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# Who was Horatio Saltonstall Greenough?

## Part 6

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### 31. His Returning to STEM-Field's Promoter

In 1897 October 3, the 52 years aged HSG wrote to Dr. Czapski with the Carl Zeiss Jena Company on his double microscope [BACZ 1579, 72]:

“We shall keep the object glasses for the present as Prof. Walerand [sic, Wallerant] is using the microscope.”

The authors conclude from this sentence and the disconnection to the Laboratoire de Zoologie (See Part 5/29) that HSG had given up his embryological investigation.



Figure 102 Wallerant as Sorbonne's Professor on Mineralogy Later Than 1903 (Detail from [https://commons.wikimedia.org/wiki/File:La\\_Sorbonne.\\_M.\\_le\\_professeur\\_Wallerant\\_\(min%C3%A9ralogie\).jpg](https://commons.wikimedia.org/wiki/File:La_Sorbonne._M._le_professeur_Wallerant_(min%C3%A9ralogie).jpg)).



The No. 28063 pre-series stereomicroscope used by Prof. Wallerant is listed on Zeiss' dispatch book in 1897 May 8 [BACZ 7712, 72] and may look like shown on left side.

Orthomorphy is achieved by adding of conical diaphragms on the objective pair resulting in only 13 mm free working distance (See Part 5/30).

Figure 103 Engraving from Czapski's Paper [Czapski, 1897].

In 1898 March 6, HSG instructed the Zeiss Gentlemen [BACZ 1579, 86]:  
 "I would ask you to send the new Microscope to Professor Wallerand [sic] at Ecole Normale Superieure whenever it is ready for delivery."

This instrument should be personified to Prof. Frédéric (Félix Auguste) Wallerant (1858-1936, see also Part 4/21). The letter mentioned at the start shows a German note written by pencil that a diasporameter shall decrease the distance of both exit pupils corresponding to his very small eye distance. A prism device is meant which displaces the optical axis laterally. This new microscope was handed over to Prof. Wallerant but he had to complain twice [BACZ 1579, 87-88]:

“ÉCOLE NORMALE SUPÉRIEURE  
LABORATOIRE DE GÉOLOGIE,  
45, Rue d’Ulm

Paris, le 8 Juillet 98

Dear Sir,

I completely forgot to mention Mr. H. Greenough's microscope. The apertures placed on the eyepieces are not centered and Mr. Greenough was very sad. Would it be possible to center them? I should be grateful if you could answer this question so that I can inform Mr. Greenough.

Where is the objective (*eyepiece correctly*, the authors) with the diasporameter ??

Dear Sir, be assured of my esteem

F. Wallerant”

Où en est l'objectif avec  
Diasporamètre ??  
Veuillez agréer, Monsieur, l'assurance  
de mes sentiments Distingués  
F. Wallerant

Figure 104 Bottom of Prof. Wallerant's Letter [BACZ 1579, 88].

On July 15, Dr. Czapski wrote to HSG [BACZ 1579, 89-90]:

“Regarding the apertures above the eyepieces, the undersigned has already written to Professor Wallerant a few days ago. In fact, we see no other means of achieving accurate centering than installing a special centering device. If you wish, we would like to do so, but then ask you to send us your eyepieces.”

Three days later HSG replied [BACZ 1579, 92-93]:

“I would say that Professor Wallerand [sic] has this day sent you by your Paris Agent Ednet (*Adnet*, the authors) the no. 2 pair of eyepiece-stops to be centered as per your letter of July 15<sup>th</sup> inst.”

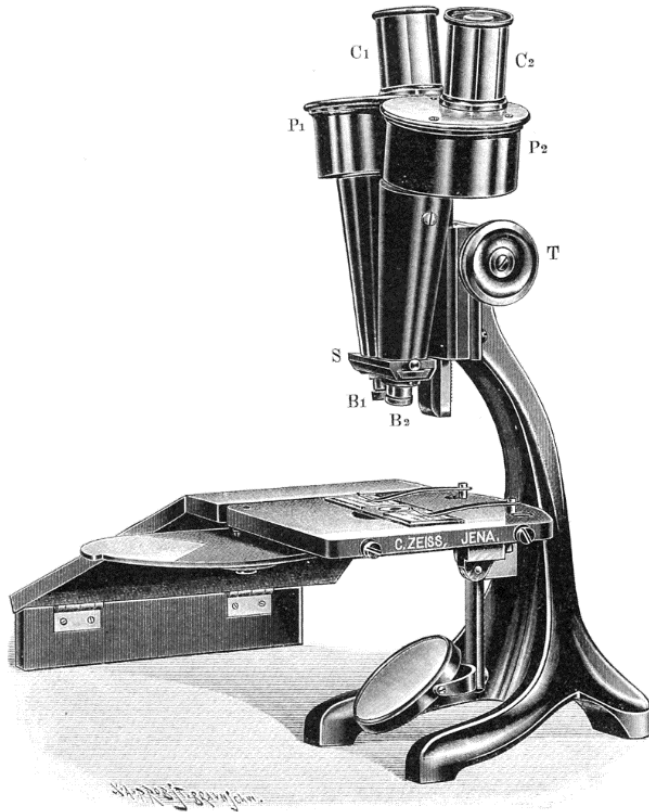


Figure 105 Engraving from Catalogue [Zeiss, 1898].

The objective pair available by Prof. Wallerant is unknown, the No. 2 eyepieces are only mentioned. There is no hint in Jena's dispatch book, probably the special modification may prevent a common notice.

Orthomorphy is achieved by putting diaphragms caps (not shown) on the eyepieces corresponding to the advice of Dr. Czapski (See Part 5/29) and to the design of Dr. Harting (See Part 5/30 and Fig. 120).

Presumably, there was a misunderstanding here: It is hard to imagine that the eyepiece diaphragms were accidentally made off-centered. This property probably harmonized with a modification of the eyepieces for lateral pupil displacement. This assumption is supported by the fact that the complete eyepieces should be returned for correction.

In 1898 July, HSG dealt also with a "special table including batteries" for the artificial sample illumination and finally "decided to wait until electric energy is actually furnished to the laboratory and in working order". Dr. Czapski offered HSG the correction sheet of Zeiss Catalogue for inspection, which had to describe firstly HSG's instruments and was prepared for 1898 mid-September (See Part 5/25).

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HSG's last letter in 1898 was addressed to his friend A. Lawrence Lowell, Boston on October 8 and gave his democratic point of view on French politics [Harvard 13/30]:

“Dear Lawrence

Your letter of the 27<sup>th</sup> ult. was most welcome, especially as I had not heard from you for a long time. You ask my opinion on the Dreyfus matter (*Alfred Dreyfus, 1859-1935*, the authors); well it is briefly this. It is nearly certain that Dreyfus was tried both illegally and unfairly and also a considerable degree of rottenness has been shown to have existed in the War Office staff and it is highly probable that there remains a great deal more still hidden ... The “affaire Dreyfus” has brought out in a striking manner a national characteristic which in my opinion renders France quite incapable of self-government & it is this: French people are incapable of agreeing upon a working compromise when they differ radically in opinion & are very generally prone to impute bad faith to each other & this feature is so marked that public meetings, when permitted generally break up in a free-fight.

The French Republic is an anonymous despotism and a very arbitrary one, without any well-defined responsibility anywhere and the pretorian spirit is very strong, but still I should be very much surprised at any attempt toward a dictatorship, thinks do not look that way but toward a continuance of the clique that has been in power, with variations for so many years past.

Life and property are well protected but there is a great deal of religious persecution and of undue interference [sic] with the liberty of the individual and the country is in my opinion in a condition of decadence from a political point of view, but there is plenty of healthy activity in other directions.

I shall I am sure enjoy your paper on oscillations of political parties; it has not yet come.”



## 32. His Further Fields of Interest

HSG's frequent correspondence to the Carl Zeiss Company was followed by a two years period of quietness beginning in 1898 summer. We know that HSG's activity was limited by his nervous decease beginning in 1897 autumn (See Part 5/29) and he looked therefore for some recreation.



Figure 106 Avenue Carnot Seen to Arc de Triomphe in ca. 1900 (No. 234 E. V. Postcard).

HSG lived at 24 Avenue Carnot in the period from 1900 up to circa 1904. Since 1942 there is established the charming 4-star Hôtel Régence Etoile. HSG's letter of 1900 February 25 was the first one sent from his new address and dealt also with politics:

"I was glad to learn by Mrs. Lowell's kind letter that you are again in England & thinking you may like a bit of news from here I write to tell you what little I can. Things have changed a good deal since you were here in September: the Dreyfus case (*Alfred Dreyfus, 1859-1935*, the authors) has ceased to be an engrossing topic, and now public attention is fixed upon the Boër war (*1899-1902 Second Anglo Boer War*, the authors).

Personally [sic] I consider most unfortunate that the French Clergy as a whole have not followed the advice of Leo XIII (*1810-1903, since 1878 Pope*, the authors) - concerning the support of the existing form of government ... - Let me know if you intend come here and when ..." [Harvard, 27/3].

In 1900 October 2, HSG reported back to the Carl Zeiss Company by a French written telegram sent from Combourg [BACZ 1576, 1]: "I am going on a trip will notify you during my arrival in Paris." HSG's stay was at Lanhélin near Combourg, Ille-et-Vilaine Dept., Brittany where his Sister Charlotte and her husband lived. On the same day HSG addressed a French manuscript of five pages to a "Docteur Ferestier" who was recommended surely by his locally cross-linked Brother-in-Law. HSG fixed the key words "Kinder-Garten – Binocular – Projective – Geometry" [BACZ 1576, 3-7].

Dr. Férester, Mairie (*town hall*, the authors) de Saint-Pierre-de-Plesguen (neighboring town of Lanhélin) forwarded HSG's paper to the Carl Zeiss Company on October 4 [BACZ 1576, 8-9]. The anatomic Prof. Karl (Heinrich) von Bardeleben (1849-1918) with Jena's university noted in German at HSG's manuscript: "The paper of Greenough is unfortunately not suitable for Anatomischer Anzeiger (*Annals of Anatomy*, the authors) in this form."

HSG drew back his paper by a letter to Dr. Czapski on October 10 [BACZ 1576, 10]: "Kindly destroy the manuscript returned to you by Dr. von Bardeleben - I have no doubt his judgement in this matter is best, - I had wished to give the results obtained before making known the method of investigation, but I am now pretty well satisfied that this cannot be done usefully, and that if these results can hereafter be made known, it can only be after a long time and more probably in some mathematical publication.

With many thanks for what you have done for me in this matter I remain ..."

A Mr. O. Hofmann reported in German on HSG by an "Exposition Universelle Paris 1900" headed letter to Dr. Charles Zeiss († 1888) on October 15 [BACZ 1576, 11]:

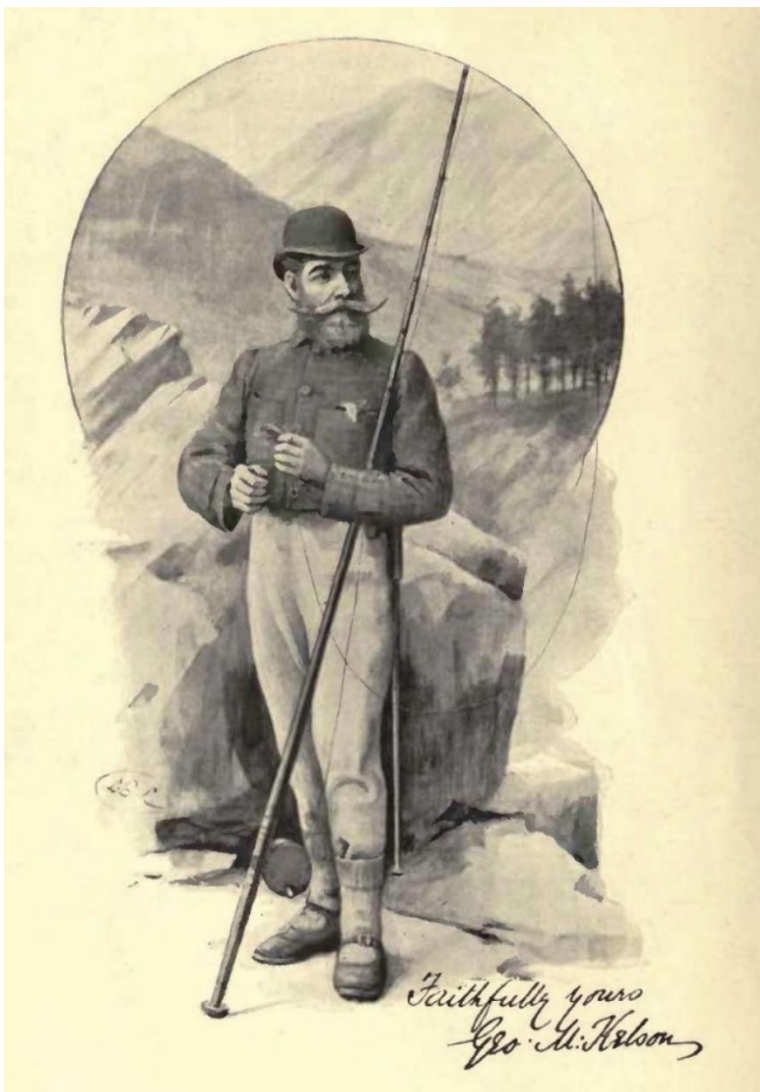
"Dear Mr. Doctor!

Enclosed I am sending you a letter from Mr. Greenough, which this gentleman gave me for you today. Mr. Greenough often visits our section during the last few days and I showed him the Tebmeter (*probably tacheometer, type of theodolite*, the authors) among other instruments. He thinks as I mentioned in my last letter to the company, that this instrument can also be used with advantage for observations and height measurements of birds of prey floating in the air. He thinks to write to you about this after his return from Scotland, where he is now going hunting. I recommend myself to you, in the expectation that you have arrived happily in Jena again ... My best recommendations to Professor Abbe and Mr. Fischer, which I kindly ask you to convey."

HSG visited the splendid World's Fair during April to November and was interested in technical innovations how he done already in the 1889 preceding one (See Part 2/7).

HSG had also roped in Dr. Czapski for his recreation planning and wrote from Paris on October 22 [BACZ 1576, no No.]:

“Take no further trouble to make enquiries concerning sporting facilities in Germany, as quite unexpected by I got yesterday, after posting my letter all the information I wish for and shall I hope go soon to Bavaria for some Hucho (*Latin for Danube salmon*, the authors) & Grayling fishing with a friend whom I found had just returned from a fishing trip there & who expects to go back by the 10<sup>th</sup> or 15<sup>th</sup> of November.”



HSG will reveal this well-informed friend later [BACZ 1576, 76-79]:

“I am looking forward to some two or three months salmon-fishing in company with Mr. George M. Kelson whom my landlord ... has invited to fish with us on the river upon which I myself have just renewed my lease.”

George (Mortimer) Kelson (1835-1920) was a former English cricketer and a current fishing expert who edited the “Land and Water” journal and had published some books including “The Salmon Fly: How to Dress it and How to Use it” in 1895 containing 510 pages of text and 54 pages of illustrations. Kelson liked to lodge at Paris in Hôtel des États-Unis [Herd, 2015]. HSG will use later note paper of this hotel [BACZ 1576, 74+86].

Figure 107 George M. Kelson from “The Salmon Fly” Frontispiece (<https://commons.wikimedia.org/wiki/File:GeorgeMKelson.JPG>).



The last mentioned HSG letter crossed with Dr. Czapski's advices of 1900 October 24 [BACZ 1576, 14-15]:

"As you had already the intention to leave now Paris for a holiday, I would strongly advise you to do so first & to strengthen your nerves which have no doubt suffered by the strain connected with your recent work. – If I were in your place, I would follow the advice of a good medical man also with regard to the kind of recreation ... I am sure your friends or perhaps Mr. Adnet will be able to give you a good advice in this direction. My friendly & urgent advice is therefore to consult the physician first about the mode of life you have to lead.

Unfortunately I am not a bit of a huntsman myself & I have almost no connections whatever with same ... If necessary, you buy Baedeker's guide book ..."

On November 4 HSG did not respond to Czapski's recommendation and described his holiday schedule [BACZ 1576, 17]:

"My permanent address is here (*24 Avenue Carnot*, the authors) ... but I expect to be away for the greater part of the time wishing to had an out of door open-air life, (for the most part) for some months to come & to do very little work indeed ...

I hope to go Kempten, Bavaria, Hotel Zur Krone within a few days and on my return to lower Brittany, after a few days here in Paris, and to pass the next few months between Pont-Aven and Arzano, three hour's drive (*ca. 30 km*, the authors) or so from Pont-Aven, and both in Finisture (*Finistère Dept.*, the authors). I wish to do a good-deal of woodcock (*Wald-Schnaepfe*) shooting and Salmon fishing thus getting plenty of physical exercise together with pleasant distraction: and I have pretty much made all the necessary arrangements though no papers are yet signed ...

P.S. Shall write again from Kempten if I go there as I hope, and later on will keep you posted as to my where-about."

Three weeks later, HSG wrote from the Grand Hotel Leinfelder, Munich, Bavaria [BACZ 1576, 19]:

"I am on my way back to Paris: - I have not sent you any Huchen, as those I caught were all under ten pounds, and though the largest weighing seven pounds was seventy six centimeters long I did not think it big enough to be worth sending, indeed this one was taken on private water, so that I was not free to dispose of it.

I shall take the Orient Express tomorrow if I can get a place in it, and intend writing shortly from Paris ...

P.S. I have enjoyed my trip very much."

An HSG paper was found in the "Country Life Illustrated" British journal of 1901 January [Country, 1901] coming back to his interest in birds. He defends his former speculations:

### PROGRESSIVE FALCONRY.

[TO THE EDITOR OF "COUNTRY LIFE."]

SIR,—I think I can best give the explanations asked for in your note to my second letter on "Progressive Falconry" by explaining in detail what I should expect to be the result of the plan suggested by myself. First, however, let me say that, though I have considerable confidence in the plan I have suggested, I am perfectly aware that in any wholly untried experiment the result may be entirely different from that indicated by theory; and it might happen that my plan would only result, as you think it would, in first spoiling hawks and then losing them. Be this as it may, I will now endeavour to show why I should expect an entirely different result. The first thing I aim at is to have a *tame* falcon in tip-top condition, hence the use of the motor-car, for this should permit of the giving of plenty of exercise at a high rate of speed, and I do not know of any other way in which this could be done. By using eyesses they could be accustomed gradually to the motor-car, and trained to fly with it by means of a long light creance of braided silk. Later on, after they had become thoroughly accustomed to the exercise and to being fed at the end of the flight with freshly-killed food, they would follow the car of their own accord and could be flown free. Exercise at the lure should come next, and this I would continue until a young falcon had become expert at stooping, and from as great a pitch as possible. I would have the motor-car always finish its run at home, the exercise flights ending there, so that the falcons, in case of straying, should return to be fed. Now the success or failure of this plan obviously depends upon two things—first, the inherited instinct to seek and kill quarry; second, the acquired habit of looking to man for food. The reason why I should expect success is very simple indeed, and is merely a special case of the operation of the principle of least-action. The motor-car-trained eyesses would have no fear of man, but would have learned by experience that food, and of the best, could be had with much less effort than by killing wild birds, and this is why I should expect lost hawks to be a rare occurrence with my plan. I should expect them when those to seek the mews as soon as they began to feel *very* hungry. In conclusion, I will again call attention to the most important features of my plan, viz., that the growing eyess should be reared in the highest possible condition, and accustomed to look to the falconer for food. If the inherited instinct proved stronger than the acquired habit, then indeed my plan would have just the result foreseen by yourself. I think, however, that the acquired habit would prevail. Well-conducted experiments could alone determine the result.—HORATIO S. GREENOUGH.

Figure 108 HSG's Paper from "Country Life Illustrated" [Country, 1901].

### 33. His Renewed Requests for Microscope Design

The already quoted Czapski letter of 1900 October 24 [BACZ 1576, 12-16] contains also a negative reply of the Zeiss scientists to an HSG design request which is not coming down:

“My dear Mr. Greenough!

When I came back from my visit to the Paris Exhibition, (I did not know your present address else I should have tried to call upon you) I found a lot of papers you had addressed partly to the firm of Carl Zeiss, partly to myself in the meantime. Unfortunately I had a bad cold shortly after my return so that I had to stay in bed for a couple of days.

This in connection with a great deal of other urgent work awaiting me after an absence of several weeks, has prevented me from entering fully into your explanations & even from giving you a preliminary reply. However in order to acknowledge at least the due receipt of the various communications sent partly direct, partly through Messrs. Hofmann & Dr. Culmann, I wired you as follows: “Your letters received answer follows”.

In the meantime several of our scientific collaborators have closely looked into your explanations, however they have only come to the following conclusion:

‘The apparatus suggested by you are not fit for the firm of Carl Zeiss owing to their construction & designation. The firm must therefore decline to carry out this construction & you are, of course, quite at liberty to have same executed wherever & by whomever you like.’ -

As mentioned above, neither I nor Prof. Abbe have been able as yet to devote our line to your problem & when I consider the great amount of work awaiting me very shortly, I can hardly name a date when I shall have a little time to spare for it. This is also one of the reasons why the firm cannot enter just now into your proposal, viz. the accumulation of other, partly most urgent construction problems.”

HSG continued to insist on his orthomorphic concept by a first letter to Dr. Czapski on 1900 December 1. It announced firstly an arc illuminator as essential accessory to his double microscope [BACZ 1576, 20]:

“The centering apparatus has been made under Professor Wallerant’s direction and works all right – the results obtained by us whilst good as far they go do not warrant the expenditure of what would be needed for the construction of the electric light attachment – Before this can be done to advantage it will be necessary to reconstruct the Dioptric portion of the microscope with special reference to the Orthomorphic effect obtainable by the use of the finest pair i.e. smallest pair of pine hole stops, in the manner indicated to me by yourself in 1897&1898 (See Part 5/29, the authors).

The objectives being built with special reference to getting a wider field, and the eyepieces specially constructed with a view to giving at a short distance above themselves real image of the imaginary centres of projection i.e. of the two extremities of the line a in my equation  $A/a=D$  (1). – Before you undertake this it will in my opinion be best 1<sup>st</sup> to construct both my “Projectograph” 1) & my Immutoscope 2) as indicated recently by myself to Dr. Culemann [sic] & thus to make yourself thoroughly familiar in a practical manner with the purely geometrical aspect of this question and also to verify by actual experiment made in the simplest manner of real practical validity of the geometrical theory of my proposed Orthomorphic Microscope; - you will obtain similar results to what are had with the Verascope (*French stereoscopic camera, see Part 4/19, the authors*) which is merely a special case of my Immutoscope viz. – when the imaginary centres of projection & the Projective Meta-centre are both (theoretically) at the point at infinity and when  $D=1$ .

I will add that it may be worth your while to reconsider the mode of construction for it still appears to me that the straight tube construction is very much better for the purpose of obtaining practical Orthomorphy. The technical difficulties are purely mechanical ones of obtaining good automatic action & with the various link motions now known should offer no serious obstacles to a capable mechanical engineer [sic]; and the practical optical advantages are very decided – small pinhole stops just in front of the eyes are inconvenient and disagreeable [sic] and with the straight tube instrument could I think be avoided – as indicated herewith diagrammatically...”

This small sketch is already known and shows straight tubes, each one includes a first and a second objective and the geometric arrangement corresponds to  $A/a=D$ . A first confused mechanical design attempt follows which will be completed later:

“I do not know if I have made myself understood – it is not easy on paper but I can go over the matter later on with Dr. Culemann [sic] when he returns to Paris ... I ask for no haste on your part but only for careful study of the question once more at your convenience.”

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1) A German reply manuscript says [BACZ 1576, 83]: “We have noted with keen interest the information you have kindly sent us about the planned “Projectograph” and its likely versatility. In accordance with your wishes, we have also submitted the matter to Professor Abbe. With his approval, we would like to inform you that we regret that we are currently unable to devote the necessary attention to your invention for its proper development ...”

A Projectograph instrument will be published later by the English lecturer T. E. Wallis which projected the image of a specimen slide on a wall screen [Wallis, 1930]. A Projectograph Corp., Wisconsin will sell a slide projector with a built-in screen.

2) Dr. Culmann stated [BACZ 1576, 37] that a stereoscope described in the 1895 book “Stéréoscopie de précision - Théorie et pratique” by L. Cazes is precisely equivalent to HSG’s Immutoscope (Latin immuto = I change).

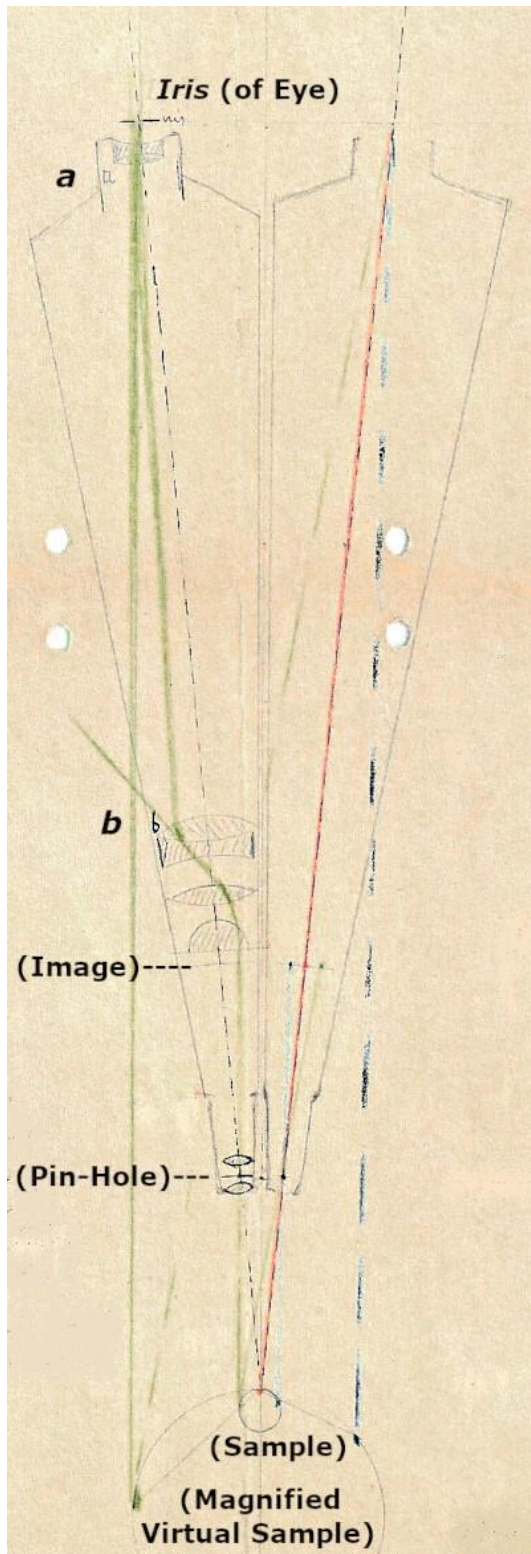
HSG's second and blurred letter of December 1 describes a new microscope version and appealed imploring to Dr. Czapski to construct it [BACZ 1576, 21]:

“My dear Dr. Czapski

Yesterday afternoon whilst at Neal's reading rooms I picked up last Thursday's Photography [Goodwin,1900] and found a short note on lenses which immediately recalled to me the original construction proposed by myself for the Orthomorphic Microscope in my letter of July 4<sup>th</sup> 1892– Owing to technical reasons this construction will probably not be applicable above  $D=20$  but may be applicable as high as that I would suggest that can as much as the construction offers one important advantage viz the independence of Orthomorphy & of the amount of stopping which only affects the focal depth with it, that you try it first for  $D=6$  (the same tubes will do for your own construction, - with the erecting prisms omitted when the Orthomorphic effect is essentially dependent upon the use of the pin-hole stops.) when the technical difficulties will be least, this magnification will already be very useful especially for the study of certain stages of animalian [sic] embryos ... and then for  $D=12$  and if possible as I think will prove to be the case for  $D=24$ ; for this magnification powers your construction may well prove to be better, and for  $D>20$  it, your construction will be necessary indispensable.

The experiments just tried by Prof. Wallerant & myself ... indicate clearly that a really practical instrument of commercial value can be constructed; all that is needed is that you should reconsider the whole matter, attacking the problem from my point of view, (i.e. the point of view of the morphologist and of the modeler) seeking to construct an instrument of which the electric-light attachment is an essential constitution as pointed out in my letter of 1898, except indeed for the very low power of  $D=6$ , and having in mind that whilst extreme real definition is not needed, yet on the other hand a good average definition for a depth equal to the field is quite indispensable to practical efficiency. - The experiments so far tried indicate truly that these results can be obtained and the practical failure of the present instrument I attribute to its being need by me for a purpose you had not in view in constructing it for it is quite apparent that the descriptive construction is not designed specially to be used with pin-hole stops over the eye-pieces ... I will now briefly recall the construction 1<sup>st</sup> proposed by myself & which will I think apply well to a microscope where  $D=6$ . – I proposed to employ 2 pair of objectives, the front pair having each one of them a symmetric doublet so constructed that its geometrical centre of projection should lie mid-way between the two component lenses ...”





HSG comments his sketch [BACZ 1576, folio size] scaled corresponding  $a/A = 6$ :

“In this sketch  $D=6$  and diameter of front objective stops is taken at  $1/3$  millimetre but this is too small to be drawn to scale. The diameter of the pupil is assumed at 2 millimeters. The Green delineating pencils both real and virtual are shown on one side and on the other the geometrical perspective for three points Green, red and blue <sup>1)</sup>. Optically the seeker Eye-piece is composed both of the mechanical eyepiece with lens **a** and of lens **b** <sup>2)</sup>”.

1) The real pencil through the lenses shows both image inversions resulting in an upright sample vision which is stated by the straight virtual pencil imaging the left sample edge (green lines). The blue dotted virtual line shall show this for a point of right sample half and the red line projects the sample center along the optical axis.

2) The achromatic divergent lens **a** inside the mechanical eyepiece creates a non-inverted virtual image like given by Galilean telescope. The lens cluster **b** looks like a microscope objective and enlarges the real image provided by the first simple doublet inclusive the pin-hole remembering to a rapid rectilinear or an aplanat. The cluster **b** is unique in HSG's sketches and was copied surely but not from Goodwin's paper. This qualified optics correlates with HSG's idea that the main magnification shall be located by the second objective (See Part 5/28).

Figure 109 HSG's Low-Power Orthomorphic Microscope [BACZ 1576, folio size], Commented by Authors.

HSG's permanent rejection of the Abbe-Porro prisms neglects the individual eye distances requiring an interpupillary adjustment which he had not yet resolved. There are arguments for convergently arranged tubes but not for urgently straight ones: "In the human optical system the convergence of the eyes and the focal length of their lenses are connected ... If a large number of flat objects has to be observed, the rest condition of the eyes (*at infinity*, the authors) with the parallel tube instrument is an advantage. If general studies must be undertaken, the eyes will be more comfortable with the convergent form of instrument. In this case, the eyes being convergent, some accommodation in depth is possible without necessarily losing fusion, as the eyes are found to be able to wander slightly between parts of the object above and below exact focus and still maintain true binocular vision. If the instrument happens to be of the stereoscopic type, the advantage of converging tubes is greater" [Burrells, 1961].

HSG wanted to continue simultaneously his recreation [BACZ 1576, 20]:

"I am leaving Paris for Pont-Aven in lower Brittany ... on the 14<sup>th</sup> of this present December and I hope to pass most of the time there from now until May having leased some woodcock-shooting and also some Salmon-fishing."



Figure 110 Dining Room of Villa Julia Hotel at Pont-Aven (Morvan editeur, Pont-Aven – Phot. Leclaire).

HSG will stay at the Villa Julia Hotel at Pont-Aven. Its lovely surrounding and the comfortably fitted hotel attracted American and English painters and today therein resides a museum presenting their works of art.



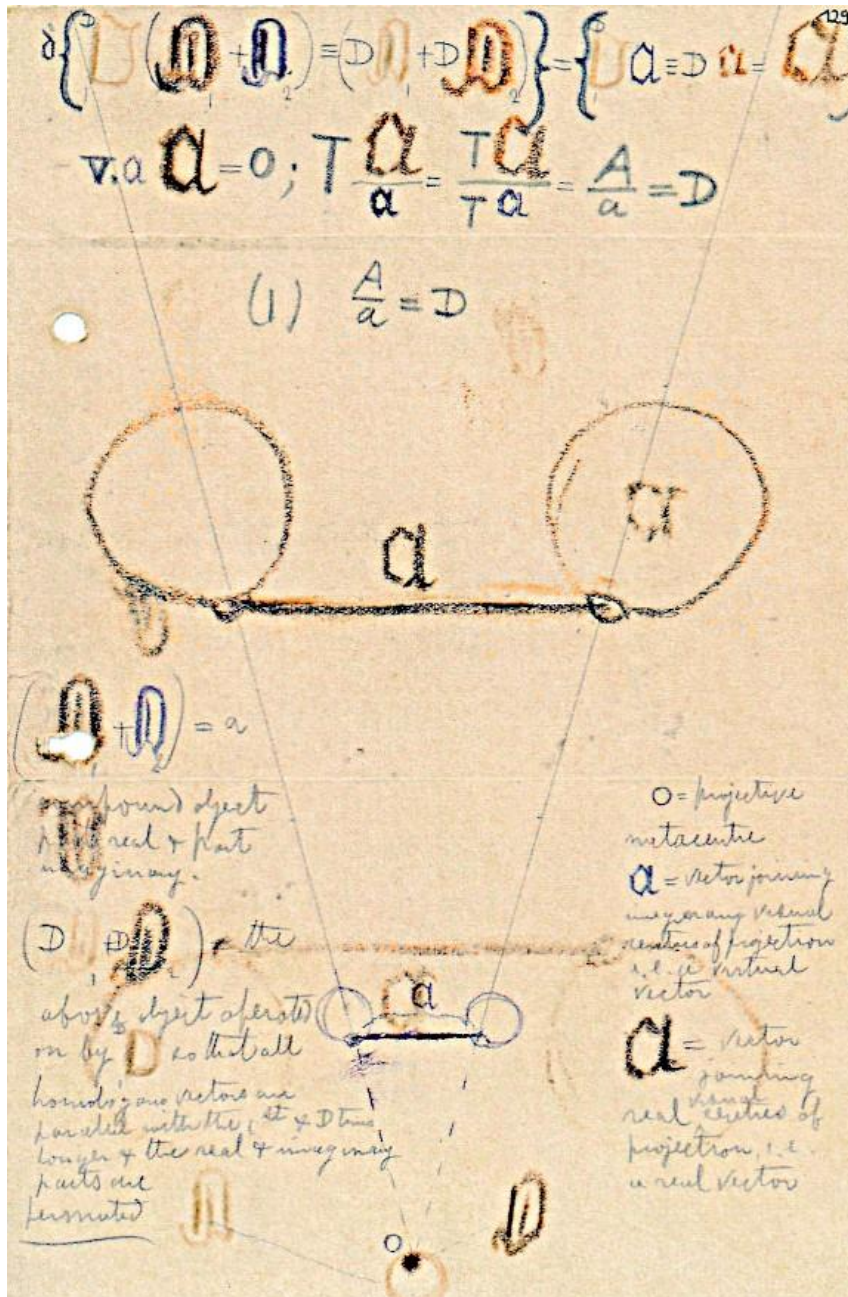


Figure 111 HSG's Demonstration of Geometrical Theory of Orthomorphic Microscope [BACZ 1576, 129].

The sketch "Demonstration of the geometrical theory of proposed Orthomorphic Microscope" dates from 1900 December 2<sup>nd</sup> and its unnecessary vector formulation is explained by HSG [BACZ 1576, 129]:

"This demonstration has been made diagrammatically to avoid the prolixity of the use of the literary form, - the Algebraic symbols represent actual geometrical operations."

In 1901 January 5, Dr. Czapski came towards HSG's intentions by a handwritten letter and proposed financial conditions for first time [BACZ 1576, 22-23]:

"Having heard from D<sup>r</sup>. Culmann that you left Paris some time ago already, we are writing you today to the address formerly given (*Villa Julia Hotel*, the authors) to the undersigned trusting this letter will duly reach you there.

In order that we joint efforts - for the construction of optical apparatus are not subject to the previsions lack of clearness respecting their financial point we herewith bag to make the following suggestions:

1) We undertake to make here at our own risk expense for the trial instrument those parts on these apparatus [sic] which are fit for our own manufacture. For the present we have fixed these costs at Mcs 1000.- at the same time mentioning that by "costs" the disbursements with the usual additional expenses are understood so that no profit whatever is taken into consideration. -

2) After the definite model has been fixed we allow you on every specimen sold through us 3% of the list price, i.e. the price valid for the user of the instrument so that the discount for agents & others is not considered.

We trust that point 1) will facilitate your entering into the trials. In view of the circumstances that in any case a considerable amount of work will have to be done by us before a definite model is attained, we thought it well to fix your share of the instruments sold, at 3%, which we found will meet with your approval. - With our best wishes for a happy New Year which particularly refer to your restoration to health ..."



In 1931 after HSG's death, the Carl Zeiss Company designed the stereoscopic loupe microscope XII as the small brother of the stereomicroscope X. The double tube XII is built by the optical blue-print of the X one but uses the economy-priced prism body of the field glasses. The three objective pairs and the three wide-field eyepiece pairs provide 4X ... 43X general magnification and are completed by a multitude of relevant stands [Mikro 464].

Figure 112 Binocular Stand Loupe XII A [Mikro 464].

In 1901 January 11, HSG replied from Paris by a personal letter [BACZ 1576, 24]:

“My dear Dr. Czapski

The letter from your house dated Jany. [sic] 5<sup>th</sup> is perfectly satisfactory in relation to every clearly defined statement that it contains. – With regard to what is implied in general terms I can only say that it has my approval so far as I understand it.

I have been obliged to return to Paris quite unexpectedly but may go back to the country after a bit & shall be glad to do so if I can as have found the out of door live very beneficial to me.

With best wishes for a happy new year ...”

A second letter from the same day expected HSG’s task of the Zeiss Gentleman [BACZ 1576, 25]:

“In reply to your favour of the 5<sup>th</sup> inst I would say that the commission of 3% on list price is perfectly satisfactory to me also I shall be pleased to enter into the trials and for this purpose will appropriate from my income a sum of Fr. 1250 being the equivalent of the Mcs 1000 which you are appropriating for such portions of the apparatus as can be made in your establishment. I would suggest that in order to secure the best possible concerted action it would be advisable for you to let me pay the appropriated 1250 francs into your hands by installments & for you to yourselves assume my content (*arc illuminator*, the authors) with Mess<sup>rs</sup> Radiguet&Massiot.”

A German note written by pencil asks: “Are their demands not exaggerated? Is the company at all recommendable?” Dr. Culmann answers on January 18 [BACZ 1576, 27]: „The company Radiguet is well known to me, it is an active company, which has made in X-ray in recent times.” By the way, this company had won four Gold Medals at the 1900 World’s Fair like mentioned by its notepaper.

HSG’s schedule threatened to change then he wrote on January 14 [BACZ 1576, 26]:

“Kindly inform me at your earliest convenience whether the business between us makes it expedient for me to remain on this side of the Atlantic. – I have been called back to Paris quite unexpectedly by letters concerning matters of which the decision requires an explicit answer to the above question.”

The reply of January 16 [BACZ 1576, 30] after Czapski’s draft of the 14th reminded HSG of his unfinished task:

“I think that after the design for the first model has been fixed, you may safely stay a couple of months on the other side of the Atlantic without prejudicing in any way the matter in question. -

In the meantime we are awaiting your further communications about your entering into a trial construction ... (*the following is handwritten by Dr. Czapski*, the authors)

I was glad to hear that some weeks staying at Pont-Aven have done you so well.”



### 34. His Arc Lamp Project Assisted by Dr. Culmann

An HSG letter of 1900 November 4 had indicated a new contact [BACZ 1576, 17]:

“I am very pleased that Dr. Culemann [sic] is to be in Paris and look forward with much pleasure to personal scientific intercourse with him – it is so much easier to get into touch with people by word of mouth & with a back-board etc. than merely by letter.”

From 1900 January the Swiss Dr. Paul (Frédéric) Culmann (1860-1936) worked as the first Sales Representative in Paris. He is well known as a bryologist but he was a physicist from his study. In 1884 he was promoted on the Philosophical Department of Berlin’s University half a year later than Dr. Czapski who was one of Culmann’s experts. Later he will revise “The Realization of Optical Imaging”, the Chapter IV of “The Theory of Optical Instruments” book [Rohr et.al., 1904].

He will publish a paper [Culmann, 1904] on a monocular and image erecting prism microscope which combines the handling of the well-tried Loupe Stand I after Prof. Paul Mayer (See Part 4/18) with the stand of the series stereomicroscope inclusive its Abbe-Porro prism. An erected image is achieved using RMS objectives both with low power (10 ... 26X) for dissection and medium power (125 or 220X) for detail observation or variable power of the a\* objective (3 ... 33X) for drawing work. This multipurpose microscope XI was probably induced by Culmann’s request in bryological investigation.

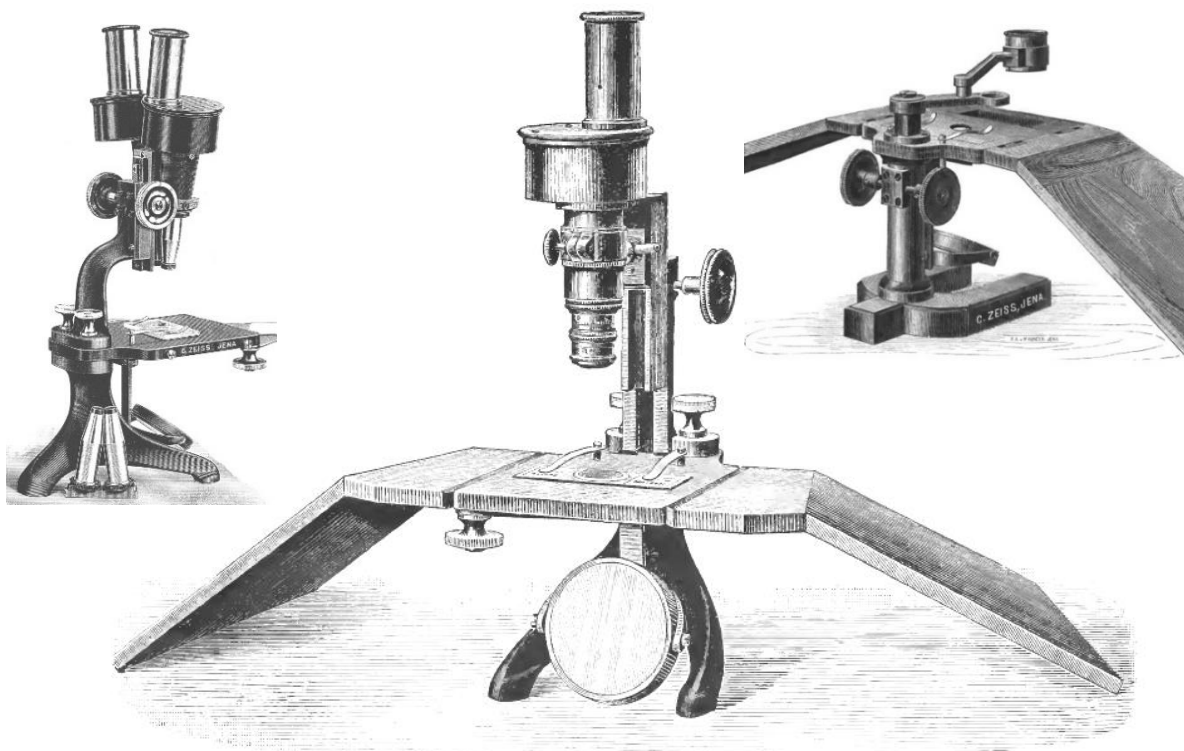


Figure 113 Dissecting Prism Microscope XI [Culmann, 1904] and Inspiring Predecessors [Zeiss, 1902].

HSG's letter of 1901 January 28 [BACZ 1576, 28] to Dr. Czapski came from Pont-Aven:

"Your favour [sic] of the 24<sup>th</sup> inst. is duly received as also the list of cameras fitted with Zeiss Lenses and the 'Palmos' Catalogue for all of which many thanks. – Should I find it practicable to take up Natural History photography as I wish to do I hope after some experience to avoid myself of your kind offer, for the immediate future I shall confine myself to doing, if anything, only what can be done with such special Naturalist's cameras as are now to be had or shortly to be put on the market in England: and I have advised Dr. Culmann to that effect.

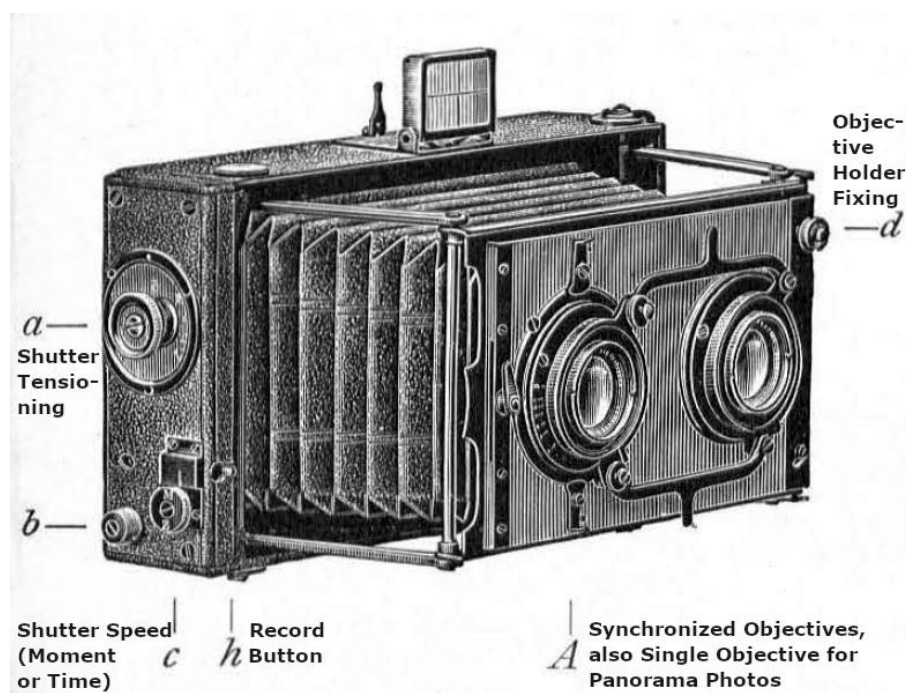


Figure 114 Stereo-Palmos 9x18 cm Camera of Carl Zeiss Jena, 1904 (Courtesy Carl Zeiss Archive), Commented by Authors.

On my return to Paris I will send you Copy of Mess<sup>rs</sup> Radiguet&Massiot's letter which refers only to one portion of the electric light attachment viz. the small arc lamp & special condenser for forming a beam of highly concentrated light nearly vertically upon the object under the Microscope ... (*Discussion of prices deleted*, the authors) - The arc lamp will have a concave mirror, an alum cell, an iris diaphragm & two lenses the front of isometric glass: The reputation of Mess<sup>rs</sup> Radiguet&Massiot is excellent both for honorability & credit. They cannot give me any more explicit statement as to price without further details from myself and these I cannot give as I have no means of making the necessary experiments ..."

HSG wrote in this sense to Dr. Culmann on February 16 [BACZ 1576, 35-36]:

“I think it will be best that your house should assume my contract with Mess<sup>rs</sup> Radiguet&Massiot, as this line of action appears to me to the most in accordance with a well-defined responsibility for the execution of the proposed electric light attachment and for the determination of working details of the same ... As I understand this agreement it will only bind your house for construction of a preliminary model & afterwards you will be quite free to do as you may deem best.”

HSG added a French written definition for the arc illuminator to this letter. HSG's description of his instrument includes the “Greenough dissecting microscope” phrase in spite of his conflict in scientific interests with the Zeiss Company [BACZ 1576, 31]: “The essential part of the apparatus consists of the Greenough dissection microscope, equipped with eyepieces for the orthomorphic effect according to Czapski system; a Greenough device must be equipped with eyepieces that have apertures above the eyepieces according to Czapski system.”

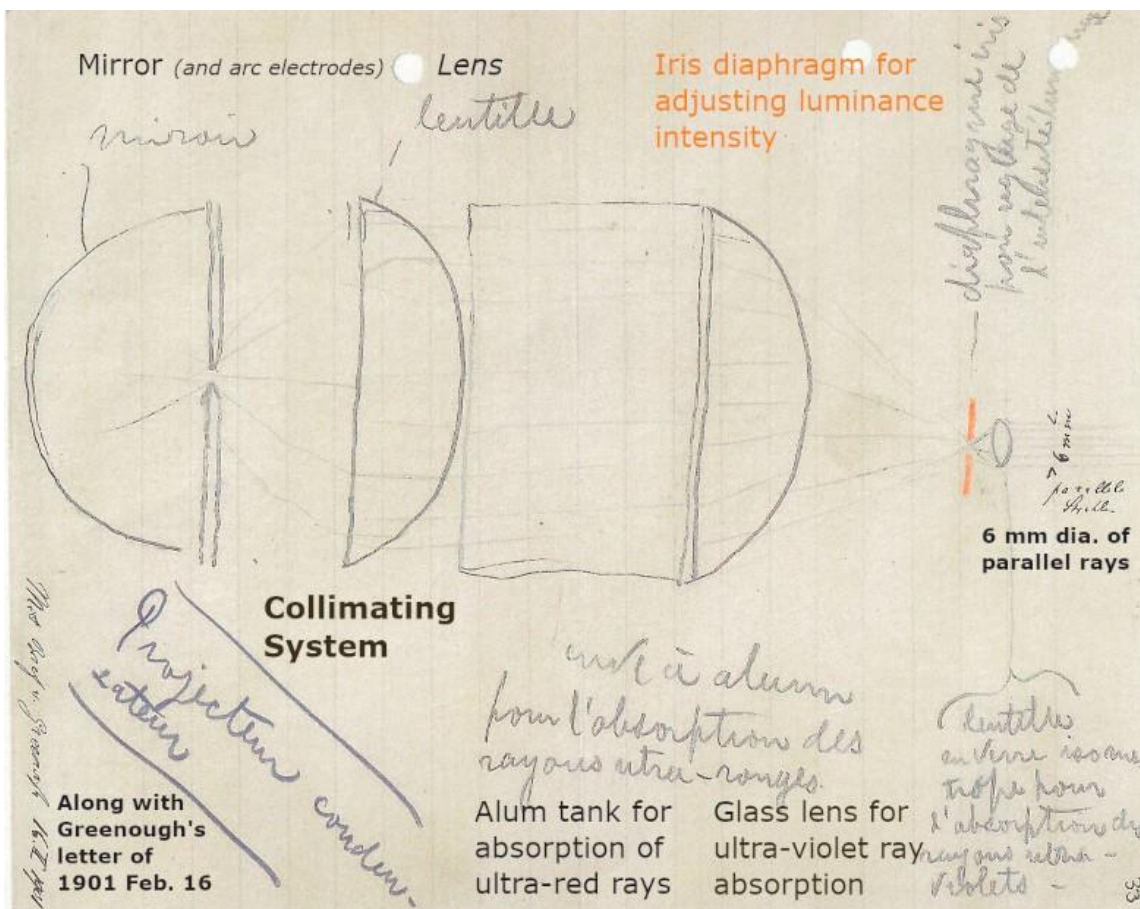


Figure 115 HSG's Sketch of Arc Illuminator [BACZ 1576, 33], Translated by Authors.

Dr. Culmann suggested to the Carl Zeiss Company on February 21 [BACZ 1576, 38]: “It would therefore be better, in my opinion, if the company would make the illuminating apparatus itself, instead of giving Radiguet more detailed instructions about the same ... The apparatus which Greenough has drawn, and which he regards only as a preliminary experimental apparatus, can be assembled with lenses available in Jena ... Mr. Greenough would also be prepared to go to Jena later to have a look at the matter.”

Dr. Culmann reported on March 5 [BACZ 1576, 39]: “I went to visit Mr. Greenough yesterday. It is very dear to him if the company takes over the execution of the lighting apparatus. He has commissioned me to negotiate with Radiguet and has given me a letter to him ... Mr. Greenough also told me that you were counting on his cooperation and asked how he could be useful to the cause. In any case, he will probably remain in Europe until November. I wonder when the apparatus will be ready?”

On March 12 Dr. Culmann added [BACZ 1576, 43]: “Mr. Greenough asks me to tell you that he hopes his presence in Jena will not be necessary, that it would be difficult for him to make the trip; if I understood him correctly, because of the costs involved.”

Dr. Culmann clarified the commissioned work by HSG on March 23 [BACZ 1576, 44]: “I was at Radiguet's on the 20th. At first, he thought it was something completely different, so he had obviously forgotten all about Greenough ... In my opinion, one could simply let the matter rest if he does not answer. He has then just nothing to charge.”

HSG will be disappointed finally because the Carl Zeiss Company did not accept his excessive wish inclusive their considerable costs. In 1901 September 27, HSG will complain to the Zeiss Gentleman about missing response on his illumination request [BACZ 1576, 53]:

“I would say that I do not see how you can test my design for the Orthomorphic Microscope properly without first having the electric-light attachment to experiment with, as I have ascertained by actual trial that other lights are not sufficient to admit of the use, in general, of the very fine stops needed for the attainment of the required depth and also that with these very small stops, the desired depth can be obtained and with an ample definition. – I hope you will provide the electric-light-attachment before doing anything more because I deem it a pure waste not only of money, but also of both time and labour [sic] to attempt anything towards the construction of the Orthomorphic Microscope, with one of its essentials omitted.”

A hand-written German note on the letter says: “Answer for the time being! When Dr. Köhler returns, we will go into the question in more detail.”



### 35. His Dwarf Parable for Orthomorphy

HSG finished the “Geometrical Theory of the Orthomorphic Microscope” summary in 1901 April 6 and sent it to the Zeiss Company [BACZ 1576, 46-50]. The long-winded introduction may shorten: Projection lines start from the so-called **C** metacenter and are tangent the object outline. Due to the angles between these lines, their distances increase by their elongation, meaning a projective dilatation of the object shadow but not a creation of a real image. This simple geometric relation is followed by HSG’s Dwarf Parable of the Orthomorphy:

“II. - Next suppose a virtual or imaginary dwarf looking at a real object and let the intersection of the optic axes be the projective metacentre [sic], - then producing the above described metamorphic-projective-pure Dilatation we have a real human observer looking at a virtual object, and if  $\underline{a}$  is the distance between the centres of the pupils of the Dwarf and  $\underline{A}$  that between the centres of the pupils of the real human observer we get of course

(1)  $\underline{A/a=D}$  and the extremities of  $\underline{A}$  and  $\underline{a}$  are situated upon a pair of straight lines radiating from the projective metacentre **C**.

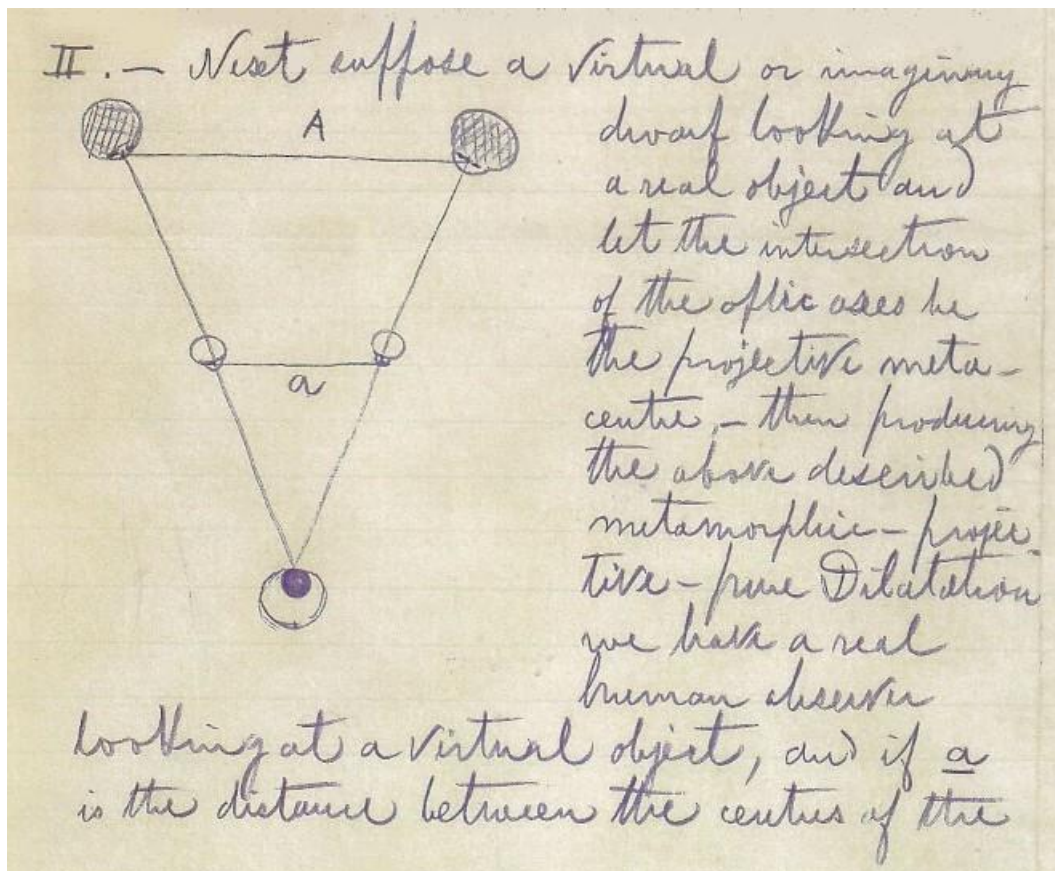


Figure 116 HSG’s Dwarf Parable of Orthomorphy [BACZ 1576, 48].



We have next to consider how by a physical agency it is possible theoretically to give practical effect to the foregoing theory. For this purpose –  
 1<sup>st</sup> suppose a pair of fine pin-hole stops to be put at the extremities of a ...”

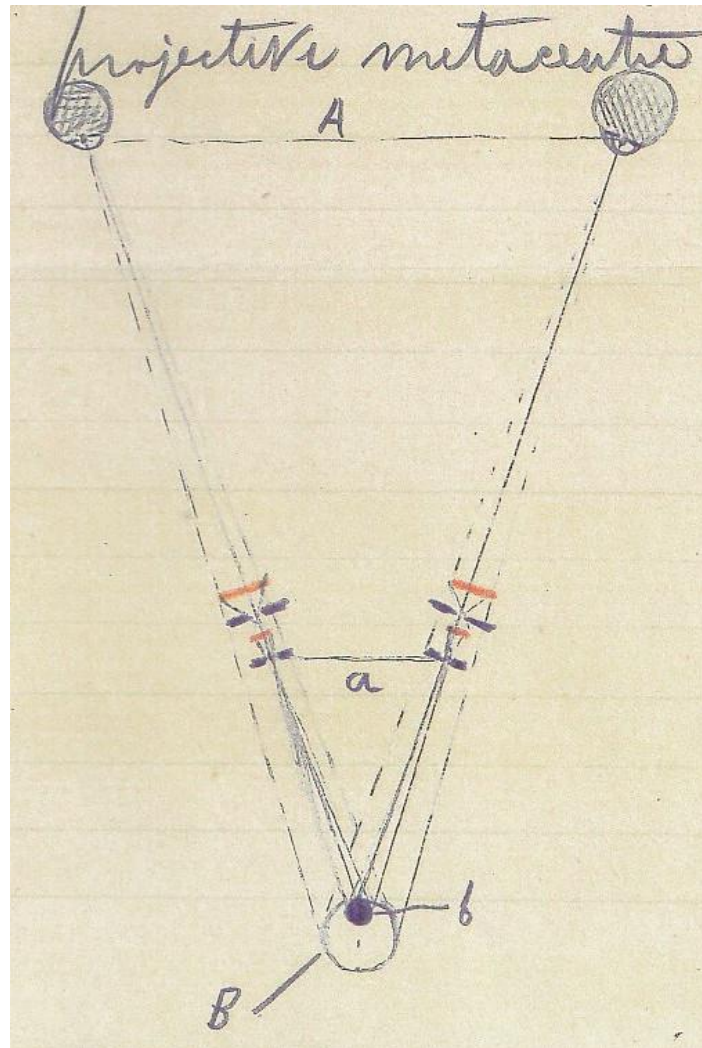


Figure 117 HSG's Physical Agency of Orthomorphic Microscope [BACZ 1576, 48].

HSG's physical agency includes no refracting components and shall need further a "Combination of properly constructed dioptric apparatus". His basic request consists in the coincidence of the **b** real object and the **B** magnified virtual image on the one hand and their related vision lines on the other hand. The drawing itself seems to show a strange mix of optical phenomena: A pinhole shall produce an inverted image like a camera obscura but unrealistically in a short distance and by an increased ray inclination similarly the Huygens' diffraction. The successive use of two pinholes would erect the **B** image corresponding to the suggested concept and HSG's wish. A maximum of image depth was HSG's principal cause of fitting in these pinholes.

“2<sup>d</sup> Suppose the human eye to be sensitive to light of immensely shorter wave-length than is actually the case, and furthermore suppose the real object **b** to be so lighted that it emits light of most intensely dazzling brilliancy, so great that if we put at the extremities of **a** a pair of microscopic pin-hole stops and a suitable pair of screens at the plans of the smaller red marks, there will be formed upon these screens a pair of images that shall still be very much too brilliant for it to be possible to look at them but of such degree of brilliancy that if we put back of them a second pair of microscopic pin-hole stops images of suitable brilliancy will be formed at the place of the larger pair of red marks. – Then under the supposed conditions the observer will see in natural colours [sic] a virtual object identical, theoretically with the imaginary object **B**.

I have thought that by the Combination of properly constructed dioptric apparatus, including as an essential of the same a pair of suitably made pin-hole stops, and of a specially designed Electric-light apparatus it should be practicable actually to give practical effect to the above theory of the proposed Orthomorphic-Microscope.”

The “light of immensely shorter wave-length” phrase could mean an UV illumination by the arc lamp (without the foreseen glass absorption) and would result in a better resolution. The apparent contradiction between the UV imaging and the “observer will see in natural colors a virtual object” phrase could be solved if HSG had observed already the autofluorescence of biological specimen. The “suitable pair of screens at the plans of the smaller red marks” could act as barrier filters.

The ultraviolet rays have been discovered in 1801 by Johann Wilhelm Ritter (1776-1810), a self-taught chemist, physicist and Romantic philosopher at Jena, who was personally acquainted with Johann Wolfgang von Goethe (1749-1832) and Alexander von Humboldt (1769-1859).

In 1900 Dr. August (Karl Johann Valentin) Köhler (1866-1948) had be invited to join the Zeiss Company and we has learned already that this illumination and microphotography specialist was participated in HSG’s project. The microscopic autofluorescence was mentioned firstly in literature by Dr. Köhler accompanying the Zeiss development of the UV microscope for increased resolution – however three years later than HSG’s note:

“The observation of the fluorescent light, which the majority of the objects I have examined emit when illuminated with ultraviolet light, could perhaps also become important in some cases ...” [Köhler, 1904].

The above quoted summery was accompanied by an HSG letter of the same day to Dr. Czapski [BACZ 1576, 51]:

"I enclose herewith rough sketches of an improved pattern of pin-hole-stop and also of method of making the same ... I did not think it worthwhile to call your attention to the matter: but on reading in the April 1901 Photogram [Bolas, 1901] that much better definition in pin-hole photographs can be had by using the improved pattern of pin-hole (readily made by the indicated punching & filing method), I have deemed it best to call your attention to this improved pattern as it appears sufficiently obvious that better definition ... would also be secured by the same device if employed in the pinhole stops of the proposed Orthomorphic Microscope ... I will add that I have no intention of urging this mode of construction upon you, but have only wished to call your attention to it leaving the decision entirely with yourself."

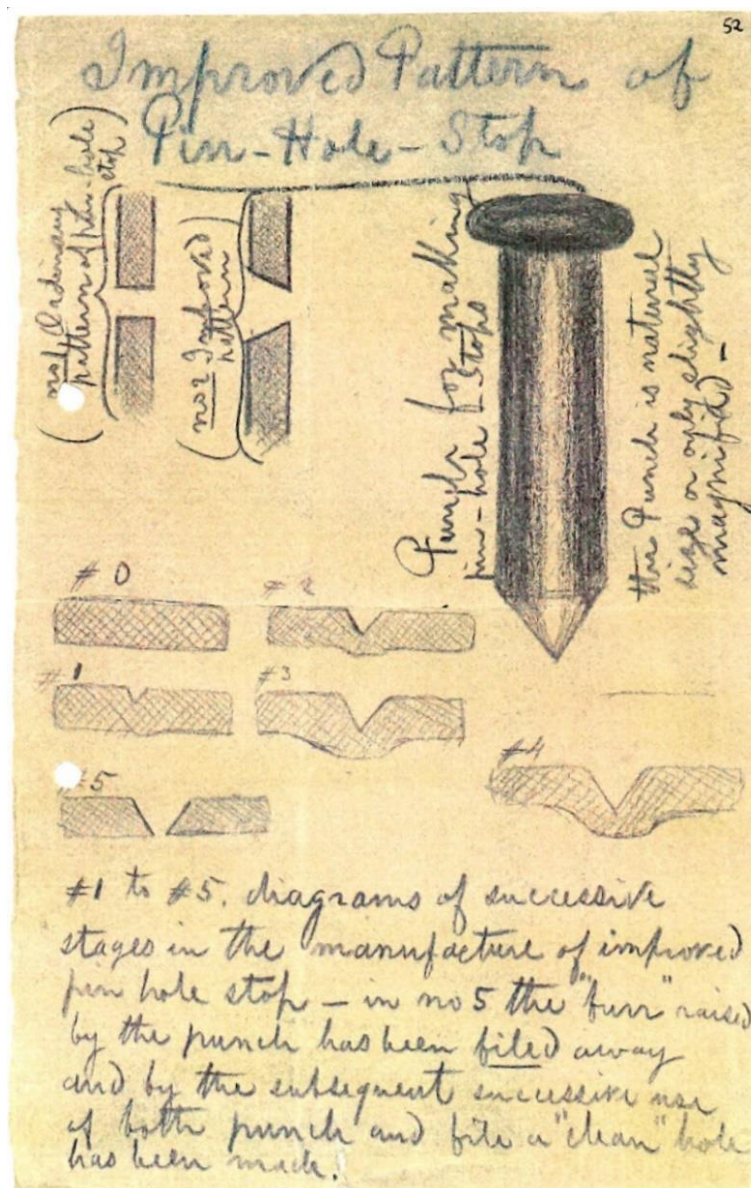


Figure 118 HSG's Sketch of Making an Improved Pin-Hole Stop [BACZ 1576, 52].

### 36. His Contradictory Correspondence to Carl Zeiss Company

In 1901 September 22, HSG revealed his low spirits to his friend Lowell [Harvard, 13/30]:

“My dear Lawrence

I am thinking very seriously of returning home for good this autumn, i.e. of coming home with a view to remaining if I find I can do so to advantage – Here I am too isolated and there is no way in which I can avoid this, it may be as bad or worse at home but I feel enclined [sic] to try it ...

In conclusion I will say that my purpose in returning home is quite independent of any considerations of work upon scientific matter. I wish to see old friends again and to have plenty of opportunity for out of door recreation in a form that I really enjoy & then too I feel that I should like to be at home; life in a foreign country is for most people an exile & it is better to be at home if possible.”

On October 22, HSG began to write a letter to the Zeiss Gentleman [BACZ 1576, 56]:

“I have this afternoon seen Dr. Culmann and from what he tells me I do not see that there is any need of my coming to Jena, though as already stated in a recent letter to yourselves I am willing to do so if necessary or advisable ... As I intend sailing on November 16<sup>th</sup> in the Campania of the Cunard line \*), I wish to settle this matter as soon as may be and hope you will accede to my request ...

I hope you will consent to my sending you cheque for six hundred and twenty-five francs ... toward payment for the electric-light-attachment, as I deem the procuring of the same most important. For through direct sunlight, somewhat condensed, is even stronger than electric-light, yet it is not available whenever wanted & hence is not suitable for that systematic & continuous course of experimentation needed to provide properly constructed pin-hole stops for the attainment of the full Orthomorphic effect of the proposed new Microscope ... – Awaiting your reply which please make at your earliest convenience ...

P.S. For test-objects I strongly advise the employment of shot (*or pellet*, the authors) (plomb de chasse) and small cubical cristals [sic], - the shot used should be of one, two and three millimetres [sic] in diameter or there about, for magnification of 20 – it can be stuck onto paper with gum, and the depth should be sufficient to have both the upper part of the shot and the paper in focus simultaneously (*By contrast with comment to Fig. 120*, the authors). – The cubical cristals may be of a corresponding size i.e. with the edges of about 2 or three millimetres. – Shot & cubical cristals are very much better test objects than tubes.”

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\*) HSG on Nov. 12: “I have decided to postpone my return to America. – I am now expecting to be absent from Paris for some time ...” [BACZ 1576, 64].



The P.S. takes up HSG's suggestions for stereoscopic test objects made four years ago (See Part 5/26). On next day, on a Wednesday morning, HSG continued this letter and intensified his previous appeals to a threat [BACZ 1576, 57]:

“Should you be unwilling to adopt the foregoing line of action, then I can only say that the nature of the present agreement between us has been completely misunderstood by myself & I must ask to have it cancelled at once and altogether, for as already explained in a former letter I regard the rejection of the electric-light-attachment, (and consequently of the small pin-hole-stops that cannot be adapted to either objectives or eye-pieces without such electric-light-attachment, in as much as sunlight is not available at will.) as the complete destruction of my design in its integrity. – Dr. Culmann told me yesterday afternoon that no experiments with the very small stops had yet been made, - now the suppression of these small pin-hole stops is not any mere modification of accessory detail but is the complete destruction of my whole design in its very pith & essence. – As long ago as 1898 I ascertained by actual experiment that a good depth can be had & with ample definition by the use of the proposed pin-hole stops, and I am still confident that you can execute my design integrally and without any serious technical difficulty, but in order so to do a change of intention on your part \*) is quite indispensable i.e. it is necessary that you seriously attempt to carry out the construction of the proposed Microscope with its dioptric apparatus permanently fitted (or else provided with special devices for centering the stops and adjusting them to the proper level on the optic axes) with pin-hole stops, properly placed and accurately centered upon the optic axes in such manner as to produce the desired Orthomorphic-effect & for this purpose, systematic & continuous experiment with a properly constructed electric-light-attachment is quite indispensable, - such attachment being an indispensable part of the microscope, for general use ...

Up to the present time I have not been able to obtain on your part any serious attempt toward the construction of my proposed Orthomorphic-Microscope. I hope you will now consent to make the trial on the lines indicated above, if so, then I am confident of success.”

Dr. Culmann outlined a letter to HSG already on October 12 to announce a new microscope example [BACZ 1576, 55]:

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\*) Proceeding from Abbe's theory and the simple low-power achromats, the Zeiss specialists recommended the use of only such eyepieces giving up to 500 X NA magnification. HSG's pin-hole stops would reduce radically the numerical aperture (NA) in interest of the focus depth and provide higher or even empty magnifications which would collide with the firm's reputation and therefore were not accepted.

“We have based our experiments on the explanations you gave last winter and this spring about the orthom. M., which we fully agree with in principle, as the basis for our experiments.

We have only deviated from your suggestions in one, in our opinion insignificant, point, in that we have replaced the fine pinhole serving as a lens with a real lens, which must of course be stopped down in order to achieve the necessary depth. In this way, we believe that the apparatus can also be used for observing objects with a finer structure, without it being questionable whether the desired outcome can be achieved. We also hope to be able to increase the light intensity in this way. The apparatus is currently being prepared for dispatch and will be sent to you by Dr. Culmann.”

The shipping was been announced on October 24. HSG’s reply letter shows Dr. Czapski’s German hint on Dr. Köhler: “Köh, with the request for consultation asap.” HSG was placated partially from testing and wrote on 29th [BACZ 1576, 58]:

“I have this morning carefully examined the new Orthomorphic Microscope at Dr. Culmann’s and have much pleasure in advising you that the Orthomorphic effect is quite satisfactory. Indeed in this respect there is between the new Orthomorphic-Microscope and any hitherto constructed all the difference between success and failure; and this is the more satisfactory [sic] to me in that it strongly confirms my confidence in the validity of the geometrical theory of the Orthomorphic-Microscope, for I do not care very much for what is only true ‘on paper’. - Besides the drawbacks of the present model referred to in your letter of the 24<sup>th</sup> inst. I note the following 1<sup>st</sup> the eyepieces can not [sic] be brought sufficiently near each other for me to be able to use the pair of objectives with the smaller stops <sup>1)</sup>. 2<sup>d</sup> the depth is not sufficient for so low a magnification as 5 ½ (*too low for general magnification*, the authors) - When using this magnification, a very useful one for many purposes, the object to be examined are generally a good deal larger <sup>2)</sup> than when using a magnification of 20 or thereabout (for this latter magnification the depth of the present model is sufficient but of course could not be had with the actual stops) (*which are orthomorphic diaphragms*, the authors) –

---

1) The a<sub>3</sub> objective pair could be meant which provides 30 ... 35X general magnification with No. 2 eyepieces and an object field of below 3.5 mm diameter.

2) HSG’s request is unrealizable and this was already stated (See Part 2/10):

“As every working naturalist knows, an apparatus that admits the use of the camera Lucida with a low magnifying power, varying from five to forty diameters, offers many advantages that are not to be obtained from any system of microscopical objectives” [Whitman, 1885].



“Confirming my letter of Oct. 24<sup>th</sup> current. I deem it expedient to make certain additions thereto for the purpose of expecting negotiation between us. In the first place I withdraw all claim to payment of any commission whatever by your House to me & moreover I find that I shall have to insist on the contract between us being cancelled, because it places me in a false position.

Furthermore if by any chance I am mistaken in assuming – because of verbal statement made to me last Spring by your Dr. Paul Culmann that you have accepted from me order for my proposed Orthomorphic Microscope to be executed by your House by integral execution of my design & the turning out, to this effect of a well-executed sample as per Workshop model already made, but with the necessary modifications and additions for practical efficiency; then & then only the hitherto existing agreement between your firm & myself is hereby cancelled without prejudice. Please give this matter your immediate attention and send me your answer at your earliest possible convenience ...”

On October 30, Dr. Culmann reported in German on HSG’s visit [BACZ 1576, 61]:

“Mr. Gr. was here again this morning. I had Adnet file down the prism drum so far that he could now use the instrument with the narrow stop. Overall, he was less satisfied with it than with the other one. He claimed that it gave a poorer result because of its smaller field of view (*probably object field of  $a_3$* , the authors). However, the difference is very small 3.5 mm with the narrow 3.8 mm with the wide aperture (*probably inner dia. of eyepiece diaphragms*, the authors). I therefore do not believe that the difference he noticed is due to this ... Mr. Greenough does not want to know anything about diffraction; he has already obtained good results experimentally with much narrower stops; nor does he want to hear anything about Drüner's stereo camera, because it does not allow living beings to be observed. By the way, he writes his report and his new proposals himself. Should I send the microscope back to Jena? Greenough says he no longer needs it and has now formed his own opinion.”

The withheld letter of Oct. 31 repeats HSG’s requested conditions [BACZ 1576, 62]:

“Confirming my letter of the 29<sup>th</sup> inst. I would add that I regard the completion of the present model of Orthomorphic Microscope as a Work-shop experiment and nothing more.



I deem all of the following conditions and in the order mentioned to be essential to the construction of the Orthomorphic Microscope in a practical and efficient manner:

- 1<sup>st</sup> The combination of a suitable electric-light-attachment together with stops as small as may be compatible with sufficient definition, in order to obtain the utmost possible depth. (the definition being about  $\frac{1}{4}$  of one per cent of the average diameter of object to be looked at, say  $\frac{1}{8}$  of one per cent of field) (See *comment to Fig. 120*, the authors).

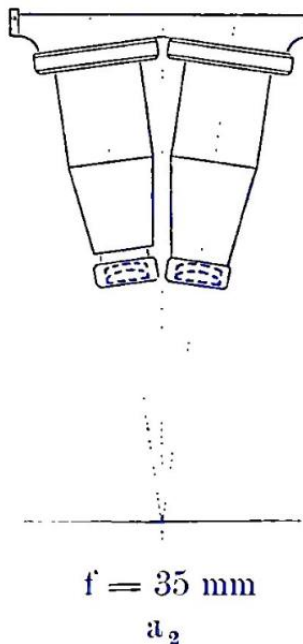
2<sup>d</sup> straight tubes

3 erection of images by 2<sup>d</sup> pair of objectives

4 Adjustment of distance between eye-pieces by means of suitable link-motion, so that the whole instrument shall come automatically into proper adjustment.

Although by no means “cock-sure” yet I am very confident indeed that your firm is perfectly capable of accomplishing the successful construction of the proposed Orthomorphic-Microscope in the manner above set forth. – Whether it be with you while to attempt it I must leave for you to decide but I cannot insist too strongly that I regard work upon the proposed Orthomorphic-Microscope undertaken upon any other lines as being radically wrong and foredoomed to total failure.

Concerning the commercial aspect of the proposed Orthomorphic-Microscope I am not competent to decide; in my judgement however it would pay after a time if scientifically successful.”



The achromatic  $a_2$  objective pair provides a 23X [Harting, 1898] ... 24X [Zeiss, 1902] general magnification together with No. 2 eyepieces. The object field measures 5.5 [Harting, 1898] ... 5.0 mm diameter [Zeiss, 1902] and the “definition being ...  $\frac{1}{8}$  of one per cent of field” moderate request means that HSG would be satisfied with 6.5  $\mu\text{m}$  resolution corresponding approximately to aperture  $\text{NA} = 0.05$  and 470 X NA – an amount inside the Zeiss span of useful magnification. The apertures of low-power objectives are not given by Zeiss catalogues but  $a_2$  may be assessed at ca. 0.09 resulting approximately in 4  $\mu\text{m}$  resolution and 260 X NA - keeping reserve in the stronger eyepieces. HSG’s supposed stopping may more than double the depth of focus from ca. 105 to 240  $\mu\text{m}$ . The 56 years old HSG was able to accommodate probably ca. 200  $\mu\text{m}$  additional focus shift.

Figure 120 Slider Carrying  $a_2$  Objective Pair, Focusable Objective on the Left [Harting, 1898].

On November 4, HSG drew up “Notes for the Carl Zeiss Firm” [BACZ 1576, 63+67]: “Since posting my letter of Tuesday last [BACZ 1576, 58] to the Carl Zeiss House, Dr. Culmann has had the Orthomorphic Microscope arranged, at Adnet’s, so that I have been able to use the pair of objectives having the smaller stops; - their field is too small, otherwise they are good (*a<sub>3</sub> objective pair probably*, the authors), though a still greater depth is needed – I have made further tests of the Orthomorphic Microscope including certain critical naked-eye experiments made at home & imitating the results had with the Orthomorphic Microscope ...

The result of the foregoing observations is that in aspect to the Orthomorphic effect obtained and as far as eye-judgement of the same is concerned the present model of Orthomorphic Microscope is all that can be wished for. – but the field is too small & the depth insufficient. – The result already obtained has never been gotten before in a workshop model and I consider it decidedly encouraging ... Whenever practicable miniature photographic objectives, as in the present model, should be used, but my laboratory experiments show quite conclusively that a good orthomorphic effect also be had with microscopic objectives provided that pin-hole-stops properly placed and accurately centered be used therewith <sup>1)</sup>.

The pin-hole stops may be placed either at the extremities of a (in the equation **A/a=D**) or at any points upon the optic axes where real images of the extremities of a are formed <sup>2)</sup> and ... the full useful effect of the pin-hole can be had & without the diffraction, that the pin-hole itself would produce. – However my experiments show that sufficiently small pin-holes can be used without producing objectionable diffraction effects but the above indicated device should increase the possible range of magnification ...

I deem it exceedingly important that unity of intention concerning the Orthomorphic-Microscope be thoroughly established between the Carl Zeiss House & myself – I am perfectly aware that the construction of the Orthomorphic Microscope in accordance with my design is a “big job” but I am confident the Carl Zeiss firm can do it and also that success can not [sic] be had in any other way.

---

1) Dr. Harting designed caps to his  $a_0$  objective pair working like the front-diaphragm of a photo-objective to enlarge the sharply seen field [Harting, 1898].

2) A sketch for orthomorphy shows an optical axis through a lens sign and on left a narrow pin-hole stop and on right a wide one. The extremities of the stereo base a are equivalent to the conical diaphragms on the prototype’s objectives. The eyepiece caps after Dr. Czapski are placed at the conjugated extremities (“real images”) of the pupil distance A.

HSG tried to praise the new microscope version and to argue constructively in hope of further Carl Zeiss concession. On the 12th, HSG accepted even the first-series microscope model [BACZ 1576, 64] and presented firstly an interpupillary distance adjustment with the requested straight tubes. A similar solution will be found also by the German mechanic Heinrich Westien (1856-1919) in 1915 (See Part 4/23) but both purely mechanical and expensive solutions were not realized.

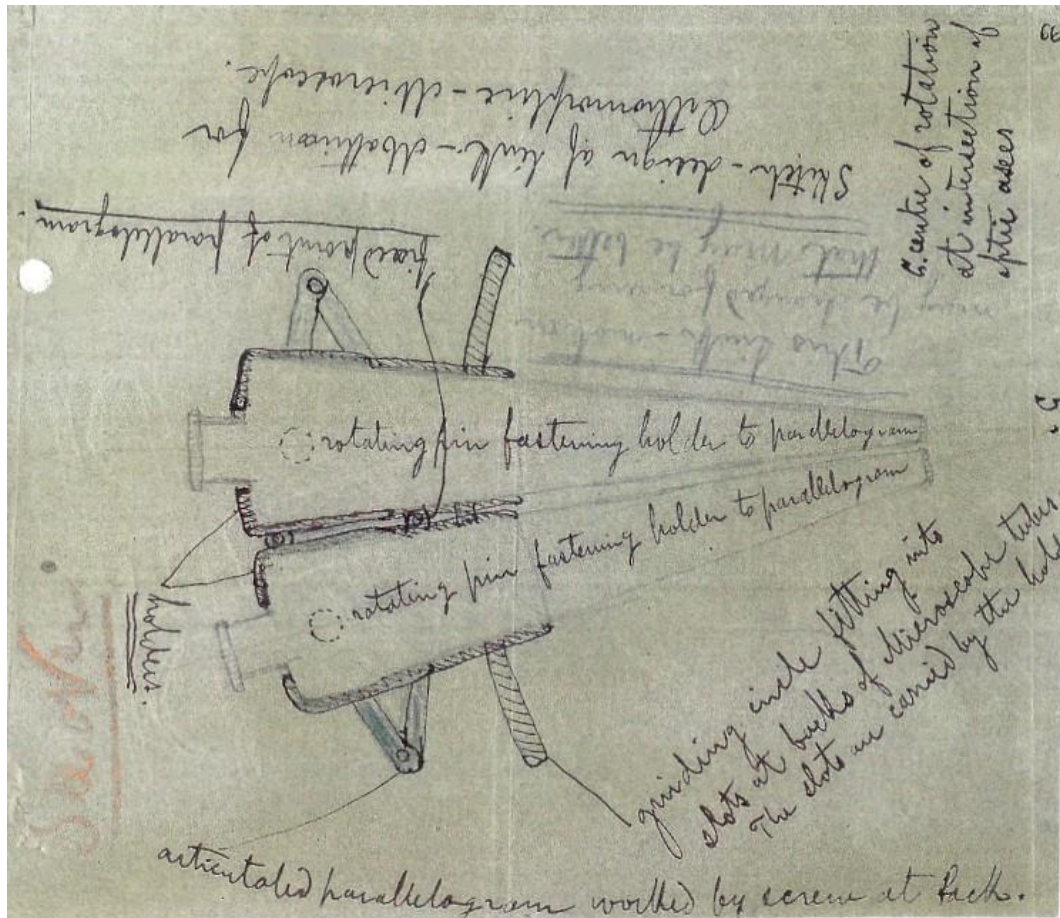


Figure 121 HSG's "Sketch-Design of Link-Motion for Orthomorphic-Microscope" [BACZ 1576, 66].

The rear of this cardboard shows the top and side view of the mechanism: A double-sided wheel is fixed at the focused microscope carrier and works by rack and pinion an articulated parallelogram frame. Each tube is coupled by a pin to his parallelogram leg and so guided along a circle-segment bar which **C** center (Seen also in Fig. 121 on the right) match the intersection of optical axes in the object plane. This condition shall guarantee that the adjusting of the pupil distance does not influence the focus setting but the stereo angle varies in contrast to the Zeiss solution using the off-center rotation of the Abbe-Porro prisms.

“If necessary for the maintenance of a working compromise I will continue to tolerate as I have hitherto done that form of stereoscopic Microscope described in your 1898 Catalogue pages 94 to 101, English edition, although I have not ceased to regard this instrument as an objectionable caricature of my own design. This statement however does not apply either to the Prism-rotator or to the Capillary Rotator both of which are good though still capable of considerable improvement in my judgement.

The workshop-model of Orthomorphic-Microscope recently sent to Dr. Culmann not only gives a quite satisfactory [sic] Orthomorphic effect but also there is, relatively to eye judgement, between this last instrument and any of the previous ones all the difference between truth and error. – I hope therefore that you may be willing to take into serious consideration the integral execution of my design for the Orthomorphic-Microscope.

I am well aware that pin-hole stops produce diffraction, but my experiments show that a good result can nevertheless be had by the use of such stops and moreover I have very serious reasons for believing that diffraction, in so far as detrimental, may be very much diminished by the construction of pin-hole stops with Beveled edges as elsewhere explained.

I enclose herewith for your information letter written on October 31<sup>st</sup> ult. but purposely withheld up to the present time and also some notes and diagrammatic rough sketches of proposed link-motion for Orthomorphic-Microscope with straight tubes.

I will be obliged to you if you will kindly acknowledge receipt of this letter by post card (*Underlined and commented by receiver: Confirm preliminary receipt.* The authors) but would request you to defer any further reply until after my return to Paris.”

In 1902 January 18, HSG was back at his Parisian home and revoked the October’s cancelling of his order [BACZ 1576, 68]:

“I sent you post card some few days ago advising you of my return to Paris. – Not hearing from you and in as much as there will not be time for any extended correspondence between now and Feby. 15<sup>th</sup> I write to say that if you prefer it you may defer answer to my last letter until such time after my next return to Paris as may suit your convenience ... I will add that my original order of 1892 holds good if you can to accept it, if not I would be obliged to you to decline the same categorically. – I do not accept your substitute for my own design though for reasons already stated I will continue to tolerate it ...

The expediency of taking out patents at your expense in case you can to accept my order I leave to your own good judgement (*no patent, see Part 4/23, the authors*) and hereby confirm my previous acceptance of 3 per cent commission on list price in case you manufacture Orthomorphic Microscope for the market ...

P.S. I am quite aware that your firm are very much more than mere tradesmen & it is only because no working agreement upon a scientific basis has been possible between us, that I have found myself obliged to negotiate with you on a purely commercial basis.”

On February 7, HSG specified the foregoing [BACZ 1576,69]:

“Confirming my recent letter & also those of the past few months I would add that I have no objection whatever to the continued manufacture & sale of the present pattern of Binocular microscope, provided that you also make the Orthomorphic Microscope & that the difference between the two instruments be properly indicated in future price lists. Even the workshop model you sent me last autumn would be very much better than nothing because although still requiring some improvements yet the Orthomorphic effect itself was all that could be wished for as far as eye-judgement goes.”

On the day before, HSG had summarized his statements in a letter to his mentor, the American zoologist, Professor Dr. Charles Otis Whitman (1842-1910), University of Chicago. HSG visited him in 1892 May (See Part 2/7+10) and their conversation was probably the starting shot of HSG’s life task. He had written to Professor Abbe:

“Indeed in this connection Professor Dr. Whitman told me last May ... that for purposes of embryological study he found powers up to 20 the most useful & that he very much desired improvements in such powers” [BACZ 1578, 41-42].



Figure 122 Charles Otis Whitman, Detail of [https://upload.wikimedia.org/wikipedia/commons/4/47/Charles\\_Otis\\_Whitman.png](https://upload.wikimedia.org/wikipedia/commons/4/47/Charles_Otis_Whitman.png)



“I write to advise you that I am returning home in April with a view to getting professional employment in some one of our many Laboratories of Biology.

I think that variable techniques devised by myself in connection with the apparatus manufactured in my name by the Carl Zeiss House of Jena – like 1898 Catalogue pages 94 to 100 – would be useful in any laboratory where dissection is practiced ... I will add that in my opinion ... various techniques of my own are of special use for the study of gastrulation in the living embryo.

I remain here until April 14<sup>th</sup> ... I have written this with copying pencil as I wish to send press copy to the Carl Zeiss House” [BACZ 1576, 70-72].

On February 14, HSG wrote to his friend (See friendship’s beginning in Part 1/5), A. Lawrence Lowell, professor of government at the Harvard University since 1898:

“I write to let you know I have taken my passage on the ‘Oceanic’ sailing from Liverpool on April 16<sup>th</sup> for New York: my purpose in coming home is, if possible, to get professional employment in some one of our laboratories of morphology: and if, as is most probable, I can not [sic] do so, I should return here after some few months at most ... Hoping to see you on my return home ...” [Harvard, 13/30].

The desired contact to American authorities changed HSG’s attitude and he informed about this the Zeiss Gentleman after his return to Paris on July 3 [BACZ 1576, 73]:

“I write to say that there are some errors in the scientific and more especially in the mathematical statements contained in my past letters to yourselves. I would therefore be pleased to have you destroy all that I have written to you concerning these matters: if however you prefer not to do so, then kindly file this present letter therewith by way of correction.”

From 1902 autumn to the end of the year, HSG will renew his requests by letters to Professor Abbe and the Zeiss Gentleman. HSG will try to involve scientific authorities in confirming his ideas: the Englishman John Lubbock (1<sup>st</sup> Baron Avebury), the Frenchman Henry Poincaré, his American friend A. Lawrence Lowell and his Canadian one Dr. George Bull and even the Editor of the Times. A single letter to Dr. Czapski will follow in 1904 and a rare correspondence around the turn of 1906/1907. HSG will live at a comfortable sanatorium outside the Parisian City from 1904 December.

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**We acknowledge Dr. Monika Marx for editing of Wallerant's letter and Dr. M. B. for his intensive literature researches.**

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