Rediscovering Dr. Reich's 150x Microscope Objective

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Ever since first reading a translation of ***The Bion Experiments on the Origin of Life*** in 1976[i], I have been puzzled by comments made by Dr. Reich about his equipment. In the preface to the book "The Essential Lab Equipment" is described as follows:

> The microscope
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> At present our institute possesses three large Reichert "Z" microscopes and one Leitz research microscope. With the Reichert microscopes it is easy to achieve a magnification of up to 3750x, as a result of the inclined binocular tubes, which increase the normal magnification by 50 percent. When a special Leitz 150x apochromat lens is used in conjunction with a 25x compensating ocular and the inclined binocular tubes, it is possible to achieve a magnification of up to 4500x, but with great difficulty.[ii]

Like most new students of microscopy, I was initially fascinated by magnification, and this paragraph stood out as a demonstration of very high magnification. But as I learned more about microscopy over time, I found Dr. Reich's comments about the use of the Reichert "Z" with a Leitz 150x apochromat increasingly confusing. The facts, as I could determine, did not agree with his statements.

When this equipment was new in approximately 1936 or 1937, there were two accepted standards for the construction of the mechanical tube length of a biological microscope, or the distance separating the objective lens and the eyepiece. Reichert, Zeiss, Beck, Swift, Watson, and Bausch & Lomb all used a tube length of 160 mm for their microscopes, while Leitz alone used a 170 mm tube length. The optical corrections of the two lenses that provided the magnification in these compound microscopes, the ocular and objective lenses, were based on the geometry of a correct tube length, so that objectives and oculars could be used interchangeably among the former group, but use of an objective lens made by Leitz would introduce unacceptable spherical aberration into the image, which would be visible as lack of

image sharpness or “fuzziness” of the image. This was especially true in the apochromats of the time, which needed a matching ocular to complete the optical corrections partially built-into the microscope objective lens. While achromatic lenses could probably be used without too great of a detriment in image quality, the use of an apochromat of high power in the incorrect mechanical tube would degrade the image significantly. Could it be that Reich used a mismatched objective in his quest for higher magnification? Could this explain some of the fuzziness of the microscope images published by Reich?

Charles Patten Shillaber published his comprehensive reference text on photomicrography in 1944[iii], ***Photomicrography In Theory and Practice***. This 773-page volume included tables of microscope objectives and their characteristics, listed by various microscope manufacturers. Lists were included of achromat, fluorite, and apochromatic lenses made by Leitz, Reichert, Zeiss, Swift, Watson, Bausch & Lomb, Beck, Spencer, and Fuess, and gave me information about objectives that were available to Dr. Reich.

These tables showed that Leitz made apochromatic objectives for their 170 mm tube length microscope with focal lengths of 2.0 mm and 3.0 mm, yielding a magnification of 92x, for use with a cover glass of 0.16 to 0.18 mm. Leitz made two versions of the 2.0 mm apochromat, one with a numerical aperture of 1.32 and one with a numerical aperture of 1.4. Shillaber also listed Leitz apochromats made for metallurgical microscopes of mechanical tube length 215 mm and for use without a cover glass. These were also 2 mm focal length lenses with N.A. of 1.32 and 1.4, respectively, with a listed magnification of 170x. While the corrections in this lens included a compensation for the absent cover glass, the increased magnification was purely a consequence of the longer tube length, not because of any additional magnification in the objective. There is no mention made of any apochromat with a shorter focal length (or higher magnification) made by Leitz, in the lists compiled by Shillaber. Further, the increased magnification of the objectives used in metallurgical microscopes was a result of their longer mechanical tube length; none of the apochromats had a focal length shorter than 2 mm, which would have been necessary to produce the larger magnification in the objective lens. Hence, it seemed that Leitz could not be the manufacturer of the lens described by Dr. Reich, unless it was so very rare as not to be listed in the tables.

(Of interest is the observation that Reichert made an apochromat for tube length 160 mm, cover-glass thickness of 0.18 mm, of focal length 1.5 mm, numerical aperture 1.30, producing a magnification of 124x.)

An original brochure for the Reichert "Z" microscope published in 1938 came up for sale on Ebay. Although I was not successful in buying the original, the purchaser kindly supplied me with a photocopy, and this publication confirmed that the "Z" had a mechanical tube length of 160mm.

Several years ago I corresponded with Mary Boyd Higgins, seeking to see if Dr. Reich's special objective might still be at Orgonon, but a search at that time was unsuccessful, and Ms. Higgins was not able to locate the objective.

Consequently, when I came to Orgonon in July to assist in teaching the lab course, I carried with me a sense of hopeful curiosity that I might be able to solve this mystery, although I did not have any great expectation that the quest would be successful. A discussion with Ms. Higgins at the Reception in the Museum on Tuesday July 16th led ot her revelation that some of Dr. Reich's the lab equipment was sold to help pay for legal expenses during the trial, and her speculation was that the objective might have been sold as a way of raising funds in the 1950s. However, Ms. Higgins did give me permission to look carefully at the microscopes in the Museum, and to touch and examine what I found. I looked at the objectives on the inverted Reichert microscope used for the time-lapse photomicrography and at another "Z" microscope on the first floor of the Museum, then looked at the two Reichert "Z" microscopes on the second floor, where Dr. Reich did his last microscopic work. These are in the small alcove at the top of the stairs just off of the study. None of these had objectives attached to the microscopes, but there were a number of metal canisters on the desk designed to hold objectives, and I turned my attention to these.

A search quickly turned up an objective made by W&H Seibert, which had been stored in a Bausch & Lomb objective canister. The lens was jammed into the metal canister, and took gentle prying to remove. But out of the container it was finished in bright chrome, with an inscription on the side: "W&H Seibert, Wetzlar, F 150." Apart from a symbol of the firm and a serial number, no other information was inscribed, such as the mechanical tube length of the

design or the numerical aperture of the objective. Of note was that the objective was a solid piece of metal and glass, without a retractible front element. (The modern practice is to mount the front lens of the objective in a spring mount, to protect both the lens and the microscope slide from being damaged if one attempts to focus too closely to the slide.)

Could this be Dr. Reich's lost microscope objective? One of the other instructors at the course, Dr. Jim Strick, suggested that perhaps the markings indicated that the lens was a fluorite objective, or a "semi-apochromat."

The next day the lab course was scheduled through midday, and after lunch on Wednesday a small group gathered to see what we could learn about the "new" objective. With a great deal of eager anticipation the objective was fitted to the nosepiece of the Zeiss photomicroscope. But initial attempts to focus were not successful, because it was designed to focus at a distance of 33 mm from the shoulder of the nosepiece to the microscope slide, whereas the Zeiss was designed for a 45 mm standard. Fortunately, I had an adapter for "short mount" objectives, and this put the objective within the possibility of being focused on the Zeiss frame.

My initial idea was to examine a diatom test plate mounted in Hyrax so that imaging the several diatoms would give an estimate of the numerical aperture of the objective. Because of the high magnification, it was clear that the lens would have a very small working distance between itself and the object to be imaged. Since it was constructed without a spring-protected front element, there was a chance of breaking the microscope slide from direct contact. Because the front lens of the objective was recessed into the metal housing, the objective was not in any significant danger of being damaged, but I had some concern for the test slide and for my microscope's condenser's safety if the slide broke. With some apprehension I oiled the slide to the condenser, and the objective to the coverslip, and then attempted to focus on the diatoms on the test plate.

However, another problem arose. The Zeiss focus mechanism does not have fine focus with an infinite range, but instead has a limited range between two mechanical stops. Hence, one

needed to move the slide close enough to the objective using the coarse focus, then attempt to focus accurately using the fine focus.

On the initial attempt I covered the entire range of the fine focus without finding a sharp image, and concluded that I was too far from the slide. The fine focus was racked back to the far end of its range, the slide lifted a little closer with the coarse focus, and attempts again were made to focus on the test plate, adjusting the fine focus a little at a time out of concern for the safety of the slide.

After what seemed like an eternity, with the microscopist acutely aware that there was no room for error and that the slide and condenser might be damaged with too large of a move, turning the fine focus knob, and again, and again, with no change in the image, while the observers in the room sat in silent expectation...

CRACK!! The slide suddenly made a loud noise that shot through the silence!!

The group gave a collective gasp, and I racked the slide away and looked for damage. A quick check showed that the coverslip was partially separated from the diatom mountant, with Newton's rings present under the coverslip showing evidence of spatial separation where they should have been none. But nothing was broken! I was very grateful that Hyrax has some flexibility and “give” in its texture. It was apparent that the depth of the mountant on the slide would prevent us from getting close enough to the diatoms to look at them. So, if we could not view the test plate, what could we look at? I considered a micrometer slide, with fine rulings that would demonstrate the magnifying power of the objective, but rejected this for fear of breakage.

Dr. Strick suggested looking at a gram stain, but after the earlier experience I was concerned that we might attempt to focus on a part of the slide where there was very little to look at and then go right through it, so I concluded that we had to find another object. Then the thought of looking at fresh diatoms came to mind, and we heated a drop of a specimen taken from Angel Falls to anneal it to the slide, and then prepared to look at it after oiling the

condenser and objective lens again. I felt confident that there would be adequate material on this slide to have an image of something, and that this would minimize the risk of damage.

After slow, cautious attempts to focus the lens, an image as the diatoms finally came into view. They were sharp and clear. The image was brilliant and crisp, and we took some photos of Pinnularia and Terpsinoe through the objective.[iv] All present took a look and it was an historic moment: the first use of Dr. Reich's microscope equipment in about fifty years, and a chance to look through the same objective that Dr. Reich used to make his observations on the bions in Norway!

Later, I examined the elements of the objective using a Bertrand lens on the microscope, and noted a number of fine particles or inclusions on or in an element of the lens. At first I thought that this was dust on the upper lens element but later realized that these were imperfections in the natural fluorite used to make the lens, giving supporting evidence to the idea that that this was a fluorite objective. (Modern objectives are constructed using optically perfect synthetic flourite, but in the 1930s the natural material was all that was available.)

Subsequent research yielded more information about the firm W&H Seibert. Brian Bracegirdle has the following entry in his book, **Notes on Modern Microscope Manufacturers**:

> SEIBERT (& KRAFFT)
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> Seibert & Krafft, WETZLAR, Germany (1871-1884)
> W & H Seibert, WETZLAR, Germany (1884- c 1925)
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> E Gundlach sold out to Seibert & Krafft when he went to the USA in 1871. A 12-page catalogue of 1883 (Katalog der Mikroskop, mikroskopischen u. mikrophotographischen Objektive & Apparate) shows that they sold a good range of microscopes and accessories, including good-quality objectives, some of them specially for photomicrography. None of the stands is very elaborate, and the photo-micrographic apparatus is basic, but there is a wide range of objectives and accessories.

> Wilhelm (1840-1925) and Heinrich (1842-1907) had issued 30 catalogues by 1903, including special lists for photo-micrography and projection. They stated that they had sold 10,000 stands by 1900. Catalogue 55 of the 1920s lists an excellent range of stands and other equipment.[v]

What did we learn from this short exercise? We learned that Dr. Reich used a flourite objective of good quality of nominal magnification of 150 diameters manufactured by W&H Seibert, at an unknown date, but presumably before 1925. We had the historic chance to look through the objective which presumably provided Dr. Reich with his primary observations of bions, confirming that the image produced by this objective on a 160 mm microscope body was clear and had good contrast. For an objective used in the 1930's for research, built at least 70 or 80 years ago, and considering that it was stored in a can for the last fifty years, the image was impressively sharp, with no fogging or breakdown of the natural fluorite used to make the objective. Although we were not able to image any diatoms with regular punctae, and thus to estimate the resolving power of the objective, we could see fine detail of the diatoms clearly. Hence, any fuzziness in published photomicrographs were not caused by the optics of the microscope equipment used, but may have been a result of the film used at that time, or may have been caused by other errors in the use of the microscope such as closing down the iris diaphragm on the condenser excessively. Finally, Dr. Reich did make an error in naming the manufacturer and corrections of this objective in ***The Bions***, but this is a minor point and does not detract from our appreciation of the quality of the optics that he purchased and used in his research.

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[i] Wilhelm Reich, ***The Bions: An Investigation into the Origin of Life***. Translated by Barbara Koopman, M.D., Ph.D. and Irmgard Bertelsen, B.S., from ***Die Bione***, Sexpol Verlag, Oslo, 1938. **journal of Orgonomy** 10 (1); May 1976, pp. 9 – 12.

[ii] Wilhelm Reich. ***The Bion Experiments on the Origin of Life***. Translated by Derek and Inge Jordan. Edited by Mary Boyd Higgins and Chester Raphael, M.D. New York: Octagon Books, 1979, p. 7.

[iii] Charles Patten Shillaber. ***Photomicrography in Theory and Practice***. New York: John Wiley and Sons, 1944.

[iv] Photos were taken with a Kodak MDS 100 camera mounted over a Nikon CF 15x eyepiece, with an Optovar setting of 1.25. Hence, the calculated magnification of the images is 2812.5x. Note that this eyepiece has no chromatic corrections in it, and would not be considered a "good match" for the fluorite objective, which should be used with a corresponding Seibert eyepiece for optimal results… but the photos are very sharp.

[v] Brian Bracegirdle, ***Notes on Modern Microscope Manufacturers***, Quekett Microscopical Club, 1966, pp. 65 – 66.