NPS Form 10-900-b
(Jan 1987)

OMB No 1024-0018

RECEIVED
MAY 24 1990
NATIONAL REGISTER

United States Department of the Interior
National Park Service

National Register of Historic Places Multiple Property Documentation Form

This form is for use in documenting multiple property groups relating to one or several historic contexts. See instructions in *Guidelines for Completing National Register Forms* (National Register Bulletin 16). Complete each item by marking "x" in the appropriate box or by entering the requested information. For additional space use continuation sheets (Form 10-900-a). Type all entries.

A. Name of Multiple Property Listing

Grain Elevator Design in Minnesota

B. Associated Historic Contexts

Grain Elevators in Minnesota to 1945

C. Geographical Data

State of Minnesota

☐ See continuation sheet

D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards for Planning and Evaluation.

[signature] Date 5/17/90
Signature of certifying official Ian R. Stewart
Deputy State Historic Preservation Officer
State or Federal agency and bureau Minnesota Historical Society

I, hereby, certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

Beth Boland
Signature of the Keeper of the National Register
Date 7/5/90

E. Statement of Historic Contexts

Discuss each historic context listed in Section B.

[X] See continuation sheet

E. STATEMENT OF HISTORIC CONTEXTS

HISTORIC CONTEXT: Grain Elevators in Minnesota to 1945

Outline:

PROLOGUE. SACKED-GRAIN STORAGE: The Flathouse
I. ELEVATOR FUNCTIONAL TYPES: Terminal and Country Elevators
II. ELEVATOR OWNERSHIP IN MINNESOTA: Line, Farmers', and Terminal Elevators
III. STRUCTURAL MATERIALS USED IN GRAIN ELEVATORS: Wood, Steel, Tile, Brick, Reinforced-Concrete
IV. NOTES
APPENDIX. GRAIN ELEVATOR TERMINOLOGY

PROLOGUE. SACKED-GRAIN STORAGE: The Flathouse

A widely used early form of grain storage construction was the flathouse, which was nothing more than a generic one-story, gable-roofed, wood-frame warehouse, in which sacked grain was stored.[1] In Minnesota, the flathouse was a very common storage facility during the early railroad years when grain was shipped by river transportation. In 1862, Winona--the state's largest wheat market--had thirty flathouses with capacities ranging from 5,000 to 100,000 bushels. The essential element in the flathouse story is a negative one; the flathouse is a flat house and not an elevator. As the elevator, designed for bulk grain, emerged, the flathouse, designed for sacked grain, declined. The flathouse was doomed by the railroads, who disliked handling grain in sacks, and "offered free sites and special privileges to companies to build beside their tracks specially designed wooden structures capable of receiving storing and shipping grain in bulk lots."[2] This observation, from a Canadian source, is somewhat confirmed for Minnesota by grain-industry historian Henrietta Larson, who wrote: "When the railroads did not provide elevators, the grain was received, stored and shipped from flat warehouses".[3] A Canadian historian reported that the first country elevator in Western Canada was built in 1879, and its construction was directly related to the coming of the railroads. Available figures for Canada are instructive: Canada had 126 flathouses in 1900, 26 in 1910, and by the twenties they were gone.[4] On the other hand, Canada's elevator population rose from the aforementioned one in 1879, to 90 in 1890, and a whopping 5,746 in 1934.[5]

It would make a neat and tidy grain elevator story if the origins of vertical, wood-elevator-storage construction were well known. Unfortunately, the early history of the wooden elevator is not clear. The reported "first" elevator of any type was Joseph Dart's 1842 wooden elevator in Buffalo, New York. Little seems to be known about its structural design, and the few descriptions of it focus almost entirely on its equipment and the technology of moving grain by elevating it via bucket conveyors. This involved devices that Dart borrowed from Oliver Evans.[6] The date of the first elevator of any type built in Minnesota is not known, but the first terminal elevator in Minneapolis is reported to be one erected by the Union Elevator Company in 1867 along the Chicago, Milwaukee, and St. Paul Railway tracks.[7]

I. ELEVATOR FUNCTIONAL TYPES: Terminal and Country Elevators

Introduction

All grain elevators do two things with grain: they "handle" grain, by moving or transporting it within the elevator, using elevating and conveying equipment, and they store grain, by keeping it in storage bins. Some elevators store great quantities and some store little. Some elevators are designed primarily to handle grain at high speed, and have little storage function. These different functional emphases, coupled with different sizes and locations, create categories of grain elevators. Historically, this has produced the two major functional types of elevator, the terminal elevator and the country elevator. There are several lesser types.

Elevator functional types relate to the position of the elevator in the general flow of grain from production to consumption. The most recent comprehensive text on elevator design and construction, outlines this as follows:[8]

1. From farm harvest to farm silo (storage and drying; transfer to truck or wagon)
2. Unloaded at country elevator (transfer to rail/truck/barge)
3. Unloaded at inland terminal elevator (transfer to larger rail, larger barge, or ship)
4. Unloaded at receiving elevator at processing plant (consumed) or export terminal elevator (transfer to ship)
5. Unloaded at import terminal elevator (transfer to rail/truck/barge)
6. Unloaded at receiving elevator at processing plant (consumed)

The major elevator types in this flow are the country elevator and the terminal elevator; secondary types are the receiving elevator and, between several of the stages above, the highly specialized transfer elevator and cleaning elevator. A receiving elevator stores grain for a processing facility, such as a mill or brewery. A transfer elevator is an elevator facility that is designed for maximum handling capacity with minimum storage. A cleaning elevator is designed for maximum cleaning capacity with minimum storage. For this study, the farm silo is considered to be part of a farm complex and will not be considered as a formal grain elevator.

Since all elevators are involved in both handling and storage, these general functions have particular application in the world's flow of grain as outlined above. Here, "handling" may be viewed as "transfer." The country elevator receives grain in small wagon and truck lots (100-150 bu.) and transfers it into railcar lots (boxcar, 2,000 bu.; hopper car, 3,000 bu.). The terminal elevator receives the railcar lots and transfers the grain into barge, ship, or other railcar lots. The receiving elevator receives the truck or railcar lots and breaks them down into smaller batches for the processor. Each stage along the way may include short- or long-term storage and other auxiliary services, which are detailed below.

These types of elevators have a variety of detailed financial and economic functions within the complex world of grain trading. The economic complexities will be touched upon while discussing other elements, but the details and intricacies will not be explicated here, since the focus remains on structures and historic preservation.

Terminal Elevators

Although the terminal elevator does not come first in the flow, it generally comes first in discussions of grain elevators because it is by far the largest and most complicated of the elevator types. It is complicated in terms of structure, function, and equipment. While sharing many design characteristics with other terminal elevators, each is unique and specially designed by engineering professionals. Terminal elevators, unlike some country elevators, usually are not built to a standard plan.

Terminal elevators have been carefully described by Cargill, Inc.'s J.E. Bailey in his 1954 discussion of the type:[9]

--Terminal Elevator Functions

1. Storage: "The prime function of a terminal elevator is the storage of cereal grain between its production and consumption. . . . Each bin may be large enough to store the annual produce of 100 farms, and to keep it safely through the months between harvest and the time it is sold to processors."

2. Improving quality: "Quality may be improved in many ways. Grain received by a terminal may be dried, cleaned, washed, separated, or sized in order to make it more attractive to the processor. Various grades and qualities may be collected, sorted, and blended. Large lots of uniform quality to meet specific processing needs may be accumulated. Insect infestations may be controlled, incipient heating or spoilage arrested, and lots that cannot be stored safely may be moved toward immediate consumption."

3. Serving the marketing process: "It always stands ready to receive grain for which there is no immediate need, thus equalizing supply and demand. It stands ready to supply the needs of the miller, maltster, manufacturer, or distiller whenever daily arrivals in the market place are insufficient. It holds parcels of grain which can be transferred from seller to buyer by endorsement of warehouse receipts. It moves grain from one mode of transportation to another, as desired; from truck into boxcar, from car to steamer, from steamer to canal barge, from barge to ocean liner. It provides a place for the storage of grain delivered in fulfillment of future contracts." In addition, the terminal operator assumes a large part of the risk from

losses due to deterioration during storage; when the elevator owns the grain, it assumes market risks. Finally, the terminal elevator provides a public warehouse for producer and/or owner of grain.

--Terminal Elevator Location

According to Bailey, "terminal elevators are usually located in terminal markets, at large rail centers, or at points of transfer from one method of transportation to another. Terminal elevator storage capacities tend to accumulate in the path of the flow of grain from large producing areas to large consuming areas. For that reason they are found predominantly to the east of the Great Plains areas in the United States and Canada, and at the export and import harbors."[10] When dealing with a potentially historic terminal elevator, therefore, a considerable part of its significance will derive from its involvement in the larger world of grain transportation and geography.

--Terminal Elevator Size and Capacity

Although terminal elevators are defined by function rather than size, they are the largest elevators, with capacities over 100,000 bushels, and running into the millions of bushels. Historian Banham thought that Buffalo's Concrete Central Elevator (1915) at 4 1/2 million bushels was one of the largest elevators ever built.[11] In 1928 however, the great Saskatchewan Pool Terminal No. 7 was constructed and, at 7,000,000 bushels, was the largest elevator built to that time.[12] Rated capacity can be deceptive when studying structures, though, since it is often reported to be the capacity of an "elevator" when it actually is the total capacity of a "complex," with its various additions and annexes. Equally misleading is individual bin capacity, because a single elevator structure can--and in fact should--have a selection of bins in different sizes to accommodate the varieties of grains stored. Bin capacity can range from 500 to 10,000 bushels.[13]

--Terminal Elevator Ownership

Being extremely large, expensive, and indispensable structures in the world food chain, the ownership is important. Terminal elevator ownership is categorized as follows:

1. Government agencies: where elevators are desirable in marketing channels but no private capital is available; they may be leased to private operators.

2. Transportation agencies: owned by railroads, for example, to induce movement of grain on their own lines.

3. Warehouse owners or grain merchants: that is, companies devoted to the storage and/or marketing of grain, such as Cargill, Inc.

4. Processors: the elevator is attached to or is near plants, such as flour mills, so they may have a supply independent of source, market, or transportation fluctuations.

As with location, ownership may play a role is the determination of an elevator's significance.

--Terminal Elevator Typology

In the early twentieth century, elevator engineer Milo Ketchum divided terminal elevators into two basic types, based on the arrangement and association of the storage area and the working area. The first type included "elevators which are self contained, with all the storage bins in the main elevator or working house, as for example, the Great Northern Railway steel elevator, West Superior, Wis." The second type included "elevators having a working house containing the elevating machinery, while the storage is in bins connected with the working house by conveyors, as for example, the Independent Elevator, Omaha, Neb."[14] This categorization was picked up by another engineer, Albert E. Macdonald, in his 1929 series of articles on elevator design. Macdonald added that the second type, with the two separate units, had the advantage of being easily augmented with additional storage annexes.[15]

To understand Ketchum and Macdonald simply, one might imagine that the first category is a giant version of a country elevator, where the bins are clustered below a cupola containing elevating and distributing machinery. In a terminal version, the cupola becomes the workhouse, and the bin unit becomes as large as anyone wishes to build. If the bin unit grew beyond the reach of distributing spouts, then a conveyor might be used. The second category can be viewed as a giant descendant of the Chase elevator (discussed under wooden elevators, below), with a workhouse standing at one end of a row or block of bins or tanks, whether they are wood, steel, concrete, brick, or tile.

The two types often resulted in structures of very different appearances. Historic photographs of large, early grain elevators sometimes depict huge, dark, rectangular boxes with towering windowed structures on top, which sometimes resemble rooftop monitor structures that have grown out of control. At times the upper structure, which is the workhouse, has unusual sloping sides. These elevators are examples of the first category, and they produced structures that resemble no other building type. The second category is the one almost universally seen today among terminal elevators, with a rectangular workhouse standing next to a bin block or structure.

An 1887 sketch of the Duluth harbor grain elevators depicts three long dockside rows of elevators, a total of 14 structures, and every one of them is clearly of the category one terminal elevator type, with the two- to four-story, full-length workhouse sitting above the rectangular storage-bin unit.[16]

Three decades later, elevator designs had changed. In 1920, the Grain Dealers Journal published a poster-like supplement to its September 25 issue, entitled "The Grain Handling Facilities of Minneapolis." It reproduces photographs, along with thumbnail descriptions, of 68 elevators in operation at that time. The supplement affords a fine opportunity to view terminal elevators of all types and sizes, since the Twin Cities constituted one of the largest collections of terminal elevators in the nation, and in 1920 most of the early elevators remained in use, alongside the newer, post-1900 examples. Of the 68, the following clearly are of category one: Atlantic, Devereux, Diamond, Dibble, Empire, Gee, Godfrey, Interior, Midway, Monarch, Shoreham, and Union. Only the Shoreham elevator remains today.[17]

A variation on the above categorization was offered by Joseph LaPray in his 1980 article on terminal elevators. LaPray's four categories are termed "generations," and add a chronological dimension. Two of his four are similar to the two above:[18]

1. First Generation Elevators: These are terminal elevators without horizontal conveyor, but with a spout distributor instead. "A scale could only discharge grain into the handful of bins within reach of its spout. Because an expensive scale and cleaner had to be installed for every few bins, first generation elevators had a very high construction cost per bushel of storage capacity." LaPray reported in 1980 that the only "first generation" terminal elevator left in Minneapolis was St. Anthony No. 2, since razed.

2-A. Second Generation Elevators (Type One): ". . . a first generation-type elevator equipped with a conveyor belt running through the first story of the cupola. In turn, the conveyor belt ran out over the top of an annex of bins built onto one end of the elevator." LaPray reported that the 1894 Shoreham elevator was the last "second generation, type A" left in Minneapolis.

2-B. Second Generation Elevators (Type Two): ". . . featured a more modern 'headhouse' at one end of the building. This headhouse contained the legs, scales and cleaners just as the cupolas did for the older style elevators. However the old fashioned cupolas ran lengthwise on top of the building and the new headhouses ran the width of the building. This arrangement provided more storage space without increasing the exterior dimensions of the structure." LaPray reported that the last example of second generation type-two with a true headhouse was St. Anthony Elevator No. 1, since razed.

3. Third Generation Elevator: LaPray's discussion is unclear at this point, but the third generation seems to be a non-wooden elevator.

The fourth generation elevators are more recent than the end date of this study:

4. Fourth Generation Elevator: These elevators are operated by remote control, with an electronic nerve center located in an office building at a safe distance from the storage unit, thus keeping workers out of the dangerous, explosion-prone environment.

Country Elevators[19]

In contrast to the massive and complex terminal elevator, the country elevator is relatively small and simple. As indicated in the general flow sequence above, the country elevator's function is to receive grain from the farmer/producer in wagon or truck lots and ship it to the terminal elevator via rail in railcar lots. It will have more or less of a storage function, depending on the flow of grain in the market. It will have little to do with grain cleaning and treating.

--Country Elevator Functions[20]

1. Storage: Elevators located in out-of-the way areas having little annual throughput offer farmers storage capacity at a fixed rate for, say, six months, and then a certain monthly rate.

2. Shipping: Country elevators offer various shipping arrangements for farmers who want to ship a carload of grain themselves, but need loading facilities.

3. Treating: They provide some cleaning and drying facilities.

--Country Elevator Size and Capacity

Although country elevators are at the small end of the capacity spectrum of elevators, generally having total capacities of 25,000 to 35,000 bushels, they are built up to 100,000 bushels and over. A large country elevator can be larger than a small terminal elevator, so while capacity is generally a clear indicator of functional type, it is not absolute.

--Country Elevator Ownership[21]

1. Independent or privately owned elevators: owned and operated by individual grain dealers.

2. Co-operative elevators: may be owned and operated by co-operative associations, such as the various Farmers' Elevator companies.

3. Line elevators: chains of elevators owned by a grain company, a mill, or other grain processor, and usually located along a railroad system.

II. ELEVATOR OWNERSHIP IN MINNESOTA: Line, Farmers', and Terminal Elevators

Introduction

An important dimension to the subject of country elevators has always been their ownership. Elevator ownership actually is a reflection of the debate over who controls grain sales and prices, the seller (the farmer) or the buyer. This, in turn, is part of a much larger debate in political and economic history, which influenced politics in Minnesota and the nation. The following discussion, however, is limited to the ownership of the elevators themselves. Country elevator ownership, as described in the previous section, is divided into four basic categories: line elevators, farmers' (cooperative) elevators, independent elevators, and mill elevators. Most elevators fall under the first two categories.

Line Elevators

Henrietta Larson has defined the "line" as "a group of country elevators, sometimes having storage at primary points, which is under one central management." Buyers at individual elevators were strictly agents of the line and were obligated to follow all of the line's instructions. The line type of elevator emerged as the dominant type of country elevator in the mid-1870s, following the depression of the early 1870s. Prior to that time, railroads had provided storage, but the depression forced financial retrenchment of the roads and control of the grain trade passed to local middlemen, the strongest of whom became line operators. Larson found three types of lines in Minnesota between 1876 and 1885: (1) the line engaged exclusively in public storage, (2) the mill line, and (3) the merchant line.[22]

During the 1876-85 period, there were a number of southeast Minnesota mill owners of elevators, including: L.C. Porter, Winona Mill Co., Hubbard Mill, Empire Mill, Eagle Mill, and several others, located on the Winona and St. Peter Railroad; Ames of Northfield and Archibald of Dundas, on the Iowa and Minnesota division of the Milwaukee road; and others on the Southern Minnesota, the Hastings and Dakota, and on the river division of the Milwaukee.[23]

By 1882 there were several important line companies in southeast Minnesota, including Hodges and Hyde, and the Cargills, both out of La Crosse, on the Southern Minnesota. Sometimes they were located at the same station, but usually at alternate stations. The largest line operator in southeast Minnesota was George W. Van Dusen of Rochester, who bought several railroad elevators from the Winona and St. Peter in 1873 and established the first merchant line in Minnesota. He also owned one of the largest elevators in Minneapolis, where he sold much of his grain. Most of the southern Minnesota lines, however, marketed their grain in Chicago, following the railroads.[24]

Lines in northwestern Minnesota were considered very powerful. There were only two lines on the Northern Pacific Railroad, Fargo's Barnes and McGill, and A.J. Sawyer of Jamestown and Duluth. In 1882 a group of millers bought Barnes's share in Barnes and McGill and reorganized it as the Northern Pacific Elevator Company, a Minneapolis line.[25]

On the St. Paul, Minneapolis and Manitoba, the first line was the Delano, Davison and Kyle, the last public storage line in the state, meaning that it did not buy and sell wheat. In 1882 it was purchased by Pillsbury and other millers. Developing in the 1870s was the Pillsbury and Hurlbut, which soon became the most powerful line in the state. In the late 1870s the Northwestern Elevator Company was organized by 30 independent elevators to oppose the domination of the Delano, Davidson, and Kyle.[26]

The railroads began to dictate the size and location of elevators along their right-of-way, with the Manitoba in 1882, and the Northern Pacific soon after, requiring that they would not accept grain from an elevator with less than a 30,000-bushel capacity. The railroads also claimed exclusive right to grant requests for sites for new elevators. Finally, the railroads attempted to control the elevators through rebates, which usually went to the larger lines.[27]

In general, the railroads and the line companies, along with the Millers Association, a very powerful buying group of Minneapolis, completely controlled the country elevator situation until the emergence of the early farmers' cooperatives in the mid-1880s. Controls on the railroads and warehouses were first established in 1885 legislation, responding to calls for reform by farmers and particularly the Farmers' Alliance, which gained control of the state legislature in 1884.[28]

Farmers' Elevators

A "farmers' elevator" is simply a cooperative elevator where the co-op owners are farmers who have joined together to market their grain, thus sharing expenses and risks while maximizing their control over the selling process. It is "cooperative" as opposed to an elevator owned by a profit-making entity, whether a line company, mill company, or independent owner, that does not have democratically shared ownership. A cooperative generally is considered to involve three essentials: the one-man-one-vote principle, the limitation of the amount of stock that one member may own, and the patronage or pro-rata dividend.[29]

The earliest farmers' cooperative organization established in Minnesota to deal in grain was created in the mid-1860s in Goodhue County. A decade later, in the mid-1870s, elevators and mills were organized by Granges. The elevators appear to have been unsatisfactory ventures and the last was discontinued in 1878.[30]

The next emergence of the cooperative movement in elevators came in the mid-1880s, with numerous co-op elevators established along the state's railroad lines. Some were successful and some were not, but most were small, flathouse operations, and were not particularly influential or trend-setting, compared to later farmers' elevartors.[31] Between 1876 and 1889 only 10 farmers' elevators were organized that remained in operation by 1915, and this refers only to the organization, not necessarily to the elevator building itself.[32]

Beginning in 1890 there were major political ramifications to the farmers' movements, which, in their larger manifestation constituted agrarian discontent and populism. Political parties and candidates, from local through national elections, rose and fell as a result of the changing agrarian-political scene. Legislation in the 1890s began to shift some power from the line elevators to the farmers' elevators.[33] Between 1890 and 1899, 20 farmers' elevators were established that remained active in 1915.[34]

At the end of the 1890s, additional legislation further advanced the position of the farmer in the grain market. In 1897 an act gave the railroad and warehouse commission power to investigate rates and recommend changes on their own initiative without any complaint having been made.[35] In 1898 an act provided for popular election of the members of the commission.[36] And in 1899 an act further limited the roads by requiring that they secure the commission's permission before they could raise rates.[37] In short, according to Henrietta Larson, private control (railroads and warehouses) was decreased and voter-determined state control (railroad and warehouse commission) increased.

About the same time that state control over private grain agencies was increasing, the farmers' cooperative marketing efforts--the farmers' elevator organizations--also were growing. "The next phase of market development was to be the growth of these cooperatives--particularly in the country--which became effective regulators in local markets," wrote Larson in the conclusion of her study, which stopped with developments in 1900.[38] "Beginning in about 1900, cooperatives in the United States took a new lease on live, achieving their greatest successes . . . among the dairy, grain, and livestock producers of Minnesota, Wisconsin, Illinois, and Iowa," wrote Saloutos and Hicks in their work on the cooperative movement. This was due to a number of factors: "(1) a favorable trend in court decisions, (2) state and federal legislation for the legalization of cooperatives, (3) the demonstrated success of cooperative undertakings abroad as well as at home, (4) the desire of farmers to emulate the efficient methods of distribution achieved by business and industry, (5) the endorsement of cooperatives by prominent men in all walks of life, (6) the multitudinous activities of a variety of state and federal agencies, and (7) the hue and cry of untold millions--farmers and non farmers alike--for money-saving reforms in distribution."[39]

In 1906 there were reported to be 1,199 line elevators and 151 farmers' elevators in Minnesota. In 1912, there were only 777 line elevators, but 300 farmers' elevators, according to Railroad and Warehouse Commission statistics.[40] A 1916 study of 296 reported farmers' elevators at that time recorded organizational dates for approximately one-third. A summary table of these dates clearly indicates the growth in farmers' elevators after 1900:

1876 (earliest recorded)-1889:	10 organized
1890-99:	20 organized
1900-09:	87 organized
1910-15:	87 organized

The individual years during which the most were organized were 1912 (22) and 1913 (21).[41]

In 1913 the state legislature authorized the University of Minnesota to obtain annual reports from all cooperatives organizations in the state, thus indicating further attention to the growth of the phenomenon.[42]

From 1917 to 1922, the next year that coop elevators were studied, the overall number of country elevators remained relatively constant, averaging 1,500 to 1,600. The distribution among the four types, however, shifted considerably, marking the continued growth of the farmers' coop movement:

Year	Line	Farmers'	Independent	Mill[43]
1917	39.2%	23.8%	22.1%	14.9%
1922	31.7%	27.4%	24.0%	16.9%

The differences are even more pronounced when calculated in terms of volume of grain handled, as opposed to number of elevators:

Year	Line	Farmers'	Independent	Mill[44]
1917	27.9%	40.4%	18.4%	13.3%
1922	22.0%	48.8%	19.7%	9.5%

In St. Paul, a unique move in the terminal elevator market was made by the Equity Cooperative Exchange. Organized in 1908 in Minneapolis, the Equity had difficulty gaining access to the Minneapolis Grain Exchange. In 1914 it moved to St. Paul, where it formed the St. Paul Grain Exchange, began to acquire a line of 70 or 80 elevators in Minnesota, the Dakotas, and Montana. Its most significant achievement was the 1916 construction in St. Paul of the first terminal elevator built by a farmers' cooperative organization in the U.S.[45]

Clearly by the beginning of the 1920s, the farmers' cooperative elevator was the dominant form of country elevator ownership, handling almost half of all grain, even though the actual number of elevators was close to that of the line companies. The trend was obvious, and even in 1916, it was reported that "Some line elevators have been torn down, and the lumber hauled to Montana to be used in constructing elevators there."[46]

In their work covering the history of the cooperative movement, Agricultural Discontent in the Middle West, 1900-1939, Theodore Saloutos and John D. Hicks state that "the years 1920 to 1932 will go down as among the greatest in the history of cooperative development. With the Great Depression of 1929, subsequent New Deal programs, and World War II, the cooperative movement became a part of a much larger world of economic problems and solutions. As Saloutos and Hicks conclude, "the surging prices [of World War II] . . . temporarily drowned out many of the farmers' complaints."[47]

Minneapolis Terminal Elevators

The first elevator in Minneapolis was the Union Elevator, a 130,000-bushel elevator built in 1867 by the Union Elevator Company and sold in 1877 to the Chicago, Milwaukee & St. Paul Railroad, who changed its name to Elevator E. It burned in 1892, but was rebuilt. In 1868 the Pacific elevator (85,000 bushels) was built on the St. Paul & Pacific. The third elevator was Elevator A, built in 1879 by the Minneapolis Elevator Company. With a capacity of 780,000 bushels, it was the largest west of Chicago. After that came the Pillsbury elevator in 1880 (550,000 bushels), and the Central elevator in 1881 (250,000 bushels). By 1899 there were 28 elevators in Minneapolis, with a total capacity of 27,485,000 bushes.[48]

III. STRUCTURAL MATERIALS USED IN GRAIN ELEVATORS

Introduction

For historic preservation purposes, one of the best ways to understand the history of the grain elevator is through the historical development of the materials used to build elevators and parts of elevators. The distinction between a terminal elevator and a country elevator is vital for understanding the structural types of elevators, because these two types, historically, have utilized different structural materials in different ways. Throughout the date scope of this study the two functional types have remained constant. The earliest elevators in Minnesota and the Midwest were of both types, terminal and country, with their respective functions. The two functional categories remained essentially unchanged through the World War II period that ends the study. The development and employment of structural materials, however, changed tremendously between the late nineteenth century and 1945. The essential materials of which grain elevators have been built--and this usually means the storage area of the elevator, which is the major structural unit--are wood, steel, tile, brick, and reinforced concrete (usually shortened to simply "concrete," since no elevators ever were built of "plain" or "unreinforced" concrete). The following sections will discuss the history and use of each of the materials.

Wood

Although today it seems difficult to think of grain elevators in terms other than concrete, the fact is that wood has been the historically dominant building material for the greatest number of elevators until the years after World War II. In retrospect, concrete would seem to have made wooden construction extinct early on. And this was the case with large, urban, terminal elevators. But in rural areas, wood continued as a widely used building material for country elevators.

Wooden elevators were known and accepted by the 1870s and 1880s, and included both structural types that remained common well into the twentieth century: the balloon frame or studded elevator, and the cribbed elevator.

The balloon-frame elevator, commonly referred to as a "studded" elevator, is simply a building with internal grain bins built on the principle of balloon-frame construction, employing wooden "studs" as vertical members, which are planked over on the interior to form the bins. The "cribbed" elevator is of similar size and shape, but its bins are constructed in a very different manner. The cribbing technique employs wooden planks laid flat in a rectangle or square, overlapping at the corners in "log cabin" fashion, and built up to the desired bin height. Between two and four sizes of lumber are used. In the largest, the construction at the base begins with 2 x 10-in planks, followed by 2 x 8, then 2 x 6, then 2 x 4 at the top. Smaller elevators may only use the last three or the last two. The exterior is usually sheathed over with siding, but many construction photographs have been published that clearly reveal the cribbing construction prior to the application of exterior siding.

Studded construction is directly related to all other balloon-frame construction in the nineteenth century. The technique might have been carried over into bulk grain storage from flathouses and barns. The origins of the cribbed technique are more puzzling, however. A 1965 history of Cargill, Inc., the international grain company based in Minneapolis, reported a long tradition in the firm which held that James Cargill was responsible for devising the cribbed technique. The author, John Work, stated that the story could not be confirmed.[49] In 1866, civil engineer Alfred P. Boller published an article in the Journal of the Franklin Institute that described early wood-cribbed elevator construction in Buffalo, N.Y. In the article, Boller seems to be discussing elevators from the 1840s, but even after a close reading it is not possible to confirm a wood-cribbed elevator construction date earlier than the early 1860s.[50] For the purposes of this study, it is not necessary to determine the date of the "first" wood-cribbed elevator; it is enough to understand that the construction technique predates any Minnesota examples, extant or otherwise.

Both studded and cribbed elevators were made possible by the production of standardized, dimension lumber, as opposed to traditional, custom-designed, post and beam construction. Standardized lumber, in large part, emerged in the nineteenth-century tide of standardized items throughout industry, as transportation--particularly railroads--allowed markets to expand through mass production.[51] As standardization and mass transportation and production emerged in a symbiotic relationship, they propelled other industries. The grain and milling industries were part of this same process, and with the coming of the railroads--as noted above--"modern" agriculture and the mass production, processing, and shipment of grain developed. One does not need to locate the "first" cribbed elevator in order to state that both elevator types, and especially the cribbed type, were integral parts of, and responses to, the mid-nineteenth century surge of standardization, mass transportation, and mass production. The modern grain industry (including the elevator), lumber industry, construction industry, engineering profession, rail system, mass marketing, all were intertwined, and suffice it to say that the foundations were firmly in place by the time railroads were established in Minnesota in the 1860s and 1870s.

--The Chase Elevator and the Studded Bin

The earliest reported wooden elevator of any standardized design was the Chase Plan of elevator, developed in 1873 and patented thereafter by the Chase Elevator Company of Chicago. The Chase Company began as a milling firm and their elevator originally was developed to provide outside-the-mill storage for flour mills rather than as a free-standing elevator working in the grain trade.[52] The first Chase elevator was said to have been built in Peoria, Ill., and within eight years there were Chase elevators in Illinois, Iowa, and Indiana. Reports on the Chase plan in 1881 and 1882 state that the Chase was a studded elevator and was designed to be an inexpensive competitor to the cribbed design, clearly implying that the cribbed elevator was common by the early 1870s.

The Chase design is interesting for at least two reasons. The first involves the plan of the bins and the transport system. The Chase employed a double row of grain bins extending behind what was called the "transfer house," now known as the workhouse. Grain was received in the transfer house, elevated to the top, and then delivered to the bins with a belt conveyor. This was a new development over the previous design of allowing grain to gravity-flow from the elevator head into nearby bins. After studying the Chase plan, Reyner Banham believed that "the evolution of the long, high, narrow elevator complexes of the early twentieth century can be traced back to this change in handling processes."[53] A qualifier must be added to Banham's remarks, however, because the twentieth-century development to which he refers applies almost exclusively to the larger terminal elevator and not the smaller country elevator, which continued to use the central distributor system instead of the extended conveyor system.

The second interesting feature of the Chase elevator appears in one of two views of a Chase structure published in the 1880s. Clearly visible in the engraving are three horizontal bands extending around the entire building at equal intervals between the foundation and the eves, a distance of perhaps 30 feet. The bands are punctuated by small circles at intervals of some 3 to 4 feet. Now, let us leap ahead in time to 1942 when the Grain Dealers Journal published the fifth and last edition of its series of Plans of Grain Elevators. In this series of examples of elevators of good design, erected between 1918 publication of the previous (fourth) edition and 1941, are photographs of at least 29 country elevators of studded construction.[54] Every studded elevator clearly exhibits the same series of bands encircling the entire structure. The "bands" are sections of wooden plank, and the "circles" along their length are the ends of tie rods that extend across the elevator interior to cross-brace the bins. As the 1881 description of the Chase elevator noted, the storage bins "are built of studding and boards tied with iron rods."[55] The Chase elevator is an example of an innovative plan that pointed to terminal-elevator design, but structurally it was a simple, traditional, studded country-elevator.

The studded design is an example of the long persistence (the 1880s to the 1940s) an elevator construction technique that must have proved beyond doubt its economy and durability, and needed no publicity whatsoever. Elevator builders never seem to have advertised studded elevators. The plank bands are the mark of the studded elevator, visible from a considerable distance, and they never appear in any photograph of a cribbed elevator.

In the 1918 edition of Plans, an article entitled "A Balloon Elevator of Improved Design" included the following synopsis of studded elevator construction: "In the early days of country elevator construction, most of the small houses were erected on what was known as the studded plan of construction, that is the bin walls were formed of 2 x 4s, placed vertical and held together by tie rods, plates and bands. The strength of these structures was generally ample to hold up all the grain that could be put into them, but frequently they gave way to a strong wind."[56] Nevertheless, studded elevators were constructed in a surprising range of capacities, considering their apparent limitations. Between 1899 and 1910, for example, studded elevators were constructed with capacities from 18,000 bushels to 40,000 bushels; plans were prepared for studded elevators as small as 4,000 bushels.[57]

It is not known if any studded elevators are extant in Minnesota, and no Minnesota studded examples have been found in the available editions of the Plans of Grain Elevators.[58]

--The Wood-Cribbed Bin

It has been impossible to discover the origins of the wood-cribbed bin, but in 1866 a very careful description of early wood-cribbed bins in Buffalo was published in a noted engineering journal by civil engineer Alfred P. Boller. Boller wrote:

> "The sides of the bins are formed of plank laid flatwise, usually two inches thick and spiked, the spikes being long enough to reach through two thicknesses of plank, and part way into a third. These bins are carried up to various heights, and, as before remarked, are usually 10 to 12 feet square. The lengths of planks are so arranged as to break joint with each other, the same plank often running through the distance of three and sometimes four bins. This arrangement frames all the bins together, and adds greatly to the stiffness in resisting the bulging tendency of the grain."[59]

Boller's text is accompanied by two figures illustrating the cribbed construction, although the term "crib" is not used.

The cribbed technique was being actively promoted into the 1970s and in some areas wood-cribbed elevator construction continues to the present. In 1977, elevator builder Clair Towne, president of Hogenson Construction Company, a long-time Minneapolis elevator firm, published an article in Grain Age advocating the use of wood-cribbed elevators. The heart of Towne's 1977 elevator, the wood-cribbed bin, is indistinguishable in description from those 75 or 100 years earlier: ". . . depending on the size of the building, two by ten or two by eight [lumber] is placed flat and spiked together with 20d spikes. This cribbing is placed so that all corners and intermediate walls are interlocked . . . . As the building progresses in height, the cribbing or lumber size is reduced from two by ten to two by eight, then two by six and a nominal amount of two by four at the top."[60]

The main advantage of the wooden crib was summarized by Banham: "Such construction was rigid enough to resist not only bursting pressure, but also its reverse, the sudden vacuums that could develop if the grain began to flow suddenly while being emptied under gravity through ports at the bottom of the bin."[61] The studded bin accomplished the same thing, of course, and cheaper, but not nearly so well and so consistently.

--The Wooden Country Elevator

Discussions of studded and cribbed wooden elevators, upon consideration, are really discussions of bins, or of the bin section of the elevator. Wooden bins have been used in both large terminal elevators or in small country elevators, although it is not known if studded bins ever were constructed for terminal elevators. The advantage of studded construction was economy with minimal strength, which worked best in small elevators. Economy with maximum strength, as the argument for cribbed construction was to become, was necessary in large terminal elevators. When the entire elevator structure is considered, wooden elevators of either bin type divide more by size and function than by bin construction. In other words, all wooden country elevators tend to be similar to each other, and different from wooden terminal elevators. A 1929 study of Minnesota country elevators stated that "local elevators are more highly standardized as regards type of construction and materials used than most other types of local marketing agencies," attributing the similarities to "the early development of the business and the building of elevators by a relatively small number of construction companies."[62] And, as with the construction technique, the state-of-the-art wooden elevator at the end of the nineteenth century was not very different from its descendant in the 1940s, in terms of overall conception and plan, and basic equipment installed and services provided. There were evolutionary, if not revolutionary changes; but these changes were more matters of increases in handling capacity and speed rather than fundamental alterations in design and conception.

Virtually all wooden country elevators are built around the wooden bin section of the elevator. The bins are supported by wooden timbers or steel beams. Some bins continue to the foundation, while other bins stop at the top of the ground floor. This floor is called the work floor and includes grain cleaning equipment and the lower end of the elevator leg or legs. Sometimes the plan of a working floor is based on the particular arrangement of bins and open space. For example, a cross type work floor is one "in which the corner bins are brought down to the work floor level and all the other bins are over a two-way work floor. This arrangement secures ample space for the several cleaning machines with plenty of overhead bins drawing to the cleaners."[63] The bins rise to the building's eaves, where a wood floor is placed over them. This is the distributing floor, where the grain is distributed from the elevator head to the various bins. The cupola is built atop this level and gives the building the appearance of having a monitor roof, as noted above. In the cupola, which is of studded construction, are the elevator heads, leg drives, and motors or line-shafting, along with the grain distributor and spouting. The distributor is a movable metal spouting device that can be directed to the bin of choice. There usually is an automatic shipping scale to weigh outgoing grain for railcars, and there may be a rough grain cleaner or screen. Outside the elevator is the receiving driveway, with a shed housing the wagon or truck dumping device, a dump grate, and a large receiving scale. There also will be an office and a powerhouse, if the elevator uses power other than individual electric motors. Sometimes the office space and engine rooms are combined in the same auxiliary structure.

A "typical" example of a Minnesota wooden country elevator from the pages of Grain Dealers Journal and American Elevator and Grain Trade between 1913 and 1942 might be 28 feet by 32 feet in plan, and a total height to the top of the cupola of 60 to 70 feet. The cribbed bins would be 40 to 50 feet in height, and there may be from 12 to 20 bins of varying sizes. The average total capacity would range from 25,000 to 35,000 bushels, with some elevators smaller, down to 20,000 bushels, and many larger, up to 60,000, 80,000, and even 100,000 bushels. Almost without exception, Minnesota examples, regardless of date of construction, have the same form, being slightly rectangular with full-length cupolas. It is not an unusual form in the U.S., but the Minnesota examples in the industry literature are surprisingly consistent, for whatever reason.

Most wooden elevators have been sheathed in corrugated galvanized steel siding (almost always termed "iron clad" in industry language) for fire protection, a practice that appears to have continued practically unchanged from the first decade of the twentieth century to its advocacy in 1977 by Clair Towne.[64]

During the 1930s industry literature was urging the use of aluminum paint on all elevators, noting that it had been used on "iron-clad" elevators for some time. One advocate of aluminum paint was prolific Minnesota builder Tom Ibberson of T.E. Ibberson Company, Minneapolis. Generally the argument was that paint protected the metal sheathing from weather and corrosion, reflected heat, and its bright, silvery color had "high advertising value," especially compared with an "unkept, unpainted elevator."[65]

Between 1900 and 1945, wooden elevators were more "fine tuned" than changed, to accommodate demands for speed and capacity. It is noteworthy that the Grain Dealers Journal brought out four thick editions of its Plans of Grain Elevators between 1904 and 1918, but waited a quarter century until 1942 to publish the fifth and last. The publisher's declared intent was always to demonstrate the best in elevator design and construction by showing off appropriate examples. Obviously the early years were times of change, while the later years were not. In his preface to the 1942 edition, editor Charles S. Clark listed the areas in which changes and modernization had occurred since 1918: concrete foundations; show windows, shelving, and warehouses for marketing the product; larger and more complex dumps and scales; improved cleaning equipment; addition of feed processing equipment in some country elevators; electric motors with high speed squirrel cage motors with speed reducers or gear motors; switching for power; no more open-topped bins; dust collectors; light-construction cupolas.[66]

"This is truly a concrete age for grain storage elevators," Clark declared, but quickly exempted the country elevator a few sentences later: "However, most of the country elevators are constructed of wood, covered with galvanized iron and supplemented with iron or concrete storage annexes."[67] A 1929 study of local elevators estimated that 90% of all Minnesota elevators were of wood-cribbed construction, with "only a small number being frame structures [studded] or brick and concrete."[68] Clark's statement was confirmed by Towne in 1977, who wrote that "there just weren't too many country elevators until the last 25 years that weren't of cribbed construction."[69]

For the architectural and engineering historian casually looking at wooden country grain elevators, it is not surprising that they all seem to look alike; they probably are very much alike. As far back as the 1880s, elevator builders did not urge clients to necessarily purchase new building styles or bin patents, so much as they insisted that elevators in general needed professional assistance. A professional elevator designer, even though located in another city, could provide plans and specifications so the new owner could use local labor on contract. As Parry, Deal & Company, an Illinois firm, put it in 1885: "We do not claim any particular style of building or any patent, but propose to do as we have done--to design a building that will suit the place and business." The firm went on to make the argument that professional elevator firms were to continue to make for years:

> "It sometimes happens that parties attempt to put up a building without any drawing whatever. But it is customary for those about to build to advise with some local builder, who, although expert in house-building, has no experience in elevator construction, or perhaps has built one or two elevators. He has but little knowledge of the operation and machinery of an elevator, and is not posted in improvements which are continually being made, and are noticed and incorporated in the buildings of those who make elevator building a business."
>
> * * *
>
> "In nine cases out of ten, buildings put up in this way cost more, are poorly constructed, and in less than two years are altered and changed to attain results that experience alone can suggest.
>
> "A professional elevator architect is supposed to have had experience and can save you something on first cost and often a mint of money in the long run."[70]

In country elevators, the structural clues to age are small, compared to some other building types. The few items that could signify age are likely to have been modernized or otherwise altered. Some hints about age may be found in the following description of the modernization of a Montana elevator, reported in the 1942 edition of Plans: "Modernization of the plant included raising of the elevator cupola, cutting off the wide cornice [overhanging eaves] and replacing with standard elevator cornice, replacing the roofs on both the elevator and attached feed mill with 26 gauge galvanized steel roofing, completely residing the elevator and repairing the siding on other buildings with cedar lapsiding, and painting of the entire plant with aluminum paint."[71] While undated, the comments on aluminum paint and the improved eaves suggest that this article was written in the mid-1930s. The elimination of the wide eaves involved the additional step of closing the open eave area with a board and then continuing a piece of metal down over the end of the eaves and rafters onto the vertical siding. This completely enclosed the eave area, thus keeping out locomotive sparks and nesting birds; it also reduced wind hazard. Finally, "connecting the iron roof with the iron siding and grounding the siding at the corners provides lightning protection that earns a pleasing credit on fire insurance premiums for owners of elevators insured in the mill or grain mutuals."[72]

From the early 1930s on through World War II, articles promoting the upgrading of outmoded and obsolete elevators were published regularly. More often than not, it was the handling facilities that needed upgrading, but with the coming of the war, greatly increased storage was needed as well. The depression itself did not necessarily interfer with country-elevator operations, so maintenance was important for the elevators' continuing use. On the other hand, a number of factors were pushing owners to install faster handling equipment: "large boxcars, large trucks, combines and hard roads have joined forces to make the old time slow handling elevator a most expensive luxury."[73] This meant generally larger, stronger, and more dependable scales; faster and more convenient dumps; larger capacity legs; more efficient head-drives, distributors and cleaners; and sometimes more bins, all to accomodate the larger and larger trucks, which by 1938 were beginning to include semi-trailers. On the outloading side, faster facilities were needed to load at least one railcar an hour, thus clearing the bins for the next day's new grain and avoid "spending half the night loading a single car."[74] The mobility of trucks produced an additional pressure for elevators, since "if there is a line of trucks waiting to unload at one elevator, the farmer drives a short distance to the next one. A few miles doesn't make much difference to an auto truck driver."[75]

--The Wooden Terminal Elevator

If the story of the wooden country elevator is one of evolutionary continuity, the story of the wooden terminal elevator is one of rather abrupt extinction. The wooden terminal elevator type simply ceased being built after new fireproof and fire-resistant materials emerged at the end of the 1890s. A wooden terminal elevator, in Minnesota at least, would almost unquestionably have been built before 1910 and almost certainly before 1900. It is possible that only a single wooden terminal elevator--the 1894 Shoreham elevator--survives in the Twin Cities.[76] Even searching the post-1900 industry literature turns up hardly a wooden terminal elevator anywhere, only a few scattered examples of new construction. When engineer Milo Ketchum first published his text on elevator construction in 1909, he had virtually nothing to say about wooden elevators, stating only that wood "is at present used very extensively for small country elevators," and that its use called for very high insurance rates.[77] For an engineer, wooden construction had become totally uninteresting after 1900, and it was left to contractors and builders, who simply could repeat proven, established designs.

After 1900, the interest was in steel, concrete, tile, or brick--in other words, anything but wood. The reason was simple: fire, and fire insurance rates, were making alternative building materials very attractive. As Banham put it, "The search for a more fireproof form of construction, preferably an <u>inexpensive</u> form, was clearly the main motive behind the many experiments with different materials and structural procedures which marked the nineties and the first decade or so of the present century."[78] Banham's reasoning is supported by engineer James MacDonald's 1901 paper read to the Western Society of Engineers: "Wood being the cheapest and most available material in America, has been adopted almost universally. The amount of timber required in a modern terminal elevator ranges from four to five feet board measure per bushel of its storage capacity . . . ."

"The cheapness of our timber has been the controlling motive for its use in this construction, but the conditions are now rapidly being revised. Timber has advanced much in price, and other available materials such as steel and masonry--either in the shape of brick, concrete, tile, or combinations of these materials, have been reduced in price; hence the changing conditions of elevator building."[79] In reviewing the Minneapolis terminal elevator population in 1920, however, the Grain Dealers Journal observed that the wooden terminal elevators remaining in use at that date had been upgraded with "special dust collecting and fire fighting equipment . . . to eliminate the fire hazard."[80] Of the 68 terminal elevators operating in Minneapolis in 1920, only the following were indicated to be wood-cribed (there may be others, since the descriptions vary in detail): Atlantic, Brighton, Delmar, Devereux, Diamond, Empire "C," Gee, Midway, Great Northern, Hunter, Interior, Interstate, Monarch, Republic, Shoreham, St. Anthony No. 1 and 2, and Union.

The 1920 supplement noted an additional distinction involving the continued use of wood in elevator construction. While the large wooden elevator reportedly had become an endangered species after 1900, it was really the cribbed wooden storage unit that had died, and not necessarily all parts of a terminal elevator. Or, one might say that the Ketchum and Macdonald category-one elevator (combined storage and workhouse) was dead, while the category two was only half dead. The Journal stated that "wood working houses are most common in connection with all other materials [other than reinforced concrete] for the storage annexes. Several wood working houses had tanks of both steel and concrete and one, the Crescent [razed in 1978], was a wood working house with both tile and steel tanks." The Journal did not explain the reason, since it probably was understood by the contemporary readers, but an earlier comment in the same article suggests an explanation. When discussing the surviving wooden elevators, it was observed that "these older houses usually are better subdivided into bins than the concrete elevators." It is possible that, given the state of elevator engineering and construction between 1900 and 1920, small and intricate bin work was still best understood in wood, and the workhouse situation of handling and treating grain quickly demanded smaller and more densely packed bins for short-term holding of small lots. The large exterior bins, designed for long-term storage, which was not constantly monitored, could benefit from the other materials.[81]

Given this distinction, an all-wood, first-category terminal elevator would be extremely significant after 1900; an all-wood, second-category terminal elevator would be extremely significant after 1900; however, a second-category elevator after 1900 with a wooden workhouse but different storage unit would be somewhat less significant (relatively speaking, of course) than an all-steel, all-brick, or all-tile elevator. Judging from the 1920 article, an all-concrete elevator might be a bit more common in the early 20th-century than all-steel, all-brick, or all-tile.

Steel

Steel elevator construction was significant in Minneapolis. In 1920, the Grain Dealers Journal declared that "at no other market is the age of steel so liberally exemplified in elevator architecture."[82] As with elevator construction in wood, the impressionistic view of the landscape from the 1980s is deceptive, and the situation seen from the turn-of-the-century was different. It was truly an age of steel for the nation, not just the elevator industry, and a contemporary observer might easily imagine that steel, not concrete, would be the building material of the future. The grain world was not instantly swept away in a sea of concrete as soon as the first concrete elevators were erected. In 1901, John Kennedy of Montreal authored an extensive review in Engineering News of all the advanced construction techniques for bins and silos, and concluded that "steel would be altogether the most suitable and economical material."[83] Nineteen years later, the Grain Dealers Journal would be taking a more retrospective view in light of the concrete onslaught, but would still revere the early steel construction in Minneapolis: "These plants [the early Minneapolis steel elevators] are fire and water proof and their fortunate owners could not replace them today at several times their cost."[84]

There is some disagreement about the earliest iron-tank elevator. Milo Ketchum reports that "the first steel [sic--it would have been iron] elevator in the United States was the Washington Avenue elevator of the Grand Point Storage Company, Philadelphia, started in 1859 and completed in 1866." It had 88 cylindrical bins and was 45 feet high.[85] Reyner Banham, who (judging from his footnotes) was not aware of Ketchum's work, does not mention the Grand Point structure, and believes that the 1865 boilerplate elevators of George H. Johnson were likely the earliest. It is possible that both refer to the same structure, since Johnson, a draughtsman for the New York Architectural Iron Works, reportedly built one elevator in Brooklyn for the U.S. Warehouse Company, and the other in Philadelphia for the Pennsylvania Railroad Company.[86] Ultimately, the question is fairly academic, since Banham notes that the Johnson structures did not engender a following and, in fact, there was a considerable reaction against the notion of a metal grain elevator, even if it was fireproof. Banham cites four reasons for slow adoption of the steel-tank elevator: (1) the high cost of the material and the specialized skills needed for fabrication, which would be different from spiked planks for wood cribbing; (2) rust and corrosion; (3) steel's poor performance as a thermal insulator; (4) the geometrical problem of "packing circular bins into a rectangular building without leaving a lot of wasteful and awkwardly shaped spaces between them."[87]

Both Ketchum and Banham agree on the first serious and influential elevators built in steel: the set of three "elevators of heroic scale" designed and built 1895-99 for the Great Northern Railway by Minnesota engineer Max Toltz. One was in Duluth, one in West Superior, Wisconsin, and the third in Buffalo, New York (1897-98). As described by Banham, who is in apparent awe of them, "all were enormous, with capacities of better than two million bushels, and were houses in brick shells of handsome architectural aspect." The West Superior version was the working house type (category one) with square bins. The Buffalo version was the working house type (category one) with round bins. Both were praised by Ketchum and Banham, with Ketchum calling the Buffalo elevator "one of the first notable examples of this type of elevator," and Banham declaring it to be "one of the most remarkable buildings in the present study." As he discussed the differences, the square-bin version made more economical use of the space, but "sacrificed the full structural performance of a cylindrical format" (but retained the desired fireproof qualities, of course). On the other hand, the round-bin version was "remarkable" for its "mode of dealing with the resulting problems of economy of space and internal transfer of grain." The round bins in the 1897 Buffalo elevator have unusual hemispherical bottoms of riveted steel plate.[88]

The three great steel elevators of Max Toltz lead us to two discussions. One is the structural and conceptual significance of the Toltz designs in the larger stream of steel-elevator evolution. The other is a more detailed discussion of round and rectangular steel bins.

The significance of the Toltz elevators, and particularly the Buffalo example in Banham's estimation, is that they stand "at the end of the line that had started with the simple shed of Joseph Dart's first elevator--a building filled with bins." That is, they had gone about as far as elevator design could go in packing bins into a rectangular space, assuming as Banham does that the cylindrical bin was the desirable bin for larger storage. One intermediate step was an unsheathed rectangular box of rectangular bins (he gives the example of the 1906 Dakota Elevator in Buffalo). This may be viewed as building the wood-crib elevator in steel. However, "the solution to the problem of packing circular bins into rectangular buildings without wasteful leftover spaces was obvious but was so radical that it clearly was not thinkable for some time: discarding the building and letting the bins stand out in the open air, even though it would deprive the contents of a layer of weatherproofing." This idea would first be actualized in steel, but eventually would be the essential plan for all materials other than wood.[89]

The first "naked" steel elevator, in which the tanks stood individually without being packed in a house, was the Electric Elevator (later the Cargill-Electric), built in Buffalo in 1897 and razed in 1984. It is one of three "classics of the steel epoch" noted by Banham. The other two are in Minneapolis and still standing: the 1901 Pioneer Steel Elevator and the 1901-07 Electric Steel Elevator. Both are very early steel elevators and very significant. Both have unenclosed round bins or tanks, and separate workhouses, making them steel examples of the category-two terminal elevator. Each has at least one added significance. The Pioneer Steel Elevator is reported to have the first all-steel working house ever built, a structure-and-materials development of considerable importance. It probably is no accident that the general shape and form of the Pioneer's workhouse is almost identical to the wooden versions with their slightly sloping walls, since the wooden model was the only one available. The Electric Steel Elevator's 12 original tanks were designed by the noted Minnesota engineer C.A.P. Turner (predating the reinforced-concrete work for which Turner is remembered).[90]

Steel elevators could employ either round or rectangular bins, as the Toltz examples illustrated. At least two patented steel bins were described by Ketchum and should be noted here. The first is a rectangular steel bin patented by the John S. Metcalf Company of Chicago. The patent date is not given, but it probably predates Ketchum's first edition in 1909, and Ketchum's photograph of the Windmill Point elevator in Montreal, which used the Metcalf bin, appears to be dated 1904. The problem with rectangular steel bins is the weakness of their walls and a tendency to buckle. Both Ketchum and Macdonald report that Toltz's Great Northern Railway elevator in Duluth had such problems with lack of rigidity that vertical Z-section bars were riveted to the middle of the sides and the Z-bars fastened together with flat steel ties for added support. Other elevators with rectangular used a variety of bars and rods for stiffening. Metcalf's patented solution was to reinforce each bin with two vertical hollow steel columns on each wall, thus eight to a bin but each shared with the neighboring bin. The columns were connected across each corner with steel stay rods. The inside of the column then was filled with cement mortar. Taking the problem from the rectangular Toltz plan, Metcalf hoped to retain the space advantage of the rectangular bin by strengthening it to match the cylindrical bin.[91]

A system for erecting circular steel bins was patented by the Macdonald Engineering Company of Chicago and described in Ketchum and in James Macdonald's 1901 paper. Macdonald hoped to try the opposite solution from Metcalf, and retain Toltz's cylindrical bin while utilizing the total amount of space available within the area encompassed by the bins. He designed bins to be assembled from plate segments of a circle, so formed that six equalled a circle and could be bolted together with overlapping joints. At the same time, each bolted joint also included the overlapping joint of the neighboring bin, so the entire block was tied together, each bin to each of the six other bins that it touched. The space between--the interspace--created a new bin of three convex sides. The indentations along the outside row of bins were to be covered by a single plate, creating outside "pocket bins," each with two convex sides and one concave side. Macdonald and Ketchum published photographs of two examples using the system: the C.H. & D. Railway Elevator "B" in Toledo, Ohio, and the Lake Shore Railway Elevator in Buffalo.[92]

All of the discussion of steel elevators to this point has related to terminal elevator design and construction, in large part because that is where the innovations in fireproof materials were demanded as noted in the discussion of wooden elevators above. Small steel country elevators were designed, promoted, and constructed, however. James Macdonald claimed in 1901 that his patented multi-plate system was "applicable to all forms and capacities of grain elevators, from the smallest country farmer's house to the modern terminal elevator of the largest capacity."[93] It is not known how many, if any, country elevators were built with his patent. A brief article in the 1913 edition of Plans stated that "a favorite form of steel construction for country elevators is to put the storage capacity of the elevator into circular tanks and place the receiving and cleaning machinery into a small steel frame house alongside the tanks," in effect proposing that the steel-bin country elevator be a miniature version of the category-two terminal elevator.[94]

The Minneapolis Steel and Machinery Company was responsible for erecting several steel elevators both in and out of Minnesota. Ketchum discussed and reproduced plans for the company's 76,300-bushel country elevator erected for the Manhattan [Kansas] Malting Company. It had four steel-plate tanks clustered next to a steel working house, which served them with a screw conveyor inside a gable-roofed gallery. It reportedly could easily be built in a 30,000- or 40,000-bushel version "for either shipping or for milling purposes."[95] The plans show an elevator that is very similar to a 120,000-bushel storage unit of eight free-standing tanks with a gable-roofed gallery and a separate, small elevator-like workhouse that Minneapolis Steel erected in Belgrade, Montana in 1908.[96]

Other Minneapolis Steel and Machinery Company elevators included a 300,000-bushel unit in 1906 for the Albert Dickinson Company, Minneapolis; a 1,000,000-bushel category-two elevator in 1907 for the Independent Elevator Company, Omaha, Neb.; and a 333,000-bushel round-bin category-two elevator, pre-1909, for the Winona Malting Company, Winona, Minnesota.[97] The Minneapolis Steel and Machinery Company's 1908 country-elevator cluster of tanks beneath a gable-roofed gallery is not unlike two attempts by other companies to promote their own design of small units in the pre-World War I era. In 1915 the Perfection Metal Silo Company (called the Perfection Metal Products Company in a later advertisement) of Topeka, Kansas, marketed a 10,000-bushel, four-tank cluster country unit with a small gable-roofed workhouse perched atop the tanks, or with a separate workhouse standing alongside. In the company's advertisement, the Perfection elevator was endorsed by prolific Minneapolis elevator builder T.E. Ibberson, who, the company claimed, had arranged to erect the units. Completed examples from Kansas and Colorado were illustrated in photographs.[98] A functionally similar country elevator termed "The Wangler Fireproof Country Station" was promoted by the Joseph F. Wangler Company of St. Louis. Its plan had four small-diameter tanks placed around a single larger-diameter tank, atop of which was a workhouse in the shape of another small-diameter tank. In the firm's advertisement, it looks like a slightly unusual cluster of farm silos.[99]

Most of the steel elevator examples cited above were reported in the 1913 edition of Plans, and only a handful of steel elevators were added for the 1918 edition. One of the new ones, in Washington State, was held up for its undesirable features (not necessarily found in the steel tank section), which were attributed to the inexperienced builders in the region: "If the grain dealers of the Pacific Northwest want modernized facilities for handling bulk grain, they should call upon the elevator builders of the middle states . . . ." The 1942 edition of Plans included no examples of steel elevators at all.[100] In his 1909 edition of Walls, Bins, and Grain Elevators, Ketchum gave the construction edge to steel, although it was close, saying that "steel has the advantage where freights are any considerable item." But two years later, in a note added to his 1911 edition, he concluded: "With present prices reinforced concrete grain bins and elevators can be built for 10 to 25 per cent less than steel grain bins and elevators."[101]

Although steel faded as the revolutionary material of the age just as concrete rapidly dominated terminal elevator construction after 1910, steel has not vanished from the scene. In his recent monumental text, Grain Handling and Storage, G. Boumans outlined the advantages and disadvantages of the two structural materials now used in elevator construction, steel and concrete.[102]

Tile

In his study of elevator design and construction, Reyner Banham found that by the early 1900s the engineering trade journals were beginning to report some concern about the structural stability of cylindrical steel construction: "that they were less structurally stable when empty, or during emptying, than had been anticipated." Banham's research is supported by the list of experiments on the grain-bin pressure reported in Ketchum, who described nine engineering experiments conducted between 1895 and 1905 There was a need for a more rigid construction, according to Banham, but the means were not available until the very end of the nineties, "when Minneapolis produced two solutions": tile and reinforced concrete. The life of the tile elevator was to be short-lived, since it quickly was displaced by reinforced concrete. The attraction of tile, he says, was the result of the ongoing search for fireproof construction, and much of the technology and materials "clearly came from the tile-built, steel-rod-reinforced floors and internal partitions increasingly used in big cities like Chicago at that time."[103]

The major system for building grain elevators in tile was developed and patented by Ernest V. Johnson, son of 1869 iron elevator builder George H. Johnson, in collaboration with Minneapolis elevator builder James L. Record of Barnett and Record. In the 1890s Johnson experimented with hollow burned clay building tiles and, with Record, was granted a series of patents beginning in 1895, according to Banham. In 1899 a single test tank was constructed in Minneapolis on the Osborne-McMillen Elevator Company property. Following the successful completion of the experiment in early 1900, the system was turned over to the Barnett and Record Company in Minneapolis.[104]

The Johnson-Record system initially employed a slightly more complicated form than it settled into soon after its introduction. Ketchum's volume contains an excellent diagram of the tile wall, but Banham's description probably is the most understandable:

> "[It] employed a single-leaf structural wall made of alternating courses of short and tall tiles; the short ones were hollow troughs into which the steel reinforcing rings were laid and then grouted down solid. Early versions of the simplified system apparently had a layer of glazed tiles lining the inter face of the wall to protect the grain or to prevent it from catching during discharge, but this was deemed unnecessary and these 'furring' tiles were transferred to the outer face of the wall to protect the main structure against damage by external fire and weather."[105]

Barnett and Record quickly built a string of elevators using the patent system, including the St. Anthony No. 3 in the Minneapolis Midway elevator district. This 1901 tile elevator was reported to be the largest tile elevator in the world when completed, and today it may be the only early Johnson-Record tile elevator surviving. The Pillsbury "A" Mill tile elevator, completed by Barnett and Record in 1909, also survives, but whether it follows the same early patent is not clear.[106]

Another tile system was reported by Ketchum, the Witherspoon-Englar Tile Grain Bin. In Ketchum's volume is a diagram showing a system similar to that of Johnson-Record, but simpler--a double-wall tile arrangement, also with steel tension bands grouted in place, in a troughed tile layer. Current research has not revealed any elevators built using this system, although the Witherspoon-Englar firm did build at least one elevator, the Gould, in Minnesota; it was a concrete, not tile, addition. In 1919 a tile system termed the "Preston Lansing Tile Grain Bin," employing "ship-lap" joined blocks, was promoted by the J.M. Preston Company of Lansing, Michigan, but it is not known how extensively this system was employed or if any elevators were built with it.[107]

Banham's study leaves the tile elevator at the end of the Johnson-Record early years in favor of the introduction of reinforced concrete, which was occurring in the same city, Minneapolis, at exactly the same time, 1899-1900. Tile elevators, however, continued to be built for many years. Barnett and Record erected a large, 700,000-bushel tile elevator for Peavey Company in Duluth in 1907. One of the most significant Minneapolis tile examples is the 400,000-bushel Pillsbury A Mill Receiving Elevator, built 1908-09 by Barnett and Record.[108]

In 1903, a Northwestern Miller article declared that "tile, next to steel, has the requisite strength and lightness and is bound to win favor, particularly in those cases where the business to be transacted will admit of the use of large storage compartments."[109] By the mid-1920s, however, the Grain Dealers Journal was reporting that "tile tanks are no longer used in the construction of large terminal storage plants, [but] we occasionally hear of one being erected at a country point . . . ." The Journal was skeptical of country elevator construction in tile, and attributed its continued use to "the seductive arguments of the tile salesman."[110] Through the remainders of the 1920s the Journal continued to announce tile elevator failures caused by collapse or fire.[111] In 1942 a new patented tile was announced, developed by the Fairchild Clay Products Company, and employed in several Kansas and Nebraska elevators. It is not known if the 1942 patent produced many elevators or if any Minnesota elevators used it.[112]

Aside from the criticisms about structural instability and lack of true fireproofing leveled against tile in the 1920s, a clear disadvantage almost from the beginning was tile's inflexibility in bin size, since size was limited to tile manufactured in predetermined radii. Tile was strong enough for grain storage only in cylindrical form, where it was indeed light, a major advantage, and "no doubt will find favor," declared J. MacDonald in 1902; but, he added, "particularly in those cases where the business to be transacted in the elevator will permit the use of large storage compartments."[113] But large bins were not particularly useful in country elevators, especially large round bins, which were a poor fit in a compact house usually intended to be designed and built as economically as possible.[114] An additional criticism, as stated by A.E. Macdonald, was that "tile construction was also slow and it was difficult to keep such construction watertight, the rain coming at the joints between the tiles."[115]

Brick

Of all the structural materials used in grain elevator construction, brick has turned out to have been used the least. At the turn of the century, when all of the fireproof materials were receiving their first experimental uses, followed quickly by early full-scale structural employment, brick was given largely equal status with the other materials in the industry literature discussions. A search through the editions of Plans of Grain Elevators, however, yields very few examples of built or planned brick elevators. As in so many other cases, though, Minneapolis had one of the most significant of the brick elevators, the Northwest Consolidated Elevator A, designed by G.T. Honstain, a local engineer, and erected in 1908-09.[116]

The first brick elevator reportedly was built at Buffalo, N.Y., in 1869 by George H. Johnson, who four years earlier had designed and erected the first two iron elevators and whose son would co-author the important series of tile-elevator construction patents. Johnson's 1869 Plympton Elevator was patented and employed a double wall of bricks specially designed to interlock vertically using projecting knobs or dowels on the bottom that fit into recesses in the top of the brick below, or that is what published drawings illustrate. A description of the actual construction states that only standard common bricks were used. As with all brick and tile elevators, iron or steel was needed to enhance the low tensile strength of the material. In the 1869 example, it is reported that: "At intervals of eighteen courses they are reinforced with cast-iron bond plates which are bolted together horizontally. Each course of bond plates is bolted to the next course of plates both above and below with vertical iron rods in the air spaces around each circle distant from each other about twenty inches." As with Johnson's iron elevators, the Plympton might be considered to have been ahead of its time, since it employed cylindrical brick bins and allowed them to stand unenclosed, a feature, as Reyner Banham has observed, that did not reemerge until the end of the century. Although this elevator was said to have been successful, and stood for 32 years, there is no indication that it inspired other builders.[117]

For reasons that are not apparent, brick seems to have been used more extensively in other countries than in the U.S. In his 1903 survey of fireproof elevator construction for the Northwestern Miller, E.P. Overmire stated that "brick grain elevators have been built successfully in Europe for many years, on both the bin and warehouse systems . . . Several large elevators with brick bins have been built at Odessa and Novorosissk, on the Black Sea in Russia." He also described a recent 1,500,000-bushel square-bin brick elevator erected in Liverpool, England.[118] Of the handful of brick examples in the 1913 edition of Plans, the most impressive is the huge 4,500,500-bushel round-bin brick elevator built in 1904 in Buenos Aires, Argentina.[119] None of the literature suggests that there was any transfer of information on brick construction between foreign and U.S. builders.

As far as brick construction in the U.S. was concerned, Overmire actually had little specific to report. In fact he did not list a single U.S. example and only discussed rather general notions about brick design and construction. Compared to tile, he observed, brick was more adaptable, allowing for both rectangular and round bins, and especially noteworthy, "Where varying sizes of bins are required, brick seems to be especially well suited, provided stability can be assured." Without naming any system or elevator example, Overmire noted that "in the brick bins, besides the adhesion between the brick courses, there is a dowel feature, which adds considerably to the tensile strength, although this system depends frankly upon iron tie rods for its main source of strength when the bins are full." It would appear that he had knowledge of the Johnson patent, since that is the only doweled-brick example that appears in any literature. Overmire also included a brick-elevator plan showing rows of rectangular bins, reinforced with tie rods, but gave no description, name, or source for the plan. In the end, his view of the brick matter amounted to a vague gesture toward the future:

> "This system [brick elevator construction in general] is adapted to both square and circular bins of varying capacities and promises well as far as the preservation of contents goes. It is too early at present to say that it will prove a complete success structurally, as only a small amount of work has been done and that of a comparatively small nature. If the claims of its advocates prove well founded, it should become an important factor in the elevator problem, particularly where small or various-sized bins are required in the same structure."[120]

Writing a few years later, Ketchum took the opposite approach and briefly described two brick construction techniques, one circular and one rectangular, without making much of a statement concerning their general application. He described a circular brick bin, which he attributed to the Cleveland Elevator Building Company of Minneapolis. The system is similar, as he notes, to the tile systems, having a double wall, with the inner wall reinforced with steel placed in a channel. The Cleveland firm built an experimental circular steel-reinforced brick tank in Minneapolis about 1902-03 for the Huhn Elevator Company.[121] The rectangular system described by Ketchum used brick pilasters on the two outer corners and columns in the two inner corners, with steel bars passing through the pilasters and columns, in the planes of the walls, making a box in plan. The brick walls would be arched, with the concave side to the exterior. His narrative neatly describes the drawing reproduced with Overmire's article.[122]

There are very few reported examples of brick elevators being constructed in Minnesota, and all of these have rectangular bins. By far the most significant is the aforementioned 1908-09 Elevator "A" of the Northwestern Consolidated Milling Company at St. Anthony Falls in Minneapolis. When completed it was declared to be the largest brick elevator in the world, having a capacity of 1,000,000 bushels. It was designed using the "Honstain-Cooley" patent system of bin construction, which employs two separate reinforcing devices. One is "band-iron linked at the [bin] corners with crucible steel links"; the other has "corner rods running through V-shaped piers of reinforced concrete." The walls are flat and not concave as in the Ketchum example.[123]

The Gould Elevator at 3110 California Street N.E. in Minneapolis is an extant example of a brick working house, built in 1907-08 by S.H. Tromanhauser for the Gould Elevator Company.[124]

Another Minnesota example described in the industry literature is the 45,000-bushel rectangular-bin elevator erected in 1916 by an unknown builder for the Farmers' Elevator Company in Lamberton and noted in the Grain Dealers Journal. The construction system is not detailed, but from an accompanying photograph it appears that the bins are flat and not concave. A 20,000-bushel brick elevator of about the same size, built in 1903 by S.H. Tromanhauser for the Farmers' Elevator Company in Rushford, did have concave bins, which were not sheathed on the exterior and therefore were quite obvious.[125] A 50,000-bushel, architecturally distinctive brick elevator built in 1902 at Watertown, South Dakota, appears to have bins employing the same concave wall and rod-reinforced design. The builder also was S.H. Tromanhauser.[126]

Why were not more elevators built in brick? Brick construction seemed to have a possible future when all of the new fireproof materials were lined up equally at the starting gate about 1901. It soon was totally eclipsed by concrete for terminal elevators, as were the rest, and never could economically compete with wood for country elevators. Even in 1901-02, as Overmire was mildly optimistic, James Macdonald was doubtful: "The great weight and volume of bin walls constructed of brick will always be a powerful argument against its adoption where either concrete, tile or steel is available."[127] And as the 1916 description of the Lamberton elevator noted: "Altho [sic] one of the oldest materials of construction brick has not come into general use for grain elevator buildings, the cost being so much more than that of the usual wooden house."[128]

Reinforced Concrete

Even though, as we have seen, Minnesota--and Minneapolis in particular--was at the forefront in the major elevator construction efforts for all materials, it is the pioneering efforts in reinforced concrete that have made it legendary. Almost any article written about grain elevators will comment on "Peavey's Folly," the world's first circular reinforced-concrete elevator. Reyner Banham discusses it in great detail, chiding local historians for being so "cautious" as to declare its "first-in-the-world" status as merely "probable." The reinforced concrete elevator is the second of the two solutions that Minneapolis provided to the problem of finding a sufficiently rigid material for cylindrical bins, the first being the tile elevator as discussed above. As Banham observes, the tile bin "was to be shortlived but conceptually important; . . . the reinforced concrete bin . . . was to become the 'industry standard' worldwide."[129]

The elevator, built in 1899, was the collaborative effort of grain dealer Frank H. Peavey and contractor Charles F. Haglin. The single bin or tank, 20 feet in diameter and 68 feet high, later raised to 125 feet, was reinforced with steel bands. It was constructed with movable, sliding or "slip forms," pioneering the technique that was to make the construction of seamless, monolithic concrete tanks technically and economically feasible. Haglin was granted patent number 662266 on the new construction in 1900. The details of the design and construction have been published in several sources and the structure itself survives and is now a National Historic Landmark. Given that, it seems unnecessary to recount the story here. It had been erected to provide engineering data to be used in the designing of a block of similar bins for the Peavey elevator in Duluth, and the Minneapolis bin successfully fulfilled its purpose.[130]

The first section of 15 bins of the Peavey elevator in Duluth was built in 1900 and quickly failed, the fault lying not with the cylinders themselves, but with the six-foot connecting walls between them that created the interstice bins. It was such a wall-created bin that collapsed. A second interstice bin failed in much the same manner in 1903. In 1901 the second 15 bins were built, using thicker walls, heavier abutments, and more reinforcing steel, and the structure remained intact. It is an interesting sidelight on the development of reinforced-concrete design and engineering that engineers Frederic W. Cappelen and C.A.P. Turner became involved in the investigation of the Duluth collapse, since Cappelen was to become important in concrete bridge design and Turner, who had just completed the Electric Steel Elevator, would shortly become even more noteworthy for his reinforced-concrete patents.[131]

The next construction in concrete was the 82,000-bushel, four-bin cluster built in 1901 by Chicago's John S. Metcalf and Company for the George T. Evans Milling Company, Indianapolis, Indiana.[132] Also in 1901, the Illinois Steel Company erected a four-bin cluster designed by E. Lee Heidenrich for storage of bulk portland cement. As with all the Peavey-Haglin structures noted above, the Evans-Metcalf and the Illinois Steel elevators employed sliding forms for the concrete, but the forms rested on the hardened concrete of the most recent pour, and did not continue up while the concrete remained plastic.[133]

According to Folwell, who worked on the project, "the first example of actually slipping the forms while the concrete was still plastic, was in the construction of the Storage Annex for the King Elevator of the Canadian Pacific Railroad at Port Arthur, Ontario, in 1903, Mr. E.H. McHenry, Chief Engineer." The contractor was Barnett and Record and Folwell was their head of engineering. The slip form was raised by travelling on eight 1 1/4-inch diameter steel vertical jack rods that were embedded and left in the middle of the completed walls. In his article on the development of slip-form construction, Folwell recounts in detail the evolution of a variety of slip-form patents from the first Haglin patent of 1900 to one of his own in 1907, in collaboration with W. R Sinks (also with Barnett and Record until 1905). Other engineers and contractors significantly involved with early slip-form innovation included James Stewart and Company, James Macdonald of the Macdonald Engineering Company, and the Fegles Construction Company. Some of these firms went on to apply their patented slip-form technology to square bins and elevator workhouses, as well as columns, girders, and various other buildings, bins, and structures.[134]

This early use of reinforced-concrete for grain elevator construction is in keeping with the early development of reinforced-concrete construction generally. According to the chronology developed by concrete historian Howard Newlon, Jr., the elevator work would be in the "period of exploitation" of new reinforced-concrete technology, 1880-1910, following the earlier "period of discovery." In fact, engineering historian Carl Condit notes three buildings that brought the new structural technique of reinforced concrete to maturing in the United States, and all three post-date the first Peavey-Haglin elevator. The Peavey-Haglin work also predates the pioneering reinforcing patents (1905-11) of Minnesota engineer C.A.P. Turner.[135]

Between these first concrete elevators in 1900-03 and 1909 when he published his first edition, Milo Ketchum apparently felt that steel construction competed equally with concrete, on an economic basis. In 1911, however, as noted above in the section on steel, Ketchum felt that the cost of a concrete elevator had dropped below steel and now had the financially competitive edge. Furthermore, he felt that concrete was more completely fireproof than any other material, including steel.[136]

"We are in the age of concrete," wrote G.M. Potter in the 1913 edition of Plans.[137] In Banham's estimation, following these first years, ". . . the cylindrical reinforced concrete bin rapidly became the prime constructive element in what might be termed the normative grain elevator and thus became a symbol of curious and ultimately atavistic power in America, as its characteristic silhouette came to dominate vast expanses of land, such as the prairies or the Texas Panhandle, where the only other object of enough bulk and height to compete with it for attention was the almost identical elevator in the next town."[138] Echoing Ketchum's comments on cost, Banham added that "The concrete cylinder elevator is still so omnipresent because it represented an almost excessively good investment when first built. If it was solidly enough made to carry its load, maintain an equable thermal environment, and resist fire for long enough to amortize the original investment, then it had to be well enough made to last more or less forever--and be well enough made to be extremely costly to demolish."[139] A.E. MacDonald in 1929 was saying the same thing in listing the advantages of concrete, which, by then, were widely accepted. Concrete had: (1) fireproof qualities; (2) low cost; (3) speed of construction (100-foot tanks built in 15 days); (4) stable environment for grain, which would keep well between shipping seasons; (5) low maintenance.[140]

Early Minnesota examples of concrete elevator construction reported in the industry literature--all built in 1908--include: Washburn Crosby's 600,000-bushel reinforced concrete elevator (today called WCCO Elevator House No. 1) next to their "A" Mill at St. Anthony Falls, designed and erected by Haglin-Stahr Company; Terminal Elevator "T" Annex in Minneapolis, a 500,000-bushel reinforced concrete storage annex, built by the Barnett and Record Company; and Merchants Elevator Company, Minneapolis, a cribbed workinghouse elevator with separate concrete tanks holding 225,000 bushels, built by L.O. Hickok and Son. It would be interesting to know why Northwestern Consolidated Milling decided in the same year as all this reinforced-concrete elevator construction to build their huge elevator in brick, but there is no indication of motive in any of the available literature.[141]

Reinforced-concrete elevator construction techniques originally were developed for terminal elevators, particularly in the Peavey-Haglin elevator in Duluth. What was the situation with country elevators? Ketchum provided plans for a very simple, 50,000-bushel reinforced-concrete elevator "designed for country service." It was about 36 by 38 feet overall, had a four-bin cluster 66 feet high with a small, rectangular, 19-foot cupola. The interstice bin in the middle of the cluster also was available for use. "This structure is fireproof and will result in a large saving in insurance," he declared, adding: "With the increased price of timber reinforced concrete country grain elevators will soon be economical to build." It is not indicated when this was put into the volume, but it might have been added in the 1911 edition along with other items on concrete elevators, an idea supported by the numbering of the figure as "187a," suggesting an insertion in the scheme.[142]

The Hickok Construction Company of Minneapolis, a prolific elevator builder, erected a 25,000-bushel square-bin concrete elevator for the Fruen Cereal Company, Minneapolis, in 1915. And when the wood-cribbed Farmers' Elevator at Brewster burned in 1914, the co-op declared that "The burned plant will be replaced by a concrete house."[143]

In 1921, H.M. Hickok, son of L.O. Hickock, firm founder, wrote an article advocating concrete for country elevator construction, noting that, as the gas engine and the electric motor replaced the "old blind horse [in a true "horse-power" elevator], so fireproof elevators are fast replacing the wooden plants." He added that "the fact that for the past ten years, all the large terminal elevators, storage tanks and the frames and floors of mills and warehouses have been built of reinforced concrete should be sufficient evidence of the superiority of this material."[144] The Hickok Construction Company did, in fact, build concrete country elevators; but, judging from all the examples in all the editions of <u>Plans</u>, they built them all in the Dakotas. They erected a 55,000-bushel rectangular-bin elevator in Hillsboro, N.D., another rectangular-bin model of 45,000 bushels in Stanley, N.D., in 1929, and a third rectangular-bin elevator of 85,000 bushels at Belle Fourche, S.D., in 1930. In their photographs, the concrete elevators are conceptually planned and arranged in the same way as the wood designs, with a set of bins beneath a cupola, with an adjacent receiving shed and office. Some have almost "moderne" styling, slightly streamlined with curves, although some--like Hickok's--have a much more angular design.[145]

If there is any reason why concrete elevators sometimes were not desirable, whether in Minnesota or not, it may be found in the comments about concrete published in the 1918 edition of <u>Plans</u>. Echoing the earlier sentiments about inexperienced barn-builders erecting poor grain elevators, this writer stated that farm silo builders had gotten into the concrete elevator business and erected poor concrete elevators because of their inexperience: "So many grain storage tanks are being erected by inexperienced silo builders and concrete mixers, that it is high time grain dealers everywhere were giving more attention to the previous work of these builders, and the character of their structures." He reported on a silo builder who normally built single cylindrical concrete silos. But when called upon to erect a cluster of four for an elevator, he was stumped. So he built the four separately and unconnected, as four single silos, then poured walls to join each silo, and smoothed it over to make it appear uniform. When the center interstice bin was filled, the grain pressure pushed the arrangement apart and caused leaking. To repair the damage, the owner drilled the elevator sides and inserted tie rods between the tanks to keep them from coming apart. Then they leaked water through the drilled holes.[146]

The busiest Minnesota elevator builder between the two wars (or at least the one who was published the most) was T.E. Ibberson, who erected wood-cribbed elevator after wood-cribbed elevator, year after year, throughout the Upper Midwest. The work of Hickok and Ibberson seems to confirm the 1942 statement of <u>Plans</u> editor Charles S. Clark: "This is truly a concrete age for grain storage elevators, as most of the large storage and central market elevators as well as many country elevators, are now built of reinforced concrete . . . However, most of the country elevators are constructed of wood . . . ."[147]

Without researching their building dates, two different conclusions can be drawn about the concrete country elevators that have been built in Minnesota. Either most of them were built after 1945, or, small, rural concrete elevators in Minnesota received no journalistic coverage in the industry trade journals for the years of this study. The second hypothesis is somewhat undercut by the fact that there are many concrete country elevators described and pictured in the journals and in the editions of the Plans, but they are all in other states. At the same time, Minnesota elevator builders, such as Hickok Construction Company and T.E. Ibberson did receive coverage for their work, both in Minnesota and elsewhere, and they did build concrete elevators. It may be no accident that the elevator builder who advocated wood-cribbed construction in the pages of Grain Age in 1977 was a Minnesotan.

IV. NOTES

Abbreviations Used:

AEGT	American Elevator and Grain Trade.
GDJ	Grain Dealers Journal.
GFJC	Grain and Feed Journals Consolidated.
NM	Northwestern Miller.

1. For a somewhat contemporary image of a flathouse, see the simple drawing of a flathouse erected at Prosper, Minnesota, accompanying the brief article, "A Flat Warehouse," Farm, Stock and Home 2 (February 15, 1886): 103.

2. See D.G. Stephens, "The Evolution of Canada's Grain Handling and Transportation System," in Grains and Oilseeds: Handling, Marketing, Processing, 2nd ed. (Manitoba: Canadian International Grains Institute, 1975), 39-40.

3. Henrietta Larson, Wheat Market and the Farmer in Minnesota, 1858-1900, Studies in History, Economics and Public Law, no. 269 (New York: Columbia University, 1926), 83.

4. Stephens, "The Evolution of Canada's Grain Handling and Transportation System," 40.

5. W.M. Nieman and D.G. Stephens, "Canada's Primary Elevator System," in Grains and Oilseeds: Handling, Marketing, Processing, 2nd ed. (Manitoba: Canadian International Grains Institute, 1975), 67.

6. Joseph Dart's elevator, and similar subsequent structures in Buffalo, N.Y., are discussed in Alfred P. Boller, "Grain Elevators, Cleaners, and Dryers," Journal of the Franklin Institute, 3rd. ser., 52 (July 1866): 2-6, and in Henry H. Baxter, Buffalo's Grain Elevators (Buffalo: Buffalo and Erie County Historical Society, 1980), 4-5. Neither article states the construction type of the 1842 Dart elevator, although it seems clear that it was built of wood. The type of wood construction in the Buffalo's early elevators is discussed below.

7. Rollin E. Smith, "Elevator Interests of Minneapolis, Part II," Northwestern Miller 47 (May 24, 1899): 963, 983. In subsequent notes, Northwestern Miller is cited as NM. See also Joseph LaPray, "Terminal Elevators," Greater Minneapolis: The Magazine of Twin Cities Business Management, November-December 1980, 84. LaPray's article is in a special commemorative issue on the Minneapolis Grain Exchange.

8. G. Boumans, Grain Handling and Storage, Developments in Agricultural Engineering 4 (Amsterdam: Elsevier, 1985), 5.

9. J.E. Bailey, "Terminal Elevator Storage," in Storage of Cereal Grains and Their Products, ed. J.A. Anderson and A.W. Alcock (St. Paul: American Association of Cereal Chemists, 1954), 358-59.

10. Bailey, "Terminal Elevator Storage," 358-59.

11. Reyner Banham, A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, 1900-1925 (Cambridge: MIT Press, 1986), 164-68.

12. Albert E. Macdonald, "Grain elevator Design and Construction--Part 4," Contract Record and Engineering Review 43 (February 13, 1929): 143.

13. James S. Schonberg, The Grain Trade: How It Works (New York: Exposition Press, 1956), 143.

14. Milo S. Ketchum, The Design of Walls, Bins and Grain Elevators, 3rd ed., rev. and enlarged (New York: McGraw-Hill Book Company), 297.

15. Albert E. Macdonald, "Grain Elevator Design and Construction--Part 1," Contract Record and Engineering Review 43 (January 16, 1929): 48.

16. The original image was published in Northwest Magazine 5 (March 1887); the view is reproduced in Duluth-Superior Harbor Cultural Resources Study (St. Paul: St. Paul District, U.S. Army Corps of Engineers, August 1976), figure 17.

17. "The Grain Handling Facilities of Minneapolis," GDJ 45 (September 25, 1920): supplement insert. See also Frame, "Grain Storage and the Development of the Elevator."

18. LaPray, "Terminal Elevators."

19. In Canada, a country elevator is officially termed a primary elevator, thanks to the 1971 Canada Grain Act. See Stephens, "The Evolution of Canada's Grain Handling and Transportation system, 1876-1974," 40, and Nieman and Stephens, "Canada's Primary Elevator System," 67. In the U.S., it remains a "country elevator."

20. Martin Johnson and Kurt Wohlert, Structural Analysis of the Grain Elevator System, Transportation Center Working Paper #601-76-06 (Evanston, Ill.: The Transportation

Center, Northwestern University, c[1976]), 4.

21. See Schonberg, Grain Trade, 140-44.

22. Larson, Wheat Market, 139.

23. Larson, Wheat Market, 140.

24. Larson, Wheat Market, 142.

25. Larson, Wheat Market, 143.

26. Larson, Wheat Market, 143-45.

27. Larson, Wheat Market, 145-47.

28. Larson, Wheat Market, 165-75.

29. L.D.H. Weld, Farmers' Elevators in Minnesota, University of Minnesota Agricultural Experiment Station Bulletin 152 (St. Paul, 1915), 7.

30. Larson, Wheat Market, 104-05.

31. Larson, Wheat Market, 205-06.

32. E. Dana Durand and J.P. Jensen, Farmers' Elevators in Minnesota, 1914-1915, University of Minnesota Agricultural Experiment Station Bulletin 164 (St. Paul, 1916), 9.

33. See Minnesota, General Laws, 1893, Chapter 28; 1895, Chapter 148; cited in Larson, Wheat Market, 213.

34. Durand and Jensen, Farmers' Elevators in Minnesota, 1914-1915, 9.

35. See Minnesota, General Laws, 1897, Chapter 67; cited in Larson, Wheat Market, 251.

36. See Minnesota, General Laws, 1899, Chapter 39; cited in Larson, Wheat Market, 250.

37. See Minnesota, General Laws, 1899, Chapter 100; cited in Larson, Wheat Market, 250.

38. Larson, Wheat Market, 256.

39. Theodore Saloutos and John Hicks, Agricultural Discontent in the Middle West, 1900-1939 (Madison: University of Wisconsin Press, 1951), 56.

40. Weld, Farmers' Elevators in Minnesota, 6; according to Weld, "The Railroad and Warehouse Commission classifies as farmers' elevators all country that call themselves by that name, altho as a matter of fact many of the so-called farmers'

elevators are not owned by farmers at all."

41. Durand and Jensen, Farmers' Elevators in Minnesota, 1914-1915, 9.

42. Weld, Farmers' Elevators in Minnesota, 6; according to Weld, "The Railroad and Warehouse Commission classifies as farmers' elevators all country that call themselves by that name, altho as a matter of fact many of the so-called farmers' elevators are not owned by farmers at all."

43. H. Bruce Price, Farmers' Co-operation in Minnesota, 1917-1922, University of Minnesota Agricultural Experiment Station Bulletin 202 (St. Paul, 1923), 30.

44. H. Bruce Price, Farmers' Co-operation in Minnesota, 1917-1922, University of Minnesota Agricultural Experiment Station Bulletin 202 (St. Paul, 1923), 30.

45. Saloutos and Hicks, Agricultural Discontent, 80; Robert M. Frame III, "Grain Storage and the Development of the Elevator," in Nicholas Westbrook, ed., A Guide to the Industrial Archeology of the Twin Cities (St. Paul and Minneapolis: Society for Industrial Archeology, 1983), 66.

46. Weld, Farmers' Elevators in Minnesota, 6; according to Weld, "The Railroad and Warehouse Commission classifies as farmers' elevators all country that call themselves by that name, altho as a matter of fact many of the so-called farmers' elevators are not owned by farmers at all."

47. Saloutos and Hicks, Agricultural Discontent, 286, 538-39.

48. Smith, "Elevator Interests of Minneapolis, Part II," 963, 983.

49. John L. Work, Cargill Beginnings . . . an Account of Early Years ([Minneapolis]: Cargill, Inc., 1965), 109.

50. Alfred P. Boller, "Grain Elevators, Cleaners, and Dryers," 2-6. Boller described Joseph Dart's first elevator, a 50 x 100-foot, 55,000-bushel structure, but did not indicate the construction type. The implication is that Dart's elevator was erected in 1841 or 1842. Boller then reported that "three more elevators were speedily commenced, improving, of course, upon the original one." Following these brief historical notes, Boller described in detail a version of wood-cribbed construction, but he never directly linked this description with the 1840s elevators, or with any other named and dated elevators. The most that can be concluded from Boller's article is that wood-cribbed construction of some type was established by the early 1860s.

51. L.W. Smith and L.W. Wood, History of Yard Lumber Size Standards (Madison, Wis.: Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, 1964), 1-2.

52. "Grain Storage for Mills," American Miller 10 (November 1882): 501.

53. Banham, Concrete Atlantis, 114.

54. Grain Elevators of North America, 5th ed. (Chicago: Grain and Feed Journals Consolidated, 1942), 414-27; hereafter referred to as Plans, 1942 ed. The previous edition is Charles Schmucker Clark, ed., Plans of Grain Elevators, 4th ed. (Chicago: Grain Dealers Journal, 1918), hereafter referred to as Plans, 1918 ed.

55. "The Chase Plan of Elevator," NM 11 (April 29, 1881): 265.

56. Plans, 1918 ed., 409.

57. Charles Schmucker Clark, ed., Plans of Grain Elevators, 3rd ed. (Chicago: Grain Dealers Journal, 1913), 178, 181, 191, 193, 222, 224, 237, 241, 321; hereafter referred to as Plans, 1913 ed.

58. See Plans, 3rd ed., 1913; 4th ed., 1918; and 5th ed., 1942. The first edition is Grain Dealers Journal, Plans of Elevators: A Book Published in the Interests of the Construction of Better Grain Elevators at Country Stations by Grain Dealers Journal (Chicago, [1904]). The second edition has not been located.

59. Boller, "Grain Elevators, Cleaners, and Dryers," 2-6.

60. Clair Towne, "Wood Cribbed Elevators Offer Many Advantages in Specific Locations," Grain Age, October 1977, 35,38. Wood-cribbed elevator construction continues to be used in Canada, for example, according to a representative with T.E. Ibberson Co., a Minneapolis elevator construction firm; David R. Berg, Vice President, T.E. Ibberson Co., interview with Robert M. Frame III, July 28, 1989.

61. Banham, Concrete Atlantis, 115.

62. Hutzel Metzger and H. Bruce Price, Economic Aspects of Local elevator Organization, University of Minnesota Agricultural Experiment Station Bulletin 251 (St. Paul, 1929), 31.

63. Description of a "cross work floor" is from ""The Robideaux Grain Co.'s Elevator at Parshall, N.Dak.," Plans, 1942 ed., 388.

64. For discussions of metal siding over several decades, see: the note on the Clark County Farmers' Elevator Company 1911 elevator in Clark, S.Dak., clad with corrugated "iron" siding, in Plans, 1913 ed., 276-77; "Metal Siding and Roofing Materials," Grain Dealers Journal [hereafter GDJ] 48 (April 10, 1922): 454; "Heavily Coated Galvanized Iron the Best Investment," Grain and Feed Journals Consolidated [hereafter GFJC] 68 (May 11, 1932): 455; and Towne, "Wood Cribbed Elevators," 38.

65. For discussions of elevator paint, see: "Will You Paint with Aluminum," GFJC 80 (May

9, 1938): 106; "Aluminum Paint for Grain Elevators," GFJC 75 (September 25, 1935): inside back cover; and zinc paint was touted in "Zinc Paint Best for Metal Siding," GFJC 75 (October 9, 1935: 302.

66. Plans, 1918 ed., 2.

67. Plans, 1918 ed., 2.

68. Metzger and Price, "Economic Aspects," 31.

69. Towne, "Wood Cribbed Elevators," 35.

70. Parry, Deal and Company, "Grain Elevators" (Peoria, Ill: Parry, Deal and Company, [1885]), 13-15.

71. See "Modernizing Speeds up Montana Elevator," Plans, 1942 ed., 456.

72. See "Construction Hints for Better Elevators," with drawing of "improved eaves," GFJC 74 (May 8, 1935): 355.

73. See "A New Elevator from an Old Plant," GFJC 73 (August 22, 1934): 149.

74. "Improved Elevators Will Handle the 1937 Crop," GFJC 78 (January 27, 1937): 56, and "Faster Handling Elevators Needed," GFJC 80 (May 11, 1938): 376.

75. M.W. George, "Speeding Up the Elevator," GFJC 88 (May 13, 1942): 396.

76. See Frame, "Grain Storage and the Development of the Elevator," 68.

77. Ketchum, Walls, Bins and Grain Elevators,297. Earlier editions were 1907 and 1911.

78. Banham, Concrete Atlantis, 113.

79. James MacDonald, "Fireproof Grain Elevator Construction," Journal of the Western Society of Engineers 7 (February 1902): 36-37. Paper presented December 18, 1901.

80. See "The Grain Handling Facilities of Minneapolis," GDJ 45 (September 25, 1920): supplement insert.

81. "The Grain Handling Facilities of Minneapolis," GDJ 45 (September 25, 1920): supplement insert.

82. "The Grain Handling Facilities of Minneapolis," GDJ 45 (September 25, 1920): supplement insert.

83. Reported in Banham, Concrete Atlantis, 132 footnote.

84. "The Grain Handling Facilities of Minneapolis," GDJ 45 (September 25, 1920): supplement insert.

85. Ketchum, Walls, Bins and Grain Elevators, 299-301.

86. Banham, Concrete Atlantis, 117; "Fire-proof Grain Storage Buildings," The Brickbuilder 11 (November 1902): 232-36; the Pennsylvania Railroad elevator also is discussed in A.C. Lewis, "Development of the Grain Elevator Leg," GDJ 44 (June 25, 1920): 1188-89.

87. Banham, Concrete Atlantis, 117; the argument about high cost is supported in James MacDonald, "Fireproof Grain Elevator Construction," 36-56, who adds: "For many years after their erection the disparity between the price of steel and wood was too great to permit of the former being used as a material for grain elevators..." (42).

88. Banham, Concrete Atlantis, 117-121; Ketchum, Walls, Bins and Grain Elevators, 300, 370-72.

89. Banham, Concrete Atlantis, 123.

90. Pioneer Steel Elevator note in "The Grain Handling Facilities of Minneapolis," GDJ 45 (September 25, 1920): supplement insert.

91. Ketchum, Walls, Bins and Grain Elevators, 364-69.

92. James Macdonald, "Fireproof Grain Elevator Construction," 43-47; Ketchum, Walls, Bins and Grain Elevators, 368-71.

93. James Macdonald, "Fireproof Grain Elevator Construction," 44.

94. A.M. Burch, "Steel Grain Elevator Construction," Plans, 1913 ed, 198-99.

95. Ketchum, Walls, Bins and Grain Elevators, 362-63.

96. See Plans, 1913 ed., 285.

97. See Plans, 1913 ed., 70 (Albert Dickinson Co., Minneapolis), 57 (Omaha, Neb.), 141 (Winona, Minn.); and Ketchum, Walls, Bins and Grain Elevators, 299-300 (Winona, Minn.).

98. C.P. Buck, "Something New in Fireproof Grain Storage," GDJ 34 (March 24, 1915): 427; see also Perfection Metal Products Co. advertisement, and "A Fireproof One-Man Elevator," GDJ 36 (January 25, 1916): 101, 123.

99. See Wangler Co. advertisement, in NM 104 (Oct. 6, 1915): 5.

100. Plans, 1918 ed., 412; Plans, 1942 ed.

101. Ketchum, Walls, Bins and Grain Elevators, 471-72.

102. Boumans, Grain Handling and Storage, 49; see also Bailey, "Terminal Elevator Storage," 360.

103. Banham, Concrete Atlantis, 132-33; see Ketchum, Walls, Bins and Grain elevators, Chapter 17, "Experiments on the Pressure of Grain in Deep Bins," (as discussed in 1909 edition); in Chapter 18 Ketchum discusses ways to stiffen the walls of cylindrical steel bins (p. 360).

104. Johnson's patents and experiments are discussed in "Fire-proof Grain Storage Buildings," The Brickbuilder 11 (November 1902): 232-36, published immediately after several of the earliest Johnson-Record elevators were completed, in Ketchum, Walls, Bins and Grain Elevators, 384-85, and in Banham, Concrete Atlantis, 133-37.

105. Banham, Concrete Atlantis, 134.

106. On the St. Anthony Elevator No. 3, see "Fire-proof Storage: Modern Elevator Plant of the St. Anthony Elevator Co. at Minneapolis," NM 54 (September 24, 1902): 626, and The Minneapolis Chamber of Commerce 1881-1903 (Minneapolis: Chamber of Commerce, 1903), 29, 41. A significant additional feature of the St. Anthony Elevator No. 3 is the horizontal conveyor running through the tops of the tanks instead of above them in a conveyor gallery. On the Pillsbury tile elevator, see "Pillsbury Mill 'A' Elevator," AEGT 29 (July 15, 1910): 9.

107. The Witherspoon-Englar system is discussed in Ketchum, Walls, Bins and Grain Elevators, 385. A concrete addition to the Gould elevator in Minneapolis was constructed by Witherspoon-Englar; it is discussed below. On the Preston Lansing Tile Grain Bin, see the Preston advertisement, GDJ 43 (October 10, 1919): 600.

108. The Peavey elevator in Duluth is discussed in Plans, 1913 ed., 48-49; the Pillsbury tile elevator is discussed in "Pillsbury Mill 'A' Elevator," AEGT 29 (July 15, 1910): 9.

109. E.P. Overmire, "Modern Fireproof Grain Elevators," Part 2, NM 56 (November 25, 1903): 1155.

110. "Another Tile Failure," GDJ 55 (August 10, 1925): 160.

111. See "Another Tile Failure," GDJ 55 (August 25, 1925): 226; "Collapse of Another Tile Tank," GDJ 56 (May 10, 1926): 525; "Tile Tanks Are Not Fireproof," GDJ 56 (May 25, 1926): 614; "More Tile Tanks at Saxman, Kansas, Collapse," GDJ 57 (August 10, 1926): 163; C.W. Gustafson, "Tile and Wood: Storage Tanks Combining Them, Often Go Up in Smoke," AEGT 48 (April 15, 1930): 598; "Metal Sheathing a Tile Tank," GFJC 75 (December 11, 1935): 467; and "Iron Siding on Tile Tank," GFJC 76 (May 10, 1936): 375.

112. "Tile Stages a Come-Back," GFJC 89 (September 9, 1942): 191.

113. James MacDonald, "Fireproof Grain Elevator Construction," 47.

114. See "Which is Better, a Concrete or Hollow Tile Elevator," GDJ 46 (May 10, 1921): 764-65.

115. Albert E. Macdonald, "Grain Elevator Design and Construction--Part 1," 50.

116. See discussions of Northwest Consolidated Elevator A (also known today as the "Ceresota Elevator," after the large Ceresota flour advertisement painted on the exterior) in Frame, "Grain Storage and the Development of the Elevator," 70, and Plans, 1913 ed., 52-53.

117. Fire-proof Grain Storage Buildings," The Brickbuilder 11 (November 1902): 232-36.

118. E.P. Overmire, "Modern Fireproof Grain Elevators (part 2)," 1155.

119. Plans, 1913 ed., 43.

120. E.P. Overmire, "Modern Fireproof Grain Elevators (part 2)," 1155-56.

121. See also advertisement for the W.S. Cleveland Elevator Building Company, Minneapolis, which states: "Our specialty is brick storage tanks under the Cleveland and Stahr patents," Minneapolis Chamber of Commerce, The Minneapolis Chamber of Commerce 1881-1903 (Minneapolis: Chamber of Commerce, 1903), 50; a photograph of a Cleveland company circular brick tank under construction is on page 39 (see note confirming Cleveland's role on page 43).

122. Ketchum, Walls, Bins and Grain Elevators, 304-05.

123. "New Elevator for the Northwestern Consolidated Milling Company," AEGT 27 (April 15, 1909): 529-31; a plan of patented bin design is reproduced with this article.

124. See City of Minneapolis Building Permit No. B-69334, 1906. A block of circular reinforced-concrete bins with hexagonal caps was added in 1913 by the tile-system designers, Witherspoon-Englar, Minneapolis; see Permit No. B-102405, 1913; see also Sanborn, Minneapolis, 1912, vol. 7, p. 849. In 1989, the facility is owned by the firm of Demeter Argo.

125. For the Lamberton elevator, see "Country elevator of Brick," GDJ 37 (September 10, 1916): 415. For the Rushford elevator, see the inventory form in National Register Multiple Resources Nomination Form for Fillmore County. Unfortunately, the Rushford elevator has been razed.

126. Only a photo of the Watertown elevator, with no description, appears in Plans, 1913 ed., 309. See also the advertisement for S.H. Tromanhauser of Minneapolis, stating: "Not the biggest elevator in the world, but the best grain elevators of fireproof brick construction in any design"; the advertisement is accompanied by a photograph

of an elevator similar to the Rushford and Watertown elevators, in AEGT 27 (October 15, 1908): 237.

127. James MacDonald, "Fireproof Grain Elevator Construction," 45.

128. "Country elevator of Brick," GDJ 37 (September 10, 1916): 415.

129. Banham, Concrete Atlantis, 133.

130. See "Peavey-Haglin Experimental Concrete Grain Elevator," National Register of Historic Places Inventory--Nomination Form, prepared May 12, 1978, by Robert M. Frame III, copy in Minnesota State Historic Preservation Office. See also, AEGT, Aug. 5, 1900, 64-65; R.H. Folwell and R.P. Durham, "The Development of Methods of Raising Slip forms Used in Forming Concrete Bins," GFJC 79 (December 22, 1937): 542 (Folwell was an engineer for Barnett and Record and reported working on slip-form elevator construction as early as 1903); and Ruth J. Heffelfinger, "Experiment in Concrete: A Pioneer Venture in Grain Storage," Minnesota History 37 (March 1960): 14-18.

131. Folwell and Durham, "The Development of Methods of Raising Slip Forms Used in Forming Concrete Bins," 542-43.

132. "George T. Evans' Concrete Tanks," NM 52 (July 31, 1901): 223; this article demonstrates no awareness of the Minneapolis and Duluth reinforced-concrete work, even though it was published in a Minneapolis trade journal.

133. Evans is discussed in Folwell and Durham, "The Development of Methods of Raising Slip Forms Used in Forming Concrete Bins," 543.

134. Folwell and Durham, "The Development of Methods of Raising Slip Forms Used in Forming Concrete Bins," 545-46.

135. See Howard Newlon, Jr., "Evolution of Concrete Structures," paper prepared for lecture series "Structural Renovations and Rehabilitation of Buildings," Boston Society of Civil Engineers, Boston, Mass., Nov. 6, 1979, p. 11, 14; Carl W. Condit, "The First Reinforced-Concrete Skyscraper: The Ingalls Building in Cincinnati and Its Place in Structural History," Technology and Culture, 9 (January 1968), quoted in Newlon, 19. The three buildings are the Ingalls Building (1902-03), the Terminal Station in Atlanta (1903-04), and the Marlborough Hotel in Atlantic City (1905-06).

136. Ketchum, Walls, Bins and Grain Elevators, 305-06.

137. G.M. Potter, "Reenforced [sic] Concrete for Grain Elevators," Plans, 1913 ed., 54.

138. Banham, Concrete Atlantis, 142-43.

139. Banham, Concrete Atlantis, 174-75.

140. Albert E. Macdonald, "Grain Elevator Design and Construction--Part 1," 50.

141. For Washburn Crosby 1906-08 House No. 1, see Plans, 1913 ed., 34-35. For Elevator T Annex, see Plans, 1913 ed., 33. For Merchants Elevator, see Plans, 1913 ed., 74.

142. Ketchum, Walls, Bins and Grain Elevators, 360-62.

143. For the Fruen Cereal Co. elevator, see "A 25,000-Bu. Concrete Elevator Being Erected at Minneapolis," GDJ 34 (March 25, 1915): 421. The Fruen elevator had an unusual power source--a rope drive from the cereal mill's water power system. For the Brewster, Minnesota, elevator, see "A Spectacular Fire at Brewster, Minn.," GDJ 32 (February 10, 1914): 238.

144. H.M. Hickok, "What Kind Will You Build," GDJ 46 (February 10, 1921): 236.

145. Plans, 1942 ed., 294 (Hillsboro, N.D.), 298 (Stanley, N.D.), 323 (Belle Fourche, S.D.).

146. Traveler, "Another Concrete Failure," Plans, 1918 ed., 388.

147. "Preface," Plans, 1942 ed.

APPENDIX. GRAIN ELEVATOR TERMINOLOGY

A shorthand industry term for the elevator structure in general is house, and references may be to the "old house" or "new house" or simply working in the "house." This is an informal term and may refer to all of the elevator structure or it may be used interchangeably with "workhouse" (discussed below) in particular. It may derive from the earlier term "flathouse" for non-bulk, non-bin storage, or it may be a shorthand for the broadest term for an elevator, "warehouse."

Elevator capacities in the United States are stated in bushels (abbreviated in modern industry literature as bu.). The bushel is a dry capacity measure and it is the equivalent of approximately 1.25 cubic feet (or four pecks or 2150.42 cubic inches). European industry literature often reports elevator capacities in tons. Different grains have different densities, of course, and weights will vary with a constant volume.

Although the "elevating" mechanism is what makes an elevator an elevator, the grain bin is really the heart of the matter when dealing with buildings and structures. Historically, the engineering of bins has been the most studied part of elevator design. Grain is stored in the storage area, which is comprised of bins, occasionally called tanks (depending on structural material, location, or shape--a "tank" is usually cylindrical). Bins have been built with almost any possible capacity, from a few hundred bushels to hundreds of thousands of bushels, limited only by engineering; there seems to be a use somewhere for virtually any size that can be built. Bins may be most any shape, but usually are round or rectangular. Debates over bin shape have occurred in the development of different structural materials. When bins are other than rectangular, and in a group or block, there will be spaces between the bins. These spaces often are also used for storage and are called, variously, interstice (pronounced inter-stice, as in "ice"), interstitial, interspace bins, or star bins. When the space occurs around the outside of the block and is walled off to form a bin, it is an outerstice or pocket bin. The most important part of a bin after its shape and wall configuration is its bottom. The bottom of a bin may be either a flat bottom or a hopper bottom, the functional difference being in the way the bin is emptied. The hopper bottom is sloped or rounded to allow grain to move down and out by gravity; flat bottomed bins must be emptied by a conveying device placed inside and shoveled clean.

A group of bins in a modern elevator is termed a block. Storage bins may be located entirely within an elevator structure (built with the headhouse), entirely separate from the headhouse or other parts of the elevator, or in both places within the same elevator complex (inside the headhouse and alongside the headhouse). The locations of these parts leads to various elevator typologies, discussed below. An additional storage unit added to an elevator is termed an annex, which usually is a separate structural unit designed as anything from a separate but almost identical elevator to a temporary shed or quonset hut.

There are specialized types of grain-holding devices within an elevator. A container for the temporary gathering of grain, awaiting its input to a machine or loading device, is a garner. Garners may hold grain for a scale bin which, in turn, will be used to periodically fill the hopper for a hopper scale. A hopper is the holding container for the batch of bulk grain as it is being weighed. When grain is delivered to an elevator by wagon, truck, or railcar, it is dumped into a receiving pit. If a scale is an integral part of this mechanism, it is a dump scale.

While grain is handled in many different places in an elevator structure, most of the handling takes place in the working house (also termed a workhouse or headhouse). Often small elevators will not have a separate workhouse and these functions take place within the elevator, which serves as a combined storage and handling structure. Workhouse functions include receiving grain, weighing grain, moving grain to and from storage, cleaning and treating grain (if necessary), and loading grain out of the elevator. Workhouses usually contain some storage bins within the workhouse structure; these are workhouse bins. An elevator without a workhouse will have a working floor, usually the first floor, located at about grade and below any internal storage bins. A "working floor" is not the same as a "workhouse" and should not be confused with it. According to one major elevator engineer, the workhouse is so critical to the functioning of an elevator that, "other things being equal, the date of its completion fixes the date when the elevator first can handle grain."[1]

Discussions of the internal parts of a workhouse tend to be descriptions of machinery rather than structural elements, but some general terms may be explained here. Of particular significance is the equipment for transporting grain. Grain must be moved vertically and horizontally. An elevator leg is the unit containing the power-driven vertical bucket conveyor or bucket elevator, which raises the grain and is what has given the grain "elevator" its name. Legs may be clustered in leg stands. A short leg that does not travel the full height of the structure may be called a jack leg. A movable leg, designed to be extended into the hold of a ship or barge, is a marine leg. The top of the leg is called the head; the bottom of the leg is the boot. In an elevator the legs must rise high above the storage bins in order to accomplish the necessary downward gravity flow to the bins or other devices. A large grain elevator will house the elevator heads at the top of its workhouse. A small elevator will house the head or heads in a small addition atop the roof ridge that is termed a cupola or, rarely, a Texas house or simply a Texas. The cupola may be small and short or it may be "full length," extending from gable end to gable end and resemble a monitor roof; in a grain elevator, it remains a cupola and is not a monitor.

While the bucket elevator in the leg moves grain up, the grain moves down by gravity through spouts, occasionally called chutes. Grain is moved horizontally with either a belt conveyor, which is nothing more than the commonly understood conveyer-belt, specially adapted for bulk grain, or a grain auger or screw conveyor. The smaller the elevator the more likely it is to have an auger and not have a belt conveyor, since the belt conveyor is for longer distances and the auger for shorter distances. Conveyors and spouts have a variety of subtypes and auxiliary devices.

Transport mechanisms, particularly conveyors, are sometimes housed in special structural units. Belt conveyors carrying grain to the storage bins and/or over the tops of the bins are usually within a conveyor gallery. When the conveyor gallery runs over the tops of the bins it usually resembles a monitor roof on the exterior. When the belt conveyor spans an open space between the workhouse and the storage structure it is a conveyor bridge; it appears to be a small, almost pedestrian bridge, carried on a trestle structure if it is long enough to warrant additional support. Belt conveyors located beneath the bins for emptying them are located in a conveyor tunnel.

Major structural units in an elevator other than the storage area and workhouse might include an office, powerhouse, and warehouse, if these functions are separate and not within the elevator structure itself. Semi-attached units may include a receiving shed for unloading wagons and trucks, or a track shed for unloading railcars. Supplemental storage may be in an attached shed-like structure or in a storage annex as described above. An old, obsolete (in terms or size or handling equipment) elevator or elevators may be physically moved adjacent to a new elevator and used as additional storage. Moving entire elevators is not unknown and has been documented in elevator literature.[2]

Elevators do not always stand alone, and can be found incorporated into larger complexes. For example, flour mills and other grain processors have on-site elevators to store their raw materials. These are sometimes referred to as receiving elevators.

1. Albert E. Macdonald, "Grain elevator Design and Construction--Part 5," Contract Record and Engineering Review 43 (February 20, 1929): 169.

2. See, for example, "Moves Six Huge Tanks One-Fifth Mile" [steel tanks of the Twin City Trading Company's Minneapolis plant], AEGT 45 (November 15, 1925): 309; "Moving Day" [moving cribbed elevator in Iowa], AEGT 33 (March 15, 1915): 597; and "Elevator Moved 44 Miles in 15 Days," GFJC, 69 (December 29, 1932): 554.

F. Associated Property Types

I. Name of Property Type Terminal Grain Elevator

II. Description

III. Significance

IV. Registration Requirements

[X] See continuation sheet

[ ] See continuation sheet for additional property types

G. Summary of Identification and Evaluation Methods

Discuss the methods used in developing the multiple property listing.

[X] See continuation sheet

H. Major Bibliographical References

[X] See continuation sheet

Primary location of additional documentation:

- [X] State historic preservation office
- [ ] Other State agency
- [ ] Federal agency
- [ ] Local government
- [ ] University
- [ ] Other

Specify repository: ____________

I. Form Prepared By

name/title Robert M. Frame III, Ph.D., Historical Consultant

organization N/A date September 30, 1989

street & number 202 McBoal Street telephone 612-291-7882

city or town St. Paul state MN zip code 55102

F. ASSOCIATED PROPERTY TYPES

I. Name of Property Type: Terminal Grain Elevator

II. Description (Terminal Elevator Property Type)

The terminal elevator is the largest and most complex of all grain elevators. It is intended to accumulate large amounts of grain from smaller lots, usually brought to it in railcars, to store the grain, and to transfer it out in similar or larger lots. To accomplish this, the terminal elevator will have complicated handling facilities and usually very large, even immense, storage capacities. A terminal elevator complex may have storage capacities ranging from 100,000 bushels to 10,000,000 bushels.

A terminal elevator normally divides the two main elevator functions, grain handling and grain storage, into two separate physical units. The handling unit is the workhouse; the storage unit contains the storage bins. Terminal elevators may be classified by the configuration and juxtaposition of these two elements in the following way: (1) a terminal elevator wherein the workhouse or handling unit is physically integral with the storage-bin area, such as being situated on top of the bins; (2) a terminal elevator wherein the two units are separate physical structures, which may be adjacent or separated by some space. An early terminal elevator, built in the 1890s or before, is more likely to be of the first category. Later terminal elevators, post-1900, are likely to be of the second category.

Structures found with terminal elevators in a complex may include one or more storage annexes with bins, warehouses, an office, power facilities, shipping and receiving facilities. Any of these may also be contained within the workhouse unit. Also, the elevator may be part of a larger milling complex, including a flour or feed milling plant, in which case it is more correctly termed a "receiving elevator." A receiving elevator has many terminal elevator functions, but is designed for supplying an adjacent processer rather than shipping out by rail or water.

Terminal elevators will be located at major shipping and receiving points, usually in urban areas, such as rail centers, lake and river ports, and at mills and other processors. Terminal elevators almost invariably have at least rail access, which often is quite extensive. If located in a lake or river situation, there will be a special elevating mechanism termed a "marine leg" designed for loading and unloading vessels. In Minnesota, terminal elevators devoted to shipping and receiving will be found only in Minneapolis, St. Paul, and Duluth. Receiving elevators, however, may be found wherever a major processor is located

Terminal elevators will be built of one or more of the following structural materials: wood, steel, tile, brick, or reinforced concrete. The workhouse may be of one material while the storage annex is another. Second and third storage annexes may be of different materials again.

Until the 1890s, virtually all elevators of any type were constructed entirely of wood. In the 1890s there was a search for new materials that were both fireproof and inexpensive. This led to almost simultaneous experimentation with all materials other than wood: steel, tile, brick, and reinforced concrete. Major pioneering structures were built in these materials about 1900. The materials competed with each other in terminal elevator construction for about the next decade, until it became clear that reinforced concrete combined the most desirable elements of fire resistance and economy.

Each structural material tends to have its own particular chronology, its own bin-construction peculiarities, and its own pioneering engineers, inventors, and builders.

Wooden elevator construction involves one of two bin types: cribbed or studded. Wooden terminal elevators will always have cribbed construction. Workhouses may be of wood while their associated storage annexes are of another material. Wooden elevators were constructed throughout the context period, but a terminal elevator constructed in wood after the 1900-10 period should be considered extremely unusual. In the years during which the building of wooden terminal elevators was common, virtually all elevator builders and engineers worked in wood.

Steel elevator bins can be found in either rectangular form or cylindrical form. There were patented versions of each type, although known patents were not by Minnesotans. An elevator with steel storage bins may have a workhouse of steel or of another material; steel storage with wooden workhouses predated all-steel elevators. A significant Minnesota engineer who designed innovative steel elevators was Max Toltz. Steel elevators were built by many contractors, but in Minnesota steel fabrication was the specialty of the Gillette Herzog Company and the Minneapolis Steel and Machinery Company.

Tile terminal elevators were built in Minnesota after 1900, although not many were constructed. The major patent for tile elevators everywhere was held by the Johnson-Record collaboration and built by the Barnett and Record Company of Minneapolis. All tile bins are round and have double walls with steel reinforcing. Tile bins also tended to be large and therefore undesirable for elevators where a great variety of bin sizes was necessary, especially small bins. Workhouses may or may not have tile construction. Tile terminal elevators were built in both the category one and two versions, but the separate workhouse and storage annex is more common.

Brick elevator bins are similar to tile in that they require steel reinforcing and usually were built with double walls. However, they could be built in either cylindrical or rectangular versions. They may or may not have brick workhouses. They may be either category one or category two. They were built in both terminal and country elevator versions, between 1900 and World War I.

Reinforced-concrete elevator construction began in Minnesota in 1899 and the original single cylindrical bin served as the concrete prototype for elevators throughout the world. Concrete elevators could easily be built with rectangular bins, and there were patented versions. A concrete elevator usually had a concrete workhouse, although other combinations were possible.

III. Significance (Terminal Elevator Property Type)

The governing historic context for this property type examines Minnesota grain elevators from the earliest years to 1945. Since research was conducted on a statewide level, there is a sound basis for making judgments of statewide significance as well as local significance.

Because virtually every large terminal elevator in Minnesota is associated with the a "broad pattern" of Minnesota agriculture, industry and commerce, one could use Criterion A liberally to find every elevator in the state eligible to the National Register. This, however, would make the process meaningless. Rather, to be eligible under Criterion A, a terminal grain elevator must have been involved in a particularly meaningful way with a significant development in the grain industry, grain trade, a transportation and shipping nexus, and/or a major processor. In evaluating an elevator under Criterion A, it is helpful to consult other historic contexts dealing with general geographical areas, especially those prepared for municipal and railroad studies.

Elevators will rarely be eligible under Criterion B. When an elevator is associated with a significant individual, it is almost always in relation to an engineer, builder, or contractor. According to National Register guidelines, such cases are to be considered under Criterion C. It is conceivable, however, that an elevator might have played a significant role in the career of an industry entrepreneur. In such a case, the elevator might be eligible under Criterion B. However, other properties may exist, such as an office or residence, which would better represent the entrepreneur's achievements.

Criterion C is most frequently invoked for finding historic elevators eligible for the National Register. As in the case of Criterion A, an overly liberal application might lead to the determination that all elevators are eligible, particularly as "representatives of a type." Rather, Criterion C should be employed to winnow a group of similar resources to a meaningful list.

The terminal elevator can be found to be constructed in one or more of the following structural materials: wood, steel, tile, brick, or reinforced concrete. It also may be arranged in one of two ways: (1) combined workhouse and storage-bin unit, or (2) separate workhouse and storage-bin annex. Virtually all elevators built before 1900 will be category one. Most all terminal elevators built after 1900 will be category two.

There are several eras in the development of grain elevators: (a) early wooden elevator construction, to 1900; (b) early fireproof elevator construction period, c1900 to World War I; (c) era of dominance of reinforced concrete, World War I to World War II. However, the design and construction of grain elevators in these eras is best understood in terms of their structural materials.

Wooden elevator construction involves one of two bin types: cribbed or studded. Both derive from the development of dimension lumber in the nineteenth century. Cribbed construction is stronger and more expensive; studded or balloon-frame bin construction is weaker but cheaper. The origins of cribbed construction are unknown but the technique dates from at least the 1860s; it has remained viable into recent years, well past the cutoff date for this historic context. All known terminal elevators were built with wood-cribbed storage units. Although terminal elevator construction turned away from large wooden storage units after 1900, wooden workhouses continued to be built through the period of experimentation with alternate materials. Any surviving wooden terminal elevator is extremely significant. Since virtually all wooden terminal elevators were built before other materials were used, all elevator builders worked in wood. However, a major Minnesota wooden elevator builders continuing past the introduction of alternate materials includes T.E. Ibberson, Minneapolis, and the Hickok Construction Company, Minneapolis.

The first important steel storage bins or tanks were built in extremely large terminal elevators in Duluth, Superior, Wisconsin, and Buffalo, New York, in the late 1890s for the Great Northern Railway by Minnesota engineer Max Toltz. Pioneering steel tank elevators were built in Minneapolis in 1899-1900. Steel continued until about World War I as a major competitor for new construction, then was relegated to secondary status as reinforced concrete dominated. However, steel continued to be used past the 1945 cutoff, largely for storage annexes. Steel bins can be found in either rectangular form or cylindrical form. Toltz's elevators variously used both, in different elevators. There were several patented bin systems: a rectangular steel bin was patented by the John S. Metcalf Company of Chicago, probably between 1900 and 1908, and a system for erecting circular steel bins was patented by the Macdonald Engineering Company of Chicago, about 1900. Very early steel-bin elevators may have the bin unit enclosed in a box of another material, such as brick. Steel terminal elevators are usually of the category-two type, and may have workhouses of steel or other materials. All steel elevators erected during the pioneering period (1900-1918) are significant. Any steel elevator associated with Max Toltz is extremely significant.

Tile terminal elevators were built experimentally and permanently during the same time period as steel, about 1900 to World War I. Their use was not extensive. The St. Anthony Elevator No. 3 is among the first tile elevators built anywhere in the U.S. Most tile bins were built with the patented system of Johnson and Record, which was used by the Minneapolis elevator firm of Barnett and Record. All known tile bins were round. The patents were issued largely between 1895 and 1905. Tile elevators usually are of the category two variety. Tile elevators are unusual enough in Minnesota that almost any example is significant; a Minnesota tile elevator's significance is enhanced by the fact that it probably employed a Minnesota designer's patent.

A few elevators were built with brick bins during the same period as steel and tile, about 1900 to World War I. Brick bins could be either round or rectangular, but all have steel reinforcing of some type. Only a handful of brick elevators are known to have been built in Minnesota, but these include the largest brick elevator built to that date (1908). It was designed by Minneapolis builder C. Honstain. Minnesota examples include both terminal and country elevators. S.H. Tromanhauser of Minneapolis is known to have built rectangular-bin brick elevators in Minnesota and elsewhere, but it is not known if he built terminal elevators. Because so few were built, all brick elevators in Minnesota are significant.

The first reinforced-concrete grain elevator bin was built in Minneapolis in 1899-1900, and the first permanent installations were built in Duluth a year later. All were the collaborative work of grain merchant Frank Peavey and builder Charles F. Haglin. All concrete elevators derive from these initial efforts. By World War I, reinforced concrete had dominated terminal elevator construction everywhere, including Minnesota, and all terminal elevator builders worked in concrete.

When the major units of a grain elevator have been constructed separately, such as the workhouse and one or more storage units, the significance of each should be considered separately. For example, it is possible that a block of bins will represent an important element in grain elevator development, while the workhouse is not particularly noteworthy. Any storage bins significant for their patented construction system should have at least one intact bin that demonstrates that system, whether the system is generally visible or not. Newer storage annexes connected to earlier workhouses or bins should not detract from the significance of the earlier structure, especially if the earlier structure is one of the pioneering examples in the development of a material type. In brief, architectural details are not as important to the significance of grain elevators as are larger engineering and structural elements. It is not necessary to have surviving equipment in order to retain integrity.

IV. <u>Registration Requirements</u> (Terminal Elevator Property Type)

Terminal elevators in Minnesota may be eligible for the National Register under Criterion A for their association with events that have made a significant contribution to the broad patterns of American history, Minnesota history, or local history, especially in relation to railroad, lake, or river transportation; the grain trade; grain processing; and the cooperative movement. In each of these cases, the significance probably will involve a firm, agency, or organization that owned and/or operated the elevator.

A terminal elevator may be eligible under Criterion B for its association with a significant person, if it was a center of significant activity for that person and that person was not the designer or builder of the terminal elevator. If the person was noted as an entrepreneur, however, other properties may exist that better represent the person's achievements, such as an office or residence.

Most terminal elevators will be eligible under Criterion C. They probably will be eligible because they embody distinctive characteristics of terminal elevator design and engineering or represent significant phases in the evolution of terminal elevator engineering and construction. They also may be eligible for their association with significant elevator engineers, builders, contractors, or fabricators, who made significant contributions to the design and construction of terminal elevators.

Functional Arrangement. Terminal elevators were built in one of two arrangement schemes: (1) combined working house and storage-bin unit, and (2) separate working house and storage annex. In terminal elevator construction, type two became more common after 1900 and type one became less common. Any type-one terminal elevator should be considered potentially significant, and investigated for additional elements of significance below.

Terminal elevators being considered under Criterion C are best examined in terms of their construction materials, as follows:

Wood. Wood was used in both bin construction and working house construction in terminal elevators. Wood-cribbed bins in terminal elevators virtually ceased after 1900 and many wood-cribbed elevators burned or were razed. They are almost unknown today. Wooden working houses in terminal elevators, in association with storage annexes of other materials, were constructed for a short time after 1900. They also are almost unknown today. All wooden terminal elevator construction of either type is eligible.

Steel. Steel, as with wood, was used in both bin construction and working house construction. It began in the late 1890s but was quickly superseded by reinforced concrete by World War I. Steel elevators did not burn, but they could be dismantled. All steel terminal elevator construction of any type dating from this early experimental period (c1895-c1920) is eligible. A completely new steel elevator built after 1920 would be unusual and the reason for its construction should be investigated for significance. A steel-tank annex built after 1920 for an existing elevator, however, is not likely to be eligible.

Tile. Tile elevator construction was very much a development engineered in Minnesota, but even in Minnesota was not widely practiced and died relatively quickly in terminal elevators in the face of competition from reinforced concrete. Its period of use is the same as steel, c1895-c1920, but fewer were built. All tile terminal elevator construction of any type is eligible.

Brick. Brick terminal elevator construction parallels tile, but brick is the rarest of all. All brick terminal elevator construction of any type is eligible.

Reinforced Concrete. Reinforced-concrete terminal elevator construction began in 1899 and by World War I had killed wooden terminal construction completely and dominated all other materials with the minor exception of steel, which continued in lesser forms. In order to better determine the eligibility of concrete terminal elevators, in lieu of a field survey of extant concrete terminal elevators, examine the historic context, property type, and registration requirements for "Reinforced-Concrete Highway Bridges in Minnesota, 1900-1945." Both concrete bridges and grain elevators had parallel experimental periods and elevators built prior to 1912, like bridges, represent the earliest pre-standardization examples. All concrete terminal elevators built prior to 1912 should be considered eligible. Between that time and the end of World War I, concrete continued to compete with other materials, but was becoming dominant. All complete (i.e., not a concrete addition to an earlier elevator) concrete elevators built as new complexes prior to 1920 should be considered eligible, because they likely will represent a total engineering approach to the problem of building in concrete. Concrete terminal elevators built between 1920 and 1945 should be examined for individual areas significance in terms of concrete construction. The development of concrete construction techniques, such as those involving slip forms, continued to evolve, and any concrete terminal elevator should be examined for evidence of new slip-form technology.

Special Consideration for Terminal Elevators. Each terminal elevator is a large, often extremely massive and expensive, undertaking. Each terminal elevator is a uniquely engineered solution to a particular grain-storage problem. There is no "standard plan" for a terminal elevator complex, although there may be standard or patent designs for particular elements, such as bins. Since terminal elevators of wood, steel, brick, and tile are relatively rare, this uniqueness presents little difficulty; almost all will be eligible. For the ubiquitous concrete terminal elevator, however, each case must be examined, especially for the period after 1920, when competition from other materials disappeared.

Terminal Elevator Integrity. As with other properties, the elevator must retain integrity of the element considered significant. For terminal elevators, this will mean integrity of the storage bins in most cases. Since most storage bins were constructed as units or blocks, the integrity of the original block largely will determine eligibility, especially in the case of a reinforced-concrete terminal elevator. For examples of wood, brick, and tile construction, the integrity of a single bin or tank will be enough integrity for eligibility, if the bin represents a rare survivor of a construction method and/or patent. This is especially true in the case of free-standing tanks of tile or brick construction. A single steel tank should not be considered to have integrity unless it is known to represent a patented type of grain elevator construction.

In the working house or headhouse, exterior structural integrity is necessary, although some historic changes in fenestration are acceptable. Since interior elevator equipment, such as cleaners, conveyors, motors, engines, legs, scales, and distributors often were replaced without altering the elevator structure, it is not necessary for an elevator to retain this replaceable equipment in order to retain integrity. Conversely, the presence of significant and large installations of equipment, such as a significant large scale (which may be so large as to be almost part of the structure) will enhance the significance of the elevator.

The absence of associated structures, such as offices and powerhouses, will not cause the loss of integrity, where the significance is embodied in the materials and design of the main storage unit. However, the presence of such structures may be used to make a case for enhanced significance if such structures are notable, such as an intact powerhouse for a steam engine.

I. Name of Property Type: Country Grain Elevator

II. Description (Country Elevator Property Type)

All country grain elevators are designed and constructed to handle bulk grain by means of elevating machinery and to store bulk grain, in a non-farmstead situation. Farm silos are excluded. This property type does not include structures designed only to handle non-bulk grain, such as sacked or bagged grain, commonly known as "flathouses."

Country elevators, officially termed "primary elevators" in Canada, have functions related to those of terminal elevators, but on a more limited scale. Generally a country elevator is intended to receive grain from farmers in wagon or truck lots, store the grain, and transfer it to railcar lots for shipment to terminal elevators. Therefore, it will be located in an agricultural region and on a rail line. In Minnesota, this would mean virtually any portion of the state other than the north central and northeast [see map and historic context for "Agricultural Development and Railroad Construction," in "Historic Context Outlines: The Post-Contact Period Contexts," Minnesota History in Sites & Structures: A comprehensive Preservation Planning Process (St. Paul: State Historic Preservation Office, 1985)].

Most country elevators are small enough that they have their storage unit and handling and elevating mechanisms combined in a single structural unit. In most cases, the core of the elevator will be a cluster or block of storage bins, with a cupola on the top containing the upper end of the elevating leg and the distribution mechanism to send the grain to the bins. As part of the structure, or adjacent to the elevator, will be the receiving shed with wagon or truck unloading facilities. Country elevators always will have rail access and railcar loading facilities. There also will be an office and possibly an engine room or powerhouse, depending on the source of power. The office may be connected to the elevator or separate. Sometimes country elevators will have separate storage annexes for additional storage. Country elevators also may provide additional services, such as grinding feed and stocking and selling other commodities, such as coal, lumber, and agricultural supplies. The later the elevator was constructed, the more likely this function was incorporated.

Country elevators may be built of one or more of the following structural materials: wood, steel, tile, brick, or reinforced concrete. Until the 1890s, virtually all elevators of any type were constructed entirely of wood. In the 1890s there was a general industry search for new materials that were both fireproof and inexpensive. This led to almost simultaneous experimentation with all materials other than wood: steel, tile, brick, and reinforced concrete. Major pioneering structures were built in these materials about 1900. The materials competed with each other in terminal elevator construction for about the next decade, until it became clear that reinforced concrete combined the most desirable elements of fire resistance and economy. In the country elevator market, however, wooden construction dominated the industry in Minnesota until at least World War II.

Each structural material tends to have its own particular chronology, its own bin-construction peculiarities, and its own pioneering engineers, inventors, and builders.

Wooden elevator construction involves one of two bin types: cribbed or studded. Wooden country elevators may have cribbed or studded bins. Workhouses may be of wood while their storage annexes are of another material. Wooden elevators were constructed throughout the context period, particularly in their country elevator form.

Steel elevator bins can be found in either rectangular form or cylindrical form. There were patented versions of each type, although known patents were not by Minnesotans. Steel country elevators, apparently prefabricated, were advertised by manufacturers and contractors, but their use is believed to be very rare. Advertised steel country elevators all had circular tanks, with the total elevator constructed on the wooden country model, with a headhouse mounted on top of a small cluster of bins.

Tile elevators for both terminal and country functions were built in Minnesota after 1900, although not many were constructed. The major patent for tile elevators everywhere was held by the Johnson-Record collaboration and built by the Barnett and Record Company of Minneapolis. All tile bins are round and have double walls with steel reinforcing. Tile bins also tend to be large and therefore undesirable for elevators where a great variety of bin sizes was necessary, especially small bins. Workhouses may or may not have tile walls. Tile elevators were built in both terminal and country form.

Brick elevator bins are similar to tile in that they require steel reinforcing and usually were built with double walls. However, they could be built in either cylindrical or rectangular versions. They may or may not have brick workhouses. They were built in both terminal and country elevator versions, between 1900 and World War I, but only a handful of country examples are known to have been constructed.

Reinforced-concrete elevator construction began in Minnesota in 1899 and the original single cylindrical bin served as the concrete prototype for elevators throughout the world. Concrete elevators could easily be built with rectangular bins, and there were patented versions. Country elevators constructed in reinforced concrete did not become common in Minnesota until after World War I.

III. Significance (Country Elevator Property Type)

The governing historic context for this property type examines Minnesota grain elevators from the earliest years to 1945. Since research was conducted on a statewide level, there is a sound basis for making judgments of statewide significance as well as local significance.

Because virtually every large terminal elevator in Minnesota is associated with the a "broad pattern" of Minnesota agriculture, industry and commerce, one could use Criterion A liberally to find every elevator in the state eligible to the National Register. This, however, would make the process meaningless. A country elevator may be eligible under Criterion A for significant contributions in the development of a community and thus would have local, if not statewide, significance. In evaluating an elevator under Criterion A, it is helpful to consult other historic contexts dealing with general geographical areas, especially those prepared for municipal and county surveys.

It is very possible that a country elevator may be involved on a local or statewide level with significant events in the grain industry and grain trade, including the cooperative movement. This would involve some aspect of the elevator's ownership and/or management. Country elevators generally fall under one of the following owners: line company, farmers' cooperative, independent, or mill. The era of line dominance was the 1870s to c1900. From c1900 to World War II, the farmers' cooperatives predominated. There were independent owners and mill owners during both eras, but they constituted a small number.

Elevators will rarely be eligible under Criterion B. When an elevator is associated with a significant individual, it is almost always in relation to an engineer, builder, or contractor. According to National Register guidelines, such cases are to be considered under Criterion C. It is conceivable, however, that an elevator might have played a significant role in the career of an industry or local entrepreneur. In such a case, the elevator might be eligible under Criterion B.

Criterion C is most frequently invoked for finding historic elevators eligible for the National Register. As in the case of Criterion A, an overly liberal application might lead to the determination that all elevators are eligible, particularly as "representatives of a type." Rather, Criterion C should be employed to winnow a group of similar resources to a meaningful list.

There are several eras in the development of grain elevators: (a) early wooden elevator construction, to 1900; (b) early fireproof elevator construction period, c1900 to World War I; (c) era of dominance of reinforced concrete, World War I to World War II. However, the design and construction of grain elevators in these eras is best understood in terms of their structural materials.

Wooden elevator construction involves one of two bin types: cribbed or studded. Both derive from the development of dimension lumber in the nineteenth century. Cribbed construction is stronger and more expensive; studded or balloon-frame bin construction is weaker but cheaper. The origins of cribbed construction are unknown but the technique dates from at least the 1860s; it has remained viable into recent years, well past the cutoff date for this historic context. Country elevators were built with cribbed bins until the World War II era, at least in Minnesota. Studded elevators are known to have been built as long as cribbed elevators, but the frequency of their use in Minnesota is unknown. A studded elevator should be examined carefully, since the literature indicates it was rare in Minnesota. Since a country elevator modernization trend seems to have occurred in the mid-1930s, any wooden elevator built earlier is more likely to be significant, especially if it somehow escaped any the modernizing elements. Major Minnesota country elevator builders included T.E. Ibberson, of Minneapolis, and the Hickok Construction Company, Minneapolis.

The first important steel storage bins or tanks were built in extremely large terminal elevators in Duluth, Superior, Wisconsin, and Buffalo, New York, in the late 1890s for the Great Northern Railway by Minnesota engineer Max Toltz. Pioneering steel tank elevators were built in Minneapolis in 1901. Steel continued until about World War I as a major competitor for new construction, then was relegated to secondary status as reinforced concrete dominated. However, steel continued to be used past the 1945 cutoff, largely for storage annexes. Steel bins can be found in either rectangular form or cylindrical form. There were several patented bin systems: a rectangular steel bin was patented by the John S. Metcalf Company of Chicago, probably between 1900 and 1908, and a system for erecting circular steel bins was patented by the Macdonald Engineering Company of Chicago, about 1900. Very early steel-bin elevators may have the bin unit enclosed in a box of another material, such as brick. Steel country elevators in Minnesota were apparently rare; when built, they probably were built by the Minneapolis Steel and Machinery Company. Any steel country elevator should be carefully considered for its significance. All steel elevators erected during the pioneering period (1900-1918) are significant.

Tile elevators were built experimentally and permanently during the same time period as steel, about 1900 to World War I. Their use was not extensive. The St. Anthony Elevator No. 3 is among the first tile elevators built anywhere in the U.S. Most tile bins were built with the patented system of Johnson and Record, which was used by the Minneapolis elevator firm of Barnett and Record. All known tile bins were round. The patents were issued largely between 1895 and 1905. Tile elevators were built in both terminal and country form, and usually are of the category two variety. Tile elevators are unusual enough in Minnesota that almost any example is significant.

A few elevators were built with brick bins during the same period as steel and tile, about 1900 to World War I. Brick bins could be either round or rectangular, but all have steel reinforcing of some type. Only a handful of brick elevators are known to have been built in Minnesota, and include both terminal and country elevators. S.H. Tromanhauser of Minneapolis is known to have built rectangular-bin brick elevators in rural Minnesota and elsewhere. All brick elevators in Minnesota are significant.

The first reinforced-concrete grain elevator bin was built in Minneapolis in 1899-1900, and the first permanent installations were built in Duluth a year later, all the collaborative work of grain merchant Frank Peavey and builder Charles F. Haglin. All concrete elevators derive from these initial efforts. By World War I, reinforced concrete had dominated terminal elevator construction everywhere, including Minnesota. Concrete was advocated for country elevators by builders such as Minneapolis's L.O. Hickok of Hickok Construction Company, but apparently few concrete country elevators were built in Minnesota before 1945, at least compared with other states. All pre-1945 concrete country elevators are potentially significant, since the literature indicates that very few were constructed.

IV. Registration Requirements (Country Elevator Property Type)

Country elevators in Minnesota may be eligible for the National Register under Criterion A for their association with events that have made a significant contribution to the broad patterns of American history, Minnesota history, or local history, especially in relation to railroad, lake, or river transportation; the grain trade; grain processing; and the cooperative movement. In each of these cases, the significance probably will involve a firm, agency, or organization that owned and/or operated the elevator.

A country elevator may be eligible under Criterion B for its association with a significant person, if it was a center of significant activity for that person and that person was not the designer or builder of the country elevator. If the person was noted as an entrepreneur, however, other properties may exist that better represent the person's achievements, such as an office or residence.

Most country elevators will be eligible under Criterion C. They probably will be eligible because they embody distinctive characteristics of country elevator design and engineering or represent significant phases in the evolution of country elevator engineering and construction. They also may be eligible for their association with significant elevator engineers, builders, contractors, or fabricators, who made significant contributions to the design and construction of country elevators.

Functional Arrangement. Country elevators almost invariably were built with a combined working house and storage-bin unit, regardless of the period of construction. This involved a headhouse built above a small cluster of bins. The country elevator may have added a storage annex or may have moved another elevator alongside to use as an annex. Any country elevator arrangement other than these is unusual and its significance should be investigated.

Country elevators being considered under Criterion C are best examined in terms of their construction materials, as follows:

Wood. Wood has been the predominant construction material for country elevators throughout the period of this context. Wooden elevator construction involves one of two bin types: cribbed or studded (balloon-frame). The origins of cribbed construction are unknown but the technique dates from at least the 1860s; it has remained viable into recent years, well past the cutoff date for this historic context. Country elevators were built with cribbed bins until the World War II era, at least in Minnesota. Studded elevators are known to have been built as long as cribbed elevators, but the frequency of their use in Minnesota is unknown. Any studded elevator is potentially eligible, since the literature indicates it was rare in Minnesota.

A country elevator modernization trend seems to have occurred in the mid-1930s, so any wooden elevator built earlier is more likely to be significant, especially if it somehow escaped any the modernizing elements, such as drastically shortening the eaves and wrapping them in sheet metal (termed "elevator eaves"), and replacing a wagon dump with a truck dump. Most modernizing, however, involved upgrading internal equipment and that would not affect structural integrity.

Wooden elevators evolved several different working (ground) floor configurations, with the "straight" floor being earlier than the "cross" floor or the "half-cross." An early (pre-1920) cross-floor example is eligible.

Major Minnesota wooden country elevator builders included T.E. Ibberson, Minneapolis, and the Hickok Construction Company, Minneapolis.

Steel. Steel country elevators (possibly prefabricated) were advertised by several fabricators and contractors, including T.E. Ibberson, but it is not clear whether very many (if any) were erected in Minnesota. Advertised examples were configured on the wooden country model of a headhouse above a small cluster of bins. Any steel country elevator is potentially eligible, and any built before 1920 is eligible. A steel-tank annex built after 1920 for an existing elevator, however, is not likely to be eligible.

Tile. Tile elevator construction was very much a development engineered in Minnesota, but even in Minnesota was not widely practiced and died relatively quickly in the face of competition from reinforced concrete. It is not clear whether many tile country elevators were built in Minnesota It's period of use is the same as steel, c1895-c1920, but fewer were built. All tile country elevator construction of any type is eligible.

Brick. Brick terminal elevator construction parallels tile, but brick is the rarest of all. All brick country elevator construction of any type is eligible.

Reinforced Concrete. Reinforced-concrete terminal elevator construction began in 1899 and by World War I had killed wooden terminal construction completely and dominated all other materials with the minor exception of steel, which continued in lesser forms. In Minnesota, however, reinforced-concrete construction does not appear to have had an impact on country elevator wooden construction, despite pleading in the literature by Hickok of the Hickok Construction Company. Concrete construction remained more expensive for a country elevator, in large part because it took great engineering and construction skill to build a good concrete elevator, therefore making it more expensive. Any reinforced-concrete country elevator built before the mid-1930s period of modernization is eligible, and any built between the 1930s and 1945 should be investigated carefully for eligibility.

Country Elevator Integrity. As with other properties, the elevator must retain integrity of the element considered significant. For country elevators, this technically will mean integrity of the storage bins, but in most cases actually will mean the structural integrity of the entire elevator, since all will be in the same structure. In the headhouse, exterior structural integrity alone is necessary, although some historic changes in fenestration are acceptable. Since interior elevator equipment, such as cleaners, conveyors, motors, engines, legs, scales, and distributors often were replaced without altering the elevator structure, it is not necessary for an elevator to retain this replaceable equipment in order to retain integrity. Conversely, the presence of significant early installations of equipment will enhance the significance of the elevator.

For examples of wood, brick, and tile construction, the integrity of a single bin or tank will be enough integrity for eligibility, if the bin represents a rare survivor of a construction method and/or patent. This is especially true in the case of free-standing tanks of tile or brick construction. A single steel tank should not be considered to have integrity unless it is known to represent a patented type of grain elevator construction.

The absence of associated structures, such as offices and powerhouses, will not cause the loss of integrity, where the significance is embodied in the materials and design of the main storage unit. However, the presence of such structures may be used to make a case for enhanced significance if such structures are notable, such as an intact powerhouse for a steam engine or an early office from the modernization period, when new and larger offices were advocated.

G. SUMMARY OF IDENTIFICATION AND EVALUATION METHODS

This study of grain elevators in Minnesota was initiated by means of a contract between the Minnesota Historical Society (MHS) and Dr. Robert M. Frame III, a historian with experience in the history of the grain and milling industries. Dennis A. Gimmestad of the State Historic Preservation Office, MHS, was overall project supervisor; Susan Roth, SHPO, was project manager. All work on the project was completed by Dr. Frame.

This project goal was to develop a history of grain elevator design and construction from the late nineteenth century to about 1945, with special attention to the situation in Minnesota. Geographically, the study was limited to the agricultural areas of the state, with special attention to terminal districts in the Twin Cities and Duluth.

This was intended to be a study, not a survey, of grain elevators. Major emphasis was placed on research. In lieu of extensive field survey, a review was made of SHPO inventory files, which include many grain elevators inventoried as part of the statewide survey process.

The study began with research in databases for references to grain elevators. National on-line and other catalogs were searched, including the On-line Catalog of the Library of Congress (OCLC), the Research Libraries Information Network (RLIN), Dissertation Abstracts, the Engineering Index, and the Industrial Arts Index. State and local databases, catalogs, and indexes were searched in Minneapolis and St. Paul. In particular, this included the Minnesota Historical Society research library's collections and the agricultural collections in the St. Paul Central Library of the University of Minnesota. A special index of grain elevator building permits in the City of Minneapolis records was searched. Important collections in New York City were searched in-person, including the Avery Architectural Library and its Avery Architectural Index at Columbia University, the Associated Engineering Societies Library, and the New York Public Library. Late in the study the private records of a Minneapolis elevator construction firm, T.E. Ibberson Company, were made available for research and proved to be valuable, although little time was left for their full utilization.

When citations and references were assembled, selected materials were retrieved and studied. Sources examined included technical texts; historical studies of technology, engineering, and architecture; and professional and trade journals. Especially useful were back files of several elevator industry trade journals held at the St. Paul Central Library of the University of Minnesota. The following trade journals were completely searched for all years available through 1945: Northwestern Miller, American Elevator and Grain Trade, and Grain Dealers Journal, which was merged in Grain and Feed Journals Consolidated in November 1930.

Research in all the sources was conducted to determine: (1) the functional differences among elevator types; (2) the evolutionary development of grain elevator design and construction; (3) the significance of structural materials used in grain elevator construction; and (4) important Minnesota developments in grain elevator design, construction, location, and ownership.

Following the intensive research, the information was analyzed in terms of the research topics and written into the statement of historic context. Almost no secondary literature on the development of grain elevators exists, so almost all sources were primary. The only secondary work of much value is Reyner Banham's 1986 A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, and some of Banham's references were provided by Dr. Frame during Banham's research.

It was decided to focus on the development of the grain elevator as a structure, so considerable efforts were made to understand engineering, design, construction, and structural materials. The development of internal elevator technology was studied only to the extent that it had a major impact on the design of the elevator structure.

When elevator ownership was analyzed, it became obvious that it was a topic too extensive to be fully explored for this study. At the same time, it was clear that some work on the history of ownership had been developed in works such as Henrietta Larson's The Wheat Market and the Farmer in Minnesota, 1858-1900 and Agricultural Discontent in the Middle West, 1900-1939 by Theodore Saloutos and John Hicks. Also, cooperative elevator movements were analyzed in a series of bulletins issued by the University of Minnesota Agricultural Experiment Station, St. Paul, between about 1915 and 1930. Future study on grain elevators should include closer examinations of farmers' elevator cooperatives, elevator "line" companies, railroad involvement, terminal elevator owners, and grain companies, focusing on Minnesota details. More detailed study of elevator engineers, builders, and construction firms, as well as Minnesota elevator patents, will greatly enhance the information developed in the present historic context.

A minimal amount of field study was conducted in Minneapolis to locate the earliest extant terminal elevators. Intensive field survey of terminal elevators remains to be done in the Twin Cities and in the Duluth port area, both of which are known to have nationally significant elevator structures. In addition, field survey of country elevators remains to be done in the south, central, and western agricultural areas of Minnesota, particularly the Red River Valley. Research and analysis for the present study suggests that the historical development of the country elevator structure will not be understood until a considerable amount of data has been assembled through fieldwork. This work will have to involve inspection of the interior plan of the elevators, particularly if they are of wood construction, since the design of a wooden elevator cannot automatically be assessed from exterior appearances. Future field survey should seek to determine the existence of any "studded" or balloon-frame elevators in Minnesota, as well as any patented types of any material. Field survey also could aid in fine-tuning the understanding of reinforced-concrete construction, to develop more tightly defined developmental stages in the evolution of the reinforced-concrete grain elevator. A field survey that made use of available construction records from elevator builders would be very informative.

H. MAJOR BIBLIOGRAPHICAL REFERENCES

Abbreviations Used:

AEGT American Elevator and Grain Trade.
GDJ Grain Dealers Journal (becomes part of GFJC in November 1930).
GFJC Grain and Feed Journals Consolidated.
NM Northwestern Miller.

"A 25,000-Bu. Concrete Elevator Being Erected at Minneapolis." GDJ 34 (March 25, 1915): 421.

"Aluminum Paint for Grain Elevators." GFJC 75 (September 25, 1935): inside back cover.

Anderson, J.A., and A.W. Alcock, eds. Storage of Cereal Grains and Their Products. St. Paul: American Association of Cereal Chemists, 1954.

"Another Tile Failure." GDJ 55 (August 10, 1925): 160.

"Another Tile Failure." GDJ 55 (August 25, 1925): 226.

Bailey, J.E. "Terminal Elevator Storage." In Storage of Cereal Grains and Their Products, edited by J.A. Anderson and A.W. Alcock. St. Paul: American Association of Cereal Chemists, 1954.

Banham, Reyner. A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture, 1900-1925. Cambridge: MIT Press, 1986.

Baxter, Henry H. Buffalo's Grain Elevators. Buffalo: Buffalo and Erie County Historical Society, 1980.

Berg, David R. Vice President, T.E. Ibberson Co. Interview with Robert M. Frame III, July 28, 1989.

Boller, Alfred P. "Grain Elevators, Cleaners, and Dryers." Parts 1, 2. Journal of the Franklin Institute, 3rd. ser., 52 (July, August, 1866): 1-11, 73-78.

Boumans, G. Grain Handling and Storage. Developments in Agricultural Engineering 4. Amsterdam: Elsevier, 1985).

Buck, C.P. "Something New in Fireproof Grain Storage." GDJ 34 (March 24, 1915): 427.

"The Chase Plan of Elevator." NM 11 (April 29, 1881): 265, 270.

Clark, Charles Schmucker, ed. Plans of Grain Elevators. 3rd ed. Chicago: Grain Dealers Journal, 1913. Referred to as Plans, 1913 ed.

Clark, Charles Schmucker, ed. Plans of Grain Elevators. 4th ed. Chicago: Grain Dealers Journal, 1918. Referred to as Plans, 1918 ed.

"Collapse of Another Tile Tank." GDJ 56 (May 10, 1926): 525.

Condit, Carl W. "The First Reinforced-Concrete Skyscraper: The Ingalls Building in Cincinnati and Its Place in Structural History." Technology and Culture, 9 (January 1968).

"Construction Hints for Better Elevators." GFJC 74 (May 8, 1935): 355.

"Country Elevator of Brick," GDJ 37 (September 10, 1916): 415.

Duluth-Superior Harbor Cultural Resources Study. St. Paul: St. Paul District, U.S. Army Corps of Engineers, August 1976. Contract No. DACW37-75-C-0125.

Durand, E. Dana, and J.P. Jensen, Farmers' Elevators in Minnesota, 1914-1915. University of Minnesota Agricultural Experiment Station Bulletin 164. St. Paul, 1916.

"Elevator Moved 44 Miles in 15 Days." GFJC, 69 (December 29, 1932): 554.

"Faster Handling Elevators Needed." GFJC 80 (May 11, 1938): 376.

"Fire-proof Grain Storage Buildings." The Brickbuilder 11 (November 1902): 232-36.

"A Fireproof One-Man Elevator." GDJ 36 (January 25, 1916): 123.

"Fire-proof Storage: Modern Elevator Plant of the St. Anthony Elevator Co. at Minneapolis." NM 54 (September 24, 1902): 626.

"A Flat Warehouse." Farm, Stock and Home 2 (February 15, 1886): 103.

Folwell, R.H., and R.P. Durham. "The Development of Methods of Raising Slip forms Used in Forming Concrete Bins." GFJC 79 (December 22, 1937): 542-46.

Frame, Robert M. III. "Grain Storage and the Development of the Elevator." In A Guide to the Industrial Archeology of the Twin Cities, edited by Nicholas Westbrook. St. Paul and Minneapolis: Society for Industrial Archeology, 1983.

Frame, Robert M. III. "Peavey-Haglin Experimental Concrete Grain Elevator." National Register of Historic Places Inventory--Nomination Form. 1978. Copy in State Historic Preservation Office, St. Paul, Minnesota.

Frame, Robert M. III. "Rushford, Minnesota, Elevator." National Register Multiple Resources Nomination Form for Fillmore County. Copy in State Historic Preservation Office, St. Paul, Minnesota.

George, M.W. "Speeding Up the Elevator." GFJC 88 (May 13, 1942): 396.

"George T. Evans' Concrete Tanks." NM 52 (July 31, 1901): 223.

Grain Dealers Journal. Plans of Elevators: A Book Published in the Interests of the Construction of Better Grain Elevators at Country Stations by Grain Dealers Journal. Chicago, [1904]. Copy in Avery Library, Columbia University. This is the first of five editions of this work. No copy of, or citation for, the second edition has been located.

Grain Elevators of North America. 5th ed. Chicago: Grain and Feed Journals Consolidated, 1942. Referred to as Plans, 1942 ed.

"The Grain Handling Facilities of Minneapolis." GDJ 45 (September 25, 1920): supplement insert.

"Grain Storage for Mills." American Miller 10 (November 1882): 501.

Grains and Oilseeds: Handling, Marketing, Processing. 2nd ed. Manitoba: Canadian International Grains Institute, 1975.

Gustafson, C.W. "Tile and Wood: Storage Tanks Combining Them, Often Go Up in Smoke." AEGT 48 (April 15, 1930): 598.

"Heavily Coated Galvanized Iron the Best Investment." GFJC 68 (May 11, 1932): 455.

Heffelfinger, Ruth J. "Experiment in Concrete: A Pioneer Venture in Grain Storage." Minnesota History 37 (March 1960): 14-18.

Hickok, H.M. "What Kind Will You Build." GDJ 46 (February 10, 1921): 236.

"Improved Elevators Will Handle the 1937 Crop." GFJC 78 (January 27, 1937): 56.

"Iron Siding on Tile Tank." GFJC 76 (May 10, 1936): 375.

Johnson, Martin, and Kurt Wohlert. Structural Analysis of the Grain Elevator System. Transportation Center Working Paper #601-76-06. Evanston, Ill.: The Transportation Center, Northwestern University, c[1976].

Ketchum, Milo S. The Design of Walls, Bins and Grain Elevators. 3rd ed., rev. and enlarged. New York: McGraw-Hill Book Company. Previous editions were published in 1907 and 1911.

LaPray, Joseph. "Terminal Elevators." Greater Minneapolis: The Magazine of Twin Cities Business Management, November-December 1980, 84, 86, 88, 90-91. LaPray's article is in a special commemorative issue on the Minneapolis Grain Exchange.

Larson, Henrietta M. The Wheat Market and the Farmer in Minnesota, 1858-1900. Studies in History, Economics and Public Law, no. 269. New York: Columbia University, 1926.

Lewis, A.C. "Development of the Grain Elevator Leg." GDJ 44 (June 25, 1920): 1188-89.

Macdonald, Albert E. "Grain Elevator Design and Construction--Part 1." Contract Record and Engineering Review 43 (January 16, 1929): 47-51.

Macdonald, Albert E. "Grain elevator Design and Construction--Part 4." Contract Record and Engineering Review 43 (February 13, 1929): 143-46.

Macdonald, Albert E. "Grain elevator Design and Construction--Part 5." Contract Record and Engineering Review 43 (February 20, 1929): 167-69.

MacDonald, James. "Fireproof Grain Elevator Construction." Journal of the Western Society of Engineers 7 (February 1902): 36-56. Paper presented December 18, 1901.

"Metal Sheathing a Tile Tank." GFJC 75 (December 11, 1935): 467.

"Metal Siding and Roofing Materialsl." GDJ 48 (April 10, 1922): 454.

Metzger, Hutzel, and H. Bruce Price. Economic Aspects of Local elevator Organization. University of Minnesota Agricultural Experiment Station Bulletin 251. St. Paul, 1929.

Minneapolis. Building Permit No. B-69334. 1906. Gould Elevator.

Minneapolis. Building Permit No. B-102405, 1913. Gould Elevator addition.

The Minneapolis Chamber of Commerce 1881-1903. Minneapolis: Chamber of Commerce, 1903.

Minneapolis, Minnesota. Vol. 7. New York: Sanborn Map Company, 1912.

Minnesota. General Laws. 1893. Chapter 28

Minnesota. General Laws. 1895. Chapter 148.

Minnesota. General Laws. 1897. Chapter 67.

Minnesota. General Laws. 1899. Chapter 39.

Minnesota. General Laws. 1899. Chapter 100.

"More Tile Tanks at Saxman, Kansas, Collapse." GDJ 57 (August 10, 1926): 163.

"Moves Six Huge Tanks One-Fifth Mile" [steel tanks of the Twin City Trading Company's Minneapolis plant]. AEGT 45 (November 15, 1925): 309.

"Moving Day" [moving cribbed elevator in Iowa]. AEGT 33 (March 15, 1915): 597.

"New Elevator for the Northwestern Consolidated Milling Company." AEGT 27 (April 15, 1909): 529-31.

"A New Elevator from an Old Plant." GFJC 73 (August 22, 1934): 149.

Newlon, Howard Jr. "Evolution of Concrete Structures." Paper prepared for lecture series "Structural Renovations and Rehabilitation of Buildings," Boston Society of Civil Engineers, Boston, Mass., Nov. 6, 1979.

Nieman, W.M., and D.G. Stephens. "Canada's Primary Elevator System." In Grains and Oilseeds: Handling, Marketing, Processing. 2nd ed. Manitoba: Canadian International Grains Institute, 1975.

Overmire, E.P. "Modern Fireproof Grain Elevators." Parts 1, 2. NM 56 (November 18, 25, 1903): 1103-04, 1155-56.

Parry, Deal and Company. "Grain Elevators." Peoria, Ill: Parry, Deal and Company, [1885]. Advertising booklet. Copy in Avery Library, Columbia University.

"Pillsbury Mill 'A' Elevator." AEGT 29 (July 15, 1910): 9.

Plans, 1904 (1st) ed. See Grain Dealers Journal. The 2nd edition has not been located.

Plans, 1913 (3rd) ed. See Clark, Charles Schmucker, ed.

Plans, 1918 (4th) ed. See Clark, Charles Schmucker, ed.

Plans, 1942 (5th) ed. See Grain Elevators of North America.

Preston Lansing Tile Grain Bin advertisement. GDJ 43 (October 10, 1919): 600.

Price, H. Bruce. Farmers' Co-operation in Minnesota, 1917-1922. University of Minnesota Agricultural Experiment Station Bulletin 202. St. Paul, 1923.

Saloutos, Theodore, and John Hicks. Agricultural Discontent in the Middle West, 1900-1939. Madison: University of Wisconsin Press, 1951.

Schonberg, James S. The Grain Trade: How It Works. New York: Exposition Press, 1956.

Smith, L.W., and L.W. Wood. History of Yard Lumber Size Standards. Madison, Wis.: Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, 1964.

Smith, Rollin E. "Elevator Interests of Minneapolis, Part II." NM 47 (May 24, 1899): 963, 983-84.

"A Spectacular Fire at Brewster, Minn." GDJ 32 (February 10, 1914): 238.

Stephens, D.G. "The Evolution of Canada's Grain Handling and Transportation system, 1876-1974." In Grains and Oilseeds: Handling, Marketing, Processing. 2nd ed. Manitoba: Canadian International Grains Institute, 1975.

"Tile Stages a Come-Back." GFJC 89 (September 9, 1942): 191.

"Tile Tanks Are Not Fireproof." GDJ 56 (May 25, 1926): 614.

Towne, Clair. "Wood Cribbed Elevators Offer Many Advantages in Specific Locations." Grain Age, October 1977, 35,38.

Tromanhauser, S.H. Advertisement. AEGT 27 (October 15, 1908): 237.

Wangler, Joseph F. Company, advertisement. NM 104 (Oct. 6, 1915): 5.

Weld, L.D.H. Farmers' Elevators in Minnesota. University of Minnesota Agricultural Experiment Station Bulletin 152. St. Paul, 1915.

"Which is Better, a Concrete or Hollow Tile Elevator." GDJ 46 (May 10, 1921): 764-65.

"Will You Paint with Aluminum." GFJC 80 (May 9, 1938): 106.

Work, John L. Cargill Beginnings . . . an Account of Early Years. [Minneapolis]: Cargill, Inc., 1965.

"Zinc Paint Best for Metal Siding." GFJC 75 (October 9, 1935: 302.