Automatic Controls 1400-1985

More Pioneers

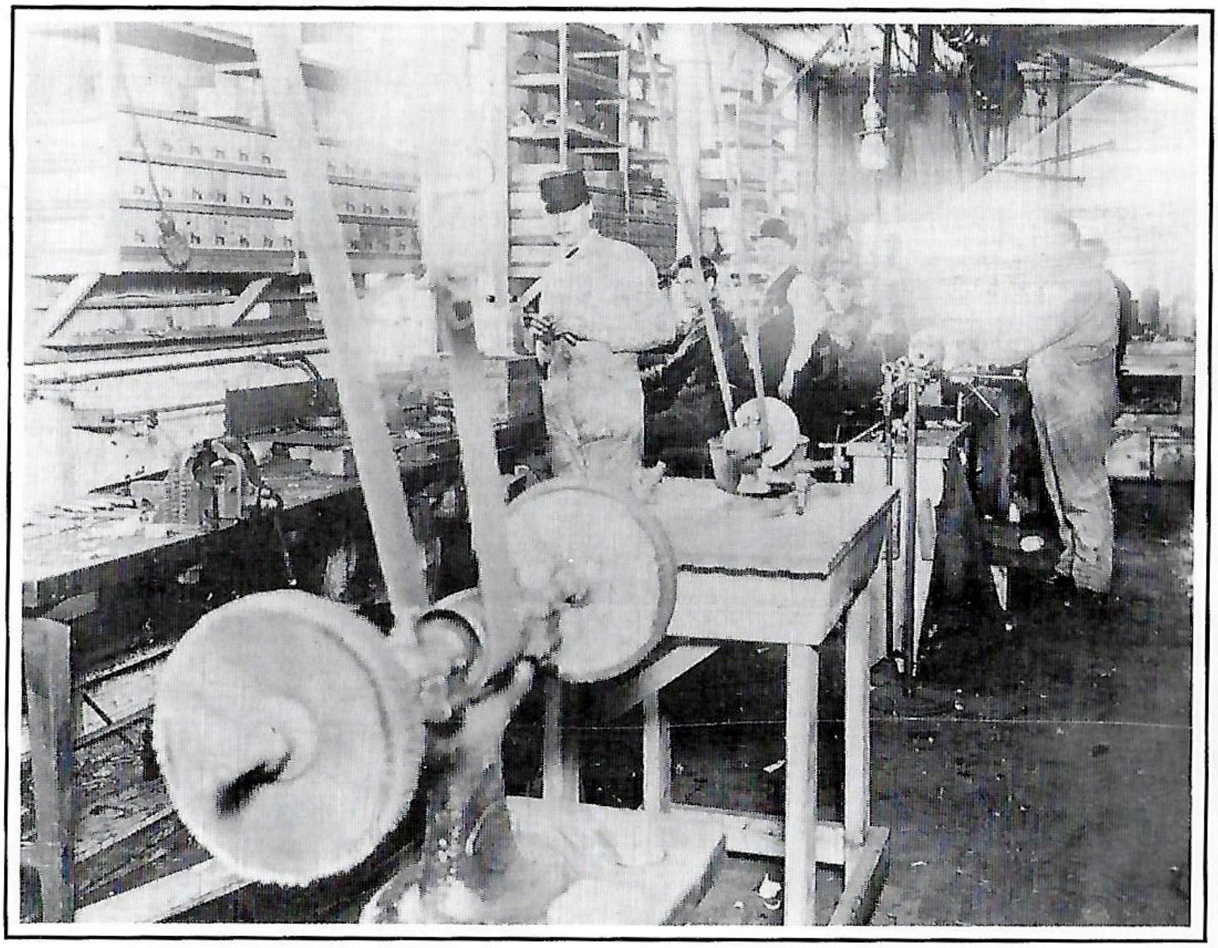


Figure 10-21 *Thermostat polishing shop—Powers Regulator Co., early 1900s (from Landis & Gyr Powers).*

From HEAT & COLD, Chapter 10
ASHRAE 1944

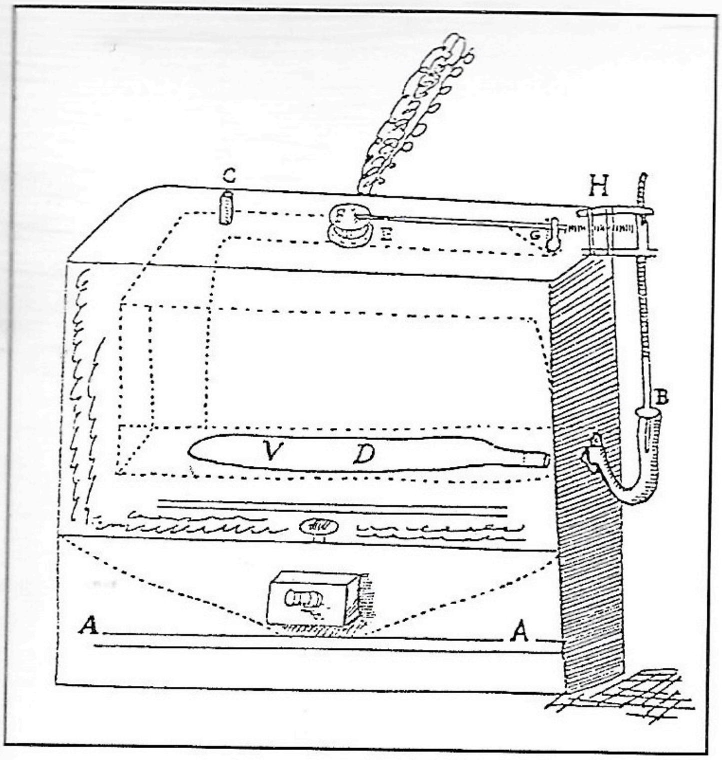


Figure 10-4 *Drebbel's thermostat, early 17th century (from Billington/Roberts).*

erating systems of less than two horsepower until it was supplanted by the capacitor-start motor in the 1930s.[15] The successful development of the repulsion-start motor was deemed significant enough by the Franklin Institute in 1902 that it gave its Edward Longstreth Medal of Merit to the Wagner Electric Company. The medal subcommittee concluded that "the Wagner Electric Co. has developed a practical single-phase motor which has given satisfactory service in commercial use."[16] Small motors soon saw such demand that the General Electric Company's fractional horsepower motor output increased every year from 1902 to 1933.[17]

Perhaps the greatest impact of electricity on the heating and ventilation industry during the early twentieth century was in the area of automatic control.

CONTROLS AND AUTOMATION

Early Developments in Automatic Control of Heating

Automatic control of equipment operation as well as heating and ventilating had been attempted on a relatively simple level in the eighteenth century, but there was initial skepticism about its value and efficiency. Initially, the control of temperature was of highest concern to ensure adequate comfort and the most efficient use of fuel. In the early seventeenth century, Cornelius Drebbel, a Dutch engineer, had developed a temperature regulator based on pressure and a mechanical damper control (Figure 10-4). "This regulator seems to have worked successfully, for Members of the Royal Society of London, including Robert Boyle, Christopher Wren, and in the following generation Robert Hooke, showed interest in it."[18]

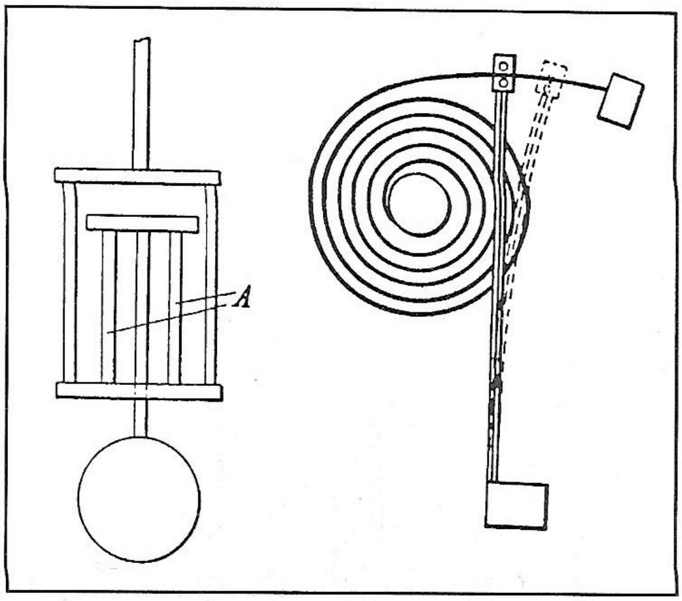


Figure 10-5 *Harrison bimetal devices (from Ramsey, 1946).*

Further work on temperature regulation was based on the application of bimetallic strips and the differential expansion of metals. Some of the earliest work in measuring the expansion of metals was done in the 1720s and 1730s. John Ellicott invented an instrument for measuring the expansion of metal, which he described in 1736, but the most important influence was the work of John Harrison, who developed compensators to adjust his marine clock for changes in temperature. "His first device, made in 1726, relied on the lengthening of metal rods. . . ."[19]

Harrison's compensated grid-iron pendulum was invented in 1726. In 1761, he produced the first device incorporating a true bimetallic strip. These early bimetals were manufactured by riveting, but sweating or welding was used before the end of the nineteenth century. The application of bimetals soon spread. M. Bonnemain used a Harrison device in 1777 to control the temperature of both buildings and incubators—probably the first attempt to control space heating automatically. The sensitive element was mechanically linked to the ash-pit door of a boiler and served to regulate the rate of combustion (Figure 10-5).[20]

Bonnemain had invented a "heat regulator" for his incubation heating systems in 1777.[21] The construction of the regulator was founded upon the unequal dilatation of different metals by the same degree of heat. The expansion of the lead was more than the iron for a like degree of temperature, and the rod enclosed within the tube being was less easily warmed, so whenever the heat rose to the desired pitch, the elongation of the tube put the collet in contact with the heel of the bent lever; then the slightest increase of heat lengthened the tube anew, and the collet lifting the heel of the lever depressed its other end through a much greater space because of the relative lengths of its legs. This movement operated near the axis of a balance-bar and sank one end of this, thereby increasing the extent of the movement, which was transmitted directly to the iron skewer. This pushing down a swing register diminished or cut off the access of air to the fireplace. The combustion was thereby obstructed, and with the temperature falling by degrees,

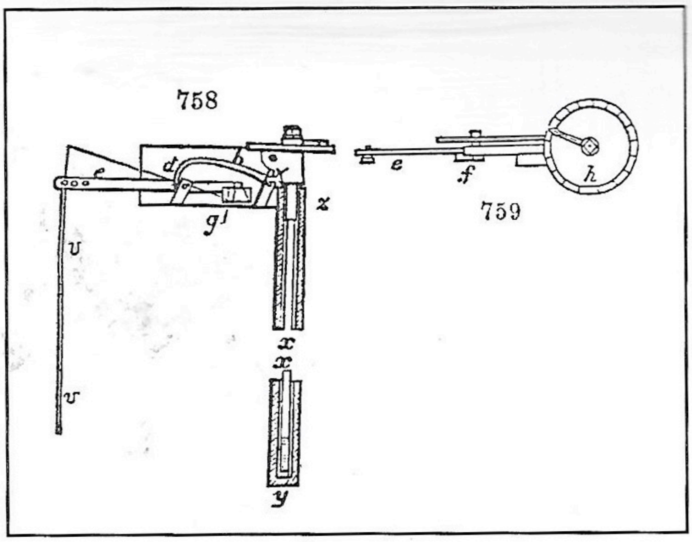


Figure 10-6 *M. Bonnemain, "heat regulator," 1777 (from A. Ure, 1853). A rod of iron, x, is tapped at its lower end into a brass nut, y, enclosed in a leaden box or tube, terminated above by a brass collect, z. This tube is plunged into the water of the boiler alongside the smoke pipe. This figure is a bird's-eye view of the dial.*

the tube shrank and disengaged the heel of the lever. The counterpoise fixed to the balance beam raised the other extremity of this beam by raising the end of the lever as much as necessary to make the heel bear upon the collet of the tube. The swing register, acted upon by this means, presented a greater section to the passage of the air and the combustion was increased (Figure 10-6).

James Kewley's heat governor, patented in 1816, was based on a different principle. It made use of the fact that mercury and alcohol expand and contract at different rates as the temperature changes.[22]

The Atkins and Marriott "thermoregulator stove" described by Mickleham (Bernan) in 1825 and the Arnott "thermometer stove" of 1836 are probably the next examples in the history of automatic temperature control. The Atkins and Marriott design, not entirely automatic, controlled the air supply for burning in the fire-chamber by a stop-cock. "When the fire is sufficiently brisk the further supply of air may be instantly shut off by turning the stop cock."[23]

Neil Arnott was more successful with his "thermometer stove" described in 1836. In one design he used a long bimetallic strip, one end of which was fixed to the casing of the stove and the other was attached to the combustion air damper. Other regulators described by Arnott relied upon the expansion of air in a tube closed by mercury; a float on the mercury surface was linked to the damper. All these devices controlled the temperature inside the stove casing, not that of the room (Figure 10-8). There was also in existence a well-known means of adjusting the temperature of a baker's oven by a self-acting thermometer.[24]

Modern Thermostatic Control—Andrew Ure

Prior to Arnott's work on his "thermometer stove," Andrew Ure (1778-1857) (Figure 10-7) had been working on defining the latent heat of different vapors[25] as well as the design of a thermostat in 1830, which he patented in 1831.

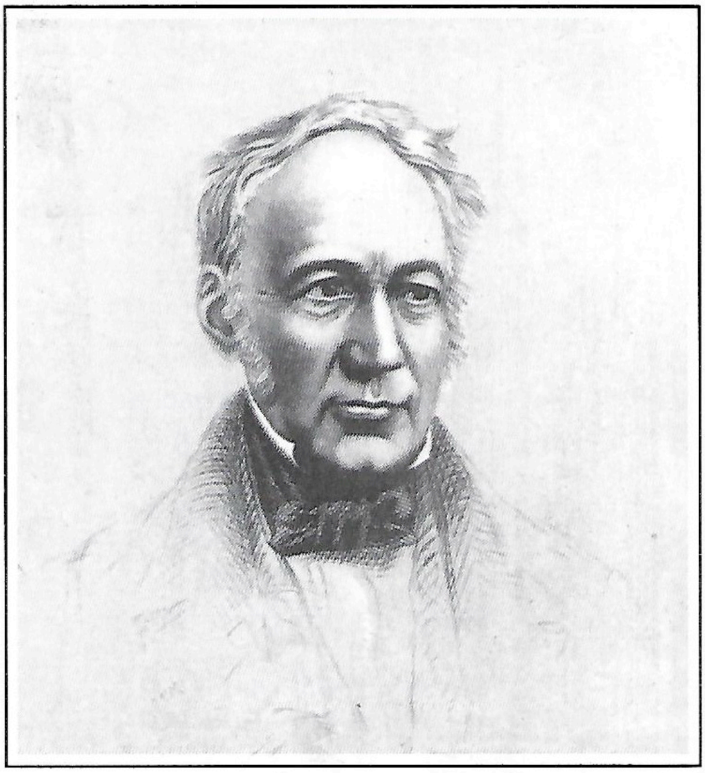


Figure 10-7 *Andrew Ure, M.D., F.R.S., etc. (from* A Dictionary of Arts, Manufactures and Mines, *1856).*

He gained his doctor of medicine degree at Glasgow in 1801 and became a professor of chemistry and natural philosophy at the Andersonian Institution in 1802. He moved to London in 1830 and was appointed analytical chemist to the Board of Customs in 1834. He was the author of a number of scientific and philosophical works; his *Dictionary of Arts, Manufactures and Mines*, published in 1839, was printed in several editions both in England and in the United States. Dr. Ure's claim to fame is based on a patent granted to him in 1830 (No. 6014) entitled "An Apparatus for Regulating Temperature in Vaporization, Distillation and Other Processes." In the specification, several forms of automatic temperature control apparatus are described and shown.[26]

Ure's thermostat, for the control of steam-heating coils, was the first of its kind. It was a bimetallic device of brass and iron whose design could be modified for controlling air or water temperatures.

> THERMOSTAT, is the name of an apparatus for regulating temperature, in vaporization, distillation, heating baths or hothouses, and ventilating apartments &c.; for which I obtained a patent in the year 1831. It operates upon the physical principle, that when two thin metallic bars of different expandabilities are riveted or soldered facewise together, any change of temperature in them will cause a sensible movement of flexure in the compound bar, to one side or other; which movement may be made to operate, by the intervention of levers, &c., in any desired degree, upon valves, stopcocks, stove-registers, air-ventilators, &c.; so as to regulate the temperature of the media in which the said compound bars are placed. Two long rulers, one of steel, and one of hard hammered brass, riveted together, answer very well; the object being not simply to indicate, but to control or modify temperature.[27]

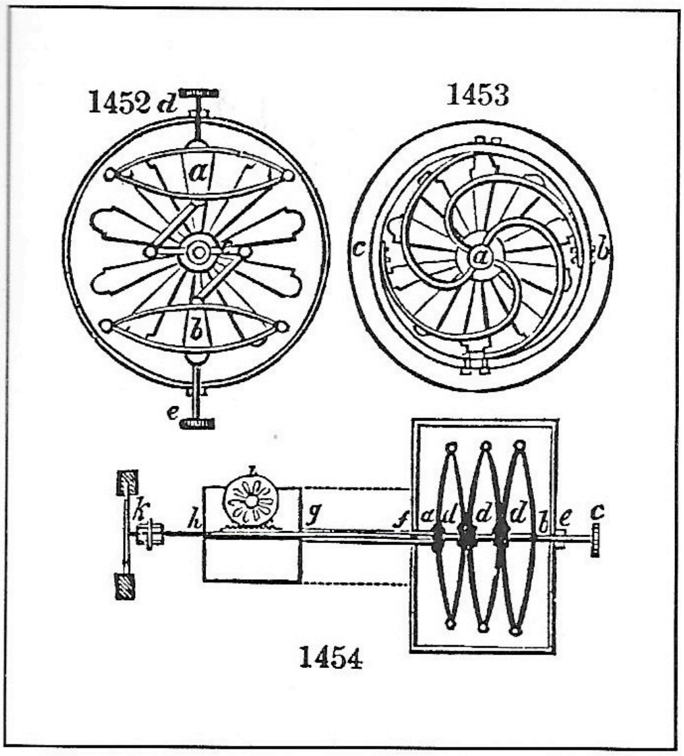
The honor of naming the heat governor the "thermostat" and of indicating wider industrial applications for it than had previously been suggested belongs to Ure.

Altogether Ure was granted five patents in one of which (No. 6016/1830) he described an air-heating stove with a thermostatic control. There is no record of Ure's thermostat ever getting into industrial use, and it is doubtful whether it would have had any success in practice because the riveting together of the two metal strips is unsatisfactory and it was not until a method of firmly uniting them by heat treatment was found that the bimetallic strip became a dependable component for a heat governor (Figures 10-9 and 10-10).[28]

Temperature Regulation for High-Temperature Systems

High-pressure hot water and steam heating posed a special problem of temperature regulation since the high pressures and concern about explosions from boilers required a great deal of attention to their operation. Angier Perkins developed a draft regulator for his high-pressure hot water system in 1840 (Figure 10-11). "The high pressure maintained was regarded, as in England, as a dangerous feature, and the attention of an engineer or skilled mechanic was felt to be a necessity."[29]

Improvements in steam heating required "safe, simple, durable, and reliable boiler" design. In the 1840s, Joseph Nason had developed the "Nason regulator" to control steam pressures. By the 1860s, low-pressure steam systems, popularized by the Gold boiler and others, were typically 2 to 3 pounds per square inch. However, some systems were operated at pressures ranging from 15 pounds per square inch to as high as 40 pounds per square inch. Boiler designs were often tested at ten times the actual operating pressures



(a) Air register thermostat.

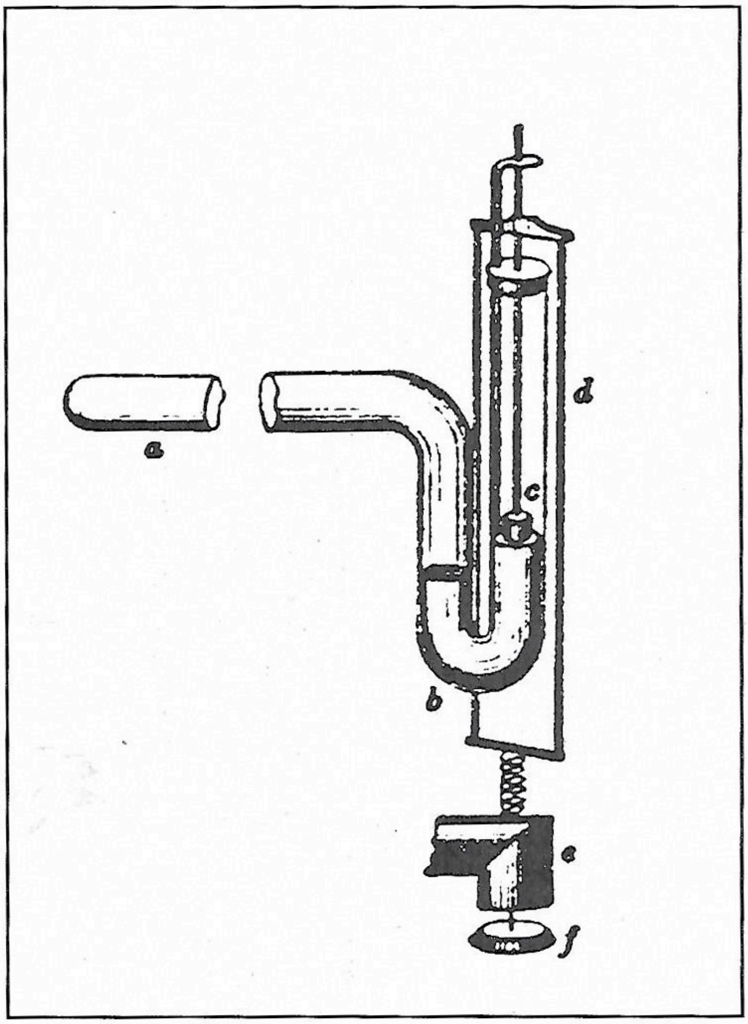
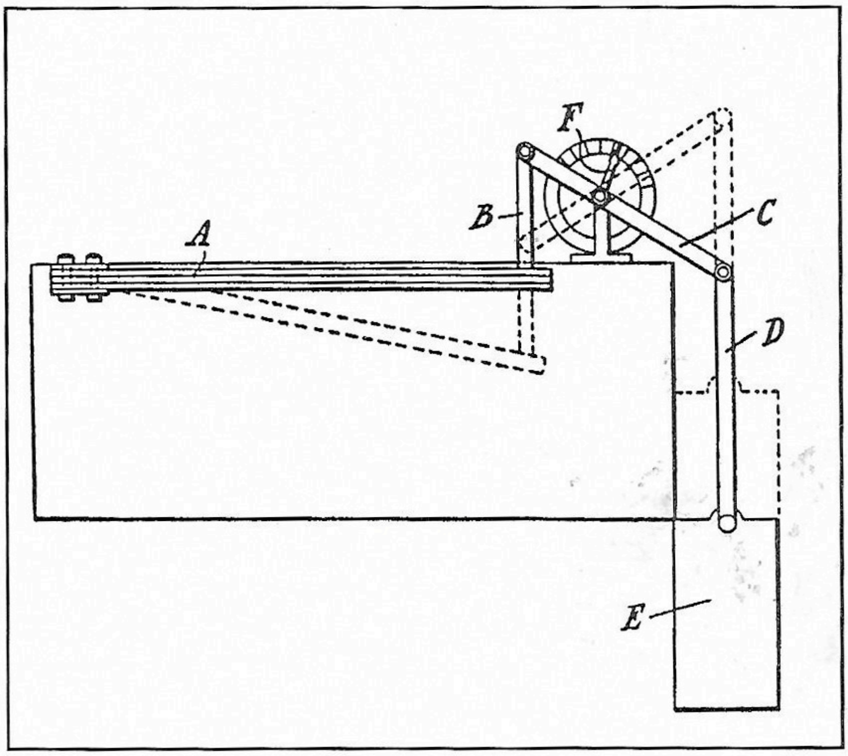


Figure 10-8 *Arnott's thermostat, 1836 (from Edward H. Knight, 1876,* Knight's American Mechanical Dictionary, *vol. III, Hurd & Houghton, New York).*



(b) Ure's thermostat, 1830 (from his patent specification).

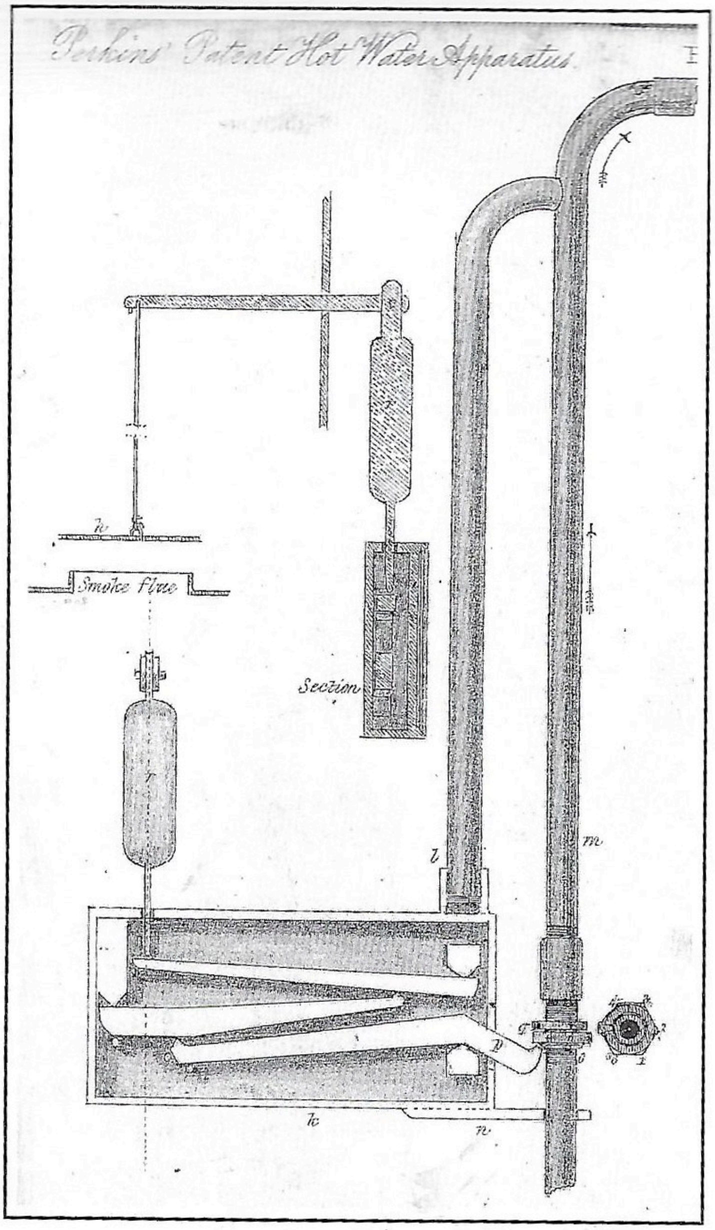


Figure 10-11 *A.M. Perkins, draft regulator, 1840.*

to ensure their safety. Boilers were furnished with safety valves, glass water gauges, gauge cocks to verify water levels, and draft regulators to maintain desired pressures. By 1878, manufacturers were, by necessity, providing complete systems. "Boilers when furnished complete include all necessary attachments mentioned, viz.: Steam Gauge, Water Gauge, Gauge Cocks, Safety Valve, Blow-off Cock, Feed Valve and Automatic Damper Regulator."[30]

> The discovery of practical applications of electricity during the first half of the nineteenth century produced a number of inventions wherein electricity was used as the motive power. Dr. Sternberg's electro-magnetic regulator for controlling the heat of rooms broke new ground in the design of thermostats in that variations of temperature were caused to complete or interrupt an electrical circuit.[31]
>
> * * *
>
> About 1880, evidence first appears of the thermostat beginning to get into practical use, but the form used was unlike any of those so far described. It was invented by Charles Edward Hearson after visiting a poultry farm and being impressed by

Figure 10-12 *Warren S. Johnson (from Johnson Controls Inc.).*

> the hit-and-miss method adopted in some experiments being carried on for the artificial incubation of eggs. Hearson applied himself to the problem and ultimately found the solution of maintaining the critical temperature level in an incubator by the thermostat. It consists of a capsule formed from sheets of metal sealed together at their edges and enclosing a piece of absorbent material such as blotting paper saturated with gasoline or any liquid which boils at the temperature at which the interior of the apparatus is required to be kept.[32]

The firm of Charles Hearson & Co. Ltd. continued to manufacture incubators controlled by these thermostats until the late 1940s. His shop in Regent Street was referred to in H.G. Wells's *The Magic Shop*, where he describes the shop next door as "the place where the chicks run about just out of patent incubators."

According to a Mr. Wilkinson, the manufacturer of bimetal strips used in thermostats originated in "the sweating together of some silver and copper coins at a fire at Soho Foundry, Birmingham . . ." and that "among the earliest thermostatic uses for (these) bi-metals (known under his registered trademark Thermoflex) was the application to control the temperature in railway coaches in the United States by the Thomson-Houston Co., and to control the pressure in gas lamps."[33]

Although bimetals had been produced previously, "the problem was to find two metals that would give the greatest amount of movement. A combination of brass and iron was tried in 1837 and brass and steel 20 years later. Combinations of zinc and copper and of nickel and brass were tried in subsequent years. All this was changed about the turn of the century when an alloy of nickel and iron was discovered that did not lengthen when heated. It was called INVAR, a word coined from its expansion characteristic, INVARiable."[34] In the 1880s, instruments were used to measure temperature, pressure, and velocity of air (Figure 10-12)

AUTOMATIC TEMPERATURE CONTROL AT THE TURN OF THE CENTURY

Warren S. Johnson

Although thermostats were manufactured "in considerable quantity" prior to 1885, one thermostat design for widespread application to heating depended on the combined use

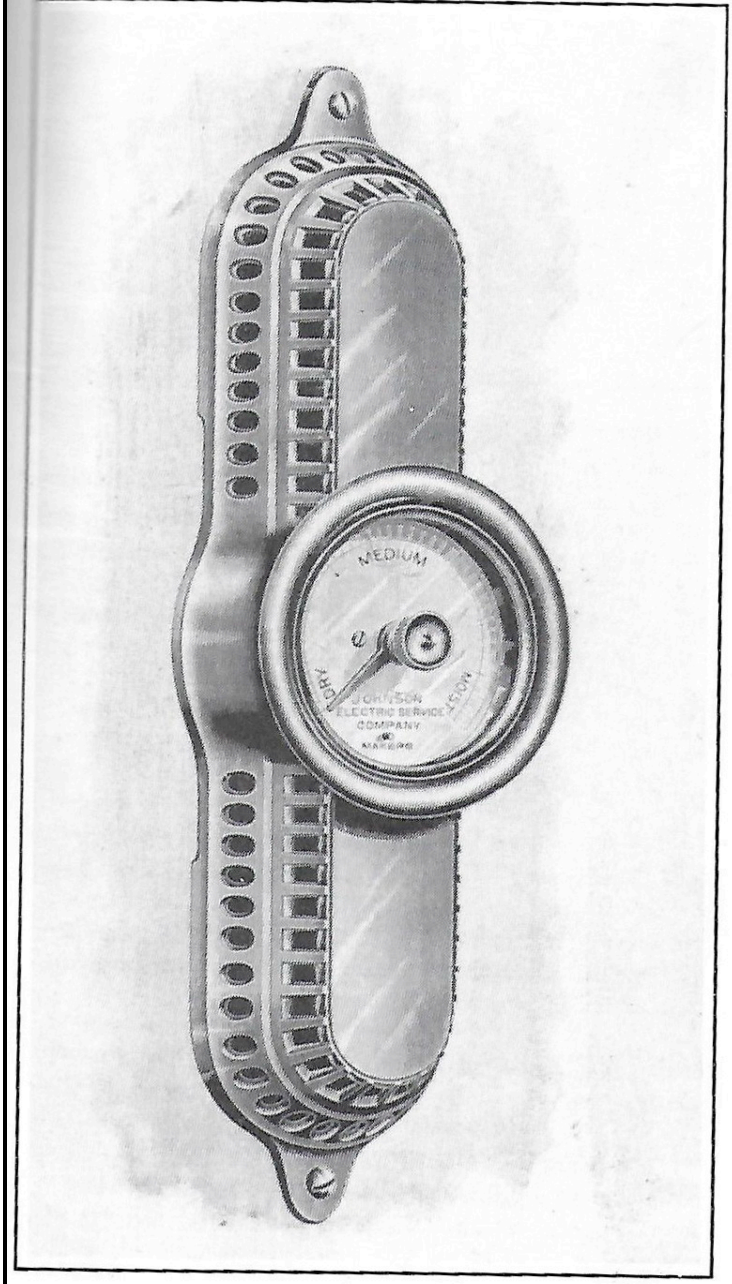


Figure 10-13 *Johnson humidistat, c. 1905 (Johnson Controls).*

of electricity and compressed air, a concept pioneered during this time by Warren S. Johnson. Johnson was born in Rutland County, Vermont, and as a young boy showed a strong interest in inventions, from sketches and descriptions "covering a wide range of subjects in mechanics, chemistry and electricity." He became a country schoolteacher and later a professor of science and art in Wisconsin. In 1873, he invented an "annunciator" system at Whitewater College, Wisconsin, to alert the janitor as to which room required heat, but "his first bonafide venture was the development of a storage battery in 1883." In that same year, he began to experiment on electric thermostats and, on July 24, was granted a patent for the "electric thermoscope."[35]

> The idea of using compressed air to operate his valves and dampers suggested itself to Prof. Johnson through his familiarity with the small hand air compressors used in various experiments in his physical laboratory at the Norman School. It was both powerful and elastic in its operation. It could be used to close a steam valve and hold it closed against pressure by means of piston or rubber diaphragm attached to the end of the valve stem. Air for his first systems was supplied from a hand compressor and by the use of a storage air tank, the janitor need pump up air once in a while between his other duties.[36]

"Johnson's `electro-pneumatic' valve, patented in 1885, consisted of a very small compressed air valve which could be successfully operated by an electric thermostat and which in turn operated to supply and exhaust compressed air to and from the diaphragm valve or damper. Electricity was supplied from salammoniac batteries as dry batteries were not yet perfected. Compressed air was supplied by a diaphragm hydraulic air compressor at 15 lbs. per square inch pressure."[37]

From the invention of the "electro-pneumatic" valve, Johnson formed the Johnson Electric Service Company to manufacture temperature control systems to be distributed through local offices in Wisconsin, Minneapolis, New York, and Chicago. "The system was first applied to buildings heated by direct steam radiators with a diaphragm mounted on top of the valve"[38] (Figure XIV, color section). In 1902, the company moved to its own seven-story building in Milwaukee, which it still occupies. From 1914 to 1920, the company dominated three quarters of the temperature control market and worked on improvements to the design of thermostats to make them more reliable and serviceable and to be smaller in size. The Johnson Electric Service Company produced a number of thermostat cover designs to fit different needs, ranging from an ornate residential thermostat (Figure XV, color section) to hotel, office, and bath thermostats. During this time, the company also developed an entire line of temperature control systems (Figure 10-13).

Albert M. Butz and William R. Sweatt

During the early 1880s, Albert M. Butz developed a thermostatically controlled draft damper for heating systems in Minneapolis, Minnesota. Butz, a partner in the Mendenhall Hand Grenade Fire Extinguisher Co., received two U.S. patents (341,092 and 347,866) in 1886 and attempted to sell his invention through the Butz Thermoelectric Regulator Company. After Butz left the company in 1888, it was renamed the Consolidated Temperature Controlling Company.

William R. Sweatt (Figure 10-14) moved to Minneapolis in 1891 at the age of 24, where he began the Sweatt Manufacturing Company to build wooden wheelbarrows, grocery boxes, and wooden washing machines. He "had not been in Minneapolis very long before he was approached by the Electric Thermostat Company to invest some money. It was the old Consolidated Temperature Controlling Company, reorganized and renamed in 1889."[39] The company manufactured a thermostat and a hand-wound, spring-powered motor that controlled indoor temperatures by opening and closing a flapper draft damper on a coal-fired furnace or boiler. However, this first product did not sell and the company continued to have financial problems until 1893, when the company raised funds and was incorporated as the Electric Heat Regulator Company (Figures 10-15 and 10-16). The following years continued to be difficult. In 1905, the company made a thermostat and two kinds of damper motors, one spring powered and the other powered by gravity. W.R. Sweatt introduced a clock thermostat in 1905. In 1912, the company changed its name to the Minneapolis Heat Regulator Company and, by 1913, there were four thermostat models available.

W.R. Sweatt turned more and more to his son H.W. Sweatt to manage day-to-day operations of the company.

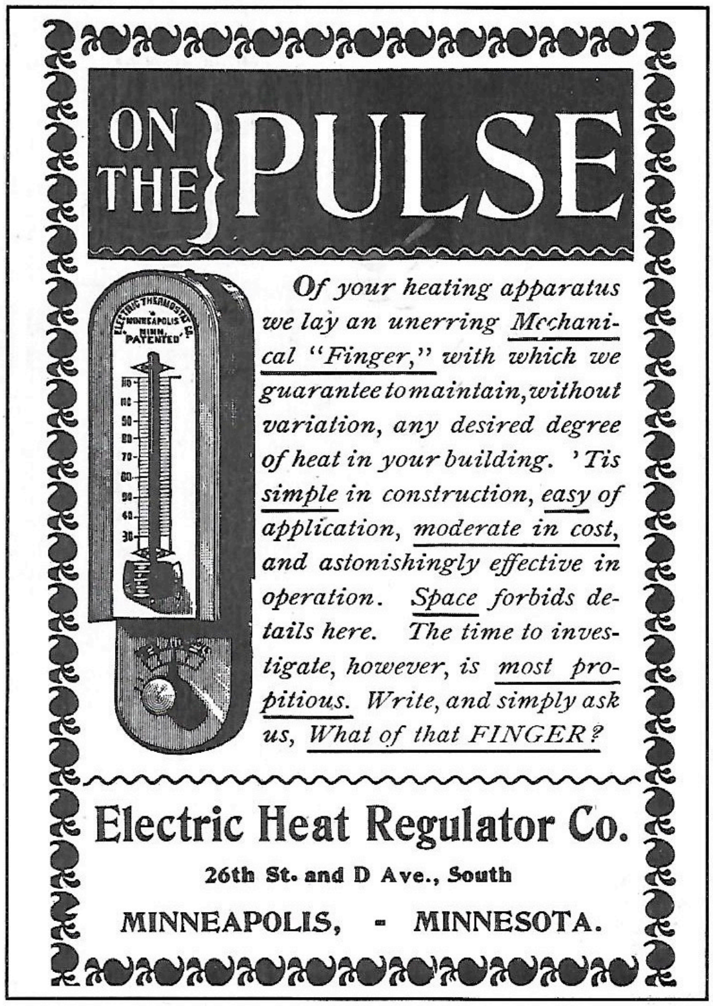


Figure 10-15 *Thermostat, Electric Heat Regulator Co., 1895 (from* Heating and Ventilation, *May 15, 1895).*

Figure 10-14 *W.R. Sweatt in 1891 (from Nessell, 1963).*

H.W. Sweatt called on heating equipment manufacturers to understand their changing needs and maintain the company's leadership. In 1917, the use of oil for domestic heating was dictated by shortages of coal as a result of World War I, and the company shifted its emphasis to oil burner controls.

In the 1920s, the largest competitor was the Honeywell Heating Specialties Company at Wabash, Indiana. "It was started by Mark Honeywell as the Honeywell Heating Specialty Company to manufacture a hot water heating appliance invented by Mark Honeywell and known as a 'Heat Generator.'"[40] In 1927, W.R. Sweatt and Mark Honeywell met to discuss the possibility of a merger between the two companies. The new company was incorporated in Delaware as the Minneapolis-Honeywell Regulator Company (Figure 10-17).

William P. Powers

William Penn Powers (Figure 10-18) formed the firm of W.P. Powers and Company in LaCrosse, Wisconsin, in 1867 to manufacture pumps, shingles, and, later, a chain belt for sawmill operations. In a letter titled "The Result of a Dull Sermon," published in October 1918, Powers describes how, in 1887, he became interested in the field of automatic temperature control:

> One Sunday during the sermon—which may have had some dull passages—the idea occurred to me of utilizing the relative boiling points of water under different pressures to control the draft. I could hardly wait for the benediction in my anxiety to consult the encyclopedia and verify my conception as to the effect of pressure on the boiling points.[41]

Powers went to Chicago in 1890 and formed the Powers Regulator Company. In 1893, the company installed its first thermostat in the First Congregational Church in Nashua, New Hampshire, and exhibited at the Chicago World's Fair that same year. The first thermostat design was round and relatively large, measuring 15 inches in diameter (Figure 10-19). It was connected to a large diaphragm motor that controlled double mixing dampers on a fan heating system.

During the early years of the twentieth century, the Powers Regulator Company manufactured a full line of controls (Figures 10-20 through 10-23) and installed temperature control systems in a number of large projects including many government and institutional buildings and schools. It installed the system in the Minnesota State Capitol and the City Prison ("The Tombs"), the Empire State Building, and the Chrysler Buildings in New York City.

Automatic Control Systems

At the beginning of the twentieth century, temperature control and other forms of commercial and industrial control were dominated by the three companies previously described. However, there were a number of other companies manufacturing controls, such as the Nash Regulating Valve Company, the Compton Electric Service Company, and Foxboro (Figure 10-24).

Automatic Control for Refrigeration

Until the 1890s, mechanical refrigeration was applied as large-capacity systems to breweries, ice making, and cold storage. However, attempts to develop refrigerating systems of small capacity that could be used directly in shops and homes necessitated a new engineering approach. Whereas large systems were continuously attended by skilled operators who constantly adjusted the refrigeration capacity to meet the load demand, small systems could not enjoy the attendance of a human operator if they were to make any economic sense. A small system had to be designed so it would run with little or no attention. To make this possible, the system not only had to be operated by a driving mechanism that needed no supervision but the refrigerating system itself had to automatically adjust to the load placed on it.

Application of thermostats to refrigeration was made possible by the availability of electric power and electric motors. Cycling a refrigerating system to load demand by coupling a thermostat and an electric motor was very simple and inexpensive. Such systems began to make an appearance concurrent with the application of thermostats to heating and with the introduction of electric power systems and electric motors (Figure 10-25).

A precursor to temperature control of refrigeration can be seen in U.S. Patent 105,609 issued in 1870 to Peter Van der Weyde for a refrigerating system that incorporated a crude thermostat:

> . . . an automatic arrangement to keep the temperature at the same height of 32 or 36 degrees Fahrenheit, or any height desired. . . . To accomplish this, two platinum wires are melted in the glass of a large mercurial thermometer, one in its lower portion, so as to always be in contact with the mercury, and one at the middle part of the tube as corresponds with 32 or 36 degrees, or any other point of the scale below which we do not desire the temperature to descend. The ends of these wires are connected with the coil of an electro-magnet and a small galvanic battery . . . the electro-magnet is, by proper leverage, attached to the power driving the (compressor) in such a way that . . . the power is detached from the pump by throwing off the belt, shutting off the steam, or in any other manner.

By the 1890s, when the advent of the electric motor and power systems provided a method of driving systems that was less complicated to control, there were attempts to apply the bimetal type of thermostat to refrigerating systems.

Figure 10-16 *Thermostat, Electric Heat Regulator Co., 1895 (from* Domestic Engineering, *vol. 9, June 1895).*

Figure 10-17 *The Minneapolis heat regulator (from* Engineering Review, *vol. 22, September 1912).*

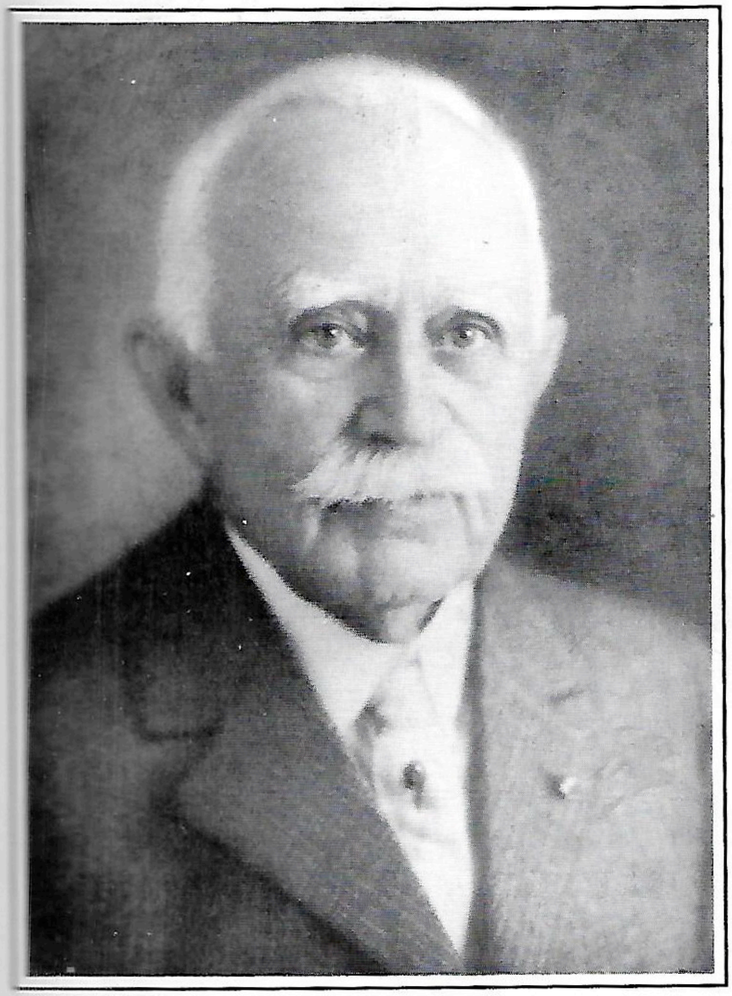


Figure 10-18 *William P. Powers (from* The Aerologist, *June 1927, p. 111).*

Figure 10-19 *Advertisement for Powers thermostat (from* Heating and Ventilation, *May 15, 1895).*

Quickly, inventors realized that the thermostat itself could not tolerate the heavy current flow an electric motor required, so they devised magnetic relays to indirectly switch the current. Thermostatic control evolved in sophistication into the early twentieth century so that by World War I, the method was developed to the point where it was ready to be perfected for widespread use.[42] Mere cycling of a refrigerating system was not enough to ensure trouble-free operation, however. The evaporator side of a vapor-compression refrigeration system will exchange heat depending on the amount of refrigerant supplied and the suction or "back pressure" applied by the compressor. The amount of heat exchanged also depends on the means provided to transfer heat to the evaporator from the refrigerator load, which varies depending on the heat gained through the walls of the refrigerator and from the product stored in the refrigerator. Thus the load placed on the evaporator changes and requires that the amount of refrigerant supplied to the evaporator be varied for optimum use of the heat exchange surface provided by the evaporator. In large systems, the changing requirements were met by hand-adjusting the refrigerant flow. This method required an attendant who usually observed the amount of frost on the suction line and changed the setting of a throttling valve admitting the liquid refrigerant into the evaporator. If the refrigerating system was shut off for any reason, the expansion valve had to be closed to prevent flooding the system. This use of "hand expansion valves" proved satisfactory where a human attendant was on duty but was an unacceptable method for a small system placed in unattended operation in a butcher shop or home.

Attempts to automatically control the refrigerant flow are actually as old as the vapor-compression system itself. The first vapor-compression system of Jacob Perkins had a

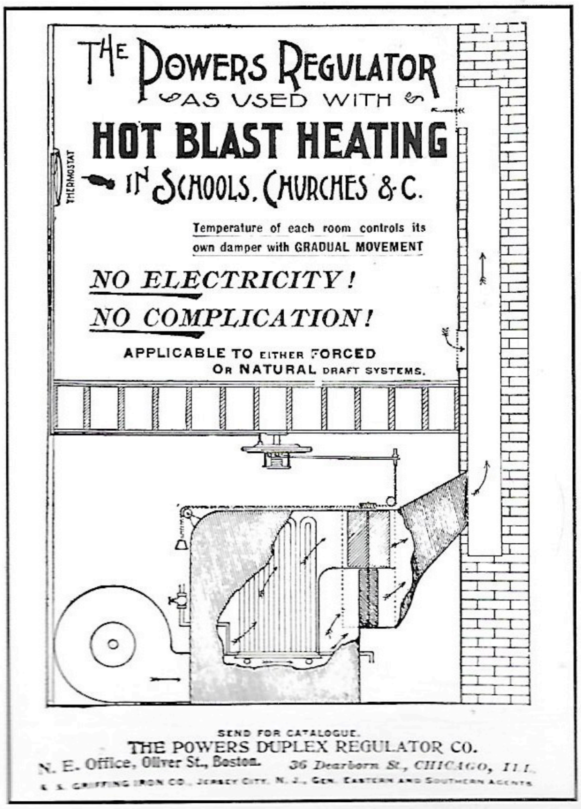


Figure 10-20 *Advertisement, Powers Duplex Regulator Co. (from* Heating and Ventilation*, December 1894).*

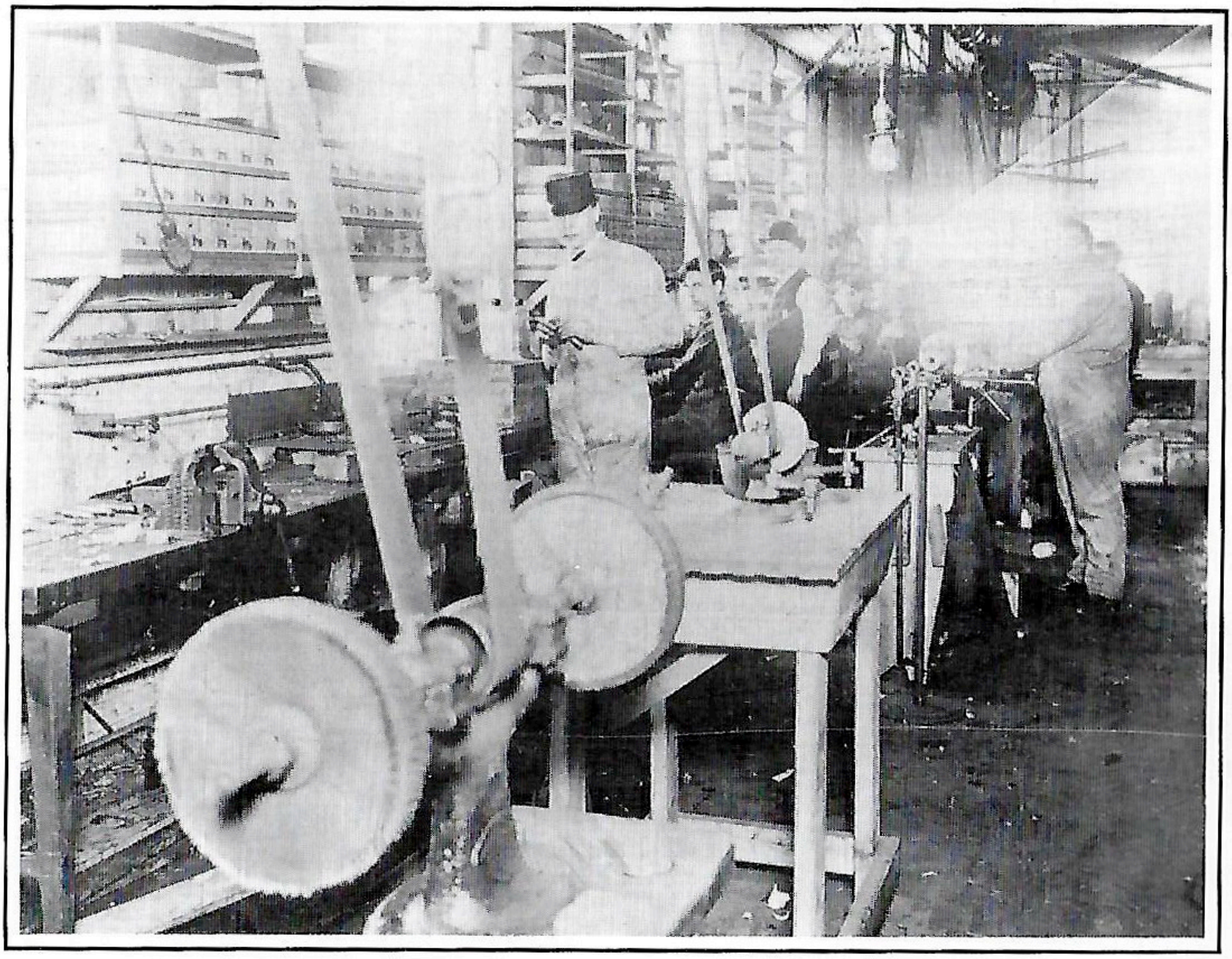


Figure 10-21 *Thermostat polishing shop—Powers Regulator Co., early 1900s (from Landis & Gyr Powers).*

weighted expansion valve, in effect a very crude form of a constant-pressure expansion valve. James Harrison employed a "high side float" in his first patents taken out in the 1850s. The high-pressure or "high-side" float device meters refrigerant to the evaporator by using a float that senses the amount of liquid provided by the condenser, metering liquid to the evaporator only as fast as it condenses. A changing heat load in the evaporator results in a changing refrigerant pressure in the evaporator, and the changing suction pressure is reflected in the amount of refrigerant circulated in the system. The float automatically responds to the change in flow by metering more or less liquid refrigerant to the evaporator. After Harrison, the high-side float control showed up periodically in various systems, but it was not used to any extent in early systems. The hand expansion valve was simple and inexpensive, and large steam-engine-driven refrigerating plants required an on-site operator anyway.

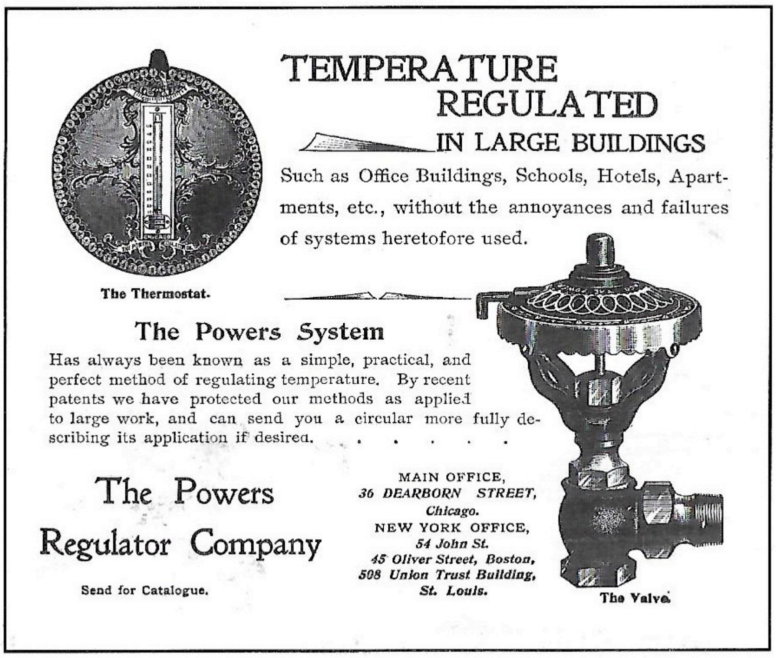


Figure 10-22 *Advertisement, Powers Regulator Co. (from* Heating and Ventilation, *April 1897).*

As the application of mechanical refrigeration spread to uses requiring small systems, the need to control refrigerant flow became evident. A study of United States patents shows that such attempts to control refrigerant began to appear in the 1880s. The first types of controls were thermostatically modulated expansion valves that responded to the temperature of the refrigerated space. Possibly the first one was incorporated in U.S. Patent 332,150 issued in 1885 to Joseph Holmes for a refrigerated corpse-cooler! Numerous other U.S. patents followed for various designs of temperature-controlled valves.[43]

About the same time that temperature-controlled valves were being developed, expansion valves that responded to the evaporator pressure were also conceived. These constant-pressure valves, now commonly called "automatic expansion valves," began to appear in United States patents in the 1890s[44] (Figure 10-26).

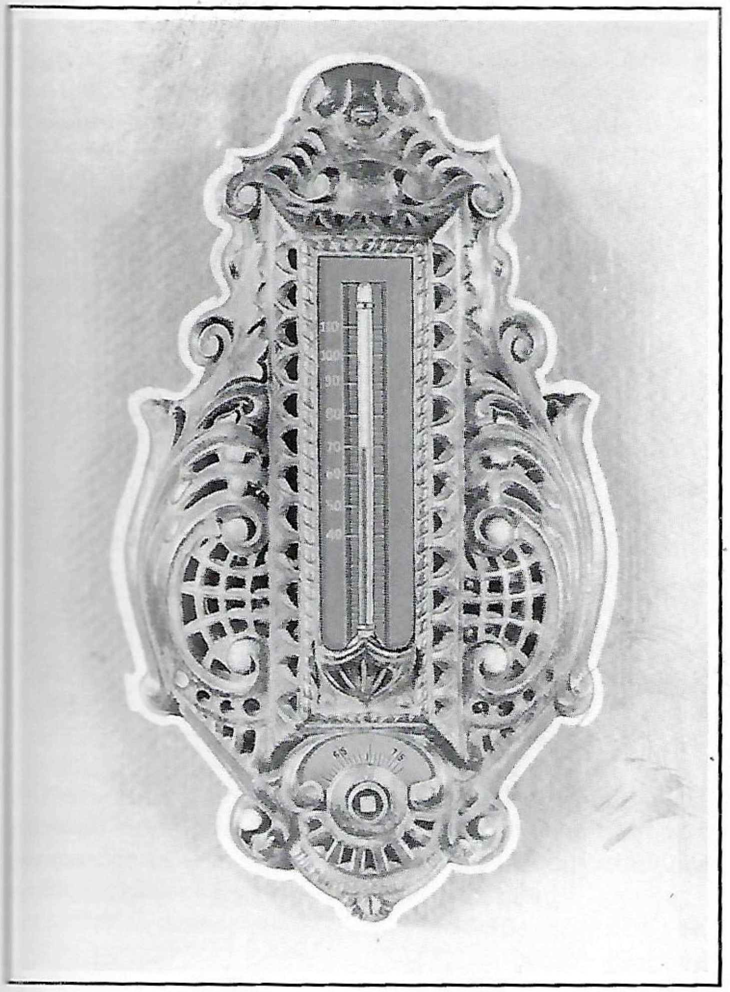


Figure 10-23 *Powers thermostat, 1903 (from Landis & Gyr Powers).*

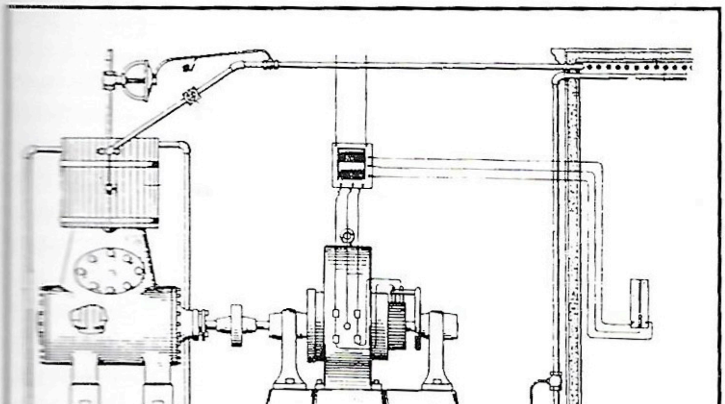


Figure 10-25 *Thermostatic control applied to a turn-of-the-century refrigerating system by William Singer, whose company, Singer Automatic Ice Machine Company, was one of the earliest to manufacture electric-driven, thermostatically controlled refrigerating systems. Singer's company merged in 1902 with others to form the Federal Automatic Refrigerating Co., which became the Automatic Refrigerating Co. in 1905 (from U.S. Patent 697,029 of April 8, 1902).*

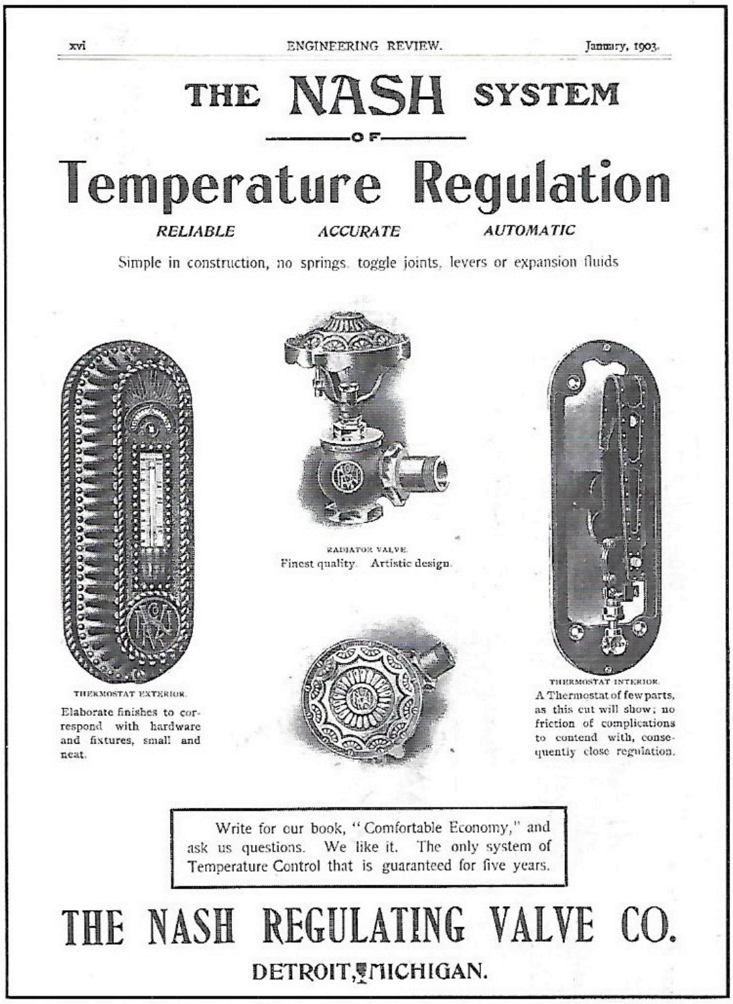


Figure 10-24 *The Nash system of temperature regulation (from* Engineering Review, *January 1903).*

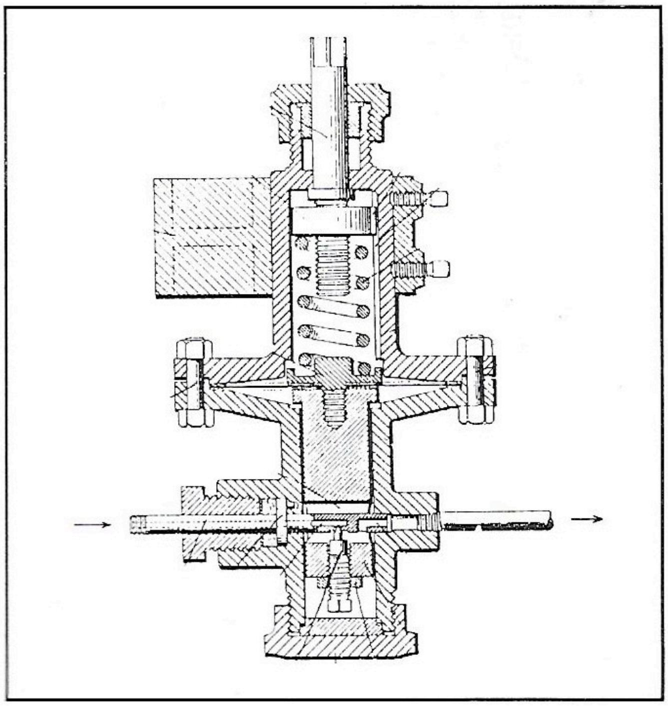


Figure 10-26 *Automatic expansion valve patented in 1905 by Albert T. Marshall. Marshall's patents for automatic control were among those consolidated when the Automatic Refrigerating Co. was formed to develop the market for small refrigerating systems (from U.S. Patent 785,265 of March 21, 1905).*