From Pails to Pipelines: The Origins and Early Adoption of Plastic Tubing in the Maple Syrup Industry

Undoubtedly there were traditionalists and "old-timers" who scoffed at the new-fangled plastic technology and the idea of stringing "clotheslines" through the woods, but by and large, the industry looked upon tubing with cautious optimism and over time recognized that it was the technological future of the maple syrup industry.

By Matthew M. Thomas

The use of plastic tubing for gathering sap in the production of maple syrup is standard practice in the twenty-first century commercial sugarbush. However, at the time of its initial appearance and adoption, plastic tubing was a significant change in the time-honored tools and methods of maple syrup production. As the designs, materials, and methods of using plastic tubing improved, its labor- and cost-saving value was embraced and more and more syrup makers made the shift, leaving their old metal spouts, pails, and gathering tanks behind. Knowing that readers of *Vermont History* have a good

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Matthew M. Thomas is an independent historian with a special interest in the history of the maple syrup industry. He is the author of the books *Maple King: The Making of a Maple Syrup Empire* (2018) and *A Sugarbush Like None Other: Adirondack Maple Syrup and the Horse Shoe Forestry Company* (2020) and maintains the website www.maplesyruphistory.com.

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understanding of the process of making maple syrup, this article assumes that many readers recognize that plastic tubing became the dominant method of gathering sap for the maple industry. I endeavor to tell the less well-known story of from whom and how the idea of using plastic tubing for moving maple sap was brought into practice. The narrative begins with the origins of pipelines as a foundation for the early development of the use of plastic tubing by maple producers. An account of the experiments and interactions between the key early plastic tubing inventors in Vermont and New York follows, before concluding with a discussion of the addition of mechanical vacuum to tubing and the eventual shift of the industry away from pails to tubing.

The Labor of Sap Gathering

Prior to the early twentieth century, gathering sap for making maple syrup and maple sugar entailed long days of backbreaking labor. Workers carried heavy sloshing pails of fresh sap through sometimes deep snow to gathering tanks waiting nearby on sleds or wagons pulled by horses or oxen, and later by tractor. The sugarbushes of the northeastern United States and adjacent Canada are often located in rather rough, hilly terrain, further increasing the effort of traveling to hundreds and thousands of trees on foot, in the snow, day in and day out, for four to six weeks each spring. Excluding the initial investment in the purchase of an evaporator and associated tapping and gathering equipment like pails, spouts, and tanks, the cost of labor associated with gathering sap was the single greatest annual expense for the maple producer. Moreover, changing rural demographics in the postwar era made it harder to find willing labor for hire in the sugarbush, both within the family and from outside. Rural populations were increasingly faced with a pull toward the modern urban sectors, coupled with a push away from the outdated ways of the ancestors.[1]

Decline in Production and Demand

From the turn of the century to the middle of the twentieth century, production levels of maple syrup declined steadily in the United States, while remaining fairly level in Canada. Consumer tastes were also changing, and pure maple syrup producers couldn't compete with the national advertising campaigns of the blended and non-maple table syrup companies. Furthermore, the demand for pure maple syrup for use in making table syrups blended with maple syrup and cane and corn syrup was shrinking as the big blenders like Log Cabin Syrup began to reduce significantly the amount of maple syrup in their formulas. In addition, the tobacco industry, which for years used enormous quantities of maple syrup and maple sugar to cure and flavor tobacco, was buying less and less maple sugar.[2]

The years of World War II set the maple industry back even further, drawing away a notable portion of the rural labor force both to serve in the military and to work in factories to aid the war effort. Maple equipment manufacturing virtually ground to a halt during the war when valuable resources like sheet metal were reserved for production that directly supported the military. Wartime rationing led to limits on the availability of commodities like table sugar and the imposition of price controls on all sugars, including maple sugar and maple syrup, which limited profitability for producers and accelerated the move away from maple production. Compounding this decline, improved prices for hardwood lumber in the 1940s led many sugarbush owners to cut substantial portions of their maple woods. Nonetheless, there was a slight overall uptick in maple sugar production during the war, largely as a result of increasing production for home consumption during the period of rationing.[3]

Mechanization and Modernization

The maple industry needed a shot in the arm to improve its success and profitability, and reinforce the belief among its producers that maple sugaring was a worthwhile pursuit. Mechanization, with improved materials and methods, was one area where rapid change was possible. Moreover, the postwar era opened many doors to new applications and technology in many areas of business and industry. Agriculture and food production were becoming increasingly mechanized, and as an agricultural pursuit, the maple industry was no different. In the 1940s and 1950s, maple producers were shifting to tractors to replace horses and oxen. Gas- and battery-powered tree tappers, lightweight affordable chainsaws, and gas-powered pumps to move sap began to appear in sugarbushes across the land. New versatile and lightweight materials like plastics spurred innovations in design, including the application of this technology for sap gathering. Creative minds across the maple syrup industry, from Wisconsin to New England, wasted no time in beginning to experiment with flexible plastic tubing for gathering and moving maple sap as well as adapting new methods and materials that became available in the postwar era. In the end, the inventions and successful development of plastic tubing for sap collection became one of the most significant advances in maple syrup production in the twentieth century.

Early Attempts at Sap Pipelines

Any maple syrup producer will realize quickly that gathering sap pails by hand is time-consuming and hard work. Not surprisingly, a variety of enterprising individuals put gravity to work for them through the invention and use of more efficient pipelines to move maple sap.

The earliest reference to the use of a pipeline to convey sap through a sugarbush to a collection point dates to the unsuccessful attempt of the Holland Land Company in upstate New York. In 1794 the company, a group of land speculators largely comprised of Dutch bankers, planned to develop and profit from a domestic source of sugar and eliminate the reliance on cane sugar from the West Indies tainted by the evil hand of slavery. Under the direction of their representative Gerrit Boon, the scheme wisely started small, with an experimental 17-acre sugarbush a few miles north of what is now Utica, New York. Boon's plan was to employ an interconnected network of finely milled, open-topped troughs suspended above the ground and running through the sugarbush. The network of troughs conducted the sap from each tree to a collection point at the base of the hill. The idea seemed sound, but the materials and technology failed them, and in no time the thin wooden troughs cracked, warped, and twisted, leaking sap and generally proving useless after being exposed to the elements. Boon attempted to improve his design with a triangular-shaped tube made of three slats nailed together, which would minimize warping and twisting of the wood, but it was impossible to nail the slats together tight enough to prevent sap leakage. The 1794 season was a loss, but Boon was not ready to give up and learning from their first season, wanted to have another go at it. Unfortunately for Boon, the investors and directors in Holland were not convinced a second year's experiment was worth the effort and expense, and chose to cut their losses and end the maple sugar endeavor after one season.[4]

The next significant reference to the use of a wood pipeline comes from Calvin Thales Alvord, a Wilmington, Vermont, farmer and sugarmaker. Writing in 1863 for the *First Annual Report of the Commissioner of Agriculture* of the newly formed United States Department of Agriculture, C. T. Alvord outlined the practical use of what he referred to as "leading spouts" on difficult to traverse hillsides. He described leading spouts as made from 14- to 16-foot-long spruce logs milled to 2½ to 3 inches square with a trough-like groove cut along their length to direct the sap. The ends of each section were tapered to overlap with each adjoining section to prevent leakage. These 14- to 16-foot leading spouts were supported and elevated above the ground on a series of stakes with pins or nails on which the sections rested. In some cases, the sections had to be secured to the stakes to prevent their collapse or disturbance by wind and animals. A gathering tub or tank was placed at the upper or high end of the spout line, with a release faucet used to drain and direct sap from the tub into the pipeline and downhill to the boiling site as needed. Novel and practical though this method may have been, Alvord acknowledged the limitations of this open-topped pipeline, especially with debris, rain, and snow diluting and clogging the sections on days of unfavorable weather.[5]

The wooden open-topped pipeline described by Alvord in 1863 closely matches the description and drawing for a patent by Moses Shelden and Wareham A. Chase of Calais, Vermont. Titled "Improvement in Spouts for Conveying Sap," Shelden and Chase's United States Patent 39,072 was awarded on June 30, 1863. The inventors admitted that the idea for long angular spouts made from planks of wood was not their own; however, they did make a patent claim on the addition of a rounded interior trough and the tapered or "chamfered" overlapping ends that allowed a smooth flow of sap and prevented leakage. Unfortunately, little is known about the success of this method or if it was even mass produced or used by sugarmakers.[6]

The next logical progression in the evolution of sap pipelines was the move from wood to metal. With the use of metal, it was possible to introduce greater strength and durability as well as have more flexibility in shaping the pipeline. The next phase of pipelines was tubular in shape, reducing the amount of debris, snow, and rain that might contaminate the sap. Reference to the use of tubular metal pipelines appears as early as C. T. Alvord's 1863 report. Described as a tubular sheet metal "leading spout" made in eight-foot lengths, these metal pipelines were about one-half inch in diameter with one end slightly larger in diameter than the other, which allowed the tapered end of the tube to be inserted into the next section.[7]

Like the earlier wood pipelines, metal pipelines were simple, efficient systems using gravity to move sap downhill from one gathering point to a larger collection tank or dumping station, and they were not connected to the spouts on each tree. Later pipelines featured pouring or dump stations attached at different points of the horizontal pipeline by short vertical pipes referred to as standpipes. The pouring stations of these standpipes might be pails with a hole in the bottom or purpose-built metal funnels.

One of the best-known uses of a metal standpipe gathering system was in the sugarbush of Abbot Augustus Low's Horse Shoe Forestry Company in St. Lawrence County, New York, between 1898 and 1908

Figure 1: Example of use of standpipe on raised tubular metal pipeline at the Horse Shoe Forestry Company maple sugaring operation in St. Lawrence County, New York, circa 1901. Photograph by George W. Baldwin. Courtesy of the Library of Congress.

(Figure 1). At this time, the Horse Shoe Forestry Company operated the largest single sugarbush in the world and used a series of pipelines to move sap downhill in portions of its 50,000-tap Adirondack sugarbush, depositing the sap in large tanks placed along a private railroad from which the sap was moved to one of four enormous maple syrup plants that each contained five large evaporators.[8]

Due to their simplicity, the use of standpipes and basic metal pipelines became more common and continued to grow for many decades. Notable examples are the sugarbushes of Colonel Fairfax Ayers in the 1930s and 1940s near Shaftsbury, Vermont, and that of Helen and Scott Nearing, whose 1950 classic *The Maple Sugar Book* describes in detail the thought process that went into their decision to use a pipeline to eliminate the majority of the time and labor costs associated with gathering sap in collection tanks pulled by horse or tractor.[9]

The Nearings didn't arrive at the idea of using a standpipe on their own. At the time they purchased their sugarbush in the mid-1930s, the previous owner had been using his own open-top, rain-gutter-like metal pipeline to move sap downhill through the maple woods. Upgrading from the open metal trough to a closed, tubular iron pipe, the Nearings improved upon this idea at their Forest Farm, a situation that was repeated by the next person to own and sugar these same woods, George B. Breen, whose efforts are discussed below.[10]

Brower's Metal Tubing System

The evolution of the sap pipeline from wood to metal and from a static pipeline to a complete sap-collection tubing system continued with the arrival of an enclosed, all-metal, taphole-to-tank tubing system. Patented in 1916, the Brower Sap Piping System was first developed by William C. Brower in 1905 at his home in Mayfield, New York. The Brower system was the most significant and innovative of the early pipeline designs, in terms of setting the stage as a model for later plastic tubing designs. This was the first enclosed system for collecting and gathering sap that ran directly from the taphole in the tree, down a dropline-like tube, through a network of lateral and mainline pipes, to a single collection point, usually at or near the boiling location. The lateral lines and main lines were made from sections of three-foot-long tubes of rolled and folded terne plate sheet metal that were inserted end-to-end in a segmented fashion (Figure 2). The lengths of tubing were suspended from a network of wires via small hooks attached to the tubing. The tubing was made in two sizes to accommodate the greater diameters needed for mainlines versus lateral lines. The other feature of the system was a curved section of tubing that connected the lateral line with a drop tube that ran off the base of the enclosed spout. All together, these interconnected components formed a single continuous piping system.[11]

Figure 2: The Brower Sap Piping System, also known as the Gooseneck system, an early-20th-century all-metal tubing system. Photograph by Matthew M. Thomas.

Popularly known as the gooseneck system in reference to the curved shape of one of the connecting pieces, the Brower Sap Piping System experienced a moderate level of success, in part because of the support of George C. Cary and the Cary Maple Sugar Company in St. Johnsbury, Vermont, the world's largest handlers of bulk maple sugar. Cary himself owned a large sugarbush in nearby North Danville, where he installed the Brower system on 4,000 taps in 1915, expanding the following year to 15,000 taps. Cary didn't just put the system to use in his own sugarbush, he also partnered with Brower to manufacture, market, and sell the Brower system as a branch of his larger Cary Maple Sugar Company in St. Johnsbury, Vermont, in the early 1920s.[12]

Despite its obvious utility, efficiencies, and improvements over hand gathering with spouts and pails, or using pipelines with dumping points, only a small percentage of maple producers, mostly wealthier and progressive farmers, made the switch to the Brower system. One anecdotal study suggested its users tended to make higher-quality, award-winning syrup; however, most maple producers felt it was too expensive and too difficult to maintain, froze too easily, and thawed out too slowly. Fallen limbs, ice, and deer occasionally disconnected sections of the pipeline, and the contraction of the metal in very cold conditions could result in the separation of the inserted pipe ends. Notably, this was also at a time when health concerns began to be raised about the lead content of the terne plate sheet metal. By the end of the 1930s the Brower system was largely no longer in use.[13]

Not surprisingly, however, the basic gravity-fed design and layout of the earliest flexible plastic tubing systems in many ways followed the general arrangement of the Brower system and a great deal of credit is due to William Brower for providing a model, albeit with some flaws, from which the developers of plastic tubing could evolve.

Introduction of Plastics

Following the end of World War II, industry and agriculture experienced significant growth in the application of plastics for both old and new uses. Fueled by federal and corporate wartime support, the petrochemical industry worked aggressively to develop lighter and stronger, noncorrosive materials that could be used to produce items quickly, consistently, and cheaply. The maple syrup industry was no different than other manufacturing and food-producing industries in taking advantage of the unique properties and benefits offered by plastics. Polyethylene (PE) and polyvinyl chloride (PVC) were the early and most popular new plastics for the maple industry, because of their flexibility and because they were easy to mass produce in molds.[14]

The first successful application of plastics to the challenge of gathering maple sap was the invention of a plastic bag to replace the metal pail and cover. The King Sap Bag, as it was known, was invented by Everett I. Soule of the George H. Soule Company, the well-known maple syrup equipment manufacturers out of St. Albans, Vermont. The choice of the name King Sap Bag followed the Soule Company's use of King as the primary brand name for their evaporator and other products. Everett Soule began developing and experimenting with his bag idea in the mid-1940s and by October 1950 had perfected a design for a 13- to 15-quart bag that was initially distributed to Soule Company equipment dealers for sale and installation for the 1951 sugaring season. The King Sap Bag was made of a transparent, heavy, but pliable PVC plastic called vinylite that was said to be the same material used by the Air Force for the packaging of food and water drops to soldiers. The bags were durable, simple to use, washable for reuse, and had the advantage of being cheaper than new pails and covers. When flattened for storage, the bags took up considerably less room than an equal number of pails. Another advantage of the King Sap Bag was that it was made of transparent plastic, which allowed one to see easily the sap volume in the bag hanging on the tree, and it was claimed, allowed sun through to provide ultraviolet light that arguably led to reduced microbial development and clearer, cleaner sap.[15]

Being well aware of the potential of plastics from their development of the King Sap Bag and always looking toward the future of the maple industry, Everett Soule's brother and the company co-owner, Raymond Soule, commented in 1950 that an important "proposed improvement" in sugaring technology was the use of plastic pipe. In noting that "its smooth surface is easier to clean and sanitary than rough and possibly rusty metal pipe," Raymond Soule was referring to rigid plastic pipe as a replacement for metal pipelines, not to flexible plastic tubing. However, in making note of the potential of plastic pipe it was clear that some in the maple industry were thinking about other applications of new materials and methods to the age-old challenge of getting sap from the tree to the boiling site. A few years later, Everett Soule went a step further and joined several inventors in designing or patenting their own flexible plastic tubing system for the maple industry.[16]

Flexible Plastic Tubing Arrives

Past developments and improvements in designing metal sap pipelines and a metal tubing system, combined with the availability of new and favorable materials like flexible plastic tubing, came together and led to a burst of experimentation by inventive engineers and maple syrup makers in the 1950s.

Among these innovators were three men of note: Nelson S. Griggs and George B. Breen, both from Vermont, and Robert "Bob" M. Lamb of neighboring northern New York. While they were not alone, nor unique in their efforts to bring forward a new way of gathering maple sap in the sugarbush, it was through the efforts of these three men that plastic tubing was perfected and became the standard method of sap collection for the maple syrup industry. They were working largely independently of each other at the same time in the 1950s, but because Nelson Griggs was the first to obtain a patent for his version of a spout-and-flexible-tubing system for gathering maple sap, it is common to see the invention of plastic tubing attributed solely to him. History is seldom that neat or simple, as this study will show.[17]

Nelson Griggs

Unlike many of the men who experimented with plastic tubing for maple sap, Griggs did not come from the maple sugaring community. Griggs, a lifelong Vermonter, was an MIT-educated engineer working in the early 1950s for Vermont State Department of Highways (Figure 3). As an ancillary activity to his job with the state, Griggs also served as an engineering consultant with the Bureau of Industrial Research at Norwich University, in Northfield, Vermont. The bureau was a nonprofit organization established and funded by the Vermont State Legislature to "provide professional level engineering assistance to Vermont Industries."[18]

It is not clear how Griggs first came to study the use of plastic tubing to gather sap. We do know he was a longtime friend of Harry Morse of the Morse Maple Farm, so perhaps it was in earlier discus-

Figure 3: Nelson Griggs working with his experimental tubing design at the University of Vermont's Proctor Maple Research Farm in the spring of 1955. Photo from Vermont Life *10 (1955): 6. Courtesy of the State of Vermont.*

sions with Morse that the idea arose. Or perhaps someone else from the maple industry or the University of Vermont's Proctor Maple Research Farm (PMRF) in Underhill, Vermont, brought the idea to the Bureau of Industrial Research. We simply do not know or have records to tell us more. Field notes kept by PMRF staff tell us that between March 8 and April 29 of the 1955 maple sugaring season, working together with the PMRF, Griggs led an experimental installation of a network of flexible plastic tubing for gathering maple sap. In addition to tubing purchased from a manufacturer, the installation employed sap spouts and fittings designed by Griggs to work with the plastic tubing.[19]

In this initial year of testing Griggs' tubing system was set up in two groups of 25 trees with the tubing laid over the ground or snow, running from tree to tree and then into a central collection tank. According to Griggs, despite the natural challenge of plastic tubing being susceptible to freezing, the pressure from the tree that forces sap out of a taphole would partly solve that problem. Specifically, "the nature of the tubing allows dilation under pressure and relatively rapid thawing is brought about by the warm sap forcing its way between the tubing wall and the frozen residue."[20]

Griggs worked with ¼-inch extruded polyvinyl chloride (PVC) flexible tubing described as "food tubing." This was attached to a "bushing style" spout that employed a straight or a tee connector made of ¼-inch aluminum tubing that was inserted into a tapered polyethylene plastic "nipple," fitting snugly into the 7/16-inch drilled tap holes. Lengths of tubing were further connected by tee-shaped and cross-shaped fittings made in a similar fashion with ¼-inch aluminum tubing and machined plastic nylon housings. The entire network of ¼-inch tubing was laid out on a downhill grade and connected by "tie-ins" to a ½-inch mainline made of rigid plastic pipe. Following the end of the sugaring season and his experiment, Griggs described the results as "very gratifying." The tests showed the experimental tubing system to be workable and more productive than conventional metal spouts and pails hung side by side on the same trees for comparison. In most cases the tubing system yielded twice as much sap as the spout and open pails, likely a result of the vacuum developing in the tubing and the improved sanitation from new unspoiled equipment free from the effects of airborne microbes.[21]

Griggs learned other important lessons working with tubing, such as that there was a limit to how much sap could freely flow through ¼-inch tubing with all of the taps connected to the same ¼-inch tube, adding that an appropriate or optimal number of taps had not yet been determined. Griggs also realized the difficulties of laying the tubing on the ground, when, following a heavy snow, it took as much as four days for the buried tubing to thaw out and begin to flow again.[22]

In addition to tests conducted on trees in the PMRF sugarbush at Underhill, Griggs noted in his project report that the experimental tubing and spouts were also installed in another, unspecified location in the Northfield area. Griggs's daughter and Burr Morse of Morse Farm Sugarworks both recall Griggs carrying out other experiments with tubing in the Morse's maple woods north of Montpelier, but the exact years of this work are not known. Field notes from the PMRF collections indicate that Griggs returned the following season for additional experiments; however, a report does not appear to have been written describing the results of work from the 1956 season.[23]

Feeling confident in the design and utility of his system of fittings and tubing, Griggs applied for a patent in February 1956, a year after the test at the PMRF. He felt that he had perfected his design to such a degree that while waiting for patent approval, commercial sugarmakers in Vermont began to install the system in their sugarbushes as early as 1957. In a *Burlington Free Press* article from April 1957, sugarmaker Guy Page of Waterville, Vermont, was said to be trying out the Griggs system on 500 taps of his over 4,000-tap sugarbush. One of the advantages of installing the pipeline, as Page described it, was that "you can set up your pipes in February…go down to your house and drink beer till the sap runs out. Then all you have to do is boil it."[24]

Three years later in March 1959 Griggs was awarded U.S. patent number 2,877,601 for his "Sap Collection System." In November 1959 Canadian patent CA 587304 was also awarded. Griggs's daughter recalled that her father felt that the patent application took longer than expected, which may have been a result of the patent claim being contested; however, looking at the filing and award date of many other similar patents around this time, a three-year lag time was relatively common.

Griggs submitted his patent idea first in 1956; however, another patent claim for a similar concept, albeit a different design, was submitted by George Breen in association with the Minnesota Mining and Manufacturing Company (3M). The 3M Company would go on to develop and market Breen's design under the brand name Mapleflo. According to George Breen, whose role in developing his own tubing system is described next, he and 3M felt that Griggs had stolen some of Breen's ideas and that they could prove that Breen's invention preceded that of Griggs, an important factor in establishing patent priority at the time. As a result, 3M applied its corporate muscle and threatened to challenge Griggs's patent claim. Instead, 3M offered Griggs a monetary settlement of $5,000 if he would agree to discontinue work with his tubing invention and not pursue patent interference or infringement counter claims of his own.[25]

Nelson Griggs's daughter confirmed in an interview that her father sold the royalties to 3M until the patent expired and got very little money for it. In addition, it was the Griggs family's opinion that he never got the recognition he deserved and that he and his invention were overshadowed by the 3M Mapleflo tubing and Bob Lamb's Naturalflow tubing. Online information associated with the Canadian patent for Griggs's sap collection system indicates that when the Canadian patent was issued in November 1959, the 3M company was the listed patent owner, confirming that at some point prior to that date Griggs had relinquished ownership of the patent.[26]

Griggs was an inventive man and received a variety of other patents, including for a fire extinguisher and metal edges for skis. Sadly, he suffered from multiple sclerosis (MS), especially in the years after his experiments and patent for the tubing system. He became progressively weaker and was soon physically unable to continue his engineering research and work. Griggs died in 1971 at the age of 56 from complications of MS.[27]

George Breen and Mapleflo Tubing

Although Nelson Griggs is often credited with the invention of plastic tubing for the maple industry, the earliest known use of flexible plastic tubing for the movement of maple sap from tap to gathering point was undertaken by George B. Breen in 1953 (Figure 4). Like Nelson Griggs, George Breen was a problem-solving engineer with limited experience in making maple syrup when he began to experiment with plastic tubing.[28]

George Breen and his wife Jacqueline had been living in Kensington, Connecticut, with their two

Figure 4: George Breen installing plastic tubing in his Jamaica, Vermont, sugarbush in the spring of 1956. From St. Louis *[MO]* Post-Dispatch*, 26 March 1956.*

young sons, where George was developing assembly line equipment for the Spring and Buckley Company, when he came across Helen and Scott Nearing's new publication, *The Maple Sugar Book*. Intrigued by the idea of sugaring in Vermont, Breen wrote to the Nearings asking if they knew of any sugarbushes for sale. Helen Nearing promptly replied that they did and suggested the Breens come to see them at their Forest Farm near Jamaica, Vermont. Little did Breen know that the Nearings had decided to sell Forest Farm and its sugarbush and move to Maine. Upon arrival, Scott Nearing promptly offered to sell the Breens their farm and 4,000-tap sugarbush, complete with all its stone buildings and two sugarhouses. An acceptable price and arrangement for sale was executed in January 1952, including four miles of galvanized metal pipeline. In the spring of 1952, following their move from Connecticut to their new home at Forest Farm and under the tutelage of Helen and Scott Nearing, the Breens took on their new roles as sugarmakers.[29]

As mentioned previously, the Nearings had installed a tubular metal sap pipeline in their sugarbush in the 1940s. Being the new owner and operator of the Nearing sugarbush afforded Breen the opportunity to see that pipeline in use, which probably helped him arrive at his idea to streamline the gathering process even further.

In 1953 Breen experimented with about 200 feet of blood transfusion tubing purchased from 3M, running the tubing from several existing metal taps to two metal milk cans. Later that same season, he placed a second order for 1,000 feet of surgical tubing to connect around 75 experimental aluminum taps of his own design, which he had produced at a local machine shop.[30]

As Breen's son Sean tells it, in one of the first springs in his new sugarbush, his father screwed a pressure gauge into a taphole and discovered that there was as much as 35 pounds of pressure releasing from the tree. Excited with his discovery, George Breen called maple specialist Dr. James Marvin at the University of Vermont, who, unimpressed with this "discovery," replied, yes, we know that. To which George Breen responded, "but you can put that pressure to work to move sap."[31] According to George Breen's memoir, "Jim Marvin let me know that he discussed my experiments with others, including a fellow by the name of Nelson Griggs. Griggs came down to the farm a short time later and I naively showed him the set-up. He said he had been thinking along the same lines and planned to look into the idea further." The visit by Griggs to the Breen sugarbush was probably in the spring of 1954.[32]

Orders of blood transfusion tubing of these lengths got the attention of executives at 3M and early in 1956 Breen received a call from Erwin

Brown, a vice president with 3M, asking what was going on in the woods of Vermont that required so much PVC tubing. Breen did his best to put him off and replied that it was secret. Of course, that only further piqued 3M's interest and later that season, when working on the tubing in his sugarbush, Breen looked up to see Brown in a three-piece suit trudging through the woods toward him on snowshoes. Brown was soon "entranced" by Breen's inventiveness and application of the tubing to sap gathering, and that same day offered a partnership to work with Breen to improve the design and technology and file a patent for the invention.[33]

Breen traveled to 3M's Irvington, New Jersey, facilities the following year to refine the design and 3M supplied him with as much as 18 miles of tubing to expand his operation and testing. He consented to work as a technical advisor to 3M and produced "A Report on Experiments Using Plastic Tubing to Gather Maple Tree Sap," dated July 1, 1957, which was a glorified promotional brochure as much as a research report.[34]

The terms of the partnership Breen agreed to with 3M called for him to travel around the maple syrup producing region demonstrating the new apparatus and rewarded him with a five percent commission on sales. Soon after, when sales reached 500,000 units sold at $1.00 a spout, 3M opted instead to give Breen a lump sum of $25,000, which he accepted.[35]

A patent application for the system was submitted by 3M on February 1, 1957, with a modification and refiling in February 1959, and the patent was awarded in July 1962. George B. Breen's name, along with John E. Cahill, a 3M employee, was on the first of 3M's patents, but it was absent from subsequent design adaptations submitted for patents by 3M. As discussed above, the 3M company was particularly aggressive in protecting its investment and used its considerable resources and patent attorneys to ensure that it was going to be the leader in the introduction of plastic tubing to the maple industry.[36]

Having a finalized design and patent application in place in early 1957, 3M began to manufacture, market, and distribute their trademarked Mapleflo in preparation for use in the 1958 sugaring season. In its initial years of availability, Mapleflo tubing could only be purchased through the Leader Evaporator Company and their agents in the United States and through Dominion and Grimm, LTD, in Canada. Advertisements also appeared in Québec in the French-language *Le Bulletin des Agriculteur* as early as 1958.[37]

The design Breen and 3M settled on for the Mapleflo system featured a molded hard plastic spout with ribbed nipples on both sides to which flexible plastic tubing was attached, with multiple trees connected in-line on a single tube before connecting to a mainline. In addition to the spouts and tubing, the system also used molded plastic fittings in the form of straight-line connectors, tees, and wyes of different sizes to interconnect tubing and mainlines or conduits. The plastic spouts tapped snuggly in the tap holes served as the primary anchor for elevating the tubing above the ground; however, stakes or other supports were necessary for supporting the wider-diameter and heavier-gauge mainlines. Mapleflo was a closed, unvented tubing system that lacked drop lines and ran sap directly from the spout into the lateral lines of tubing. Drop lines are short connecting lengths of tubing that run vertically from the spout down (dropping) to the lateral tubing. Mapleflo took advantage of the natural outward pressure from within the tree to move sap along the tubing, although it was recommended to use the positive effects of slope and gravity when laying out the system. It was initially designed to be dismantled, cleaned in sections, and stored indoors between sugaring seasons.[38]

Even after the initial Mapleflo system was developed and offered for sale, Breen continued to experiment with and test new ideas to improve the tubing and fittings. In the 1958 sugaring season, Breen was at UVM's Proctor Maple Research Farm to help install the Mapleflo system for testing the pressure and effectiveness of its closed, unvented, or what they called "deadhead" spouts against a vented tubing system like Griggs's. One additional feature, the brainchild of Breen's wife Jackie, was to add black stripes to the tubing, with the idea that the darker color would absorb heat and slow the freezing of the lines in cold weather and likewise promote the thawing of iced-up tubing. Unfortunately, it worked too well and ended up warming the sap too much, spoiling the sap and enhancing the growth of unwanted bacteria in the sap.[39]

Breen continued to operate his sugarbush through 1963 but sold the farm, sugarbush, and sugaring equipment the following year, transitioning to selling real estate full time in southern Vermont. 3M phased out its interest and manufacturing of Mapleflo in the early 1980s and the Leader Evaporator Company, Mapleflo's primary distributor, stopped advertising it in *Maple Syrup Digest*, the industry trade journal, in the summer of 1984.[40]

Robert Lamb and Naturalflow Tubing

Robert "Bob" M. Lamb came to work with the maple products industry not as a maple syrup producer but as a respected chainsaw dealer in the logging community, and as an inventor and troubleshooter (Figure 5). According to Fred Winch, former Cornell University maple specialist, Lamb's entry into the world of plastic tubing began in 1955 when one of his chainsaw sales agents and a Cornell University extension forester, Dick Howard, saw a sugarmaker from Cattaraugus County named Leon Wright trying to use hard plastic tubing to connect trees to 10-gallon pails. Howard knew that his colleague Bob Lamb had an inventive mind and was good at problem solving, so he asked Lamb if there was a better plastic tubing on the market. From that initial question, Dick Howard and Bob Lamb began working on an idea for a tubing system and by the time of the annual New York maple producers tour in 1956, their tubing system was on display. Fortunately, some of Lamb's early designs and sales displays have been preserved and are on exhibit in the International Maple Museum and Centre in Croghan, New York.[41]

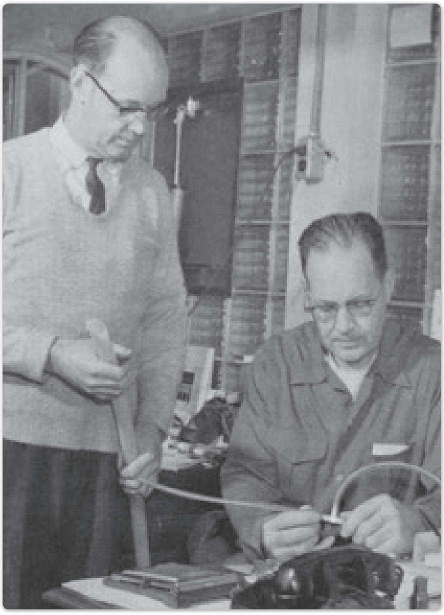

Figure 5: Bob Lamb (seated) and brother Clifford Lamb examining fittings of the Naturalflow tubing system. Image from Naturalflow sales brochure, circa 1963. Courtesy of the Leader Evaporator Company.

Even though Lamb's initial designs were relatively crude by today's tubing standards, he continued to work to improve his design, and by late 1957 Lamb's "Plastic Tubing System for Gathering Maple Sap" was available for sale through the family's company, A. C. Lamb & Sons out of Liverpool, New York. Bob Lamb was a wise and aggressive businessman and he wasted no time in advertising his new tubing system as well as bringing dealers on board from more distant corners of the maple-producing region. For example, as early as 1958, Reynolds Sugar Bush, maple equipment dealers in Aniwa, Wisconsin, were advertising Lamb Tubing Systems in the *Wisconsin Maple Syrup and Sugar Producers Annual*.[42]

Initially Lamb sold his tubing system through the family chainsaw and marine motor business he ran with his brother Clifford. Started by their father Ambrose C. Lamb in the 1930s, the sons took over the company following their father's death in 1947. With the growing success of plastic tubing, the brothers agreed to split A. C. Lamb & Sons in 1966. Bob and his wife Florence took over the maple syrup supply business and began operating as R. M. Lamb out of Baldwinsville, New York. As a former small-motor salesman, Lamb continued to sell power tappers, pumps, and, of course, chainsaws to maple producers. Although he had never been a maple syrup producer himself, he did install and test some of his design ideas for fittings and tubing on maple trees around a second home he had near Leisher Mill in Lewis County, New York.[43]

In the first few years of sales and marketing, Lamb referred to his tubing product as "Lamb's Plastic Tubing System for Gathering Maple Sap." However, by early 1959 the company began advertising the brand name "Naturalflow" for their tubing system. Lamb's tubing was also made available for sale in Canada through a corporation formed in Québec in 1963. Bob Lamb patented his designs for the use of tubing in sap collection, with 1962 as his earliest patent application date. This date suggests that Lamb didn't get into the early patent battles experienced between Griggs, Breen, and 3M in the late 1950s, despite Lamb having developed and marketed a working design at that time.[44]

The Lamb Naturalflow design differed from the Mapleflo design in that the Naturalflow system was initially a vented system that was laid over the ground surface with air allowed into the tubing network to combat the problem of airlock, a natural occurrence with vacuum in tubing. Lamb's Naturalflow system also differed from Mapleflo with the addition of long droplines between the spouts placed at chest height and the lateral lines laid over the ground. As later research at the PMRF showed, a dropline improved sap yields by reducing the ability of trees to reabsorb the exuded sap in the lateral lines coming from uphill trees during subsequent freeze cycles. This led to the recommendation for a suspended tubing system and a 15-18" minimum length for droplines, which are in use today. Early tubing systems such as Naturalflow were designed to be taken down at the end of the sugaring season and then reinstalled the following spring. Even with research evidence to the contrary, Bob Lamb strongly believed that a vented system was a superior design to a closed tubing system. Lamb was a hard-nosed defender of his ideas and took advantage of his influence in the industry and the use of paid advertising space to share his views in *Maple Syrup Digest*.[45]

It was only with evidence that significantly greater sap production could be achieved with the addition of applied vacuum, which would only work with a closed system, that Lamb changed the Naturalflow design to discontinue the use of vented spouts. Similarly, the Naturalflow system was modified based on evidence from comparison studies that led to better methods of installation and maintenance, such as suspending the tubing rather than laying it over the ground and leaving tubing installed permanently.

The Lamb company didn't just design and develop spouts and fittings to attach to plastic tubing manufactured by another company. The Lambs purchased their own extruder and manufactured many miles of tubing in a facility at Bernhard's Bay on Oneida Lake, not far from Syracuse, New York. Lamb constantly made adjustments and improvements to his designs. Unlike the behemoth 3M company that made hundreds if not thousands of products, almost all of which were more financially successful and significant than their Mapleflo tubing system, the Lamb company was solely focused on making the best plastic tubing system it could for the maple industry. In doing so, Bob and Florence Lamb worked hard to promote and sell their products, becoming integral members of the maple producer's community, while Naturalflow became the leading tubing system on the market.

By the early 1980s, 3M had stopped production of Mapleflo and relinquished sales of its remaining stock to the Lamb Company, and Lamb was selling Mapleflo side by side with his Naturalflow tubing. In 1985 the Lamb Company entered a partnership with G. H. Grimm Company of Rutland, Vermont, for sales and manufacturing of Lamb Naturalflow and Mapleflo tubing systems. The Grimm Company and its affiliate the Lamb Company were in turn purchased by the Leader Evaporator Company in 1989.[46]

Other Inventors and Experiments

In addition to Nelson Griggs, George Breen, and Robert Lamb, there were others who experimented with plastic tubing in the years before it became commercially available for the maple industry. For example, Basil Hummer in Titusville, Pennsylvania, was noted for first experimenting with tubing in his sugarbush as early as 1955. By 1956 Hummer was said to have 7,000 feet of tubing in use.[47]

In Sauk County, Wisconsin, Chester A. Wilson was using nearly two miles of plastic tubing on 400 trees in his sugarbush in 1955. Newspaper accounts suggest that Wilson began experimenting with plastic tubing in 1952. Like Basil Hummer in Pennsylvania, Wilson appears to have contented himself with developing a working tubing system for his own use and did not go the route of applying for a patent or promoting it for wider adoption.[48]

As mentioned earlier, in 1958, Everett Soule of the George H. Soule Company filed for a patent for a sap-gathering system using flexible plastic tubing, spouts, and fittings. Soule's patent was awarded in 1960, but there is no indication that the Soule Company ever went forward with developing and marketing this design, or if they had any patent interference or infringement issues with the 3M company or Lamb Tubing Systems.

George Butler of Jacksonville, Vermont, began using plastic tubing in his sugarbush in the 1956 season. That year he installed 3,000 taps connected by surgical plastic tubing using a system of his own design. However, Butler gave up on tubing in 1960, arguing that contrary to his expectations it did not prove to be the labor-saving technology he had expected. Butler was a rare exception who instead found that tubing installation was time consuming and slow, and that he still spent hours a day inspecting the lines for leaks and damage. Unfortunately for Butler, his involvement with tubing was in the early experimental years and many of the challenges he faced were later solved with a better understanding of the tubing technology and sap flow mechanics, as well as improved materials and equipment designs.[49]

While there are no state-level agricultural census data or industry-wide longitudinal surveys to trace the rate of replacement of pails and the adoption of tubing, it is clear that maple syrup producers quickly realized tubing's potential and were cautiously open to this new technology. From the earliest days of its commercial availability, smaller-scale research studies found that plastic tubing systems outperformed pails in terms of volume of sap produced. With the addition of vacuum, tubing systems often produced twice as much sap as traditional taps and pails. In addition, limiting the exposure to air and the elements with the use of tubing slowed and reduced the levels and rates of bacterial and microbial growth encountered in the sap and tap holes across the sugaring season, leading to longer seasons and better overall sap quality.[50]

From an economic and risk assessment standpoint, there were real costs to transitioning from the old tried and true and paid for methods versus spending limited resources on the new and not yet fully proven plastic tubing. Some producers initially tried tubing on an experimental basis, converting only a portion of their sugarbush from pails. Not surprisingly, larger operations could take advantage of economies of scale. The potential savings and reduction in labor costs associated with employing gathering crews led larger operations to become some of the earliest to try plastic tubing. However, other mid-sized commercial producers took to tubing as well. Early economic studies found the basic equipment cost per tap for tubing versus pails, excluding the cost of labor, to be roughly the same. It was recognized in these early analyses that a unique advantage of installing tubing was that it permitted tapping of steep terrain and areas with deep snow that would otherwise be too difficult for daily collection of sap in pails. When the early studies were being made it was believed that the tubing needed to be installed, then removed at the end of the season, and again restrung at the beginning of the next season, amounting to substantial annual labor costs. Later, it became better understood that tubing could be hung once and remain permanently strung in the sugarbush, to be connected to newly drilled tap holes each new season, thus realizing one of the real labor savings of tubing. Economic studies from the 1980s found that the break-even point, "where income from the sugarbush just covers the cost of operation" for a new installation using pails, was around 3,000 taps, whereas the break-even point for a new sugaring operation with plastic tubing was notably lower at 2,000 taps. As was shown by the experience of George Butler, there were kinks to work out in early tubing technology, most notably problems with the thermal resistivity of the plastic and the formula for manufacturing the tubing, with some tubing getting too elastic, soft, and tacky, and other tubing becoming too brittle. Undoubtedly there were traditionalists and "old-timers" who scoffed at the new-fangled plastic technology and the idea of stringing "clotheslines" through the woods, but by and large, the industry looked upon tubing with cautious optimism and over time recognized that it was the technological future of the maple syrup industry.[51]

Application of Vacuum to Plastic Tubing

The use of plastic tubing proved to be a practical, efficient, and cost-effective new way to gather maple sap, but it also presented new questions and problems to solve. It was soon discovered that the gravity on a downhill slope would produce a naturally occurring vacuum in plastic tubing that could facilitate the outward flow of sap through the tubing lines. It was further discovered that natural vacuum developed best in unvented, closed systems like 3M's Mapleflo. Working on that knowledge, sugarmakers and researchers went one step further and added mechanical (pumped) vacuum to the tubing system to further increase the vacuum. Added vacuum artificially reduces atmospheric pressure in the tubing and at the tap holes, enhancing the level of sap flow experienced with gravity alone. Added vacuum also functions to help move sap through the tubing lines regardless of slope, reducing spoilage and allowing tubing to be used in flat as well as hilly sugarbushes.[52]

With improved methods and higher levels of vacuum, later studies showed that roughly twice as much sap could be collected with vacuum versus tubing using gravity only. Other research found one of the most effective uses of vacuum was during periods of naturally low sap flow, so-called "weeping flows." On days when the air pressure in a tree is nearly equal to the atmospheric pressure, sap flow slows, and tubing using only gravity to move sap will do little to enhance flows. However, with applied vacuum, atmospheric pressure within the tubing system is reduced to a level below the air pressure in the tree, facilitating a more substantial sap flow. Such enhanced flows also extend the length of the sugaring season, and allow sugarmakers to tap trees many weeks, even months earlier.[53]

According to Québec maple historian Réjean Bilodeau, the first vacuum system designed and marketed specifically for the maple industry was the Sysvac system introduced in 1973 by Les Industries Provinciales Ltd, also known as IPL. IPL, located in Saint Damien, Bellechasse, Québec, has been manufacturing flexible plastic tubing for the maple industry since the early 1960s. Bilodeau refers to IPL's Sysvac system as "the greatest innovation in the evolution of Québec maple syrup production."[54]

There were early examples from the 1960s of simple pump designs for adding vacuum to tubing by individual enterprising sugarmakers such as the Clement St. Cyr Sap Releaser or the Milk Can Vacuum Dump Unit; however, none of these was ever patented or adapted for widespread commercial production and sale. While other vacuum pumps came on the market soon after Sysvac, such as the Universal Milking Machine Company's Maple Sap Extractor, it is fair to say that IPL's Sysvac was the maple industry's first successful commercially available vacuum system for use with plastic tubing. The Sysvac became available in Québec in 1974 in time for use in the 1975 season. Following the perfection and marketing of added vacuum systems, more and more syrup producers, especially commercial producers, began to shift from pails to tubing for sap collection.[55]

The invention and adoption of flexible plastic tubing systems for gathering maple sap from the taphole to the collection tank fundamentally changed how the maple syrup industry works and how sugarmakers interact with their sugarbushes. The evolution to a fully operational and successful plastic tubing system, going from a wood trough to metal pipeline to metal tubing system and finally to plastic tubing, became realized only when the concept and design came together with the right materials to handle the task, namely molded plastic fittings and flexible plastic tubing. Switching from an active system of daily collection of pails to a passive system where sap comes to you via a network of tubing drastically reduced labor demands and the timing, pace, and duration of the sugaring season. Leaving tubing up all year round further reduced the need to install and dismantle the system each syrup season. In addition to boosting sap production, the closed tubing systems improved taphole tubing sanitation, resulting in lower and slower microbial growth and higher-quality sap and syrup. Maple producers began to experience levels of sap production never seen before. Perfecting the use and technology of external vacuum to facilitate sap draw and movement within plastic tubing was a second radical change that further boosted sap and syrup production. Applied vacuum fully modernized sap collection and took it to a new level of sophistication.

Ideas for using materials and new technologies must start somewhere, and as this history shows, they don't always come from the most obvious places or people, and often result from partnerships, borrowing, and cross-pollination. Such collaboration characterizes all aspects of this history, from Griggs and Norwich University, to Breen and the 3M company, to Lamb with Cornell extension forester Howard, to UVM's Proctor Maple Research Farm working with all three men. Similarly, bringing the successful application of vacuum to tubing on a commercial scale was perfected in Québec only after creative minds among the maple producers combined their experiments and ideas with those of university agricultural engineers. The invention and successful application of tubing and vacuum relied on ideas and engineering experts from outside the industry as much as from within, and was ultimately tested, developed, and perfected for commercial use through partnerships of individuals and institutions working together from both the private and the public sector, and from within and from outside the maple syrup industry.

Notes

[1] For a rich discussion of the midtwentieth-century changes rural states faced see Joe Sherman, *Fast Lane on a Dirt Road: A Contemporary History of Vermont* (White River Junction, VT: Chelsea Green Publishing, 1991).

[2] Michael Farrell illustrates changing maple production levels in the U.S. and Canada with an excellent graph on page 3 of his book *The Sugarmaker's Companion* (White River Junction, VT: Chelsea Green Publishing, 2013). Based on U.S. and Canadian agricultural statistical services and the national agricultural census, one can see in this graph how North American production was dominated by U.S. producers in the nineteenth century, only to drop off severely after the turn of the century, while Canadian production made slow improvements from the late nineteenth through the early twentieth century before doubling and tripling in volume in the late twentieth century. For more on the changing nature and shrinking use of maple syrup in blended table syrups see Matthew M. Thomas, "When Towle's Log Cabin Syrup Was a Maple Syrup Company," http://maplesyruphistory.com/2017/08/31/when-towles-log-cabin-was-a-maple-syrup-company/, accessed on August 31, 2017.

[3] *Maple Products, Sugar and Sirup: Trees Tapped, Production, Disposition, Price, Value, by States, 1916-1959*, Statistical Bulletin No. 2313, USDA Statistical Reporting Service (Washington, DC, 1962); *Maple Products: Investigation into an Alleged Combine in the Purchase of Maple*

Syrup and Maple Sugar in the Province of Québec, Report of Commissioners, Combine Investigation Act, Department of Justice (Ottawa, Canada, 1953).

[4] Paul D. Evans, *The Holland Land Company* (Buffalo, NY: Buffalo Historical Society, 1924).

[5] C. T. Alvord, "The Manufacture of Maple Sugar," *Report of the Commissioner of Agriculture for the Year 1862,* House of Representatives 37th Congress, 3rd Session (Washington, DC: Government Printing Office, 1863).

[6] Moses Shelden and W. A. Chase, *Improvement in Spouts for Conveying Sap,* US Patent 39,072, issued June 30, 1863; Hale Mattoon, *Maple Spouts Spiles Taps & Tools* (Vershire, VT: Flying Squirrel Press, 2017), 18-19.

[7] Alvord, "The Manufacture of Maple Sugar."

[8] Photographs from 1901 of the Horse Shoe Forestry Company maple syrup operation show a workman pouring a pail of sap into a funnel at a standpipe gathering point. From this photo and other photos in the same collection we can see that Low's pipeline was designed to assist with gathering sap. Other photos of Low's operation show the pipelines running downhill to collection tanks alongside rail lines, as well as sap pipelines running directly into the syrup plants. A. A. Low's maple operation lasted for a little over ten seasons, before a 1908 forest fire ravaged his sugarbush. See Matthew M. Thomas, *A Sugarbush Like None Other: Adirondack Maple Syrup and the Horse Shoe Forestry Company* (Vallejo, CA: Maple History Press, 2020); Mark F. Clark, "The Low Dynasty," *The Quarterly* 19, no. 4 (1974): 9-15; James M. Lawrence and Rux Martin, *Sweet Maple: Life, Lore & Recipes from the Sugarbush* (Shelburne, VT: Chapters Publishing LTD, 1993); Michael Kudish, *Where Did the Tracks Go in the Central Adirondacks?* (Fleischmanns, NY: Purple Mountain Press, LTD, 2007).

[9] Dave Mance III, "The Colonel: A Sort of Remembrance," *Northern Woodlands* (Spring 2019): 59-65; Helen and Scott Nearing, *The Maple Sugar Book* (New York: The John Day Company, 1950). *The Maple Sugar Book* presents a nice overview of the history of pipeline use by others prior to the Nearings' use in their own sugarbush operation, also noting the earlier examples of Gerrit Boon and Holland Land Company and Alvord's 1863 report. An image of a standpipe in use in a Québec sugarbush appeared in a 1913 report by J. B. Spencer, *L'Industrie du Sucre D'Érable au Canada,* Dominion du Canada, Ministére Fédéral de L'Agriculture, Bulletin 2B (Ottawa, 1913); Margaret O. Killinger, *The Good Life of Helen K. Nearing* (Burlington: University of Vermont Press, 2007).

[10] In the Nearings' sugarbush, sap was collected in galvanized metal pails and carried a short distance by hand to dumping points equipped with portable funnels along their pipeline network. This method didn't eliminate the need for human labor to bring the sap from the tree to the pipeline, but it did eliminate the need for horses or oxen to pull gathering tanks through the snow and mud of the sugarbush. Employing one-inch-diameter galvanized steel pipe in five-foot lengths, they installed vertical standpipes every 100 feet into which a portable funnel equipped with a debris filter was inserted for dumping sap from the collection pails into the pipeline. In laying out their pipeline they elected to keep it in place in the sugarbush year-round and place the line very close to the ground, allowing it to be buried by snow over the winter and through the sugaring season. The Nearings made good use of their pipeline before leaving Vermont for Maine and selling their farm and sugarbush to George and Jacqueline Breen in 1952. For a more detailed review and critical analyses of the Nearings' back-to-the-land story and maple sugaring operation see Killinger, *The Good Life*, and Greg Joly, "Epilogue," *The Maple Sugar Book,* 50th anniversary edition (White River Junction , VT: Chelsea Green Publishing Company, 2000), 253-68; George B. Breen, *Personal Memoir*, Vermont Historical Society, MSA 896:01.

[11] William C. Brower, Sap-Collecting System, US Patent 1,186,741, filed December 17, 1914, issued June 13, 1916; Matthew M. Thomas, "A History of The Gooseneck: The Brower Sap Piping System and Cary Maple Sugar Company," *Maple Syrup Digest* 17A, no. 3 (2005): 25-30. Terne plate is a kind of thin sheet metal coated with an alloy of lead and tin.

[12] Lois G. Greer, "America's Maple King: George C. Cary," *The Vermonter* 34, no. 10 (1929): 2-8; *The Brower Sap Piping System* (St. Johnsbury, Vermont: Cary Maple Sugar Company, 1920); Matthew M. Thomas, *Maple King: The Making of a Maple Syrup Empire* (Vallejo, CA: Matthew M. Thomas, 2018).

[13] John A. Hitchcock, "Economics of the Farm Manufacture of Maple Syrup and Sugar." Vermont Agricultural Experiment Station Bulletin 285 (Burlington, VT, 1928).

[14] Will H. Shearon, "Trends in Industrial Piping," *Chemical and Engineering News* 30, no. 4 (1952): 316-21. For more on the history of plastics and the plastic and petrochemical revolution

following the war, see Jeffery L. Meikle, *American Plastic: A Cultural History* (New Brunswick, NJ: Rutgers University Press, 1995); Stephen Fenichell, *Plastics: The Making of a Synthetic Century* (New York: Harper Collins, 1996); Harry J. DuBois, *Plastic History U.S.A.* (Boston: Cahners Books, 1972).

[15] "Top County Maple Producer Tests Modern Plastic Sap Keelers," *Meyersdale* [PA] *Republican,* 1 March 1951, 7; R. C. Soule, "What is New in Maple Sirup Industry," *Report of Proceedings, Conference on Maple Products*, USDA Eastern Regional Research Laboratory (1950), 28-29. At the time of his invention, Everett I. Soule was the president of the George H. Soule Company, having taken over as president in 1938 following the death of his uncle and company founder George H. Soule in 1937. Along with his brother Raymond L. Soule, Everett continued to run the family-owned company and he became a prominent individual in the maple industry for many years. Following his death in 1964 the Soule Company was sold to Leader Evaporator Company, including the manufacturing and sale of the King Sap Bag. Under Leader's ownership the printing on the exterior of the bag was changed from "*George H. Soule Co." to "Leader Evaporator Co., Inc." Although* Everett Soule obtained a patent in Canada for his sap bag (CA 598853) in May 1960, it does not appear that a U.S. patent was ever secured, despite marketing language of patent pending. The King Sap Bag continued in production into the late 1960s, but by the 1970s it was essentially abandoned as flexible plastic tubing was perfected and became more widely accepted.

[16] R. C. Soule, "What is New in Maple Sirup Industry"; Everett Soule, Sap Collection Apparatus and Method, US Patent 2,944,369, filed August 6, 1958, issued July 12, 1960.

[17] Nelson Stevens Griggs, Sap Collection System, U.S. Patent 2,877,601, filed February 28, 1956, issued March 17, 1959.

[18] *Burlington* [VT] *Free Press,* 16 September 1955, 12; Archie M. Palmer, "Nonprofit Research and Patent Management Organization," National Academy of Sciences—National Research Council, Publication 372, Washington, DC (1955).

[19] The spring of 1955 is the earliest confirmed dates we have for Griggs experimenting with tubing. A May 1955 report of these investigations mentions earlier experiments on a small scale, but no dates or details are provided. Nelson S. Griggs, *An Improved System for Maple Sap Collection* (Northfield, VT: Bureau of Industrial Research, Norwich University, May 1955). See also, Annual Seasonal Research Field Notes on File in Library/Archives of the University of Vermont's (UVM) Proctor Maple Research Center (PMRC), Underhill, VT. Many readers will be familiar with the Proctor Maple Research Center not being called a farm. However, during the period of discussion in this story the name of the UVM research facility was originally the Proctor Maple Research Farm; it was changed to Center in the 1980s. An examination of the field notes from the Proctor Maple Research Farm (PMRF) from the early 1950s indicates that as early as 1952 UVM staff began using short sections of flexible plastic tubing in experiments to connect individual taps to single collection containers like pails and the King Sap Bags in conjunction with various volume- or pressure-measuring devices. It was clear that this use of tubing was not as a pipeline or gathering network; however, this use of tubing, even in short segments, does show that PMRF scientists like Fred Laing and James Marvin were aware of the properties and availability of flexible plastic tubing but had yet to put it to use on a greater scale.

[20] Griggs, *An Improved System for Maple Sap Collection*.

[21] Ibid.

[22] Ibid.

[23] As Burr Morse tells it, Griggs conducted some of his tubing research and experiments in the Morse sugarbush, which may have been part of the smaller-scale tests carried out before 1955, or may have been after 1955. With his home in Montpelier, the nearby Morse sugarbush was a convenient test site for Griggs, not to mention his taking advantage of discussing his ideas and progress with Harry Morse, a seasoned sugarmaker. In recognition of the contribution he made to the maple sugaring industry and his time working in the Morse sugarbush, the Morse family has installed a plaque in their sugarbush honoring and remembering Nelson Griggs. Burr Morse, "A Sugarmaker's Thank You," *Sugar Words: Musings from an Old Vermonter* (Montpelier, VT: Morse Farm Maple Sugarworks, 2012); Jackie C. Griggs, personal interview with author, 16 May 2017.

[24] "Pipeline Cuts Need for Sap Buckets at Guy Page Maple Bush in Waterville," *Burlington Free Press*, 1 April 1957, 13.

[25] Breen, *Personal Memoir*.

[26] Nelson S. Griggs, Sap Collection System, Canadian Patent 587304, issued November 17, 1959; Jackie C. Griggs, interview.

[27] "Nelson Griggs of Montpelier is Dead at 56," *Burlington* [VT] *Free Press,* 24 May 1971, 6; Nelson Griggs, Vermont Department of Health, Copy of Certificate of Death, May 22, 1971; Jackie C. Griggs, ibid.

[28] A significant portion of the George Breen story comes from two sources that are not always in agreement with each other. These are Greg Joly's "Epilogue" to the 2000 reissue of Helen and Scott Nearing's *The Maple Sugar Book,* 50th Anniversary Edition, and George B. Breen's undated *Personal Memoir.* Joly interviewed Breen a few years before he passed away in 2012 at age 92. Breen's undated personal memoir was written in his later years when, according to family members, his memory was such that his narrative was intact but he did not always get the details exactly right.

[29] There is some confusion and discrepancy as to the dates of things happening in the Nearing/Breen Forest Farm sugarbush around 1952 and 1953. Some sources say the Nearings sugared at Forest Farm for the last time in 1952 and then instructed the Breens on their first season in 1953 (Killinger, *The Good Life).* Other sources suggest that the Breens were in total control and began to experiment with tubing by the 1952 sugaring season (Joly, "Epilogue"). I think the safest interpretation is that the Breens had acquired the sugarbush from the Nearings in early 1952 and sugared with them in the 1952 season, learning the ins and outs of the process. For the 1953 season, the Breens were completely on their own and George Breen began more concerted experiments with tubing as a labor-saving device. According to Killinger (61), the Breens paid the Nearings $15,000 for 54 acres of farm and forest, including the stone buildings, on January 4, 1952.

[30] Sean Breen, personal interview with author, 19 May 2017.

[31] Ibid.

[32] Breen, *Personal Memoir.*

[33] Breen, *Personal Memoir*; Sean Breen, interview; "Maple Sap Pipeline: Vermont Farmer Collects Spring Yield Through Plastic Tubing," *St. Louis Post Dispatch,* 25 March 1956, 159.

[34] Joly, "Epilogue," 263-64.

[35] Breen, *Personal Memoir.*

[36] 3M first filed a patent application on February 1, 1957, then replaced that with a new application on January 24, 1958, which itself was also replaced with a final application on February 24, 1959, ultimately awarding George B. Breen and John E. Cahill U.S. Patent 3046698 on July 31, 1962. It received a Canadian patent for this design in 1965 (CA 699374). Efforts by the author to contact patent attorneys at 3M to see if the company retained any records related to patent interference or protecting this patent were unsuccessful. 3M submitted an additional patent design for a vented spout in 1959, awarded in 1962 (US 3057115 / CA 652576), but there is no indication this design was ever developed and sold commercially.

[37] "Plastic Tubes Boost Output of Maple Sap," *Stevens Point* [WI] *Journal*, 13 September 1957, 11; advertisement for "Mapleflo Brand Sap Gathering System," *Wisconsin Maple Syrup and Sugar Producers' Annual 1958* (Madison, WI: Wisconsin Maple Producer's Council, 1958), 6; *Le Bulletin des Agriculteur* (December 1958): 48.

[38] Breen and Cahill, U.S. Patent 3,046,698; "Instructions—How to Use the Mapleflo Brand Sap Gathering System." (Minnesota Mining and Manufacturing of Canada, LTD, n.d.).

[39] PMRF seasonal field notes on File at PMRC archives. The Mapleflo system was installed and tested at the PMRF in 1958, 1959, and 1960. In 1959, experiments compared the all-clear plastic tubing with the striped ¼-inch tubing. In 1960 the unvented and elevated Mapleflo system was tested side by side with Robert Lamb's vented, groundline Naturalflow system, and both were tested against traditional spouts and pails. The 1959 and 1960 seasons also saw the first PMRF tests of the use of a pump attached to the tubing to apply artificial vacuum to tubing. PMRF field notes also mention in both the 1959 and 1960 seasons that Russell Baker and Erwin Brown, representatives of 3M, visited to observe the testing setup. Sean Breen, interview; Frederick M. Laing and Earl L. Arnold, "Use of Vacuum in Production of Maple Sap: Progress Report," *Vermont Agricultural Experiment Station Research Report* MP64 (February 1971).

[40] Breen, *Personal Memoir*; Joly, "Epilogue," 263.

[41] Fred E. Winch, "Looking Back," *The Maple Syrup Digest* 1A, no. 3 (1989): 15-18; "Maple Syrup Men Two-Day Tour," *Democrat and Chronicle* [Rochester, NY], 27 July 1956; "Syrup Meeting Planned Today," *Democrat and Chronicle,* 13 December 1956. The date of 1955 for the start of Lamb's experiments with plastic tubing also appears in his obituary from the *Maple Syrup Digest*, "In Memorium: Robert Melvin Lamb," *Maple Syrup Digest* 9A (1997): 7. Accession notes for the Adirondack Experience museum collections of Lamb tubing materials also include a note that the system was invented by Lamb in 1955. The Lamb collection was donated to the Adiron-

dack Experience museum by the Studdiford family. Andrew Studdiford was a son-in-law of Bob Lamb.

[42] "Annual Sirup Meeting at Belmont is Well Attended," *Wellsville Daily Reporter* [Wellsville, NY], 21 December 1957, 6; "Maple Syrup Producers Discuss Work," *Troy Record* [Troy, NY], 28 February 1958, 19; *Lamb's Tubing System for Gathering Maple Sap—Pricelist—January 1, 1958*, A. C. Lamb & Sons, Liverpool, NY. courtesy of the Leader Evaporator Archives. "Syrup Maker's Supplies Advertisement for Reynolds Sugar Bush," *Wisconsin Maple Syrup and Sugar Producers Annual* 1958*,* 6.

[43] The company was started by Bob and Clifford Lamb's father, Ambrose C. Lamb, selling and servicing milk coolers in upstate New York. Later, Ambrose Lamb turned the business into a company that ran a marina and sold boats, along with selling and repairing chainsaws, pumps, snow machines, and boat motors. A. C. Lamb & Sons developed their own brand of chainsaws in the 1950s. For more information about the company see http://vintagechainsawcollection.blogspot.com/p/chainsaw-value.html. Adirondack Experience—The Museum at Blue Mountain Lake, photograph collections accession notes, catalog number 2007.051.044, photograph number P071370. The Adirondack Experience preserves an excellent collection of different examples of fittings, tubing, and photographs documenting Lamb Naturalflow system technology.

[44] "Lamb Naturalflow Maple Sap Gathering," *Pulaski Democrat* [Pulaski, NY], 5 February 1959, 10. The corporation in Québec was named "Naturalflow Maple Sap Plastic Tubing and Supplies, LTD" and was established in August 1963 by Richard J. Riendeau, Roy L. Heenan, and Rafe J. Plant. Notably, the Lamb name was not a part of the Québec corporation. *Official Gazette of Québec,* October 5, 1963.

[45] Lamb was awarded patents for at least four different designs, both in the U.S. and Canada, of tubing system components, setup and operation, and tubing itself. These were US 3156069 / CA 724365, US 3204370, US 3226883 / CA 731871, and US 4512104 / CA 1227043.

[46] *Maple Syrup Digest* 1A, no. 3 (1989): 21-23. With the partnership with G. H. Grimm, Bob Lamb worked his way into a phased retirement with the Grimm company taking over the manufacturing and sales. Bob Lamb passed away in 1997 followed by his wife Florence Lamb in 2001.

[47] "Maple Syrup Makers Begin Tree-Tapping," *The News Herald* [Franklin, PA], 3 March 1956.

[48] "2 Miles of Pipeline in Sauk Woods Take Maple Sap to Bottle Cooker," *The Capital Times* [Madison, WI], 2 April 1955; Peter D. Weber, "Wisconsin Maple Products: Production and Marketing," *Wisconsin State Department of Agriculture Bulletin* 335 (1956): 36.

[49] "Modern Methods Revolutionize Sugaring but Oxen Still Useful," *Burlington Free Press,* 17 April 1956; "Ex Hartford Minister Tries Sappy Stunt and Finds that Maple Sugaring Defies Automation," *Hartford Courant* [Hartford, CT], 6 March 1960, 7.

[50] One can make some qualitative inferences from production numbers in some of the census data and attempt to extrapolate some idea about the role of tubing, but the reality is that understanding changes in syrup production (such as changes in the gallons of sap or syrup per tap) is much more complex with a variety of factors involved, including the adoption of other new technology, the weather, and the relative size of an operation.

[51] Lloyd Sipple, "A Cost Account of Plastic Tubing vs. Buckets for Sap Collection," *Report of Proceedings, Fourth Conference on Maple Products*, USDA Eastern Regional Research Laboratory (1959), 29-31; Neil K. Huyler, "Tubing *vs*. Buckets: A Cost Comparison," USDA Forest Service Northeastern Forest Experiment Station, Research Note NE-216 (1975); Neil K. Huyler, "Economics of Maple Sap and Syrup Production: Sap Collection Systems," *Sugar Maple Research: Sap Production, Processing, and Marketing of Maple Syrup*, USDA Forest Service Northeastern Forest Experiment Station, General Technical Report NE-72 (1982).

[52] Barton M. Blum, "Plastic Tubing for Collecting Maple Sap: A Comparison of Suspended Vented and Unvented Installations," *U.S. Forest Service Research Paper* NE-90 (1967).

[53] Laing and Arnold, "Use of Vacuum in Production of Maple Syrup."

[54] Réjean Bilodeau, *L'historie de l'acériculture et des sucriers du Bellechasse: berceau technologique modial acéricoles, 1716-2016* (Saint-Damien, Québec: Réjean Bilodeau, 2016).

[55] "Promotion de l'acériculture*," Le Courrier de St. Hyacinthe,* 26 June 1974; "Québec accorde une aide á la modernization de érabliéres," *Le Soleil,* 29 August 1978; "Les produits de l'érable: Un secteur de L'avenir," *L'Artisan,* 23 May 1979; Monique Brunelle-Ferland, "La mise en marché n'a pas suivi le boom de la tubulure," *Le bulletin des agriculteurs* (January 1981): 34-40; Lewis J. Staats, "'Milk Can' Vacuum Dump Unit," *Maple Syrup Digest* 11, no. 1 (1972): 19-21.