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## THE ELECTRIC-LAMP INDUSTRY:

*Technological Change and Economic  
Development from 1800 to 1947*

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manufacturers. In those areas also the American Edison Company was at first more active than its competitors.

Despite the slower start of incandescent-lamp production in continental Europe, by the beginning of 1891 there were more than fifty producers in operation in nine countries (see Appendix B). France and Germany led the continent, with more than half of the companies located within their borders. Among the other countries with growing lamp industries were Belgium, Holland, Austria, Italy, and Hungary. As a rough approximation, it may be said that total output of the rest of the world was at that time a little greater than production by American incandescent-lamp manufacturers.

The French lamp industry increased in size at first more rapidly than any other in continental Europe. As in other countries, the interests of the opposing Swan and Edison companies soon clashed, and a compromise similar to the British solution was reached in 1888 with the formation of the *Compagnie Générale des Lampes Incandescentes*. Patent conflicts and litigation continue in France, however, between the *Compagnie Générale* and the increasing number of competitors. By 1891 there were at least eighteen producers in operation. Court decisions did not give the French Edison patents the sweeping victory which they gained in England and the United States, even though some infringement prosecutions were successful. Lacking a conclusive decision, competition in France continued very keen, and the market was fairly open. The standard lamps sold for about 25 cents each.

In Germany the Edison and Swan lamps supplied most of the market for a few years.<sup>58</sup> When the inevitable patent conflict arose, the Germans did not resolve the problem by consolidation, as the British and French had done. The German Edison Company sued the Swan United company for infringement. In 1891, after several years of litigation, the Supreme Court at Leipzig decided that the Edison patent was valid, but that the Swan lamp did not infringe.

The German patent monopoly was weakened even before the

<sup>58</sup> The Swan United Electric Light Company operated a lamp plant at Cologne until 1894, when the company was merged with the Edison & Swan United company.

final court decision, for as early as 1887 the German Edison Company terminated its obligations to the *Compagnie Continentale Edison* and agreed with Siemens & Halske to the same rights and duties for the German industry. At the same time it changed its name to *Allgemeine Elektrizitäts-Gesellschaft*<sup>57</sup> to make known its independent position.<sup>58</sup>

The influx of new lamp producers in Germany was greatest during the year 1889. Competition became intense, and prices were forced to levels well below a shilling for the standard lamp. According to one German writer,<sup>59</sup> it was neither lawsuits nor patent-precipitated consolidations which held down the number of firms in the industry, but rather the inability of many producers to keep up with the others in productive efficiency. This seems also to have been true in Austria, Italy, Hungary, Holland, Belgium, and other countries. The European product suffered seriously in quality as a result of the violent price competition. Representatives of the German electrical-goods companies met in 1894 to study the problem, and they concluded that the complaints about low lamp quality were justified. Poor manufacturing techniques produced uneconomical lamps of short life, and imperfect sorting and false marking were common.

Faced by that situation, and in the absence of a patent monopoly such as existed in England and America, the Germans turned to another device. The representatives of the electrical-goods companies worked out an agreement for raising and standardizing the quality of incandescent lamps and for reducing competition. A retail price equivalent to about one shilling was established, as well as wholesale and manufacturers' prices. The organization of German incandescent-lamp producers had for its purpose "removing economic losses by common agreement."<sup>60</sup> That association was the predecessor of the lamp cartel that has controlled the bulk of European lamp production since 1903. Originating in Germany, it soon spread to the other Euro-

<sup>57</sup> It is frequently called A.E.G., *Allgemeine*, or the German General Electric Company.

<sup>58</sup> Basch, *op. cit.*, p. 56.

<sup>59</sup> E. A. Krüger, *Die Herstellung der elektrischen Glühlampe*, Oskar Leiner, Leipzig, 1894, pp. 3-4.

<sup>60</sup> Basch, *op. cit.*, pp. 66-68.

## DECLINE OF EDISON LEADERSHIP

During the first few years of commercial incandescent electric lighting, the Edison lamp excelled in almost all respects. It won first place at the Paris Exposition over the lamps of Swan, Maxim, and Lane-Fox. By the beginning of 1884 it had also received awards at the London Crystal Palace and at expositions in Cincinnati and Louisville. Supplementary tests at the Paris Exposition showed that the lamp compared very favorably in efficiency with all its rivals at that time.

After the original introduction of the incandescent lamp and its first rapid changes, however, the Edison Electric Light Company did not introduce many important new developments. Edison himself turned to other problems, and the company's technical leadership in incandescent lighting was not revived until after the merger with Thomson-Houston. It made no significant contribution to the filament advances mentioned above. To be sure, after 1888 the Edison lamp was somewhat improved in efficiency by a thin coating of asphalt on the filament; but it was not until 1894 that General Electric replaced bamboo with the squirted filament. After the merger, the Edison lamp works were also able to use the "flashing" process on lamp filaments and catch up with competitors who had previously been using the process.<sup>11</sup>

The first commercial Edison lamps were rated at 1.68 lumens per watt when new.<sup>12</sup> Improvements in the untreated bamboo filament increased its initial rating to 2.25 lumens per watt in 1881. The asphalt-treated filament of 1888 was rated at 3 lumens per watt, and the rating rose to 3.3 lumens per watt with the use of the "filament-flashing" process in 1893.

Despite the improvements in the Edison lamp, a number of its competitors had improved their lamps even more rapidly. As early as 1885 the lamps of several manufacturers were tested by a committee of the Franklin Institute, and, although the Edison lamps were found still to excel in certain respects, particularly in length of life and uniformity of performance, they consumed more energy than any other make tested for an equal amount of

<sup>11</sup> "Flashed" lamps gave on the average about one-third more light for the same energy consumption than those in which the process was not employed.

<sup>12</sup> Edison's experimental lamps of 1879 are estimated to have had an efficiency of 1.4 lumens per watt.

light output. The tests showed the average efficiency of the standard Edison lamp at that time to be 4.47 watts per spherical candle (2.8 lumens per watt), and that of the competing lamps tested to range down to 3.45 watts per spherical candle (3.65 lumens per watt).<sup>13</sup> Efficiency advantages permitted many of the other American concerns to compete very successfully with the Edison lamp after 1885 and to improve their positions steadily until the corporate reorganizations and the establishment of patent supremacy regained for the Edison lamp commercial supremacy as well.

Initial efficiency is not the only measure of a lamp's value; its life and its maintenance of candlepower throughout life are equally important. There is an inverse relationship between incandescent lamp efficiency and life. A lamp can be made which will provide a very high candlepower for a few seconds, a very low candlepower for tens of thousands of hours, or a candlepower anywhere between. The candlepower of an incandescent lamp falls off with use, and for carbon lamps the decline was often found to be the greatest for those with the highest initial efficiencies. After very long use of 2,000 or 3,000 hours, lamps which had not yet burned out frequently gave less than one lumen per watt. It became clear that since electric-lighting costs consist largely of current consumption, the optimum balance of lamp efficiency and life required replacement after from about 600 to 1,000 hours. The lower efficiency of the Edison lamp made it less economical than many competing lamps, despite its long actual life of up to 2,000 hours. The declining candlepower which accompanies long life and which usually makes lamp replacement desirable before filament failure began to be recognized as important only around 1890. Methods of reducing bulb blackening as one means of maintaining light output were not explored seriously until after that date.

The economy of American lamps in general surpassed that of lamps of British and continental European manufacture throughout the entire period from 1880 to 1896. The slower start of continental producers and the obstacles to expansion of the British industry gave the Americans an initial advantage which they were able to maintain. American superiority resulted primarily from greater manufacturing precision and care. Although many con-

<sup>13</sup> Franklin Institute, *op. cit.*

Guillaume-Lahmeyer Werke, A.G.,<sup>19</sup> and the Bergmann Elektrizitäts-Werke. As in the United States and other countries, the full-line producers were favored in the sale of incandescent lamps. In general, they were able to maintain prices for all electrical goods and prevent "injurious" competition through working agreements; their profits were substantial.

There were still many German producers of incandescent lamps, however. A number of them had joined in 1894 to raise lamp quality and to maintain prices. Out of that organization grew the Verkaufsstelle vereinigter Glühlampenfabriken Gesellschaft, or the International Incandescent Lamp Cartel of 1903,<sup>20</sup> which was formed under the leadership of A.E.G. and Siemens & Halske. At the time of organization the cartel included eleven lamp producers in Germany, Austria, Hungary, Holland, Switzerland, and Italy. The cartel began operations in 1904 and remained more or less in force until World War I. Its principal tasks were to fix lamp prices, establish quotas for the various members, and divide the profits. It was concerned only with carbon-filament lamps, on which there were no basic patents; at that time carbon-filament lamps were virtually the only type of incandescent lamp made. The cartel members produced about 30,000,000 lamps each year and included most of the principal lamp producers of continental Europe.

The development and introduction of a number of new types of patented lamps during the first decade of the twentieth century weakened the carbon-lamp cartel somewhat after about 1905. The A.E.G. introduced and pushed the Nernst lamp; the Deutsche Gasglühlicht Aktien-Gesellschaft introduced the osmium lamp; Siemens & Halske developed the tantalum lamp; and a number of concerns developed and introduced various types of tungsten lamps. The competition of these lamps, all of which were far more efficient than the carbon lamp, kept the sales of carbon lamps from rising. Members of the cartel continued to sell about 30,000,000 carbon lamps each year, but profits fell by two-thirds as the increased market pressure forced prices down. Besides the metal-filament lamps and price reductions, the competition of new firms outside the cartel and the depressing

<sup>19</sup> The Felten-Guillaume-Lahmeyer company was absorbed in 1910 by A.E.G.

<sup>20</sup> See Basch, *op. cit.*, pp. 68-72.

effect of taxation on lamps were important factors in the declining profitability of carbon-lamp production.<sup>21</sup>

Despite its technical and commercial leadership in metal-filament lamps, the German industry by 1910 found itself in the situation which had confronted it in 1894 for carbon-filament lamps. There was an alarming tendency toward careless manufacture and poor lamp quality as a result of efforts to reduce costs and compete on a price basis. The seriousness of the problem was intensified early in 1910 by the sudden announcement by A.E.G. of a reduction in the prices of metal-filament lamps. It appeared that either the carbon-filament cartel would be so weakened as to fall apart or metal-filament lamps would have to be brought into the cartel.<sup>22</sup> In 1911 the three producers who held the most important European patents for metal-filament lamps, A.E.G., Siemens & Halske, and the Deutsche Gasglühlicht Aktien-Gesellschaft, formed the Drahtkonzern, or Filament Trust, through which they pooled their patent rights.<sup>23</sup> Although output and sales were not strictly controlled, the companies did make agreements for the maintenance of prices.

#### THE BRITISH INDUSTRY

The British manufacturers of incandescent lamps had dropped far behind the Germans by 1900, as indeed had all the British electrical industries. The great legal obstacle to electrical expansion was removed in 1888. The obstacles which remained, and which largely persisted from 1897 to 1912, were apathy, limited ability, and a lack of specialization. The British made no technical contribution to the development of metal-filament lamps. There

<sup>21</sup> In 1910 German manufacturers produced 26,000,000 carbon-filament lamps, 42,000,000 metal-filament lamps, and 249,000 Nernst lamps. Although total production was not quite as great as American output at that time, the proportion of metal-filament lamps to the total was considerably larger in Germany. See *Electrical World*, Vol. LXIII, p. 54 (Jan. 3, 1914).

<sup>22</sup> In 1910 eighteen companies in Germany, Austria, Hungary, Sweden, Holland, Italy, and Switzerland were members of the cartel. The few French concerns which had joined did not remain members. British producers had not joined at all.

<sup>23</sup> Under German patent law and the interpretation of the German courts it was much harder to obtain a complete patent monopoly than it was in the United States or Great Britain. Under those circumstances, it was natural for the owners of the German patents covering all important ways of making tungsten filaments to pool their patents and obtain basic protection in that fashion.

was not a single lamp-research laboratory in Great Britain during all that time, and all important innovations were imported from Germany, Austria, and the United States.

The make-up of the British incandescent-lamp industry reflected its technological reliance upon America and Germany. The large lamp producers abroad had subsidiaries or affiliates in England which held the British patent rights of the parents, imported and marketed goods made by the parents, or conducted actual manufacturing operations under the patents of the parents. General Electric and Westinghouse were represented in Great Britain principally by the British Thomson-Houston Company, Ltd.,<sup>24</sup> and the British Westinghouse Electric & Manufacturing Company, Ltd.<sup>25</sup> The German and other continental leaders also had their affiliates or agents.

There were still, of course, many exclusively British producers in the lamp industry, and they carried on the bulk of production. The General Electric Company, Ltd., became the industry leader after the turn of the century.<sup>26</sup> It was a more aggressive firm than the others and was the first to secure British rights for the German-developed Nernst lamp and the Austrian-developed osmium and tungsten lamps. Its ownership of the basic British tungsten-lamp patent was probably the principal single factor in its preeminence in British lamp making to the present.<sup>27</sup> As was true in other countries, the fact that it was a full-line electrical-goods manufacturer gave it an additional advantage in the sale of lamps. The two pioneer lamp makers still in business were the Edison &

<sup>24</sup> General Electric gained a controlling interest in the British Thomson-Houston Company in 1901 by buying out the French and German holdings in the company. The British company had originally been a licensee of the American Thomson-Houston company.

<sup>25</sup> Westinghouse formed three electrical subsidiaries in Great Britain in all. The Westinghouse Electric Company, Ltd., was organized in 1889 to handle patent rights. The Westinghouse Electric & Manufacturing Company, Ltd., was established in 1899 as a manufacturing concern. The Westinghouse Metal-Filament Lamp Company, Ltd., was formed in 1906 to work with an Austrian Westinghouse company in the marketing of tungsten-filament lamps.

<sup>26</sup> The British General Electric company, which has had no financial connection with the American General Electric company except from 1928 to 1934, began to produce incandescent lamps after the controlling Edison patent expired in 1893.

<sup>27</sup> The G.E.C. carried on its lamp production through subsidiaries, the Robertson Lamp Company for carbon lamps and the Osram Lamp Company for tungsten-filament lamps.

Swan Electric Light Company, Ltd., and the Sunbeam Lamp Company, Ltd. There were also many newer companies of varying size and importance.

Competition in carbon-lamp production and sale was very keen in Great Britain. Since there were no longer any important patents on carbon lamps, the industry was open to all who wished to enter. By 1910 prices had been pushed down to about ten cents for the standard sixteen-candlepower lamp. Despite the keen competition, however, the quality of production did not fall to the extent true for Germany. The larger and better established producers in England generally managed to keep quality fairly uniform, although they tended to prefer low-efficiency lamps of long life rather than lamps of high efficiency and shorter life.

The technology of the new metal-filament lamps was imported into England from Germany and Austria, and later from the United States, between 1900 and 1910. Besides the effect of the metal-filament lamps on the old carbon lamps, there was an important effect upon the organization of the entire British lamp industry. The G.E.C. owned what proved to be the basic tungsten-filament patent, which was granted in 1904 on the work of Alexander Just and Franz Hanaman, even before the commercial lamp appeared on the market.

When domestic competitors introduced their own brands of tungsten lamps and foreign manufacturers commenced exporting tungsten lamps to Great Britain on a large scale, the G.E.C. and its Osram Lamp Works initiated a series of lawsuits to test their patents. The first important infringement suit was instituted in 1910 against G. M. Boddy & Company, an importer and distributor of lamps made in Holland by the Dutch N. V. Philips' Gloeilampenfabrieken (Philips' Metallic Glow Lamp Works) of Eindhoven. Before the lawsuit was completed the litigants came to an agreement out of court. Philips and Boddy took licenses under the G.E.C. patents and agreed to pay royalties on all lamps exported to Great Britain as well as to limit total exports. Prices and discounts were also to follow those set by the G.E.C. Other infringement proceedings by the G.E.C. were similarly successful. The British General Electric Company adopted a policy of requiring other manufacturers to take patent licenses and pay royalties rather than of trying to force them to withdraw from

to remove artificial barriers to international trade in such products.

Some of the goals of the Department of Justice had thus been achieved before the case was reopened. Westinghouse and Corning had accepted consent decrees; the license and quota system had been virtually ended; and the trademark "Mazda" had been abandoned for all but a limited number of special lamps. There still remained several other aims of the Department of Justice in its action. It wished to end the agency method of distribution used by General Electric and Westinghouse in their control of lamp prices to the retail level. It wished to force General Electric to give up around 25 per cent of its lamp business, on the assumption that no single company should control more than half the lamp market. It wished to require General Electric to grant royalty-free licenses freely under its present lamp and lamp-machinery patents and low-royalty licenses under its future lamp and lamp-machinery patents.<sup>62</sup> It also wished to end all restrictions and discrimination in the supply of lamp parts and lamp-making machinery. Although some of the government's goals may not be realized, it appears that the eventual outcome of the case may well be to loosen up the patent situation in lamp making, end discriminatory parts pricing and generally increase competition in the domestic-lamp industry.

The government had quicker success in another of its antitrust suits against General Electric and Westinghouse over their conduct of international operations in other product lines. On March 12, 1947, a consent decree was entered in which the principal defendants and their international subsidiaries agreed to end cartel agreements with European producers which allocated orders, divided the business with competitors, and established prices for electrical equipment. Even though the decree did not apply directly to electric lamps, it indicated growing success in the government's attempts to reduce General Electric's control over competition in various phases of the electrical-goods business.

<sup>62</sup> Temporary compulsory licensing in the incandescent-lamp business might encourage such large buyers as Ford, General Motors, and Chrysler to manufacture their own lamps in the future.

## Chapter XI: INTERNATIONAL RELATIONSHIPS IN THE ELECTRIC-LAMP INDUSTRY: 1912-1947

AFTER 1912 the production of tungsten-filament and other incandescent lamps increased rapidly in all nations. The expansion of output in Germany, Japan, the Netherlands, the United Kingdom, France, Belgium, and the Scandinavian countries was particularly noteworthy. Nevertheless, the United States increased its percentage of world output to exceed that of all other countries combined.

The leading lamp producers in the principal industrialized nations evolved a working arrangement whereby international sales competition was reduced to a minimum while technological advances were passed from one to another. International competition came mostly from small producers who were not associated with the cartel. Since the allocation of territory by the cartel customarily gave to each nation its colonies as well as the mother country, only a few industrially undeveloped areas of the world remained free for competition by the largest manufacturers. In addition to restrictive cartel and license agreements, most countries imposed tariffs and import quotas for the protection of their domestic electric-lamp industries. Exports by the American industry were smaller than those by any other important producing country in relation to the size of total production. Exports by the Netherlands, Germany, the United Kingdom, and Japan were each normally more than double in value those of the United States.

### 1. *Growth of the Cartel*

The international lamp cartel was a European development. It grew out of the 1894 association of continental producers and was formalized in 1903.<sup>1</sup> The cartel was strengthened by the

<sup>1</sup> See pp. 113, 159-161.

formation in Germany in 1911 of the Drahtkonzern, which brought tungsten-filament lamps under control as well as carbon lamps. During the next two years patent-licensing and trade agreements were executed by the Drahtkonzern with British, French, Dutch, Hungarian, and other lamp manufacturers. Like the United States lamp industry, however, the German industry experienced an inrush of new manufacturers after the development of the tungsten-filament lamp. The German patent rights to the ductile tungsten filament had been included in the pool of patents held by the Drahtkonzern. When that patent was upheld in 1917, most of the new lamp producers were forced to cease production. The leading survivors entered into the price-fixing agreements of the Drahtkonzern, and the agreements were soon extended to include manufacturers in other central European nations.<sup>2</sup> The outbreak of World War I disturbed the community of interest that had reduced international competition in electric lamps, nevertheless, and the international agreements among the lamp manufacturers of opposing belligerents were terminated.

During World War I N. V. Philips increased its relative importance in the international lamp industry. Markets which had customarily been supplied by Osram and other belligerents were seized by Philips, and the Dutch company retained a considerable proportion of that trade after the end of the war. After General Electric won its patent-infringement suit on the Just and Hanaman patent against Laco-Philips, the Dutch parent discontinued its export of lamps to the United States. Each of the two companies agreed not to disturb the domestic markets of the other, while marking out exclusive areas to reduce competition.

The Osram-Werke G.m.b.H. was formed in Germany in 1919, to regain the markets which had been lost during the war years. It comprised the lamp works of A.E.G., the German Welsbach Company (Deutsche Gasglühlicht Aktien-Gesellschaft), and the Siemens group, which had been associated in the Drahtkonzern, and it controlled most of German lamp production. Within a very short time the Osram company had acquired other German lamp producers and had extended its influence into the lamp industries of several countries. It acquired part or con-

<sup>2</sup> George W. Stocking and Myron W. Watkins, *Cartels in Action*, Twentieth Century Fund, New York, 1946, pp. 316-317.

trolling financial interests in a number of active companies and organized several new firms in addition. By 1929 Osram's financial interests included companies in Spain, Czechoslovakia, Norway, Poland, Switzerland, Austria, Denmark, Sweden, and Italy.

The international lamp cartel was revitalized after World War I, mainly through the efforts of the Osram company. The dislocation of normal trade during the war years had led to a considerable expansion of productive capacity in many countries, and Osram desired to avoid price competition from producers striving to hold their gains. Osram encouraged the formation in 1921 of the International Union for Regulating Prices of Incandescent Lamps (Internationale Glühlampen Preisvereinigung). This organization, composed of the Osram company and producers of Central Europe, together with N. V. Philips and a Swiss company, allocated markets and established prices and conditions of sale. Although British and American companies did not at that time join the cartel, in 1921 and 1922 Osram made bilateral agreements with the British and the American General Electric companies regarding sales territories and other matters. The agreement with the American concern provided for "the exchange of patents and technical experience and 'marked out exclusive sales areas for the two contracting parties, and thus set territorial limits to the competition between these undertakings by applying for the first time the principle of the protection of the home market.'"<sup>3</sup>

By 1924 the cartel had grown to include about twenty-seven producers of electric lamps, including eight trusts made up of thirty-six affiliated companies. The Osram company and Philips were leading forces in its activities. By 1939 almost every important lamp producer in Europe was a member, in particular Osram, Philips, the French Compagnie des Lampes, the Italian Società Edison Clerici Fabbrica Lampage, and the leading British producers.

In 1917 the leading British companies had incorporated the Electric Lamp Manufacturers' Association of Great Britain, Ltd., to succeed the earlier Tungsten Lamp Association of 1912. The

<sup>3</sup> U.S. Tariff Commission, *op. cit.*, pp. 57-58. (Original source, *Review of the Economic Aspects of Several International Agreements*, League of Nations, Geneva, 1930, p. 70.)

Tungsten Lamp Association had been the vehicle for patent pooling and allocation of the market. Its usefulness had been impaired by the 1917 invalidation of Coolidge's British patent of 1906 on the drawn-tungsten filament.<sup>4</sup> The new organization brought in additional lamp manufacturers, pooled all remaining patents, fixed prices, and established a common policy of resale price maintenance.<sup>5</sup> Association members controlled more than 90 per cent of British lamp production. Out of this stronger domestic association and bilateral agreements with foreign concerns grew a more active participation in the activities of the cartel. About 1925 the General Electric Company, Ltd., British Thomson-Houston Company, Ltd., Edison-Swan Electric Company, Ltd.,<sup>6</sup> Siemens Brothers, Ltd., and the Metropolitan Vickers Electric Company, Ltd.,<sup>7</sup> became full members of the cartel. The British market was then set aside largely for British producers, in accordance with the established practice. The British industry was further concentrated in 1928 by the amalgamation of British Thomson-Houston, Edison-Swan, Metropolitan-Vickers, and another electrical-goods manufacturer, the Ferguson Company, as the Associated Electrical Industries, Ltd.

A Convention for the Development and Progress of the International Incandescent Electric-Lamp Industry was established in 1924, when the previous system of price control broke down. Under the agreements supporting the new and more rigid Convention patents were pooled, technical experience was exchanged, and territorial limits of competition were determined. The American General Electric Company played a very important part with Osram, Philips, and the other leading European lamp producers in setting up the Convention. Its agent in the arrangements was the International General Electric Company of New York, Ltd., a British subsidiary of the American International General Electric Company.

Although the cartel does not itself fix uniform prices, its sales committee does decide general sales policies and gives directions for the

<sup>4</sup> See p. 245, n. 25.

<sup>5</sup> See Stocking and Watkins, *op. cit.*, p. 320.

<sup>6</sup> The Edison-Swan Electric Company, Ltd., amalgamated with the British affiliate of Philips around 1920.

<sup>7</sup> The Metropolitan Vickers Electric Company, Ltd., was controlled by Westinghouse.

fixing of prices and conditions of sale to the national assemblies of producers in various territories. Furthermore, and notwithstanding the fact that limitation of output is stated not to be a function of the cartel, production is indirectly regulated through the allocation of specified market territories to the members, the quota assigned to each national group usually comprising most or all of the consumption in its home market.<sup>8</sup>

The success of the cartel in maintaining high prices varied with the organization of the industry in the various countries. Where control was strongest, as in Holland and Germany, prices were particularly high, even though the leaders in these countries were technologically the most active lamp producers in Europe. In some countries patent loopholes, more active independent manufacturers, cartel conflicts, and other conditions weakened the cartel somewhat. Even though the cartel's effectiveness declined somewhat after 1930, until World War II between 80 and 90 per cent of the total electric-lamp production of Europe was controlled by the cartel. This percentage was applicable to the production of Germany, Austria, Hungary, Czechoslovakia, the Netherlands, and Belgium; and only slightly smaller proportions were controlled by cartel members in France, Italy, and the United Kingdom. Even in Japan, cartel members produced more than half the total output.

To administer the terms of the Convention and the agreements signed under it, the Phoebus Company (Phoebus S. A. Compagnie Industrielle pour la Développement de l'Éclairage) was organized. It was located at Geneva and acted as an intermediary in the exchange of technical information and in the acquisition of patents. Although the agreements were originally scheduled to expire in 1934, they were extended to 1955. The outbreak of World War II again disrupted the operation of the cartel.

## 2. The Cartel and the American Lamp Industry

Despite the fact that the American General Electric Company has never been an official member of the international cartel, it has operated in essential harmony with it through foreign subsidiaries and through a long series of licensing agreements with

<sup>8</sup> U.S. Tariff Commission, *op. cit.*, p. 58.