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The Social Construction of Fluorescent Lighting, Or How an Artifact Was Invented in Its Diffusion Stage

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Technology is assumed to be designed, developed, and produced by engineers.[1] They are at the drawing boards and behind the laboratory benches; they apply for patents, model the prototype, and test in the pilot plant; they show the newly born artifact to the press and, if lucky, they figure prominently in the glossy photographs of stories about heroic inventors. Once these engineers have produced the technology, it is passed on to the sales people, the managers, the trade, and, finally, to the users. Engineers design technology, managers produce it, salespeople sell it, tradespeople distribute it, users use it. Alas, this neat and orderly image of technical development, so pervasive in all but the most recent technology studies, is not only too simple—it is wrong.

This chapter has two aims. First, I want to show that the application of a linear stage model of technical development is detrimental to understanding the development of technical artifacts. Rather, no stages can be distinguished. I will demonstrate how the modern fluorescent lamp was designed during what commonly would have been called its "diffusion stage." If the fluorescent lamp is considered a static artifact, forever fixed and unchanging since it left the General Electric laboratories on April 21, 1938, it is difficult to understand what actually happened and the original lamp's relation to the present fluorescent lamp. Instead, I will analyze, from a social-constructivist perspective, the fluorescent lamp as something that was continually reshaped and redesigned by the various social groups involved.[2] The second aim of this chapter is to provide an illustration of the possibilities of integrating the social-shaping and the social-impact perspectives on technology.[3]

Part of the development of the fluorescent lamp is described in detail, using the social constructivist approach (SCOT).[4] In the SCOT descriptive model, *relevant social groups* are the key starting point. Technical artifacts do not exist without the social interactions within and among social groups. The design details of artifacts are described by focusing on the *problems and solutions* that those relevant social groups have with respect to the artifact. Thus, increasing and decreasing degrees of stabilization of the artifact can be traced. A crucial concept in SCOT (as well as in the Empirical Program of Relativism, EPOR, in the sociology of scientific knowledge, to which SCOT is closely related) is *interpretative flexibility*. The interpretative flexibility of an artifact can be demonstrated by showing how, for different social groups, the artifact presents itself as essentially different artifacts. The theoretical concept of *technological frame of a social group* is employed to explain the interactions within and between social groups that shape the artifacts; these technological frames shape and are shaped by these interactions (Bijker 1987).

Relevant Social Groups

It is relatively easy to identify the relevant social groups by "following the actors".[5] They are themselves quite explicit about it. For example, Howard W. Sharp, utility executive and member of the Lamp Committee of the Edison Electric Institute, used the phrase "I have delayed replying . . . in order to coordinate with the rest of the boys,"[6] referring to what I will call the social group of utilities. Other social groups are clearly identified as well: "It is apparent that dealing with the fixture manufacturers, as a group, involves delicate negotiations."[7] Historical actors sometimes even seemed to be anticipating the problems of historians and sociologists of technology and, in the case of the fluorescent lamp, deliberately tried to maintain their group's integrity. For example, Sharp wrote, in connection with the fluorescent lighting developments:

> It is quite desirable that we maintain the united front that has been established so far in connection with this light source [. . . and] concerted action on the part of responsible people in the lighting business is necessary in order to prevent "runaways."[8]

Actors' accounts may correct the researcher's intuitions. For example, in 1984 I employed the fluorescent lamp as an "obvious" example of a technical development where it would not be useful to consider a separate social group of women: neither for the actors, nor for me as analyst, would that provide any further insight—or so I thought then. (Pinch and Bijker 1984, 415). However, O. P. Cleaver, a leading Westinghouse executive, thought otherwise when he analyzed the problems in the home lighting field with respect to fluorescent lighting:

> The widespread acceptance of fluorescent lighting in the home will depend directly upon the housewife, who is generally alert to new ideas that give comfort to her family and beautify her home, provided the cost does not exceed the family budget—and more important, provided she is made conscious of the advantages of the new equipment through national advertising and neighborly example.[9]

This executive clearly recognized the social group of women as relevant for the development of the fluorescent lamp.

Actors provide an effective starting point from which to identify relevant social groups. In that sense, "relevant social group" is an actor category. However, it is indeed only a starting point, and this method is not proposed as an "idiot-proof" recipe for carrying out a social constructivist case study. Several methodological issues are still unsolved. For example, it may be difficult to decide whom to treat as spokespersons for a specific relevant social group, although this will, again, often become clear if we let the actors speak for themselves. In some instances—for example, when one social group is splitting into two—groups may not accept someone acting as its spokesperson, but that will again become evident by "listening" to the actors.[10] Another problem is that only "vocal" attributions of meaning are analyzed, and there is always the danger of the analyst not "hearing" the voices of some parties. This ethnographic approach deliberately focuses on meanings attributed to artifacts and does not take the route of imputing hidden interests to social groups as, for example, Marxist structuralism or Parsonian functionalism would do.

After following the actors, the second step in identifying relevant social groups is what might be called "historical snowballing."[11] While following the actors by reading historical documents, the researcher notes each actor and every social group that is mentioned. Subsequently those new actors and social groups are also followed, and at some point no more new names or social groups will be encountered. Of course this is an ideal sketch, because the researcher will have intuitive ideas about what set of relevant social groups is adequate for the analysis of a specific artifact and, consequently, will not follow this road to its very end. This methodological model serves here primarily to argue that there is no essential problem involved in using the concept "relevant social group" in empirical (whether sociological or historical) studies of technology.

The problem of delineating relevant social groups (and, for example, deciding whether it is more effective to use two different groups rather than one) is still a matter for the intuition of the researcher. Obviously, the list of relevant social groups that results from this strategy needs to be simplified and ordered. To start with, many actors may be taken together to form one relevant social group, but then some of the groups thus created may turn out to be too large. For example, in the case of the bicycle it was decided that a separate group of women cyclists needed to be incorporated in the description (Pinch and Bijker 1984). Similarly, in the later stages of the fluorescent lamp case, the social group "government" had to be split into the Antitrust Division of the Department of Justice and the War Department. Also here, an important starting point is to let the actors speak for themselves.

"Relevant social group" is both an actor and an analyst category. When following the actors in their identifications, definitions, and delineations, it is the actors' relevant social groups that we get. The central claim in the social construction of technology is that these relevant social groups *are also relevant for the analyst*—"relevant social group" is also an analyst concept.

I will now describe the relevant social groups in the fluorescent lamp case. Only two social groups will play an important role in this chapter—the Mazda companies and the utilities. The other groups will be described briefly.

The Mazda Companies

The social group of Mazda companies consists of General Electric and Westinghouse.[12] They were, at that time, commonly referred to as "Mazda companies" after their incandescent lamp trademark "Mazda." Through its licensing system, General Electric had control of about 90 percent of the incandescent lighting market during the period 1913–1940 (Rogers 1980). The General Electric patent-licensing system consisted of two classes of licenses. The class A license was granted only to Westinghouse. It gave the licensee the right to produce a certain percentage of General Electric's own lamp output and, among other things, the right to use General Electric's Mazda trademark. Licensees with a class-B license were allowed to produce a smaller quantity of certain types of lamps, and they could not use the trademark. Hygrade Sylvania Corporation was such a class-B licensee.

A crucial role in maintaining this almost absolute control of the lighting business was played by the intimate connections between the lamp manufacturers (General Electric and Westinghouse) and the electricity-producing utilities. This is a specific example of the general observation that relevant social groups do not only constitute themselves, but they also help to maintain other social groups and the relations between them. The basis of the relations in this case was an understanding that each side would work in the interests of the other. The utilities undertook to sell and promote Mazda lamps—and the appliances and other electrical apparatus of the Mazda manufacturers as well—and, for their part, the Mazda manufacturers undertook to promote their products in such a way as to add to electricity consumption. The Mazda companies also supported and participated in campaigns and programs conducted by the utilities to increase the use of electricity supplied by them. For example, in the 1930s a large number of utilities gave their customers free renewals of lamps of higher wattage to keep their sockets filled. The lamps used in these campaigns were Mazda. General Electric and Westinghouse supplied the lamps at reduced prices to the utilities, with free renewals. The intimacy of the relations between the Mazda companies and the utilities is evident in that the utilities not only sold Mazda lamps, they also advertised them and promoted their use.

The Utilities

Obviously, the social group of utilities is going to play a prominent role in this story. Who were they? Each utility was a private company, operating one or several central stations to generate and sell electricity. The utilities had a number of strong collective organizations and can be seen as acting, through these organizations, as one social group. The utilities, although ordinarily independent of each other, did act in concert in matters affecting their common interest. For instance, over one hundred utilities belonged to the Edison Electric Institute (E.E.I.). Another large organization of utilities was the Association of Edison Illuminating Companies (A.E.I.C.). Each of these associations extended to every part of the country. The E.E.I. and A.E.I.C. were made up of committees and groups, composed of representatives of the member utilities, who among other things handled policies for the industry. The policies were either determined at the meetings of the organizations as a whole or formulated by the particular committees themselves, on the basis of their knowledge of the desires of the industry. Frequently this knowledge was derived from questionnaires sent out to all utilities.

Two important committees were the Lighting Sales Committee (E.E.I.) and the Lamp Committee (A.E.I.C.). These committees had over many years worked very closely with representatives of General Electric and Westinghouse in setting policies with respect to the manufacture, distribution, and use of (incandescent) lamps manufactured by the two Mazda companies, and the promotion of such lamps by the utilities. The Electrical Testing Laboratories also played an important role. This organization was owned by the utility companies and engaged in commerical testing of electric lamps and other electrical equipment.

The Fixture Manufacturers

The social group of fixture manufacturers deserves separate mention. In the fields of both incandescent and fluorescent lighting, the Mazda companies produced mainly lamps. Sockets, reflectors, and other kinds of auxiliaries were produced by smaller companies. For incandescent lighting, a system of specifications had been set up, and fixture manufacturers had to design their products according to those specifications. Their products were tested by the Electrical Testing Laboratories. A similar plan was to be developed in the field of fluorescent lighting.

The Independents

The social group of independents consisted of lamp manufacturers not bound to General Electric by patent licenses in the fluorescent field. Hygrade Sylvania, a B licensee of General Electric in the incandescent lamp field, was the only company in this social group. According to its B license, Hygrade Sylvania was allowed to produce 9.124 percent of General Electric's net sales quota in incandescent lamps (Bright and Maclaurin 1943). With only about a 5.5 percent market share, Sylvania did not have a great stake in the incandescent field. It acquired a patent position on fluorescent lamps to counter that of General Electric and Westinghouse. Hygrade Sylvania started production of fluorescent lamps in 1939 and soon had 20 percent of the fluorescent market. The company had developed its fluorescent lamp independent of General Electric and was, in this field, not bound by license agreements—hence the name "independent."

The Customers

The social group of customers does not have its own direct voice in this story. However, the results of market research conducted by the utilities and the lamp maufacturers reveal some of the attitudes of this social group. Also, an analysis of the popular technical press may reveal parts of the meanings as attributed by the social group of customers, since this press may be considered to reflect the views of customers.

The Government

A peculiar role in the fluorescent case is played by the social group of the government—or more precisely, by two groups: the Antitrust Division of the Department of Justice, which filed an antitrust suit against General Electric and Westinghouse in 1942; and the War Department, which asked the Attorney General to make an application to the court for an adjournment because such a trial would seriously interfere with General Electric's contribution to the war effort.[13]

The Interpretative Flexibility of the Fluorescent Lamp

The interpretative flexibility of the fluorescent lamp can be demonstrated by showing how different relevant social groups attributed different meanings to it, constituting three quite different artifacts in the period 1938–1942: the "fluorescent *tint* lighting lamp," the "high-*efficiency* daylight fluorescent lamp," and the "high-*intensity* daylight fluorescent lamp." The first two artifacts played an important role in the "load controversy" between the Mazda companies and the utilities. The third artifact was at the same time instrumental in and resulting from reaching closure in this controversy.[14]

On April 21, 1938, the fluorescent lamp was released commercially by the Mazda companies, General Electric, and Westinghouse. These "fluorescent lumiline lamps" were explicitly aimed at "tint lighting." The new lighting device could provide brighter and deeper colors of a wider variety than was previously possible with incandescent lamps. Because of their ability to produce "light in hitherto unobtainable pastel tints as well as pure colors,"[15] they were expected materially to affect many phases of lighting practice. Moreover, although their installation costs were higher, they were thirty to forty times more efficient than incandescent lamps for color lighting.[16] Lighting applications mentioned ranged from theater interiors to ballrooms, from specialty shops to art galleries, from showcases to game machines, from railway cars to homes. Some of the applications suggest that the Mazda company executives were already thinking of general indoor lighting, but this is not very explicit.

In these early days of fluorescent lighting, the lamp was a "fluorescent *tint* lighting lamp" for the relevant social group of utilities, just as it was for the Mazda companies. This is not surprising, because the utilities' knowledge of these lamps was rather limited and based almost exclusively on information provided by the Mazda companies. The new lighting device was introduced in a way that did not suggest any revolutionary change in lighting practice. Three utility men remembered the occasion:

> Its presentation was as casual as developments in incandescent sources were wont to be. There was the usual amount of discussion, but the impression seemed to be that here was a light source rich in color and high in efficiency, but low in total light output, expensive, and generally suitable for only special applications.[17]

Thus even when daylight lamps were discussed, this was done in the context of special purposes and tint lighting, as is clear from a memorandum of the Chairman of the A.E.I.C. Lamp Subcommittee:

> The daylight tubes it is to be anticipated will have most utility. Because of the small wattages and small production of heat these lend themselves particularly well to showcase illumination. Because of the white light they should find large application for color matching purposes.[18]

The origins of this specific artifact, the "fluorescent *tint* lighting lamp," can be traced back to the 1939 New York World's Fair. Of course, the standard histories of discharge lighting in general, and of fluorescent lighting more specifically, go back to the Geissler tube (1860), the Moore tube (1895), the Cooper-Hewitt lamp (1901), the Claude neon tube (1912), and the Risler, Küch, and Holst lamps (1920s to 1930s).[19] Often, these histories are presented in the perspective of a quest for general indoor white lighting. Considering what we know now about the presently stabilized usage of fluorescent lamps (i.e., general indoor daylight lighting), it is intriguing why that first artifact was the fluorescent tint lighting lamp and not immediately the other lamp that eventually stabilized: the high-intensity daylight fluorescent lamp. The fluorescent *tint* lighting lamp seems to be a strange deviation from the (retrospectively apparent) linear path, which ran from the goal of general white indoor lighting to, at its end, the artifact high-intensity daylight fluorescent lamp. The actors show how to understand this detour by guiding us to the World's Fair.

Ward Harrison, engineering director of the incandescent lamp department of General Electric and most prominent spokesperson of the Mazda companies in the early days of fluorescent lighting, admitted,

> There were a couple of World's Fairs in the offing that were going to be lighted almost entirely with the high tension tube lighting if they were not supplied with some lamps of ours.[20]

Other relevant social groups also saw the World's Fairs as the reason for dragging the fluorescent lamp "out of the research laboratories by a caesarian operation."[21] As the fixture manufacturers described this episode retrospectively,

> The pressure of the demand for a new illuminant to be exploited at two World's Fairs was too much [for conservative judgment to prevail]. The 15- and 20-watt fluorescent lamps were produced for use at the Fairs—others wanted them—and a new illuminant, with a lot of unexplored implications, was launched.[22]

This view is confirmed by the lighting engineers of the World's Fair themselves (Engelken 1940). This context makes the emphasis on tint lighting understandable. In the $150 million transformation of 1,200 acres of salt marsh and wasteland into the New York World's Fair, so vividly described in the novel by Doctorow (1985), color schemes of architecture and artificial illumination played an important role:

> A zoning and color scheme adopted prior to the construction insured architectural unity, and harmony of plan, design, and treatment throughout the whole area. . . . The color scheme . . . is coordinated with the physical layout. Starting with white at the Theme Center, color treatments of red, blue or gold radiate outward with progressively more saturated hues. Adjoining hues blend circumferentially along the avenues. The illumination was fitted to this scheme [so] as to maintain the basic pattern by night as well as by day, but with new and added interest and charm after sunset. (Engelken 1940, 179)

Obviously, tint lighting was an important objective for the lighting engineers who were designing the first large-scale applications for these fluorescent lamps.

But within half a year of the introduction of the fluorescent tint lighting lamp, another artifact emerged: the high-efficiency daylight fluorescent lamp. A flood of advertising over the signatures of the major lamp companies streamed out, containing such statements as, "three to two hundred times as much light for the same wattage," "cold foot-candles," "amazing efficiency," "most economical," and "indoor daylight at last." The utilities started to fear that the high efficiency of the fluorescent lamp might reduce their electricity sales. As the utility executive Carl Bremicker of the Northern States Power Company said about his utility employees, "They had better get their white wing suits ready because very shortly General Electric and Westinghouse would have them out cleaning streets instead of selling lighting."[23] An internal Westinghouse memorandum lends support to the utilities' worries. It concluded that "the average utility lighting man sees in the rise of fluorescence a decrease in his relative importance."[24] The memorandum presents a comparison of the profits, based on a 4 cent rate and with equal costs to the user. The design data were unfavorable to fluorescence—almost any other selection would have emphasized the differences. The result of the comparison was that, to the utility, fluorescence was only half as important as incandescence; to the lamp suppliers it was six times as important, to the equipment manufacturers three times as important, to the contractor 20 percent more important.[25]

Thus a controversy developed—the "load issue." It took the form of a competition between the two fluorescent lamp artifacts. The utilities, having been alerted by their discovery of the high-efficiency daylight fluorescent lamp, tried to keep the other artifact, the fluorescent tint lighting lamp, in the forefront. They argued that claims about high efficiency were true, but only when fully qualified. And this, they claimed, was not done. For example, when the "three to two hundred times as much light" statement was accompanied by the picture of an office, the customer might expect amazing efficiencies. And this, the utilities argued, could have been true only if that customer was willing to have green or blue light.[26] The utility lighting staff was irritated by this misleading publicity, and in trying to fill in the rest of the story found that they were being immediately accused of excessive self-interest. They resented their position of apparently throwing cold water on fluorescent lighting because they were trying to tell the complete story. Long and detailed arguments were given to point out that the high-efficiency daylight fluorescent lamp really did not exist, but that it was mistaken for the fluorescent tint lighting lamp, which indeed was a valuable new lighting tool, but only for limited purposes.[27]

The principal spokespersons for the Mazda companies did not agree with the conclusion that the load on the electricity networks would fall, thus decreasing the utilities' profits. And so they continued to push, albeit carefully, the high-efficiency daylight fluorescent lamp. Harrison, for example, was convinced that only in some instances would consumers cut down on electricity use, but that, on average, their electricity consumption would go up.[28] However, the Mazda companies had their own problems with the high-efficiency daylight fluorescent lamp: at the moment of its commercial release, there was no known relation between life and efficiency in fluorescent lamps; in fact, the life of the lamp was not known. They knew that it was something more than 1,500 hours when the lamps were given their original rating, but they did not know whether it could work out to be 15,000 hours or much more. As Harrison said to an audience of utility executives, "Instead of having 93 per cent of our business in renewals in good times and bad, it may be that our first sale will be almost our last sale to a given customer."[29] Nevertheless, the Mazda companies were developing a more differentiated line of fluorescent lamps because, as Harrison explained in 1940,

> The effect of changes in the efficiency of fluorescent lamps, changes in their rated life and changes in price have radically affected their over-all operating costs, so that in twelve months ... [these changes have] brought the lamp more seriously into the field of general lighting.[30]

Obviously, the artifact he was describing was the high-efficiency daylight fluorescent lamp, not the fluorescent tint lighting lamp.

The controversy was fierce, probably because the relevant social groups of Mazda companies and utilities both felt that their common control of the lighting market, as exerted in the incandescent era, was at risk. This threat became especially acute when a third relevant social group entered the arena—the independents, notably the Hygrade Sylvania Corporation. In late 1939, the Mazda people started to worry about Hygrade Sylvania:

> There are figures which seem to indicate that the Hygrade Company is selling as many fluorescent lamps as General Electric and Westinghouse combined. Apparently, they are going out and "beating the bushes," so to speak, installing sockets in the smaller companies on main streets throughout the United States.[31]

The aggressive sales policy employed by Hygrade Sylvania created as much of a problem for the utilities as it did for the Mazda companies. The utilities sensed a realignment of forces taking place among the lamp manufacturers. Hygrade claimed to have basic patents for the manufacture of fluorescent lamps and did not recognize the patents held by the Mazda companies. The utilities feared that this realignment of forces, together with the competitive situation that attended it, might lead to methods and activities that would disorganize the whole lighting market "to the detriment of the public and the utilities who were standing on the sidelines." That Hygrade Sylvania was capturing a sizable portion of the market was claimed by the company and acknowledged by the Mazda people.[32] Hygrade Sylvania clearly was advancing the high-efficiency daylight fluorescent lamp, although downplaying the economic risk for the utilities. For example, the Hygrade manager W. P. Lowell, before an audience of utility and Mazda company executives, argued in answer to the question why fluorescent lighting was demanded by the public:

> Why is it demanded? For many reasons: its daylight color, soft quality, reduced shadows, novelty (it's new, modern, smart), real or imaginary economy. But don't worry too much about those who think they are saving money by using fluorescent lighting to save a few watts. If the overall value—combining the sheer dollars and cents with all other qualities—if the net value is not right, the product will fall of its own weight. You can't fool all the people all the time.[33]

Thus, Hygrade Sylvania's activities resulted in pouring oil on the fire.

Various ways of closing this load controversy were tried. One was a certification plan for fluorescent lamp fixtures. With such a certification scheme the Mazda Companies hoped to stimulate and control the production of fixtures by the auxiliary manufacturers and thereby to check the growth of Hygrade Sylvania, which was producing its own fixtures. The realization of this certification plan took a long time because the specifications initially proposed by the Mazda companies were unacceptable to the utilities; only after negotiating for almost a year, could the specifications be agreed upon. Then it only further consolidated the closure of the load controversy, which had by that time been reached through another process. This other process was the design of a new fluorescent lamp—the high-intensity daylight fluorescent lamp. In the next section I will describe this closure process.

Stabilization of the High-Intensity Daylight Fluorescent Lamp: Changes in Technological Frames

To understand how closure was reached in the controversy between the Mazda companies and the utilities through the design of the high-intensity daylight fluorescent lamp, I will describe the changes in the technological frames of both groups. These technological frames will be sketched by focusing on three of their dimensions: goals, current theories, and problem-solving strategies. The fluorescent technological frames of the Mazda companies and the utilities were quite similar but for two or three crucial differences relating in particular to the goals and problem-solving strategies.

The utilities' main goal was to sell electricity, whereas the Mazda companies' goal, in the context of this study, was to sell lamps. Left at that, this would be a rather trivial observation. However, goals do not straightforwardly define the actions taken by the relevant social groups. The respective technological frames influence, for example, the way these goals are translated into problem-solving strategies.

The theoretical base of the Mazda companies' fluorescent frame was formed by electricity and gas discharge physics, whereas the utilities obviously used, primarily, power electricity physics. Neither played an explicit role in the historical episode I describe here. The utilities' frame was supplemented by what they called the "science of seeing," which focused on the quality of lighting, including such things as brightness, contrast, shadows, diffusion, and various kinds of glare. This theoretical part of the utilities' frame did play a role: emphasis was placed on seeing and the prescription of lighting that would contribute maximum visibility to the task. As the utility people said themselves, rather pretentiously, about the years of incandescent lighting: "A true Science of Seeing was born.... It was here that the Cooperative Better Light–Better Sight Movement was started, and lighting practice became firmly entrenched in the philosophy of 'results to customers.' "[34]

The last words in this quotation hint at an important element in the problem-solving strategy of the utilities: they pictured themselves as servants of the public, or even teachers of that public. Thus an important goal was to increase public confidence in lighting technology and to promote (the utilities' version of) knowledge about that technology. In this context, the utilities highly valued cooperation with the Mazda companies:

> The lighting industry, based upon a sound Science of Seeing and united by the Better Light–Better Sight Movement, has presented a solid front to the public. This has captured the interest of strong professional groups, increased the customer confidence so important to future growth, and has proved successful commercially.[35]

The implication for the technological frame of the utilities is that, when confronted by a problem, their standard strategy was to reformulate the problem as educational—and hence to design better advertising strategies and sales methods. This is what happened in the case of the load problem. Talking about the public, which was thinking about lighting costs in terms of current costs instead of "true costs," they formulated as their task "to educate them properly to the true cost and value of adequate lighting [, which] is not an easy job."[36] It is important to see that this problem-solving strategy was not the only one possible. Another strategy would have been, for example, to define appropriate standards and impose them on other relevant social groups, thereby solving the problem. The utilities did indeed adopt this strategy, but only as a second choice at a relatively late stage, when the Mazda companies had already proposed the certification scheme for the fixture manufacturers.

After this brief characterization of the two technological frames, we will resume the story where we left off: early in 1939, when the load controversy took the shape of a conflict between two competing artifacts—the fluorescent tint lighting lamp and the high-efficiency daylight fluorescent lamp. During the first year after the commerical release of the fluorescent lamp, the tension increased between the Mazda companies and the utilities.[37] A dissociation of the cooperation established in the incandescent lighting era seemed not unlikely. Mueller, Sharp, and Skinner remembered: "The question was quickly asked . . . : could it be that the sound principles of the Science of Seeing so assiduously promoted were built upon sand, to be cast aside at the first gust of commercial expediency?"[38]

To settle this conflict, a conference of representatives of the utilities and the Mazda companies was held on April 24 and 25, 1939, at the headquarters of the General Electric Lamp Department at Nela Park, Cleveland. The utility representatives referred to this meeting as "the fluorescent council of war."[39] At this conference the idea emerged that fluorescent lighting might be reserved exclusively for high-level lighting. Retrospectively, one can argue that a third fluorescent lamp was designed—not on the drawing board or at the laboratory bench but at the conference table. This artifact—the high-intensity daylight fluorescent lamp—came slowly into being during this meeting, as is apparent from the minutes:

> There was considerable discussion on the outstanding features of fluorescent light with particular reference to daylight quality. Some thought that low footcandles of daylight fluorescent lighting made a person appear sallow—on the other hand, 100 or more footcandles in the Institute Round Table Room (previously inspected) seemed satisfactory to everyone. From the discussion, it was generally agreed that 50 to 100 footcandles of fluorescent lighting could readily be installed without creating any impression of high level lighting. At least in some instances it was believed that 50 footcandles of fluorescent lighting would appear like no more illumination than 25 footcandles of filament lighting.[40]

Now, what could be expected to happen to this idea? Considering the utilities' technological frame, it is understandable that the situation was perceived in terms of advertising. It was decided that the use of fluorescent lamps for general lighting would not be emphasized "until commendable equipment is available giving 50 to 100 footcandles levels." This decision clearly demonstrates the effect of the specific problem-solving strategy in this technological frame. Instead of treating the problem primarily as one to be solved by advertising and educating, it would have been conceivable to treat it as, for example, a mainly technical problem—concentrating all efforts on the development of lamps and fixtures to provide high-intensity lighting. Indeed, quite the contrary happened, as I will try to show.

In line with their technological frame, the utilities pressed the Mazda companies to adopt specific ways of advertising the fluorescent lamps, and they were quite satisfied with the result. After a difficult start on the first day, the second day's discussions produced what utility executives saw as "a most complete capitulation."[41] Mueller thought he understood how closure was reached:

> I think it was probably due to the fact that they realized they were definitely on unsound ground the way they had been operating, and they also knew . . . that the utilities realized it and were going to do something about it, and they knew that they really couldn't put across any lighting promotion without the help of the utilities. They were anxious to settle these matters with our group, because they thought that we were in the best position to get something in return for their capitulation.[42]

The large lamp companies issued statements of policy concerning the promotion of fluorescent lamps and tried to implement the new policy in all parts of their organizations. For example, in the "statement of policy" by General Electric, issued officially on May 1, 1939, the company conceded that

> because the efficiency of fluorescent lamps is high, it might be assumed that the cost of lighting with them is less than with filament lamps; as often as not this conclusion is erroneous. The cost of lighting is made up of several items—cost of electricity consumed, cost of lamp renewals, and interest and depreciation on the investment in fixtures and their installation. All of these factors must be properly weighted to find the true cost of lighting in any given case. The fluorescent Mazda lamp should not be presented as a light source which will reduce lighting costs.[43]

Similarly, the Westinghouse statement read in part, "We will oppose the use of fluorescent lamps to reduce wattages."

Mueller believed that one of the most important results of the conference was that the lamp companies seemed inclined to take the utilities into their confidence, as part of the lighting industry, in the development of promotional plans, instead of "shooting the works" first and then letting them know about it.[44] The Mazda companies clearly had the same ideas as the utilities about the need to reach an agreement. According to J. E. Kewley, manager of the lamp department of General Electric, "The ... statement of policy [was] issued particularly to allay the fears of the utility companies." And E. H. Robinson, another General Electric official, viewed the policy statement as a declaration by the lamp department signaling "Here's how we stand, boys, we'll play good ball with you central stations but we'll expect the same brand of ball from you too" (Committee on Patents 1942, 4772). Thus, the agreement on the new high-intensity daylight fluorescent lamp not only solved the load controversy but also saved the cooperation between the two important relevant social groups.

One would imagine that this must have been quite a successful lamp to have had such an impact on the two most powerful social groups in the electric lighting business in the United States. This was not the case, however, at least not in any straightforward way. The lamp did not even exist. According to Walker, the antitrust division attorney, there even was no immediate prospect of fluorescent lamps (or any other kind) that would give anything like 50 footcandle levels. The average with incandescent lamps in 1939 was probably about 15 footcandles, and no single installation gave anything like 50. Nevertheless, the impact of this artifact, the social construction of which started at the Nela Park conference, was not small. Ironically, part of its impact at that conference may have been caused by its not yet being available, as Walker argued:

> The reason why the utilites did not want the fluorescent lamps promoted until they . . . would give 50 to 100 footcandles levels of lighting was that the utilities felt that if they could ever get fluorescent lamps of intensities that strong, fluorescent lamps would then use so much electricity that the utilities would not suffer as a result of the fluorescent lamps replacing the incandescent lamps. (Committee on Patents 1942, 4771)

The new General Electric and Westinghouse policy statements were not widely broadcast, and it is not difficult to guess why the public was not informed about the cancellation of the high-efficiency lamp and the effort to sell the high-intensity lamp instead (Committee on Patents 1942, 4773).

Thus, the utilities' technological frame (partly) shaped the fluorescent lamp. On the other hand, as result, the technological frames of the utilities and the Mazda companies had to change to adapt to this new artifact, the high-intensity daylight fluorescent lamp.[45] And so the fluorescent lamp had a social impact in turn. For example, an adaptation of the theories element in the utilities' technological frame was one of the first effects. After the agreement at the Nela Park conference, the utilities immediately started to elaborate on the idea of high-intensity lighting. Two days after the conference, a note was written by the Electrical Testing Laboratories for the A.E.I.C. Lamp Subcommittee arguing for daylight lighting by providing a theoretical evolutionary/biological justification:

> It will be noted that our eyes have evolved under the brilliant intensity of natural light in the daytime and under the dull flow of firelight in the evening. There is some reason to think that with light of daylight quality people will not be satisfied with the low intensity of illumination which is more or less acceptable in the case of light of warmer tone as that of tungsten filament lamps. Where the daylight lamps are to be used, the logical procedure is to work toward the equivalent of daylight illumination, which at once moves practice into higher ranges of illumination intensity.[46]

In a later report, this argument was pursued further. It was claimed that lighting research indicated that the human eye functions more naturally above 100 footcandles than under 15 to 50 footcandles—considered the upper limit of most incandescent general lighting systems at the time. The ultimate advantage of fluorescent lighting to the consumer was, therefore, to be found in properly designed installations giving at least 100 footcandles. Experience with the user's reaction to general lighting from sources of "natural" daylight quality indicated, it was said, a preference for daylight quality if high intensities were provided. In an E.E.I. memorandum, an elaborate argument was forwarded to explain why this leap to 100 footcandles was not as big as it seemed—and, indeed, was quite necessary for fluorescent lighting:

Lighting of substantially daylight quality, when appraised by the eye, appears to be much less than equivalent footcandles of light from normal incandescent sources. The reasons for this are scientifically and psychologically obscure, but the fact remains that general satisfaction with lighting is based in large measure upon the user's appraisal of the amount available, and as such must be taken into account when applying light to large areas. Furthermore, the light from the "colder" tube appears blue and depressing at low intensities and produces an uncomplimentary effect upon goods or people in commercial or work areas. This effect disappears at levels of illumination above 100 foot-candles.[47]

Thus the utilities' technological frame was adapted to the new high-intensity daylight fluorescent lamp.

The stabilization of this lamp did not come about smoothly. Neither party to the Nela Park agreement adhered to it without occasional lapses, and in particular, the utilities felt that the Mazda companies were regularly violating the agreement in their advertising. On May 24, 1939, Sharp wrote to Harrison that utility employees had complained to him about a display in the General Electric building at the New York World's Fair. This display purportedly consisted of a 20-watt fluorescent lamp and a 20-watt incandescent lamp, with a footcandle meter showing how much more light was given by the fluorescent than by the incandescent lamp. Objecting to General Electric having this display on exhibit in their building at the World's Fair, Sharp stated,

If this demonstration is as explained to me I think it does violate the sprit of the understanding that our group had in Cleveland. As a matter of fact, I would think it violated the fundamental concept of the lamp department that advances in the lighting art should not be at the expense of wattage but should give the customer more for the same money. I hope you can find a way to change this exhibit, so that it does not give misleading impressions to the crowd who will see it.[48]

Harrison replied to Sharp that the exhibit was not intended to demonstrate the amount of electricity that could be saved by the use of fluorescent lamps, and that the exhibit was being withdrawn.[49]

I have discussed one adaptation of the utilities' technological frame—the addition of a theoretical explanation of the need for high-level lighting. Another adaptation of the technological frames of both utilities and Mazda companies further enhanced the stabilization of the high-intensity daylight fluorescent lamp and thereby contributed ending the controversy between the Mazda companies and the utilities. This adaptation involved the development of a standard method for comparing the costs of incandescent and fluorescent lighting. These "standard cost comparisons" are analogous to testing procedures used in engineering. Such testing procedures, if they exist, form an important element of technological frames.[50] In this case, it was not easy to reach agreement on such a standard method; in part, the cause of the problem was that this generation of lighting people had little experience with competitive illuminants. The incandescent lamp had been well-nigh universal, so that lighting design principally involved technical considerations, with relatively simple arithmetical calculations of equipment cost. Now that there was a light source as radically different as the fluorescent lamp, lighting design involved a more complicated cost comparison before it became clear which source would best meet specific requirements.[51]

However, an even more serious barrier to an agreement on standard cost comparisons were intrinsic differences in interests between the two parties. First, there was a difference in focusing on the costs of electricity versus focusing on the costs of the apparatus. For the Mazda companies, it was attractive to emphasize the low cost of electricity and disregard the high price of the apparatus itself, whereas for the utilities the opposite was true. Secondly, the utilities' primary aim in developing a standard method of comparing lighting costs was to pursue the fight against the high-efficiency lamp. The Mazda companies, despite their "capitulation" at the Nela Park conference, were of course not anxious to help the utilities in that fight.

Late in 1939 the E.E.I. Lighting Sales Committee did propose a standard method, which it claimed to be universal in application and to ensure an evaluation of all factors. Utility lighting people seem to have been almost unanimous in their approval of this method, whereas manufacturers gave only lukewarm assent. Utility executives commented on this lack of enthusiasm by the Mazda companies:

Their reluctance is founded on the fact that true cost calculations bring out the items of high fixed charges and expensive fluorescent lamp renewals.

> These are customarily slighted by manufacturers' representatives and jobbers in their eagerness to bring out unquestioned reductions in energy cost, foot-candle for foot-candle. Wide experience with the use of this method in investigating fields of fluorescent application have shown that no blanket statement as to cost can safely be made. As often as not, when a true cost comparison is made on a five- or six-year depreciation basis, the fluorescent installation is more expensive for the customer than filament incandescent lighting. This clearly points out that it is fallacious to sell fluorescent lighting on the basis that it is the most economical form of lighting.[52]

But, apparently, there was not much choice open to the Mazda companies: some months later Mueller could come to the conclusion that "this method possibly cannot be dignified by being called an 'industry standard', [but] it comes pretty close to that. It has also been endorsed by the lamp companies and is used by them."[53] Thus, the development of this cost comparison method as a new element in the utilities' technological frame strengthened their struggle against the high-efficiency lamp and contributed to the stabilization of the high-intensity lamp.

And indeed, after their initial hesitations, the Mazda companies decided that the utilities' promotion of the high-intensity lamp could be profitable to them as well. Harrison, arguing to a utility audience, observed that if they would just substitute the fluorescent lamp for incandescent on a candlepower-for-candlepower basis, in the long run they might wind up with less lamp business: "Only by using fluorescent lamps to at least double the present standards of illumination can we hope to get renewal business enough to make it worthwhile for us—and then the lamp will be valuable to you."[54] And General Electric developed a new line of fluorescent lamps of higher wattages, thus giving physical existence to the high-intensity lamp at last.

Dynamics of Technological Development: Interactions between and within Relevant Social Groups

The social construction of the high-intensity daylight fluorescent lamp took place in a situation in which two technological frames were dominant. Elsewhere I have argued that in such a situation *symmetrical amortization* or *amalgamation of vested interests* is one of the possible stabilization processes.[55] Indeed, if we take the phrase "amortization of vested interests" in its true heterogeneous sense (as compared to its common, narrower, financial definition), it provides an adequate characterization of what happened in the fluorescent lighting case. The Mazda companies dropped the high-efficiency lamp and agreed to restrict themselves to making the high-intensity lamp. On the other hand, the construction of the high-intensity lamp certainly was not a complete victory for the utilities. Mueller clearly viewed the Nela Park agreement as a compromise when he argued the need for the E.E.I. Lighting Sales Committee to make some additional concessions to the Mazda companies:

> Unless our committee does something now to give them [i.e., the Mazda companies] some publicity on their change of pace, and to get the utility industry as a whole interested in the promotion of fluorescent lighting along sound lines, I think they will drop us and either try to get action through some other body, or else come out with another "To Hell With The Utilities" campaign, and go it alone, knowing that they have quite a strong customer appeal in their efficiency and novelty story.[56]

And so the utilities started slowly to adapt their policy toward advertising the fluorescent lamp, switching "from informing to selling" in their fluorescent lighting presentations. Thus the conflict was indeed solved by a piecemeal adaptation by both parties to the new situation: amalgamation of vested interests.

Until now I have treated the utilities and the Mazda companies as monolithic entities. However, the pressures from outside caused by the process of closing the load controversy created tensions within both organizations. For example, within General Electric there was opposition to the Nela Park agreement. The lamp department, which had participated in the Nela Park conference, experienced resistance within the large General Electric organization. When the General Electric Supply Corporation published a catalog listing and picturing fixtures unequipped with shielding, Harrison (of the lamp department) objected because "the repercussions from central stations are likely to be formidable."[57] The catalog showed fixtures both bare and equipped with shields. However, all the listed prices applied to the bare lamp fixtures only; the shield was shown as an extra item, requiring separate and additional catalog numbers when ordered. Then the statement appeared that the use of shields would result in 30 percent less light. It is evident that this way of presenting the fluorescent lamps would stimulate customers to buy the unshielded lamps, thus getting more light out of the lamp for the same amount of electricity. Harrison threatened: "Of course, it is up to the General Electric Supply Corporation ... to formulate their own policies, but I do not think that a penny of Lamp Department money should be spent to support a campaign of this kind."[58]

In its answer to Harrison's letter, the G.E. Supply Corporation justified its advertising on the grounds that it was necessitated by Hygrade Sylvania competition.[59] The background of Harrison's threat was that the Nela Park conference had been that fluorescent lamps would not be installed without "proper shielding." In the case of incandescent lighting, shielding was necessary to avoid glare. This was hardly the case with fluorescent lighting, but evidently shielding would decrease the net light output.[60]

Tension like that within General Electric is likely to arise between actors with different degrees of inclusion in one technological frame (Bijker 1987). The G.E. Supply Corporation was bound to have a relatively low inclusion as compared to the G.E. lamp department because the latter was more intimately involved in the establishment of the new fluorescent frame of the Mazda companies, in which the selling of only the high-intensity lamp was the goal, and which was aimed at nursing the collaboration with the utilities. For the salespeople of the Supply Corporation, the "old" incandescent technological frame of simply selling as many lamps as possible, and thereby competing with other lamp manufacturers, was more prominent.

Similarly, such tensions can be observed within the group of utilities. For example, Bremicker (of the Northern States Power Co.) wrote to Mueller, after having received a report on the Nela Park conference, that this was not enough: he wanted a specific retraction from the Mazda companies stating "that fluorescent lighting is not known to be applicable for any lighting purposes except colored or atmospheric lighting and certain phases of localized lighting such as wall cases, showcases, display niches."[61] Bremicker concluded that he did not want the utility companies to be hoodwinked into a cooperative program of promoting fluorescent lighting. The position of Bremicker was similar to that of the General Electric Supply Company, in that he did not attend the Nela Park meeting and, hence, was only marginal in the newly established technological frame. Although Bremicker was the only member of the Lighting Sales Committee of the E.E.I. who did not endorse the results of the conference, this may not lead us to the conclusion that his critique was entirely exceptional. Sharp proposed to Mueller (both were participants in the Nela Park conference) not to send out the entire minutes of that meeting. Instead, a letter with only a brief outline should be sent out, which "would indicate that the committee is still on the job, [and which would] serve to keep the utility group united, and give our committee some additional backing from the field, thereby making it harder for anybody to divide our forces.[62]

Sharp recognized the potential tension between the highly included participants of the Nela Park conference and the other utilities executives with a much lower inclusion.

Conclusion

The first point I wanted to illustrate with this case study is the saliency of the social constructivist approach in understanding the development of artifacts in their "diffusion stage," as it is called in the "old" technology studies. To understand the design process of technical artifacts, we should not restrict ourselves to the social groups of design-room engineers or laboratory personnel. Basic to all "new" technology studies is the observation that even in the diffusion stage, the process of invention continues.

In demonstrating the interpretative flexibility of the fluorescent lamp, it became clear that, after the official release of the lamp and thus during its diffusion stage, there were at least two different artifacts. In this first step of the SCOT model I showed that "laws of nature," or the claim that "it is working," did not unequivocally dictate the form of this artifact. Thus it was clear that something more was needed to explain the constituency of the fluorescent lamp. In the load controversy that originated from the competition between these two artifacts—the tint-lighting fluorescent lamp and the high-efficiency daylight fluorescent lamp—closure was reached by designing a third artifact, the high-intensity daylight fluorescent lamp, as a kind of compromise. The specific form of this invention in the diffusion stage could be explained while making the second point of this chapter.

This second issue I wanted to address concerns the integration of the social shaping and social impact perspectives on technology. One of the key elements in recent technology studies can be captured by the "seamless web" metaphor: the development of technical artifacts and systems should be treated as if technology and society constitute a seamless web. Indeed, historians and sociologists of technology are trying to reweave the web of technology and society in such a way that they can avoid traditional categories such as "society" and "technology" altogether (Hughes 1986a; Bijker, Hughes, and Pinch 1987b). Thus, for example, the social shaping of a technical artifact and the social impact of that technical artifact are to be analyzed with the same concepts, within the same frame and, preferably, even within the same study.[63]

A concrete example is the high-intensity daylight fluorescent lamp. I have tried to show how this artifact emerged from the social interactions between the Mazda companies and the utilities during their efforts to reach closure in the load controversy—thus the high-intensity lamp was indeed socially shaped. On the other hand, this artifact also influenced society by giving rise to new lighting standards which in the end became universally accepted—so this artifact also had quite a social impact. Offices, for example, turned into potential surgical suites from which, after 1974, one could remove up to half of the original fluorescent tubes without any damage to the clerks' working conditions. How can both sides of the coin, both faces of the Janus head (Latour 1987), both parts of the seamless web, be described and analyzed within one conceptual frame?

To capture this double-sided character of technological development, I have employed the concept "technological frame." The technological frame of a social group is shaped while an artifact, functioning as exemplar, further develops and stabilizes within that social group—the social impact side of the coin. But a technological frame in turn also determines (albeit to different degrees, depending on the degree of inclusion different actors have in that frame) the design process within that social group—the social shaping side of the coin. Thus forms the concept "technological frame" a hinge between the social impact and the social shaping perspectives on technology.

Notes

1. I am grateful to David Edge and Robert Frost for their stimulating comments on different drafts of this chapter. This research was funded by the Netherlands Organization for Scientific Research (NWO), grant 500-284-002.

2. This chapter is mainly based on one source: the hearings held before the Committee on Patents of the U.S. Senate, August 18, 1942 (Committee on Patents, 1942). This committee had a specific political mandate to investigate possible violation of antitrust regulation by General Electric, Westinghouse, and the electric utility companies. Especially the contributions by John W. Walker, attorney of the Antitrust Division, Department of Justice, and the questions asked by the committee's chairman, Senator Homer T. Bone, do reveal some bias in this respect. This, however, does not affect my use of this source, because I used primarily original documents, reproduced as evidence in the hearings. References to these hearings will be made, where appropriate, by giving the number of the exhibits of evidence, most of which were presented to the committee by Walker.

3. For a discussion of this problem, see MacKenzie and Wajcman 1985, Hughes 1986, and Bijker, Hughes, and Pinch 1987b.

4. See Pinch and Bijker 1984; the relevant part is also published in Bijker, Hughes, and Pinch 1987a, 17–50.

5. I borrowed this term from Latour (1987).

6. Howard M. Sharp to John Mueller, letter dated April 6, 1939 (Walker Exhibit No. 137), 4993.

7. Howard M. Sharp to Ward Harrison, letter dated March 26, 1939 (Walker Exhibit No. 143): 5000.

8. Ibid.

9. O. P. Cleaver, Westinghouse Lamp Division, Westinghouse Elec. & Mfg. Co., "Fluorescent Lighting in the Home Field," paper presented at the Industrial Conference on Fluorescent Lighting, March 22, 1940, Chicago, Ill. (Walker Exhibit No. 41): 4903.

10. There are some theoretical and methodological problems connected to this issue of spokespersons that I will not discuss in this paper. Identifying spokespersons is one of the central methodological problems at this moment in studying sociotechnology. See, for example, Latour 1987.

11. Harry Collins (1981a) used the snowballing method in his sociology of scientific knowledge studies to identify the core-set.

12. Using a single name to label a social group seems to suggest that this group is a monolithic entity. As will become clear later in this chapter, this is typically not the case.

13. Henry L. Stimson, Secretary of War, to the Attorney General, letter dated April 20, 1942 (Committee Exhibit No. 21): 5030.

14. For an introduction of the term "closure" in the context of studying scientific and technological controversies, see Pinch ad Bijker 1984.

15. Harrison and Hibben (1938, 1530); see also Inman and Thayer 1938.

16. This efficiency, the 'overall efficiency" specifying the efficiency of a lamp to transform electrical power input into light output, was measured in the units "lumens/watt" or "lightwatts/electric watt" (Moon 1936). However, the unit "footcandles/watt" was often used, which is, strictly speaking, not right: footcandles were the unit for the illumination of a surface, whereas lumens were the unit for luminous flux from a lamp.

17. J. E. Mueller, H. M. Sharp, and M. E. Skinner, "Plain Talk About Fluorescent Lighting," paper presented at the 55th Annual Meeting of the Association of Edison Illuminating Companies, January 15–19, 1940 (Walker Exhibit No. 4): 4803. Mueller was Manager of Commercial Sales, West Penn Power Company and Chairman of the E.E.I. Lighting Sales Committee; Sharp was Manager of the Lighting Bureau of the Buffalo Niagara & Eastern Power Corporation; Skinner was Vice-President of the Buffalo Niagara & Eastern Power Corporation; Sharp and Skinner were members of the E.E.I. Lighting Sales Committee as well.

18. Preston S. Millar, "Advanced Memorandum for Meeting of Lamp Subcommittee, May 27, 1938" (Walker Exhibit No. 8): 4821.

19. See, for example, Bright 1949.

20. W. Harrison, talk, probably to a E.E.I. Lamp Committee meeting in fall 1939 (Walker Exhibit No. 80): 4945. He is referring to the high-voltage discharge lighting (for example, neon tubes), mostly employed for outdoor advertising purposes. The history of the introduction of neon discharge lighting into the United States by the

French company Claude Neon and the subsequent negotiations between Claude and General Electric are an interesting part of the prehistory of fluorescent lighting, but will not be discussed here.

21. A. F. Wakefield, The F. W. Wakefield Brass Co., "The Objectives of the Fleur-O-Lier Association," paper presented at the Industrial Conference on Fluorescent Lighting, March 22, 1940, Chicago, Ill. (Walker Exhibit No. 41): 4900.

22. "The Object of the Fleur-O-Lier Association," synopsis of suggested presentation before E.E.I. Sales Meeting, spring 1940 in Chicago (Walker Exhibit No. 104): 4961–4962.

23. Quoted by D. W. Prideaux, Incandescent Lamp Department General Electric Company, to A.B. Oday, Engineering Department General Electric, letter dated February 1, 1940 (Walker Exhibit No. 111): 4973.

24. Westinghouse Commerical Engineering Department to Westinghouse Lamp Division, letter dated July 12, 1939 (Walker Exhibit No. 6): 4818–4819.

25. Ibid. The comparison results in the following table:

For every dollar the user spends annually with incandescence,		
	the utility gets	80 percent
	the contractor	10 percent
	the equipment suppliers	6 percent
	the lamp suppliers	4 percent
For fluorescence, the dollar is divided into		
	the utility	44 percent
	the contractor	12 percent
	the equipment suppliers	20 percent
	the lamp suppliers	24 percent

26. Mueller, Sharp, and Skinner: 4803.

27. See, for example, J. L. McEachin to G. E. Nelson, letter dated Dec. 15, 1939 (Walker Exhibit No. 59): 4921; and H. Restofski, Sales Promotion Manager, West Penn Power Company, Pittsburgh, Pa. to James Kernes, Chicago, Ill., letter dated May 7, 1940 (Walker Exhibit No. 92): 4953–4954.

28. W. Harrison, "The Need for More and Varied Types of Fluorescent Equipment," paper presented at the Industrial Conference on Fluorescent Lighting, March 22, 1940, Chicago, Ill. (Walker Exhibit No. 41): 4896.

29. Harrison talk, fall 1939 (Walker Exhibit No. 80): 4945.

30. W. Harrison, "The Need for More and Varied Types of Fluorescent Equipment."

31. O. P. Cleaver, Westinghouse Electric and Manufacturing Company, Commerical Engineering Department, internal memorandum dated April 25, 1940 (Walker Exhibit No. 95): 4955.

32. J. E. Mueller, H. M. Sharp, M. E. Skinner, "Today's Fluorescent Lighting Situation," prepared for the Sales Executives' Conference, Association of Edison Illuminating Companies, Hot Springs, Virginia, September 30 to October 3, 1940 (Walker Exhibit No. 5): 4816.

33. W. P. Lowell, Jr., Hygrade Sylvania Corp., "Industrial Applications of Fluorescent Lighting," paper presented at the Industrial Conference on Fluorescent Lighting, March 22, 1940, Chicago, Ill. (Walker Exhibit No. 41): 4899.

34. Mueller, Sharp, and Skinner, "Plain Talk About Fluorescent Lighting": 4803.

35. Ibid.: 4802.

36. Ibid.: 4807.

37. This tension resulted not only from the load controversy, described previously, but also from a second controversy: the power factor issue. This latter conflict over low power factor will not be discussed in this paper.

38. Mueller, Sharp, Skinner, "Plain Talk About Fluorescent Lighting": 4803–4804.

39. Sharp (Walker Exhibit No. 21): 4848.

40. Draft of detail minutes of the Nela Park conference, April 24–25, 1939 (Walker Exhibit No. 19): 4846.

41. Jim Amos, quoted by J. E. Mueller in a letter to H. M. Sharp, dated May 29, 1939 (Walker Exhibit No. 32): 4858.

42. J. E. Mueller to H. M. Sharp, letter dated May 29, 1939 (Walker Exhibit No. 32): 4858.

43. "Statement of Policy Pertaining to Fluorescent Mazda Lamps," published by the General Electric Company Incandescent Lamp Department in *Lamp Letter* No. S-E-21A (Superseding S-E-21), May 1, 1939 (Walker Exhibit No. 19): 4841.

44. J. E. Mueller to H. E. Dexter, Commercial Manager Central Hudson Gas & Electric Corp., letter dated May 11, 1939 (Walker Exhibit No. 30): 4855.

45. The mechanism of the emergence of a technological frame "around" an artifact as exemplar has been introduced in the context of Bakelite; see Bijker 1987.

46. Notes from the Electrical Testing Laboratories prepared for the A.E.I.C. Lamp Subcommittee Meeting, May 18, 1939, April 28, 1939 (Walker Exhibit No. 135): 4991.

47. Lighting Sales Committee E.E.I., "Recent Developments in Fluorescent Lighting and Recommendations for the Immediate Future," supplemental to report of April 1939 (Walker Exhibit No. 39): 4872.

48. H. M. Sharp to W. Harrison, letter dated May 24, 1939 (Walker Exhibit No. 49): 4916–4917.

49. W. Harrison to H. M. Sharp, letter dated June 1, 1939 (Walker Exhibit No. 50): 4917.

50. It has been argued that testing procedures are an important focus for technology studies. See Constant 1983, Pinch and Bijker 1984, and MacKenzie 1989.

51. Mueller, Sharp, and Skinner, "Plain Talk About Fluorescent Lighting": 4806–4870.

52. Ibid.

53. J. E. Mueller, West Penn Power Co., "The Economics of Fluorescent Lighting," paper presented at the Industrial Conference on Fluorescent Lighting, March 22, 1940, Chicago, Ill. (Walker Exhibit No. 41): 4884.

54. Harrison talk (Walker Exhibit No. 80): 4945.

55. See the "third type of technological development" discussed in Bijker (1987, 184–185). An example of "symmetrical amortization of vested interests" was given

by Thomas Hughes when he described the closure reached in the controversy between AC and DC systems of electricity supply, the "battle of the systems": "it ended without the dramatic vanquishing of one system by the other, or a revolutionary transition from one paradigm to another. The conflict was resolved by synthesis, by a combination of coupling and merging. The coupling took place on the technical level; the merging, on the institutional level" (Hughes 1983, 120–121). Misa (forthcoming) uses the term "amalgamation of vested interest" because of its less narrow economic connotations.

56. J. E. Mueller in a letter to H. M. Sharp, dated May 29, 1939 (Walker Exhibit No. 32): 4858.

57. W. Harrison to N. H. Boynton and E. E. Potter, letter dated May 20, 1940 (Walker Exhibit No. 52): 4917–4918.

58. Harrison talk (Walker Exhibit No. 80): 4945.

59. W. Booth, Manager Lighting Sales, to W. Harrison, letter dated May 28, 1940 (Walker Exhibit No. 53): 4918.

60. This strategy of emphasizing the installation of "proper shielding" offers an example of the social shaping of technology and of the inadequateness of an explanation of technological development which is based on the assumption that "the best working artifact will be chosen." Here, lamps and fixtures were designed to limit light output without much reason or technical benefit (as in the case of incandescent lighting). And although we may now recognize this as the best solution in terms of the utilities' technological frame, it obviously was not the best in any "objective" sense.

61. C. T. Bremicker to J. E. Mueller, letter dated May 16, 1939 (Walker Exhibit No. 31): 4856.

62. H. M. Sharp to J. E. Mueller, letter dated May 22, 1939 (Walker Exhibit No. 34): 4860.

63. Of course, one could say that an author subscribing to the objectives of a seamless web approach should not be writing a sentence like this, using phrases such as "technical artifact" and "social impact." I think that such pedantic criticism is unfruitful. The substantial methodological challenge is to develop analytical concepts that will allow us to realize the aim of analyzing technology and society in such a "seamless web way," but on our way toward that goal one has to make do with what there is—using common language, but as carefully as possible.

II

Strategies, Resources, and the Shaping of Technology