A Short History of Man's Attempts to Move Through Snow

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Man's early need to move in a snow-dominated environment merely required his remaining on the surface. The use of skis undoubtedly began in ancient times, and Stone Age carvings on rocks in northern Norway are the most ancient images of skiers known. Remnants of skis unearthed in Lapland have been dated from 6000 BC by analysis of pollen sticking to them. The early skis were not attachments to shoes or boots, but rather were elongated boots into which the foot was thrust at the rear. Snow did hamper military operations, but provided the surprise for Hannibal in 216 BC to overcome a superior force when he crossed the Alps in early winter contrary to what the enemy thought possible. History is replete with the effects of snow on man's activities and on his battles. Some of the forces to which men were subjected on the North American continent, and their responses to them, form the substance of this brief review of snow removal technology.

In spite of the great influence snow has had through the years on military operations, military requirements historically have not played a significant role in the development of snow removal techniques and equipment. Cities in snow areas had to cope with snow as best they could, using sleighs for transport and later wedge-shaped plows towed behind teams of horses or oxen. The life of cities at times slowed greatly during bad winters. Cotton Mather, the outspoken American clergyman, was moved to deplore the elements that kept his church empty for 2 consecutive Sundays during Boston's snowy winter of 1717. The need to move readily and for any distance was not a great necessity for the mid-nineteenth century city-dweller either. Indeed, the poet of 100 years ago (11) could write:

> O the snow, the beautiful snow,
> Filling the sky and the earth below.
> Over the house-tops, over the street,
> Over the heads of the people you meet,
> Dancing,
> Flirting.
> Skimming along,
> Beautiful snow, it can do nothing wrong.

This sentiment was not voiced by those who built the Central Pacific Railroad from Sacramento east over the Sierra Nevada Mountains in California to meet the Union Pacific at Promontory Point, Utah, in May 1869. During the first winter of construction in 1865-66, thousands of laborers fought to keep the completed portions of the railroad clear of snow by hand shoveling. Many of the locomotives were equipped with pilot plows, wedge-shaped sheet-iron devices attached to the cowcatcher and commonly used on eastern railroads where they proved adequate. They were not adequate to cope with the heavy western snows, however, so a heavy wedge or "bucker" plow was constructed in the Sacramento shops of the Central Pacific in 1866. This first attempt was mounted on 2 ordinary freight car trucks and weighed 12 tons. The wedge flared up at an angle of 45 deg, and then flared outward. In action during its first winter, three 36-ton locomotives pushed the plow into the snow at full speed and kept going until stalled by snow higher than the plow. Men wielding shovels then had to clear the tracks behind the plow before it could be backed out of the cut. Many derailments showed that the plow was too light to hold the rails, so its weight was increased to 19 tons by the addition of pig iron. This heavier plow sometimes required as many as 12 locomotives to drive it through high drifts.

A large crew of men was still carried with the heavy bucker plows to shovel out snowsheds, which had been built in slide areas, and to shovel out the plow itself when it all too frequently got stuck, and sometimes derailed.

The inadequacy of the bucker plow led some to think of better ways of cleaning track. A Toronto dentist, J. W. Elliot, had patented a "Revolving Snow Shovel" in 1869 and built a small hand-operated model, but had never done more to promote his idea. In the same year, and independently, Charles W. Tierney of Altoona, Pennsylvania, received a patent for a mechanical snow removal device consisting of a revolving screw feeding snow into a large rotating fan, the whole mounted on a flatcar and driven by a stationary steam engine. Tierney built a model but was unable to interest any railroad. The first full-scale mechanical plow was the Hawley, exhibited at the Centennial Exposition in Philadelphia in 1876. This consisted of a large vertical screw into which snow was fed through a funnel-shaped casing in front. It proved a total failure when tried by the Canadian Pacific (1).

Others were working on new ideas, however. In 1883 Orange Jull, the mechanically talented owner of a flour mill in the village of Orangeville, Ontario, conceived the idea of mounting a large rotating fan on a railroad car to chop up the snow and cast it aside. Rather than make a model, he interested John S. and Edward Leslie, brothers who operated a machine shop in Orangeville, in building a full-sized operating machine. Jull's original idea was to mount a cutting wheel rotating at high speed in front of a rotating fan wheel; snow would be cut by the knives on the front wheel and fed to the fan, which would cast the snow to the side through an opening in the housing. The Leslie brothers advised Jull to patent his plow, which he did in 1884, assigning the rights to the Leslies who agreed to pay royalties if the "Rotary Steam Snow Shovel" were successful.

The Canadian Pacific became interested in Jull's plow and lent assistance in its construction and subsequent test. The first trials showed that the snow-casting wheel should be reversible so snow could be cast in either direction. This modification was quickly made and appeared satisfactory, so a new plow was built embodying these changes. During the first use in heavy snow in Wyoming during the winter of 1885-86, the machine was unable to overcome the forces developed by the snow moving between the counter-rotating wheels. The Leslies dropped the 2-wheel scheme and adopted a single, reversible fan wheel with reversible cutting knives mounted on trunions on the forward part (Fig. 1). This design proved immensely successful, and orders poured into the Leslies, who by now were having the machines built by the Cooke Locomotive and Machine Works in Paterson, New Jersey. This design has not been radically changed to the present day.

This is not the end of the fascinating story of railroad snow removal and of Orange Jull. Jull and the Leslie brothers disagreed on financial matters and parted company. Because he had assigned the basic patent to the Leslies, he decided to design a completely different device. The resulting "Centrifugal Snow Excavator" was shaped like a huge auger that fed snow to a rotating fan wheel as in his earlier design. Jull formed his own company to manufacture this plow. Altogether he made and sold 10 Excavators. Competitors such as Caldwell's "Cyclone Steam Snow Plow" made claims that had to be disproved in actual track clearing tests, but no plow was as successful as the Leslie machine.

Snow removal practices in cities developed rapidly in the years shortly after the turn of the twentieth century. The key to snow disposal plans in many cities was the use of sewers for flushing away snow hauled or pushed to manholes. Both Pittsburgh and New York City developed these techniques to a high degree, as did a number of smaller cities in the eastern United States, even to the extent of installing water jets in the walls of some manholes to assist in the flushing action. It was found that 2 cu yd/min was the maximum rate snow could be shoveled into a 24-in. manhole without plugging (2). Horse-drawn wedge plows and horse-drawn carts were the extent of the equipment available, and armies of men wielding shovels were the backbone of the snow removal forces. In a February 1914 heavy snowfall in New York City, for instance, over 12,000 men were deployed to man the shovels. Motor trucks for hauling and for pushing small blade plows began to make their appearance around the beginning of the second decade. They lacked traction and power, and not infrequently had to be hauled

Figure 1. Leslie-type rotary snowplow used in 1890 on lines of the Southern Pacific Company in the Sierra Nevada Mountains. (Photograph courtesy Southern Pacific Company.)

out of drifts by teams of horses. The horse-drawn plow was still the main piece of equipment well into the second decade. In fact, New York City used practically no mechanical equipment until the winter of 1920-21, when 212 5-ton 6-cu yd trucks (White), 100 2-ton 3-cu yd trucks (Mack), 600 tractors, 150 towed blade graders, and 300 blade plows were first used (3).

At a snow removal conference held in 1914 in Philadelphia, one of the earliest on record, one engineer stated that "the same old cart-and-horse methods of snow removal seem to be used that were adopted when the problem became serious some twenty years ago." In his opinion, snow melting devices offered the most likely possibility for improving snow removal practices (4). A lady engineer present (Dr. Marie D. Equi, Portland, Oregon) said she was convinced that engineers were clever enough to invent a device like a steam-heated concrete mixer that would solve the snow removal problem once and for all (5).

It was reported at the Philadelphia snow removal conference that salt was then extensively used for snow removal in Liverpool, London, and Paris. Salt alone was spread on city streets during and immediately after a snowfall, and after the snow had been reduced to a slush by melting and by traffic action, the streets were flushed with water and the slush washed into the sewers. The conference doubted that this practice would ever be successful in the United States because of the heavier snowfalls, and also because the Society for Prevention of Cruelty to Animals raised serious objection to the use of salt. In some cities its use was actually prohibited by ordinance.

The years between 1920 and 1929 marked the most rapid change in snow removal technology on highways. Passage of the Federal-Aid Road Act by the United States Congress in 1916 authorized the federal government to give states financial aid for highway improvement. The piecemeal development of the national highway system was replaced by an integrated road network as a result of legislation passed in 1921 requiring that a federal-aid system be designated and that all federal assistance be concentrated on it. The demand for complete removal of snow from roads grew yearly, and the need for bigger, more capable equipment and better techniques became apparent.

During these years blade plows became bigger and heavier, truck plowing speeds increased from less than 5 to 30 mph or more as power and weight increased, trucks became the most important tool in snow removal (though tractor or horse-drawn wedge plows continued to be made into the 1930's), and rotary plows were developed or adapted for highway use (Figs. 2, 3, and 4). The most common type of rotary plow was the so-

Figure 2. Straight blade snowplows attached to truck in use in 1925 (12).

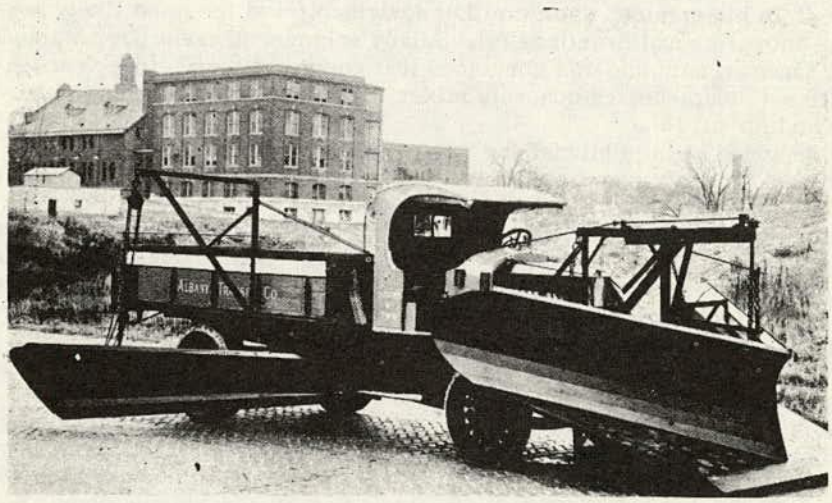

Figure 3. Displacement snowplow mounted on truck used in central and northern New York in 1926 (13).

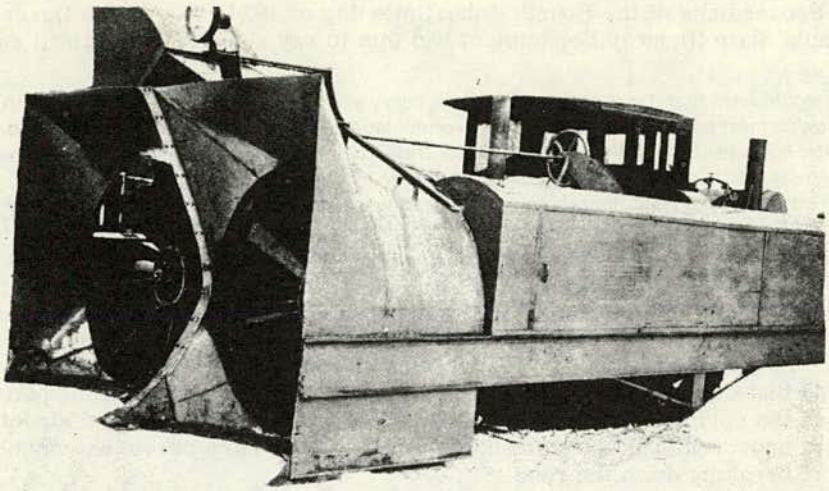

Figure 4. Front-type rotary snowplow mounted on heavy tractor in use in 1926 (13).

called lateral rotary, in which the axis of the rotating elements (usually there were two) was normal to the direction of travel (Fig. 5). The plow, using horizontal augers to feed snow to a centrally located impeller, was developed in the middle of this decade and is one of the few designs of that era to survive to the present day (6, 7, 8).

The first consideration of snow and ice control on highways by the newly organized Highway Research Board occurred at the Second Annual Meeting in November 1922. The Third Annual Meeting Proceedings of November 1923 refer to a proposed study of snow removal to be made by the U.S. Bureau of Public Roads, and also carry the statement that "the committee believes that further research is necessary on this subject, particularly with the end in view of developing snow-removal equipment for highway work" (9).

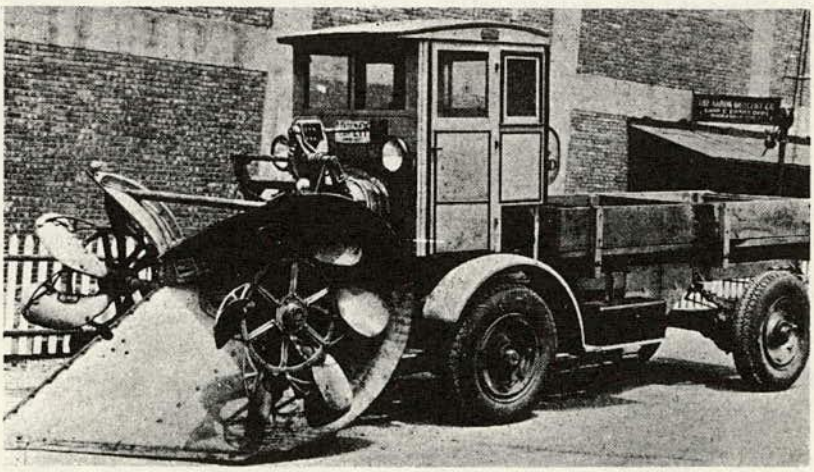

Figure 5. Lateral-type rotary snowplow suitable for mounting on truck used in New York in 1927 (14).

In the Proceedings of the Fourth Annual Meeting of 1924, W. A. Van Duzer of the Pennsylvania State Highway Department had this to say about snow removal equipment:

> It would seem that it is generally agreed that heavy equipment, i.e., caterpillar tractor with V plow, is most practical for moving heavy accumulations of snow, say in excess of 24 inch depth. Lighter equipment, typically 3 to 5 ton motor truck equipped with straight blade of moldboard pattern, is most economical and efficient for moving lighter accumulations of snow.
>
> In estimating the limitations of equipment as above, 24 inches is assumed as the maximum occasional limit for the truck plow; that is, the truck plow is recommended for light work and for occasional drifts up to 24 inches, but the truck and straight blade is not considered adequate for long distances of 24-inch depth.

Even by 1925 highway engineers were debating the value of snow removal from rural highways. Two objections were offered: that the cost of the work exceeded the benefits gained, and that clearing the road of snow increases frost action with intensified heaving resulting in the spring. On the other hand, some advantage to the road structure resulted from snow removal because snow on roads led to cars developing narrow tracks with rutting breaking down the road (8).

Prior to 1941 it was the usual practice to spread chloride-treated sand on compacted snow or ice-covered pavements. Enormous quantities of abrasive materials were required when all roads were sanded rather than only curves, hills, and intersections. Experiments were begun in New Hampshire in February 1941 using sodium chloride alone as an ice preventive. In accord with earlier practice, it was considered desirable to clear the center of a 2-lane road for a width of at least 6 ft. This was accomplished by spreading course-crushed salt at the rate of ¼ lb/sq yd for a width of about 2 ft along the centerline immediately after completion of snowplowing. The equipment used in this early work was open-bed stake or dump trucks hauling bagged chemical, requiring a workman to load the funnel of a gravity-feed salt distributor. Though the comparison is subject to some simplifications, the cost of snow removal and ice prevention in the winter of 1944-45 in which nearly all straight salt was used for ice control was about $260 per mile, compared with $312 per mile in the winter of 1940-41, the last winter in which abrasives were used exclusively. Moreover, the average snowfall was 18 in. greater in 1944-45 than in 1940-41 (10).

I have dwelt at length on railway and city snow clearance because of its importance in the historical development of snow control technology. This review is necessarily spotty, and I must leave to others more detail of the important work that has been carried out in the United Kingdom, Europe, Scandinavia, Japan, and Russia.

But from this overview I think you can see that the technology of snow control today is not much different from that of earlier days I have described. In a sense we are still in the "cart-and-horse" days decried at the 1914 Philadelphia conference. Let us not substitute quantity for innovative ideas. It is the purpose of this Symposium to describe today's new approaches, and to stimulate tomorrow's.

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