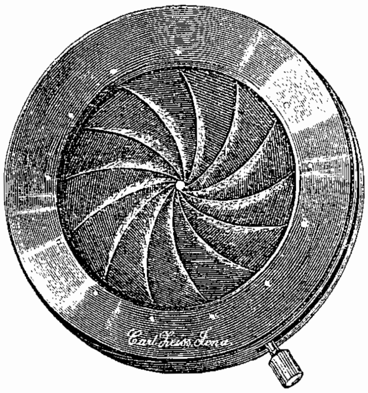


Fig. 22. Iris diaphragm.

The new iris diaphragm (price Mk. 15.—) is a very convenient substitute for the ordinary interchangeable diaphragms, as it affords a ready means of

No.		Marks
	increasing or diminishing the aperture with the greatest precision. Smallest aperture about 0.5 mm, largest — in the newest form — equal to the full aperture of the condenser system, so that it may remain in situ when either the central spot diaphragm or polariser is in use	55.—
18	***Simplified Illuminating Apparatus** for stands IV² and V². Condenser system of 1.20 num. aper., with iris diaphragm (not adjustable excentrically); giving therefore central illumination in any degree but not oblique. Fitted to the under side of the stage in these instruments by a bayonet catch exactly as the cylinder diaphragm	40.—
19	***Illuminating apparatus** for stands VI and VII. Condenser of 1.0 num. aper., to fit in place of the cylinder diaphragm. Without diaphragms. The graduation of the (central) illuminating cone is effected by sliding the system in its jacket	10.—
	Numbers 18 and 19 may be ordered at any time by possessors of the corresponding stands, as they are made to fit these without any alteration.	
20	**Achromatic Condenser.** Specially constructed for the requirements of photo-micrography, to project a sharp image of the source of light in the plane of the object (see special catalogue for photo-micrography). Achromatic condenser of 1.0 num. aper. with iris diaphragm and centering adjustment. Made to fit the jacket of the ABBE apparatus in place of the ordinary system (see No. 17). Focussed by the rack and pinion motion of the illuminator	75.—

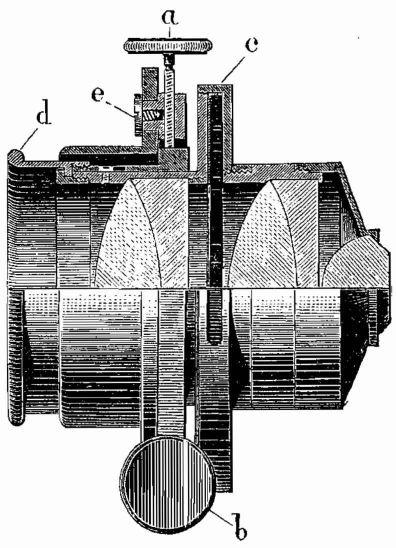


Fig. 23. Achromatic Condenser.

B. Illuminating apparatus for spectroscopially decomposed light.

No.		*Marks*
	When it is required to illuminate a portion of an object in the field of the microscope with a single pure spectral colour, or to observe the effect of the whole spectrum upon it, or finally to bring into action the spectrum of polarised light, the use of such appliances as N^os. 21, 22 and 23 is necessary. These are connected to the ABBE illuminator by the centering arrangement shown on page 48 and adjusted to the object plane by the rack and pinion motion.	

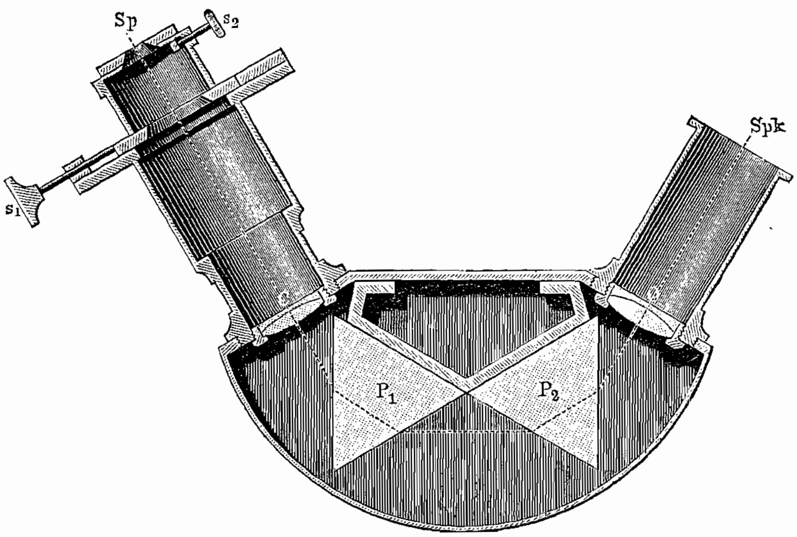


Fig. 24.
Illuminating apparatus for monochromatic light.

21 **Illuminating Apparatus for monochromatic light,** after **HARTNACK.** A spectrum of considerable length is projected on the specimen by means of a series of prisms of great dispersion,

No.		Marks
	so that with rather high magnifications the whole visual field is illuminated by approximately monochromatic light. On shifting the slit by means of a screw the different colours are successively made to occupy the field of vision	80.—

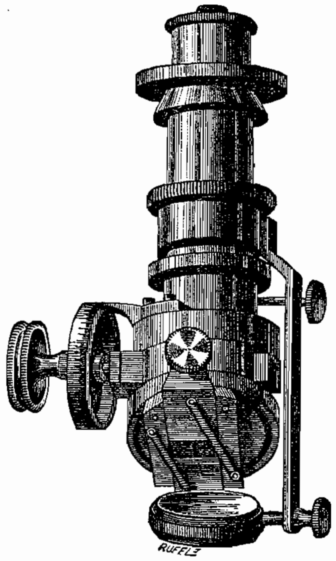


Fig. 25.
Micro-spectral objective after ENGELMANN.

22 **Micro-spectral Objective after ENGELMANN,** for observing and measuring the effect of the colours of the spectrum on microscopical objects (Bot. Zeitung 1882 No. 26; PFLÜGER'S Archiv Bd. XXVII p. 464, Bd. XXIX p. 415). Slit mechanism, collimator lens, AMICI prism and projection objective are combined in a tube about 77 mm in length, which fits below the stage concentrically with the axis of the microscope so as to project a real spectrum upon the preparation under observation. The edges of the slit are moved symmetrically by a screw with two reversed threads, so that the middle of the slit remains unaltered in position; the divided head of the screw shows the width of the slit as adjusted in 100ths of a mm; the length of the slit may be shortened on both sides by two slides acted upon by screws. — Ordinary objectives are used for projecting the spectrum,

No.		Marks
	either A, B, C or D according to the desired size of the spectrum, and which screw by the narrow gauge thread on the lens mounts over the AMICI prism. (Fig. 25.)	**124.—**
23	* **Spectro-Polariser after ROLLETT** (Zeitschrift für Instrumentenkunde, Jahrg. I, p. 366) as modified by DIPPEL, for determining the character of double refraction in microscopical specimens. Combination of two flint-glass prisms, giving a deviation of 90°, having on one side a moveable slit and collimator and on the other a microscope objective, which projects from below a real spectrum on the specimen under observation. Scale tube on the box containing the prisms, with mirror, collimator-lens, and a scale divided and numbered according to the wave lengths (as in the spectroscopic eye-piece No. 53); by reflexion from one surface of the prism a real image of this scale is projected with the spectrum in the plane of adjustment. The edges of the slit are moved symmetrically by a double threaded screw so that the middle of the slit always occupies the same position. A PRAZMOWSKI prism mounted on a revolving arm in front of the slit serves as a polariser, and between it and the slit is a revolving ring to receive selenite films for producing interference lines in the spectrum. An A, B, C or D objective is used to project a spectrum of the desired dimension and is screwed to the box containing the prisms by the narrow gauge thread on the lens mount. The apparatus is arranged for connection with the framework of the ABBE Condenser by means of the centering adjustment (p. 48). The vertical motion is made by rack and pinion but the shifting of the spectrum in the transverse plane is effected by two milled-head screws acting on double slides. (Fig. 26.) Including two selenite films for red of the second and third order	**240.—**

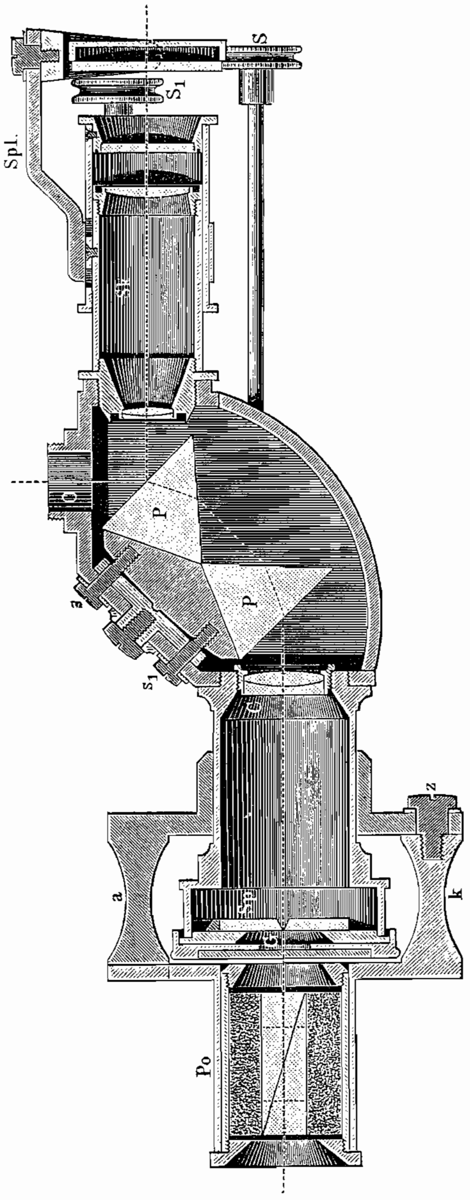


Fig. 26.
Spectro-Polariser.

Appliances for changing the Objectives on the Stand.

No.		*Marks*

These contrivances are required to fulfil two conditions: 1) that the image should not disappear on changing the objectives, so that only a touch of the micrometer screw is necessary for perfect adjustment, and 2) that the centering should be good, i. e. that the same spot in the specimen remains in the field after changing the lens.

The first condition is fulfilled by adjusting the lengths of the mounts, so that on changing them their focus lies at a correponding distance from the plane of the object. The second condition can only be guaranteed in the ordinary nose-piece when it is specially adjusted to the particular objectives intended for use with it. It is impossible therefore to be answerable for the exact centering of nose-pieces subsequently supplied. To avoid this inconvenience we have lately constructed the Sliding Objective-changer (see below) which has a special arrangement for centering and can therefore be adapted to any objective.

No.		Marks
24	**Revolving Nose-pieces.**	
	a) Revolving nose-piece for 3 objectives. (Fig. 27.) . .	27.—

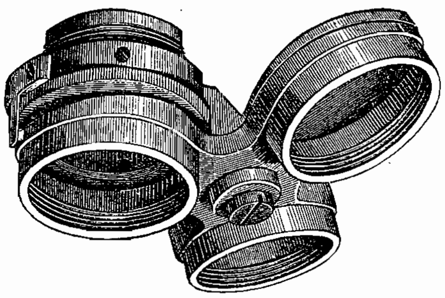


Fig. 27.

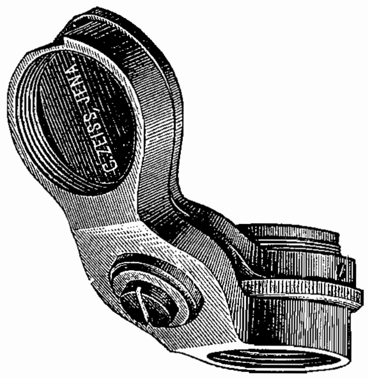


Fig. 28.

Revolver.

	b) Revolving nose-piece for 2 objectives. (Fig. 28.) . .	20.—
	The quadruple nose-piece is no longer made.	

25 * **Sliding Objective-changer.** This apparatus possesses an arrangement by which each individual objective can be centered and it permits the use of any number of glasses. (Figs. 29 and 30.)

It consists of:

a) The tube-slide. This is screwed on the end of the body like an ordinary nose-piece *with the grooves directed anteriorly*. The plane of the sliding motion is not made at right angles to the optic axis but inclined at a small angle to it.

b) The objective-slide. The plane of the slide is inclined to the axis at an angle corresponding to the tube-slide, so that the objective rises on its withdrawal and cannot damage the specimen. At one end of this fitting is a screw turned by a watch-key which acts as a stop to bring the objective always back to the same position and which also serves as a centering adjustment in the direction of the slide, while the adjustment in the transverse direction is effected by a similar screw working at right angles to the first.

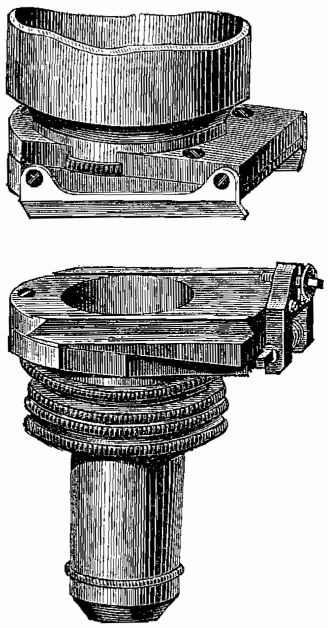


Fig. 29.

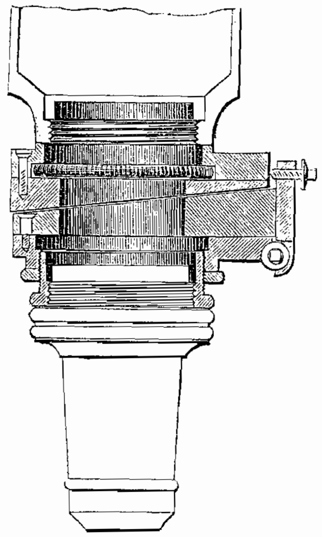


Fig. 30.

Sliding objective-changer.

No.		Marks
	Objectives whose settings are approximately compensated for their focal lengths can, by means of the clamping screw on the objectve-slide, be set once for all in their proper position. The two pieces fit one another accurately; any number is supplied with the tube-slide or subsequently as may be required. On changing the objectives, if the slide has been properly adjusted, the same part of the object always occupies the field and so nearly in focus that only a slight adjustment by the micrometer screw is necessary.	
	Tube-slide	10.—
	Objective-slides, each	10.—

Apparatus for measuring and counting microscopical objects.

A. Measuring Apparatus.

No. | Marks

With regard to measurement of the thickness of microscopical objects see p. 26.

The following apparatus is intended for measuring the length and breadth of microscopical objects.

26 **Stage Micrometer.** One millimeter divided into 100 parts; on a glass slip, in case . . . . 10.—

This serves merely as a standard of known value for adjustment of the measuring apparatus proper.

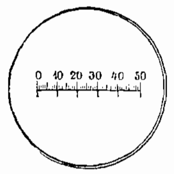


Fig. 31.
Eye-piece micrometer.

27 **Eye-piece Micrometer.** Divisions on a glass disk to drop into the eye-piece; for measuring the magnified image of an

No.		*Marks*

object; the real value of the divisions therefore must be estimated by means of the stage micrometer for each objective and eye-piece combined. Approximate values, sufficiently accurate for ordinary purposes, are given in a table supplied with our micrometer eye-pieces. (Fig. 31.) . . . . 5.—

28 **Micrometer Eye-piece for ordinary objectives.** Huyghenian eye-piece (2 or 3 as desired) with sliding eye-lens for exact adjustment to the eye of the observer and table of values of the divisions. (Fig. 32.) . . . . 15.—

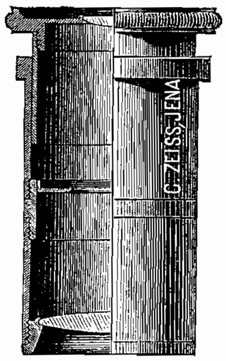


Fig. 32.
Micrometer eye-piece.

29 **Micrometer Eye-piece for the apochromatic objectives.** Compensating eye-piece 6 with $^1/_1$ micron divisions. The divisions in this eye-piece are so computed that the value of one interval (with a body-length of 160 mm) for each apochromatic objective equals just as many micra, μ, (0.001 mm), as its own focus equals millimeters, e. g.

Apochromat:	16.0 mm	8.0 mm	4.0 mm	3.0 mm	2.5 mm	2.0 mm
1 interval:	16 μ	8 μ	4 μ	3 μ	2.5 μ	2 μ.

A table of values is therefore superfluous for this eye-piece, as they are indicated by the designation of the objective in use . . . . 30.—

No.		Marks
30	**Screw Micrometer Eye-piece.** For more exact measurement of objects which occupy a large portion of the field. Ramsden eye-piece. Glass plate with crossed lines, which together with the eye-piece are carried across the image formed by the objective by the measuring screw, so that	

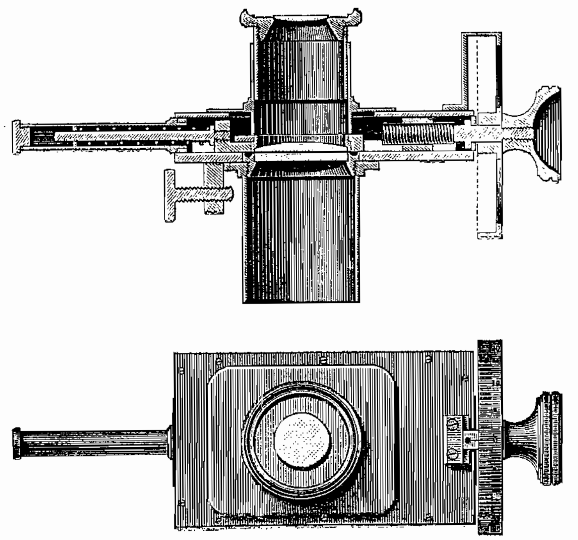


Fig. 33.
Screw micrometer eye-piece.

	the adjustment always remains in the centre of the ocular field. Each division on the drum corresponds to 0.002 mm. Whole turns are counted on a numbered scale seen in the visual field. Measures the image projected by the objective up to 8 mm. (Fig. 33.)	60.–
31	**Stage Screw Micrometer,** for the exact measurement of objects too large to be included in one visual field. A revolving disc divided on the edge, for fixing the position of the object, supported on struts extending from the	

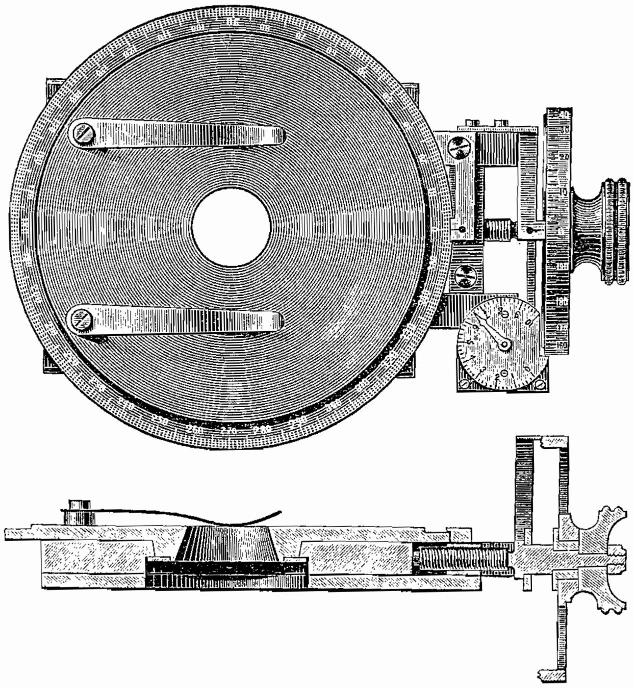


Fig. 34.
Stage screw micrometer.

No.		*Marks*
	frame of the micrometer screw. The divisions on the drum read off to 0.002 mm; whole turns of the screw are indicated on a dial. The screw measures up to 10 mm. Arranged to fix on the stage of the larger stands	**120.**—

B. Apparatus for Counting.

32	**Crossed-line Micrometer,** for dropping into the eye-piece. A square of 5 mm divided either into whole or half mm according to order; for counting scattered particles in the visual field . .	**5.**—
33	**Crossed-line Stage Micrometer** with chamber 0.100 mm in depth. The bottom is divided into 400 squares each equal to $^{1}/_{400}$ sq. mm; the cubic contents of the fluid resting on one	

No.		Marks
	square, when the chamber is full, therefore equals $^1/_{4000}$ cubic mm. With 2 plane cover-glasses. In case	15.—
34	**Apparatus for counting blood corpuscles after THOMA.** The above crossed-line micrometer with an exactly caliberated mixer for diluting the blood to a fixed amount. With method of use. In case	30.—
35	**The same,** with a small moveable stage, enabling the divided surface of the chamber to be moved across the visual field by a screw	40.—

C. Measuring Apparatus for various other purposes.

36	**Brass measure,** 100 mm, with chamfered edge	1.50
37	**Measures on plate glass,** for drawings, in which the divisions lie on the surface of the paper without parallax, with fine, sharply engraved lines:	
	300 mm glass rule, divided to single mm	9.—
	200 mm do. do.	5.—
	100 mm on glass slip 125 × 25 mm	1.50
	50 mm divided to half mm on a 3 × 1 inch slip	1.50
38	**The two latter with double divisions,** English inches and lines, or half lines, and mm; each	2.50
39	**Fully divided Circles** on plate glass discs, with centre marks, for use as transposers:	
	Circle 80 mm in diameter, entire degrees	5.—
	Circle 120 mm in diameter, half degrees	9.—

No.		*Marks*
40	**Goniometer Eye-piece** (No. 2), for estimating the angles of microscopical objects, with divided circle and glass plate marked with a series of parallel lines; sliding adjustment to eye-lens . .	30.—
41	**Cover-glass Tester,** for the exact measurement of cover-glasses, thin plates etc. The measurement is effected by a clip projecting from a box; the reading is given by an indicator moving over a divided circle on the lid of the box. The divisions show hundredths of a millimeter. Measures to upwards of 5 mm	36.—

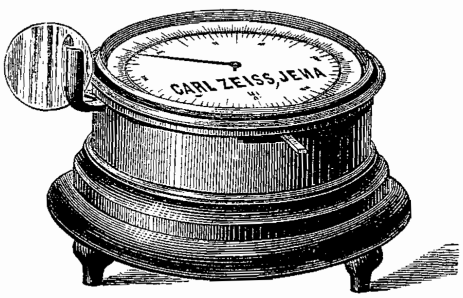


Fig. 35.
Cover-glass tester. Nr. 41.

No.		*Marks*
42	**Cover-glass Tester** of more simple construction; screw with divided disc and arrangement to regulate the zero-point. Also gives measurements to 0.01 mm	12.—

No.		Marks
	mounting. The apparatus is adjusted for the No. 2 Huyghenian and the compensating eye-pieces 4, 6 but can also be used with the + 6 aplanatic lens on the large dissecting stands I, II and III when mounted on a special fitting. (Fig. 36.)	30.—
44	Whilst recommending the Camera described above as being more handy, we make to order another form with larger mirror and longer arm, which quite obviates any distortion of the drawing	36.—

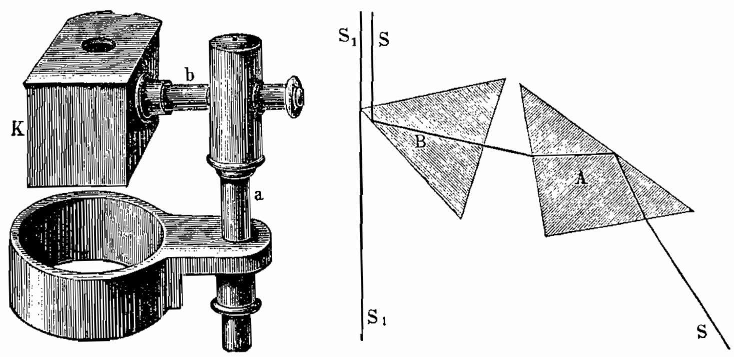


Fig. 37.
Camera lucida.

45	**Camera lucida** with two prisms; for fixing over the eye-piece. (Fig. 37.)	21.—

Camera lucida after ABBE, Nos 43 and 44, so arranged that the prism case together with the mirror may be swung back round a horizontal pivot, or, if desirable, withdrawn altogether, the underpart remaining meanwhile on the tube in its adjusted position.
Add M. 10.— to the prices quoted for Nos 43 and 44.

Arrangements for Polarisation.

No.		*Marks*
46	**Polarisers:**	
	I. For use with the illuminating apparatus of the large stands. NICOL prism with disc on the mounting to fit the carrier of the condenser, so that the ordinary diaphragms and also selenite and mica films may be placed over the polarising prism.	15.—

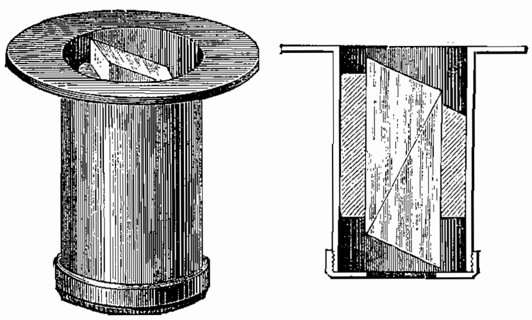


Fig. 38.
Polariser Nr. 46 I.

	II. To fit the cylinder diaphragm of the smaller stands. NICOL prism with condensing lens	18.—

No. | Marks

47 **Analysers:**

I. Prazmowski prism in brass mount for placing above the eye-piece . . . . 16.—

II. The same with divided circle . . . . 31.—

48 **Complete Polariscopes for the larger stands** (with Abbe condenser).

a) Polariser I and Analyser II (with divided circle) . . . 46.—

b) „ I „ „ I (without divided circle) . . 31.—

49 **Complete Polariscopes for the smaller stands** (without condenser).

a) Polariser II and Analyser II (with divided circle) . . . 49.—

b) „ II „ „ I (without divided circle) . . 34.—

50 **Eye-piece for observation of axial images.** For use with Polariser I and Analyser II. Huyghenian eye-piece 2 with sliding eye-lens combined with a collective system made up of two simple lenses, which is adjustable to the upper focal plane of the objective by a sliding tube. (Fig. 39.) . . . . 30.—

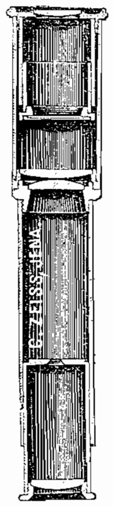


Fig. 39.
Axial images eye-piece.

51 **Series** of 8 selenite and mica films after Mohl . . . . 10.—

Possessors of the Goniometer eye-piece No. 40 can use the divided circle thereof for the analyser as well. The price of the polarising arrangement in this case therefore must be reckoned minus this item.

Spectro-polariser, see No. 23.

Spectroscopic Eye-pieces.

No.		Marks
52	**Spectroscopic Eye-piece.** Eye-piece with slit mechanism between the lenses. The upper achromatic lens adjustable to the slit. Amici prism to place over the eye-piece. The whole connected with the body by a clamping screw	72.—
53	***Spectroscopic Eye-piece (Micro-spectroscope) after ABBE.** Achromatic upper lens adjustable to the slit as above. Mechanism between the lenses for contracting and expanding the slit by symmetrical movement of the edges (after Merz) (worked by the screw *F*); this opens so widely as to permit a view of the whole visual field. The slit is shortened by the screw *H*, so that when the comparison prism is inserted the aperture is contracted to such an extent, that the image of the object under investigation completely fills ist. Comparison prism with lateral frame and clips to hold the compared object and the mirror. All these parts in a drum combined with the eye-piece. Above the eye-piece an Amici prism of great dispersion, which turns aside on a pivot (*K*) to allow of the adjustment of the object; the axial position of the prism is indicated by the spring catch *L* which keeps it in place. A scale is projected on the spectrum by means of a scale-tube and mirror attached to the mount of the prism; the divisions of the scale give the wavelengths	

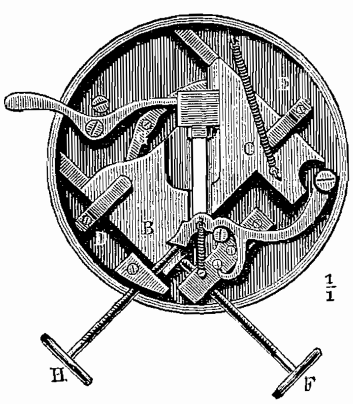


Fig. 40.

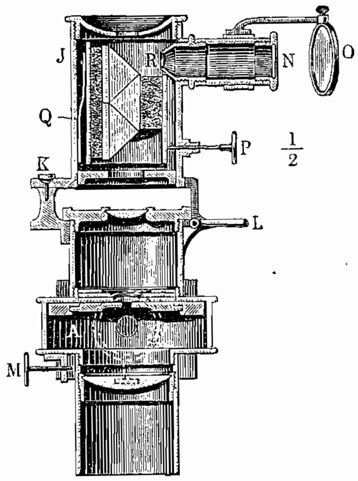


Fig. 41.

Micro-spectroscope after Abbe.

No.		*Marks*
	of that section of the spectrum on which they fall in fractions of a micron. The screw *P* is for adjusting the scale relative to the spectrum. In case, including a number of lithographed scales for recording observations. (Figs. 40 and 41.)	**165.—**
54	* **Micro-spectrometer after** **ENGELMANN.** Constructed on the principle of VIERORDT's spectro-photometer for quantitative microspectral analysis. In place of the eye-piece the box *A* is attached to the body of the microscope by the tube *R*; it contains two independent, conaxial, moveable slits in juxtaposition, which are symmetrically opened and closed by opposed reverse-threaded screws. The width of each slit is read off on the drums *T* and *T′* accurately to 0.01 mm and by estimation to 0.001 mm. One slit is occupied by the image of the object under investigation and the other by light from the source of comparison, which is brought to it by a superimposed reflecting prism and lateral tube *d* with collimator lens, diaphragm carrier *n* and mirror *S*, or incandescent lamp. In the upper opening of the box *A* is placed either an eye-piece in a sliding jacket, which is accurately adjusted to the slit, or instead of this (after proper adjustment of the image of the	

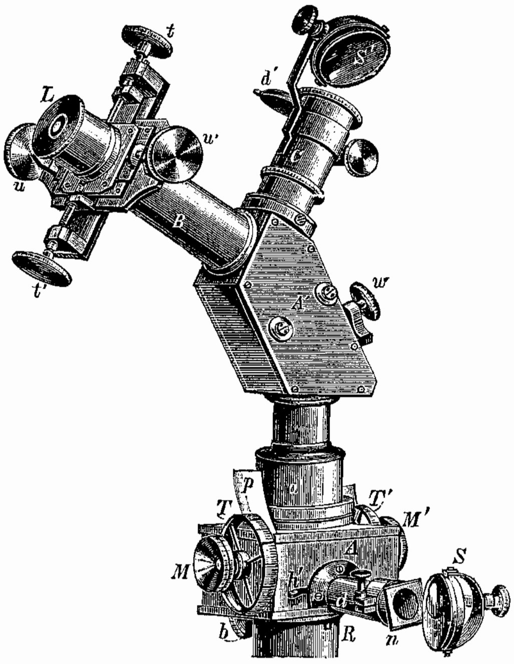


Fig. 42.

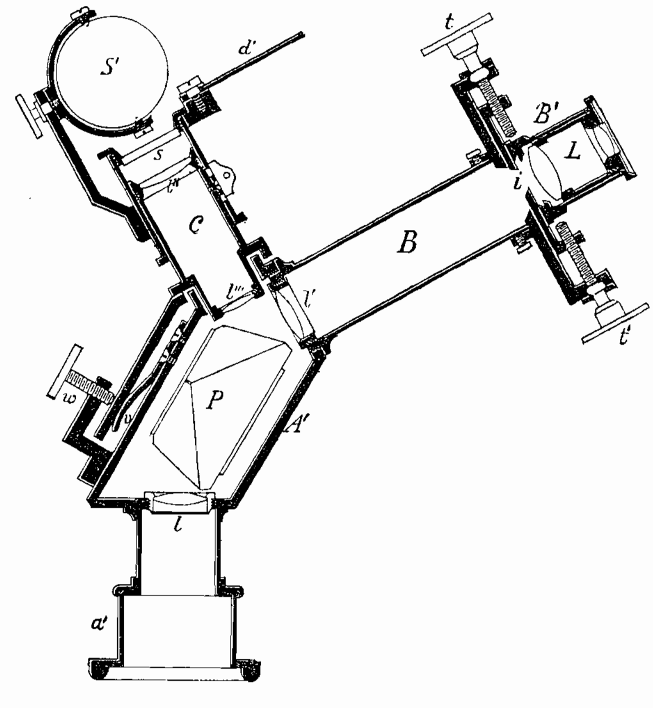


Fig. 43.
Micro-spectrometer after Engelmann.

No.		Marks
	specimen in the objective slit) the spectroscopic apparatus a' A' B C, which is fixed in the proper azimuth by an arresting mechanism. This apparatus consists of the box A' which on one side, the upper end of a', contains a collimator lens l, to render parallel the cone of rays proceeding from the objective before they fall on a RUTHERFORD prism P of great dispersion. By the lens l' on the other side, at the lower end of B, the parallel rays proceeding from the prism are again brought to a focus and this real spectrum is observed by an eye-piece L. By two slit mechanisms at right angles to one another, actuated by the screws t t', u u' in the focal plane of the eye-piece, the visual field can be limited at pleasure according to the procedure of VIERORDT. By means of two lenses shown at C, an image of a wavelength scale is projected on the spectrum by reflexion from the end-surface of the AMICI prism, which is illuminated by the mirror S' and put out of action by closing the shutter d'. Adjustment of this scale is made by inclining the whole scale-tube C with the screw w, which is opposed by a counter spring v. (Figs. 42 and 43.)	**480.—**

Various Optical and Mechanical Apparatus.

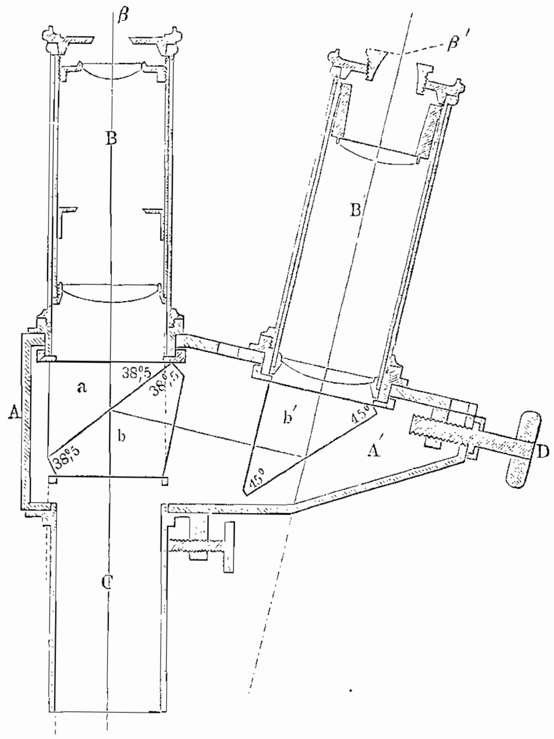


Fig. 44.
Stereoscopic eye-piece.

No.		Marks
55	***Stereoscopic Eye-piece after ABBE,** for stereoscopic and binocular observation of microscopical objects with any degree	

No.		Marks
	of high magnification. (Zeitschrift für Mikroskopie, Jahrg. 1880, p. 207; CARL's Repertorium d. Experimentalphysik, Jahrg. 1881, p. 298; Journ. of the R. Micr. Soc. 1881, p. 203.) — The division of the bundle of rays proceeding from the objective to produce two separated images, takes place at the upper end of the body by partial reflexion from a thin stratum of air between two juxtaposed glass prisms. The direct rays proceed to an eye-piece in the axis of the body, the divergent undergo another reflexion through a prism in a second eye-piece placed excentrically, so that its axis forms an angle of 14° with that of the body. Both eye-pieces give images of equal magnification. The excentric eye-piece is adjustable by a screw to the inter-ocular width of the observer. Bisection of the ray bundles for producing stereoscopic effects is made by adjustable semi-diaphragms above the eye-pieces; without these the apparatus gives binocular non-stereoscopic vision. Available with low or high powers on any of the larger stands provided with rackwork coarse adjustment and which permit of the body being shortened to at least 160 mm. (Fig. 29.) In case . . .	150.—
	In ordering this binocular apparatus for any microscope it will be sufficient to send a sharp sealing-wax impression of the upper end of the body.	
56	**Reversing Prism after NACHET** (prisme redresseur), for obtaining erect images in dissecting with the compound microscope. With plate mount to fix above No. 2 eye-piece	18.—
57	***Diffraction Plate after ABBE**, for demonstration of the effects of refraction on the formation of microscopical images (Zeitschrift f. Mikroskopie, II. Jahrgang, Heft 2; Monthly Micr. Journ., Febr. 1877). — Three cover-glasses silvered on their under surface with traced groups of parallel and crossed lines, cemented on a glass slip; in case	7.—

No.		Marks
58	***The same,** with a set of diaphragms and an arrangement for placing and revolving the same above the objective, designed for objective aa	12.—
59	**Bulls-Eye Lens** 100 mm in diameter, on stand; in case .	50.—
60	**Ditto** 80 mm	36.—
61	**Ditto** 60 mm	27.—
62	**Microscope Lamp.** Gas lamp of special construction on brass stand with vertical adjustment, combined with a glass globe which is filled with water or ammonio-cupric solution to act as a condenser. To obtain a proper illumination the gas flame should be about 15 cm behind the globe and the mirror of the microscope the same distance in front of it with the most concentrated part of the cone of rays impinging on it. The lamp gives an excellent bright and white light which almost completely supplies the place of good daylight	35.—
63	**Hand Spectroscope** (Pocket Spectroscope) **after Browning,** for observing the effect of absorption in larger objects — with adjustable slit and Amici prism of high dispersion.	
	a) Without Comparison prism	30.—
	b) With Comparison prism	40.—
64	**Saccharimeter,** for estimating the percentage of sugar in fluids. With tube for liquids 200 mm long made to slide in a brass tube, which carries a polariser and double quartz plate at	

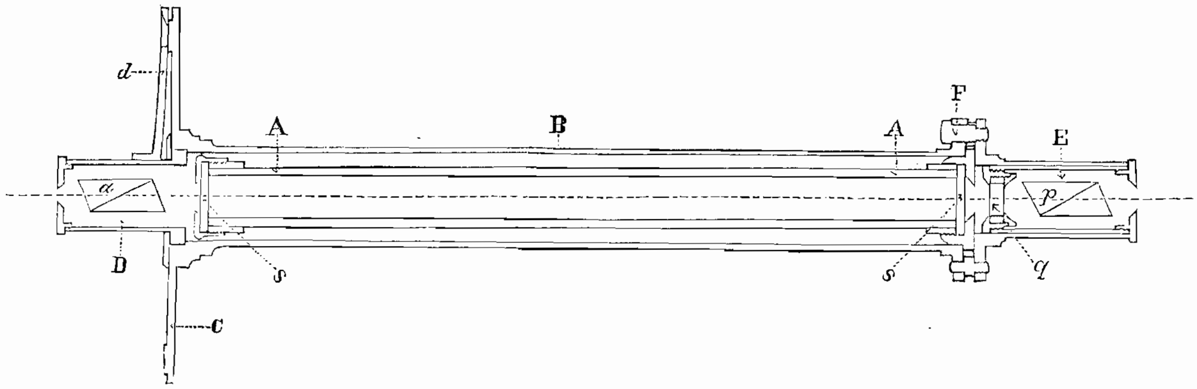


Fig. 45.
Saccharimeter.

No.		Mark
	one end and at the other an analyser with divided circle. The circle is divided to semi-degrees and tenths can be estimated with accuracy. Observation is made by adjusting the so-called transition colour on both halves of the quartz plate, the tube being directed by hand towards a white surface. Only intended for fluids containing a small percentage of sugar. With method of use	65.—

65 **Heating Arrangement** for warming microscopical objects during observation. After Pfeiffer.

The arrangements hitherto used for this purpose leave the observer in doubt, as to whether the temperature to which the object is raised, really corresponds to that indicated by the thermometer. The present arrangement affords full security on this point, as it permits of the object, together with the stand and the surrounding air being brought up to and maintained at a certain temperature.

It consists of a mahogany box enclosing the whole stand in a nearly air-tight manner; in the anterior wall is a glass window to permit the necessary incident light; on both sides are closely fitting doors to enable the specimen being moved by the hands. The whole affair stands on a thick metal plate and tripod. This

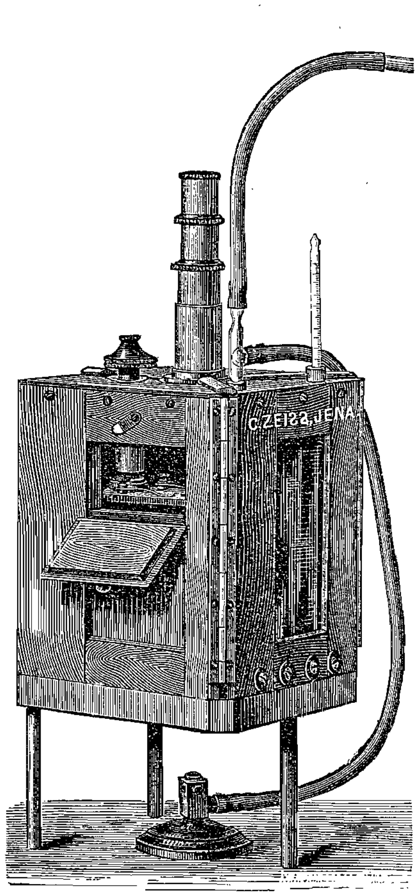


Fig. 46.
Heating arrangement.

No.		*Marks*
	is heated from below by a gas-burner regulated by a thermostat. The temperature inside the box is controlled by a thermometer and may be raised up to 45° C. without damage to either stand or objective. (Fig. 46.)	
	a) For large stands	70.—
	b) For medium stands	60.—
66	**Turn Table** on wood base, for making varnish rings . . .	9.—

Apparatus for Photo-micrography*.

Large photo-micrographic Apparatus.

The chief constituents of this apparatus are as usual, Microscope and Camera. Instead however of being combined on a single supporting board, each

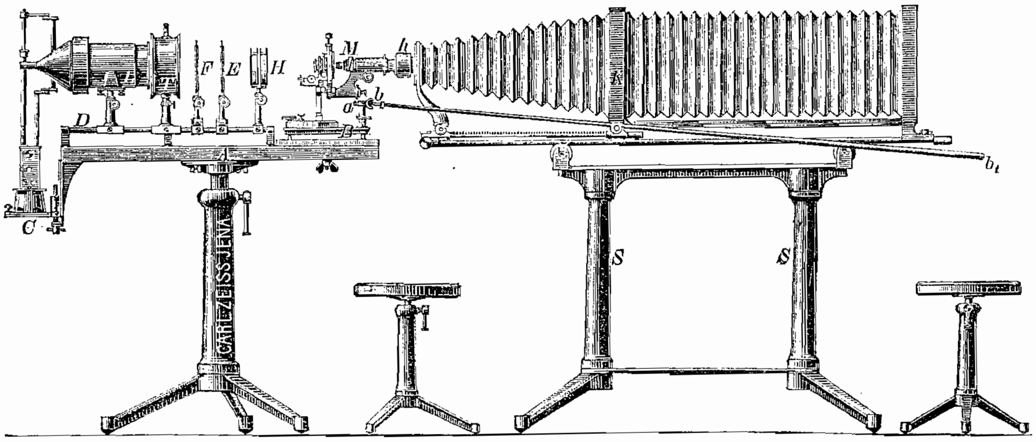


Fig. 47.
Large photo-micrographic apparatus.

with its own accessories is mounted on a separate stand and they are only connected when the picture is being taken. This arrangement was chosen: 1. in order to enable the necessary manipulations with the microscope being carried

*) A special catalogue is issued for photo-micrographic apparatus. **(Price Mk. 3.)**

on in a sitting position, instead of the bent and inconvenient posture which the ordinary mounting imposes; 2. to render the apparatus without the camera available for projection. Whilst the separation of the two parts possesses these advantages, they are capable of being connected by the light-excluding arrangement described further on and, from the camera moving on runners, this light-tight connection is effected in the easiest and most rapid manner.

Either of the larger inclining stands supplied by the firm is suitable for many of the purposes concerned, but **the stand for photo-micrography** Fig. 10 is specially designed for the requirements of this branch. It is set up on a **microscope table** *A* (Fig. 48), adjustable vertically on a firm cast-iron pillar; on the end which is directed to the camera is fitted a metal plate *B*, levelled by three screws, to carry the instrument and at the other an angle plate *C* to support an arc lamp. The space intervening between the stand and the lamp is occupied by a so-called optical bench *D*.

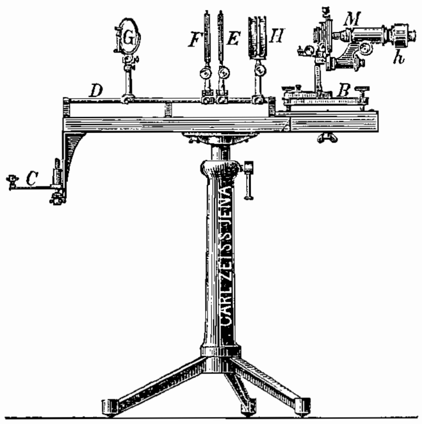


Fig. 48.
Microscope table for photography.

This is intended to carry the following illuminating accessories: for use with sunlight are two diaphragm carriers *E*, *F*, adjustable vertically by rack and pinion; they can be rapidly turned aside on a hinge and when replaced a stop ensures exact coincidence with their former position (they are also used to hold a ground-glass screen, which serves as the source of light with low magnifications); a plane mirror *G* with coarse and fine adjustments in both horizontal and vertical axis, to compensate the small irregularities in the motion of the heliostat, and a holder *H*, also adjustable vertically by rack and pinion, for taking absorption cells.

For use with the electric arc lamp, as shown in Fig. 47, beside the above is a water chamber *T*, with plate-glass walls for absorbing the heat rays and a collective system *L* for projecting the image of the carbon points on the focussing screen.

On the metal support *B* (Fig. 47) is a removable fitting *a* which carries over the motion of a HOOKE's joint bb_1, worked from the camera end, to the geared head of the fine adjustment of the microscope. The body of the latter is provided with a double jacket *h*, into which slides a piece of tube at the microscope end of the camera when this is rolled forwards and which forms a very perfect light excluding fitting without actual contact between the two.

As before mentioned, **the camera for photo-micrography** *K* is separated from the microscope and like it is mounted on a light but firm cast-iron support *SS* with rollers on which it runs easily and without jerk. The total length of the bellows is 1.5 m; by shortening it is available for any lesser distance of image. With the intention of enabling fluid preparations (pure cultures &c) to be photographed the camera has been divided into two halves, that next the microscope being capable of elevation and fixture either perpendicularly, as shown in Fig. 49, or in any intermediate position. Motion of the image plane is effected by a strong racked stay, on which the microscope end of the camera also moves.

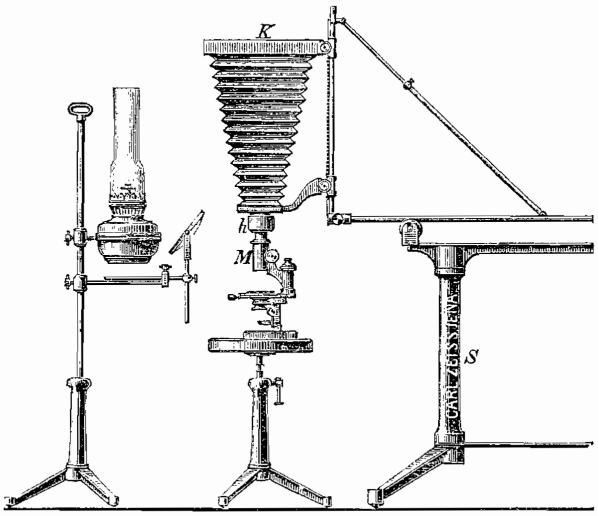


Fig. 49.

This as before carries the light excluding fitting, which is attached to a removable slide so that it can easily be changed for a macroscopic photographic lens, thus making the camera available for ordinary photographic work.

Both halves of the camera are made to take sliding backs giving a picture 24 $\times$ 24 cm, but by putting in frames any smaller sized plates may be used.

Two focussing screens complete the arrangement, one of these is a ground glass for superficial orientation of the picture, the other is transparent, with a diamond cross on the side next the microscope and magnifier for the fine adjustment of the image. If desired another back is supplied of peculiar construction, which allows a number of impressions to be taken close together on a single plate, for ascertaining the best length of exposure. For this purpose the back is made to slide in a groove and, stopping as often as desired, is carried past a slit which allows only a slender strip of the image to fall on the sensitive plate, this however being quite sufficient upon which to form a judgement. Finally, the bellows can be slightly lifted off the back in order to inspect the picture from the front, the image being thrown upon white paper pasted on the slide (NACHET's method).

For the **optical equipment** of the photo-micrographic apparatus the apochromatic objectives and projection eye-pieces are specially recommended. The achromatic condenser (N°. 20), which projects a sharp image of the source of light on the object, is advised for the higher magnifications. For the 75 mm system a collective lens of long focus serves as a condenser, throwing an image of the light in the system.

With the electric light a collective lens-system is made use of, which differs from the ordinary combination for similar purposes in that it consists of 2 plano-convex and one concavo-convex lens. The part of the lens directed towards the carbon points, which collects the diverging into a bundle of parallel rays, and which is fixed once for all at the most suitable distance from the lamp, is a concave surface to diminish the spherical aberration. The part of the system directed to the microscope, which combines the parallel rays in an image, is mounted in a sliding jacket which permits a movement of the image in the optic axis within somewhat wide limits.

The 75 mm system is used without an eye-piece and inserted into the body from the upper end by a special fitting. The other objectives are either screwed on as usual, or attached to a revolving nose-piece, or use is made of the newly constructed objective-changers (N°. 25), which are very convenient for the present purpose.

No.		Marks
67	**Large photo-micrographic Apparatus.**	
	I. Stand for Photo-micrography with accessories.	
	Mikroscope stand, including ABBE Condenser	350.—
	Achromatic condenser with iris diaphragm and centering adjustment, to fit in place of the ordinary condenser system . .	75.—
	Centering adjustment alone, for using the ordinary objectives as condensers	20.—
	Small collective lens, to replace the condenser system, for use with the weakest objectives	5.—
	Metal support for the microscope, on three screws, with HOOKE's joint and arrangement for working the fine adjustment from the camera	30.—
	Microscope table with optical bench	100.—
	Equipment of the optical bench:	
	1. For sunlight.	
	Reflecting mirror	45.—
	2 Diaphragm carriers with diaphragms and ground-glass disc	52.—
	Trough holders with 2 cells	37.—
	2. For artificial light.	
	Electric arc lamp by SIEMENS and HALSKE, 1200 candle-power, including funnel and connecting piece (factory price) .	215.—
	Collective system for electric arc light	110.—
	Water chamber for absorbing the heat rays	47.—
	2 Diaphragm carriers } as above. Trough holders } as above.	
	3. For lamplight.	
	Convex lens on stand	36.—
	Transport	1122.—

No.	II. Camera for Photo-micrography with accessories.	Marks
	Transport	1122.—
	Camera, with iron stand, including 2 dark slides	195.—
	2 Stools on pillar with vertical adjustment	28.—
	Dark slide for making exposure scales	25.—
	Focussing lens	15.—
		263.—
		1385.—
	Extra dark slides, each	18.—

68 Small Photo-micrographic Camera after Francotte.

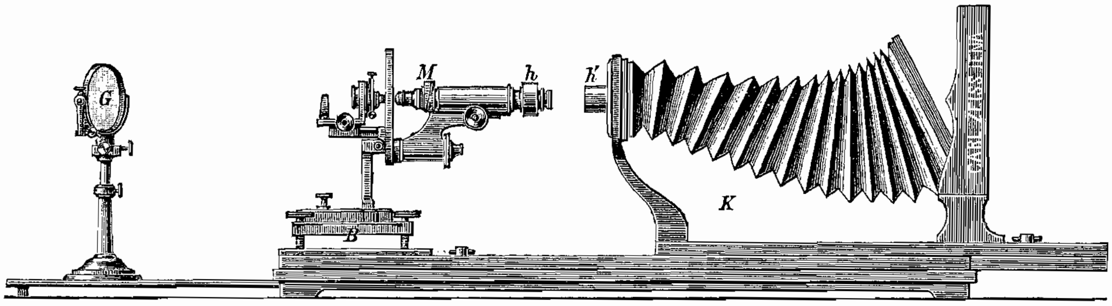


Fig. 50.
Small photo-micrographic camera after Francotte.

	Bellows 60 cm in length, sliding on a stout board, for use with any inclining stand, including metal support (on 3 screws) for the stand, 2 dark slides (18 × 18 cm) ground-glass and transparent screens	70.—
	Extra dark slides	12.—

CARL ZEISS

OPTICAL WORKS

JENA

OPTICAL MEASURING INSTRUMENTS

1893

Timothy, P, Epps

CARL ZEISS

OPTICAL WORKS

JENA.

OPTICAL MEASURING INSTRUMENTS.

1893.

The following two separate catalogues, German, English and French editions, may be had on application, free of charge:

Illustrated Catalogue of Microscopes and Microscopical Accessories.

Illustrated Catalogue of Photographic Lenses.

Any of the instruments contained in this catalogue are supplied singly or in any combination at the prices affixed to the several items.

The prices do not include packing or carriage from Jena.

All prices are strictly Nett and payment should be made in Cash, Cheques or Short Bills drawn upon English, German or French Banks.

Goods are forwarded at the expense and risk of the consignee, insured or under declaration of value. Orders from abroad are, in the absence of special instructions, despatched by the quickest, safest and cheapest route.

It is requested that orders be accompanied by distinct signatures and addresses.

Jena, 1893.

Carl Zeiss,
Optical Works.

Telegraphic address: **"Zeiss Werkstaette Jena".**

We shall be pleased to place blocks of illustrations contained in this catalogue at the disposal of authors of scientific publications.

The whole of the instruments and apparatus described in this catalogue have, both in principle and construction, originated in our works and took their existence from problems arising from our own requirements. They were constructed in the course of years by the scientists attached to the firm, either for immediate assistance in the manufacture of our leading optical instruments or for experimental research suggested by the work of the firm. Accordingly, the instruments have been tested throughout by our own use, which in several cases has been continued for many years, and those among these which have already been previously described, constitute in their present form the definite result of experiment and experience.

Until recently these instruments have only occasionally been supplied for the use of others. But as they appear to commend themselves to the interest of many engaged in scientific research and technical work or of teachers of physical sciences, we have now formed in our works a special department in which instruments of this class are regularly manufactured. This department is under the care of Dr. C. Pulfrich, a physicist of practical experience on the subject of philosophical instruments. Beside the instruments described in this catalogue we undertake to construct other appliances of the same class according to special designs.

Jena, December 1892.

Carl Zeiss,
Optical Works.

Contents.

Apparatus for determining refractive and dispersive power of solid and liquid bodies.

Various optical measuring Instruments and Apparatus for optical Demonstration.

Apparatus
for determining
the Refractive and Dispersive Powers
of solid and fluid bodies.

No. I. Abbe Spectrometer (Fig. 1 on following page).

This spectrometer has, during the last few years, only received a few minor improvements, otherwise it is essentially the same as described by Prof. ABBE in his paper on "Neue Apparate zur Bestimmung des Brechungs- und Zerstreuungsvermögens fester und flüssiger Körper", Jena 1874. It is the same instrument which has been used in our own laboratory for several thousands of determinations of optical data and which in all these cases has proved perfectly satisfactory.

In constructing the spectrometer it has been our aim to embody the following conditions: To *simplify the instrument as much as possible* by removing all such parts that were at all dispensable; to so arrange its mechanism that the instrument might be *adjusted with ease and precision* and that *all the necessary readings* for a complete determination might be taken *without the necessity of in the least altering and readjusting the instrument*, and, finally, to provide the instrument with a *simple and convenient micrometer arrangement* so as to render it possible *to find the data required for the determination of the dispersion independently of the goniometric reading by means of the divided circle*, in order that the graduation of the circle need not be finer nor the construction of the instrument and its manipulation any more delicate than is required for the exact determination of the absolute value of the refractive index.

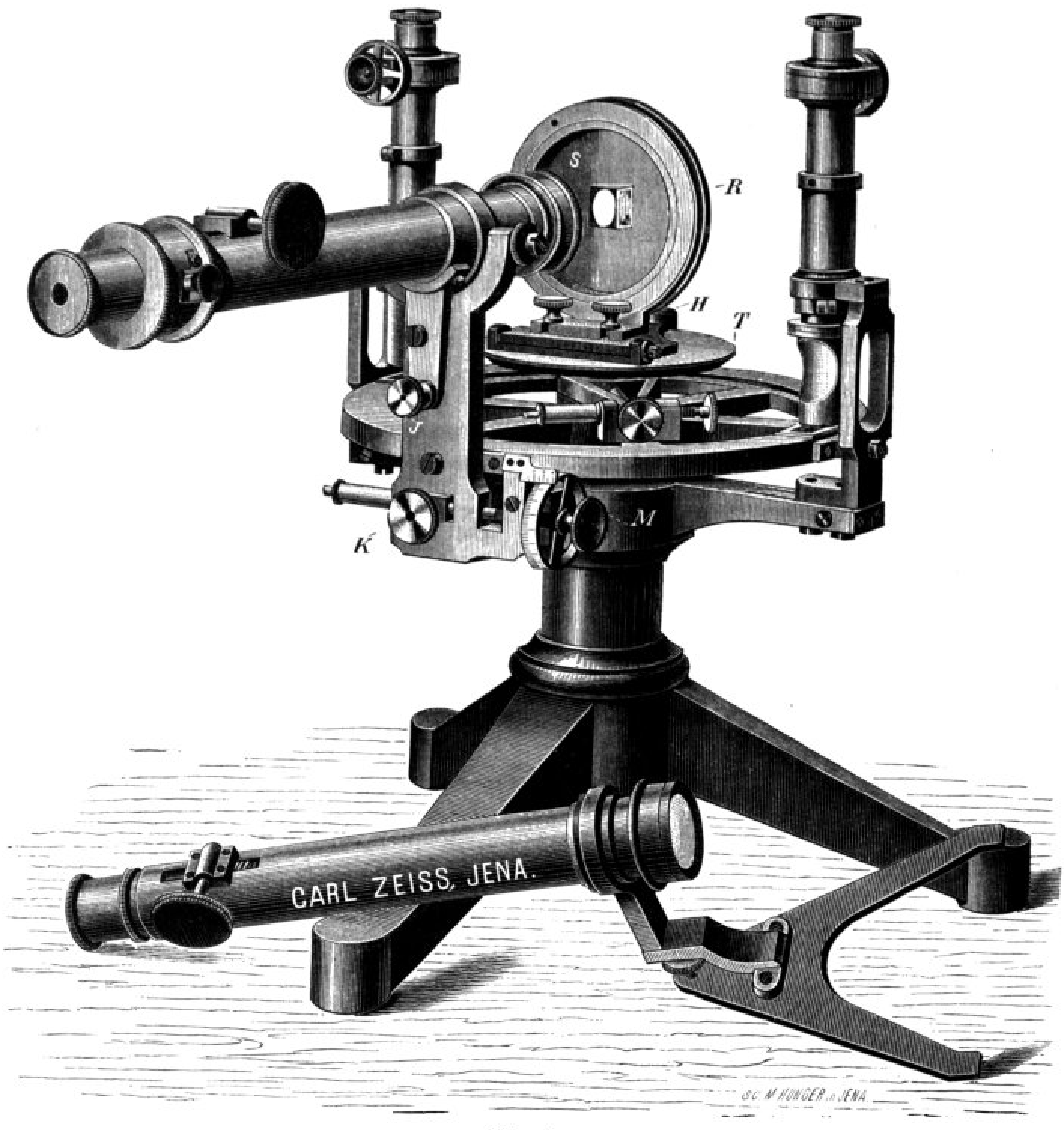


Fig. 1.
Abbe Spectrometer (No. 1).
$^1/_3$ Full Size.

The principle upon which the construction of the apparatus is based is that of autocollimation (method of a ray returning along its own path). The same telescope serves for observation and illumination. In the focal plane of the telescope objective is placed a vertical slit which is illuminated by means of a small reflecting prism, which covers it and reflects upon it the light from the source of light placed at the left hand side. Monochromatic flames or GEISSLER tubes, the latter being placed longitudinally (vid. Nos. 2 and 3, p. 5) form suitable illuminants. The parallel pencil of rays emerging from the telescope objective is reflected either directly by the surface of the prism, or it is first refracted and then reflected by the posterior surface. In the case of normal reflection the pencil of rays returns along its own path and forms an image of the slit which is coincident with the latter itself. The path of the light is identical with that due to minimum deviation of a prism having double the refracting angle (Fig. 2). Both methods, therefore, agree as regards the similarity of the object and its image; the taking of the reading is, however, in our case, greatly simplified in as much as the determination of the minimum deviation is entirely dispensed with, it being only necessary to make coincide the image of the slit with the latter itself. The slit being covered by the reflecting prism, a web is stretched across the free half of the focal plane in a direction parallel to the slit, and this web has to coincide with the image of the slit, which appears as a bright line upon a dark ground[1]). The width of the slit may be regulated externally. The perpendicular position of the telescope with respect to the axis of rotation of the divided circle is obtained by means of the adjusting screw *J*.

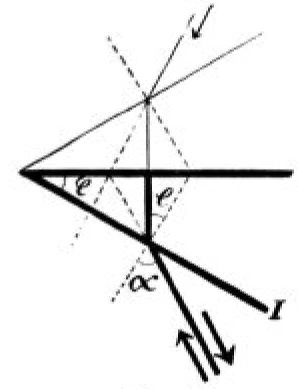


Fig. 2.

The prism which is to be examined is, as a rule, not placed upon a stage but is affixed with wax to a circular disc with central opening (*S*, Fig. 1), which, by means of spring-clips, may be connected to a ring *R* fixed with screws upon the spectrometer stage *T*. The ring rotates on its horizontal axis. Thereby one of the prism surfaces is placed very approximately in the axis of the spectrometer. The exact adjustment of this surface in a direction parallel to the same axis is effected by means of the screw *H*. Subsequently, the other surface of the prism is, by rotation of the ring, also placed parallel to the axis of the spectrometer. This mode of attaching the prism requires, therefore, no special preparation of the prism; consequently, particularly also on account of the small prism angle (about 30° instead of the usual angle of 60°) the material to be examined may be economised in the most welcome manner.

1) The intensity of the spectrum thus formed may be made nearly equal to that obtained with transmitted light by covering the back of the prism with mercury (rub a few globules of mercury upon a piece of tin-foil and apply the latter to the back of the prism).

In the case of prisms of large dimensions, particulary of fluid prisms, this mode of attachment is not sufficiently secure. For this reason all the parts connected with the ring *R* above the stage *T* are made to readily remove so as to be replaced by a small stage with three levelling screws, which is supplied with the apparatus; this levelling-stage is adjusted in the usual manner.

The angles are, by means of two micrometer-microscopes, read off a circle of 20 cm diameter divided into $^1/_6$ degrees; the reading taken being exact within a few seconds. The stage of the spectrometer is made to rotate by itself and to repeat the angular positions previously determined. This is effected by means of the arrangement shown in the figure below *T*, which consists of a clamp acting in a radial and an adjustment-screw acting in a tangential direction.

The determination of the dispersion is not proceeded, as is the case with the usual methods, by a determination of the refractive indices for various lines of the spectrum but is found by differential measurement with the aid of a micrometer arrangement.

This method has over that of direct determination of each individual refractive index the advantage of being not only much simpler and easier to perform but also of being much more accurate in its results under equal conditions. The micrometer arrangement (*M*, Fig. 1) is composed of the screw effecting the fine adjustment of the divided circle and a drum divided in 100 parts fitted with scale, indicating complete revolutions. The angular equivalent of each complete revolution is exactly 10 minutes, therefore that of each division on the drum 0′,1 or 6″. The angles read off the micrometer screw are, of course, capable of repetition in the same way as are those read off the divided circle.

For measurements with reflection-gratings the spectrometer may be used without being altered. The coincidence of the incident and diffracted rays enhances, in fact, greatly the accuracy of the readings, in the same sens as in the case of the minimum of deviation in prisms.

In order, however, that the spectrometer may also be used according to the older methods (determination of the refractive index by the method of minimum deviation, measurement of the wave-length by means of gratings in transmitted light), another telescope, shown in the figure at the foot of the spectrometer, is supplied with it. It is connected with the divided circle in an easy manner, which need not be described here; the same applies to the counter-poises supplied with the apparatus.

The whole apparatus, in cabinet fitted with lock and key M. **800.**—

Auxiliary and Accessory Apparatus for the Spectrometer.

No. 2. Illuminating Apparatus mounted on a stand, adjustable in height.

This apparatus collects the rays proceeding from the transverse section of a GEISSLER tube and projects a convergent cone of its light upon the illuminating prism where it forms a real magnified image of the source of light.

Inclusive of a GEISSLER H-tube and stand for same **M. 55.**—

No. 3. Geissler Tubes for longitudinal vision, with Dr. RIEDEL's spiral aluminium electrodes.

Filled with hydrogen or hydrogen and mercury; these give a very pure and intense H-spectrum.

Each M. **10.**—

No. 4. Glass Prisms for spetrometric examinations, with optically perfect surfaces (refracting angle about 30°).

The price varies according to the size of the prisms and the quality of the glass employed. We are also prepared to supply prisms cut from material sent to us.

No. 5. Hollow Prisms for examining fluids.

A block of black glass (black so as to exclude false reflections) has two good plane surfaces inclined to each other at 30°. In a direction at right angles to one of these surfaces the prism is traversed by a hollow cylinder of about 16 mm diameter. The open ends of the cylinder are closed by plano-parallel polished plates, one of which is silvered at the back; both plates have to be cemented to the prism every time a new experiment is made. The hollow cylinder is filled by means of a canule which may again be closed by means of a ground in stopper or a thermometer. Height of the prisms 40 mm.

M. **35.**—

The so-called KUNDT prisms, which are chiefly intended for the examination of fluids lacking in transparency, are also made if specially required. The price of these depend upon the size of the plano-parallel plates.

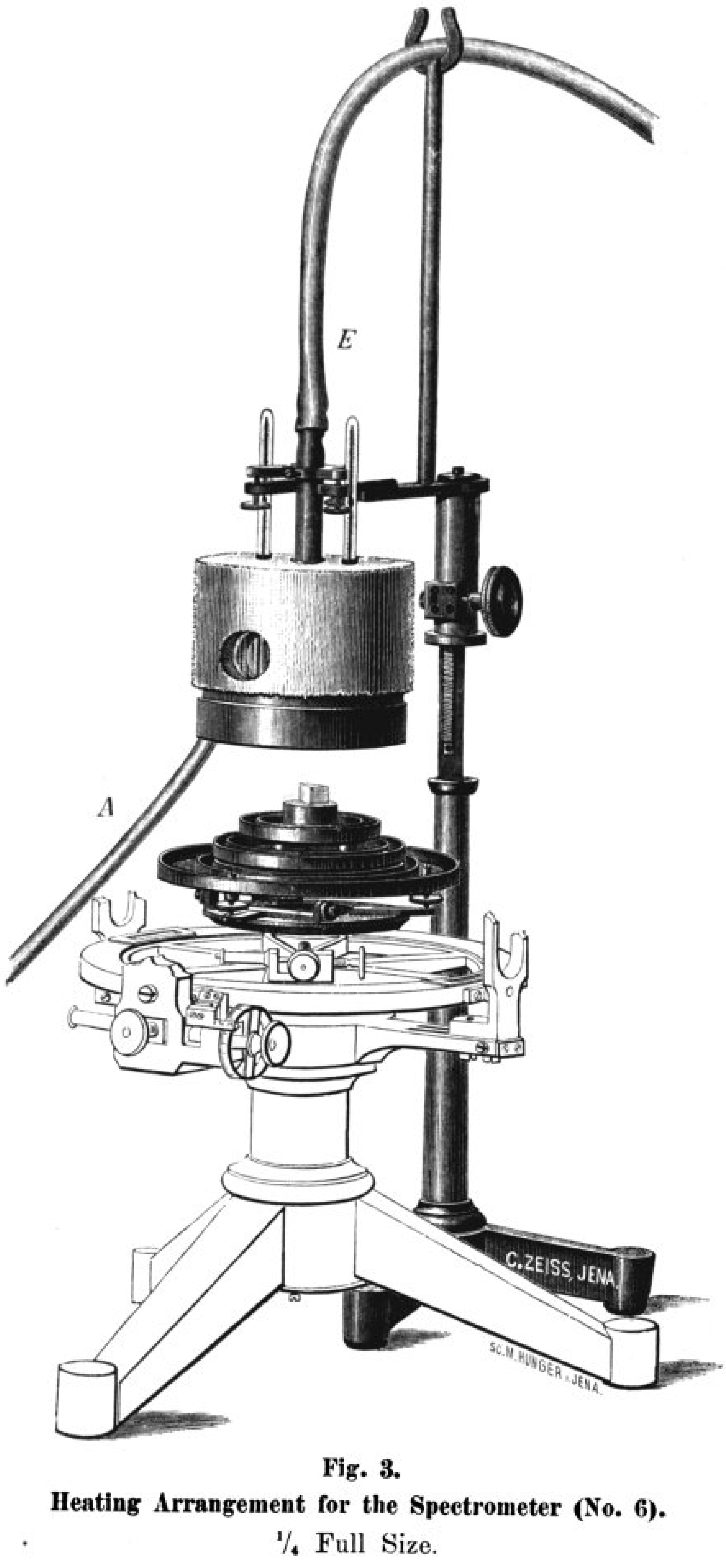


Fig. 3.
Heating Arrangement for the Spectrometer (No. 6).
$^1/_4$ Full Size.

No. 6. Heating Apparatus (Figs. 3 and 4).

By means of this apparatus it is possible to maintain the prism which is to be examined with the Abbe spectrometer at a constant temperature; it thus furnishes also the means of investigating the effect produced by change of temperature upon the refractive power of solid and fluid bodies.

Respecting this latter mode of application of the apparatus (viz. the influence of temperature upon the refractive power of glass) we refer to C. Pulfrich's paper in Wiedem. Ann. 45, p. 609, 1892.

The apparatus consists mainly of a double walled cylinder the bottom of which is formed by three dishes; this bottom is adjustable and can be placed upon and moved with the spectrometer stage, the latter having previously been cleared of all its fittings, whereas the upper casing is supported externally and remains stationary. Air-tight connection between the upper double jacket and the bottom dishes is made by filling the three annular grooves of the latter with

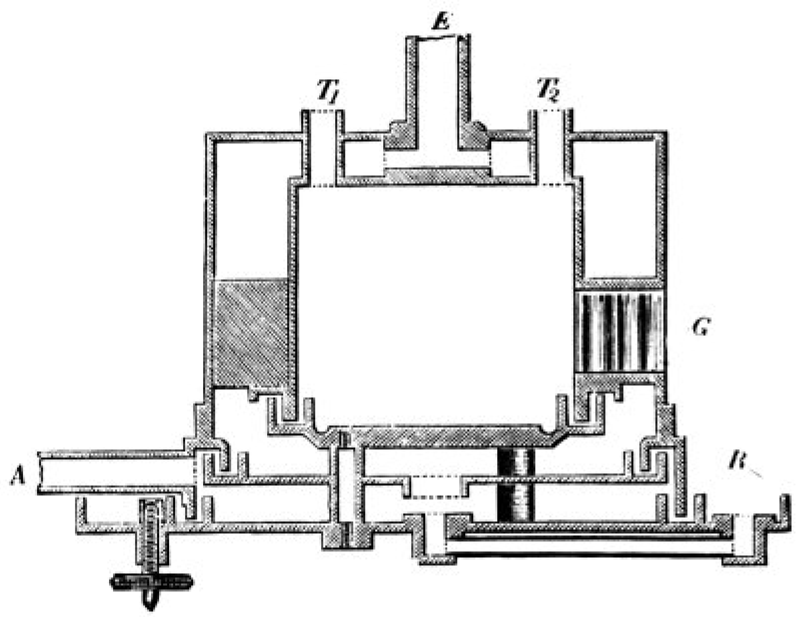


Fig. 4.
Cross Section of the Heating Chamber (No. 6).
½ Full Size.

mercury or oil or other suitable fluid; by this means the free movement of the bottom dishes and the spectrometer stage is in no way impeded. Fig. 3 shows the general arrangement of the apparatus coupled with the spectrometer, fig. 4 is a vertical section of the heating chamber.

Heating is effected by the vapours of liquids with constant boiling points. The vapour enters at E; A is the outlet. The middle bottom dish is perforated; the vapour is thus compelled to surround the inner casing which contains the prism. The condensed fluid collects partly in the lowest dish, which is made to form a reservoir, and partly it is allowed to flow off at *A*. The wide groove *R* is provided to catch any mercury that may accidentally flow over. The passage leading to the vapour jacket is closed by a stopper.

For the purpose of observation the casing is pierced by a tubulure, closed by a plano-parallel plate of glass (*G* in Fig. 4). The whole casing is surrounded by a coating of felt to minimise loss of heat by radiation; the same applies to the lower side of the bottom dish. The tubulures T_1 and T_2 serve for the insertion of two thermometers.

The upper stationary part of the heating chamber is supported by a stand placed near the spectrometer and may be raised or lowered by means of a rack and pinion movement. The prism may be placed either directly upon the upper dish of the bottom casing or upon a separate stage placed upon it. The prism is adjusted together with the dish by means of three adjusting screws.

Price of the heating chamber, incl. stand M. **125.**—

Two thermometers divided into whole degrees, the one ranging from 0 to 50° C, the other from 50 to 100° C. M. **4.50**

Abbe Refractometers,

principally for the examination of fluids.

All the instruments Nos. 7 to 11 described herein embody the same principle. The required number is deduced from the observation of the total reflection which a very thin stratum of the fluid under examination placed between prisms of a more highly refracting substance produces in transmitted light (Abbe, "Neue Apparate etc.", Jena 1874). A single drop of any fluid, let it be ever so intransparent in thick layers, is, therefore, sufficient for the examination. The whole process of examination, which may be made with diffuse day-light or lamp-light, consists in a single simple adjustment and subsequent notation, either from a graduated arc (Nos. 7 and 8) or from an ocular scale (Nos. 9, 10 and 11). This reading gives the actual result, no calculation being necessary.

The facility with which these refractometers lend themselves to exact measurements render them suitable for many scientific and practical purposes. Irrespective of the advantages which scientific chemists derive from the speedy and exact determination of refractive and dispersive powers, these instruments are of great utility to pharmaceutical and manufacturing chemists and others engaged in compounding substances; these, by the refractive index, are enabled to distinguish many substances and to ascertain their degree of purity (adulteration of victuals), or to determine the percentage or concentration of many solutions and mixtures.

No. 7. Large Refractometer (Figs. 5a and 5b).

The instrument consists of a double prism of a highly refracting flint-glass fixed to an alhidade, both revolving together about the center of a divided arc. This arc has fixed to it a small telescope, which turns with it on a horizontal pin; the whole is mounted on a heavy brass foot. The telescope supports before its objective a system of two revolving AMICI prisms (compensator for achromatizing the critical line of total reflection), the amount of rotation being indicated by a divided drum. The graduation of the arc directly reads the refractive indices to the third place of decimals. The 4th decimal is estimated with accuracy within 2 units, say, by means of a lens (not shown in the illustration) which is attached to the pointer. The dispersion ($C—F$) may be found from the reading taken from the divided drum of the compensator with the aid of

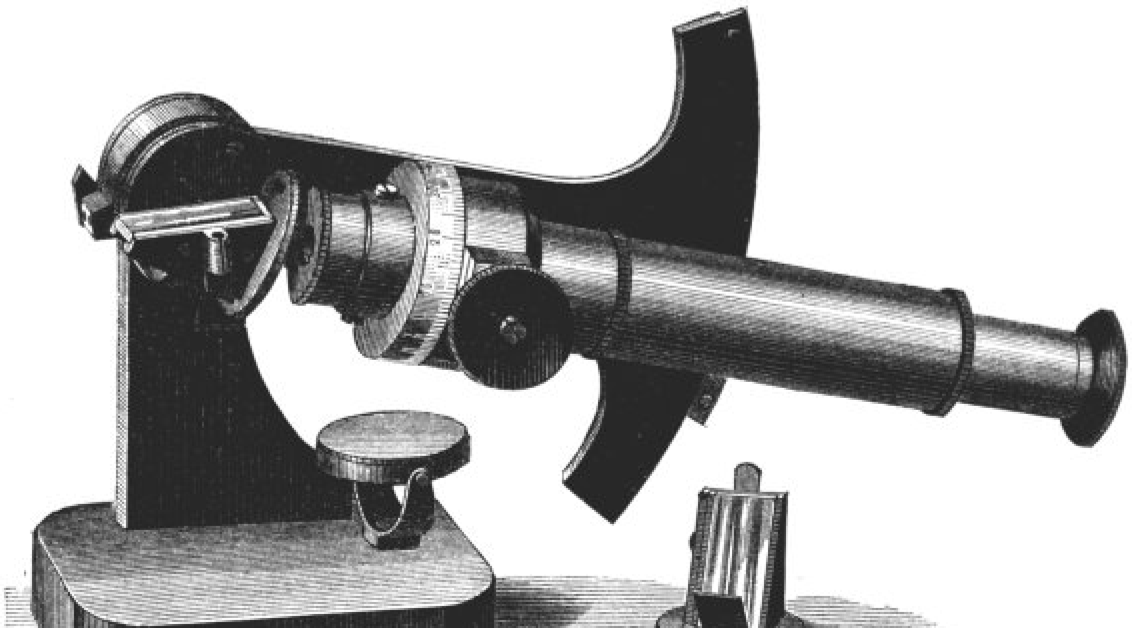


Fig. 5 a.
Large Refractometer (No. 7)
shown in the position in which the drop of liquid is applied.
½ Full Size.

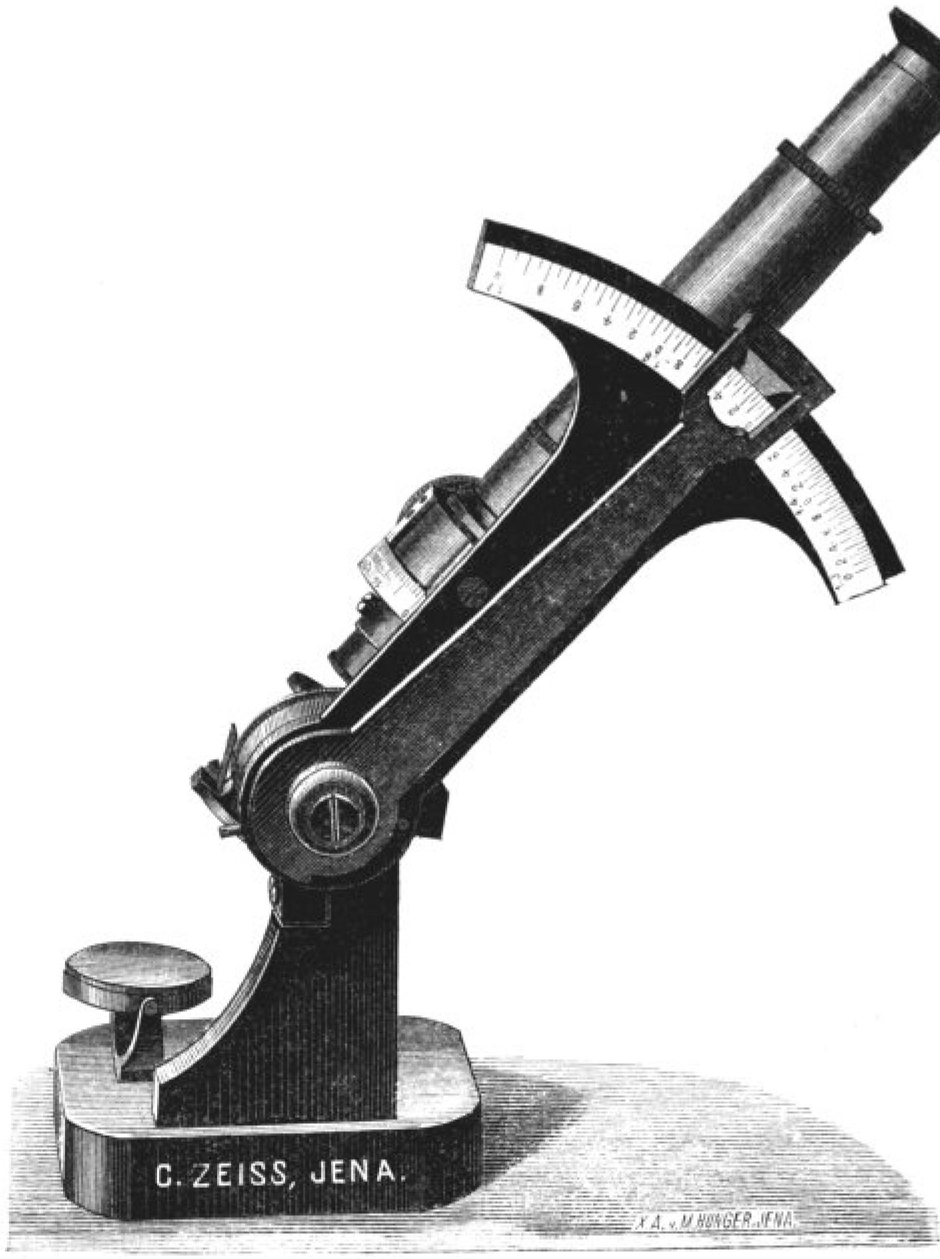


Fig. 5 b.
The same apparatus (No. 7)
shown in the position in which the reading is taken.
$^1/_2$ Full Size.

a table supplied with the refractometer. The refractometer may be used for refractive indices between 1.30 and 1.70.

For the examination of solid bodies having one polished surface by means of reflected (in lieu of transmitted) light, the metal cap should be removed from the small illuminating prism which is cemented to the fixed refractometer prism.

With directions for using, in case with lock **M. 260.—**

No. 8. The same Apparatus with heating arrangement.

The latter (designed by Dr. WOLLNY) consists, as in the case of No. 11, Fig. 7, of a double walled metal casing, which encompasses the two glass prisms cemented therein and leaving only those surfaces free which are traversed by the line of vision. Water of a constant temperature is made to flow through the casing. The two halves of the casing, which is made to open out, are joined by hinges. This arrangement may be used in conjunction with a reservoir for flowing water, or in conjunction with a thermostat for circulating water. In other respects the general arrangement and manipulation are the same as in the case of No. 7.

With directions for using, in case fitted with lock M. **300.**—

Thermometers, divided in whole degrees, 0—75 ° C. **M. 2,50**

By dispensing with the compensator and, therefore, with the means of measuring the dispersion, thus rendering the apparatus available for use as a refractometer only, limited to sodium-light, the prices of Nos. 7 and 8 become reduced to **M.** 185.— and 225.— respectively.

No. 9. Percentage-Refractometer, with ocular-scale, for finding the concentration of solutions and liquid mixtures (Fig. 6).

Small hand-telescope with revolving AMICI prism for chromatic compensation; with ocular-scale reading refractive indices directly to units of the

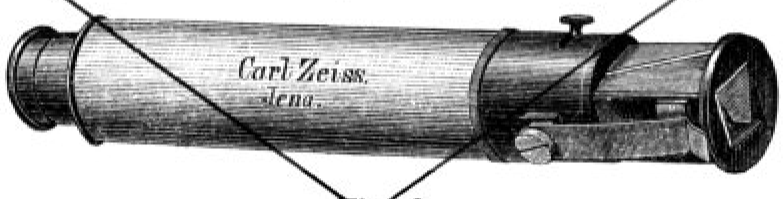


Fig. 6.
Percentage-Refractometer (No. 9).
$^1/_2$ Full Size.

vide following page

third decimal, smaller differences being estimated. The scale ranges from 1.30 to 1.40. The two parts of the double prism are held together by a spring clamp.

With directions for using, in case, with lock **M. 105.**—

A second scale in the ocular field (beside the one reading refractive indices) for directly reading the percentage of a certain liquid (sugar solution etc.), extra **M. 5.**—

)* **Nr. 10. Refractometer after Prof. Krümmel** for determining the percentage of salt in sea-water (refracto-salinometer).

The refractometric, as compared with the hydrostatic, salinometer has the advantage of yielding accurate results without being interfered with by the motions of the ship.

An instance of the application of the refractometer for this purpose is given in Dr. G. Schott's account of his voyage, Verhandl. der Ges. f. Erdk., Berlin 1892, Heft 2, 3, 4.

The instrument includes a hand telescope about 30 cm in length fitted with compensation prism. The double prism is held together as in No. 9.

In this instrument distilled water is used as a comparison fluid together with the salt water which is to be examined. The reading is thus nearly unaffected by changes of temperature. For this purpose either of the prism surfaces enclosing the stratum of liquid are longitudinally divided in two halves by a deep incision of some millimeters. A drop of distilled water is placed upon one of these halves, a drop of sea water upon the other half. Thus two liquid strata lying in one plane are formed and there is a narrow interspace separating them. By means of a cap fitted before the double prism either half may be uncovered alternately for observation with transmitted light. The position of the critical line is first read off for pure water and then for sea water; from the difference of the two readings (which is practically independent of the temperature) the percentage of salt is found, exactly within 0.05 %, from a simple table of reduced values which is supplied with each instrument. The position of the scale is adjusted by means of a watch key.

With directions for using, in case M. **200.**—

No. 11. Refractometer for special technical purposes, with heating arrangement and ocular scale (Fig. 7).

In principle these refractometers differ from those previously described only in that in this case the critical line of total reflexion for a certain substance or a certain class of substances is achromatized, not as in the case of the other refractometers by a special compensating arrangement, but by the refractometer prisms themselves (patented) the dispersion coexistent with the total reflection between glass and substance being exactly compensated by the dispersion due to the surface whence the light emerges from the double prism in the direction of the telescope. Accordingly, the critical line appears colourless (achromatized) for the standard substance or

)* In lieu of the Refractometers № 9 & 10 we are now supplying the Dipping-Refractometer, M. 220.—, with all accessories about – 280.—
Descriptive price list will be forwarded free on application.

standard solution for which the prisms have been calculated; whereas all other substances which differ from the standard substance with respect to refractive and dispersive power cause the critical line to appear more or less blue or red, the latter line being, however, in all cases, sufficiently distinct to admit of its exact position in the scale being ascertained.

Substances are thus distinguished not only by the different positions of the critical line but also by the differences in its appearance. Refractometer prisms of this class are, therefore, preeminently adapted for discerning adulterations and impurities and render, by their power of indicating differences in dispersion, a distinction possible even in such cases where the substances

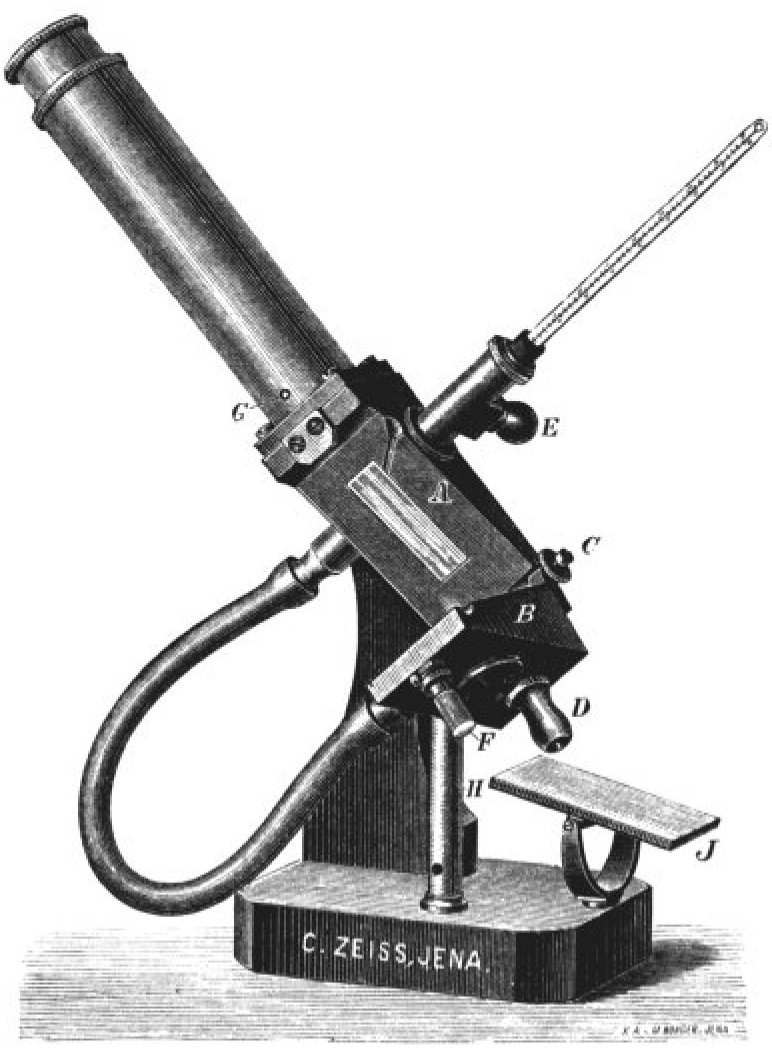


Fig. 7.
Butyro-Refractometer (No. 11).
1/3 Full Size.

have by refractometric examination proved to possess the same refractive index.

The refractometers constructed on this principle are mounted in a position suitably fixed for convenient observation. Fig. 7 represents a refractometer of this kind, specially adapted for refractometrical analysis of butter (distinction of margarine and natural butter). The prisms are, as in the case of No. 8, mounted in a double walled metal casing; this being passed through by water, the substance enclosed by the two prisms can be kept at a constant low or high temperature. The position of the critical line is ascertained by an ocular scale divided in 100 parts, which reads to $^1/_{10}$ divisions (mean equivalent 7 units of the 5th decimal of n). For adjusting (once for all) the ocular scale the objective may be set by means of a watch-key. The readings of the scale may be either directly compared with one another or they may be transformed in terms of refractive indices by means of a table of reduced values supplied with each instrument.

Self-evidently, any one of these instruments is, beside the immediate purpose which it serves, like any other refractometer, adapted for refractrometric examination of any liquid or liquified substance whose refractive index is within the limits of the scale of the particular instrument. For instance, the butyro-refractometer given above as an example (the scale of wich ranges from 1.42 to 1.49) may also be used for refractometric examination of fats and oils, for determining the percentage of water (within $^1/_3$ $^0/_0$ with accuracy) in concentrated glycerine solutions and for similar purposes.

With detailed directions for using, in case	M. **170.**—
Thermometer, divided in $^1/_2$ ^{0}, from 0^0 to 50^0, extra	M. **2.25**

Nr. 12. Differential Refractometer (Fig. 8).

This apparatus differs in principle from the preceding refractometers. The instrument consists essentially of two fluid prisms having equal refracting angles and placed one behind the other in such a manner that the deviations which they produce are in opposite directions; both prisms will, therefore, produce a deviation if the fluids differ from one another with respect to their refractive powers. The apparatus is fitted with two prisms of this kind so placed one above the other that the deviation produced by the upper double prism is directly opposite to that due to the lower double prism. A distant vertical line

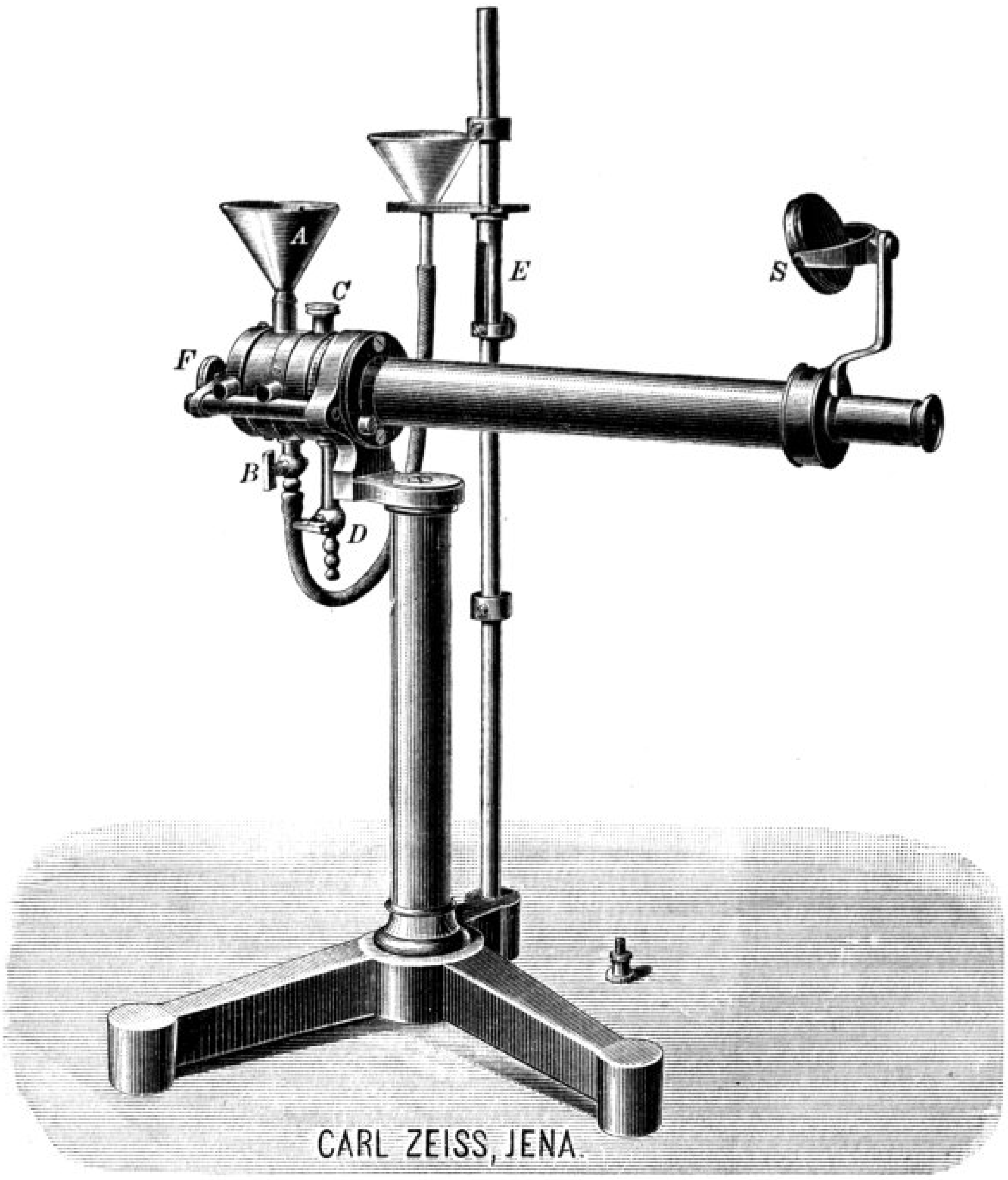


Fig. 8.
Differential Refractometer (No. 12)
$^1/_4$ Full Size.

(say, a staff) viewed through such a combination of prisms appears as two parallel halves of a staff laterally displaced, the distance between which is the greater the more the fluids differ in their respective refractive powers, both halves being in a straight line only when both liquids have the same refractive index.

The whole combination of prisms is fitted in a metal cylinder which is closed by glass plates and held together by means of the binding screw *F*, Fig. 8; the cylinder is provided with inlet and outlet tubulures. The standard fluid is placed in the two front chambers, which communicate with one another, and is protected against evaporation by a screw stopper (*C*). Similarly, the two back chambers, which form recipients for the fluid to be examined, communicate with one another. Both compartments are filled by means of glass funnels and india rubber tubing, the stopper *C* being replaced by the funnel ***A***. The glass funnel is mounted upon the stand ***E*** and may be moved up or down when it is required to fill or rinse the compartments.

The reading is taken by means of a telescope (autocollimation) by noting the relative positions of the two images of an ocular scale placed in the focus of the telescope objective and illuminated by day-light (mirror *S*), the images being formed by reflection at a plane mirror placed behind the prisms. This apparatus furnishes extremely accurate results, so much so that differences in the refractive indices not exceeding a few units of the 5th decimal may be recognized and estimated with precision. As this method only involves differential measurement, variations in the temperature of the locality have no appreciable influence upon the accuracy of the reading. The apparatus is not subject to any limitation with respect to the height of the refractive index.

In such cases where liquids possessing definitely ascertained and prescribed properties are to be produced in large quantities, the Differential Refractometer will form a suitable gauge which might be permanently appended to the plant (inlet at ***B***, outlet through piping screwed in lieu of the funnel ***A***).

With directions for using M. **240.**—

Abbe Refractometer

for the examination of crystals.

No. 13. Crystal Refractometer, large instrument (Figs. 9 and 10).

The refractive indices of the substances which are being examined are deduced from the critical angle of total reflection in heavy flint glass with respect to that substance.

A detailed description of and directions for using this instrument will be found in the "Zeitschrift für Instrumenten-Kunde", 1890, p. 246; Neues Jahrbuch für Mineralogie etc. Beilage Band 7, p. 175, 1890.

A hemisphere (*K*, Fig. 10) of flint glass having a refractive index of 1.89 with respect to yellow rays may be rotated together with the azimuth circle *H* (divided in $^1/_1$ degrees) about its vertical axis and can be fixed in any position by means of the clamping screw *U*. The solid body which is under examination is loosely placed upon the plane surface of the hemisphere, optical connection only being established by a drop of a liquid having a higher refractive power than that body. The mirror *Sp* which is attached to an arm so as to be capable of rotation about the horizontal axis *Ff* reflects the light emitted from a (monochromatic) luminant placed in the direction of the axis *Ff* upon the surface in which the crystal touches the hemisphere in such a way that the incident light just grazes the hemisphere or passes through the latter in the direction indicated by its critical angle. The critical curve of total reflection is viewed through the telescope *Oc*-*Ob*, to which is connected the vertical circle *VV*. The position of the latter is read by 2 verniers *NN* fitted with lenses *LL*. The circle has a diameter of 135 mm and reads to 20″. It is fixed by clamping screw *M* and is finely adjusted by a screw fitted with counter spring (shown in Fig. 9). The telescope has three bends. By means of successive reflections at the oblique surfaces of the cemented glass prisms *PP* the rays emerging from *K* are at any position of the telescope made to pass into the horizontal limb *F*-*Oc*. This enables the observer to retain his head in a fixed position. By means of the ring *R* the telescope and the vertical circle may be rotated about their horizontal axis. Ocular *Oc* provided with single crossed lines serves for observation and adjustment.

The objective of the telescope is so constituted as to compensate the refraction of the reflected pencils produced by the spherical surface.

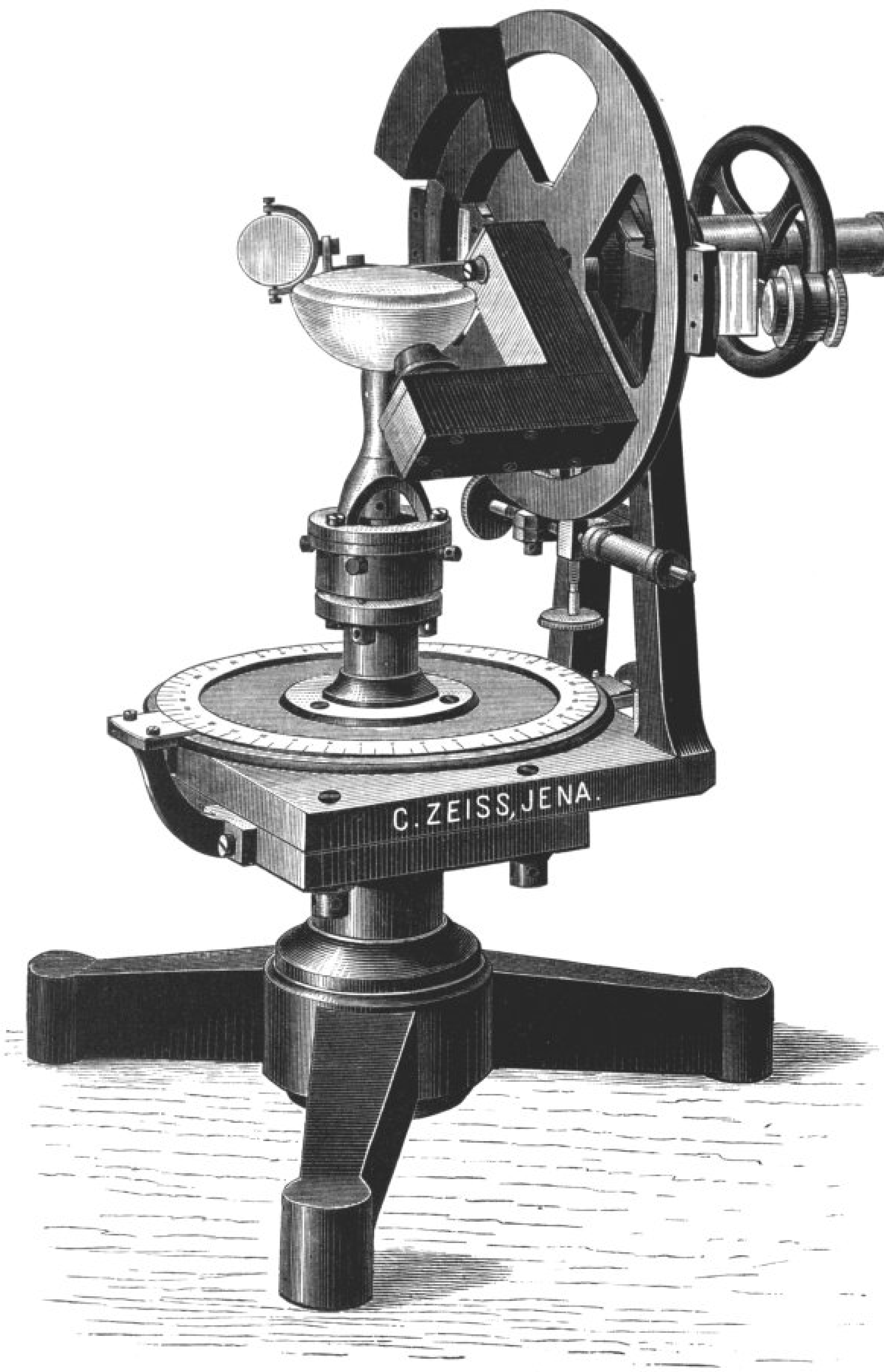


Fig. 9.
Large Crystal Refractometer (No. 13).
$^1/_2$ Full Size.

The critical curves are thus sharply defined. By means of an auxiliary lens it can, for the purpose of adjusting the apparatus, be commuted into an ordinary telescope (adjusted for parallel incident rays).

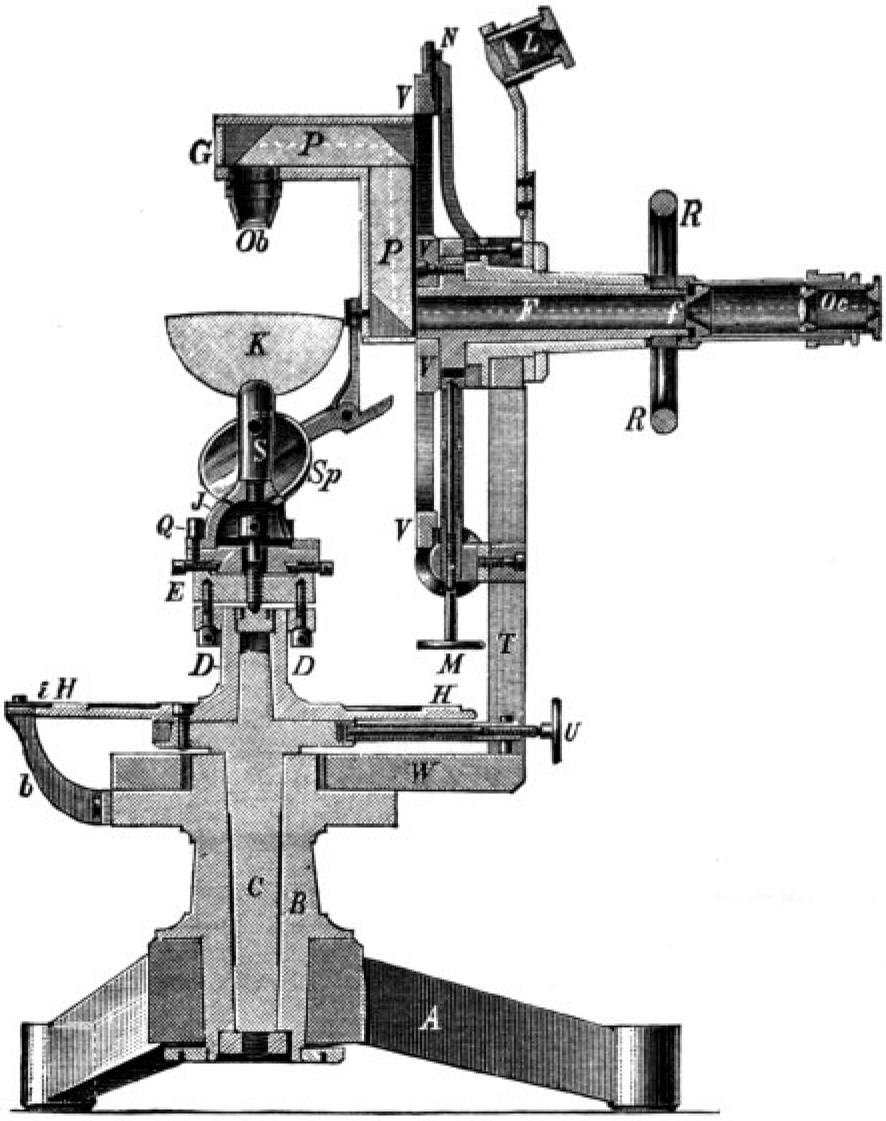


Fig. 10.
Cross Section of the Crystal Refractometer.
$^1/_3$ Full Size.

The hemisphere is, by means of a special fitting *DEQ* adjusted in such a manner as to satisfy the following conditions: 1) the axis of the hemisphere must be at right angles to that of the vertical circle, 2) both axes must intersect, and 3) the center of the hemisphere must be coincident with the axis of the vertical circle.

The vertical circle reads directly the value w of the critical angle of total reflection within the hemisphere with respect to the substance under examination. The refractive index of the latter is, therefore, $n = N . \sin w$, N being the refractive index of the hemisphere. This index is communicated by the maker and may, by total reflection of the hemisphere with respect to air, be verified at any time. A prism of the same glass as the hemisphere is supplied with the apparatus, if desired, for spectrometric verification of the optical constants of the hemisphere.

The apparatus arranged for observation with monochromatic light, in case with lock **M. 650.—**

The same apparatus provided with a hemisphere of a lighter flint glass having a refractive index of 1.75 **M. 640.—**

Accessory Apparatus for the Refractometer:

An analyser with or without divided circle may be placed upon the ocular (*Oc*) and the ocular itself may be replaced by a spectroscopic ocular or a goniometric ocular. The analyser furnishes the means of investigating the properties of the critical curves with respect to polarization; by means of the spectroscopic ocular readings may be taken with polychromatic illumination and the dispersion may be measured; the goniometric ocular serves for measuring the inclinations of the critical curves of double refracting substances.

Goniometric Ocular, containing a system of parallel lines placed in its focus, with divided circle M. **30.—**

Analyser (PRAZMOWSKI prism), fitting on ocular:

without divided circle M. **20.—**

with divided circle M. **35.—**

Goniometric Ocular and Analyser combined M. **50.—**

Spectroscopic Ocular for the refractometer M. **30.—**

In cases where these accessories are ordered at a later date separately from the refractometer itself it will be necessary to return the latter for the purpose of adapting the accessories.

No. 14. Crystal Refractometer, small instrument.

This instrument does not essentially differ from the larger instrument except in point of size, the dimensions being reduced throughout and its arrangement being simplified in consequence of such reductions while the principle of construction and the manner of using the instrument are the same in both.

The hemisphere made of flint glass having a refractive index of 1.89 with respect to yellow rays has a radius of 20 mm (as compared with 25 mm with the larger instrument).

The hemisphere is rotated about its vertical axis by means of a milled disc divided in $^1/_1$ degrees which is fitted below the centering arrangement and immediately above the standard supporting the telescope.

The vertical circle has a diameter of 80 mm (as compared with 135 mm with the larger instrument). It is divided in $^1/_1$ degrees reading by a vernier to 5′, equivalent to about 2 units of the 3rd decimal of the refractive index. This degree of exactness is sufficient for the great majority of cases in crystallographic determinations. The instrument is, therefore, applicable to all such cases which do not demand the highest degree of attainable exactness.

The telescope which rotates together with the vertical circle is essentially of the same type as that forming part of the larger instrument; it is, in particular, also fitted with an objective corrected with respect to the hemisphere by a plano-concave compensating lens. The triple bent form of the telescope, which somewhat complicates the larger instrument in the interest of more convenient handling (inasmuch as thereby the axis of the ocular coincides with that of the vertical circle and the eye retains a fixed position), is here replaced by a single bent telescope as, owing to the reduced distances, the necessary displacement of the eye does not constitute a serious objection.

This telescope is, as in the case of the larger instrument, made to rotate conaxially with the vertical circle. It may be clamped in any position and may also, in the usual way, be finely adjusted by means of a screw acting upon a pin fitted with counter-spring.

The illumination of the surface of the crystal placed upon the hemisphere is effected, in exactly the same manner as with the larger instrument, by a mirror which as with that instrument admits of rotation about the axis of the vertical circle and telescope independently of these.

The whole is mounted upon a single slightly conical pillar fixed in a disc-shaped foot. The height of the instrment is 25 cm. The instrument is used in precisely the same manner as the larger instrument.

In case with lock **M. 270.—**

All other parts as in No. 13.

Various
Optical Measuring Instruments
and
Apparatus for Demonstration.

Abbe Thickness Micrometer, Comparator and Spherometer.)[x]

(Figs. 11, 12 and 13.)

The instruments described under Nos. 15, 16 and 17 are intended *for measuring distances of a few centimeters with greatest exactness (within* 0.001 mm). They are therefore specially adapted for use in physical laboratories. — Detailed description and directions for using will be found in Dr. Pulfrich's paper in the "Zeitschrift für Instrumentenkunde", 1892, p. 307.

All these instruments have been designed with a view to realizing the following two conditions:

1) *The measurement to be exclusively based in all cases, both contact and by sight-adjustment, upon a divided standard of length with which the unknown length is directly compared.*

2) *To so construct the apparatus that the unknown length forms the continuation in a straight line of the divided standard.*

The former condition arises from the consideration that divided measures can be made with greater certainty and accuracy than any other measuring appliances, their individual defects may be once for all determined, the laws governing their changes due to oscillations of temperature can be taken into consideration and, finally, such irregular and incontrollable sources of error, which are e. g. inseparable from screws, can practically be eliminated.

The second condition envolves the aim of rendering the comparison of the unknown lengths with the standard independent of the degree of perfection of the

)[x] For the last few years we supply for each measure fitted to the apparatus described hereafter a Certificate from the "Physical-Techn. Reichsanstalt" for which we only charge the cost-price (from 15 to 30 Marks) mechanism effecting the movement for comparison. By this means it is possible to employ loosely fitting guides for the moving parts. With all other measuring appliances where this condition is not satisfied, the reading envolves an error equal to the product of the distance of the two straight lines and the angle of deviation of the guide block. If that distance be equal to 0, as is the case with the present instruments, the influence of deviation upon the reading is almost completely eliminated, viz. to the approximation of small quantities of the second order.

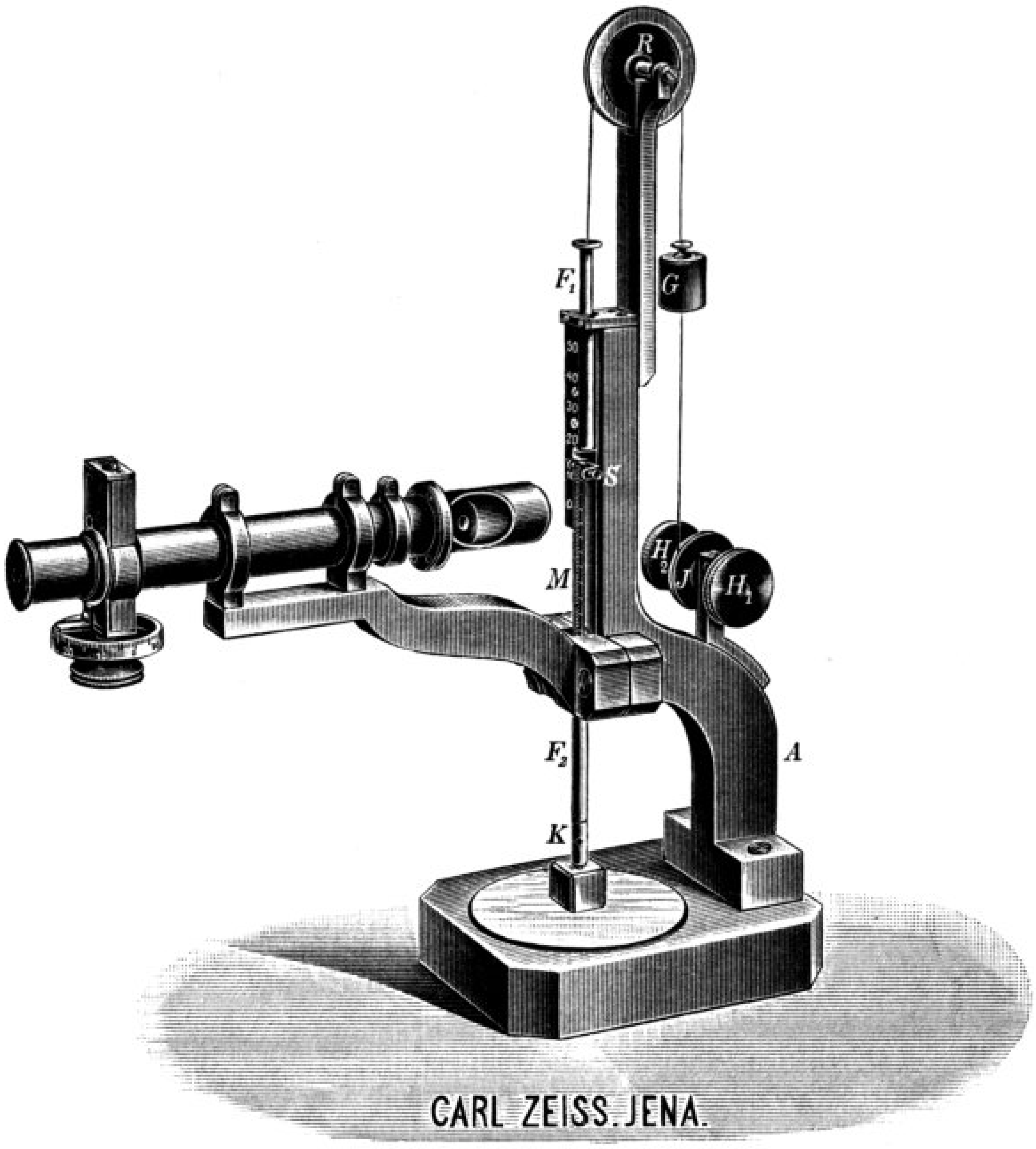


Fig. 11.
Thickness Micrometer (No. 15)
1/3 Full Size.

No. 15.[a] **Contact Micrometer,** a thickness micrometer, measuring up to 50 mm, for bodies possessing solid boundaries suitable for fixing the point of contact (Fig. 11).

Divided silver lamina (*M*), suspended between two pointed pins (*S*) forming the rectilinear continuation of the contact pin (*K*), the lower extremity of the guide-bar (F_2). The contact pin (*K*) is fitted with a spherically bevelled agate tip. The guide-bar is raised and lowered, as will easily be seen from the illustration, by means of a combination of a cord, pully (*R*), counter-weight (*G*), guide pully (*J*) and the two milled heads (H_1, H_2). The contact tip rests always with uniform pressure upon the object or the base disc. The latter is a plane polished glass disc 7 cm in diameter and 1 cm thick let into the sole plate and resting upon three metal heads.

The scale is divided in $^1/_5$ mm, each integer being figured. The subdivisions of the $^1/_5$ mm are read off by a stationary micrometric microscope which is so adjusted as to indicate each division of the scale by two complete turns of the drum; the latter being divided in 100 parts, each division indicates 1 μ.

In case, with lock M. **280.**—

№ 15 b) Large Thickness Micrometer, measuring up to 100 mm M. 450.—
№ 15 c) " " " with measure of 100 mm length, together with the reading microscope this apparatus may be shifted by 100 mm on a threeedged guide-prism provided with a mm scale; Measuring up to 200 mm; about M. 600.—

No. 16.[a] **Small Comparator,** for visual adjustment, measuring up to 100 mm for measuring divided scales, gratings, spectra, sidero-photograms etc., or, in general, for ascertaining the dimensions of such objects the boundaries of which can be focussed by means of a microscope (Fig. 12).

Short firm tripod surmounted by a bed fitted with slide plate (*AA*). Microscope I for observing the standard measure (*M*), microscope II for observing the object. The slide plate is displaced by hand and also by means of the adjusting screw (S_1). A second plate fitted so as to slide upon the main slide plate *AA*, the object slide (*B*), moves with the main slide but can also be moved independently by means of the adjusting screw S_2. Illumination: reflected light by means of the reflectors of the microscopes, transmitted light by means of the mirror underneath the slide plate (*B*). The comparator is fitted with adjusting appliances in such a manner as to enable the observer to adjust the parts of the apparatus himself with the greatest ease. Division of the standard scale as in No. 15.

In case, with lock M. ~~**400.**~~— 450.—

№ 16 b) Large Comparator with inclinable object-plate, measure of 200 mm length, & reading microscope of 50 diameters. Without objective & eyepiece of the object microscope about M. 1050.—

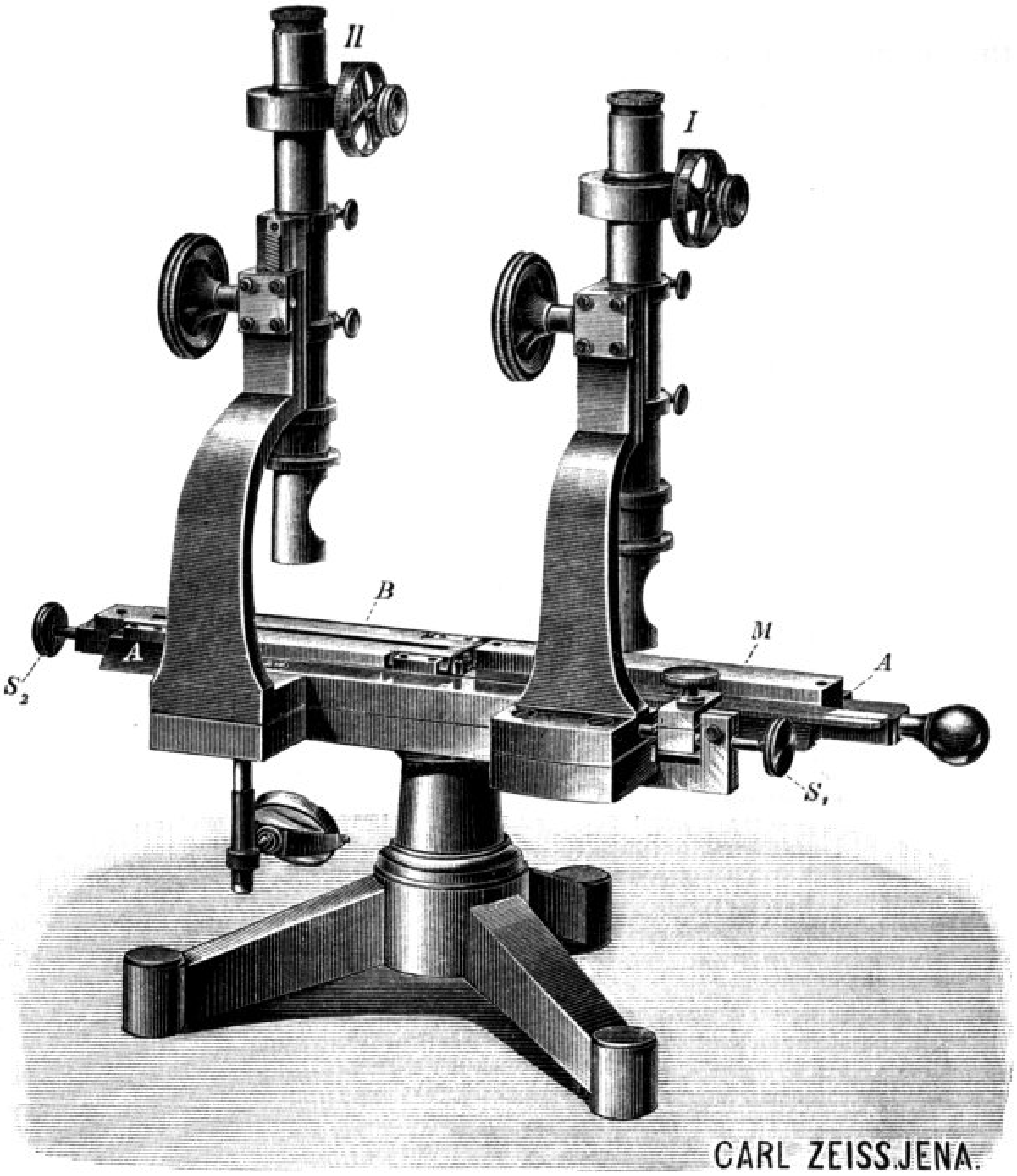


Fig. 12.
Comparator (No. 16).
$^1/_3$ Full Size.

No. 17. Spherometer, for determining the radii of curvature of spherical surfaces (Fig. 13).

The mathematical principle of this instrument is the same as that of all other spherometers: The instrument measures the height h of a spherical segment, the radius r of the circular base of which is known, and hence the required radius R of the sphere is found by the formula

$$R = \frac{r^2}{2h} + \frac{h}{2}$$

Detachable rings of hard gun metal (upon which the spherical surfaces are to be placed) with carefully ground edges. The innermost of the two circles, which are 0.5 mm apart and whose diameters are measured by the comparator, is intended for taking convex, the outer circle for taking concave lenses. This device reduces considerably the risk of injury as compared with a single sharp edge. Owing to the ring being loosely placed upon face plate ***P*** which is supported by stout standards the danger of twisting or bending the rings, which with rings or parts of rings held down by screws is scarcely avoidable, is entirely obviated.

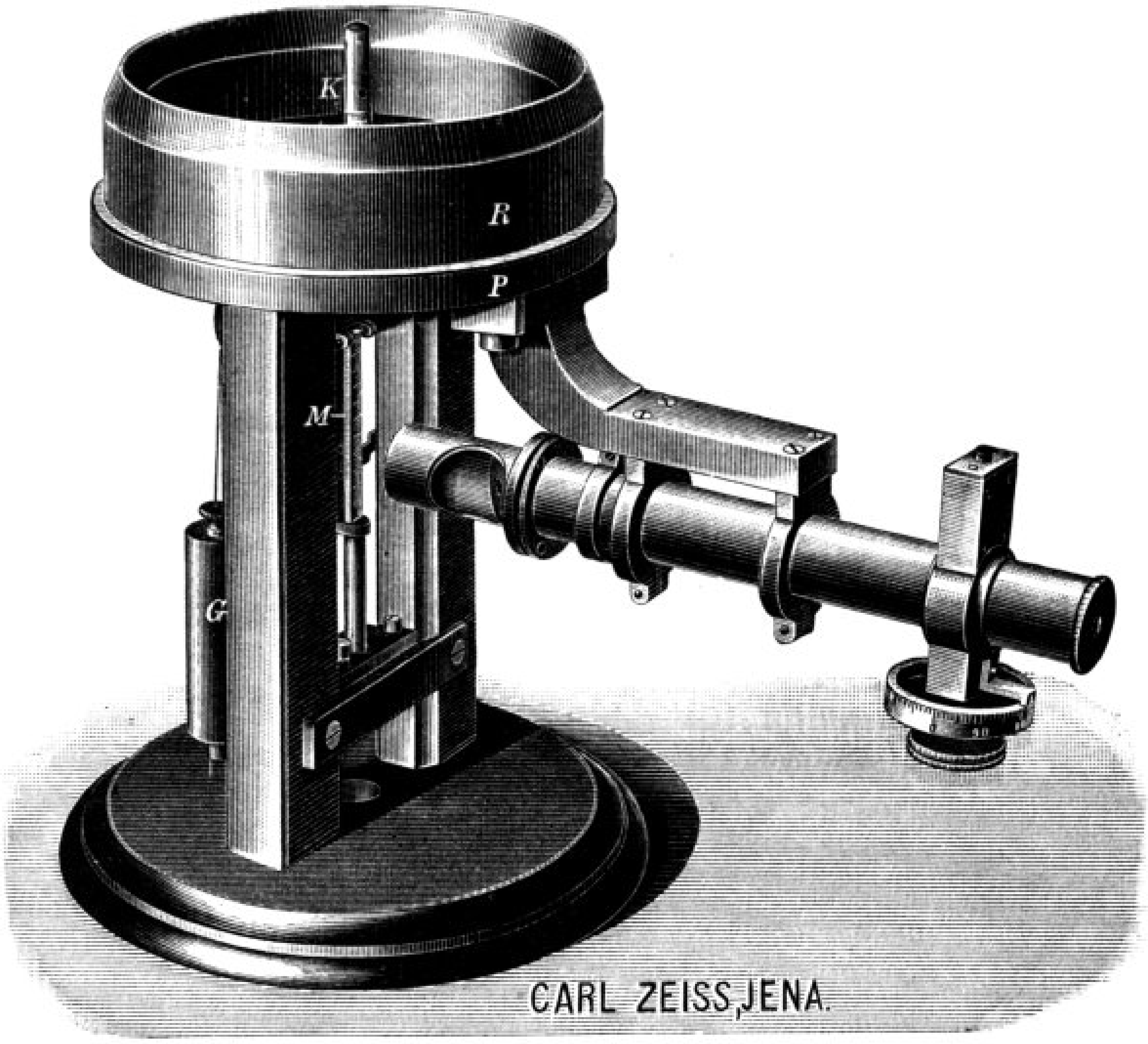


Fig. 13.
Spherometer (No. 17).
½ Full Size.

The other parts of the spherometer are copied from the thickness micrometer (No. 15). The contact pin (*K*) is caused to abut from below upon the spherical surface with uniform pressure just sufficiently great to ensure contact. Divisions and micrometric reading appliances as with the two other instruments.

The apparatus is supplied with two rings. In ordering, selections should be made from the following diameters: 100, 80, 65, 50, 40 and 30 mm.

In case fitted with lock M. **290.**—

Each separate ring beyond the two supplied with the instrument M. **10.**—

No. 18. Apparatus for measuring the focal lengths of systems of lenses (Focometer) (Figs. 14 and 15).

The construction of this instrument is based upon the method of determining the focal length of a system of lenses and the position of its cardinal points from the magnifications of the images of two objects of given distances, in this case divided glass rules. By this method the required magnifications are found entirely independently of the position of images; only the distance of bodily objects, which admit of certain measurement, supply the necessary data. The linear magnitude of the image of such an object (glass scale) is, however, determined by a method which 1) admits of deducing from the ratio of magnitude of image and object obtained with finite (greatest possible) dimensions of either the fundamental value of the magnification, i. e. the ultimate value of this ratio for infinitely small dimensions, and which 2) renders it possible to determine the ratio of the magnifications independently of the uncertainty inseparable from the determination of the position of an image.

In its present form as described in the following lines the apparatus is adapted for the determination of the constants of positive and negative systems of about 50 mm focus and upwards, provided the dimensions do not exceed 100 mm in diameter and 50 mm in thickness (or height).

With achromatic lenses with focal lengths exceeding 100 mm the focus can easily be measured correctly within 0.1 % and the distances of the principal points are correctly measurable within 0.1 mm.

A detailed description of the method and the instrument and directions for its use have been published by Dr. Czapski in the Zeitschrift für Instrumentenkunde, 1892, p. 185.

The apparatus consists essentially of a microscope stand of large size with draw-tube having upon its stage a movable slide *W*. This slide is roughly adjusted by hand, the fine adjustment is effected by a micrometer screw. The amount of the displacement may be found by means of a micrometer scale *s* reading by vernier *N* to about 0.02 mm.

Beneath the stage a glass scale *T* divided in $^1/_2$ millimeters is fixed at a distance of about 100 mm. Another smaller glass scale divided in $^1/_{10}$ millimeters may by means of the small lever *H* be passed into the axis of the microscope and temporarily fixed by a projecting tooth in a level with the upper surface of the slide *W*.

The system of lenses which is to be measured is placed upon the slide *W* approximately in the axis of the microscope. An objective of suitable focus is attached to the centering nose-piece *Z* of the microscope tube and the microscope is first made to focus the image formed by the system of lenses of scale *T* and then (after changing the objective) it is adjusted so as to have the image of the upper scale *t* in focus. After each adjustment a reading is taken of the displacement of the slide *W* which is necessary to cause certain lines (symmetrically disposed with respect to the axis) of either scale to be successively superposed by the cross line of the ocular.

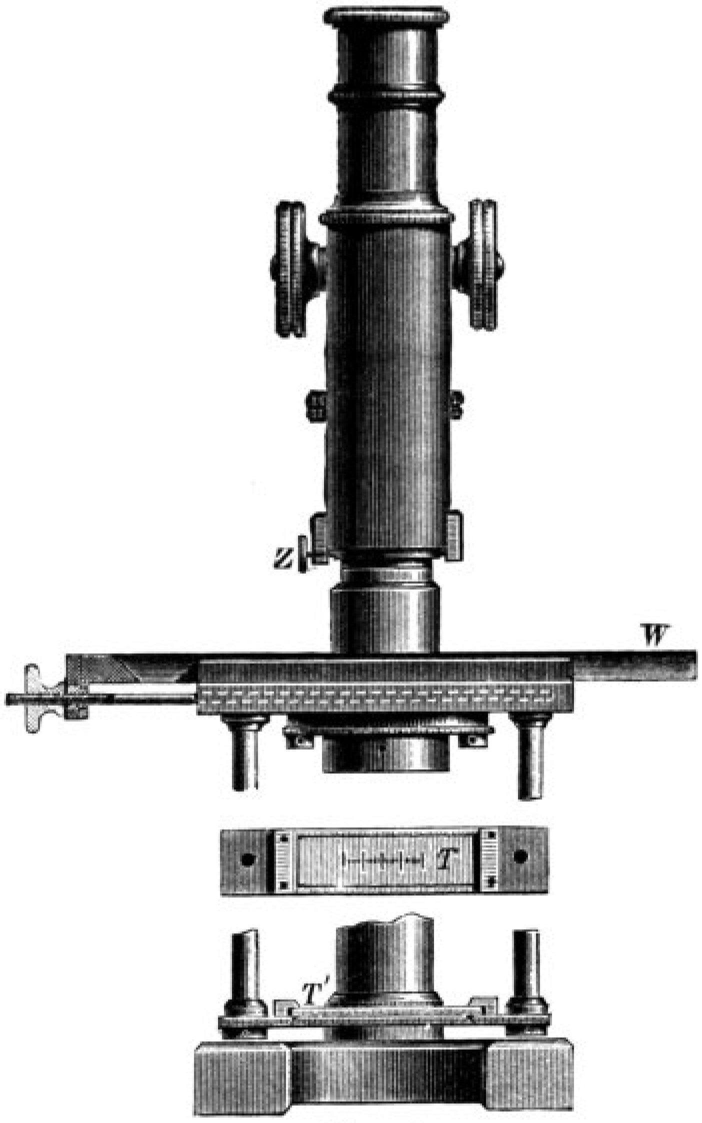


Fig. 14.

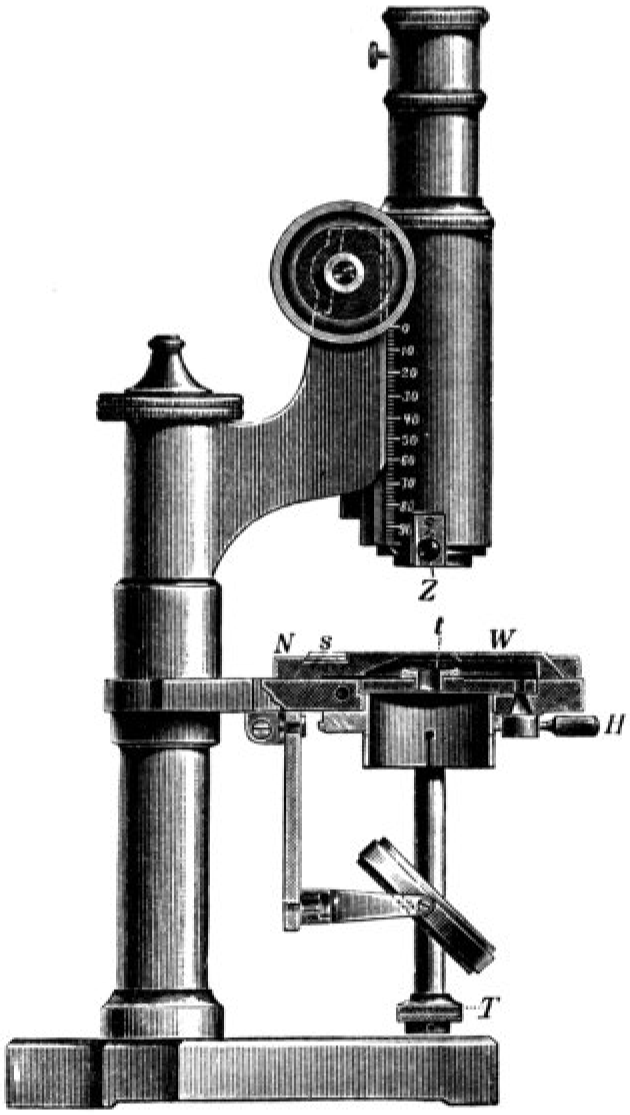


Fig. 15.

Focometer (No. 18).
$^1/_3$ Full Size.

The amount of the necessary displacement for two or more divisions read off scales *T* or *t* furnishes the data for finding the ultimate value of the linear magnification of the image, formed by the system of lenses, of infinitely small objects taking the place of the corresponding scale. The data thus obtained are free from errors due to inexact focussing of the image viewed by the microscope. The measurement of the distance between scales *T* and *t* from the upper surface of the slide completes the data required for the calculation of the focal length of the system as well as the distances of the principal points from the slide *W*.

The apparatus includes: 5 objectives of suitable focal lengths, a micrometer ocular fitted with interchangeable double cross lines and micrometer scale (10 mm divided in 0.1) and a gauge for measuring the distances of the two scales and of the two apices of the lenses from the slide *W*, divided up to 100 mm, reading by vernier to 0.1 mm.

The whole apparatus, in case fitted with lock M. **380.**—

As this instrument possesses all the essential features of a large-sized microscope stand, it may with the addition of higher powers be used as a microscope proper, especially for physical research, in particular for determination of foci of microscope objectives, oculars etc. according to usual methods.

If the instrument be intended for use in this manner beyond its original limited purpose, it is advisable to add to it a condenser and iris-diaphragm (price M. 40.—) which fits into a sleeve fixed to the under side of the stage.

No. 19. Abbe Dilatometer, for determining after the manner of FIZEAU the coefficients of expansion of solid bodies.

(The general arrangement of the dilatometer is shown in Fig. 16 on the following page. Fig. 18, p. 33 illustrates the path of the rays. Fig. 17, pag. 32 represents FIZEAU's adjustable tripod stage).

This dilatometer was constructed by Prof. ABBE in 1884 and was first described by G. WEIDMANN in a paper contributed to Wiedemann's Annalen 38, p. 453, 1889, which also contains a few notes concerning measurements of the expansion of glasses made with the apparatus. During the last two years the apparatus has been utilized by Dr. PULFRICH in numerous determinations of the coefficients of expansion of glasses made in the Jena Glass Works. The results of these measurements have partly been published (Dr. SCHOTT, "Ueber die Ausdehnung von Gläsern und über Verbundglas", Berlin 1892, and PULFRICH, "Lichtbrechung des Glases", Wiedemann's Annalen 45, p. 659, 1892). The experiences gathered from these researches have given us abundant opportunity of carefully testing the arrangement of the apparatus and to remove any deficiencies which became noticeable during usage. The new apparatus now fitted up in our laboratory is calculated in its present form, as compared with the temporary instrument which preceded it to satisfy the most advanced exigencies as regards ease and precision in taking the readings.

A detailed description of the dilatometer and its mode of manipulation will shortly be published in the Zeitschrift für Instrumentenkunde.

ABBE's dilatometer differs considerably from the original arrangement of FIZEAU [1]) in several important respects. The modifications to which ABBE has

1) which has been introduced in a slightly modified form in the bureau international des poids et mesures by the investigations of BENOIT "Etudes sur l'appareil de FIZEAU pour la mesure des dilatutions", Travaux et mémoires etc. I. 1881, and "Nouvelles études etc." ibid, VI. 1888.

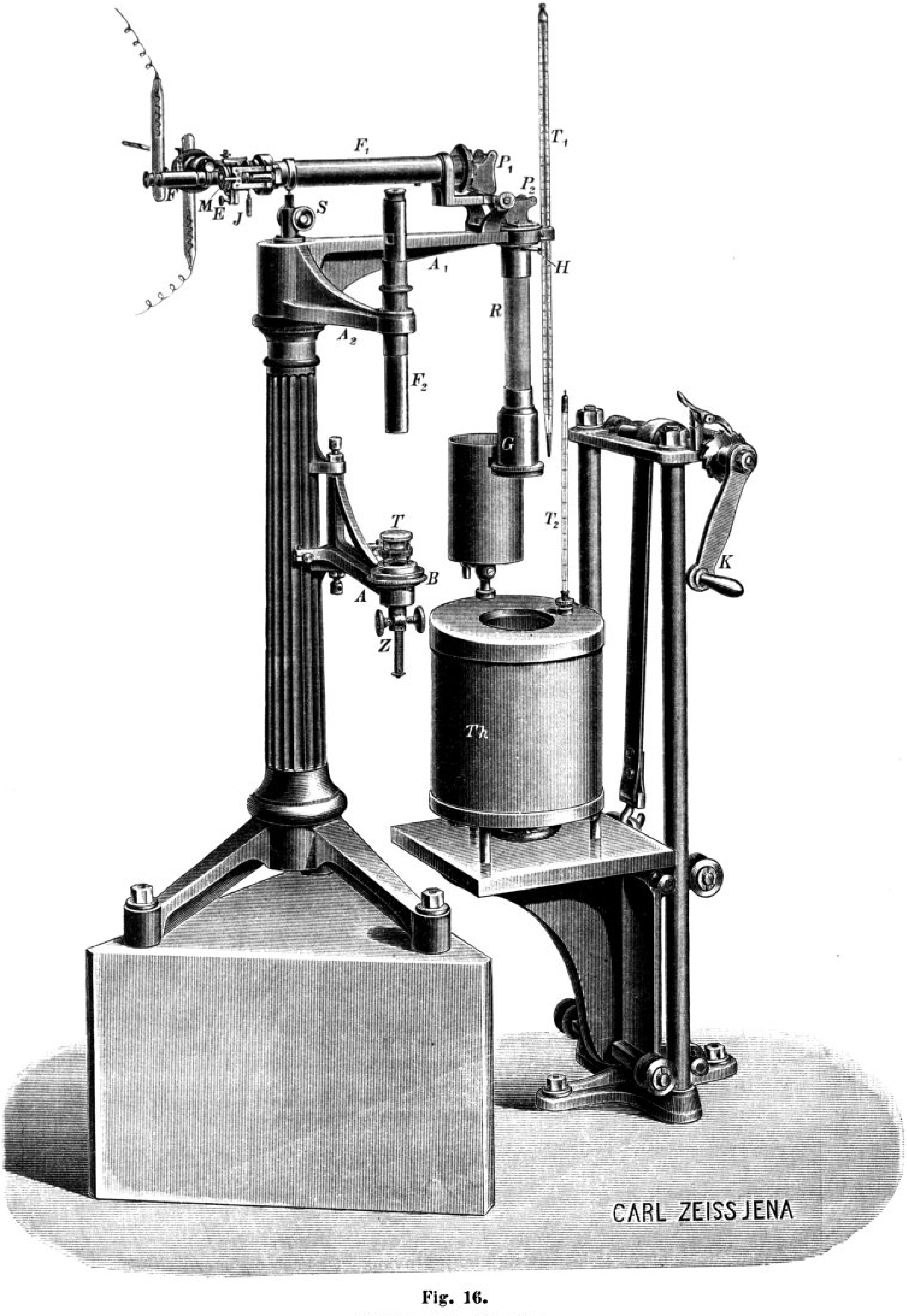


Fig. 16.

Dilatometer (No. 19).

$^1/_7$ Full Size.

subjected FIZEAU'S apparatus tend to essentially simplify and quicken the process of observation but also to enhance the delicacy of the measurements.

These improvements envolve:

1) the simultaneous employment of monochromatic light of two or more wave lengths in observing the positions of the systems of striae corresponding to each of these wave lengths, and

2) the determination by micrometric measurement of the displacement of the striae produced by a certain difference of temperature.

In the first place the illumination is not, as in the case of FIZEAU and BENOIT, effected by monochromatic flames (sodium light) but by the projection of spectroscopically decomposed light upon the interference apparatus. This arrangement has the advantage of admitting of the employment of luminants, such as GEISSLER tubes, which in themselves are not monochromatic but possess a greater intensity. The most important feature, however, is that light waves of differing lengths are simultaneously brought into operation. This renders it possible to deduce by calculation the entire multiples of the displaced striae from successive observations made with two different colours and from the ratio of the wave lengths of the rays employed. Changes which occur in widely separated intervals may thus be completely determined by solely observing the initial and final position of the striae, continuous observation of the changes for ascertaining the number of displaced striae being entirely dispensed with.

Furthermore, ABBE fixes the position of the striae, unlike FIZEAU and BENOIT, who estimated the relative position of the striae with respect to a number of fixed points, by means of micrometric measurement, which has the advantage of being both more methodical and practical. In order to obtain sufficiently exact results, FIZEAU determined the relative position of the striae not only with respect to one but 10, BENOIT as many as 25 to 30 regularly arranged fixed points. This method is both very inconvenient and coupled with many disadvantages. ABBE'S dilatometer has only one such marking point, viz. a small circular disc of silver with sharp edge and about $^3/_4$ mm in diameter. For micrometric measurement it is essential that the striae be as rectilinear and equidistant as possible, which is easily obtained by providing the object plate with an approximately plane surface.

The interference apparatus proper, FIZEAU'S tripod stage, is shown full size in fig. 17. It consists of the following parts: *T* is a steel disc which is well annealed, i. e. free from internal strains, fitted with three setting screws of equal length treated in the same manner and made from three successive pieces cut from the same steel rod so as to ensure greatest possible uniformity of expansion; *O* represents the object which is to be examined and *P* the glass plate cover provided with plane slightly inclined surfaces; to the lower of these surfaces is attached the above mentioned silver disc (*m*). The glass plate cover is placed upon the points of the three screws while the object plate *O*, which has approximately plano-parallel surfaces, is made to rest upon three points projecting from the steel tripod stage (*T*). The stratum of air separating the object and glass cover is regulated by means of the three screws [1]). To prevent the three screws from working loose, they can be fixed by three small set screws sunk into the stage *T*; by means of these the position of the screws may be fixed without straining. — In order that this same tripod stage may also be used for absolute measurements (longitudinal expansion of the screws), the underside of the steel plate is ground and polished perfectly plane.

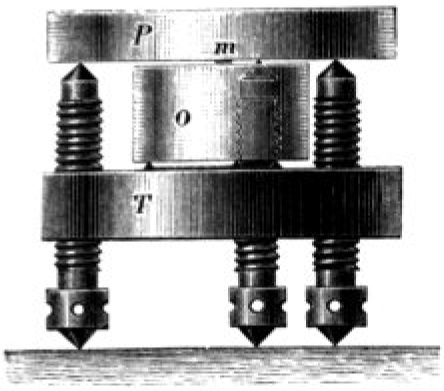


Fig. 17.
Interference Apparatus.
Full Size.

The arrangement of the optical apparatus is as follows: In the anterior focus of the objective *O* (Figs. 16 and 18) of a telescope F_1 fixed in a horizontal position is placed a totally reflecting prism (*p*) which is illuminated from the side by a source of light (GEISSLER tube filled with H and Hg, vid. No. 3 of this catalogue) by means of an illuminating lens *L*, all these parts being rigidly connected with the telescope. The rays meeting the prism *p* form a 4 times magnified image of the luminous section of the GEISSLER tube and have an angular aperture which corresponds to the size of the objective *O*, the latter being thus completely filled with rays. The parallel pencil of rays emerging from the objective passes through two flint glass prisms P_1 and P_2 with horizontal refracting edges, the angles of which have been computed so as to make the total deviation of the rays of medium refrangibility equal to 90°. By raising and lowering the telescope by means of the screw *S*, the homogeneous pencils of rays of different colours are successively made to emerge from prism P_2 in a vertical direction. The axis of rotation of the telescope coincides with the line of intersection of the two prism

1) Fig. 17 represents, through an error of the engraver, the threads of the three setting screws far too coarse. The pitch of the thread is in reality only 0.2 mm.

surfaces facing each other. Thus the system of prisms adjusted so as to produce minimum deviation with respect to a particular colour, will also in any other position of the telescope produce minimum deviation with respect to that pencil of coloured rays.

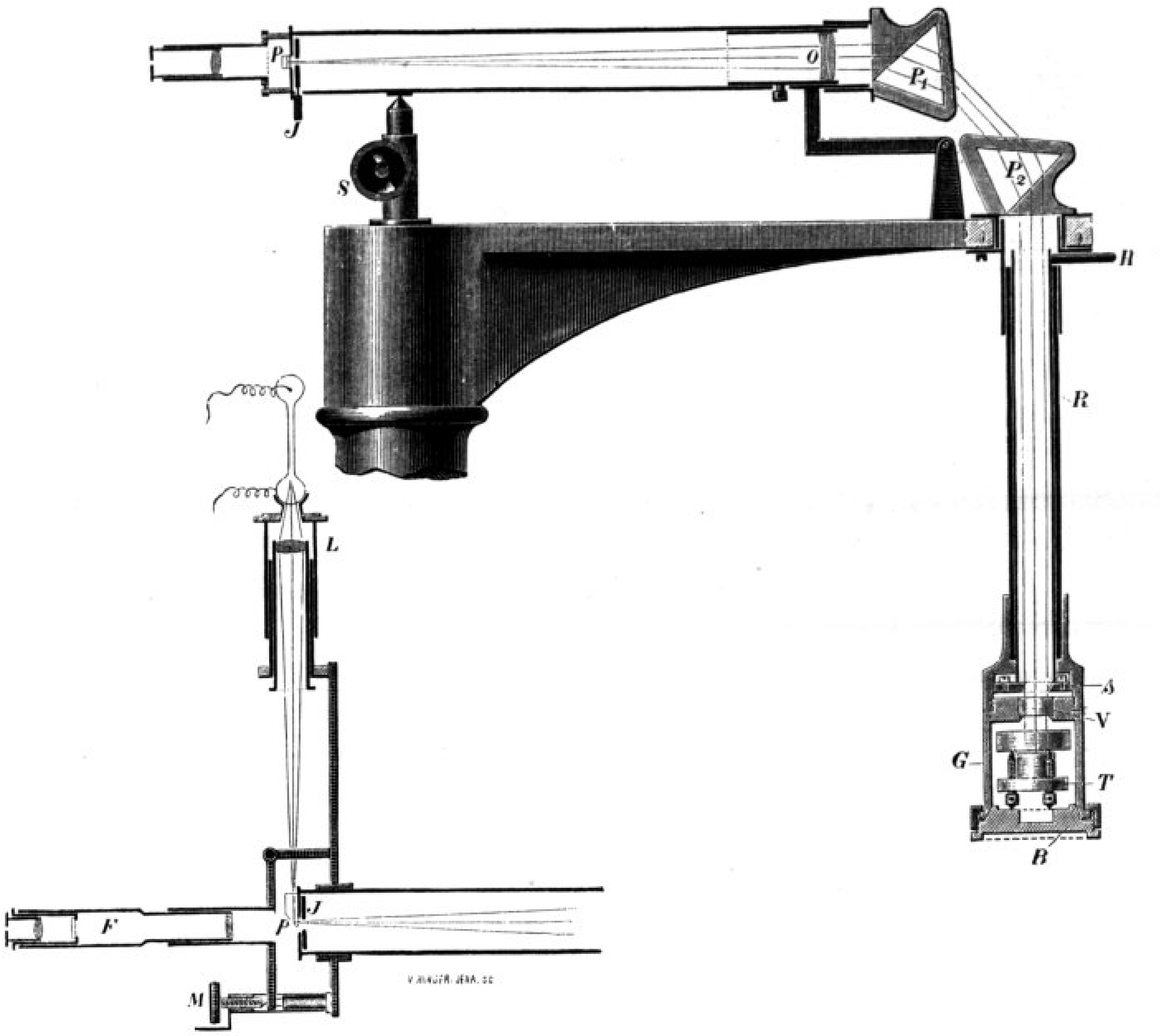


Fig. 18.
Path of Rays in the Dilatometer.

That pencil with respect to which the apparatus has been adjusted, enters vertically into the porcelain tube (*R*). This porcelain tube terminates in a brass casing (*G*) into which is placed the Fizeau tripod stage. The rays pass through the opening of a metal slide (*s*) which is intended to prevent loss of heat due to continous radiation upwards and is only opened while the readings are being taken. Thence the pencil proceeds through a slightly cuniform plate of glass (*V*) placed in the upper part of the casing and provided with plane surfaces inclined to each other at 20′. The position of the refracting edge is marked by a line drawn parallel to it upon the glass. The plate is mounted in such a way that this line is placed at the right hand side of the observer and also so as to exclude displacement of the plate during transport. The deviation of the pencils of rays produced by plate V is compensated by the glass cover plate P of the FIZEAU stage, which also has its plane surfaces inclined at 20′ to each other, provided that in adjusting the interference apparatus care be taken that the refracting edge of the glass cover plate (P) whose direction is also indicated by a line drawn parallel to it, is placed at the left hand side of the observer, the expressions "right" and "left" referring to the position of the observer.

The rays being reflected normally by the lower surface of the cover plate and the upper surface of the object return by the same path into the telescope and form in the focal plane of the telescope objective two partly superposed images of the aperture illuminated by the prism p. In order that the aperture may be accurately focussed, the objective O is made to move in the direction of the axis. By slightly turning the prism P_1 (or P_2) these two images, which are viewed by an ocular at the back of P, may be projected into the free aperture immediately beside the prism p. As soon as the mages have been placed in their correct relative position, the striae of interference become already visible to the naked eye.

An iris diaphragm J is placed immediately behind the prism p. The center of this iris diaphragm is made to exactly coincide with the edge of the prism and the optical axis of the telescope. In finding and adjusting the images due to reflection, the iris diaphragm should be fully opened. In this case also the image due to reflection by the upper surface of the cover plate becomes visible. The reduction of the aperture of the iris diaphragm — which may be adjusted by means of an external scale — not only causes that reflected image and all other extraneous light to be cut off by the diaphragm but also allows of all rays which are incident upon the prism only those to be transmitted which emanate from points lying in the proximity of the axis; the distinction of the interferential striae produced by thick plates renders this limitation necessary.

The curvatures of the objective lens O have been chosen in such a manner as to avoid indistinctness arising from reflections at the anterior and posterior surfaces of O. The first, concave, surface having a radius of curvature equal to the focus, produces an image which by placing the objective slightly oblique, is projected behind the prism p or the iris diaphragm. The image due to the second surface lies immediately before the objective and, owing to the great divergence of the rays, produces only the effect of slightly enhancing the general brightness of the field.

The interference apparatus is adjusted by means of a special adjusting telescope fitted with slit and reflecting prism (F_2, Fig. 16), which is supported by bracket A_2 fixed to the main standard. The FIZEAU stage placed upon the foot plate B rests in this case upon three setting screws with rounded points screwed into a plate supported by bracket A and is by means of these brought into its vertical position with respect to the axis of the telescope. In order to adjust the tripod stage it is sufficient to notice the position of the images, due to reflection, of the slit illuminated with white light. The adjustment being completed, bracket A, which is made to swing on a vertical axis and is fitted with stops, is swung out so as to bring the tripod stage under tube R. The tripod stage may then by rack and pinion movement Z be raised into tube R and plate B connected with the casing G by a screw union, the conical shoulder of B being firmly screwed into its conical seat in G.

The following directions may serve for the adjustment of the interference apparatus with the aid of the adjusting telescope: Let the thickness of the stratum of air be less than 0.1 mm and let also the three images, produced by reflection, of the ocular slit be visible in the ocular field of the adjusting telescope, the slit being parallel to bracket A and receiving its light from the left (or right). Let also the glass cover plate be so placed that the line drawn upon it appears on the right hand side of the observer standing before the adjusting telescope and let this line be nearly parallel to bracket A. Then the first requirement is that also the refracting edge of the air wedge shall be parallel to bracket A, in order that the striae may be vertical in the field of the reading telescope proper. To avoid errors respecting the direction of the displacement of the striae, it is a good plan to let the refracting edge of the air wedge always point towards the same side, either to the right or to the left. Let, therefore, the air wedge have its refracting edge in the opposite position to that of glass cover plate P, then the same rule always holds good for the relative position of the three images: 1) the image of the slit due to the surface of the object, which may be easily distinguished from the other two images of the slit by removing and replacing the glass cover plate (the latter images being at fixed distances) must in all cases be brought together with the image of the slit on the left; 2) the two images of the slit must with their entire lengths be so placed one beside or above the other that the first named image always appears on the right hand side of the second image. — By illuminating the slit with sodium instead of white light, the appearance of the striae may be examined, the simple lens having previously been removed. The amount of superposition necessary to obtain striae of a suitable width (say 1 turn of the micrometer) for measuring is fixed for all future cases by a single preliminary experiment.

Assuming the interference apparatus to be adjusted in the manner described, the displacement of the interferential striae viewed by telescope F acts as follows. If the striae be displaced in a direction from right to left, the inference is that the stratum of air has increased, i. e. the expansion of the screws is greater than that of the object. Conversely, wandering of the striae from left to right indicates diminution of the stratum of air; the expansion of the screws is in this case less than that of the object.

While the apparatus is being adjusted, bracket *A* can easily be fixed by means of a pin (not shown in the figure). A dish lined with velvet, which is supplied with the apparatus, may in a most expedient manner be temporarily attached to bracket *A* during the adjustment of the tripod stage. It is intended to act as a guard preventing parts of the interference apparatus from dropping upon the ground. It will also be found a useful receptacle for accessories, such as the focussing lens, fixing pin etc.

The width of the striae and the position of the silver disc within the system of striae is measured by a small special telescope (*F*), which is substituted for the single lens. This telescope has fitted to it a micrometer screw (*M*) with drum divided in 100 parts and pointer and also a short double line drawn upon glass which may be brought to coincide with the single lines of interference and the silver disc. By means of the adjusting screw *E* shown in Fig. 16 the telescope may be turned about a horizontal pivot so as to obtain the correct position of the mark. A single micrometer reading taken of the relative position of the striae and the silver disc envolves an error which does not exceed the $^1/_{100}$ part of the width of the striae. The changes in the thickness of the stratum of air are thus indicated to the approximation of about $^3/_{1000000}$ mm. — The thickness of the object plate and that of the stratum of air can easily be ascertained by means of the thickness micrometer (No. 15 in this catalogue).

The last appendage to be described is the heating apparatus (*Th*), which is a D'ARSONVAL thermostat specially adapted for the dilatometer. The casing is filled with water or linseed oil. If the latter be used, the temperature may be raised beyond 250 C. The temperature is taken by a thermometer (T_1) suspended alongside of the porcelain tube *R*. The inner chamber is closed by semi-circular discs so shaped as to clear tube *R* and the thermometer. The heating apparatus is envelopped in a coating of asbestos mill board to minimise radiation of heat. The apparatus may be conveniently raised or lowered by means of a winch. Detailed instructions for working the thermostat are supplied with the apparatus.

Fig. 16 shows the apparatus mounted so as to be suitable for observation in a sitting posture. The foundation stone is 30 cm high. By increasing the hight of this stone the apparatus may, of course, also be used in an erect posture.

The whole apparatus, incl. a GEISSLER tube filled with H and Hg (No. 3 in this catalogue), without thermometer . **M. 1060.**—

Note: For connection with a hot air chamber, the optical part is also mounted by us in a different manner so as to have the prisms in a horizontal position. The hot air chamber used by BENOIT consists of a series of concentric metal cylinders the sides of which are fitted with glass plates arranged along a horizontal straight line. The rays pass normally through these plates and are by means of a rectangular prism reflected downwards upon the tripod stage placed in the interior. A dilatometer adapted by us to an existing heating chamber of BENOIT's type has already been fitted up in the First Division of the Imperial Physical and Technical Institute in Charlottenburgh.

No. 20. Apparatus for observing curves of interference produced by glass plates (Figs. 19 and 20).

By means of this apparatus FIZEAU'S curves and MASCART'S rings exhibited by nearly or perfectly plano-parallel plates may be observed under conditions which may be accurately determined and which may be modified so as to suit the nature of the case. A detailed description of this apparatus has been published by Dr. CZAPSKI, Zeitschrift für Instrumentenkunde, 1885, p. 149.

NEWTON'S (or FIZEAU'S) curves of interference, which are produced by variations, due to oscillations in the thickness of the plate, of the difference of the undulatory phases of rays reflected from the front and back surface and which appear in the vicinity of the former, are only in that case also the curves of uniform thickness of the plate, when the rays meeting the plate have all the same angle of incidence. For various reasons normal rays are the most suitable for producing these curves. Accordingly, a monochromatic luminant placed behind screen *M* at the side of the apparatus is, by means of a reflecting prism *P*, reflected into the anterior focal plane of a system of lenses *O*, whence the pencils emerge with their axes parallel to the axis of the system (Fig. 20). The plate which is to be examined, is by means of spring clips attached to the adjustable stage which is approximately mounted in the second focus of the system *O*. By adjusting the inclinations of the stage the plate may be set at right angles to the

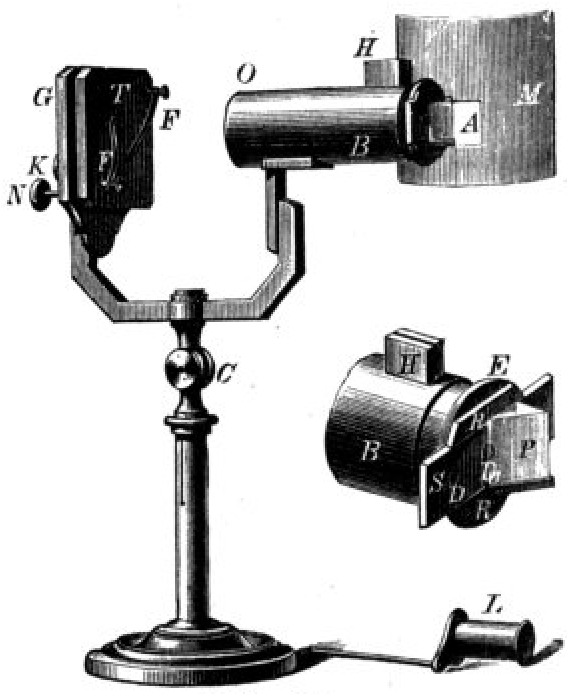


Fig. 19.
1/6 Full Size.

axis of the system. This is accomplished when the semi-circular image of that half of the aperture at *F* which is covered by the prism, has its diameter exactly superposed by that of the other half.

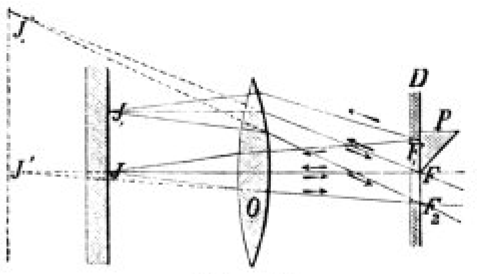


Fig. 20.

If the aperture be correctly placed in the focus of *O* and if the test plate have plane surfaces, the aperture and its image must simultaneously appear sharply defined. If this be not the case, the necessary correction may be effected by lengthening or shortening the diaphragm draw tube *E*.

The greater the thickness of the plate which is to be examined, the narrower must also be the incident pencil in order that by too great a diversity of effects produced within each pencil, the phenomena be not destroyed. Accordingly, the apparatus is fitted with a plate *S* provided with various sized holes D, D_1, which slides in a frame *R* fixed below the refracting prism and by means of which the aperture of the pencils may be limited according to requirement.

The curves become visible by looking towards the plate through the uncovered semicircular aperture *D* of the diaphragm.

With plano-parallel plates of very high perfection, in which Fizeau's striae are 1 cm apart or entirely absent, the interferential rings first described by Mascart may be viewed. These are due to variation in the difference of the phases produced in pencils of parallel rays of varying inclinations in one certain place of the plate. These rings become, therefore, visible in the focal plane of the system *O* itself. In order that they may be viewed, the plate and illumination should be adjusted as before and the lens *L* be placed so as to focus the plane of the diaphragm; then on removing the slide *S*, a system of concentric semi-circles will be perceived in the plane of the diaphragm, the center of which may be either bright or dark. If it remain unchanged while the plate is being displaced upon the stage, this shows that the variation of the thickness of the plate along the path of the displacement is less than $^1/_4\ \lambda$ in glass. Whenever the difference of thickness is exactly $^1/_4\ \lambda$, the center of the circles passes from brightness to darkness or vice versa.

The area of the surface brought into operation should be diminished in a measure as the inclination of the two surfaces of the plate increases, in order that the differences of the phases due to different thicknesses of the plate may not neutralize the interferential curves. This limitation of the effective surface is obtained by a very narrow aperture in the ocular cap of the lens *L*.

No. 21. Apparatus for demonstrating the connection between diffraction and the image of an object (Figs. 21 and 22).

The apparatus is essentially a horizontal microscope fitted with an objective of very long focus, by means of which objects (viz. gratings) are viewed by transmitted light.

The objective which is composed of two similar achromatic lenses mounted at the ends of tube *M*, has a focal length of about 28 cm and an aperture of about 25 mm. Its foci are situated at *O* and *D* respectively. The object is

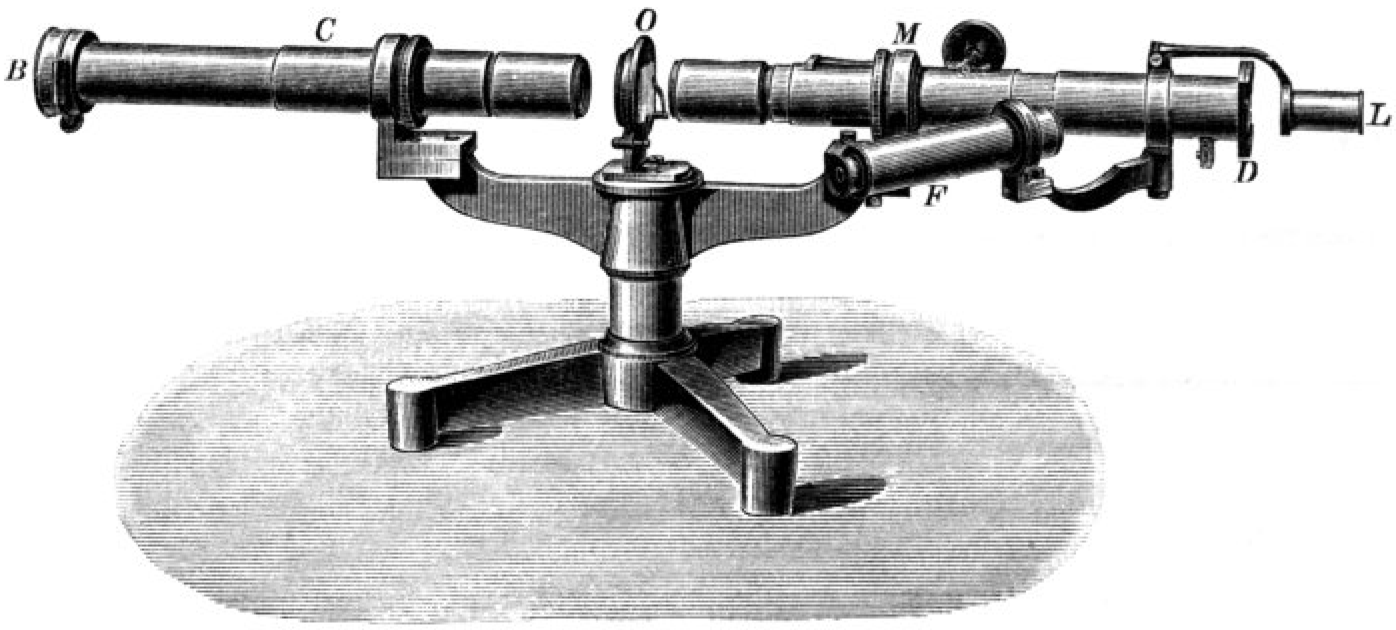


Fig. 21.
Apparatus for demonstrating the connection between diffraction and the image of an object (No 21).
ab. 1/6 Full Size.

placed at *O*. The real image formed at *D* by the objective of the Fraunhofer diffraction phenomena produced by this object, may be viewed by means of a hinged lens *L* and stopped down to any desired degree by means of various devices. The virtual image of the object itself formed by *M* is viewed by means of telescope *F* which is made to take the place of the ocular; for quickly throwing it into and out of action it is mounted upon a pivot.

The object is illuminated by means of a condenser system *C* which for reasons of convenience has a focal length equal to that of *M*. Any bright lamp may be used as an illuminant. In the anterior focal plane *B* an adjustable slit or iris diaphragm may be fixed and by lateral movements of these all the effects of central and oblique illumination may be produced.

The object stage O is made to swivel on a vertical pivot for demonstrating the difference between oblique position of a centrally illuminated object and normal position of an obliquely illuminated object.

A detailed description of the instrument will shortly be published in the "Zeitschrift für Instrumentenkunde", vid. also Dippel, "Das Mikroskop", 2nd ed., Brunswick 1882, p. 144—161.

The apparatus may also be used for objective demonstrations. In this case a lower power ocular should be placed on the telescope and sun light or electric light should be substituted for the lamp.

The apparatus is supplied together with 5 specimens, viz. gratings of various forms reproduced photographically, with the aid of which several particularly characteristic experiments illustrative of the theory of secondary delineation may be made. These experiments are shortly described in the following paragraphs.

The whole apparatus in case fitted with lock M. **400.**—

The most important experiments which may be made with the specimens are:

1st **Specimen**, being a narrow single parallel grating. Place the slit parallel to the direction of the lines and let only the central and one lateral maximum of the first order enter the objective. Let by means of the sliding diaphragms only the central non-diffracted light enter so as to exclude the lateral spectra; then only uniform illumination of the ocular field will be the result; this is the case with this as well as any other specimen. The addition of a lateral spectrum is sufficient to render the structure visible.

If the effective aperture of the objective be reduced to the distance of two adjoining spectra and if the illumination be central and sufficiently narrow, only one spectrum goes to form the image: in this case the ocular field is of uniform brightness. If the slit be displaced until its image reaches the margin of the effective aperture, then the spectrum nearest to the first spectrum also enters the free aperture and the structure again becomes visible (this case illustrates the effect of oblique illumination). The same result is obtained by opening the slit in its central position, until the lateral maxima reach into the aperture from both sides (effect of illumination by wide pencils).

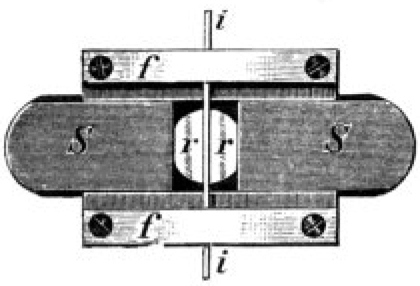


Fig. 22.
½ Full Size.

If the aperture at D of the objective be left undiminished and if only the central (non-diffracted) light be cut off by a cross bar, the distance of the remaining efficient spectra becomes doubled and consequently the image is a grating which is twice as fine as the actual grating.

2nd Specimen. Single reciprocal parallel grating. Ratio of the width of the cross bar to that of the slit in the lower half of the field 1 : 2, in the upper half 2 : 1. The spectrum of the grating which is visible at *D* consists in the principal maximum and several lateral maxima, provided a sufficiently narrow slit be placed at *B* parallel to the lines of the gratings. The 3rd, 6th etc. spectrum on either side of the bar have zero intensity, i. e. do not exist. With respect to the intensity of the remaining lateral spectra it is immaterial which of the two halves of the grating is made to form the image (this alternative may be effected by closing the upper or lower half or the grating by means of a card); only the intensity of the principal maximum (non-diffracted light) varies according to the two halves of the object, being greater in the case of the brighter half. The stoppage of this principal maximum by means of a thin bar or thin needle fixed with wax has the effect of making the images of the upper and lower halves of the object equal, i. e. the effect is that of a single parallel grating (ratio of width of bar to that of slit 2 : 1 with diminished contrast) viewed with the telescope *F*.

3rd Specimen. Reciprocal parallel grating. Ratio of width of slit to that of bar in both halves of the grating = 1 : 1, the upper half being displaced one width of bar with respect to the lower half. Diffraction may be seen at *D*, the same slit being used as before: again we have an achromatic principal maximum and lateral spectroscopically decomposed maxima. The 2nd, 4th spectrum at either side have zero intensity, they are, therefore, invisible. By stopping the non-diffracted principal maximum, a series of spectra remains which are throughout of double the distance as compared with that of the principal maximum and its two adjacent maxima. The image viewed with the telescope represents a grating which is twice as fine as the real object (i. e. as the object seen without the stop). By adjusting with extreme exactness the ratio of the width of the bar to that of the slit in the grating and by carrying out the experiment with extreme care, the width of the lines which are very fine in any case, becomes 0, i. e. the field appears to be uniformly bright within the limits of the grating.

4th Specimen. Gratings crossed at 90°. At *B* replace the slit by a circular diaphragm or an iris diaphragm, and do the same at *D*. Stop all spectra with the exception of the principal maximum. Then all difference of structure will be found to have disappeared from the image viewed by *F*. The iris diaphragm being opened at *D*, the image successively approaches, as in the case of specimens 1, 2, 3, in appearance that of the merely geometrically magnified object. If all the spectra be stopped with the exception of a series of spectra which may be vertical or horizontal or inclined at 45°, the effect produced is that of a single parallel grating of striae which are horizontal, vertical or inclined at 45°. By stopping the principal maximum, only the ratio of the intensities of the field become reversed (dark becomes bright, bright becomes dark).

5th Specimen. Grating crossed at 60°. Adjust iris diaphragms at *B* and *D* as previously. Place diaphragm *B* central and admit only the first series of diffraction spectra surrounding the principal maximum. Then the image at *D* will be similar to that formed by microscopes of high aperture in the case of Pleurosigma angulatum. Admit partially or wholly the 6 diffraction spectra; the image will then have a changed appearance; this proves the analogy of Pleuros. ang. viewed with dry and immersion systems. Limit diffraction to single series or spectra grouped at different angles; the image will exhibit striation in a direction at right angles to the series of the diffraction spectra as under 4.

Beside these 5 specimens, the following two **accessories** will be found useful for demonstrating the manner in which variation of phases and rotation of the direction of undulation in the diffraction spectrum affects the image.

Glass wedge compensator. 2 similar glass wedges of small angularity are cemented together so as to have their horizontal refracting edge on opposite sides, thus forming a plano-parallel plate. One half (right) of one of these wedges is detached and may be moved from top to bottom by means of a micrometer screw. This half of the compound plate is capable of undergoing variation of thickness and retarding power. Use specimens 1, 2, 3, set the slit narrow at *B*, admit at *B* only two spectra, blocking out the principal maximum. Adjust the compensator at *D* so as to cause one spectrum to pass through one half, the other spectrum through the other half of the compensator before reaching *F*.

In the middle or zero position of the right wedge there will be uniform retardation of both spectra; the image will, therefore, appear unchanged as when viewed without compensator. If now the wedge be moved, the striae in the image wander towards one or the other side. By increasing the amount of the displacement of the wedge and by using white light, the structure may be ultimately made to disappear in either direction of the displacement. If monochromatic light be used, the effective difference of retardation is unlimited.

Price of the compensator **M. 40.—**

Double quartz plates: a) 2.1 mm, b) 4.2 mm thickness, for placing before *D* in lieu of the compensator. In other respects the experimental arrangement is the same as before. Monochromatic illumination (sodium light). If a) be used, the plane of polarization of one of the spectra undergoes a rotation of 45° in one direction, that of the other in the opposite direction to the same amount, the result being that both lose their power of giving rise to interference, no structure being therefore visible at *F*. If b) be used one of the quartzes rotates the plane of polarization of one of the spectra through 90° in one direction, the other quartz that of the other spectra through the same angle in the other direction, the result being that the directions of polarization become again coincident, there being only a difference of phase of half a wave length. Image at *F* the same as without quartz plate but laterally displaced as far as half the width of one of the striæ.

Price of each mounted double quartz plate **M. 22.—**

Hermann Pohle, Hofbuchdruckerei, Jena. — 1135

CARL ZEISS

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JENA.

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1902.

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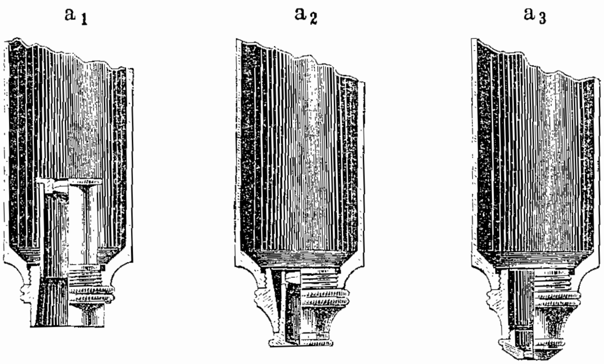


Fig. 5. Objective a 1, a 2, a 3, verbunden mit dem Tubus.

(1/2 natürl. Grösse.)

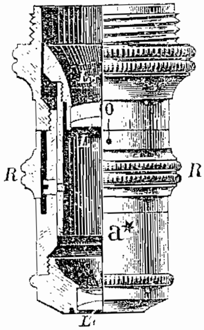


Fig. 6. Objectiv a*.

Durch Drehen des Ringes *RR* kann das obere Linsenpaar (L_2) in die gestrichelt angedeutete Lage (L_2') gehoben werden.

(Natürl. Grösse.)

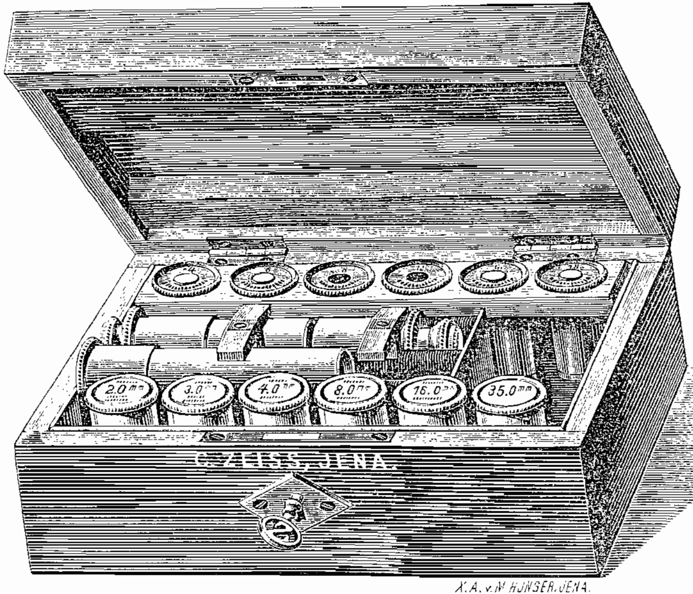


Fig. 7.

Mahagoni-Kästchen für Objective und Oculare.

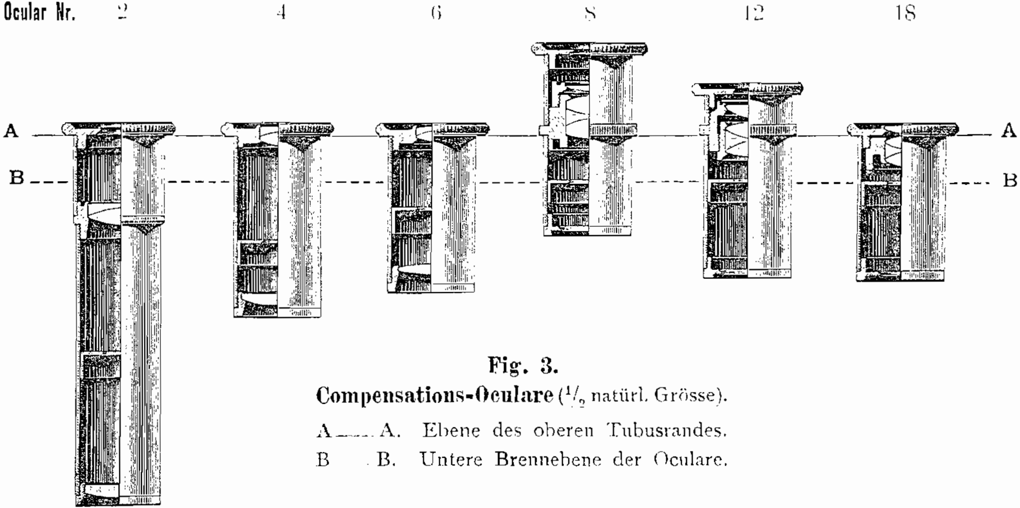


Fig. 3.

Compensations-Oculare (1/2 natürl. Grösse).

A——A. Ebene des oberen Tubusrandes.

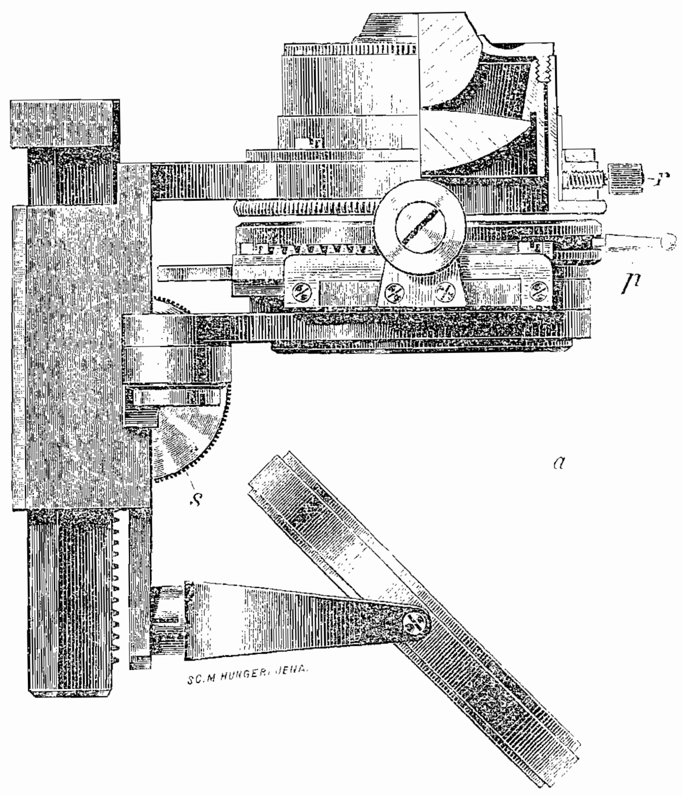
B – – B. Untere Brennebene der Oculare.

Verzeichniss der Achromate.

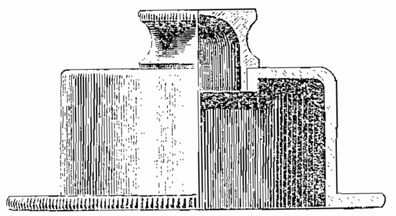
	Bezeichnung	Aequivalent-Brennweite in mm	Numerische Apertur	In Verbindung mit HUYGENS'schem Ocular 2 bei 160 mm Tubuslänge: Freier Objectabstand in mm	Objectives Sehfeld, Durchm. in mm	Preise ohne Correctionsfassung Mark	Preise mit Correctionsfassung Mark	Telegrammworte
Trocken-Systeme	a_0	45	—	32	14	12.—		Pajeria
	a_1	39	—	20	11	12.—		Pajillo
	a_2	37	—	30	8	12.—		Pajonal
	a_3	28	—	33	4.5	12.—		Pajuncio
	a*	43—29	—	13—53	10—25	40.—		Pajuela
	aa	26	0.17	14	4	27.—		Palabra
	A	15	0.20	9	2	24.—		Palacial
	AA	17	0.30	7.5	2.5	30.—		Palacio
	B	12	0.35	3	1.5	30.—		Paladar
	C	7	0.40	1.8	0.9	36.—		Paladino
	D	4.2	0.65	0.6	0.5	42.—		Palamallo
	DD	4.3	0.85	0.4	0.5	54.—	74.— Palamenta	Palanca
	E	2.8	0.90	0.25	0.35	66.—	86.— Palampora	Palangana
	F	1.8	0.90	0.17	0.23	84.—	104.— Palatal	Palastro
Wasser-Immersionen	Pl Planktonsucher	25	0.11	36	4	20.—		Paleceer
	D*	4.4	0.75	1.5	0.55	75.—		Palente
	H	2.5	1.18	0.2	0.32	110.—	130.— Palatina	Paletada
	J	1.8	1.18	0.2	0.23	144.—	164.— Paleton	Paletero
Homogene Immersion	1/12"	1.8	1.30	0.15	0.25	160.—		Paliador

Wegen der Bedeutung der Ausdrücke „freier Objectabstand" und „objectives Sehfeld" vergl. S. 10.

Betreffs der zu dem System homogener Immersion gehörenden Immersionsflüssigkeit vergl. S. 5.



a



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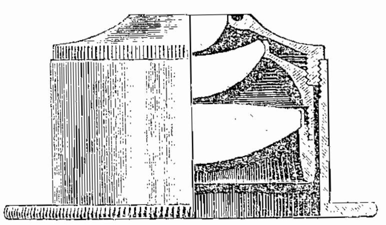
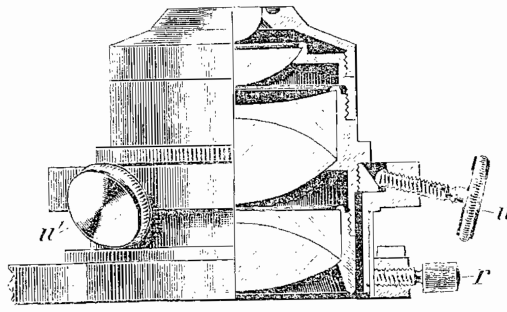
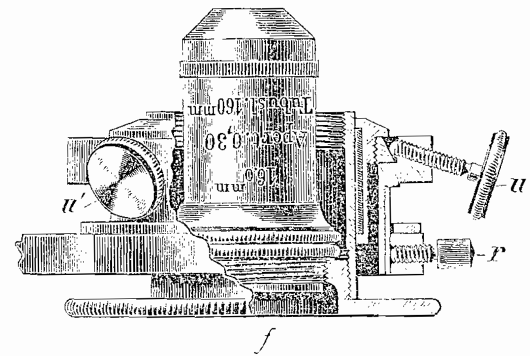


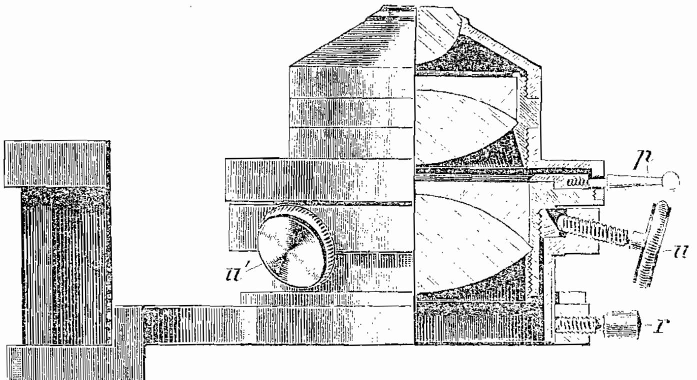
b



e



f

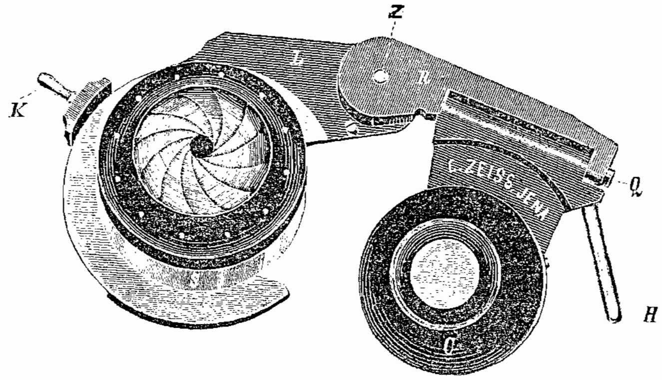


d

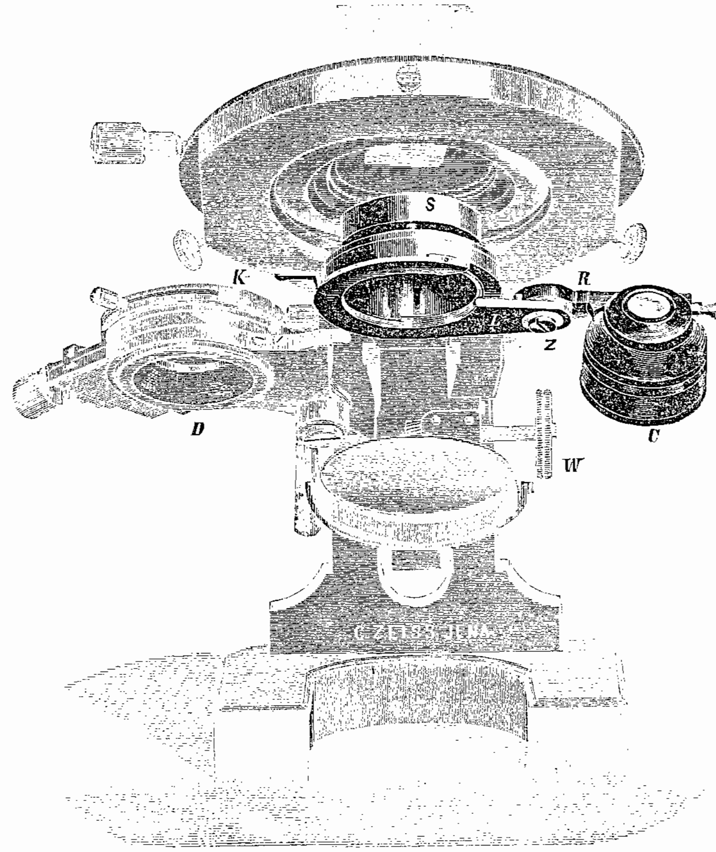
Fig. 11.

ABBE'scher Beleuchtungsapparat nebst der Cylinderblende, verschiedenen Condensoren und der Centrirvorrichtung für Objective.

r: Schraube zum Festklemmen der Condensoren in der Schiebhülse; *p*: Knopf der Irisblende; *u* und *u'*: Centrirschrauben; *s*: Trieb zum Heben und Senken des Beleuchtungsapparats.



A



B

Fig. 12. Ausklappbarer Condensor.

A: aus der Schiebhülse des Beleuchtungsapparats herausgenommen: B: in Verbindung mit dem Beleuchtungsapparat und dem Mikroskop. In beiden Figuren ist das Condensorsystem herausgeklappt und zur Seite geschlagen.

(A.: $^3/_4$, B.: $^1/_2$ natürl. Grösse.)

Wir fertigen vier verschiedene Apparate dieser Art an; es sind dies:

1. ***Grosser Kreuztisch** No. **44**, Fig. 16. Der Spielraum für die Bewegungen bei diesem Tische beträgt in der einen Richtung 50 mm, in der anderen 35 mm; die Verschiebungen lassen sich in beiden Richtungen mittels Nonien an Scalen ablesen. (Vergl. Zeitschr. f. wiss. Mikrosk. XI, 301—304, 1894.) Neuerdings wird an diesem Tische noch eine **dritte Scala nebst Nonius** angebracht, um die Stellung des verschiebbaren Anschlages, an den der Objectträger angedrückt wird, ablesen zu können. Diese Einrichtung ermöglicht, den Apparat bequem als **„Finder“** zu verwenden; ausserdem wird dadurch die Centrirung des Tisches mit Hilfe des beigegebenen **Centrirglases**, eines **Objectträgers mit Strichkreuz**, erleichtert. (Vergl. Gebrauchsanweisung.)

Preis: Mk. 100.—. Telegrammwort: **Paranza.**

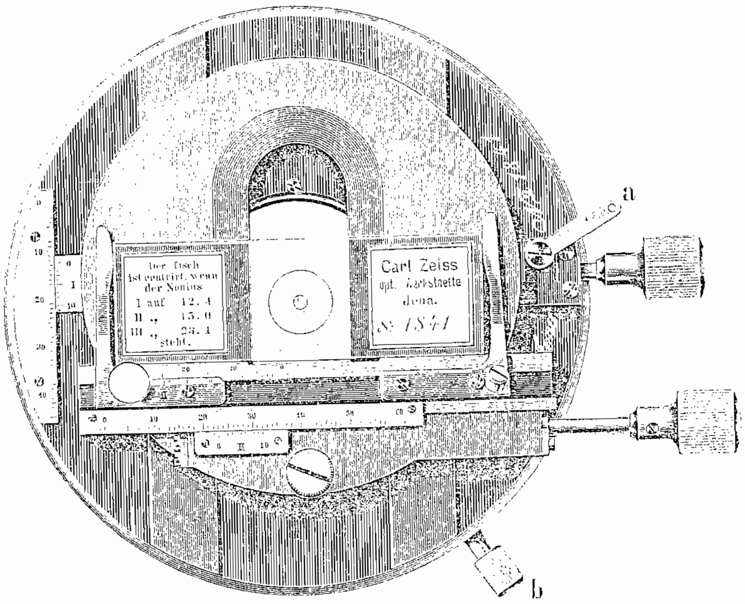


Fig. 16. Grosser Kreuztisch No. 44.
a: Bügel zum Festklemmen des unteren Schlittens. *b:* Klemmschraube für die Arretirung der Drehbewegung.

Der grosse Kreuztisch lässt sich in Verbindung mit einer Centrirvorrichtung an den Stativen Ia und Ic anbringen. Er kann an diesen Stativen ohne Weiteres gegen einen drehbaren Hartgummitisch, No. 45, ausgewechselt werden.

Preis des Hartgummitisches No. **45**: *Mk. 25.—.* Telegrammwort: **Parar.**

An dem Stativ Ib kann der grosse Kreuztisch ebenfalls angebracht werden, er wird aber an diesem Stativ nicht mit Centrirvorrichtung versehen und lässt sich deshalb nicht gegen den Hartgummitisch auswechseln.

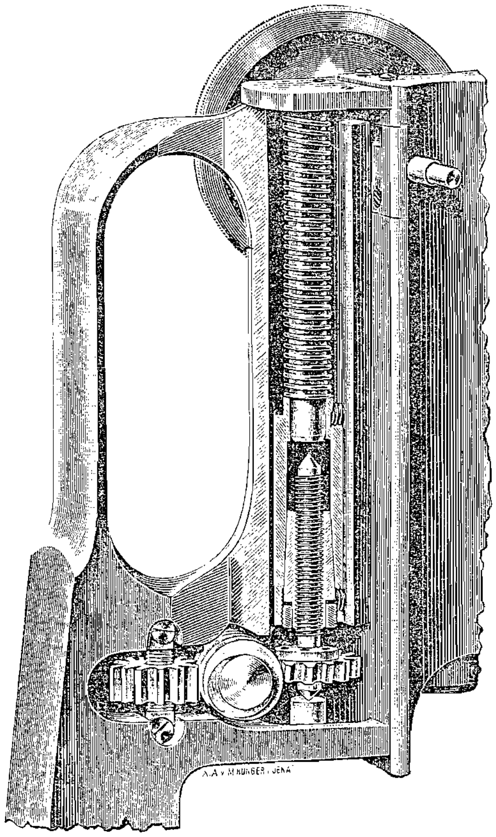


Fig. 19.

Mechanismus der Mikrometerbewegung nach M. Berger.

(Natürl. Grösse.)

Eine ausführliche Beschreibung dieser neuen Form der Mikrometerbewegung und der damit im engsten Zusammenhange stehenden weiteren Aenderungen des Stativ-Obertheiles wurde von ihrem Urheber, Herrn Max Berger, dem Vorsteher unseres Constructionsbureaus, in der Zeitschrift für Instrumentenkunde (XVIII, 129—133, 1898) gegeben. Wegen Einzelheiten der Construction müssen wir auf diese Mittheilung verweisen.

Die **wesentlichsten Vortheile,** die diese Form des Obertheiles gegenüber der älteren bietet, sind folgende:

1. Die **Ausladung des Tubus,** d. h. der Abstand der Tubusachse von der das Obertheil tragenden Säule, ist so gross, dass Objecte von einem Durchmesser bis zu 150 mm auf dem Tische des Mikroskops Platz finden und vollständig durchsucht werden können. Diese Ausladung kann sogar noch bedeutend grösser gewählt werden. Wir haben von dieser Möglichkeit auch bereits Gebrauch gemacht, indem wir ein **Stativ für Gehirnschnitte, Stativ I^{d}** (Fig. 25, S. 57) construirten, dessen Objecttisch gestattet, Präparate zu durchsuchen, die bis zu 250 mm Durchmesser besitzen.

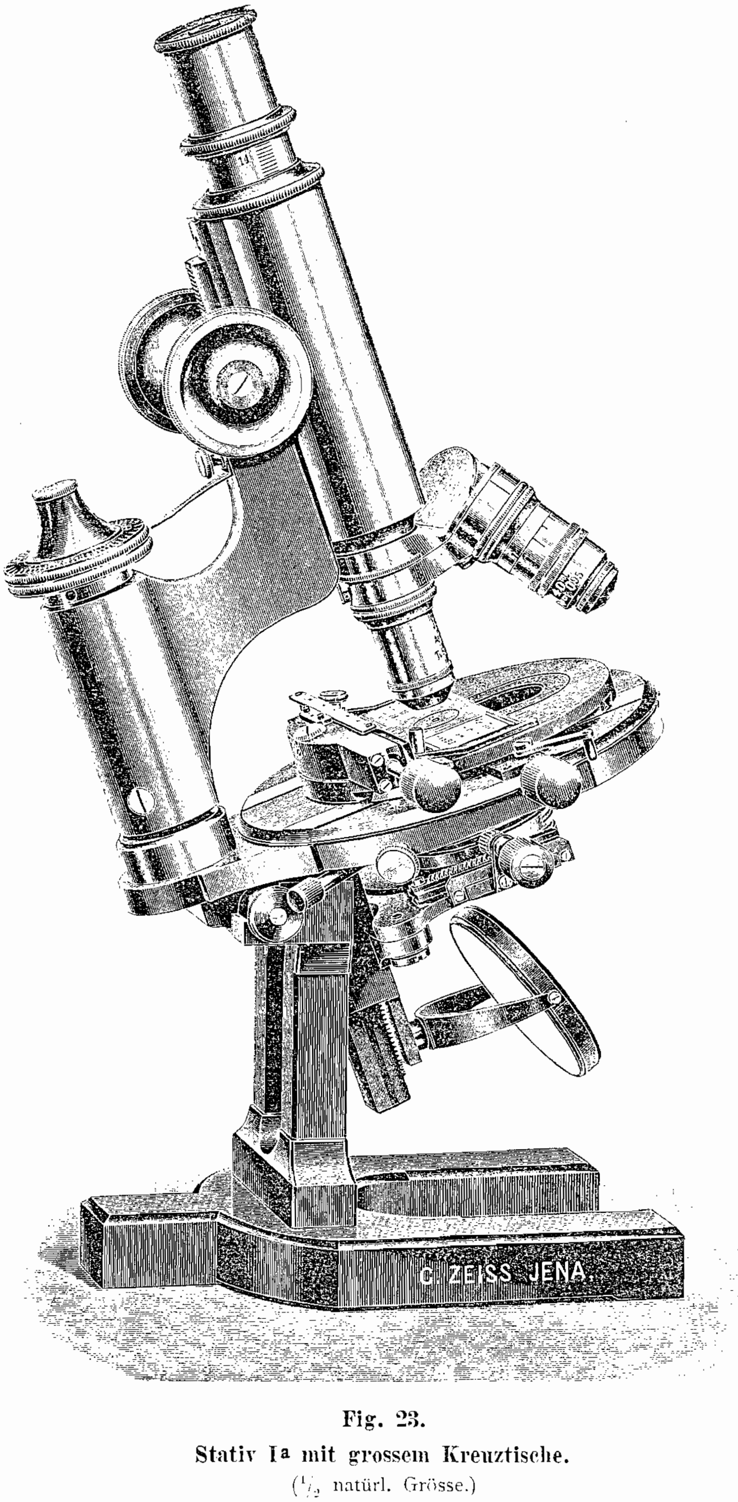


Fig. 23.
Stativ Ia mit grossem Kreuztische.
($^1/_2$ natürl. Grösse.)

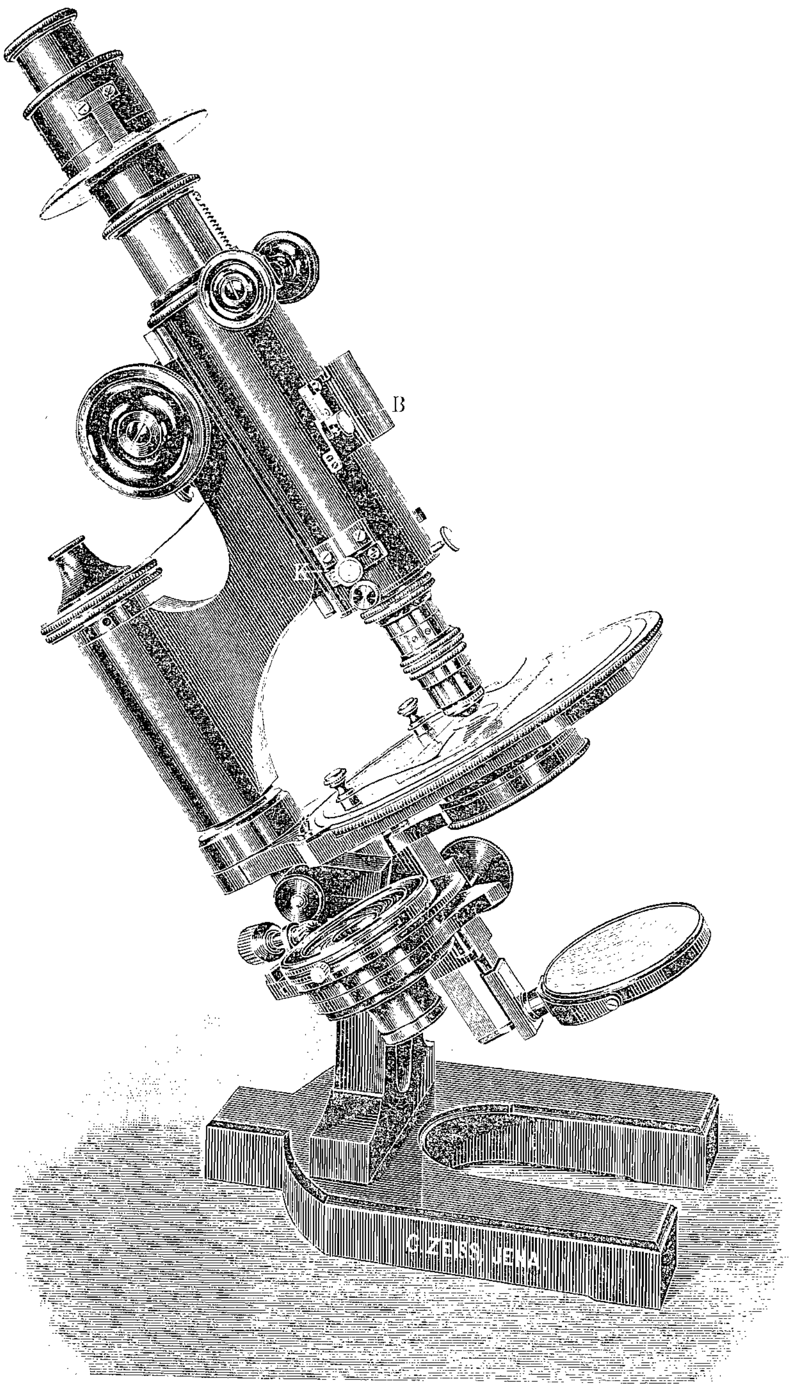


Fig. 24.
Statif Ib (grosses Statif für Mineralogie).
($^1/_2$ natürl. Grösse.)

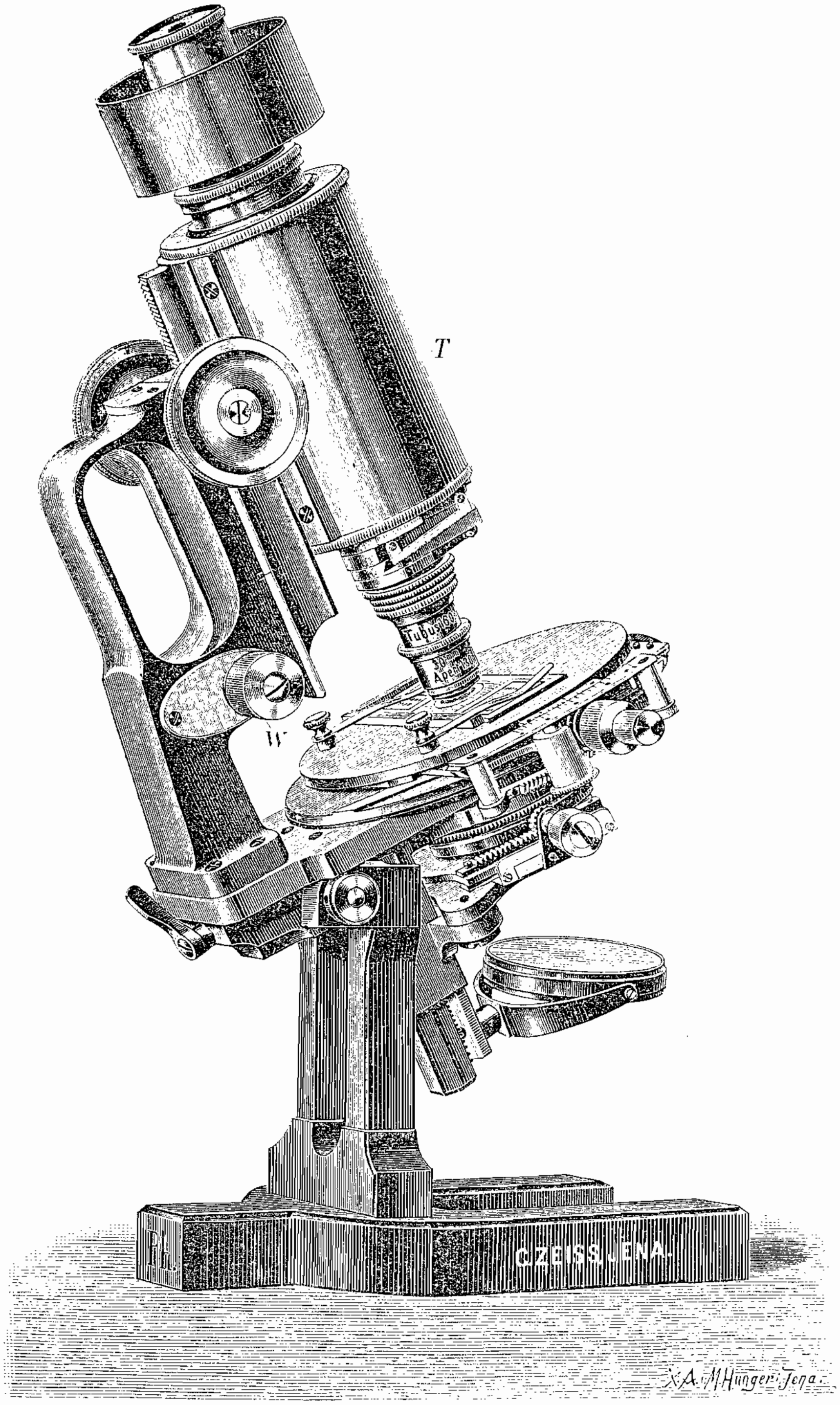


Fig. 25.

Statiy Ic mit mikrophotographischem Tische (Stativ für Mikrophotographie und Projection).

($^1/_2$ natürl. Grösse.)

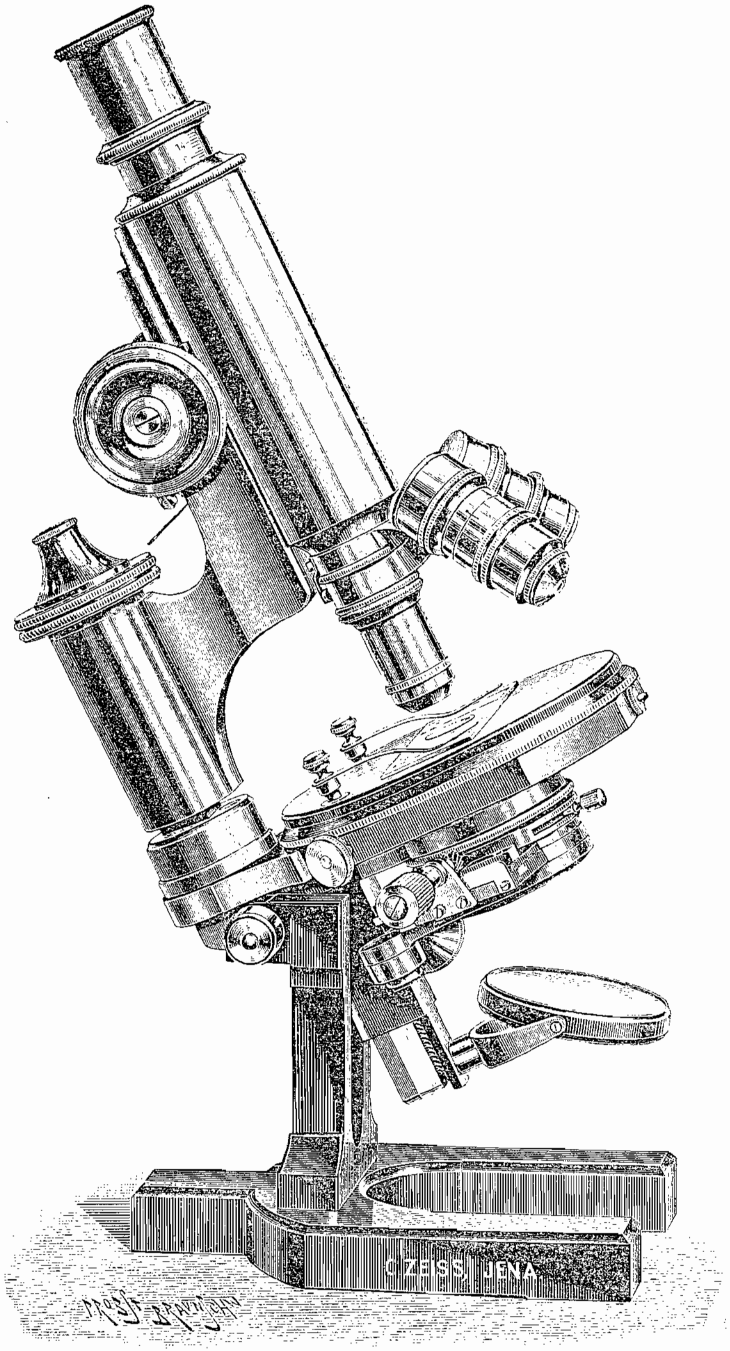


Fig. 27.
Stativ IIa.
(1/2 natürl. Grösse.)

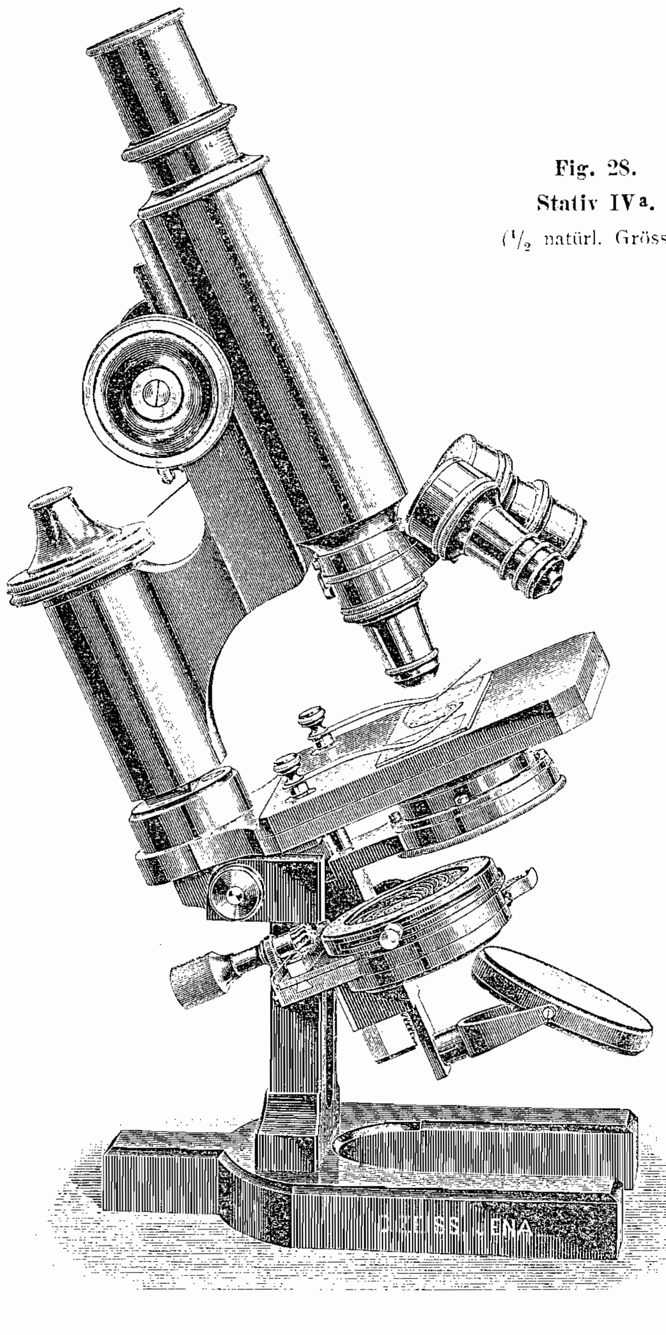


Fig. 28.
Stativ IV a.
($^1/_2$ natürl. Grösse.)

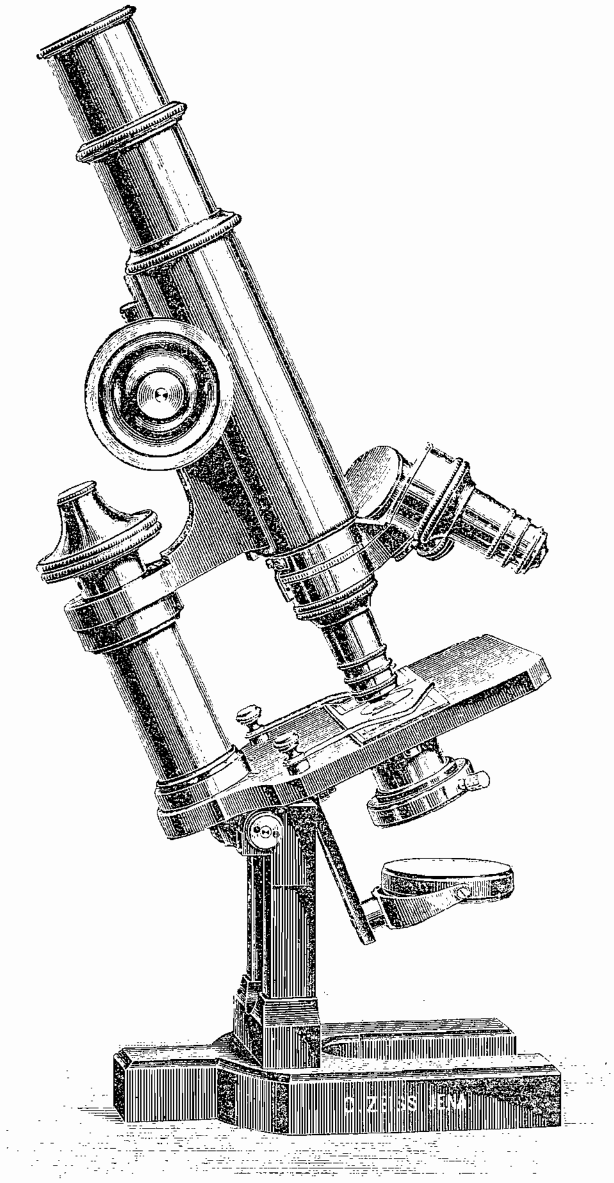


Fig. 29. Stativ VI^a.

($^1/_2$ natürl. Grösse.)

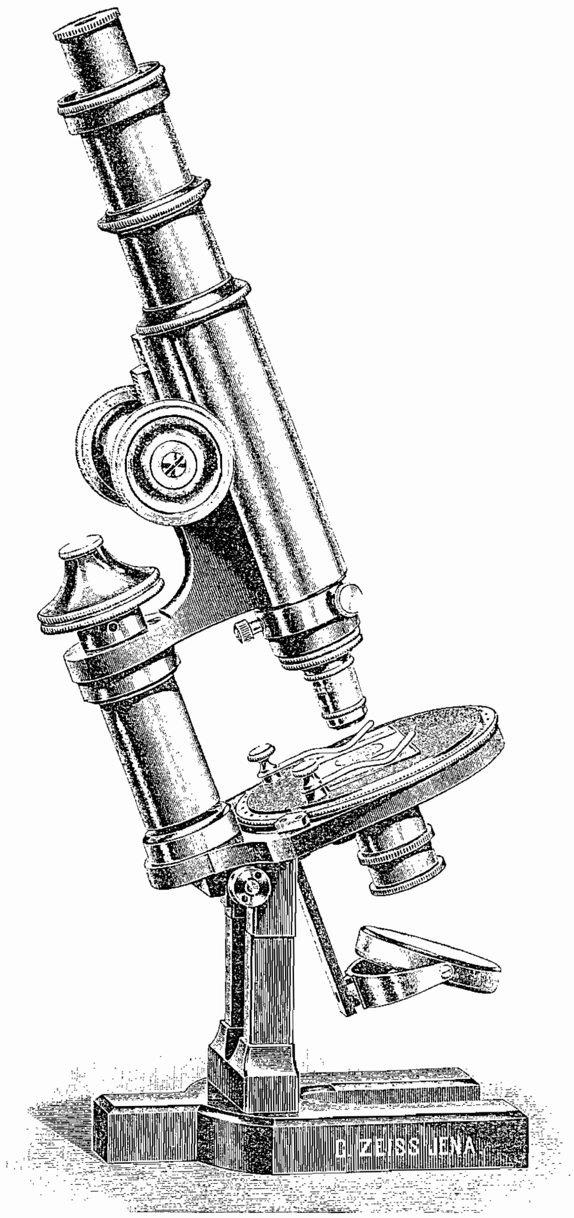


Fig. 30.
Stativ VI^{b} mit Polarisationseinrichtung No. 174.
($^{1}/_{2}$ natürl. Grösse.)

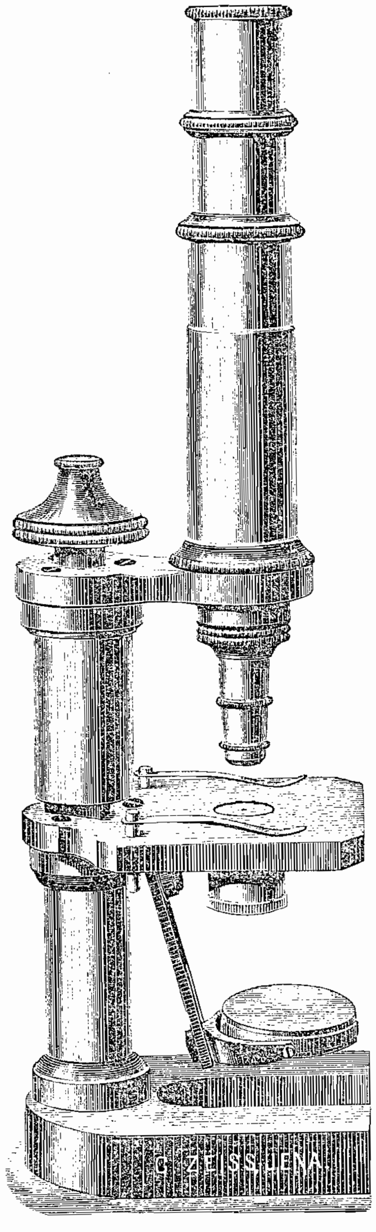


Fig. 31. Stativ VII.

($^1/_2$ natürl. Grösse.)

Auch für die übrigen Stative (mit Ausnahme des Präparirstativs **P V** und der Lupenstative) liefern wir geeignete Schränke, theils aus Mahagoni, theils auch aus anderem Holze.

In den Preisen für die Stative sind stets die Schränke und Kästen mit einbegriffen.

Wir geben jedoch auch die Mikroskopstative **VI**, **VII**, **IX** bei Bestellung einer grösseren Anzahl ohne Mahagonibehälter ab. Die Stative werden dann zusammen in einer grösseren Kiste verpackt. Die Preise dieser Stative erfahren dadurch eine Ermässigung um 15—30 Mk., je nach Art der Verpackung.

Lederkoffer zum Schutze der Mahagonischränke für die Reise werden in verschiedener Grösse von uns angefertigt. Fig. 45.

Preise für die Lederkoffer je nach Grösse Mk. 18.— bis Mk. 30—.

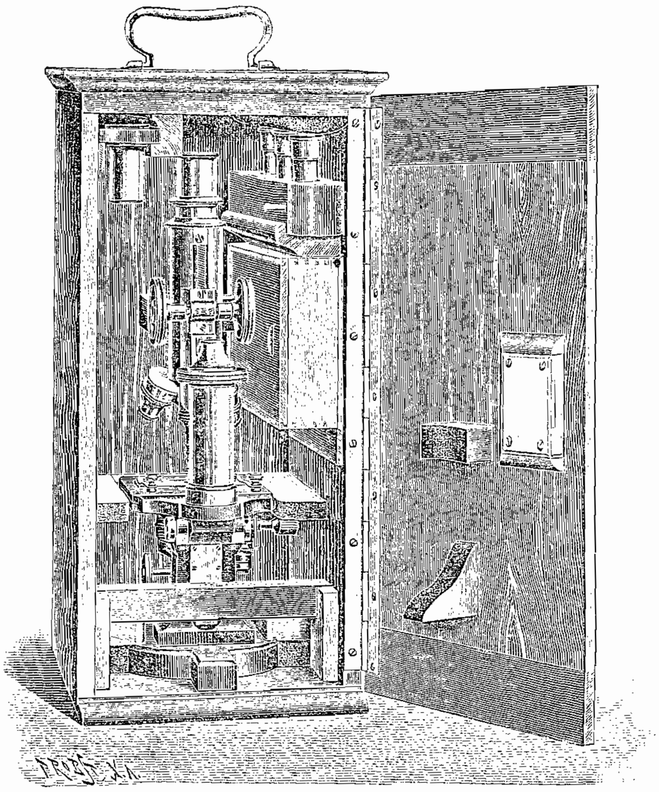


Fig. 44. Stativ IV a im Schranke stehend.

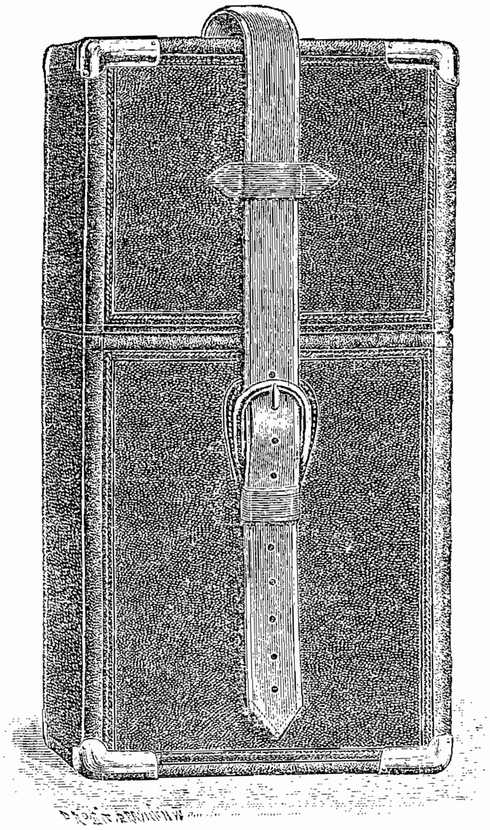


Fig. 45. Lederkoffer für den Stativschrank.

Auf Wunsch besorgen wir auch die **Gravirung eines Namens** auf den Fuss der Stative.

Preis dieser Gravirung: Mk. 3.—. Telegrammwort: **Patriota.**

Für die Mahagonikästen liefern wir vernickelte **Metallschilder mit Namengravirung.**

Preis eines Metallschildes mit Gravirung: Mk. 5.—. Telegrammwort: **Patricio.**