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Can Artisans Be Scientific Authors?

The Unique Case of Fraunhofer's Artisanal Optics and the German Republic of Letters

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> The class that is the ruling *material* force of society is at the same time its ruling *intellectual* force. The class that has the means of material production at its disposal simultaneously has control over the means of mental production; therefore, generally speaking, the ideas of those who lack the means of mental production are subject to it. The ruling ideas are nothing more than the ideal expressions of the dominant material relationships, the dominant material relationships grasped as ideas.
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> —Karl Marx, 1845–46

Joseph von Fraunhofer (1787–1826) was a rather remarkable figure in the history of science and technology. He was a working-class optician whose work on physical optics revolutionized the production of achromatic glass, telescopes, heliometers, and ordnance surveying instruments. He served as a bridge that spanned two distinctive, yet critically linked communities: artisans and savants, or scientific instrument makers and *Naturwissenschaftler*. Although instrument makers had been crucial to the scientific enterprise since the Scientific Revolution, by the early nineteenth century, experimental natural philosophers generally could not do without these artisans, as few savants possessed the necessary manual skills to build their instruments. Yet artisans were rarely granted the status of experimental philosopher for three reasons. First, as I have argued elsewhere, the importance of secrecy to the arti-

sanal trade was seen as anathema to the Republic of Letters, whose members prided themselves on the openness of scientific knowledge.[1] Second, savants were reluctant to accept artisans as their intellectual equals, as craftsmen were members of a commercial nexus and financial interests tainted their work.[2] And finally, members of the Republic of Letters argued that instrument makers merely manipulated preexisting materials; they did not create anything. This slavish "following of craft rules" was deemed as the antithesis of creative, scientific knowledge.

Because Fraunhofer was so precariously perched between these two groups, he is such a fascinating and historically informative character. Although he undoubtedly belonged to the artisan population, he strove for scientific recognition. He clearly contributed to the corpus of scientific knowledge. His work on the dark lines of the solar spectrum, which now bear his name, as well as his work on diffraction gratings, which was to support the nascent undulatory theory of light so eloquently proposed by Thomas Young and Augustin Fresnel, formed the cornerstone of an impressive spectrum of disciplinary research during the nineteenth century, including spectroscopy, photochemistry, and of course stellar and planetary astronomy. But Fraunhofer also offered the scientific community first-rate optical instruments, particularly his superior achromatic lenses and prisms. And herein lies the tension that this paper explores. The craft processes necessary for the construction of those optical lenses and prisms were a company secret. Because Fraunhofer was employed by a profit-seeking company, the Optical Institute, he was never permitted to divulge the processes of manufacture. Indeed, because a portion of his annual salary was based on profits of sold merchandise, it was in his financial interest not to make his artisanal practices public. Here, the commercial and clandestine practices of craftsmen, which savants so deplored, were intimately related. On the one hand, he was the creator of superior scientific devices. On the other hand, Fraunhofer authored important scientific articles. But, as I shall argue below, some savants questioned Fraunhofer's status as a scientific author.

This doubt was a very painful and devastating critique of Fraunhofer, as it denied him scientific recognition. Normally, artisans were rewarded with patents for their inventions. Questions of authorship seldom arose in practice, because instrument makers had no interest in

rendering commercial secrets public. Patents, however, were never an issue for Fraunhofer, as his employer, Joseph von Utzschneider, the co-owner of the Optical Institute, was convinced that no one could reproduce his institute's products. Hence, Fraunhofer never applied for patents. And Fraunhofer was also unique as he, unlike other craftsmen, was able to publish papers in journals highly regarded by *Naturwissenschaftler*. Although artisans often published articles about their instruments, often to publicize their products, this entrepreneurial connection disqualified them from being considered scientific authors.

Fraunhofer's position, and the attempt by several savants to thwart his status as a scientific author, must be understood in its proper historical context. The German Republic of Letters (*Deutsche Gelehrtenrepublik*) was defining the rights of authors, including scientific authors. They attempted to wrestle the ownership of their printed works away from the book dealers. In so doing, they drew upon the works of Edward Young and others in order to argue that an author was someone who was not a craftsman, but an inspired genius. Creativity was a product of the mind, not the hands. Manual skills were merely ways of following certain rules laid down by the master. Authors transcended those rules, which were intended for those less intellectually gifted. Also, the German Republic of Letters began to police itself during the late eighteenth and early nineteenth centuries by discouraging its members from authoring books for the masses. Such commercialism, they argued, harmed literature and corrupted the Republic. These condemnations greatly affected Fraunhofer's attempt to ascend into the Republic of Letters. In short, Fraunhofer's role as scientific author was inextricably bound to debates on social class, secrecy, market forces, and creativity.

I. The Secret of Success: The Market

During the early nineteenth century, two different sets of patent laws existed in Bavaria. The first, which was applicable to the Bavarian Palatinate on the Rhine, was France's patent law of January 7, 1791, resulting from Napoleon's occupation of that region. The second, which was practiced in the "seven older districts" of Bavaria, including where Fraunhofer labored, did not come into existence until September 11,

1825, or less than a year before Fraunhofer's death.[3] Previous to that date, Bavaria had not enjoyed an official patent policy. Rather, the *Strafgesetzbuch Bayerns* of 1813 was used in cases where individuals profited from others' inventions. But the paragraph dealing with the "rights of the inventor" was obscure and not quite relevant to Fraunhofer's optical lenses.[4]

Patents never seemed to concern Utzschneider; there is no archival evidence of patenting the work done at his Optical Institute, even before 1825. Lenses for microscopes and telescopes did not lend themselves to patenting. Achromatic lens manufacture is an extremely sophisticated procedure that cannot be easily replicated. The percentage of ingredients needs to be tinkered with until the most efficient combination results. Stirring the molten glass proves to be a highly coveted skill. Because lead oxide, which is a very dense material, is a key ingredient in flint optical glass, complex stirring techniques are required to ensure homogeneity throughout the glass. And, the glassmaker must ensure that oxygen bubbles do not form as a result of an aggressive stirring of the mixture. After a highly regulated cooling procedure, a glass slab is formed. This slab needs to be cut and polished into the correct dimensions for the requisite telescope. Fraunhofer performed all of these diverse practices with astonishing precision.

Because of this complexity, Utzschneider felt that the chance of someone successfully copying this procedure was minimal. Indeed, to ensure the market's fidelity, he did not permit Fraunhofer to either publicize the recipe or techniques for achromatic glass production, or to demonstrate the procedure to anyone, save a few chosen apprentices of the Optical Institute. Because of the company's strict policy of disclosure, the only way one could successfully replicate these optical devices was to ferret out the skilled techniques solely from the final products. Both Utzschneider and Fraunhofer, however, were convinced that such attempts would be futile. Indeed, Fraunhofer often offered his final products free of charge to visiting experimental natural philosophers to convince them of the superior quality of his craftsmanship. Also, both patent systems existing in Bavaria and many of the German territories in the early nineteenth century required that the applicant provide detailed descriptions of the inventions as well as the process procuring them. Neither Utzschneider nor Fraunhofer wished to disclose such

information. And in the case of achromatic lenses, each lens was unique, depending upon the specifications of the refracting telescope. In addition to these reasons for not patenting the fruits of his labors, the design of Fraunhofer's optical lenses was not original, as he used the typical construction of the period: a convex/concave doublet of crown and flint glass first implemented by John Dollond and Chester Moor Hall in mid-eighteenth-century England.[5] Fraunhofer's contribution to his profession lay in his skilled manipulations of optical glass production, changes in the recipes, and his calibration technique for determining the refractive and dispersive indices of glass with amazing precision and accuracy. Generally, changes in the chemical composition of lenses were not sufficient to warrant a patent.[6]

As was the case with all forms of artisanal knowledge, secrecy was paramount to Fraunhofer's manufacture of optical glass. The importance of secrecy to the success of the Optical Institute is evidenced by the contracts between Utzschneider and the Swiss watch and bell maker, Pierre Louis Guinand, who was the Optical Institute's first achromatic glassmaker. In the first contract dated May 10, 1806, the first paragraph states that

> The [optical glass] work must be done by him [Guinand] and his wife, Rosalie Bourverot, with their own hands only to ensure that the secret of their glass production . . . will be guarded in the utmost and will, under no circumstances, be told to a third party.[7]

Utzschneider reminded Guinand of his obligation in paragraph 5 of the contract by declaring that the artisan's pay was contingent upon him strictly adhering to this policy.[8] In case of death, his wife would continue to work and be compensated as long as she kept to the agreement signed by her husband.

In the second contract between Utzschneider and Guinand signed nearly a year later, secrecy is once again underscored. Utzschneider informed him that he was neither permitted to dismiss anyone, nor to permit anyone to see the glass hut without Utzschneider's consent.[9] Also, Utzschneider warned Guinand that should the Swiss craftsman decide to leave Benediktbeuern, he would not be allowed to teach anyone the method of producing optical glass.[10] After numerous

quarrels with his young assistant, Fraunhofer, Guinand decided to leave Benediktbeuern and return to his native canton of Neufchatel, Switzerland. Before he and his wife departed, Guinand needed to sign an agreement with Utzschneider that neither he nor his spouse would divulge to anyone any information regarding the production of optical glass, and that neither one would work on optical glass ever again. Otherwise, Utzschneider would suspend further payments.[11]

Unfortunately, we do not know what the original agreement between Fraunhofer and Utzschneider entailed when the young apprentice was hired in 1806, but since Guinand's contracts were rather typical for the period, one would assume Fraunhofer's original contract would have emphasized the importance of secrecy as well. In a contract dated February 7, 1809, when Fraunhofer was promoted to assist Guinand in optical glass manufacture, Utzschneider made it perfectly clear that he alone was the owner of the flint and crown glass goods, all of the buildings in Benediktbeuern, and the optical glass machines, tools, and various other forms of equipment.[12] And Utzschneider also reminded Fraunhofer that visitors to Benediktbeuern were not permitted access to the optical glass hut.[13]

The important point about secrecy here is that Utzschneider felt that he, as owner of the Optical Institute, was also the owner of the practical knowledge of optical glass production at Benediktbeuern, even though he himself conducted only a few experiments in the manufacture of optical lenses, all of which were failures. His role was predominantly, and nearly exclusively, managerial. He owned the materials of production: the glass hut, the raw materials, the optical equipment, and he owned any practical, artisanal knowledge produced by those employed by him, particularly Guinand and Fraunhofer. This was clear from contractual agreements with his employees. Any breech of these contracts was punishable under Bavarian law, ranging from fines to imprisonment. But enforcement was difficult, as many glassmakers, such as Guinand, would leave Bavaria (and indeed the German territories altogether) in order to resume their careers. In the case of the Optical Institute, ownership was coextensive with authorship.

But one need not conclude from this that Utzschneider was a diabolical owner exploiting his workers. Early nineteenth-century Bavaria was certainly not early nineteenth-century Britain, and the secularized

cloister of Benediktbeuern was neither a dark, satanic mill, nor a Dickensian workhouse. Fraunhofer was rewarded handsomely for his labors. He undoubtedly belonged to the group of artisans who financially benefited from their association with science and technology. The earliest record of Fraunhofer's salary dates from May 7, 1808, two years after entering the Optical Institute as an apprentice. His monthly wage was a meager 40 guilders per month.[14] Such an amount was slightly less than the average income of a glassmaker at the time. From 1809, the year of his second contract, until 1813, he received 67 guilders a month.[15] From 1814, the year of his third contract, to 1819, his monthly income was 125 guilders a month, plus profits earned, usually totaling 700 guilders a year. He also received an astonishing 10,000 guilders in 1814 as he now shared in the Optical Institute's ownership with Utzschneider, but as a junior partner.[16] Fraunhofer was now set for life. And, although the company's secrets were still the property of Utzschneider, he encouraged Fraunhofer to publish scientific articles on the theory of his work—in the optician's own name, without disclosing any information on production—so as to increase his reputation, as well as the reputation of the institute. From 1819, when the Optical Institute returned to Munich (although the optical glass manufacture remained at Benediktbeuern) until his death in 1826, Fraunhofer earned 150 guilders per month, plus approximately 700 to 800 guilders per year from profits. In 1823, after being named *Konservator* of the Royal Bavarian Academy of Sciences' Mathematical and Physical Instrument Collection, he received an additional 800 guilders per year.[17] This was a very good wage indeed, certainly permitting Fraunhofer to enjoy a lifestyle far more lavish than he experienced as a child.

In short, secrecy was necessary to ensure the Optical Institute's monopoly of the optical-glass market. Even after Fraunhofer was appointed co-owner, the veil of secrecy was never lifted. But secrecy also proved deleterious to Fraunhofer, as it thwarted his attempts to be recognized as a *Naturwissenschaftler*. As will be argued in the next section, among nineteenth-century circles of German *Naturforscher*, secretive knowledge stood starkly opposed to scientific knowledge. Savants claimed that scientific knowledge was knowledge made accessible to other savants for the common good. This knowledge, however, necessarily discriminated against any form of artisanal knowledge,

which by its very nature was secretive. Guild secrets, and later trade secrets, were standard practices throughout the German territories until the late nineteenth century. But the German Republic of Letters also discriminated against the possessors of such knowledge, the skilled artisans. Most skilled craftsmen were not interested in scientific authorship. They certainly expected rewards for their inventions, but in the form of patents. Fraunhofer, who could not obtain patents for his work, sought the reward of scientific authorship. It is when the craftsmen desired the creative status of the savant that tensions arose.

II. The Academy Must Not Become a "Corporation of Artists, Factory Owners, and Artisans"

Although Utzschneider argued that Fraunhofer was a gifted *Naturforscher* who should receive all the benefits and privileges of any other savant, including scientific authorship, would an article published by an artisan that dealt with the theory of science, rather than being a mere description of his newly invented scientific instrument, be considered to proffer the same philosophical and creative results as the essays published by members of the Republic of Letters, such as Carl Friedrich Gauss or John Herschel? While it is certainly clear that well before the 1810s instrument makers were claimed to be crucial to the scientific enterprise, whether the knowledge those skilled artisans generated was creative, like the intellectual labor of experimental natural philosophers, was a point of contention.

Before discussing the attitude of several savants to Fraunhofer's work, it is necessary to see how the German Republic of Letters defined the role of authorship during the late eighteenth and early nineteenth centuries. During the late eighteenth century, a literary culture was finally blossoming in the German territories, lagging far behind either Britain or France. As a result of this rapid transformation of the literate middle class, a bifurcation resulted among German literary circles: those high-brow authors forming around Friedrich Gottlob Klopstock's *Deutsche Gelehrtenrepublik* (German Republic of Letters) of 1772, and those authors who catered to the predilections of "the masses." Not surprisingly, many of the latter low-brow authors needed to sustain their rather humble existence; hence, the move to pen

simplistic tales and to *self-plagiarize*—the process of regenerating themes in order to write more numerous works—was rather common.[18] Those authors enjoying less challenging financial circumstances, such as Johann Wolfgang von Goethe, who earned his keep as the privy councilor to Duke Carl August of Weimar, frowned upon those authors who capitulated to the base whims of the public, thereby squashing the author's creativity.

The sentiment that succumbing to the predilections of the lower classes destroys creativity was a powerful one by the turn of the eighteenth into the nineteenth century in the German territories. Artisanal knowledge had historically been considered the antithesis of inspired genius. During the Renaissance, for example, being a craftsman, or a "master of a body of rules or techniques," had been deemed to be one of the two necessary components of authorship.[19] Craftsmanship had been defined in contrast to the other component of authorship—inspiration, or genius. Inspiration was seen as being creative and intellectual—as opposed to manual, a higher form of knowledge not shamefully following the rules or techniques required of the craftsman. And as time went on the role of the author as craftsman began to wane, until the late eighteenth century when, as theorists of the period exclaimed, it had been totally eclipsed by inspirational genius. Following Edward Young's claim that "imitations are often a sort of manufacture wrought by those mechanics, art and labor, out of pre-existent materials not their own,"[20] the German literary intelligentsia saw the author as the transcender of rules. Indeed, between 1773 and 1794 a debate over the ownership of intellectual property flared throughout the German territories sparked by Klopstock's announcement in *Deutsche Gelehrtenrepublik* that authors should circumvent publishers and present their work directly to the public via subscriptions.[21] The critical shift in defining the author as a creative, inspired genius was accompanied by the belief that the author had rights; the message of the book was his or hers, rather than the audience's. When authors had been seen as being mere craftsmen, the book dealers and publishers had been the owners of the knowledge presented in the text. The debate culminated with a lengthy treatise by Ernst Martin Gräf, *Forschungsbericht: Versuch einer einleuchtenden Darstellung des Eigenthums des Schriftstellers und Verlegers und ihrer gegenseitigen Rechte und*

Verbindlichkeiten. Mit vier Beylagen. Nebst einem kritischen Verzeichnisse aller deutschen besonderen Schriften und in periodischen und anderen Werken stehenden Aufsätze über das Bücherwesen überhaupt und den Büchernachdruck insbesondere (*A Research Report: An Attempt toward a Classification of the Property and Property Rights of Writers and Publishers and Their Mutual Rights and Obligations. With Four Appendices. Including a Critical Inventory of All Separate Publications and Essays in Periodical and Other Works in German Which Concern Matters of the Book as Such and Especially Reprinting*). Gräf's *Forschungsbericht* sided with Klopstock's *Deutsche Gelehrtenrepublik* that authors should be the owners of their work. He wanted

> to ascertain whether it might be possible by arranging such subscriptions for scholars to become the owners of their writings. For at present they are so only in appearance; book dealers are the real proprietors, because scholars must turn their writings over to them if they want to have these writings printed. This occasion will show whether or not one might hope that the public, and the scholars among themselves, . . . will be instrumental in helping scholars achieve actual ownership of their property.[22]

As obvious as Klopstock's plea might sound, before this period throughout the German territories, a book had been seen as a collaborative enterprise, each group of artisans receiving the same amount of credit as the others. For example, in 1753, the *Allgemeine Oeconomisches Lexicon* listed all of the artisans responsible for producing a book in its entry for "Book": the writer, the paper maker, the type founder, the typesetter and the printer, the proofreaders, the publisher, and the book binder. They had all been equally deserving of credit of the manufacture, authorship, and ownership of the book's contents. Klopstock's intervention attempted to thwart the egalitarianism of the mid-eighteenth century by granting ownership exclusively to the author, who was no longer considered to be part artisan.

Klopstock's trials were to be rewarded, but not until 1810, after the Napoleonic occupation of the German territories. Baden jurists added laws covering literary property to the *Code Civile*:

> ¶ 577.da. Every written transaction is originally the property of the person who composed it, as long as he did not write it on the commission of another and for the advantage of another, in which it would be the property of the person who commissioned it.[23]

Fraunhofer's Bavaria defined the object of the author's proprietary rights in 1813 by drawing upon Johann Gottlieb Fichte's work and Article 397 of the Bavarian Penal Code:

> Anyone who publicizes a work of science or art without the permission of its creator, his heirs, or others who have obtained the rights of the creator by reproducing it in print or in some other way without having reworked it into an original form will be punished.[24]

As detailed below, these debates about authorship spilled over into debates about scientific authorship during the 1820s.

Within certain circles of Bavaria, whether artisanal knowledge counted as scientific knowledge and whether instrument makers should be considered scientific authors were topics of debate, particularly within the confines of the Royal Academy of Sciences in Munich. Fraunhofer's nomination to the rank of ordinary member of the mathematics and physics section of the academy can be used to trace the contours of the debate over the status of artisanal labor and its relationship to scientific authorship. The debate centered on the argument of whether Fraunhofer was a *Naturforscher* (investigator of nature) or a *geschickte Handwerker* (skilled artisan).

In 1820, Fraunhofer was proposed for a promotion from corresponding member, which he had been since February 15, 1817, to ordinary visiting member.[25] The recommendation stated that

> Herr Professor Fraunhofer has become famous among physicists over the past several years for his direction of the Optical Institute formally in Benediktbeuern, now in Munich. His secret of the manufacture of flint and crown glass and the production of optical glass of a size hitherto unheard of have secured an everlasting name for him in the history of science.[26]

The letter continued by praising Fraunhofer's sharp sense of observation, which had led to discoveries in the field of optics.[27]

This recommendation elicited an immediate protest from the director of machinery of the prince's Coin and Mining Office (*Maschinendirektor beim kurfürstlichen Münz- und Bergmeisteramt*), Joseph von Baader, an ordinary member of the mathematics and physics section. In his letter to the academy dated March 31, 1820, Baader complained that Fraunhofer's reputation was insufficient for an ordinary membership. He quoted the academy's constitution paragraph XIII, title 1, which stated that ordinary members may be accepted only if the world of scholars has been convinced of the merit of the potential member's published works, or if the academy has been privy to important discoveries made by the potential member in lectures.[28] Baader continued by emphasizing that Fraunhofer was not university educated, and indeed never even attended *Gymnasium* (high school). Although Fraunhofer was admittedly well versed in the *Kunstfach* (art) of practical optics as a result of his training in optical glassmaking, this knowledge was insufficient for Fraunhofer to be called a mathematician or physicist.[29] Baader's mean-spirited attack became most vitriolic when he warned that the academy must not become a "corporation of artists (*Künstler*), factory owners (*Fabrikanten*), and artisans (*Handwerker*)."[30]

Baader's diatribe, however, did not stop there. He proceeded to attack Fraunhofer's article "On the Determination of the Refractive and Dispersive Indices of Differing Types of Glass" by asserting that although the article was very interesting and useful for artisans working on the perfection of optical instruments, it lacked any form of a scientific discovery (*wissenschaftliche Entdeckung*). To Baader, an artisan, by his very nature, could not make any theoretical, philosophical discoveries relevant to science, the product of creative genius. He even questioned whether Fraunhofer had written it himself. Since his essay was published in the Academy's *Denkschriften*, Fraunhofer had fulfilled one of the necessary (and sufficient) conditions for appointment as a regular member of the mathematics and physics section. His essay offered a detailed account of how one could observe the dark lines of the solar spectrum, and how one could use those lines as a calibration technique for the precise determination of the refractive and dispersive

indices of various types of optical glass samples. But, he never divulged how he procured his superior glass samples, which he would have needed to do if applying for a patent under Bavarian law. In order to disqualify Fraunhofer's candidacy, Baader publicly questioned whether Fraunhofer actually authored the piece himself, strongly suggesting that the true author was his employer, Utzschneider. Clearly, questions of authorship were deeply rooted in issues of social class. Baader concluded his letter by arguing that the secretive nature of glassmaking is "not of a scientific nature, but of an artistic, artisanal one."[31] Fraunhofer's private and entrepreneurial knowledge was, in Baader's eyes, the antithesis of science. For Baader, being a scientific author and *Naturwissenschaftler* were coextensive; therefore, social, historical, and epistemological issues were inextricably intertwined.

Baader's protest was joined by an attack on Fraunhofer's character by Julius Konrad Ritter von Yelin, Munich's chief financial advisor (*Oberfinanzrat*). Ritter von Yelin was a physicist and chemist. His assault was brief, but just as harsh as Baader's. Yelin echoed Baader's concern that Fraunhofer was self-educated. Such a lack of formal education, Yelin argued, would result in an inability to follow the complex lectures that periodically took place in the mathematics and physics section of the academy. Yelin's anger was most evident in his concluding remark: he found it personally insulting that Fraunhofer would join the same section, at the same rank, as he.

It should be noted that Yelin was not opposed to the application of technology in the service of the state. Quite the contrary, he extolled the progress made by Bavarians in science and technology and how such progress had strengthened Bavaria. Indeed, Yelin played a critical role in Bavaria's *polytechnischer Verein*, which had the express goal of applying scientific and technological advances to the fledgling Bavarian economy. What Yelin objected to was that those responsible for such progress should necessarily be considered *Naturforscher*.[32]

Baader's and Yelin's resistance sparked Fraunhofer's supporters in the academy to take a concerted action. They argued that there had been historical precedents whereby men without a university education had become ordinary members of the academy.[33] Indeed, the section's secretary and botanist Franz von Paula Schrank composed a memorandum listing members of other academies who did not possess a

university education. Johann Georg von Soldner, Bavarian Court astronomer and major contributor to the theory and practice of geodesy, defended his friend's work. He simply could not agree with Baader's claim that Fraunhofer's work did not contain a single scientific discovery. The dark lines of the solar spectrum, for Soldner, was an example of such a discovery.[34] At the actual vote, he continued his plea: "Through these lines *exact measurements* of the solar spectrum are now possible, and the possibility of exact measurements and their implementation is the goal of what one considers to be *exact science*. I consider this discovery of Fraunhofer's to be the most important one in the area of light and colors since Newton."[35] Hence, the academy should not bar Fraunhofer based on the grounds that his work did not belong to a recognized scientific canon. By placing Fraunhofer's name in the same sentence as Newton's, Soldner was indeed considering Fraunhofer to be a great physicist and mathematician.

In the end, it was decided that appointing Fraunhofer to an ordinary membership was too controversial. On June 27, 1821, then, he was promoted from corresponding member to an extraordinary visiting member of the academy after a vote on the previous May 30 of 19 to 1 in his favor.[36] With an extraordinary visiting membership, Fraunhofer was at least permitted to attend sectional meetings. In that same year, Fraunhofer's most theoretical piece hitherto was accepted for publication in the Academy's journal, *Denkschriften der königlichen Akademie*, entitled: "Neue Modification des Lichtes durch gegenseitige Einwirkung und Beugung der Strahlen" ("New Modification of Light through Reciprocal Effects and Diffraction of the Rays"). Soldner took the lead in proposing the paper to the *Denkschriften*. He argued that it marked "a new epoch in the physical theory of light."[37] Other academy members agreed, including Reichenbach; the physicist, Benedictine monk, and later professor of the University of Munich, Thaddäus Siber; Schrank; and even Baader. This article was not simply a description of a scientific instrument, such as Fraunhofer's amazing diffraction gratings. Rather, it sought scientific status as it offered a compelling account of the undulatory theory of light proposed by Thomas Young and Augustin Fresnel. Nothing in the paper was based on secret knowledge. Yelin protested again, arguing that the work of someone with such little formal education should not be included in

such a prestigious journal.[38] This time, his protest was to no avail. In 1823 Fraunhofer was appointed *Konservator* and professor of the academy's collection of mathematical and physical instruments with a stipend compensating him for lectures periodically delivered at the academy until his death in 1826.[39] He was also elected member of the *Gesellschaft für Naturwissenschaften und Heilkunde* of Heidelberg in 1825 and was even knighted by King Maximilian I in 1824.[40] It is clear, then, that the issue of whether the skilled labor of artisans such as Fraunhofer was sufficiently elevated and creative to be granted the status of scientific authorship was hotly contested during the third decade of the nineteenth century in Bavaria.

III. Conclusion

In short, during the late eighteenth and early nineteenth centuries, the German Republic of Letters was defining the role of author and actively seeking a change in the archaic laws. They successfully lobbied for the linkage of the author to ownership by severing the previous link between the market (book dealers), authorship, and ownership. The commercial interests of the market place thwarted their role as authors. This was one of their objections to Fraunhofer's work, as it too arose out of market interests. And because they were keen to distinguish themselves from the craftsmen-like elements of the profession, they were not interested in including artisans such as scientific instrument makers in their "republic." Craft secrecy challenged their commitment to the openness of scientific knowledge. Finally, echoing the concern of Young, German intellectuals questioned the creativity of artisans, arguing that they merely manipulated preexisting materials rather than creating something truly novel. Allowing artisans the status of scientific authorship would mean returning to mid-eighteenth-century obscurity and irrelevance.

This story has raised an important question concerning the status of artisanal knowledge vis à vis scientific authorship. The craftsman seeking scientific credibility faced a serious dilemma: because artisans worked in guilds, their knowledge was necessarily shrouded in secrecy and connected to a commercial network. And, their labor was seen as being uncreative, unlike the savant. Members of the Republic of

Letters, on the other hand, could take individual credit for their intellectual labors by becoming scientific authors. Craftsmen affiliated with the scientific enterprise were often denied such status. Questions of authorship during the late eighteenth and early nineteenth centuries were part of a larger attempt by experimental natural philosophers to distinguish clearly between intellectual and mechanical labor and skill. During this period of intense mechanization, what counted as skill, creativity, or authorship was being redefined. And the politics of labor sheds light on how certain individuals created and maintained these categories.

Notes

1. See Myles W. Jackson, "Illuminating the Opacity of Achromatic Lens Manufacture: Joseph von Fraunhofer and the Architecture of his Monastic Laboratory," in *Architecture in Science*, eds. Galison and Thompson (Cambridge, Mass. and London: MIT Press, 1999). See also Myles W. Jackson, *Spectrum of Belief: Joseph von Fraunhofer and the Craft of Precision of Optics* (Cambridge, Mass., and London: MIT Press, 2000); and Myles W. Jackson, "Buying the Dark Lines of the Solar Spectrum: Joseph Fraunhofer and His Optical Institute," vol. 1 of *Archimedes*, ed. Jed Z. Buchwald, 1996, 1–22.
2. Such logic also prevailed in seventeenth-century England. See Steven Shapin, *A Social History of Truth. Civility and Science in Seventeenth-Century England* (Chicago and London: University of Chicago Press, 1994), 355–407.
3. R. Klostermann, *Die Patentgesetzgebung aller Länder nebst den Gesetzen über Meisterschutz und Waarenbezeichnungen systematisch und vergleichend* (Berlin: I. Guttengerb, 1869), 217.
4. Ludwig Gieseke, *Die geschichtliche Entwicklung des deutschen Urheberrechts* (Göttingen: Otto Schwarz & Co., 1957), 122.
5. Interestingly, there was a priority dispute over the patenting of optical lenses between Dollond and Hall during the 1730s.
6. Klostermann, *Die Patentgesetzgebung*, 40.
7. As reprinted in Adolf Seitz, *Joseph Fraunhofer und sein Optisches Institut* (Berlin, 1926), 15.
8. Ibid., 17.
9. Ibid., 21.
10. Ibid., 23.
11. Ibid., 50.
12. Fraunhofer Nachlaß, Archiv 6079, Deutsches Museum (Munich), 1.
13. See Myles W. Jackson, "Artisanal Knowledge and Experimental Natural Philosophers: The British Response to Joseph Fraunhofer and the Bavarian Usurpation of Their Optical Empire," *Studies in History and Philosophy of Science*, 25 (1994): 549–75, particularly 567–72; and Jackson, *Spectrum of Beliefs*, 74–77.
14. Staatsbibliothek Preußischer Kulturbesitz Berlin (hereafter cited as SPKB), Utzschneiders Nachlaß, Box 1, 7 May 1808.
15. Joseph von Utzschneider, *Kurzer Umriß der Lebens-Geschichte des Herrn Dr. Joseph von Fraunhofer, königlich bayerischen Professors und Akademikers, Ritters des königlichen bayerischen Civil-Verdienst, und des königlich dänischen Dannebrog-Ordens, Mitgliedes mehrerer gelehrten Gesellschaften, etc.* (Munich: Rösl'schen Schriften, 1826), 19.
16. Ibid.; and SPKB, Utzschneiders Nachlaß, Box 1, 21 June 1817. Twice a month from 1809 to 1814, Utzschneider sent Fraunhofer 500 guilders for expenses incurred during the glass-making procedure. It should be noted that 10,000 guilders were 40 to 50 times the average monthly salary of a worker at that time. See Deutsches Musuem, Archiv 7323; and Hans-Peter Sang, *Joseph von Fraunhofer* (1987), 73.
17. Von Rohr, *Leben, Leistung, und Wirken* (1929), 196; and Seitz, 91. As a comparison, his assistants were generally earning between 18 and 24 guilders per month in 1820. SPKB, Fraunhofer Nachlaß, Box 5, "Lohne der Arbeiter."
18. We are told that Karl Philipp Moritz (1756–1793) was a shameless recycler of his ideas. This portion of my paper owes much to the outstanding work of Martha Woodmansee, *The Author, Art, and the Market: Rereading the History of Aesthetics* (New York: Columbia University Press, 1994), 29–53.
19. Ibid., 36.
20. Edward Young, *Conjectures on Original Composition in a Letter to the Author of Sir Charles Grandison*, in *English Critical Essays: Sixteenth, Seventeenth, and Eighteenth Centuries*, ed. Edmund D. Jones (London: Oxford University Press, 1975), 274.
21. Woodmansee, *The Author*, 48.
22. As quoted in Woodmansee, 48, and Helmut Pape, "Klopstocks Autorenhonorare und Selbstverlagsgewinne," *Archiv für Geschichte des Buchwesens*, 10 (1970): cols 1–268, here columns 103–4. See also Philipp Erasmus Reich, *Zufällige Gedanken eines Buchhändlers über Herrn Klopstocks Anzeige einer gelehrten Republik* (Leipzig, 1773).
23. As quoted in Woodmansee, *The Author*, 53. Original: Ch. F. M. Eisenlohr, ed., *Sammlung der Gesetze und internationalen Verträge zum Schutze des literarischen-artistischen Eigenthums in Deutschland, Frankreich und England* (Heidelberg: Bangel and Schmitt, 1856), 11.
24. As quoted in Woodmansee, *The Author*, 53. Original: Ludwig Gieseke, *Die geschichtliche Entwicklung des deutschen Urheberrechts* (Göttingen: Otto Schwartz, 1957), 122.
25. From the time he worked on the dark lines of the solar spectrum in 1813 and 1814, Fraunhofer wanted to be regarded as a *Naturwissenschaftler* for personal reasons. This is quite clear from his private correspondence with Utzschneider.
26. Bayerische Akademie der Wissenschaften, Akten der königlichen

Akademie der Wissenschaften, Personal Akten: Herr Joseph Fraunhofer, 1821–26 (hereafter cited as BAW:JF), 1.

27. Ibid.
28. Ibid., 8–9. See also Sang, *Joseph von Fraunhofer*, 96–97.
29. BAW:JF, 8.
30. Ibid. It should be noted that the German word *Künstler* meant something like the French word *artiste*, someone well versed in the mechanical (as well as fine) arts.
31. Ibid.
32. von Yelin, "Rede gehalten" (1818), 601–8.
33. BAW:JF, 16–17.
34. Ibid., Akt V, 12, no. 25, 4 April 1820.
35. Ibid. Emphasis in the original.
36. This might sound confusing to the modern reader. In German states, ordinary memberships and ordinary professorships were higher in stature and salary than extraordinary members and extraordinary professorships; ibid., 27; 28.
37. Ibid., 28.
38. Ibid., 26.
39. DMA, Fraunhofer Nachlaß, N14/27, 5417.
40. See SPKB, Haus II, Fraunhofer Kasten 3, letter no. 7; and DMA, Fraunhofer Nachlass, 14/9, 5415; and 14/7, 5420 a/c.

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