HSG

Who was Horatio Saltonstall Greenough?
Part 5

Berndt-Joachim Lau (Germany) **R. Jordan Kreindler (USA)**

25. His Struggle for Orthomorphic Concept

Three years after the receipt of the stereomicroscope prototype and shortly before launching its commercial version, HSG looked on and on for arguments on the importance of the orthomorphic vision by the double-tube microscope.

On March 20, 1897 [BACZ 1579, no No.] HSG relied in questionable manner on his sculptor friend:

"P.S. Mr. Paul W. Bartlett, Chevalier de la Legion d'Honneur, one of the leading sculptors in Paris and a most accurate modeler, informs me that he has frequently modeled purely from memory and I can testify from observation that work so done is good. He tells me moreover that in working from a front view the profile aspect presents itself spontaneously to the mind and is found on trial to be fairly correct: this last statement shows conclusively that "Orthomorphic Vision" is used in the study of solid shape."

Figure 82 Statue of General Lafayette by Paul W. Bartlett in 1908 (Postcard by Conrard, Metz).

Paul Wayland Bartlett (1865-1925) was born in New Haven, Connecticut, and in 1880 he began to live in Paris and to study modelling – his course of life seems similarly this of the 20 years older HSG. He was familiar also with the heroic subject of the Frenchman Marquis de La Fayette (1757-1834) in the American War of Independence (1775-1783). The following cutline states this [Forbes, 1925]:

"Bust of Lafayette in the Senate Room in the State House, Boston, presented in 1898 by Horatio S. Greenough to Governor Wolcott. It was offered to the State by Augustus P. Loring in behalf of the donor. Mr. Greenough's father was the sculptor."

In beginning of 1897 May, Dr. Siegfried Czapski visited Paris and brought along a pre-series stereomicroscope to HSG. He elaborated immediately two detailed letters both dated of May 11. Among other things HSG assessed the performance of the new Zeiss instrument and wrote in his first letter [BACZ 1579, 15]:

"P.S. For dissecting it will often be preferable to use the instrument without the electric light & also for various preliminary manipulations, such as making the capillary-tube preparations. For studying the real shape of solid objects I cannot too strongly urge the necessity of employing the electric light together with the very smallest pairs of stops provided – it is only under these conditions that the instrument manifests its specific and distinctive character – Orthomorphy – when so used the general shape of the object under examination is well seen and with a good average definition: it must however be born in mind that the full defining power of the instrument is only to be had by removing the stops, using with full aperture & focusing to different depths; under these conditions a stereoscopic effect is still had but the instrument no longer merits its name of Orthomorphic Microscope."

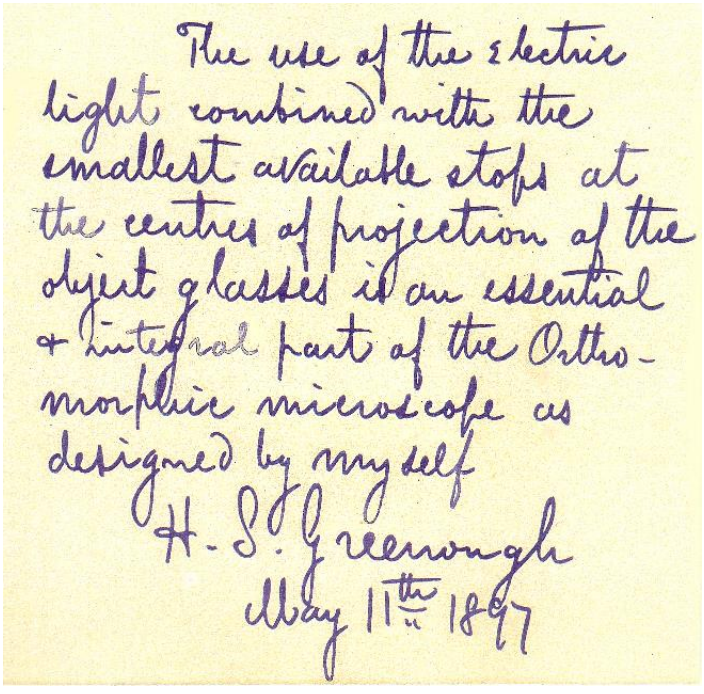
The use of the electric light combined with the smallest available stops at the centres of projection of the object glasses is an essential & integral part of the Orthomorphic microscope as designed by myself
H. S. Greenough
May 11th 1897

Figure 83 HSG's Summery [BACZ 1579, 17].

The stops or better named conical diaphragms may be added to both objectives in interest to provide the correct ray entrances according HSG's formula. A 21X magnification requires an entrance base of only 3 mm but the a_2 achromats get a larger front diameter (See Part 4/19+20). These both objectives work well due to their long working distance resulting in a larger distance of optical axes at the front lens position - but there the orthomorphic rule is not fulfilled. The light loss due to the tiny stop openings necessitates the electrical lightening.

The second letter includes HSG's new focusing idea by a foot pedal and his known orthomorphic requests which would have overturned the nearly completed Carl Zeiss product development [BACZ 1579, 18-20]:

"Dear Dr. Czapski

To be available for accurate modelling the present Orthomorphic Microscope must undergo some modifications of construction.
1st for each magnification employed the position of the centres of projection of the object glasses must be a fixed one on each of the optic axes, satisfying of course equation (1) so that different degrees of stopping whilst altering the depth of focus shall leave Orthomorphy intact for such depth as exists – This condition is quite indispensable because without we shall have distortion of detail.

For the study of the general shape obliteration of fine detail is appositive advantage & is always taught for in practice by sculptors – so that lack of fine definition when using the smallest stops is a higher perfection and not a defect in the instrument: but the finer details should in many cases be subsequently and accurately studied: now in as much as it is necessary for this purpose to employ the full aperture of the instrument it becomes obvious that Orthomorphy must be unchanged by variation of stopping.

The next condition though not I think quite as important as the foregoing be exceedingly useful to compensate for the fixedness of the Optic axes and consequent fixedness of focal planes – focusing should be capable of being done rapidly & safely by foot pedal and also the substage should be capable of two simultaneous rectangular movements; so that by operating with one foot & both hands the different parts of the object may be brought in rapid succession in the near neighbourhood [sic] of the intersection of the optic axes. – Of course [sic] any other device that would accomplish the above result would be efficacious and the simpler the better.

Now I do not ask you to undertake the above work for me but knowing that Professor Dr. Whitman wished to make the systematic production of accurate models an important feature in his laboratory & also that your house does not look exclusively to the commercial aspect of things; I have thought it worthwhile to call your attention to the above and to request that you will give it careful consideration.

With kind regards to Professor Dr. Abbe believe me always.
Very sincerely yours.
Horatio S. Greenough

P.S. Should you be able to construct an Orthomorphic Microscope satisfying the conditions above set forth & with straight tubes so as to produce the virtual dilatation "in situ". Such instrument would be "in potentia" (*from Latin for potentially*, the authors) a visible and tangeble [sic] demonstration of the method of mathematical investigation upon which I have been engaged as I told you for some twenty odd years – and I venture to hope that because of the scientific interest of the subject you may yet see your way to carry out my design integrally & to find time to do it.

Horatio S. Greenough

May 12th 1897

Show this to Professor Dr. Abbe"

The mentioned "present Orthomorphic Microscope" was the No. 28063 pre-series stereomicroscope listed "Prof. Greenough, Paris / m. Prismen - Capillar Rotator" at Jena's dispatch book in 1897 May 8 [BACZ 7712, 72]. The Figure 96 will show its probable design corresponding to the first publication [Czapski,1897].

Dr. Czapski wrote a conciliatory reply on July 10 [BACZ 1579, 23-24, 21] but also explained the non-practicable conical diaphragms in cases of considerably differing objective magnifications by three figures which do not come down:

"Dear Sir

I only found time today to answer the letters which you have handed me at Paris and those which you sent me after I had left the city. Since then I have been extremely busy with extraordinary work and I hope therefore that you will excuse my long silence.

Now I am happy to inform you, that the improvement of the microscope, in the sense suggested by you, is making good progress, we had some difficulties in finding suitable rheostat, but we have now purchased some.

The application of stops for those objectives, which are now to be provided with the microscope offers no difficulties but for objectives considerably less or considerably more powerful the application of stops is impossible or at least connected with considerable disadvantages ...

The alterations designed by you in the prism rotator are being made, we are doing this with a specimen we have here, and would ask you to send us yours, when we shall have sent you the one altered. We also hope to procure lamps of this kind desired by you...

Yours faithfully

S. Czapski

f Carl Zeiss

I am leaving Jena on Thursday for a month. All letters attended to the firm will reach and will be sent to me in the shortest favorable time."

An electrical microscope illuminator was not yet state-of-art at that time. HSG was ahead of the times with such a request and especially with his serviceable idea of the remote control of the mechanical focus adjustment. One year later an arrangement inclusive of a gas burner will be offered for the first time as artificial microscope illumination [Zeiss, 1898].

The 1902 catalogue will show a small incandescent lamp used into a spot illuminator by which the Binocular Corneal Microscope [Zeiss, 1902] is equipped. Its monocular predecessor designed by Dr. Czapski owned however already an electrical illuminator [Schanz, 1893].

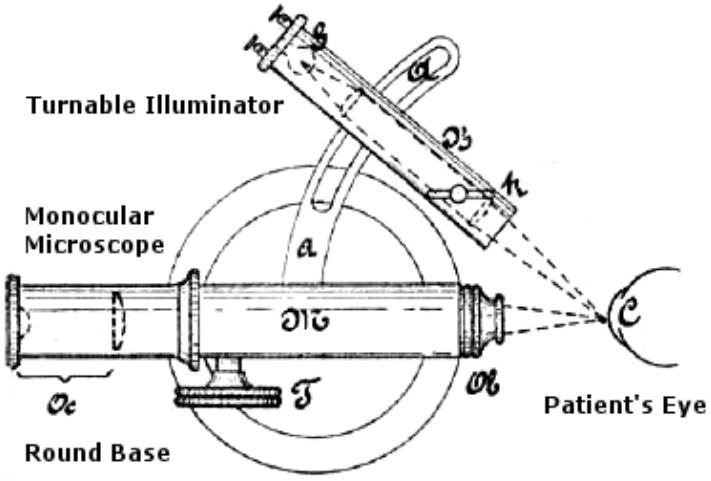

Figure 84 Monocular Corneal Microscope Seen from Above [Schanz, 1893] and Commented by the Authors.

In 1898 July 11, HSG will send a paper sheet headed by a Place de la Concorde Signet and imprinted by Neal's Reading Rooms. He will ask whether a special working desk including batteries could be designed and when the Carl Zeiss Catalogue will be published on the stereomicroscope [BACZ 1579, 91]. Dr. Czapski will reply by a typewritten German draft on July 15 [BACZ 1579, 89-90]:

"As for the table for use with the new microscope, we would highly recommend that you have the same made there. Apart from the fact that such large pieces are not insignificantly expensive due to transport, it would also be relatively difficult to agree on the details in writing, especially since we are not an electro-technical, but only a mechanical-optical establishment. We therefore believe that you will best obtain what you require from an electro-technical firm there ... We ask you not to interpret the rejection of your request as a lack of good will, but out of an effort to recommend to you what is most practical for you ... We are already busy publishing our new catalogue. The German and English editions will be published almost simultaneously around mid-September. If you are interested, we will send you the correction sheet describing your microscopes for inspection."

On July 18 HSG will accept the rejection and postpone the special table to the electrification of laboratory and it shall be made in Paris [BACZ 1579, 92-93].

26. His Lecture on Fribourg's Catholic Congress

The already mentioned letter of 1897, May 14 [BACZ 1579, 13] included also HSG's request to Dr. Czapski for supporting of a congress demonstration:

"If you can adjust the stops especially the smallest available pair at distance of 3 mm & test for orthomorphy with the electric light in time for the Fribourg congress I should be much pleased to have you do so – if not there is no occasion for immediate hurry – but I should like to have the Orthomorphy of the instrument well & practically demonstrated at Fribourg if possible. Also I should be very glad to have the improved prism put into the prism rotating apparatus if it can be done in time for the same congress…"

On July 17 [BACZ 1579, 26] the instrument shipment was ordered up to August 10 by a post card but on August 11 [BACZ 1579, 34] a letter sent to Fribourg stated that the "desired object glasses and prism rotating apparatus are not ready yet." On August 12 HSG expected to leave Paris to Fribourg, Switzerland [BACZ 1579, 33]. We will see in following that the missed instruments were not the cause for HSG's previous change the lecture subject.

On July 31 [BACZ 1579, 29] HSG requested a copy of his own manuscript (of 1897, Feb. 24, see Part 4 end) from the Carl Zeiss Company and revoked this wish four days later [BACZ 1579, 31] when the manuscript was already outgoing:

"I have decided to substitute therefore a brief note in which there is no question of technical Construction, In as much as the new microscope is not yet on the market & as your special catalogue is not yet published, I deem the above course fairer to yourselves; and moreover I very much prefer it, because since Dr. Czapski's visit in May last I have wished more & more to leave entirely with yourselves the full & entire responsibility for the mode of construction of the present instrument.

I say this with all deference but there is a decided difference of opinion between us upon this point & therefore it is very much better that I should say nothing bearing on technical method of construction."

"Congres Scientifique International des Catholiques" is hold in 1897, August 16 to 20. The Very Rev. Father Osmund Cooke (1857-1901), Superior of the Passionists in Paris, serves as Secretary-General of this congress and had won HSG over as a speaker (See also Part 4/21). Some parish members of the St. Joseph's Church read papers on natural science at the Fourth Catholic Congress:

Mr. Greenough (Paris)	"The Orthomorphic Microscope",
Mr. K. S. Smith (Paris)	"Modern Photography",
Dr. Bull (Paris)	"The Science of Vision" [Tablet, 1897].

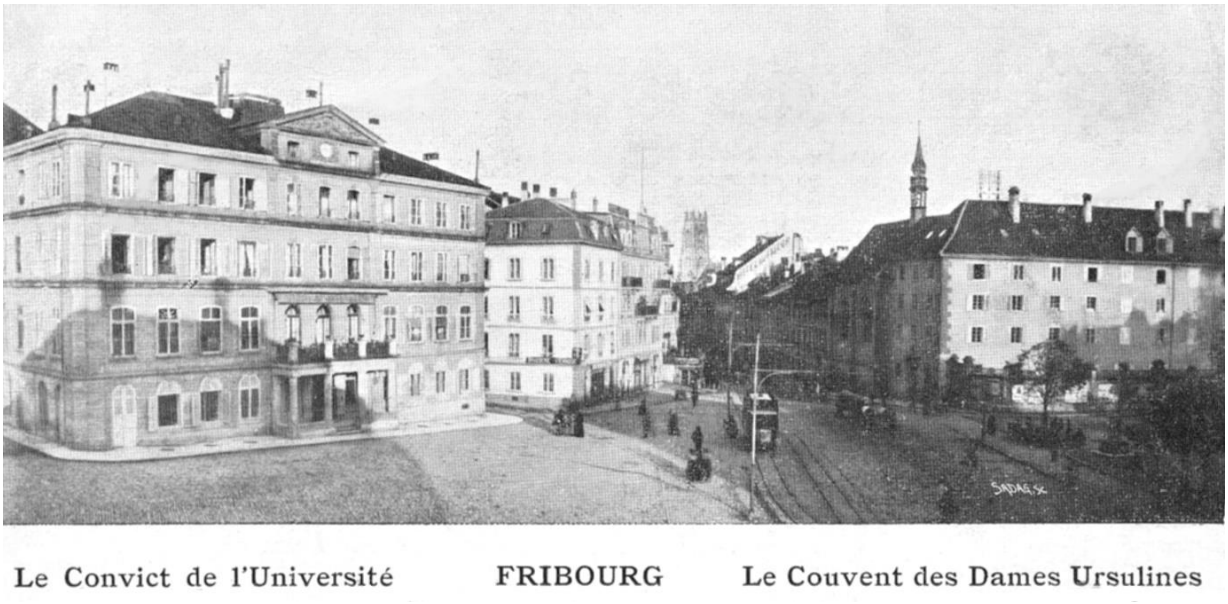

Figure 85 Catholic Convict at a Former Hotel in the 1890th (Postcard 33 Librairie Josué Labastrou à Fribourg).

HSG repeated his own requests on the microscope and added ones on its marketing written from Hotel Terminus, Fribourg on August 21 [BACZ 1579, 36-37]:

"…I will now say a few words concerning more especially the commercial aspect of the new microscope – In my opinion it is expedient that it should be placed on the market as soon as practicable, but in your forthcoming Catalogue I would most strongly recommended that the attention of the Scientific public be called to the fact that Orthomorphy is only had when using the instrument with the smallest pair of conical stops provided – and with the object lighted by the electric lamps provided for the purpose – and would further recommend that test objects e.g. small spheres & cubes be provided for convenience of purchasers - For many purposed Orthomorphy is not needed and the instrument can then be used with full aperture & this also should be noted in a conspicuous manner in the new Catalogue .

Lastly I would earnestly request you to state that my design contemplates the satisfaction of the equation A/a=D. – 1st by the use of objectives whose nodal points do themselves satisfice the equation so that the geometrical centres of projection shall occupy a fixed position on the Optic axis for each value of D. – 2d erection of the real image by second pair of objectives – 3d straight tubes – so that the virtual dilatation takes place in situ.

Adding that for technical reasons you have deemed it expedient to adopt the mode of construction actually in use.

I sincerely hope you will agree to the making of all of above statements for I deem this to be the only course that is thoroughly & completely fair both to yourselves & also to the Scientific public & to me.

P.S. The Congress closed yesterday & I read a brief note giving only the equations (1) & (2) and a definition of Orthomorphic Vision, and stating withdrawal of my paper awing to delays in placing of the new Microscope on Market & publication of new Catalogue. – nothing concerning technical construction was said."

We see that HSG avoided as a precaution a reference of the Carl Zeiss product before its launching. He mentioned also that a repeated Czapski meeting at Paris could not be possible due to his own holidays. He had been informed that Czapski will go probably to Paris in some weeks after his holidays [BACZ 1579, 32]. Dr. Czapski got at least two causes for his numerous Paris trips: His Koch Parents-in-Law lived there and since 1896 June the Parisian instrument designer (Charles) Emile Adnet sold exclusively Carl Zeiss microscopes and analytical measuring instruments [BACZ 16039, 3].

From August 26 HSG spent holidays at a picturesque Atlantic coastal strip near Le Havre – at Hauville Hotel, Étretat, Normandy [BACZ 1579, 35]. The local chalk cliffs were become well-known of paintings by Gustave Courbet (1819-1877) and Claude Monet (1840-1926).

Figure 86 Shore of Étretat, Normandy Region and Hauville Hotel (38 G. F. Postcard, Le Havre).

27. His Conflict with Carl Zeiss Company

HSG let culminate firstly the conflict with the Carl Zeiss Company in the following letter [BACZ 1579, 38]:

"12 Avenue Wagram Paris Sept. 14th 1897

Messrs Carl Zeiss Gentlemen

Your Dr. Czapski having recently written to me that he is about preparing for publication a paper on the new Microscope and also some account of this 'Orthomorphic Microscope' for the new edition of your Catalogue – I think, after due reflection, that it is better for me – without waiting further for a reply to certain requests made by me in a letter dated from Fribourg August ult. – to state very plainly that I am entirely and completely unwilling that my name be in any manner whatsoever associated with the instrument you are about to put upon the market, unless indeed, you publicly assume the full responsibility for the method of construction adopted by yourselves – Now this would of course indicate at least by an obvious implication that I disapprove of such method – If therefore you deem it inexpedient for any reason to make this public statement then I must ask you to assume the above mentioned responsibility in another way, to wit: by suppressing my name altogether! – In one of the earlier letters of our correspondence upon this subject you stated that you assumed the full responsibility for the method of construction you intended to adopt & I now request that you will give practical effect to the promise you then made. – Lest the motive for the foregoing should perchance be misconstrued I will take this occasion again to thank you most heartily for the support & cooperation you have given to me and I wish to add that I deem the experimental verification of the possibility of Orthomorphic 3 dimensional magnification – a verification I have myself made in a rough manner with the present instrument when used with electric light & stops such as to satisfy approximately the fundamental equation of Orthomorphy viz.
(1) **A/a=L/l=D** a very valuable one indeed.

Awaiting your reply I remain gentlemen very sincerely yours

Horatio S. Greenough"

We learn the author of the typed German concept of the official company reply from a handwritten postscript [BACZ 1579, 47-48]:

"P.S. The text of the above letter was written down by Dr. Czapski in German shortly before he started a weekly trip on business matters. We hope that we have correctly reproduced the meaning of his remarks above."

The authorized officer, Max Fischer (See Part 4/20), translated surly the concept because he signed the copy of the handwritten English letter [BACZ 1579, 40-45] of September 18. The three German concept pages are stroked vertically as a sign of carrying out and out-going the English letter:

„Concept. /keep! Cz *(handwritten addition)*/ Jena, September 16, 1897.

Mr. Horatio S. Greenough

Paris

12 Avenue Wagram

Dear Sir!

We were just about to write to you when we received your last letter of the 14th of this month and now want to answer your various letters together. We want to do this only briefly, since a detailed discussion in writing would lead too far and since, on the other hand, our Dr. Czapski will probably come to Paris in the second week of October, so that you will have the opportunity to discuss the doubtful points with him in more detail orally.

As far as the instruments ordered by you are concerned, we will send them to you by mail, firstly the objectives with conical diaphragms *(handwritten underlined)*. Unfortunately, it is not possible to adjust them without the instrument itself. We must therefore ask you to try whether the objectives on your microscope prove to be adjusted; if not, there would be little choice but to send us the entire microscope again for adjustment. The experiment with the diaphragms has shown that in addition to a not very significant reduction in brightness, they also result in a reduction of the field of view. We have therefore begun attempts to compensate for this reduction by enlarging the objectives and hope that we will be successful in this (*See 30. and [Harting, 1898]*, the authors). ~~Our attempts to directly observe the influence of the diaphragms on orthomorphy did not have a positive result~~ *(handwritten deleted)*.

We will also send you the prism rotator modified *(handwritten underlined)* according to your wishes. The addition of a second lateral prism has, as you yourself foresaw, necessitated a rather extensive modification of the apparatus ~~itself~~ *(handwritten deleted)*, namely the introduction of a /new *(handwritten added)*/ carriage movement perpendicular to the original one. Unfortunately, this has also made the apparatus considerably more expensive, so that we want to keep the original, simpler one in addition to this one in any case.
/By the way, we mention that with this second lateral prism the conical diaphragms are no longer applicable, because the object distance is too short (*Cligny will confirm this*, the authors). Enclosed photogr. shows you how we have thought of the attachment of the small lamps at the rotator *(handwritten added)*/ (*Fig. 39 in Part 3*, the authors)

We will also send you three incandescent lamps with cemented tubes to go with this rotator. We have started negotiations with several manufacturers for the production of suitable incandescent lamps, but these have /~~not yet~~ already led to a satisfactory (*handwritten changed*)/ conclusion.

Finally, we are sending you three rheostats for these bulbs. We have chosen the strength of the rheostats according to your earlier specifications /for (handwritten *added*)/ accumulator batteries of 6-8 volts. If a stronger primary current is present, a larger main resistor, most simply one or more large incandescent lamps, must of course be switched on. (The calculation about these things /~~you will find enclosed)~~ <u>follows</u> (*handwritten changed*)/).

Regarding the wishes you expressed in your letter of July 16 concerning the optical construction of the microscope, we can only explain that you are asking for something impossible. Dr. Czapski can give you more detailed reasons for this orally, if you wish. According to our conviction, the elimination of the diaphragm tubes would not even have an advantage for the optical performance of the instrument /even (*handwritten added*)/.

Figure 87 Max Klinger's Herm Inside Henry van de Velde's Memorial (1911) to Abbe at Jena.

Likewise, you know that, according to our conviction, the erection of the images by means of inverting lenses instead of prisms would not bring any advantage, but in some respects would make the construction more difficult. Dr. Czapski has discussed all these points in his description of the microscope, which he first wrote for /~~a journal~~ the Zeitschrift für wissensch. Mikroskopie (*handwritten changed*)/, - not for a catalog. We have only a press copy of the description. We would like to make you an English translation /of the whole (*handwritten added*)/, if this would not be too much trouble. We believe, however, that in this description is /~~so~~ completely (*handwritten changed*)/ clearly expressed what we have done at your suggestion and what we have done against your advice, /so (*handwritten added*)/ that your wishes in this respect are completely satisfied. We believe we have thereupon not only the duty but also the right to mention your name as that of the originator of the instrument...

We are very sorry to read from your last letters an /~~apparently increasing~~ certain *(handwritten changed)*/ disgruntlement against us. We are really not aware by what we have caused the same. We hope, as I said, that when you get to read our description, you will find that we have acted quite openly and honestly.

/~~1 Invoice.~~ 1 Photogr. separately *(handwritten changed)*/"

(Please see Fig. 39 in Part 3)

The paper of Dr. Siegfried Czapski and the anatomist (Franz August Max) Walter Gebhardt (1870-1918) arrived the editorial office of "Zeitschrift für wissenschaftliche Mikroskopie und für mikroskopische Technik" in 1897, September 29. The paper is titled in German "Das stereoskopische Mikroskop nach Greenough und seine Nebenapparate" [Czapski, 1897] meaning „The Stereoscopic Microscope after Greenough and its Accessory Apparatus". This publication describes the three instruments suggested by HSG. His repeated interventions regarding the microscope design could not get immediate success then:

"In the course of 1897 we introduced a new form of binocular microscope after designs by Mr. HORATIO S. GREENOUGH in which **stereoscopic vision** is obtained, not by division of a pencil of light passing through a single **object-glass**, but by a **combination of two microscopes, complete in themselves and combined with erecting prisms**" [Zeiss, 1902].

28. His Summarizing of Microscope Proposal

HSG replied diplomatically by a telegram in 1897 September 20 [BACZ 1579, 49]:

"Many thanks. your letter of 18th inst receiven [sic] regret misunderstanding. Will write shortly. Greenough."

On the same day HSG sketched [BACZ 1579, 51] and confirmed [BACZ 1579, 52] his indicated construction of the orthomorphic microscope:

"Messrs Carl Zeiss Gentlemen

I have this day sent you a telegram, acknowledging receipt of your favour of the 18th inst and now write to reply the same.

In the 1st place I wish to say I regret exceedingly any annoyance my latter letters have caused you and I beg to apologize for any want of courtesy to yourselves they may appear to have contained – I will add that the explanations you give are completely and entirely satisfactorary [sic]: Concerning your statement that what I ask in my letter of July 16th ult is impossible I would reply that I think we have failed to understand each other & this owing to my unfortunate and very great ignorance of Dioptric and of its technical terms. I am therefore sending you a diagram I have just drawn & hope that this together with the statements I shall now make concerning it will enable us to come to a better understanding of the matter in question than has hitherto been the case, and if as may well happen I am mistaken in any or in all the statements I am about to make I shall be pleased to have you point out my errors.

The figure at the top of the drawing-paper *(See Fig. 88,* the authors) indicates in a diagrammatic manner the form of 1st pair of objectives I would suggest – i.e. of the front pair whose geometrical centres of perspective are to satisfy the equation **A/a=D** – the ruled squares indicating that the perspective is a true one – the red lines denote geometrical perspective, the paths of "rays of light" are not drawn at all – (*U called subdivision follows*, the authors)

1st the distance from the plane **P_1** to the plane **P_2** being constant the position of **C** upon the optic axis is a fixed one.

2d there should be some plane between **P_1** & **P_2** where the condensation of light due the objective is a maximum

3d Is there not some plane normal to the optic axis and between **P_1** and **P** [***P_2*** *correctly*, the authors] where different degrees of stopping can be used without causing the position of the geometrical centre of perspective to shift on the optic axis – the objectif (*French*, the authors) being assumed to have been so constructed as to satisfy the indicated geometric perspectif (*French*, the authors) when used with its full aperture?

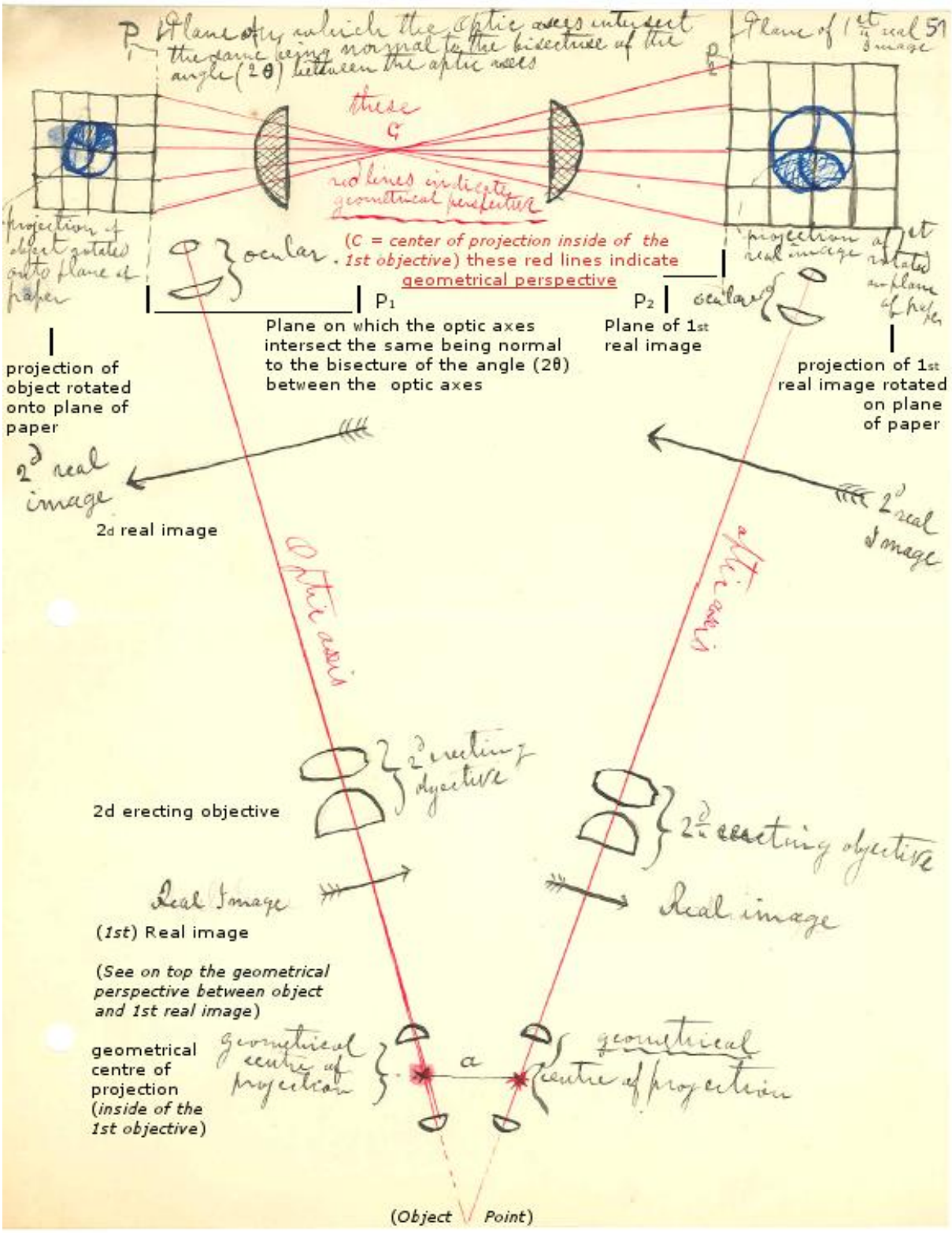

Figure 88 HSG's Sketch of September 20, 1897 [BACZ 1579, 51], Italic Comments in Brackets and Transcription by the Authors.

Upon the answer to the above question depends the whole value of the construction indicated diagrammatically in the lower part of the drawing-paper, i.e. on all the rest of the sheet.

4ly Assuming provisionally that 2d is correct and that the answer to 3d is "yes" – will the planes of maximum condensation & of non-shifting of projective centre by stopping coincide?

If as then "non-shifting of projective centre stopping" will also be most economical of light for a stop of given diameter!

I now pass to the lower figure – Assuming provisionally that conjecture 3d is correct, the indicated construction makes it possible (*L called subdivision follows*, the authors)

1ly to satisfy equation no (1) above written for all degrees of stopping – a most important consideration.

2ly my indicated construction will admit it appears to me of a wider "effective aperture" than the present one because the 1st pair of object glasses are nearer the object –

3ly the field obtainable should be larger

Lastly if all my conjectures be correct the indicated construction should give some economy of light over that now in use.

It goes without saying that my two figures are mere diagrams & do not at all actual proportions any more than constructive shape & detail."

Awaiting your reply I remain gentlemen
very truly yours
Horatio S. Greenough"

HSG's apologizing for figures' proportions isn't necessary because both diagrams agree with HSG's idea to locate the main magnification in the second imaging step. His humbleness takes precautions and seems as his making for harmony.

Note to U subdivision and upper diagram: The assumed geometric projection between the object and the first reversed image represents a very low magnification of ca. 1.4X. Indeed, the mentioned distance is constant and the perspective is fixed (See U1). We know that the objective exit pupil or its back focal plane provides as well as the "maximum condensation of light" (See U2), the "different degrees of stopping" (See U3) and these both in the same plane (See U4). In contrast to these right conjectures the **C** center of geometrical perspective doesn't stand inside the first objective and isn't identical with the exit pupil but lays in the infinity behind the object due to the telecentric arrangement of the microscope.

Note to L subdivision and lower diagram: HSG sketched both optical axes with an excessive stereo angle of 35° and the **D** magnification may be estimated at ca. 7X corresponding to his **D=A/a** formula. This equation can be satisfied for all degrees of stopping (See L1) but only for one magnification step in a fixed setup. A shorter working distance would increase the "effective aperture" (See L2) if the lens opening could keep constant. Unfortunately, the advantage in aperture would not widen the object field (See L3). The „economy of light over that now in use" phrase means surely a better transmission in comparison to the prisms and would work only in expense of the working distance which is essential in dissecting or using the prism rotator.

On following day HSG returned to his former suggestion of frosted screens inserted in the first intermediate images and emphasized the different magnifications in both magnification steps [BACZ 1579, 53-55]:

"I am now writing a postscript to my letter of yesterday. – I would say that, assuming provisionally that the construction therein set fourth [sic, forth] and illustrated by the diagrams therein enclosed, is quite impossible it occurs to me that it might still be made possible by means of an artifice, to wit:
By changing the 1st or front pair of real images into what would be - for the purposes of Dioptric – an actual flat material object. This could be done by putting screens at the places where the 1st pair of real images are formed – such screens being made by grinding the anterior surfaces of two very thin "cover-glasses"; the grinding to be as fined grained as present technical methods permit of.
In view of the results actually had in the enlargement of photographs I have thought the above indicated construction might be worth making, as a scientific experiment, with values of **D** of 5 and 10 respectively ..."

HSG will be more daring at the letter bottom:

"… **D** could easily in theory be made, equal to 20, 40 and 80. – I do not suppose however that the screen construction at present would permit of more than **D**=10 or at the very most **D**=20.
– It occurs to me that suitable screens might be made by pulverizing glass as finely as possible – sprading [sic] is evenly over a flat metallic plate & then heating the plate to bright redness or a somewhat more!"

An infinitesimal definition of the separated $\mathbf{D_1}$ and $\mathbf{D_2}$ magnification was following.

"Now in my proposed screen-construction **D_1** is a little greater than unity and only a little greater; hence I presume that a very good definition could be had with moderate stopping (*See A Note*, the authors) – If now it be possible to produce screens as fined grained in texture as the emulsion of a dry plate such screens should "transform" the 1st pair of real images into a pair of flat objects shining with their own light and in such manner that every point radiates light in every direction: hence the 2nd pair of object glasses will act upon these screen images just as they would upon an exceedingly thin section upon ordinary microscopic slide; so that the 2nd pair of object glasses may be made of wide angle so as to throw the 2nd real image not very far back from the 1st and to utilize a large aperture for economy of light – the 2nd real images are supposed to be thrown upon a plane whose position is such that they are the real geometrical perspective (from the centres of perspective of the eyes of the observer) of a virtual object coinciding in one of its points with the real object under the microscope …"

HSG tried to describe the projection by "an operator of my own & is the simplest ease of an extension of Sir William Hamilton's method of Quaternions".

"… – the observer will see a virtual object … and because the 1st pair of real images projected upon screens are flat – the 2nd pair are not supposed to be projected upon screens – the virtual object will be well defined throughout its depth (*See B Note*, the authors).
… it will I think be possible to use different degrees of stopping without causing the geometrical perspective centre to shift upon the optic-axis and this condition must be fulfilled in some manner if the Orthomorphic Microscope can by any means whatever be so improved – hereafter – as to make it practically available for the purposes for which I have designed it! – If indeed no substantial improvement be possible in any manner whatsoever then we must be content to do the best we can with the present mode of construction; but in view of the considerable scientific interest of the subject I hope you will not consider me obstinate in defending my own opinion by writing of my letter of yesterday and the present one.

P.S. Of course, with the proposed screen construction the electric light would be quite necessary and indispensable for the sufficient illumination of the object under the microscope, so that sufficiently brilliant screen-images could be had."

A Note:

The 1:1 imaging scale is the unique but trivial case wherein the lateral and axial magnifications were equal. HSG had wanted this applicative advantage but the inevitable higher magnification of the second-step would destroy usually this ideal.

B Note:

HSG saw a way out: The frosted screen defines a flat image, then the second-step magnification cannot transfer any image depth and no axial distortion shall occur. The screen shall provide also an increased numerical aperture behind the first intermediate image at the expense of its intensity. The second objective shall get a short focal length and use the increased aperture for its higher second-step magnification.
The tandem microscope (Doppelmikroskop in German) [Lau, 1961] by Prof. Ernst Lau (1893-1978) work similarly: A rotating ground glass is placed at the first intermediate image. This instrument shall enlarge the tiny exit pupil of a high-power objective in order to avoid a disturbed observation by floaters in the eye. HSG's low-power microscope needs no such an improvement and a hoped-for gain in resolution cannot be obtained [Michel, 1962].
The first intermediate image projected on a flat screen leaves its depth and any accommodation into depth becomes impossible. The live stereoscopic observing has to be changed consequently to a fixed view of a picture stereoscope. Later an orthomorphic stereoscope [Braus, 1908] was realized by August Köhler (1866-1948) and Moritz von Rohr (1868-1940) using photographic image pairs acquired by Drüner's Stereoscopic Camera Microscope.

HSG had requested advanced accessories for a presentation at Fribourg (See 26.) but Dr. Czapski announced these not until 1897 September 16 (See 27.). A shipping note with "CARL ZEISS JENA" seal [BACZ 1579, 71] for sending to HSG mentions:

> "1 pc. prism rotator with 3 pc. holders (*carrying lamps*, the authors),
> orthoscopic stops attached at two objectives (*identical ones*, the authors),
> 2 pc. No. 3 Huygenian eyepieces (*5.5X*, the authors),
> 3 pc. electric lamps, 3 pc. rheostats (*limiting resistors*, the authors)."

On September 22 HSG thanked for consignment [BACZ 1579,56] and on next day he tackled with it by a four paged letter to Dr. Czapski [BACZ 1579,59-60]:

"I am today writing you more as to a personal friend than as the assistant Director of the Zeiss-Werkstätte, though I do write to you in both capacities.

In the first place let me say that Mr. Cligny & I both found the consignment yesterday received from your house on the whole decidedly good; but to you I will say what I did not deem it expedient to state in my letter of yesterday to your house, to wit: I am <u>considerable annoyed</u> at substancial [sic] defects, foreseen both by you & by myself and against which you & I had guarded long ago!

In the 1st place the stops do not satisfy equation (1) the distance between the centres providing upon measurement to be above 4 ¼ millimetres & this corresponds to a value of **D** of 14.1 instead of 20, for which (**a**) the distance between stop centres should be 3 millimetres *) as we agree upon when you were in Paris last spring, also the stops are too large to get the best effect – at least I think so in the light of the experiments made yesterday with the Auer gas-burner, an incandescent one.

The 2d defect is that the Prism rotator cannot be used with the stops, but observation showed us that it could be almost so used & had the upon prism been placed as you & I agree upon some two years ago, or at any rate very long ago. there would have been ample room for the use of conical stops. – You may remember that we intended having the fixed prism so mounted that, the rotating one should pass under it, an interval of 1/20 millimetre separating the two as shown in diagrams herewith annexed.

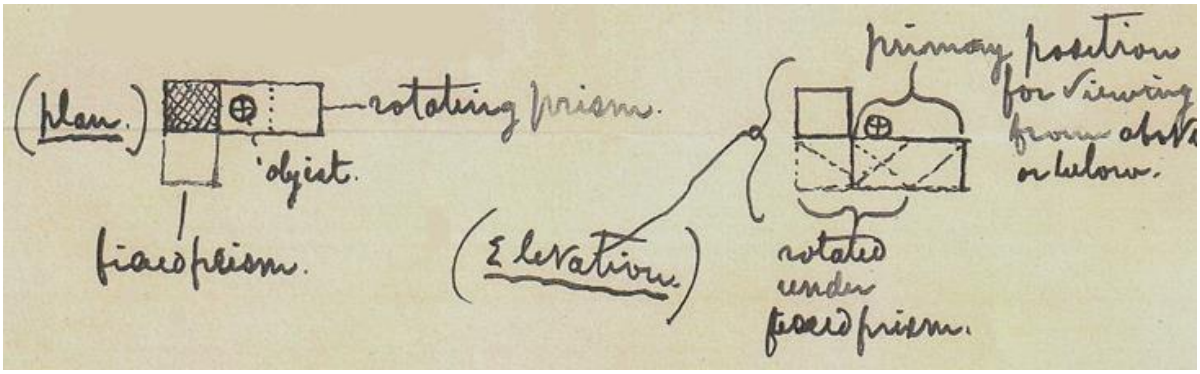

Figure 89 HSG's Diagram of Optimized Prisms Arrangement [BACZ 1579, 59].

Mr. Cligny's observations & my own indicate that it would not even be needful to bring the fixed prism – as seen in plane – so near the rotating one as hereabove drawn.

Returning now to the conical stops – Their use produces a marked increase toward Orthomorphy through a slight prolate distortion is still observable, and moreover the definition is quite satisfactorary [sic].

---

*) HSG's orthomorphic request to Prof. Abbe was dimensioned by 60 mm eye distance divided by 3 mm objective distance resulting in 20X magnification (Please see Fig. 59 in Part 4). The now measured 4.25 mm guides theoretically to **D**=14.1X after the **A/a=D** equation (1). These both objectives were not characterized here but may be the same optics described by [Czapski, 1897] which provide 46 mm working distance or only 13 mm equipped by the conical diaphragms.

I come now to the main purpose of this present letter – I would earnestly request you to personally condukt & safervise [sic] an experiment which I will proceed to indicate & this because if successful it will enhance very much indeed the value of the present instrument,- of the microscope i.e. as at present constructed, in fact it will make all the difference between hit and miss; for in its present condition the microscope though nearly a "hit" is still a "miss", and with the single exception of dissections and other manipulations is inadequate for the purposes for which I have designed it. For these purposes Orthomorphy is necessary and indispensable; I now pass to the experiment I would have you make to wit: …

Believe me these experiments are worth trying & if successful would in my opinion very greatly enhance the commercial value of the present instrument ...

P.S. If you could hasten the sending me a pair of stops to satisfy equation (1) I should be very much pleased as if successful in thus obtaining practical Orthomorphy I would like to show the Microscope to Mr. Bartlett, before he goes to America in November next."

HSG gave a concession to the optical resolution by a telegram three days later:

"Do not mind decreased definition seek practical orthomorphy definition of i per cent of average diameter of object will be ample Greenough." [BACZ 1579, 50]

29. His Partners' Comments

Adolphe Pierre Cligny (1870-1938) wrote a letter of recommendation also in 1897 September 23 [BACZ 1579, 57-58]. In 1895 Cligny, a graduate of the Parisian École Normale Supérieure and associate professor of natural science, was appointed as a preparator of zoology at ENS. He was the successor of Professor Maurice Caullery (1868-1958) [Débats, 1895] who was contacted by HSG in 1894 (See Part 4/19). This sheet shows the "Laboratoire de Zoologie, École Normale Supérieure" imprint like HSG's letters also at that time:

"Monsieur

Monsieur Greenough having made me try the binocular microscope with the new objectives that you sent him, and the rotation apparatus that you built, asked me to write you my appreciation on these instruments.

As far as I could see by a quick examination the microscope is excellent and of a convenient handling: it reaches perfectly the proposed goal by giving the almost exact sensation of the relief: nevertheless I believe that there remains a slight deformation of the image in the sense that if one examines a sphere one observes an ellipsoid of revolution with a vertical major axis: and even it seems to me that the lower hemisphere would be more elongated than the other so that the shape would approach that of an egg seen by the large end. This is a minor inconvenience in most cases. It is especially noticeable with the eyepieces 3 (*meaning maximum magnification*, the authors) and even more so if the conical diaphragms of the eyepieces (*objectives correctly*, the authors) are removed.

At the same time, one loses in definition by removing these parts: M. Greenough thinks that it would be interesting to lengthen these diaphragms, so as to diminish the spacing of their openings, to diminish also the diameter of these openings: I believe, as he does, that by this one would gain in clearness; but one would undoubtedly loose of light (*definition and clearness could mean the sharpness and the seen depth of object*, the authors).

The rotation apparatus has been tried without the help of electric lamps and with the light condensed from an Auer nozzle: the only defect of the apparatus is the following one (*announced by Czapski already*, the authors): when one wants to have a lateral view of the object and that one points the objective on the fixed prism, one is embarrassed by the support of this prism: It is impossible to lower the diaphragms to the desired point without touching laterally this piece: there is thus reason to modify the support of the prism and the correction would be easy.

(*See Fig. 90 for the French version of following paragraph*, the authors)

It would be enough to hollow out the part A along the dotted line: and this would not appreciably harm the solidity of the apparatus. I doubt that one can use the cuvette for observation in a liquid medium, if only because of the length of the diaphragms.

Please accept, Monsieur, the assurance of my best wishes

AP. Cligny
Agrégé préparateur de Zoologie
á l'Ecole Normale."

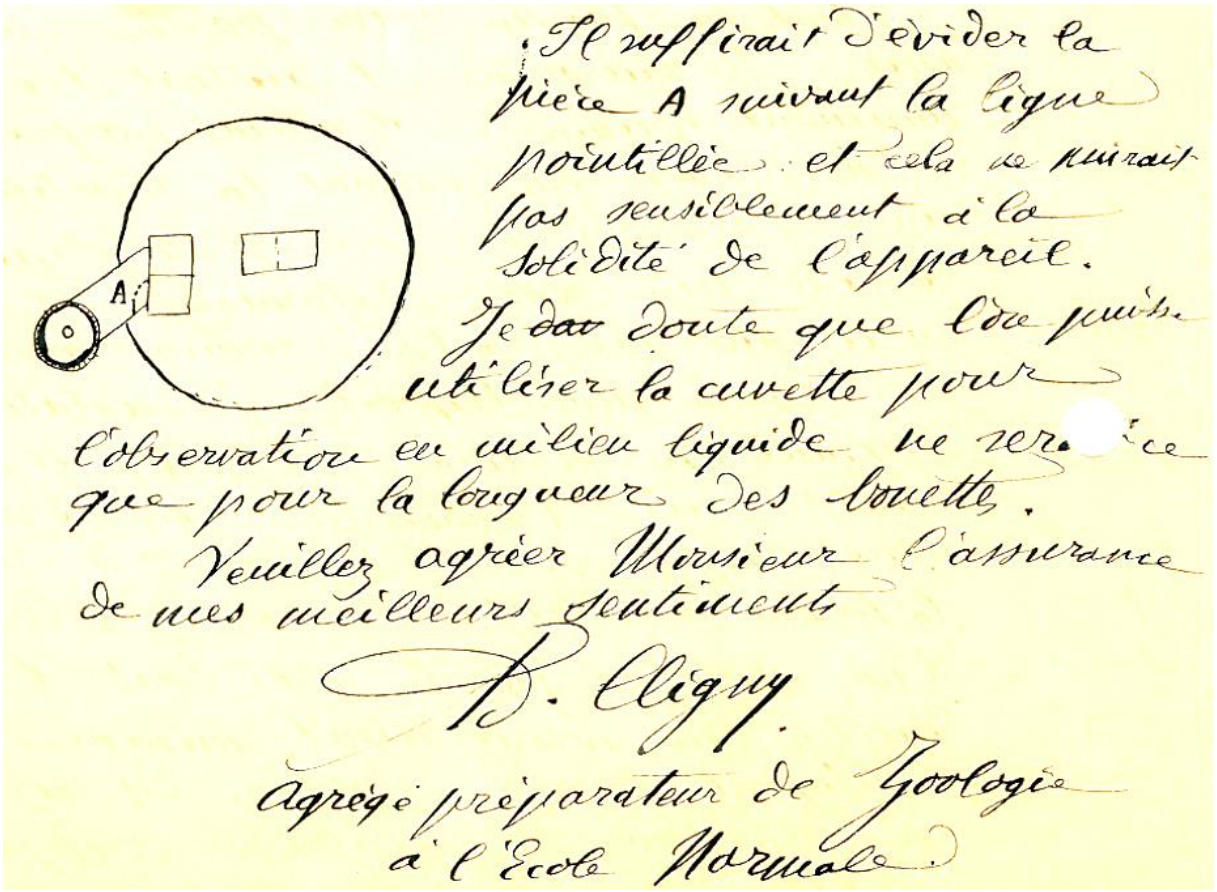

Figure 90 Extract from Prof. Cligny's Letter of September 23, 1897 [BACZ 1579, 58], See Translation Above.

The typed German reply by Dr. Czapski to HSG of September 29 [BACZ 1579, 61-62] is better legible than the deficient copy of the translated and handwritten letter from the following day:

"Dear Sir!

I have finally come to answer your letters of the 20th, 21st, 22nd and 23rd of this month. As far as the apparatus you received is concerned, I am sorry to hear that the conical diaphragms were not quite right. I very much suspect, however, that this is only due to a minor circumstance. Namely, the length of the diaphragms is exactly correct (*handwritten underlined*) and must not be changed under any circumstances. The length has not only been chosen according to your equation 1, but I have also calculated it completely independently of this equation according to my own definition (using the nodal points) and verified it by measurement /as correct (*handwritten added*)/. So, if the distance between the centers of the openings is really 4 ½ mm instead of 3 mm, this can only be due to the fact that the diaphragms are screwed on crookedly /or bent (*handwritten added*)/, or to something of the sort. However, this cannot be judged from a distance; you would have to return us the objectives together with the diaphragms again.

By the way, the incident made me aware that equation 1 is the necessary but not the sufficient condition for the orthomorphy. If you put a screen with 2 holes exactly 3 mm apart, perpendicular to the middle axis of the two microscopes and move it up and down in this axis, your equation would be fulfilled for every position of the screen. But you will admit yourself that only for **o_n_e** position the orthomorphy would be present. The complete condition of the orthomorphy therefore requires the addition to your equation that the centers of projection for the entering rays must lie on the axes of the microscopes. With the form of expression chosen by me that they must be the nodal points, this results from itself.

By the way, it occurred to me that the conical diaphragms under the objectives can be avoided completely, namely that they can be replaced by diaphragms on the eyepieces. The latter diaphragms must have the same opening as the objective diaphragms and must be located at the place where a real image of the objective diaphragm is formed. In the present construction, this is the upper surface of the eyepieces. Therefore, if small caps are placed on the eyepieces, which are as close as possible to the glass, exactly the same purpose is achieved as with the conical diaphragms and the disadvantage of these is avoided, /namely (*handwritten added*)/ extending the free object distance. I take the liberty of sending you a few diaphragms, suitable for the no. 1 eyepiece (*3X*, the authors), for testing purposes.

The fact at the eye circle (*exit pupil*, the authors) of the orthomorphic microscope lies in the upper surface of the eye (*eyepiece correctly*, the authors) must be considered unfavorable for various reasons. Therefore, we have already started to replace the eyepieces currently in use by others in which this eye circle is located somewhat higher. The insertion of small diaphragm discs at this eye point seems to me to be such a simple means of achieving different degrees of dimming that any other means would be less expedient.

For this reason alone, I do not think I should go into more detail about the constructions proposed in your first two letters. However, I also find that these letters are based on a great misunderstanding. It would take me too far if I were to explain it to you in writing. I can therefore only briefly assure you that both your views on the relationship between geometric and optical projection (*See Fig. 88,* the authors) and on the influence of matte screens at locations of the real image on the depth and brightness of the images are in contradiction with what is now recognized as valid in optics /generally (*handwritten added*)/. I hope, as I said, that your wishes, whose justification I fully recognize, will be fulfilled in a simpler way …

The deformation of a sphere into an egg instead of an ellipsoid, which Mr. Cligny noticed, I attribute to an error in the orthoscopy of the microscope. We also hope to eliminate this error by the new construction of the objective and the eyepiece which is now in progress.

More electric lamps we want to get for you soon. The prismatic rotator of older construction indicated to us and the case for the capillary rotator have been correctly obtained from Messrs. Pitt & Scott.

In conclusion, let me say that we do not hold your adherence to your plans against you in any way; on the contrary, we sincerely appreciate it /as absolutely justified (*handwritten added*)/. We only ask you not to hold it against us either, if we openly express and represent our view. When I am in Paris in about 14 days, I hope to be able to give you /even more (*handwritten added*)/ detailed information about some of the points connected with the apparatus. In the meantime, please convey our best thanks to Mr. Cligny for his kind messages."

On October 4 the delivery of three diaphragm pairs and three lamps will be announced [BACZ 1579,69]. Dr. Czapski's new and advantageous placing of the diaphragms bases on the knowledge of the conjugated pupil planes in the microscope ray path which was beyond HSG's optical capability for the time being. The Catalogue [Zeiss, 1898] will offer the No. 2 (4X) and No. 4 (7X) Huygenian eyepieces as orthomorphic ones supplemented by putting-on diaphragms. The eyepiece with a higher located exit pupil and including diaphragm caps will be the no. 4 orthomorphic eyepiece [Zeiss, 1902] designed optically after the British instrument maker Jesse Ramsden (1735-1800) like one from Abbe's Stereoscopic Eyepiece.

Dr. Czapski wrote in his paper [Czapski, 1897]:

“However, to achieve orthomorphy, the same (*conical diaphragms*, the authors) are quite indispensable, as a comparison of vision with these diaphragms and without them teaches *). Instead of diaphragming the entrance pupils, here the anterior nodal points, suitable diaphragms can be placed in the exit pupils, the upper nodal points of the microscope. This seems to be the more convenient for use.”

Figure 91 Dr. Czapski in ca. 1900 (Courtesy Carl Zeiss Archive) Sitting on Desk at his Villa and its Entrance.

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*) This assessment differs to Dr. Czapski’s meaning after testing the prototype in 1894 March [BACZ 1578, 66]:

“Furthermore, your equation: **A/a = B** will be satisfied. Because, of course, the middle of diaphragm becomes the center of perspective for the image. You wanted us to do experiments in this direction. We have done this and we would like to give you the opportunity to convince yourself, which is why we are also sending you these diaphragms.

The result seemed completely negative to us.”

On October 3, HSG seems to be ill and wants to be substituted [BACZ 1579, 72]:

"My dear Dr. Czapski
It may now I think be justly said that there is no substancial [sic] difference of opinion between us. We shall keep the object glasses for the present as Prof. Walerand [sic, Wallerant] is using the microscope. I have asked Mr. Cligny to attend the matters for me for the present as I am really tired and wish to take a good rest."

HSG adds three days later:

"Since my return I have thought of a very much simpler demonstration of my equation (1) than had hitherto occurred to me – I have submitted this demonstration to Prof. Houssay who finds it correct – I hope to show it to your Dr. Czapski when he comes to Paris, though I may not have it on paper by that time as being somewhat fatigued. I only write & draw when I feel quite like it ..." [BACZ 1579,73]

It seems that HSG changes his promoters: Cligny and Houssay are mentioned here for the last time. Or has HSG get on Professor's nerve that they showed him the door? He will remain loyal to the École Normale Supérieure at Rue d'Ulm of the Quartier Latin but now to the Laboratoire de Géologie and no longer to the Laboratoire de Zoologie.

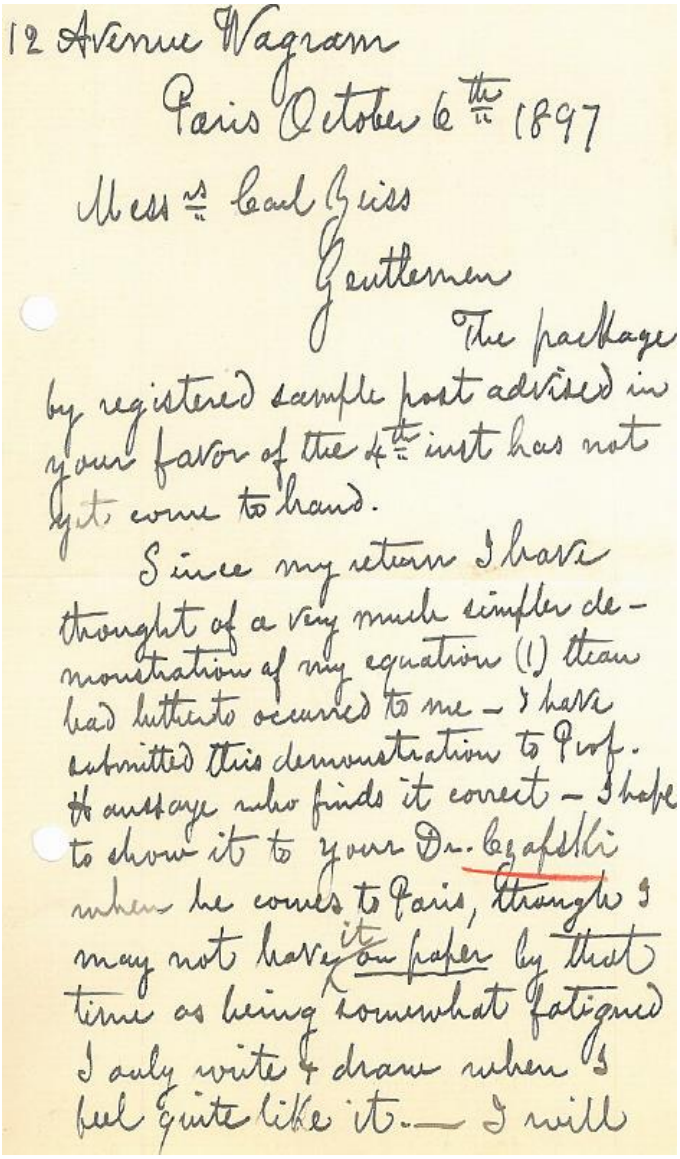
12 Avenue Wagram
Paris October 6th 1897
Messrs Carl Zeiss
Gentlemen
The package by registered sample post advised in your favor of the 4th inst has not yet come to hand.
Since my return I have thought of a very much simpler demonstration of my equation (1) than had hitherto occurred to me – I have submitted this demonstration to Prof. Houssay who finds it correct – I hope to show it to your Dr. Czapski when he comes to Paris, though I may not have it on paper by that time as being somewhat fatigued I only write & draw when I feel quite like it. – I will

Figure 92 HSG's Handwriting Changes for the Worse Over Page due to Tiring [BACZ 1579, 73].

In 1897 November 4, HSG asks for diagrams and explanation for stopping of the Ramsden circle (exit pupil) to understand the alternative proposal to the conical diaphragms [BACZ 1579, 75]. Dr. Czapski sends a typewritten page from an English paper by Prof. Abbe describing the effect of such a diaphragm BACZ 1579, 76-77].

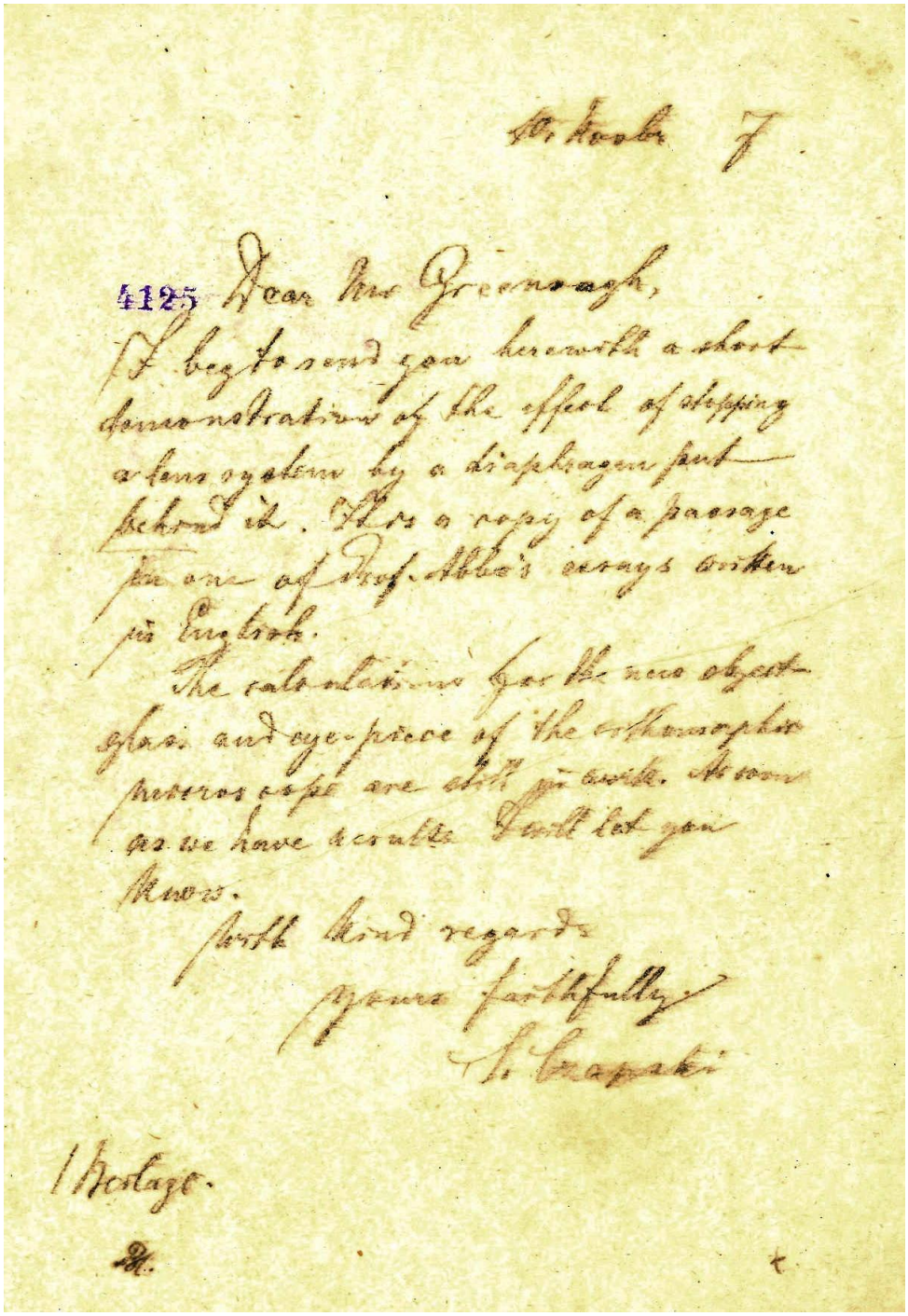

Figure 93 Dr. Czapski's Letter of 1897 November 10, Copy of That Time [BACZ 1579, 77].

Up to 1897 end, HSG replied by some letters with optical sketches concerning the stopping and the geometrical projection at the orthomorphic microscope. On December 1, HSG wrote to the Carl Zeiss Gentlemen:

“I find on further consideration that although I now understand that stopping the image of a given diaphragm in front of dioptric system is equivalent to stopping the diaphragm itself. Yet I do not understand the effect of the stop in front of the dioptric system, especially how it shifts the geometric centre of projection along the optic axis: for it I understand your general statement, the final effect is as shown herewith

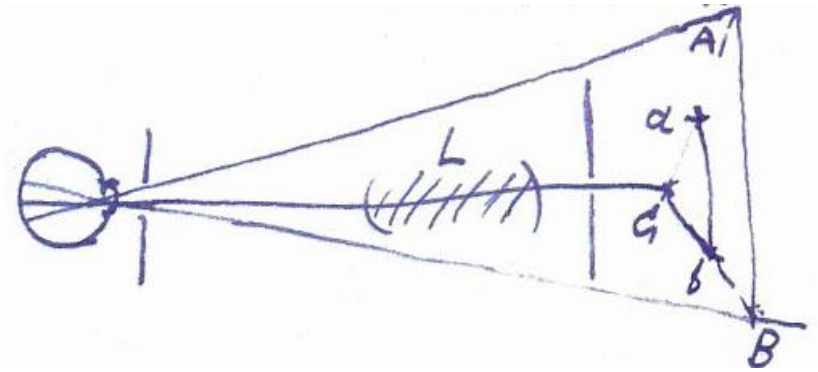

Figure 94 Mixing of HSG’s Geometric View Incl. L Lenses Sign and Correct Eye’s Ray Path [BACZ 1579, 80].

that the retina receives an image identical to the geometrical perspective of the real object mere it dilated in situ, the point C remaining fixed. – I do not know whether this can be explained in such form as to be comprehensible by myself; but I should like very much if possible to understand in a general way the optical construction now being made – In conclusion would you send me the titles of any works or memoirs that may be useful for me to read upon this matter?” [BACZ 1579, 80]

HSG added for it to Dr. Czapski three days later and also inquired about some further items:

“Hearing from your house that you will not return for some days I write to supplement the questions asked in my last letter. – It occurs to me that a minute pin-hole stop placed at any point of the optic axis of centered dioptric system must determine a nodal point where it is placed – if this be correct the construction now in process is quite comprehensible to me as to its essential character“ [BACZ 1579, 81].

HSG’s headstrong view on optics could not be accepted by the Zeiss specialists. In the following years HSG will contact independent scientific authorities and try to get appreciation for some of his doubtful ideas. The younger Zeiss staff will come back to HSG’s basic concept of orthomorphy and finally put it into action.

30. His Double Microscope Realized Commercially

The capability for trans-illumination was indicated for the stand due to HSG's marine samples. The Carl Zeiss Company decided to modify the simple Stand IX from the 1889 catalogue, its price was only the half of the older small Stands VI and VII [Zeiss, 1889]. A predecessor from 1877 had be named also Stand IX but got a round base. The new Stand IX was offered originally for laboratory and technical purposes and became most famous in its trichinosis version equipped by a convertible objective. This curved tripod was cast from brass and seems as unique structural design among the common horseshoe-shaped and milled microscope bases.

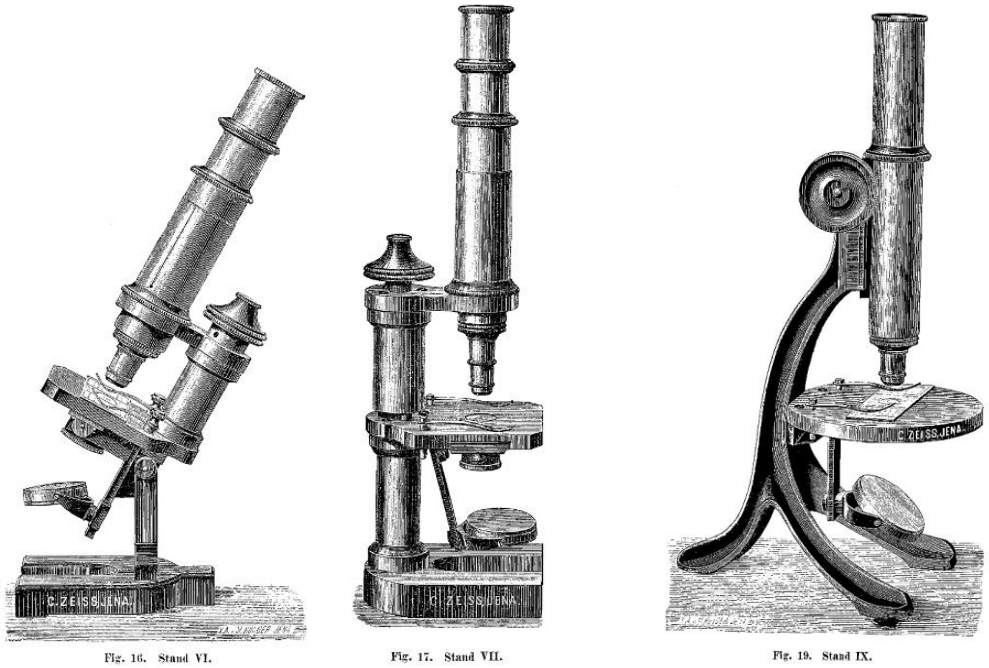

Figure 95 Small Carl Zeiss Stands VI, VII and IX [Zeiss, 1889].

The monocular Stand IX included a pinion, the rack was fixed at the respective tube and a dove-tail guide way connected both. This new and solid focusing construction permitted the use of medium powers like ca. 300X. The only one-sided focusing wheel was added by a second one for the binocular application. The 100 mm diameter stage was replaced by a square one resembling that of Paul Mayer's Dissecting Stand I (See Fig. 57 of Part 4) to which wooden folding hand-rests may be attached. The sample clamping by two springs was continued.

A black or white disk is closed below the stage and may be slipped under the object into recess provided in the stage. One of the disks may be used as contrasting ground of samples illuminated by incident light. The mirror for the trans-illumination was enlarged from 40 to 50 mm diameter and placed lower for lightening of the wider fields in the low-power stereoscopic application. The authors own a stand IX and its modifications relating the new use are stated in comparison to following engravings.

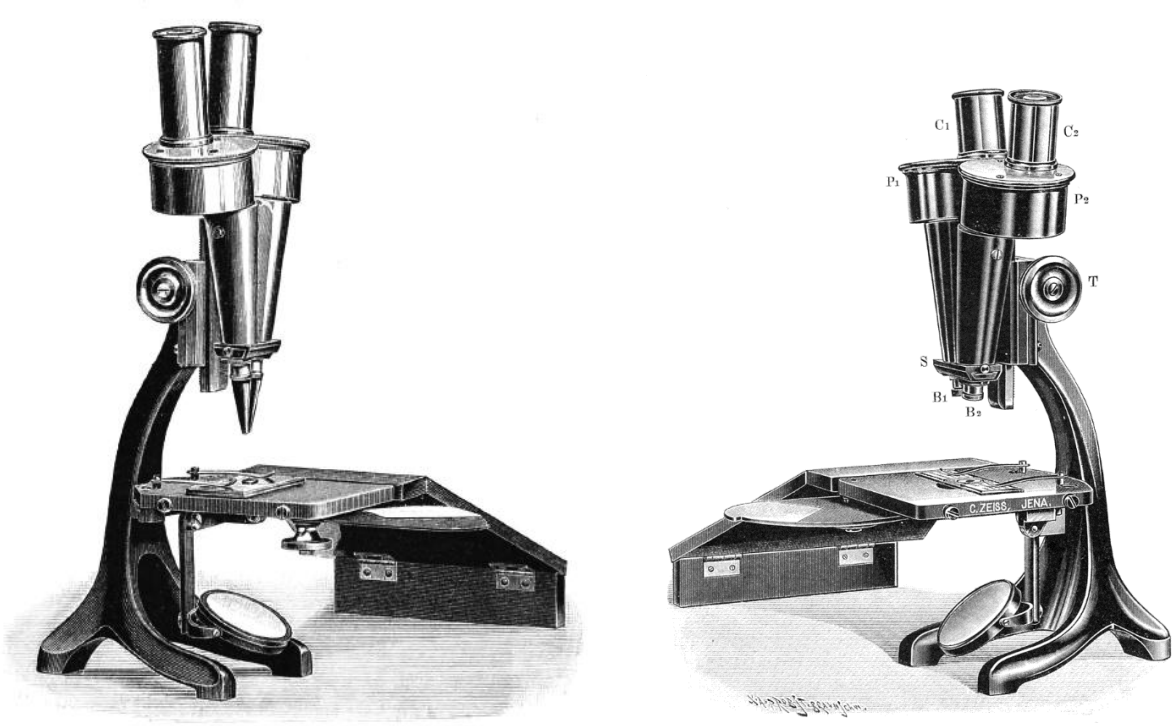

Figure 96 Engraving from Czapski's Paper [Czapski, 1897] on Left and from Catalogue [Zeiss, 1898] on Right.

Figure 96 proves that Dr. Czapski's paper [Czapski, 1897] displays the series stand but a double tube similarly the prototype. The conical diaphragms are added to the objective pair and the resulting working distance of only 13 mm is shown too long. The factory adjusted mounting of the objective pair on a slider surpasses the prototype and introduces a customer interface for changing the main optics.

The convenient working distance of ca. 46 mm is approximately correct shown at the engraving of the series double tube [Zeiss, 1898] which is now ca. 25 mm shorter to allow weaker magnifications in the future. A lower and a little bit more convenient eye position also results within the scope of the vertical line of vision. Inclined eyepiece tubes will be available only in the 1930's. Any eye distances between 56 mm and 76 mm were served by the rotation of the prism boxes. The No. 2 or No. 4 orthomorphic eyepiece pair provided 25X or 40X general magnification.

The stereomicroscope was faster advanced than stated in catalogues. The 32173 serial number, a Dermatoscope stand version (See Fig. 98), may serve as an example which was manufactured together with an a_2 objective pair in 1899, June and shipped to Paris in 1901, January 9 [BACZ 7714, 320]. This stand will be published firstly by the 1902 catalogue (95 catalogue no.) and also some new accessories. All shipped items (See Fig. 97) were intended for use by the Adnet retailer and later by Dr. Paul (Frédéric) Culmann (1860-1938), the first Carl Zeiss Sales Representative at Paris, and surely also informally by HSG (See Part 6/34).

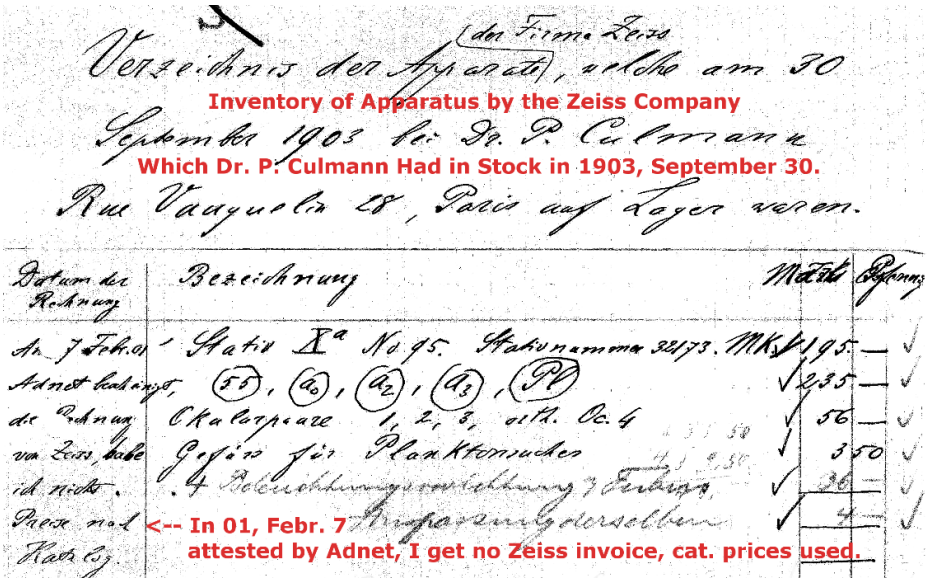

Fig. 97 Inventory of Parisian Zeiss Sales Representation [BACZ 4938, 8], Translated by the Authors.

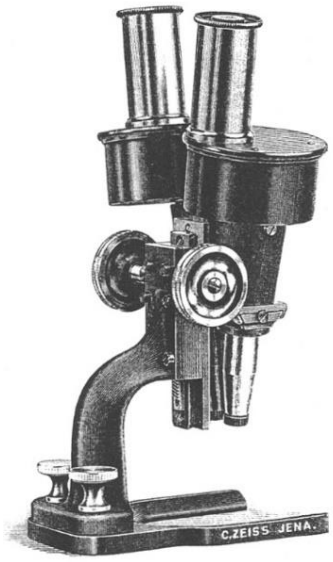

Table of Magnifications, Free Working Distances and Diameters of the Area of Objects embraced by pairs of Objectives adjusted for Binocular Microscopes,

calculated for an image distance of 250 mm (about 10 in.).

Pair of Objectives		Huygenian Eye-pieces						Ortho-morphic Eye-piece 4	
		1		2		3			
Desig-nation	Free working distance mm	Magni-fication	Diameter of visible area of object mm	Magni-fication	Diameter of visible area of object mm	Magni-fication	Diameter of visible area of object mm	Magni-fication	Diameter of visible area of object mm
(55)	70	8	13	10	13	13	10.5	15	7.5
(a_0)	54 without diaphragms | 40 with diaphragms	13	7.5	16	7.5	23	6.5	28	4.0
(a_2)	40	20	5.0	24	5.0	33	4.2	45	3.0
(a_3)	30	30	3.3	35	3.2	50	2.7	65	2.0
(Pl)	35	35	3.0	42	3.0	58	2.5	72	1.8

Fig. 98 Dermatoscope Stand Version and Optics Table from Catalogue [Zeiss 1902].

Fig. 99 Stand X[a] and its Box in 1910 (Courtesy Collection of Historical Scientific Instruments, Harvard University), Objective Pairs Noted by the Authors.

Now the 1898 stand was divided (and undone later, see Fig. 2) to a lower base inclusive mirror and stage and to an upper tube carrier inclusive the focus drive (See Fig. 99). A vulcanite fork was always supplied with each such stand X[a]. This fork and the upper part form the Dermatoscope stand for incident-light observation and were capable of focusing down to the surface below the fork (See Fig. 98). Sometimes this small device is designated incorrectly as the earliest Greenough binocular.

The optician Dr. (Carl August Johannes) “Hans” Harting (1868-1951) designed and published the new objective pairs [Harting, 1898] offered in 1902 catalogue (See Fig. 98). A pair of front diaphragms was supplied only to the newly calculated and brightly imaging a_0 objective pair - not intended for orthomorphic vision but to enlarge the sharply imaged field. The Pl pair (f=35 mm) was intended for dipping into water.

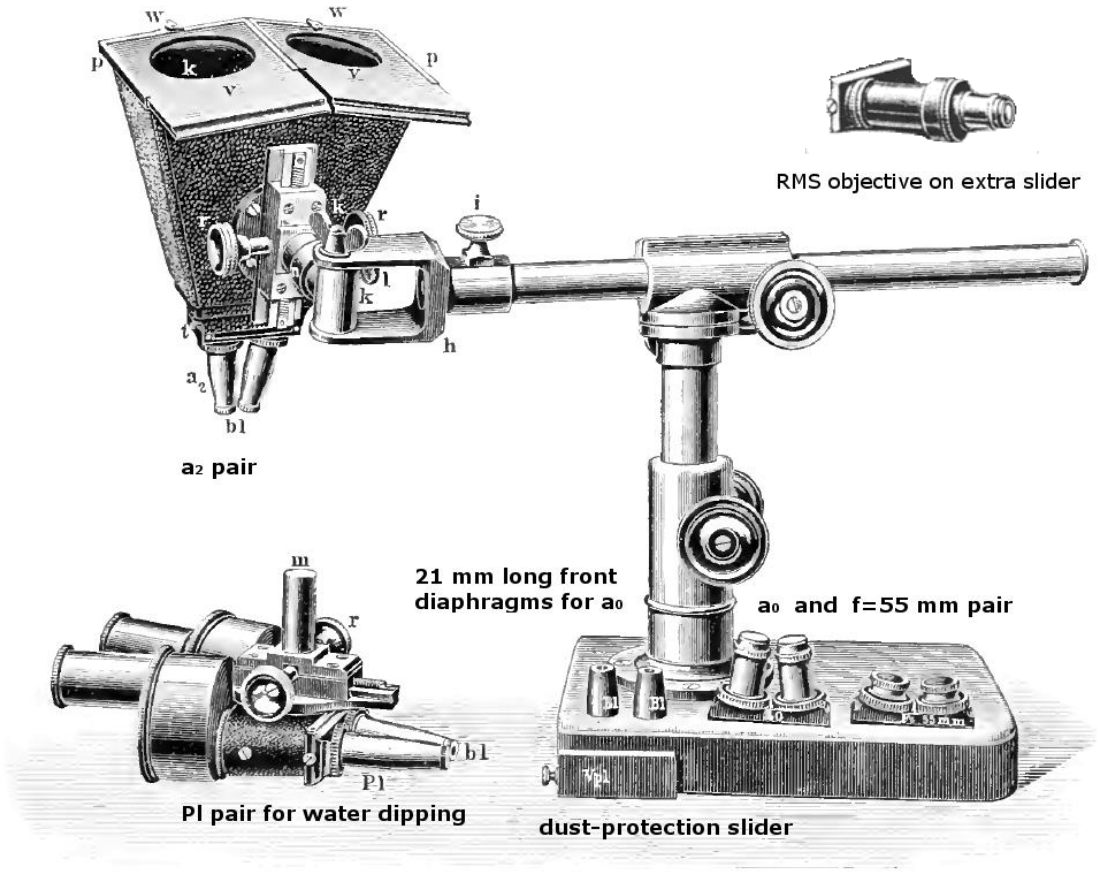

Fig. 100 Stand X^b with Stereoscopic Camera (without Cassettes), Double Tube with Pivot [Drüner, 1900] and RMS Objective on Extra Slider [Zeiss, 1902], Commented by the Authors.

The new stand X^b looks similarly the Braus-Drüner dissecting stand from the 1898 catalogue. On top of the stand plate [Drüner, 1900] we see two additional objective pairs (See Fig. 100). At the suggestion of Professor Leo Drüner (1870-1940), a stereoscopic camera may be immediately substituted for the double tube at the stand X^b by a new pivot junction. The aluminum body included an instantaneous shutter used with Auer nozzle and a time shutter with sunlight. Two 9X6 cm plate cassettes captured simultaneously image scales between 1.6:1 and 7:1 with the various pairs. This earliest (1901 autumn) stereoscopic microscope camera was HSG's demand.

The extra sliding piece for a RMS sized objective is already known. It closes the opening of one tube and completes the 160 mm mechanical tube length of the other tube qualifying it for monocular imaging with high magnification. An additional prerequisite is that the observation tube has to direct vertically to the object surface which now is done easily by rotating the body in the pivot support. In common stereoscopic viewing, each tube is 7° inclined to the vertical on object surface.

The 1902 catalogue shows the first specific application of HSG's microscope in the ophthalmology. Dr. Czapski had known Westin's Binocular (stereoscopic) Corneal Loupe [Zehender, 1887] and created a monocular Corneal Microscope (See Fig. 84) together with ophthalmologist Dr. Fritz Schanz (1863-1923), Dresden [Schanz, 1893]. In 1899 Czapski incorporated the suggestion of binocular observation by Professor Adolph Barkan (1845-1935), a European ophthalmologist in San Francisco. Czapski replaced immediately the planned mono-objective binocular microscope with the stereoscopic one. This essential modification using the f=55 mm objective pair and the introduction of stand X^c resulted in the direct precursor of today's slit lamp. The sliding sole-plate upon a chin-rest base was suggested by the Bavarian ophthalmologist Professor Oskar Eversbusch (1853-1912), Munich [Czapski, 1899].

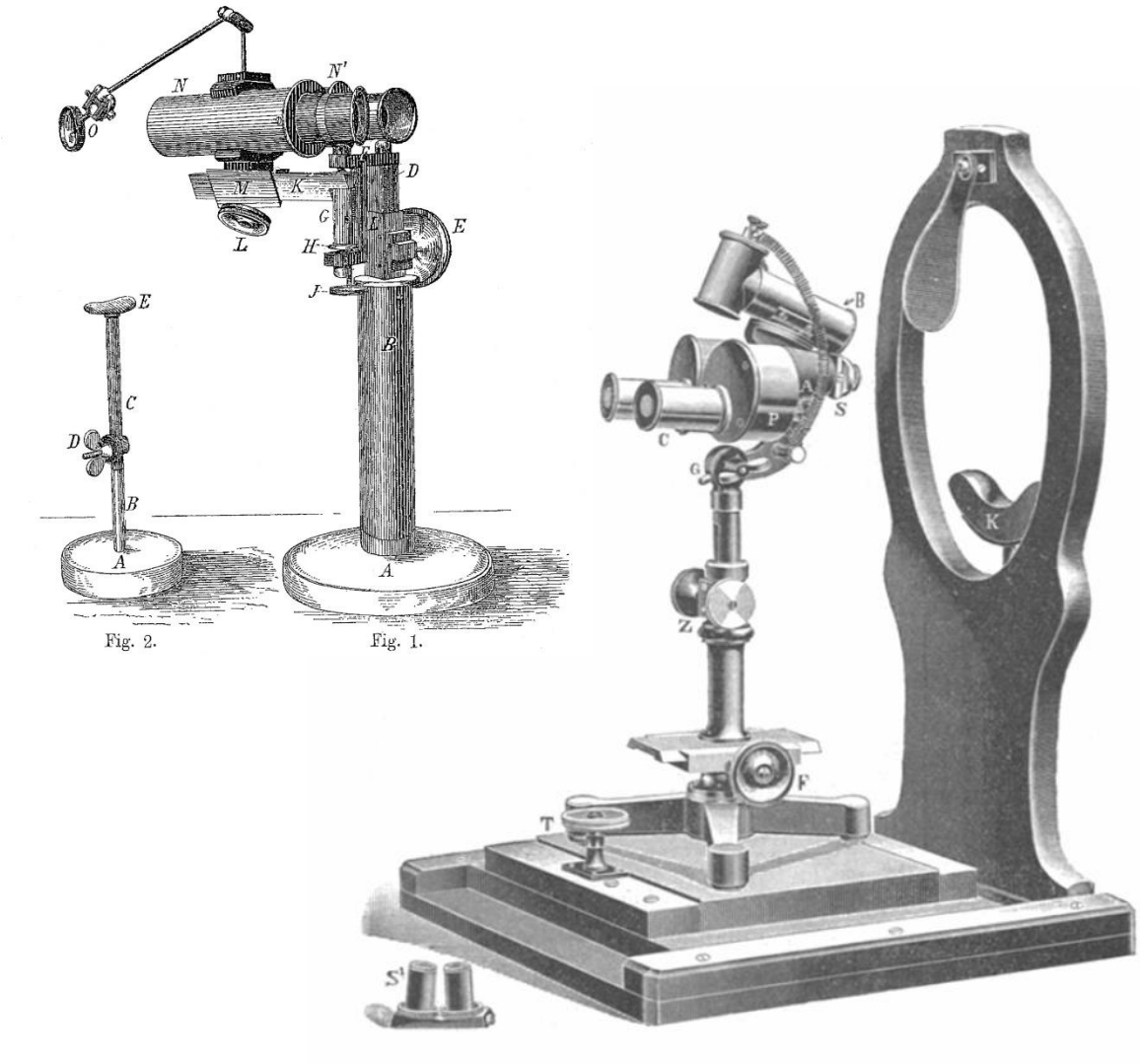

Figure 101 Binocular Corneal Loupe [Zehender, 1887] on Left and Binocular Corneal Microscope [Czapski, 1899].

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This list gives a not-English reference originally, but its content in this paper was translated to English by the authors.

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