The Social Shaping of Technology

How the refrigerator got its hum

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Failed machines

If the landscape of American social history is cluttered with the remains of failed communes and cooperatives, the landscape of American technical history is littered with the remains of abandoned machines. These are not the junked cars and used refrigerators that people leave along roadsides and in garbage dumps, but the rusting hulks of aborted ideas: patents that were never exploited (the patent record contains literally millions of them); test models that could not be manufactured at affordable prices; machines that had considerable potential but that were, for one reason or another, actively suppressed by the companies that had the license to manufacture them; devices that were put on the market but that never sold well and were soon abandoned. The publications of the Patent Office and the 'new patents' columns in technical magazines reveal that the ratio of 'failed' machines to successful ones is high, although no scholar has yet devised a formula by which it can actually be determined. Some nostalgia buffs have even become collectors of these 'rusting hulks,' filling scrapbooks with advertisements for bizarre devices and selling extant versions of them to one another at flea markets and antique shows.

The women's magazines of the nineteenth and twentieth centuries are filled with such aborted ideas: an ice-making machine driven by a small water wheel; a rocking chair that simultaneously propels a butter churn and a cradle; individual household incinerators; central vacuum-cleaning systems; sanitary toilets that do not use water; fireless cookers. There was a vast array of devices, some ludicrous but many, at least on the surface, very sensible. What resident of a drought-prone area today would not be grateful for a toilet that does not use water? How many energy-conscious housewives would be unwilling to try out a fireless cooker? In what city and town, plagued by erratic and expensive garbage pickup, would a householder not be pleased to be the first on the block to own a household incinerator? Why are these items either no longer on the market or not there at prices that most households can afford? Why do we have popcorn makers and electric can openers but not gas refrigerators or inexpensive

central vacuum cleaners? If we can put a man on the moon, why have we been unable to pipe our garbage disposals into our compost heaps?

The answers to these questions are not simple: they involve economic decisions made by complex social institutions operating over long periods. In order to find out why a particular patent was not exploited, one must discover something about the Patent Office, something about the inventor, and something about potential consumers; in order to find out why a particular test model was never manufactured, one must learn about the technical problems involved, the decision-making procedures within the company that developed the test model, the state of the general economy, the availability of resources, and so forth. Yet if one wants to learn why our houses and our kitchens are constructed in certain ways but not in others – that is, why household work is shaped by certain constraints and not by others – then an exploration of the forces that cause some machines to 'fail' and others to 'succeed' may well be in order. One such case, which I shall here consider as an example of all the others, was the rivalry between the gas refrigerator (the machine that failed) and the electric refrigerator (the one that succeeded).

The refrigerator: gas versus electric

All mechanical refrigerators create low temperatures by controlling the vaporization and the condensation of a liquid, called a 'refrigerant'; when liquids vaporize they absorb heat and when they condense they release it, so that a liquid can remove heat from one place (the 'box' in a refrigerator) and transport it to another (in this instance, your kitchen). Virtually every refrigerator on the market in the United States today controls the condensation and the vaporization of its refrigerant by a special electric pump known as a 'compressor.' Compression is not, however, the only technique by which these two processes can be controlled. The simplest of the other techniques is 'absorption.' The gas refrigerator is an absorption refrigerator. Inside its walls, a refrigerant (ammonia, usually) is heated by a gas flame so as to vaporize; the ammonia gas then dissolves (or is absorbed into) a liquid (water, usually), and as it dissolves it simultaneously cools and condenses. The absorption of ammonia in water automatically alters the pressure in the closed system and thus keeps the refrigerant flowing, hence making it possible for heat to be absorbed in one place and released in another, just as it would be if the flow of the refrigerant were regulated by a compressor. The absorption refrigerator, consequently, does not require a motor – the crucial difference between the gas refrigerator and its electric cousin. Indeed, with the exception of either a timing device or a thermal switch (which turns the gas flame on and off so as to regulate the cycles of refrigeration), the gas refrigerator need have no moving parts at all, hence no parts that are likely to break or to make noise.

The basic designs for both compression and absorption machinery were perfected during the nineteenth century.[1] The phenomenon of latent heat (the heat absorbed when a liquid changes to a gas and released when the process is reversed) was discovered late in the eighteenth century and explored in great detail in the nineteenth because of its importance both in the new science of thermodynamics and in the new technologies of the steam engine. In those same decades, the need for mechanical refrigeration was growing as cities began to expand, both in Europe and in the United States, and ever larger quantities of food had to be preserved for longer periods of time as people continued to move farther from the places where it was grown. Between 1830 and 1880, dozens upon dozens of mechanical refrigerating machines were patented – machines that would make ice as well as machines that would cool large compartments without making ice. By the end of that period, the fundamental designs for large-scale compression and absorption installations had been perfected, largely through inventive and commercial trial and error. As a result of all this activity, manufactured ice became available throughout the southeastern United States by 1890 and throughout the northeast (where natural ice was more readily available through much of the year) by 1910. By 1890, nearly every brewery in the United States had purchased a refrigerating machine to remove the heat generated during the fermentation of beer and to cool the finished product while it aged and awaited transportation. Before the nineteenth century had turned into the twentieth, meat packers were using mechanical refrigeration in the handling and processing of meat, cold-storage warehouses had begun to appear in cities, icemen were carrying manufactured ice through the streets, and refrigerated transport (which utilized manufactured ice in railroad cars and refrigerating machines on ocean-going vessels) was becoming increasingly common and less expensive.

Operating a commercial refrigerator was an ambitious undertaking. Few machines weighed less than five tons, and a substantial number of them weighed from one hundred to two hundred tons. All the compression, and some of the absorption, machines required a source of mechanical power; and, as the electric motor was not yet perfected, this source was most commonly a steam engine (although hot-air engines and water turbines were occasionally used), which itself might weigh several dozen tons. As automatic controls were primitive, the machine was tended night and day by skilled operators, and each machine required a staff of even more skilled people to perform normal maintenance activities. Designing these machines was no simple task, since each one was built to unique specifications. By the turn of the century, a new profession had emerged: the refrigeration engineer – a person who could design and maintain refrigeration equipment. The American Society of Refrigerating Engineers was formed in 1904; and the Refrigerating Machinery Association, which represented the interests of manufacturers, one year earlier, in 1903.

None of this activity affected American households directly, even as late

as 1920. Indirectly, many Americans benefited from lower prices for ice and greater availability of fresh meat, poultry, dairy products, and eggs during the first two decades of the century, but mechanical refrigeration was not yet possible in the household itself. The technical obstacles to developing a domestic mechanical refrigerator were substantial: such a refrigerator would have to be small and light enough to fit somewhere in a household, automatic enough not to require constant supervision, reliable enough not to require constant servicing; and it would have to have a power source that could be operated by a totally unskilled worker. Ultimately, it would also have to be designed so that it could be mass-produced, and it would have to be safe: many of the refrigerants then in common use were either toxic or flammable, and 'ice-house' accidents were regularly highlighted in the newspapers. That a potential market existed was clear, for the use of ice and iceboxes in American households expanded drastically after 1880. In Philadelphia, Baltimore, and Chicago, over five times as much ice was consumed in 1914 as in 1880; and in New Orleans, the increase was thirteenfold; the dollar value of iceboxes manufactured in the United States more than doubled between 1909 and 1919.[2] In the early years (1910–20), neophyte manufacturers of domestic refrigerators had no difficulty finding investors willing to lend them money and large coporations willing to buy them out. Just before and after the First World War, the problems involved in initiating domestic refrigeration were technical, not financial or social, and appear to have been about as great for the absorption machine as for the compression one. Indeed, since, until about 1925, gas service was more widespread than electric service, one might guess that the absorption machine would have had the competitive edge.

The electric compression machine

The first domestic refrigerator actually to go into large-scale production, however, was a compression machine. The honor of being first seems to belong to A. H. Goss, then an executive of the General Motors Company; to E. J. Copeland, a purchasing agent for General Motors; and to Nathaniel B. Wales, a Harvard graduate who was an independent inventor.[3*] On

*In matters technological, the question of who was 'first' is difficult to resolve, initially because one must be careful to specify 'first at doing *what*,' and then because available accounts, embedded as they are in the history of extremely private enterprises, are frequently vague, often in conflict, and most commonly nonexistent. Most authorities say that the Kelvinator was the first successful domestic refrigerator, but they may do so only because, at some point, the Kelvinator Corporation donated one of its 'first' models to the Smithsonian. A reporter for *Air Conditioning and Refrigeration News* (then, *Air Conditioner, Heating and Refrigeration News*) asserted that the Isko Company (which was started 'by Fred Wolf with the backing of . . . Detroit capitalists') went into business in 1912, and that the Guardian Frigerator Company (which later became Frigidaire) was started in 1916, but provided no date for the commencement of manufacturing in either case.[4] Lacking more complete information, Kelvinator remains 'first.'

14 September 1914, Goss and Copeland contracted with Wales to do the development work on a domestic refrigeration machine. After creating several test models, Wales settled on a compression machine using sulfur dioxide as a refrigerant; he had originally worked on an absorption machine, but – for reasons that are unclear – those plans were dropped. On 13 May 1916, this enterprise was incorporated as Goss & Copeland Electro-Automatic Refrigerator Company; but a few months later, the name was changed to 'Kelvinator.' At this juncture, Wales left the enterprise. In 1917, Copeland developed a satisfactory automatic control device and a solution to the problem of gas leakage (sulfur dioxide is toxic); and in February 1918, the first Kelvinator refrigerators were sold.

The path that Goss and Copeland pioneered quickly became a beaten track. By 1923, when the officers of the General Electric Company decided to do a thorough study of the domestic refrigeration business, the mechanical engineer to whom they entrusted the job, A. R. Stevenson, was able to identify fifty-six companies that were already involved in the business.[5] Some of these, such as Kelvinator and its rival, Frigidaire (which had been founded in 1916 and purchased by General Motors in 1919), were heavily capitalized and had already produced several thousand refrigerators. Other companies had just entered the field and had only test models and/or faltering finances. In those early years, compression refrigerators dominated the field; and out of the fifty-six companies, only eight were yet either well financed or well on their way to large-scale production.

Yet, in 1923, even the compression domestic machine was still in its developmental stage: the machines on the market did not inspire every middling householder to reach immediately for a checkbook. They were, to start with, expensive: the price had fallen from its original peak; but in 1923, the cheapest still ran to $450 – not an inconsiderable sum at a time when most people earned less than $2,000 a year. Furthermore, refrigerators were difficult to run. Electric utilities estimated that, once every three months, they serviced the machines that they had sold: the tubes leaked; the compressors malfunctioned; the thermostats broke; and so did the motors.[6] All these early machines were, in addition, 'separated' machines – and water-cooled ones at that. The refrigerating machinery was sold separately from the refrigerating compartment, which might well have been simply the icebox that a family had previously used; the machinery could be set up in the basement, say, and the icebox put in the kitchen. The compressor had additional work to do, since the refrigerant had to be moved a considerable distance, but it must have been a relief to householders to have the noise, the oil, and the serviceman in some remote part of the house. Water cooling (the standard technique in large commercial installations) was not convenient in the home. The water pipes froze in some locales in the winter time (turning a refrigerator back into an icebox); or the water frequently leaked into parts of the machinery where excess humidity created excess problems. F. C. Pratt, a vice president of G.E. in

1923, forwarded Stevenson's report to Gerard Swope, president of the company, with the following warning:

> There reads through Mr. Stevenson's report the important fact that all existing practice carries a more than normal hazard of being revolutionized by inventions of a fundamental character. So many active minds throughout the country are being directed to the solution of these problems that it would be perhaps surprising if some such inventions did not materialize. The business is a rapidly evolving one, making real strides from the developmental to the commercial stage.[7]

Pratt was right, as it turned out. In the decade between 1923 and 1933, inventions that would profoundly alter the design of domestic refrigerators did, in fact, materialize; and, again as he predicted, they materialized in more than one quarter. In Sweden, for example, two young engineering students, Carl G. Munters and Baltzar von Platen, figured out how to design an absorption refrigerator that would run continuously and thus would not require expensive automatic controls; this machine (the Electrolux-Servel) went on the market in 1926. Engineers at Kelvinator and, later, at General Electric discovered techniques for dispensing with water as a cooling agent. In 1927, General Electric became the first manufacturer to make a hermetically sealed motor and to sell the box as an integral part of its refrigerating machinery. Within a year, other manufacturers followed suit and also began mass production of refrigerator boxes made from steel rather than from wood. In 1930, chemists at General Motors (which still owned Frigidaire) developed a series of artificial refrigerants (the Freons) that were neither toxic nor flammable; and in 1932, engineers at Servel designed an air-cooled absorption machine. By the middle years of the Depression, most of the fundamental innovations in domestic refrigeration design (with the exception of automatic defrosting, which came later) had been made.[8]

These innovations did not occur out of the blue. They were the end result of deliberate assignments given to a large number of highly trained (and highly paid) people, and of the equally deliberate expenditure of large sums of money not only to develop these ideas but to equip assembly lines that could realize them in production. The stakes were thought to be very high. The potential market for domestic refrigeration was enormous: by 1923, it was clear that every household in the United States was going to be equipped with either gas or electric service (and probably both in many places); and, thus, that if the price could be brought low enough, every household would become a potential customer for a refrigerator.[9] The potential revenues for the gas and electric utility companies would be even more enormous, since, unlike other household appliances, the refrigerator operates twenty-four hours a day. Thus, it is hardly surprising that the money and the time necessary to achieve these innovations was available – especially during the economically free-wheeling 1920s. Yet, to

say that the stakes were high is also to say that the risks were great. Some manufacturers were going to succeed, and others were going to fail – and one of the failures would turn out to be the only manufacturer in a competitive position to keep the gas refrigerator on the market.

One of the manufacturers that succeeded, and whose success helped carry the compression refrigerator to dominance, was General Electric. By the 1920s, General Electric was an enormous corporation with vast resources and had its finger in almost every aspect of the electrical industry in the United States, from the design of large generating plants to the manufacture of light bulbs.[10] The refrigerator that General Electric introduced to the public in 1925 (called the 'Monitor Top' because the working parts were located in a circular box that sat on top of the refrigerating cabinet itself) was the product of almost fifteen years of developmental work on the part of General Electric employees. In 1911, G.E. had agreed to manufacture a commercial refrigerator for the Audiffren Company, which held the American rights to a patent owned by a French monk, the Abbé Audiffren. Sometime during 1917, engineers at the Fort Wayne, Indiana, plant (where the Audiffren was manufactured) began to build test models of a modified Audiffren design, suitable for use in the household. Immediately after the First World War, G.E. found itself in poor financial condition; in 1922, the company was reorganized, and Gerard Swope was brought in as president. Swope believed that General Electric was going to have to enter the consumer electric market and, to this end, instructed A. R. Stevenson, who was then head of the engineering laboratories in the company's main headquarters in Schenectady, to review the current state of the refrigerator business.[11]

Stevenson's report, a model of engineering and econometric skill, provides glimpses of the factors that influenced decision makers at G.E. The report contained everything from engineering tests on competing machines to projections of the potential market for refrigerators sold at various prices. Stevenson had been asked to recommend a course of action to the managers of the company, and he did so without equivocating. Was it worth entering the domestic refrigeration business at all? Certainly Yes, concluded Stevenson. If it did, should G.E. purchase one of the many small companies already in the field (No) or make cross-licensing arrangements (our motors for your compressors) with one of the larger companies (No). Should G.E. take advantage of the development work that had already been done at Fort Wayne and try to work with an Audiffren type of apparatus (Yes). Was it worth spending the time and money that would be required to switch from water to air cooling? Absolutely, said Stevenson, not just because water cooling was a problem for home owners, but also because General Electric had to worry about the interests of its most important customers – not the home owners but the electric utility companies:

> the electric power bill of the air cooled machine would be about $1.30 more in six months than the water cooled machine. . . . Since the General Electric Company is entering this field for the benefit of the central station [the utility company that is generating electricity] it would seem wise to exploit a machine in which the total revenue would accrue to the central station rather than partly to the water works.[12]

Stevenson understood that General Electric would be assuming a considerable risk if it entered the refrigerator business; but he believed the risk to be worth taking for a number of reasons: he believed that there was a good chance that G.E. would be first, that the company had the resources to sustain the initial losses, that after this initial period the profits would be great, and finally that 'widespread adoption [would] increase the revenue of the central stations, thus indirectly benefiting the General Electric Company.'[13] G.E. stood to gain, both coming and going, from developing a successful refrigerator.

The managers of G.E. must have agreed with Stevenson. During 1924, a group of engineers worked on developing an air-cooled model of the original Fort Wayne design. In the fall of 1925, limited production began, and the 'Monitor Top' was introduced to G.E.'s sales force and to the electric utility companies. During 1926, construction of an assembly line began (at a total cost of eighteen million dollars), and the design was modified again to allow for mass production. In 1927, a new department of the company was created to promote and market the machine; and within months of its establishment, the first mass-produced Monitor Tops had found their way into kitchens across the land. By 1929, fifty thousand Monitor Tops had been sold – a figure that may have been as surprising to the top management of General Electric (the company had anticipated sales of seven thousand to ten thousand per year) as it was to everyone else.[14]

General Electric stimulated sales of its refrigerators by means of outlandish advertising and public relations techniques. Franchised distributors were appointed in the major cities across the country and given exclusive rights to sell and service their territories. Rex Cole, in New York, was famous for constructing a neon sign that could be read three miles away, and for staging promotional parades. Judson Burns of Philadelphia had his new store designed in the shape of a Monitor Top. When G.E. introduced its first all-steel cabinets in 1929, a novel 'Pirate's Chest' sales campaign was broached:

> For some time previous to March 22 mysterious looking old iron-bound boxes closely resembling pirates' treasure chests had been on display in the windows of General Electric refrigerator dealers, with a sign saying that they would be opened on March 22. The night before, large door keys were hung on door knobs in the residential sections with an invitation to attend the opening the following morning.

> The event had been advertised in newspapers and through direct-by-mail literature. Many distributors and dealers arranged parties for the opening. A greater number provided radio programs. . . . In some cities the mayor was invited to open the box. In various stores, pirates swashbuckled inside and outside the sales rooms, and rode on floats with jazz bands.
>
> Promptly at 11 o'clock that morning, in the presence of crowds of onlookers, numbering from 200 to 800 each, the chests were unlocked and disclosed the new All-Steel G.E. Refrigerator.[15]

Special exhibition railroad cars toured the country, displaying refrigerators. Animated puppets danced in dealers' windows:

> The June ANIMATED Window Display dramatized the shortest 'short story' ever produced . . . and the action takes place in a realistic stage setting in the interior of the G-E refrigerator.
>
> Prologue: A BRIDE IN JUNE. Stage set consists of an illuminated cathedral interior during a wedding ceremony.
>
> Act I: A SERVANT IN SEPTEMBER. A revolving stage discloses a second illuminated set consisting of a wearied housewife in an old-fashioned kitchen without electrical conveniences.
>
> Act II: FREEDOM IN A G-E KITCHEN: The revolving stage shows a third set consisting of a glorified G-E Kitchen and the symbolical 'Freedom' figure [a vaguely-Grecian female with arms extended in a gesture of leaping joyousness].[16]

The millionth Monitor Top was presented to Henry Ford in a special radio broadcast in 1931, and another one was sent on a submarine voyage to the North Pole with Robert Ripley (the originator of 'Believe It or Not') in 1928. The most expensive media device of all was undertaken in 1935 – a film that told 'an interesting story in which comedy and romance are skillfully blended, all of which pivots on and revolves about the complete electric kitchen.' An anonymous publicist waxed ecstatic:

> It is of no avail to attempt to describe this picture, 'Three Women.' We can tell you that it is the most pretentious [*sic*], the most beautiful, the most effective commercial story ever told on the talking screen; that it is the first commercial Technicolor film ever made; that for gorgeous color and amazing realism it is on a par with outstanding examples of cinema artistry.[17]

The film ran for close to an hour and starred such Hollywood notables as Sheila Mannors and Hedda Hopper, Bert Roach and Johnny Mack Brown.

General Electric was not alone, either in these outlandish promotional schemes or in its effort to develop a successful compression refrigerator; the other major refrigerator manufacturers, just as anxious to attract consumer attention (especially during the straitened Depression years), were just as willing to spend money on advertising and promotion. The electric

utility companies, which were then in a most expansive and profitable phase of their history, cooperated in selling both refrigerators and the idea of mechanical refrigeration to their customers. By 1940 the market for household refrigerators was dominated by the four manufacturers of compression machines which had at their disposal the financial resources of enormous corporations: General Electric; Westinghouse, which began to manufacture refrigerators in 1930; Kelvinator, which was then owned by American Motors; and Frigidaire, which still belonged to General Motors.[18] Cross-licensing and mass-production techniques had made it possible for the manufacturers to lower their prices; installment plans and occasional price wars had made it possible for ever larger numbers of people to purchase refrigerators. Despite the Depression, and despite the still relatively high cost of refrigerators (when compared with other household appliances), roughly 45 percent of American homes were taking advantage of mechanical refrigeration by the time we entered the Second World War.[19]

The gas absorption machine

The manufacturers of gas absorption refrigerators were not idle during these years, but they lacked the large sums of money, the armies of skilled personnel, the competitive pressure, and the aggressive assistance of utility companies that the compression manufacturers had been able to command. When Stevenson surveyed the refrigeration business in 1923, he located eight prospective manufacturers of absorption refrigerators.[20] In the next several years, several of these went out of business – hardly surprising, since they had had little or no paid-in capital with which to work; the Common Sense Company, for example, was working with thirty thousand dollars in the same year in which Kelvinator had one million dollars.[21]

There seems to have been little question among knowledgeable people that the absorption refrigerator had the potential to be a superb machine for household use; and adjectives such as 'ingenious' and 'clever' were frequently appended to descriptions of gas refrigerators in the technical literature. 'Thousands of people have examined this machine, among them a large number of engineers; in fact, generally speaking, the more technical a person is, the greater is the appeal made by the machine,' wrote one commentator.[22] From the consumer's point of view, these refrigerators' chief advantages were that they were virtually silent (refrigerators with compressors once made a lot more noise than they do now – and they still hum noticeably); that, having few moving parts, they were potentially easy to maintain; and that operating costs could be kept fairly low, especially in locales where gas was cheaper than electricity. Stevenson's report on the Common Sense machine noted, for example:

> The salesman at the People's Gas Company in Chicago claims that they have sold about fifty of these machines. Some of them have been in service

> for two years, and he claims that they have no trouble or service calls. . . . Mr. Robertson of . . . [G.E.'s] Chicago office, says that this ice machine is different from any other that he has seen, in that it has no rotating parts, and the machine appears to be very simple to maintain.[23]

Yet the absorption machine, like the compression machine, was going to require expensive development and promotion before it could be made commercially successful; all the absorption machines that Stevenson located were water-cooled, and there was a public prejudice against the use of ammonia as a refrigerant. It remained to be seen whether anyone was going to undertake the developmental work, which would be both time consuming and expensive.

By 1926, when the American Gas Association met in Atlantic City for its annual convention, only three manufacturers of gas refrigerators remained in the field; and of these three, only one – Servel – would succeed in reaching the stage of mass production.[24] In the early 1920s, Servel (whose name stood for 'servant electricity') had been funded by a group of electric utility holding companies to manufacture and market compression refrigerators. But in 1925, it had purchased the American rights to the Swedish patents on the continuous absorption refrigerator, and had reorganized (with the injection of five million dollars from the financial interests that controlled the Consolidated Gas Company of New York) to devote itself principally to gas refrigeration.[25] Since it had a manufacturing plant already in existence when it purchased these new patents, it was able to commence production quickly; the Servel gas refrigerator went on the market in 1926 to the accompaniment of a good deal of publicity.

The other two manufacturers failed within a few years: they could neither compete with Servel nor sell the machines on which they held patents to any of the large corporations that might have had the resources to compete. The trials and tribulations of these small businesses are exemplified in the story of the SORCO refrigerator, which was one of the other two on display in Atlantic City in 1926.[26] SORCO was the creation of Stuart Otto, an engineer who had patented an absorption refrigerator in 1923. He owned a factory in Scranton, Pennsylvania, that produced dress forms for seamstresses, and persuaded twenty of the leading businessmen of Scranton to put up five thousand dollars apiece so that he could develop his machine and modify his factory to produce it. These early SORCO refrigerators were advertised in gas-industry periodicals ('Build Up Your Summer Load – and fill your daily valleys: Gas controlled entirely by time-switch to be set by your service man') and were sold to gas utility companies.[27] The results of the tests being more or less positive, Otto decided in the fall of 1926 that the time had come to attempt large-scale production:

> I was not able to raise the money from my stockholders when I informed them that $1,000,000 or more would be required. My only alternative was to buy out my stockholders. So I made an option agreement with them to

> pay them for their stock within a year. I then went about the country offering manufacturing companies non-exclusive licenses for the manufacture of my machines under our patents, of which some fifteen existed.
>
> I licensed Pathe Radio & Phonograph Co., Brooklyn, N.Y., Crocker Chair Company, Sheboygan, Wisconsin, Plymouth Radio & Phonograph Co., Plymouth, Wisconsin.
>
> Each of these companies paid me a cash down payment on signing of $25,000 and agreed to a guaranteed minimum of $35,000 per year royalty on a 5% of net sales, for 17 years.[28]

Otto had tried to interest General Electric and General Motors in his refrigerator. General Electric was, however, just about to bring out its own refrigerator; and General Motors had just purchased the patent rights on an English machine that utilized a solid rather than a liquid solvent.* Otto was trying to enter the national market with ludicrously small sums of money; the days in which David had any reasonable chance of succeeding against Goliath had long since passed. Within a few years, Otto was forced to acknowledge failure: 'Unfortunately . . . we were not financially able to carry the loads. After two years I managed to collect only a small portion of the accrued royalties.'[29]

Thus, Servel was essentially alone: from 1927 until 1956, (when it ceased production of refrigerators), it was the only major manufacturer of gas-absorption refrigerators in the United States. Never as highly capitalized as its competitors in the field of compression machinery (G.E., after all, had invested eighteen million dollars just in its production facilities in 1927, when Servel's entire assets amounted to not more than twelve million dollars), Servel had entered the market somewhat later than the other manufacturers and was never able to compete effectively. The gas utilities, notoriously conservative companies, were defending themselves against the encroachments of electricity and were not helpful; they complained that Servel was badly managed, that its refrigerators were more expensive than comparable electric machines, and that the lack of another manufacturer meant a lack of models with which to interest prospective customers.[30] Servel did not succeed in bringing out an air-cooled refrigerator until 1933, six or seven years after the electrics had done so; and by then the race was virtually lost. For all its virtues as a machine, the Servel, even in its peak years, never commanded more than 8 percent to 10 percent of the total market for mechanical refrigerators.[31]

The demise of the gas refrigerator was not the result of inherent deficiencies in the machine itself. The machine was not perfect when it was first brought on the market, but it was no less perfect than the compression machine, its rival. The latter succeeded for reasons that were

*This refrigerator, the Faraday, was marketed, on a limited basis, by G.M. in the mid-1930s; but, as it was water-cooled and very expensive, G.M. soon dropped it.

as much social and economic as technical; its development was encouraged by a few companies that could draw upon vast technical and financial resources. With the exception of Servel, none of the absorption manufacturers was ever able to finance the same level of development or promotion; and Servel never approached the capabilities of General Motors, General Electric, or Westinghouse. The compression refrigerator manufacturers came on the market earlier and innovated earlier, making it doubly difficult for competing devices to succeed. The fact that the electric utilities were in a period of growth and great profitability between 1920 and 1950, while the gas manufacturers and utility companies were defensive, conservative, and financially weak, cannot have helped matters either. If Stuart Otto had been able to obtain either capital or encouragement from the gas utilities, if Servel had been managed well enough to have innovated earlier, if either one of them had been able to command a chemical laboratory capable of discovering a new refrigerant, if there had been a sufficient number of gas-refrigerator manufacturers to have staged price wars, or license innovations to each other, or develop cooperative promotional schemes along with the gas-utility companies – well then, the vast majority of Americans might have absolutely silent and virtually indefatigable refrigerators in their kitchens. The machine that was 'best' from the point of view of the producer was not necessarily 'best' from the point of view of the consumer.

The profit motive and the alternative machine

The case of the gas refrigerator appears, in many particulars, to be structurally similar to the cases of many other aborted or abandoned devices intended for the household. There were, at one time, dozens of different kinds of washing machine: contraptions that simulated the action of a washboard; tubs with sieves that rotated inside fixed tubs filled with soapy water; tubs that rocked back and forth on a horizontal axis; motor-driven plungers that pounded the clothing inside a tub. All these washing machines yielded, during the 1920s and 1930s, to the agitator within the vertically rotated drum, because of the aggressive business practices of the Maytag Company which owned the rights to that design.[32] The central vacuum cleaner, which technical experts preferred, quickly lost ground to its noisier and more cumbersome portable competitor, in part because of the marketing techniques pioneered by door-to-door and store-demonstration salesmen employed by such firms as Hoover and Apex.[33]

Furthermore, many of the companies that pioneered successful household appliances had already developed a sound financial base manufacturing something else. Fedders, for example, made radiators for cars and airplanes before it made air conditioners; Regina made music boxes before it made vacuum cleaners; Maytag made farm implements; Sunbeam made scissors

and clippers for shearing sheep; Hoover made leather goods.[34] Alternatively, small companies with innovative ideas rarely succeeded unless they were purchased by, or made cooperative agreements with, much larger companies that had greater financial flexibility and the resources necessary to broach the national consumer market. Hotpoint belonged to General Electric, as did Edison Electric. Birdseye became part of General Foods; Norge, of Borg-Warner; Kelvinator, of American Motors. Bendix Home Appliances was a subsidiary of the Bendix Corporation, manufacturers of airplane parts. A larger corporation frequently purchased smaller ones or introduced new products when one (or several) of their old lines were failing. William C. Durant, of General Motors, for example, purchased Frigidaire because he wanted his salesmen to have something to sell when automobiles went off the consumer market during the First World War. Landers, Frary & Clark began to sell small appliances (under the name 'Universal') when their cutlery trade fell off. Westinghouse went into refrigerators as a cushion against the Depression. Maytag started making washing machines because of seasonal slacks in sales of farm machinery.[35]

By itself, the gas refrigerator would not have profoundly altered the dominant patterns of household work in the United States; but a reliable refrigerator, combined with a central vacuum-cleaning system, a household incinerator, a fireless cooker, a waterless toilet (otherwise known as an 'earth closet'), and individually owned fertilizer-manufacturing plants (otherwise known as 'garbage disposals that make compost') would certainly have gone a long way to altering patterns of household expenditure and of municipal services. We have compression, rather than absorption, refrigerators in the United States today not because one was technically better than the other, and not even because consumers preferred one machine (in the abstract) over the other, but because General Electric, General Motors, Kelvinator, and Westinghouse were very large, very powerful, very aggressive, and very resourceful companies, while Servel and SORCO were not. Consumer 'preference' can only be expressed for whatever is, in fact, available for purchase, and is always tempered by the price and convenience of the goods that are so available. At no time, in these terms, were refrigerators that ran on gas really competitive with those that ran on electric current.

In an economy such as ours in the United States, the first question that gets asked about a new device is not, Will it be good for the household – or even, Will householders buy it? but, rather, Can we manufacture it and sell it at a profit? Consumers do not get to choose among everything that they might like to have, but only among those things that manufacturers and financiers believe can be sold at a good profit. Profits are always the bottom line, and profits are partly compounded out of sales – but only partly. Profits are also compounded out of how much staff time has to be spent, whether a marketing arrangement is already in place, how easily manufacturing facilities can be converted, how reliably an item can be mass-produced – and similar considerations. General Electric became interested

in refrigerators because it was experiencing financial difficulties after the First World War and needed to develop a new and different line of goods. G.E. decided to manufacture compression, rather than absorption, refrigerators because it stood to make more profits from exploiting its own designs and its own expertise than someone else's. Once having gone into the market for compression refrigerators, G.E. helped to improve that market, not just by its promotional efforts on its own behalf, but by the innovations that it could then sell to, or stimulate in, other manufacturers. And having done all that, G.E. helped to sound the death knell for the absorption machinery, since only a remarkable technical staff and a remarkable marketing staff, combined with an even more remarkable fluidity of capital, could have successfully competed with the likes of General Electric, Westinghouse, General Motors, and Kelvinator.

Notes

1 The account that follows is based upon Oscar Edward Anderson, Jr., *Refrigeration in America: A History of a New Technology and its Impact* (Princeton, N.J., 1953).

2 These figures come from U.S. Census Bureau data as quoted in Anderson, *Refrigeration* [1], pp. 114–115.

3 See 'Arnold H. Goss Ends His Life,' *Electric Refrigeration News* 25 (26 October 1938): 1, 2, 11. In addition to this article, my account of the origin of the Kelvinator is based on Anderson, *Refrigeration* [1], p. 195; obituary of Nathaniel B. Wales, *New York Times* (18 November 1974); J. W. Beckman, 'Copeland Tells Story of Household Refrigeration Development' *Air Conditioning, Heating and Refrigeration News* 6 (6 July 1932): 9–11; and Giedion, *Mechanization Takes Command* (New York, 1948), p. 602.

4 Beckman, 'Copeland Tells Story' [3].

5 Stevenson's report, 'Domestic Refrigerating Machines,' can be found, in its original typewritten form, in the Technical Data Library, General Electric Company, Schenectady, N.Y., Data File 1120. The original report was dated 17 August 1923, but many appendices were added in the ensuing five years, making a document that runs to several hundred pages. I was given access to it originally and will quote from it (citing it as (*DRM – GE*) through the kindness of Dr. George Wise, Corporate Research and Development, General Electric Company, Schenectady. The pagination in various sections of the report is not sequential. The complete list of companies and the report on their products is *DRM – GE*, vol. III.

6 *Electric Domestic Refrigeration, 1924*, a report of the Electric Domestic Refrigeration Committee, National Electric Light Association (New York, 1924), p. 2, table 1.

7 Letter, Francis C. Pratt to Gerard Swope, 17 August 1923, *DRM – GE* [5], p. 4.

8 Anderson, *Refrigeration* [1], chap. 11; 'Electrolux Inventors Receive Franklin Award,' *Gas Age* 70 (2 July 1932); 'Industry Pioneer Number,' *Air Conditioning, Heating and Refrigeration News* 19 (7 October 1936), passim.

9 See *Electric Domestic Refrigeration, 1924* [6], p. 2; and *The Facts About Gas Refrigeration Today*, American Gas Association (New York, 1933).

10 There is no scholarly history of General Electric; the best of the popular accounts is John Winthrop Hammond, *Men and Volts, The Story of General Electric* (Philadelphia, 1941),

the copyright on which was held by G.E. See also David G. Loth, *Swope of G.E.* (New York, 1958). On the history of G.E.'s refrigerator, see *DRM – GE* [5], Report 2, General Survey, Historical Introduction, pp. 1–2; and Report 1, Summary and Conclusions, Audiffren, pp. 16–19, and appendices 21 and 22.

11 See Loth, *Swope* [10], pp. 116–18; and letter from Pratt to Swope, 17 August 1923, *DRM – GE* [5].

12 *DRM – GE* [5], Report 1, Summary and Conclusions, Reasons for Exploitation, p. 24.

13 *DRM – GE* [5], Report 1, Summary and Conclusions, Reasons for Exploitation, p. 17.

14 'Outline History of the General Electric Household Refrigerator,' (typescript, Public Relations Dept. G.E., Schenectady, N.Y., 1970); 'G.E. Announces New Refrigerator,' *G.E. Monogram* (October 1925): 22; Ralph Roeder, 'General Electric Refrigerators' (typescript, Public Relations Dept., G.E., Schenectady N.Y., n.d.); and T. K. Quinn, *Giant Business, Threat to Democracy, The Autobiography of an Insider* (New York, 1956), chap. 8. Quinn was in charge of the refrigerator division of G.E. during the late 1920s and early 1930s.

15 'Door of All-Steel G.E. Refrigerator Slammed Shut 300,000 Times but Remains in Excellent Condition,' *G.E. Monogram* (April 1929): 25. *G.E. Monogram*, was an in-house magazine for G.E. employees.

16 'June Bride Animated Display,' *On the Top* 9 (June 1935): 23. *On the Top* was a newsmagazine of G.E.'s Specialty Appliance Department.

17 Both quotations are from 'Three Women a Smash Hit,' *On the Top* 9 (June 1935): 7.

18 For a summary of the refrigerators that were available in the late 1930s and their relative advantages and disadvantages, see John F. Wostrel and John G. Praetz, *Household Electric Refrigeration, Including Gas Absorption Systems* New York, 1938). For the relative market share of each manufacturer, see Frank Joseph Kottke, *Electrical Technology and the Public Interest* (Washington, D.C., 1944), pp. 168–70.

19 *Sixteenth Census of the United States, Housing, 1940*, vol II, *General Characteristics*, part I, *United States Summary* (Washington, D.C., 1943), p. 2.

20 *DRM – GE* [5], vol. III, appendices.

21 Ibid., especially appendices on 'Common Sense' and 'Kelvinator.'

22 H. B. Hull, *Household Refrigeration*, 3rd ed. (Chicago, 1927), p. 321.

23 *DRM – GE* [5], vol. III, appendix on 'Common Sense.'

24 'Survey of Gas Refrigerators.' *American Gas Journal* (2 April 1927), pp. 329–34.

25 This and subsequent summaries of the early history of Servel are based upon the following articles in the *New York Times:* 11 August 1925 (26:4); 22 December 1925 (28:2); 23 January 1926 (23:1); 17 March 1926 (32:2); 18 March 1926 (34:2); 15 October 1926 (34:2); 5 August 1927 (23:6); 3 January 1928 (36:2); 5 May 1928 (3:1); and 15 October 1929 (48:5); as well as upon the entries for Servel in *Moody's Manual of Investments* for 1928 and 1940.

26 The discussion that follows is based upon material in the *Stuart Otto Papers* (hereafter cited as SOP), Department of Manuscripts and University Archives, Cornell University (no. 2389); especially the typewritten documents, 'Household Refrigeration by Gas,' 26 June 1957 and 'Memorandum *re* Gas Refrigeration Corporation,' 19 June 1940.

27 Advertisers proof copy, *Gas-Age Record* [16 May 1925], *SOP* [26].

28 'Household Refrigeration by Gas,' pp. 1–2, *SOP* [26].

29 Ibid., p. 2.

30 The judgments made in this paragraph are based upon statements made by Stuart Otto

to various correspondents; see, for example, 'Report to United American Bosch Co., Spring, 1934,' typescript, *SOP* [26]. *The Facts About Gas Refrigeration Today* American Gas Association (New York, 1933), will give the reader some sense of the reluctance of gas utility companies to become actively involved in selling gas refrigerators.

31 On estimates of the sales of Servel, see H. B. Hull, *Household Refrigeration*, 4th ed. (Chicago, 1933); and Don Wright, 'Gray Sees Bright Future for Gas Refrigerator', *Gas Age* 34 (March 1958): 84; and 'When Everybody Loves a Competitor,' *Business Week* (25 November 1950), p. 72.

32 On some of the different forms of washing machine, see Giedion, *Mechanization Takes Command* [3], pp. 562–70; as well as Edna B. Snyder, *A Study of Washing Machines*, University of Nebraska, Agricultural Experiment Station Research Bulletin 56 (Lincoln, 1931). On the tactics of the Maytag Corporation, see U.S. Federal Trade Commission, 'Kitchen Furnishings and Domestic Appliances,' vol. III of the *Report on the House Furnishings Industry* (Washington, 1925); and 'U.S. Supreme Court Hears Patent Suit Arguments,' *New York Times*, 20 April 1939 (25:3).

33 On the advantages of the central vacuum cleaner over the portable forms, see M. S. Cooley, *Vacuum Cleaning Systems* (New York, 1913), chap. 1. On the sales techniques of the portable vacuum cleaner manufacturers, see Frank G. Hoover, *Fabulous Dustpan: The Story of the Hoover Company* (New York, 1955); and Earl Lifshey, *The Housewares Story: A History of the American Housewares Industry* (Chicago, 1973), chap. 8.

34 The information in this sentence is derived from promotional material distributed by each of the companies mentioned; I am grateful to Richard Grant for helping me acquire these materials. See also Lifshey, *Housewares Story* [33], passim.

35 On Durant, see Mel Gustin, *Wild Billy: William C. Durant, Founder of General Motors* (Detroit, 1963), p. 187. On Landers, Frary and Clark, 'A History of Landers, Frary & Clark' (typescript) in *Dean S. Paden Collection* (no. 281), Baker Library, Harvard University. On Westinghouse, see 'Westinghouse Electric,' *Fortune* (February 1938), p. 45. On Maytag, see Jacob Swisher, 'The Evolution of Washday,' *Iowa Journal of History and Politics* 38 (1940): 39.

16

Moyra Doorly

A woman's place: Dolores Hayden on the 'grand domestic revolution'

In the last half of the 19th century and the first quarter of this one, there existed in the United States a remarkable school of feminist thought which tied together architecture and economics in a cogent social theory. The most basic cause of women's inequality, they argued, was the economic exploitation of women's labour by men. Women suffered from two of the fundamental characteristics of industrial capitalism: the physical separation of household space from public space and the economic separation of the domestic economy from the political economy.

These women – 'material feminists,' as they are dubbed in Dolores Hayden's classic study of their ideas – demanded a grand domestic revolution.* They wanted wages for housework. They set up new kinds of neighbourhood organisation – such as housewives' cooperatives which would undertake housework for payment. Most significant of all, they chivvied architects into exploring radical new types of building. They pushed architects and town planners into looking more intently at the effects of design on family life.

The central object of their campaigning was the need to socialise domestic work. They wanted all household labour and child care to become social labour, in home-like, nurturing neighbourhoods. They wanted neighbourhoods planned to provide laundry facilities, dining and cooking services and extensive child care facilities. In her book, *The Grand Domestic Revolution*, Dolores Hayden records their belief 'that women must create feminist homes with socialised housework and child care before they could become truly equal members of society.'

Two of the more influential women were Melusina Fay Peirce, and Charlotte Perkins Gilman. Melusina Fay Peirce laid out her proposals for cooperative housekeeping in 1868. She loved Cambridge, Massachusetts and after six years of marriage to a Harvard lecturer she described the 'costly and unnatural sacrifice' of her wider talents to 'the dusty drudgery of house ordering.' Her idea was that 'groups of 12–50 women would

*_The Grand Domestic Revolution_, subtitled _A History of Feminist Designs for American Homes, Neighbourhoods And Cities_, by Dolores Hayden is published by the MIT Press.