THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Marc Carl Leager final oral examination for the degree of

Master of Science

We recommend that the degree of

Master of Science

be conferred upon the candidate.

H. Bruce Price
Chairman

Holbrook Working

A. M. Field

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10-20 5M

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Marc Carl Leager for the degree of Master of Science They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science

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10-20 5M

A COST ACCOUNTING SYSTEM

for a

TERMINAL GRAIN ELEVATOR

By

Marc C. Leager

A Thesis submitted to the

Graduate School of the University of Minnesota

in partial fulfillment of the requirements for the degree of

Master of Science

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CONTENTS

Preface

This study was undertaken as part of a larger project of the Agricultural Economics Division of the University of Minnesota, which embraces the subject of Dockage in its various phases. It was desired to find the cost of removing dockage, the information to be used in ascertaining the value of dockage. A terminal grain elevator was chosen as the base which should be used in determining costs of obtaining dockage and in order to get this figure it was necessary to prepare a complete cost accounting system for a typical terminal elevator.

It was discovered early that no work on this subject had ever been done. Grain offices do not use cost finding methods and it was sometimes difficult to convince them that such methods could be applied to their business. The method of finding information was to get it thru personal interviews, and these were had with elevator superintendents, grain men, and bookkeepers. No opposition was encountered, rather an open-minded co-operative attitude. The opinions of the men interviewed were combined into a composite result which appears in the following pages. The study has centered around one specific house, and the effect of this is to make the results more consistent as being based on one particular case. The methods can be applied, with slight changes in distribution, to any house which it is desired to study.

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Chapter I. Introduction

1. The purpose of this study is to devise a Cost Accounting system for a Terminal Grain Elevator. It seems desirable to introduce the subject with a brief survey of terminal warehouse facilities in the Twin Cities, a description of the equipment and operation of a terminal elevator, and a statement of the necessity of a cost-finding system, and the problems connected with it for this type of business.

2. Warehouse facilities of the Twin Cities.

There are two major classifications of grain warehouses, Regular and Private. The latter are operated for the use and benefit of their owners who are companies engaged in some specific branch of the grain trade. The flour mills own and operate large storage warehouses in which they store their wheat until it is desired to mill it. The warehouses of this type are the largest in the Twin Cities, and the capacity of a few is given.

* Pillsbury Concrete	3,500,000	bushels
Washburh-Crosby	3,500,000	"
Electric Steel	4,000,000	"

The latter house is classed as a regular public warehouse, but it is used to store wheat for the Russell Miller Milling Company. Private houses vary greatly in size as is shown in the following table:

Table I - Capacity of Minneapolis Terminal Elevators (Private)

* Capacity	Number
less than 100,000 bushels	9
100,000 and less than 200,000 bushels	8
200,000 " " " 300,000 "	2
300,000 " " " 400,000 "	5
400,000 " " " 500,000 "	2
500,000 " " " 1,000,000 "	7
1,000,000 and greater	5

*Annual report of Minneapolis Chamber of Commerce 1921.

Linseed oil companies, malting companies and feed mills own elevators, and many line elevator companies own and operate houses to handle their own grain.

* Annual Report of the Minneapolis Chamber of Commerce 1920.

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3. Regular houses are those operated under Chamber of Commerce Rules and State regulations. Their capacity does not vary as much as the private houses as shown in the following table.

Table II. Capacity of Public Elevators

Capacity	Number
*500,000 and less than 750,000	8
750,000 " " " 1,000,000	3
1,000,000 " " " 1,500,000	5
1,500,000 " " " 2,000,000	7
2,000,000 and more	5

The total capacity of elevators in the Twin Cities is as follows:

Table III Total Capacities

	Number	Capacity
* Regular Elevators	28	36,535,000 bushels
Private	38	19,020,000 "
Total		55,555,000 "

4. The Regular Public Elevators may be classified as to their principal function. Thus, the Soo Line Terminal with a capacity of two and a half million bushels is primarily for the purpose of receiving large amounts of grain into storage, and the same is true of the Sheffield K with a capacity of one and eight tenths millions. Large houses such as these are sometimes referred to as tanks on account of the large number of grain tanks or bins. They receive great quantities of grain in the fall when crop movements are heavy.

The other type of terminal warehouses is sometimes called a hospital house or handling house. In such a house the capacity is often not large, and grain taken into storage is treated and handled to improve its condition and raise its grade. These matters will be taken up in detail in a later section.

5. Volume of grain handled.

With the total capacity of 55,555,000 bushels in mind it is interesting to know the amounts of the different kinds of grain actually received in Minneapolis in one year. The following figures are for the crop of 1919 covering the period from September 1,1919 to August 31, 1920.

* Mpls. Chamber of Commerce Annual Report of 1920.

Table IV. Grain Receipts - Crop of 1919

Grain		Receipts	
Wheat		116,588,810	bushels
Corn		8,841,410	"
Oats		17,311,180	"
Barley		12,165,330	"
Rye		8,335,470	"
Flaxseed		5,355,770	"
	Total	168,597,970	"

It is seen from these figures that the capacity of the terminals was used 3.04 times in handling the 1919 crop. The tank-houses were used a smaller number of times than the smaller handling houses owing to the nature of their operations.

6 Description of a Terminal Warehouse.

Let us now proceed to a description of the warehouse itself. There are two portions of the structure which are found in all terminal elevators. These are the storage bins and the head-house, and they are found in some form in every large elevator. Plates I and II show these two portions very plainly both in floor plan and in side elevation, the taller portion being the head-house and the group of circular structures the storage bins. In the head-house is done all the handling of the grain; the cleaners are located here, weighing is done here. A reference to Plate No. IV shows that the head-house is divided into a number of small bins, a total of twenty in this instance. These are used for the purpose of holding grain temporarily, for example, clean grain that is waiting to be loaded into a car, or dirt that has been cleaned out of grain. Grain which is run thru the house for the purpose of transferring it from one car to another is put temporarily in one of these bins. The cross sections of the head house, shown on Plate IV, can be easily found on the side elevation on Plate II. In this instance the cleaner floor is at about a third the height of the head-house, but is usually found in Twin City houses on the ground floor.

7. Equipment of the Elevator.

Let us now take up a detailed description of the equipment of the elevator and show how it is used in handling grain.

8. Weighing Equipment.

The weighing apparatus is always found at the top of the head-house. Weighing equipment is clearly shown on both Plate II and III. At the top is a garner or receiving bin into which grain is first elevated. As soon as it is full the weigher lets a little less than 2,000 bushels or 120,000 pounds onto the scale, which is located directly beneath the garner. He then adds grain, a few pounds at a time, till the even weight is reached. These scales are wonderfully accurate and are sensitive to a difference of a very few pounds. The weight is recorded on a ticket by the official weigh-master of the Railroad and Warehouse Commission. This official is paid by the Commission, but the man who does the work of letting the grain onto the scale is an employee of the elevator. The elevator illustrated in the plates is planned so that the grain can be taken from the scales and at once put into the bins, but this necessitates a very high head-house as is plainly shown. The usual type found in Minneapolis is not built on this plan but is built lower and provides for the grain to be taken to the bins by an extra elevation.

9. Elevating Equipment.

This type of structure derives the name "Elevator" from the fact that all grain coming to it is elevated many times, in fact the vertical movement predominates here. The equipment used for this purpose consists of an endless belt on which are fixed cups that dip the wheat from the "boot" and which discharge it at the top. The location and arrangement of the receiving and shipping "legs" are shown vertically on Plates II and III, and shown sectionally on Plate I. The receiving leg takes the grain from the car and dumps it into the garner for weighing as shown at the very top of Plate II.

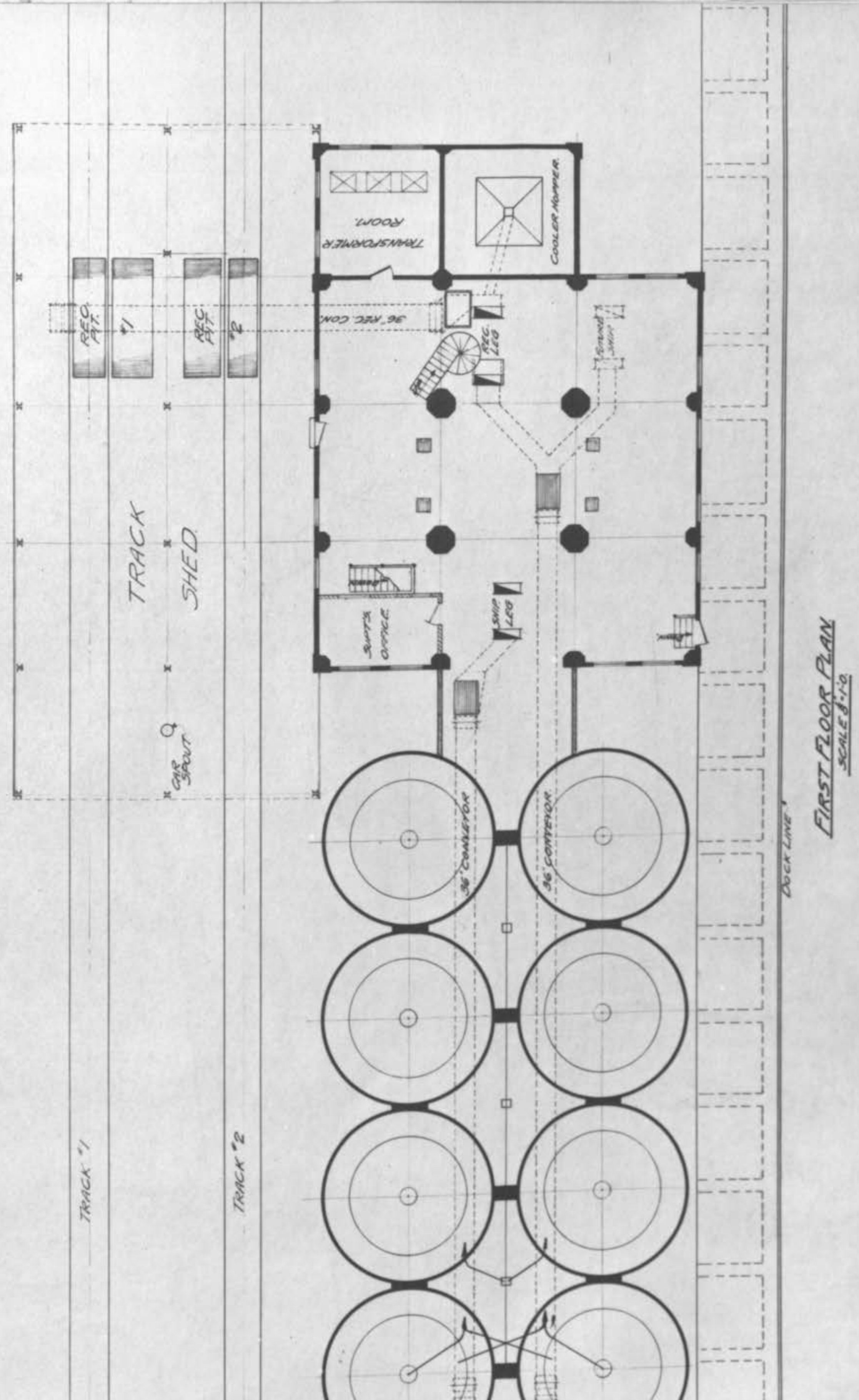


Plate I - First Floor Plan of a Terminal Grain Elevator.

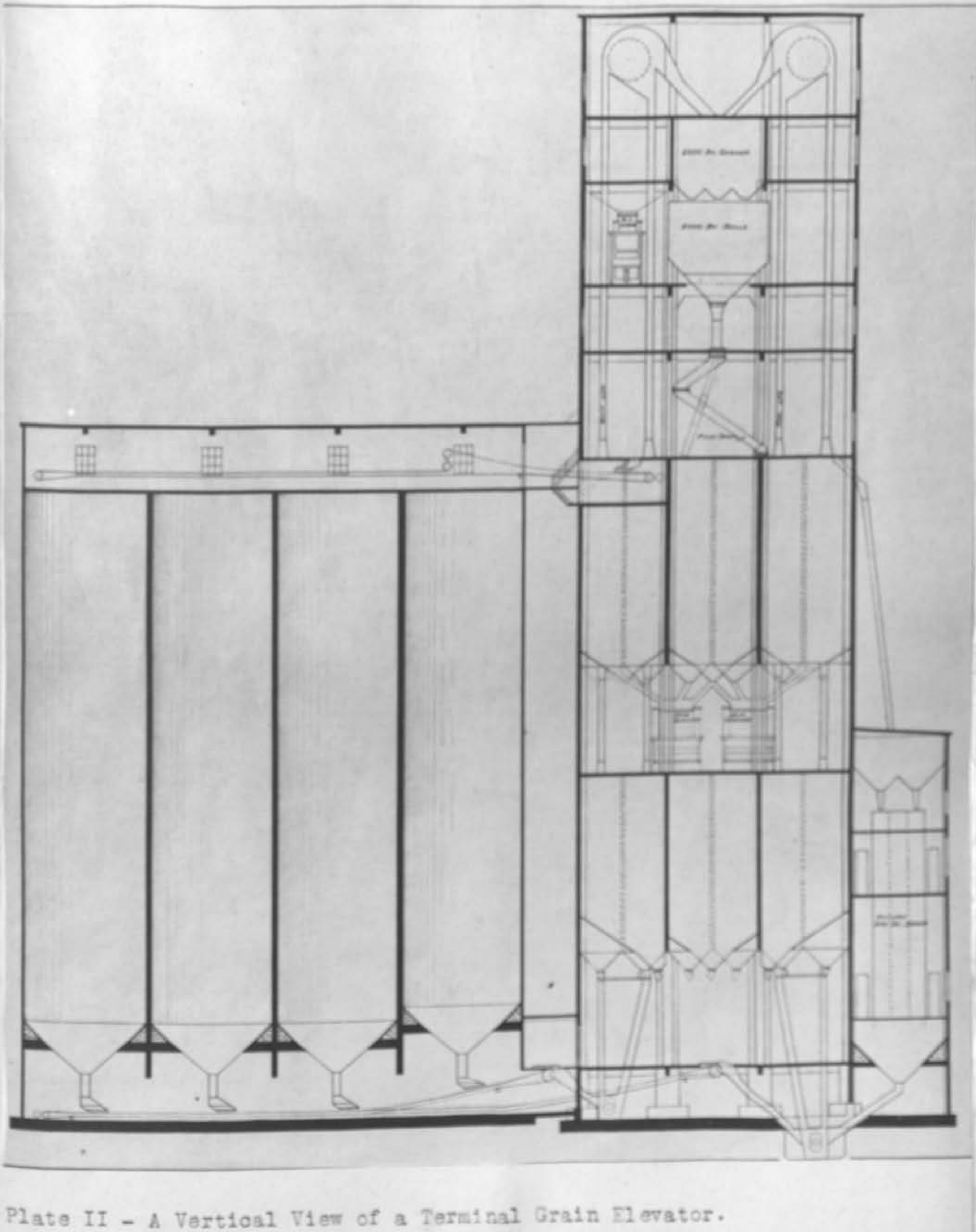


Plate II - A Vertical View of a Terminal Grain Elevator.

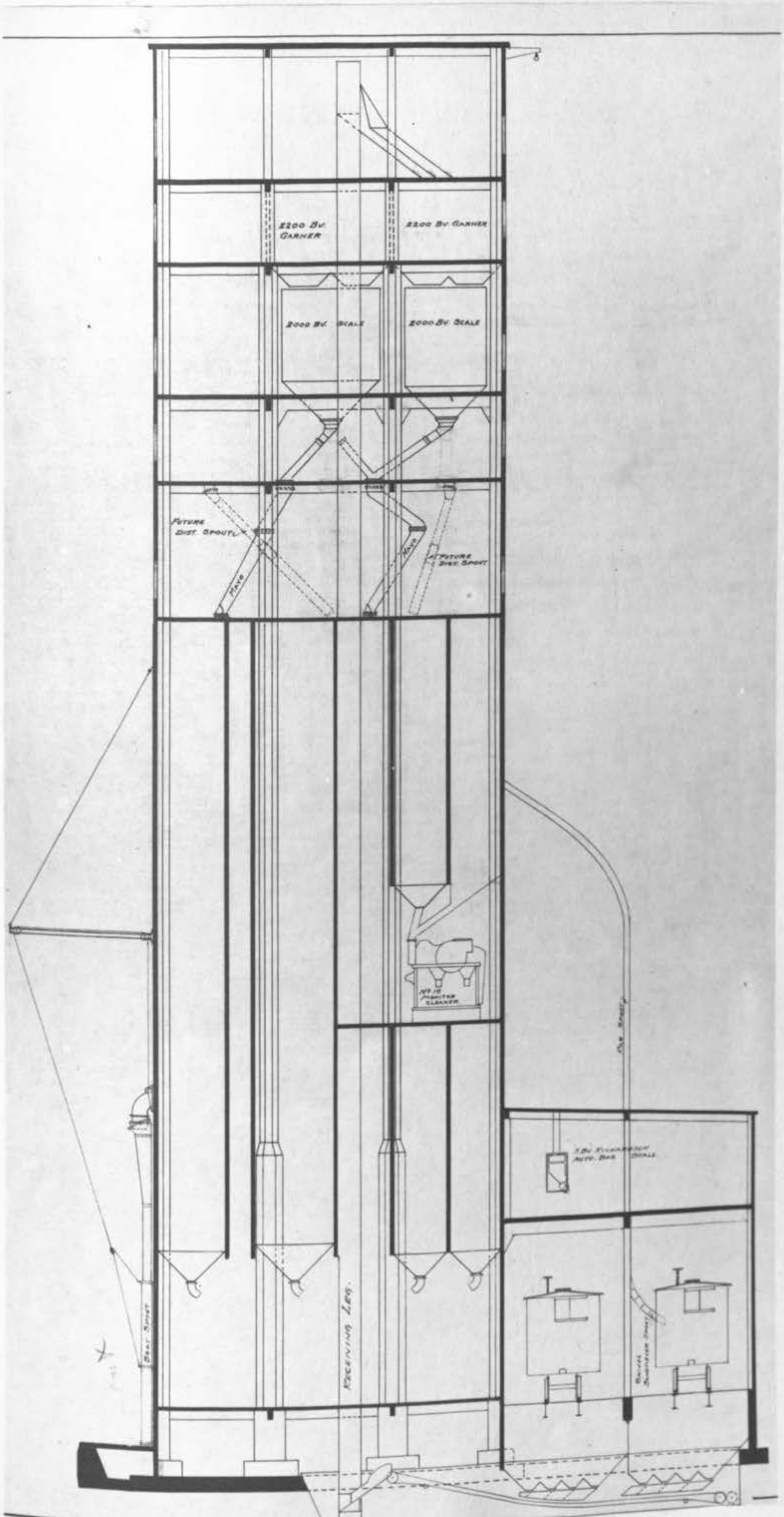
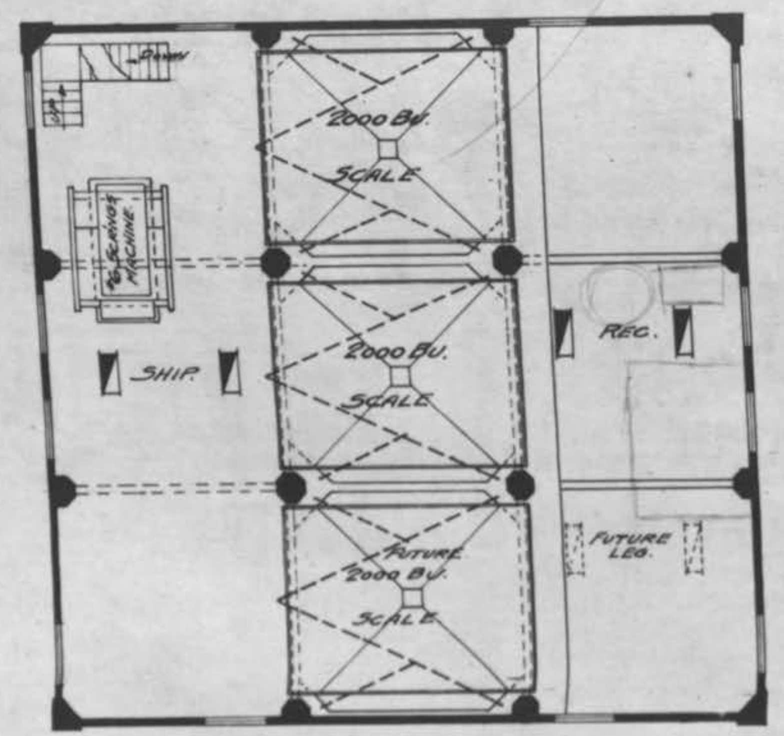
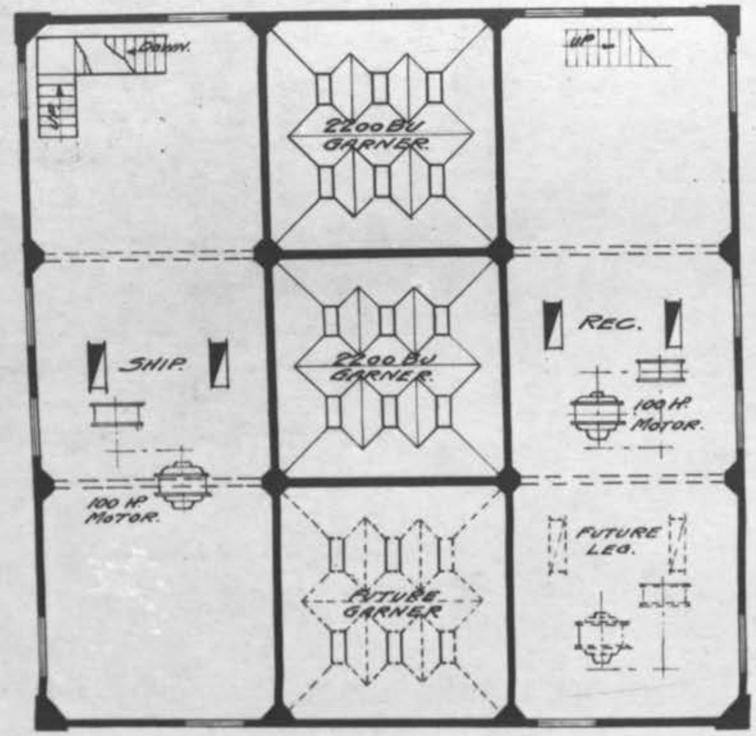


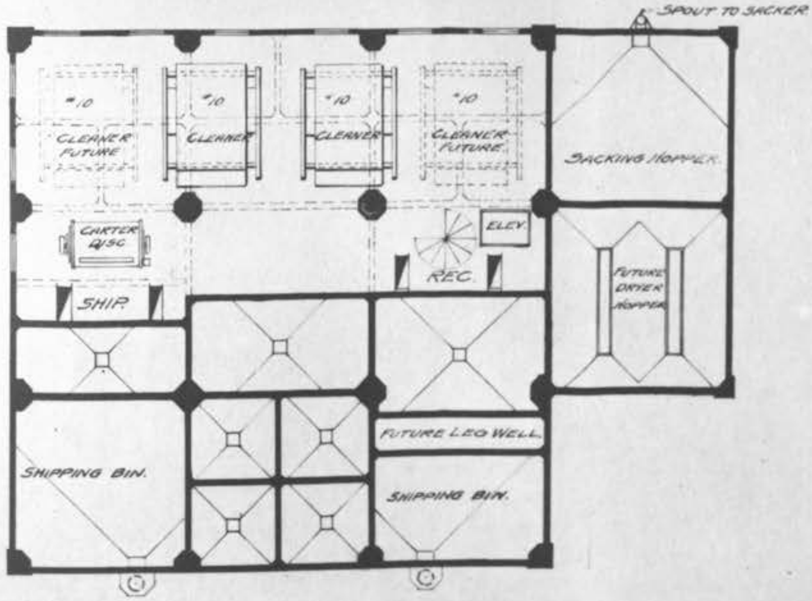
Plate III - A Vertical View of a Terminal Grain Elevator.



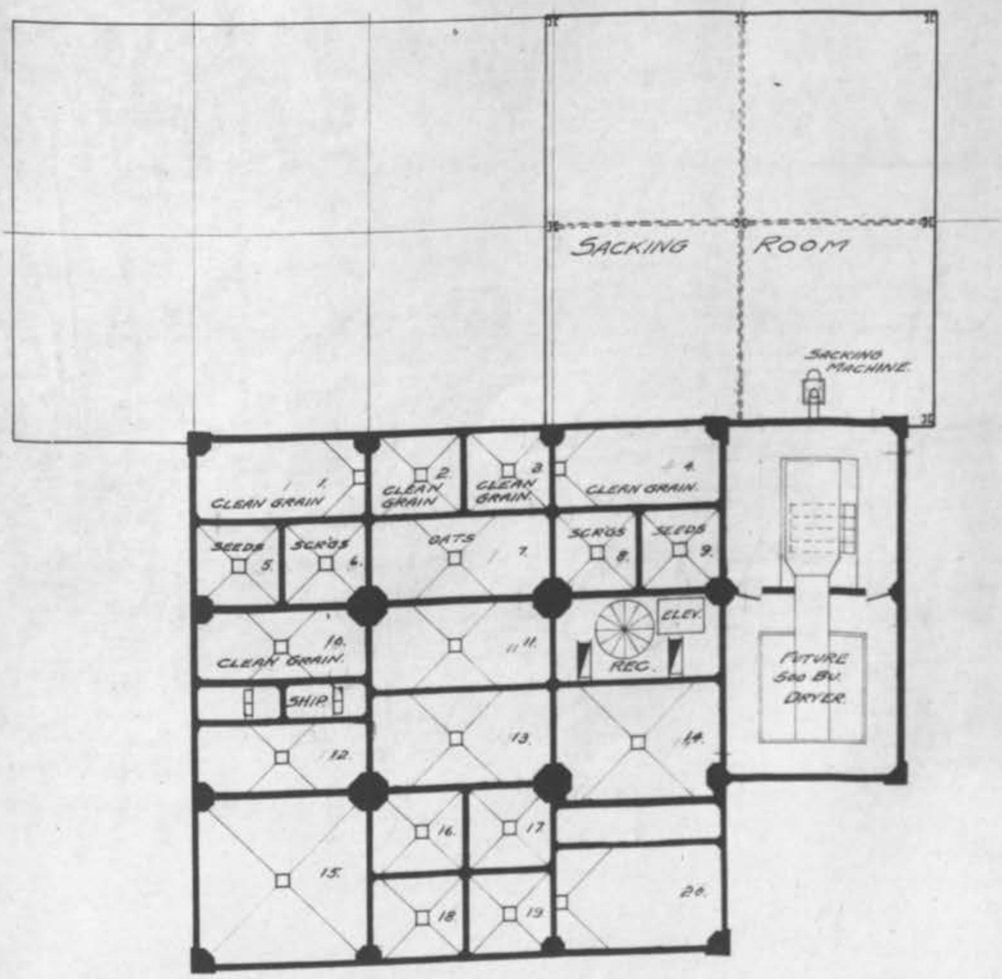
PLAN OF SCALE FLOOR.



PLAN OF MACHINERY FLOOR.



PLAN OF CLEANER FLOOR.



SECTION THRU LOWER BINS.

The shipping leg takes grain from the bin and dumps it into the garner for weighing out.

10. Unloading equipment.

A side view of the equipment used in unloading cars is indicated on Plate III, while on Plate I its location on the floor plan is given. The grain is thrown from the car by means of broad wooden blades which scoop it out. These blades are pulled by steel ropes which pull and release alternately, and they are guided by workmen who plunge them into the grain and guide them to the car door. After all the grain possible is gotten by this method, the workmen sweep the car to get all the grain. As the grain leaves the car it falls into a pit directly under the car. At the bottom of the pit runs a broad endless belt which takes the grain to the boot of the receiving leg.

11. Loading Equipment.

This form of equipment is much simpler than that for unloading. It consists of a spout leading from the bottom of the scale. This spout ends in an adjustable swiveled spout which can be directed to all parts of the car. The car spout is shown in Plate III. The grain is spouted to the car by gravity. It is leveled off by hand and the aid of the adjustable spout.

12. Conveyors.

Grain enters the elevator thru the head-house and then is taken to the storage bins on a wide endless belt, the conveyer belt. This belt runs thru an alley between the tops of the double row of bins running over rollers so placed that its surface is concave. There is also one on the ground floor, which takes the grain away from the bins. Grain is delivered to this lower belt by gravity. It is delivered to the upper belt by the receiving leg. In the upper belt is a tripper or apparatus for doubling back the belt. The tripper is on a movable car which can be placed in front of any desired bin. The velocity of the grain throws it off the belt into a chute which leads to the bin. Both upper and lower belts and tripper are shown in Plate II.

13. Course of Grain thru the Elevator.

Let us now take up the operation of the house; tracing the course of the grain in its progress into and from the house and during its handling while in the house.

The incoming car is spotted directly over the receiving pit, and the grain is dumped therein. Plate III shows the track-shed, pitx and cars in place. The belt conveyor takes the grain to the boot of the receiving leg whence it is elevated to the garner at the top of the house. As fast as the weigher weighs the grain, it is dropped to the boot of the elevating leg from which it is elevated to the upper conveyor belt. From this belt is is thrown into the proper storage bin.

14. The reverse of this procedure takes place when grain leaves the storage bins. It is let onto the lower belt thru the spouts shown in Plate II, and taken to the boot of the shipping leg. This discharges it into the garner from which it goes thru the scale as before. From the scale it goes to the car spout and is delivered into the car.

15. Moving and Conditioning.

When grain is in storage it is not always possible to leave it in the tank until it is desired to ship it. Sometimes it is stored at such high temperatures that if left alone it will heat and sweat and cause great deterioration. If it has a high moisture content it is more likely to get out of condition than if the moisture content is low. Much valuable scientific investigation has been made on this subject, but it is not pertinent to this paper, which is concerned with the actual practices of terminal elevators.

The results of this investigation show that grain which has a moisture content above 14% will not keep well. Therefore grain is graded lower when it has a high moisture content than when it has a low percentage of moisture.

Thus No. 1	wheat	must	contain	not	more	than	14%	moisture
" 2	"	"	"	"	"	"	14.5%	"
" 3	"	"	"	"	"	"	15%	"
" 4	"	"	"	"	"	"	16%	"
" 5	"	"	"	"	"	"	16%	"

This does not mean that wheat which grades Number five will keep with 16% moisture. It means that it will not keep as well and is therefore graded down.

The method adopted and practiced by all terminal elevators is to keep the grain moving. During the winter, theseasonable low temperatures are utilized by taking the grain from the bins, dumping it into the receiving pit and returning it to the bins. This process effectually cools the grain. It also aerates the grain and tends to dry it. A common remark in an elevator while grain is being moved is "You can hear it now" which means the grain is dry enough to make a scratching sound as it runs thru the pipes.

16. The grain is taken from the bin by the lower belt conveyor, elevated and dumped into the receiving pit. From here it is taken to the elevating leg, elevated to the upper conveyor, and thence back to the bins. This operation is being carried on constantly in order to move all the grain. During the season, all the grain in the house is moved at least twice.

17. Mixing.

Another operation of terminal elevators is mixing of grain of different grades. The ethics of this much debated question are not pertinent to this paper. The fact is that, since it is being done daily, it constitutes one of the operating costs of a terminal elevator, and so its economic aspects must be considered. The object of mixing is to raise the grade of grain so that it will bring a higher price. Among other considerations, grain is graded on the weight of a measured bushel. Thus

No. 1	wheat	must	weigh	not	less	than	58	pounds	per	bushel
" 2	"	"	"	"	"	"	57	"	"	"
" 3	"	"	"	"	"	"	55	"	"	"
" 4	"	"	"	"	"	"	53	"	"	"
" 5	"	"	"	"	"	"	50	"	"	"

Wheat which weighs 56-1/2 pounds per bushel would therefore be graded No. 3 and it will at once be seen that it will bring no better price than wheat which just makes the grade at 55 pounds per bushel. The profit from mixing is made possible by this fact. An elevator which has some grain which is heavier than is necessary can mix it with some that is lighter and still retain the higher grade. Or it can take grain of two different grades and mix them in order to make the resultant conform to the grade between the two. This would be done when the average price would show a profit on the operation. This is explained in the following illustration.

18. On March 25th, 1922, the following cash prices were quoted on the Minneapolis Chamber of Commerce.

No. 1 Dark Northern Wheat	$1.65
No. 2 " " "	1.55
No. 3 " " "	1.51
No. 4 " " "	1.42

If the house had some No. 4 Dark Northern Wheat of good quality which weighed 54 pounds per bushel it could profitably mix equal amounts of No. 4 Dark Northern and No. 2 Dark Northern. Thus

1 bushel #2 Dark Northern	57 pounds
1 " #4 " "	54 "
Total	111 "
Average	55.5 "

This is sufficient to be graded as #3 Dark Northern. The values are as follows:

1 bushel #2 Dark Northern	$1.55
1 " #4 " "	1.42
Total	2.97
Average	1.48½

But No. 3 Dark Northern (the resulting grade) is selling at $1.51; the gain being two and one half cents per bushel.

19. After the calculations have been made and the decision arrived at, the actual mixing is done. The flow of grain from the bins is regulated by a device known as a Graver feeder, which can be adjusted to deliver any desired amount of grain. One bin is set to deliver 54 pounds in the same time the

other delivers 57 pounds. The two streams run onto the same belt and are thoroughly mixed. The combined stream is thrown into the boot of the elevating leg. It is then elevated to the upper conveyor belt and dumpted into the bin containing #3 Dark Northern Wheat. This may be done to fill particular orders or as is usual it may be done deliberately as found convenient through the season.

20. Cleaning

There are three fundamental reasons for cleaning grain. The first is that wheat is not suitable for milling when mixed with other seeds. The second is that the by-products (or the seeds that are separated from the grain) are valuable. The third is that the grade of a grain like oats may be raised by cleaning. Any one of these reasons would probably impel cleaning. In the case of oats, a grain which carries a husk or shell, the presence of loose husks would greatly lessen the weight per measured bushel of oats of a high quality. The removal of this loose, light material is therefore a "paying proposition".

21. Farmers occasionally plant what they call succotash, a mixture pf wheat and oats. The resulting crop is about a half and half mixture. There is often a considerable amount of volunteer oats mixed in wheat. Whether cultivated or wild oats, they are valuable when gotten out. Other foreign seeds, such as buck-wheat, weed seeds, and other non-cereal seeds found in wheat, have a varying value. The treatment of screenings can be made profitable by again separating the by-product into further classes to be used as poultry and stock feeds. On March 22, 1922, a car of screenings sold at $9.00 per ton, and they have been quoted as high as $20.00 and $22.00 per ton. Thus it is shown that the value of the by-products is a stimulus for cleaning and separating grains.

22. If all foreign seeds and material were entirely valueless it would still be necessary to clean grain. Flour mills, which form the chief market for wheat, have developed the handling of wheat in the manufacturing of flour to a

high degree of perfection. The public has been educated to use white flour and it is the business of the mills to supply it. Any ingredient in wheat which will darken the flour or in any other way injure its baking qualities lowers the value in the eyes of the miller. Therefore, they clean their wheat again and again until it has an admixture of foreign materials so small that it does not injure the flour.

23.

Cleaning Equipment.

The equipment used in cleaning varies from the common fanning mill found on nearly every farm to the high capacity machine which separates and cleans in the terminal elevator or the flour mill. The principle of the sieve is an old one, in fact the sieve is one of man's oldest implements. It depends for its action on the difference in size of particles to be separated. Thus if one were to run wheat mixed with oats and weed seeds over a sieve with holes larger than wheat but smaller than oats, the oats would be left behind. Further if he were to run the wheat and weed seed mixture over a sieve with holes smaller than wheat, he would sift out the smaller seeds and leave the wheat. This is the underlying principle on which separators are built, altho there is an infinite number of variations in the machines of different makes.

24.

There is another principle used in connection with the above mentioned one. That is the fact that when a mixture is agitated, the lighter particles composing it rise to the top. Thus in a mixture of wheat and oats, the oats would come to the top because they weigh but approximately half as much. Advantage is taken of this fact in running the grain over the sieves. The sieves are given a side-wise shaking motion which causes the heavier wheat to go to the bottom where it immediately falls thru the holes in the sieve. The oats rise to the top and as long as there is any wheat in the mixture they do not touch the sieve. When all the wheat has passed thru, the oats rest

11.
on the sieve and of course have a tendency to go thru. Thus the cleaning is most thoro the first third of the sifter surface and least thoro the last third. To adjust this so that cleaning is most efficient is the problem of makers of cleaners.

26.
When the grain has passed over the first sieve, the oats and larger particles of foreign matter, such as stems, tail off at the lower edge. The wheat and smaller seeds has dropped thru onto the lower sieve. Here the wheat remains on the sieve and tails off at the lower edge. All smaller particles go thru and are collected in a bin. To get an approximately perfect result in cleaning one must have a machine with gangs of sieves, equipped with an air-blast and a repeating attachment. Flour mills, however, use the simpler form for their receiving separator, and the simpler type is often found in terminal elevators.

27.
The Carter-Mayhew disc separator is used where grain must be made unusually clean. It consists of steel discs into which have been sunk holes just large enough to contain wheat kernels. These discs are set vertically and as they revolve thru the grain, they pick up the wheat and throw it into a small trough which carries it away. The fact that wheat for export must be very clean (within.5%) has caused these discs to be much used in Canada - at Port Arthur and Fort William. Minneapolis terminal elevators do not use them.

28.
When it is decided to clean grain, the grain is let onto the lower conveyor belt,xxelevated by the elevating leg, and dropped by gravity to the cleaners. As fast as it is cleaned it is elevated to a bin provided for clean grain, which is usually located in the head-house.

29.
Trans-Shipment.

It sometimes becomes necessary to transfer grain from one car to another. At times when railroad companies will not allow their carxx to leave their lines trans-shipping is necessary. If a car should arrive in bad order, the grain would very likely be changed to another car. The operation would consist of unloading the grain, elevating it and dumping it into a small bin in the head-house, and then loading it onto another car.

30. Functions of a Terminal Elevator.

The foregoing description of operations has also described the functions of a terminal elevator. These functions are storing, cleaning, mixing, moving, or conditioning and trans-shipping. Of these there are three which are of primary importance and two which are secondary. The primary functions are storing, mixing and cleaning. The secondary ones are conditioning and trans-shipping. Conditioning is so inseparably connected with storing that it is really not a separate function but rather an operation which is necessary to successful storage. Trans-shipping is done to such a slight extent in the average or typical house that it has relatively little importance.

31. Some necessary assumptions.

Altho the fore-going description will apply to the operations of nearly all terminal houses and the processes outlined are peculiar to this business, yet there is a great difference between houses. Some houses clean all their grain, others ~~have purchases who~~ prefer to ~~get~~ keep the grain in its original state. Some houses do custom-cleaning, others do not. Some merely store grain as is the case with the large tank-houses, while others do a large amount of mixing. The business also varies from year to year according to the nature of the crop and prevailing business conditions. Grain is not kept in store unless the price warrants it. That is, unless the grain can be sold for delivery at the next delivery date at an advance in price which covers the storage charge, it will not be profitable to hold it in storage. For that reason, there is a great preponderance of oats in the terminal elevators this year, because wheat does not have a "carrying charge" but oats does.

32. It is, thus, obvious that for the purposes of this study a typical house must be selected. Twin City terminals vary from 20,000 bushels to 4,000,000 bushels capacity, but the typical hospital or handling house runs from one half million to one million. The one selected for this study has a capacity of 500,000 bushels of which 100,000 is in the head-house and 400,000 in the bins. We must assume that the management is of average efficiency and that the moving and conditioning of grain is well done, which implies that all the grain in the house is thus moved twice per season.

33. Before leaving our assumption we must dispose of the question of Cost of Reproduction. In order to secure the capital costs for this elevator the cost of reproducing a typical house has been obtained from two large elevator builders and an insurance agent who specialized on elevator and flour mill insurance. The information received from these sources agrees very closely. The cost of a head-house in Minneapolis has run from eighty five cents to one dollar per bushel capacity. The figure of one dollar being considered correct for construction undertaken at the present time. The cost of the storage bins is quite constant and is set at twenty five cents per bushel capacity. These figures are exclusive of equipment. Thus, the plant selected would cost as follows:

Head-house	100,000 bu. capacity	@	$1.00 per bu.	$100,000.00
Storage bins	400,000 " "	@	.25 " "	100,000.00

The construction companies agree that the elevator equipment costs twenty-five per cent of the head-house cost. Thus the equipment of the above house would cost $25,000.00. The cost, including the cost of necessary electric motors, is divided among the different classes of equipment as follows:

Conveyors	$6,500.00
Elevators	5,000.00
Cleaners	4,500.00
Scales	4,000.00
Unloading	3,000.00
Loading	2,000.00
Total	25,000.00

The total cost of reproduction of the house is therefore $225,000.00, which is the final assumption which we must make.

34. The above description gives an intimation of the desirability of a Cost-Accounting System for a terminal elevator. The advantages which accrue to any business thru such a system, accrue to this. The variation between houses in methods of handling grain and the variation between different years business make it apparent that it does not always cost the same to handle grain. However, the terminals of Minneapolis do not analyze their business on a cost-accounting basis, being satisfied to make their charges for custom cleaning, transferring, etc., on the basis of experience and their own statistics. The present study, therefore, had no ground broken before it.

A terminal business cannot be classes as a job-order system, neither is it a process system. It is rather a handling business, and the commodity handled is a crop of grain. There is no possible point at which the process can be said to be completed, nor is it ever completed until the grain leaves the house. The only possible approach is to analyse the cost of a crop year or in other words the handling of one crop. The year as of September first to August thirty-first will, therefore, be chosen as being in line with practice in grain offices.

Chapter II

Dockage in its Relation to Cost of Cleaning.

1. The subject of dockage is a large one, and has been discussed in many of its phases. Therefore, it will not be discussed here except in its relation to this study. It will be well, however, to review the definition given in the Federal Grain Grades. Dockage, according to Federal standards, is the foreign material which can be screened from wheat. In short, if it can be separated by commercial cleaning methods, it is classed as dockage and if it is inseparable, it is classed as "foreign material other than dockage". Dockage is measured in terms of per cent and the percentage is based on the total weight including the dockage.

2. After the dockage has been removed, the grain that is left is graded. As previously explained, the grade depends in part on weight per measured bushel. It also depends in part on the nature of the foreign material left in it. The maximum amounts of such material in wheat are in the following table.

Table V Foreign Material Content in Different Grades

Table V.

Grade	Limit	
No. 1	1 %	of which .5% may be non-cereal
" 2	2 %	" " 1.0% " " "
" 3	3 %	" " 2.0% " " "
" 4	5 %	" " 3.0% " " "
" 5	7 %	" " 5.0% " " "

3. Nature of Dockage.

Dockage may include dirt, sand, cinders, stems, chaff, straw. It may also include seeds of various kinds. The following classification of foreign seeds may be useful:

Cereal Grains
Rye, Barley, Emmer, Spelt, Flax,
Einkorn, Corn, Sorghum, Oats, Rice

Non-cereals.

Chess, Kinghead, Cockle, Vetch,
Wild Rose, Buck-wheat, Wild Onion

Weed Seeds
Pig-weed, Mustard, Fox-tail
Pigeon Grass, Sow Thistle
Russian Thistle, Lambsquarters

4. Value of Dockage

It is obvious that these seeds could all be used for poultry and stock feed. Cleaners are to be had which will separate out oats and flax and these would then carry the prevailing market value. There is no question that dockage often has a high value, but on the other hand much dockage is valueless, for example, stems, chaff, sand, dirt, straw. There have been recent periods when a strong demand for screenings existed and even the chaff and straw had a value. At present, the value is low, even of the better grades of screenings.

5. The question of dockage has been very vital to the grain-growers of the Northwest, and it has been a persistently discussed problem. Farmers have felt keenly that they had a grievance. They have brought grain to their local market and have seen it docked because of the presence of foreign material which they knew to be valuable, and they have said that they should be paid for such material. The reply of the elevator and grain men has been that foreign material is detrimental to the wheat since to get it out is an expensive process. In short, they have acted on the principle that the cost of separating dockage is, in the long run, just about equal to the value of the by-product. There is an important implication here, that the greater the amount of dockage present, the greater is the expense of separating it.

6. Relative Cost.

One of the purposes of this study is to throw some light on the cost of cleaning grain. If the implication mentioned in the last paragraph be true, and there is in reality a difference in cost of cleaning between grains of high and of low dockage content - a study such as this should show it. It was determined early in the study to include some findings on this phase of the matter. For purposes of making comparison an accurate index was desired, one which would indicate the true difference between costs for varying mixtures of grain. For this purpose, power consumption was chosen. Power constitutes a large share of cleaning costs, it can be accurately measured and mathematically analyzed. The other cleaning costs are not so variable as is power, and do not show small changes caused by varying conditions. Labor, for example, is a fairly constant cleaning cost.

Therefore it was decided to conduct an experiment in which power consumed in cleaning grain of varying dockage content would be measured. The co-operation of the State Experimental Flour Mill was enlisted in the experiment. The wheat used at the Experimental Mill is run over a receiving separator immediately on its receipt, after which it is placed in a bin until needed. This separator corresponds to the type usually found in flour mills and terminal elevators. The motor which drives it also drives the receiving leg (which takes the grain to the scales), and a short leg which takes it from the separator to the bin. This unit of the mill is a sufficiently small part of the equipment for handling the grain at the Experimental Mill to make the costs of operating it comparable to the cost of cleaning at a commercial mill or elevator.. The General Electric Company co-operated in the experiment by installing a Watt-meter which would measure the current consumption of that one motor. The chemist of the mill made the necessary meter readings on the grain received while the experiment was conducted, and the wheat-buyer secured cars of varying dockage content for the experiment.

7. As a point from which to compare readings, wheat with zero dockage (or in other words, clean wheat) is highly desirable. In order to make the readings

on such wheat it was arranged to run some clean wheat thru the system. Clean wheat was, therefore, spouted to the receiving pit, from which it was elevated to the scales, weighed, run over the separator, and then elevated to the bin from which it came. The pit held 6231 pounds of wheat. After this meter reading was made, a reading was taken for every car that was bought. It was decided to make the comparison in terms of 1,000 pounds, and thus obviate the confusion between the measured bushel, and the legal bushel of sixty pounds weight.

Table VI

Relative Power Consumption per different dockage content per 1000 pounds.

Car	Dockage	Weight	Power Consumed	Kilowatt per 1000 lbs.	Variation from pred. cars	Minutes per 1000 Lbs.
1	0%	6231	1.8 W	.2888		
2	2%	100.819	27.7	.2747	- .0141	1.88
3	2%	[illegible]		[illegible]		
4	3%	65.890	17.0	.2580	- .0167	1.89
5	4%	88.087	21.0	.2384	- .0196	
6	5%	65.828	16.5	.2506	+ .0122	1.97
7	6%	82.289	20.5	.2491	- .0015	1.82
8	6%	88.462	22.	.2487		
9	8%	83.579	20.	.2393	- .0098	

Power consumption for amounts required to produce 1,000 lbs. clean wheat.

8. The significant feature of the data obtained from the experiment is the comparative uniformity in the amount of power required for different lots of grain. In no case is the difference between one reading and its immediate predecessor greater than .02 kilowatts. The mean of the series is .2472 kilowatts and the greatest deviation from the mean is .0416 kilowatts xx (the case of the clean wheat). The range of the series is .0504 kilowatts. Either of these variations is entirely negligible when reduced to terms of bushels. The conclusion is plain, that the power consumption per unit is practically uniform. Inasmuch as the grade is fixed on the clean wheat and the amount of the clean wheat determines the number of bushels, it was thought desirable to reduce the above figures to terms of 1000 pounds of clean wheat. In other words to clean enough of the original mixture to produce 1000 pounds of clean wheat as a result.

Furthermore, as the grain becomes bulkier by the addition of foreign matter the friction involved in moving it is less. Clean wheat packs more firmly than wheat which contains some dockage, and the friction developed in moving it is greater. Power requirements decrease, therefore, when dockage is present.

Table VII

Car	Dockage	Clean Wheat	Dockage	Amount mixture necessary to produce 1000# clean wheat	Power required to clean 1000# wheat plus dockage	Variation
1	0%	1000	0	1000	.2899	
2	2%	980	20	1020.4	.2803	-.0085
3	3%	970	30	1030.9	.2659	-.0144
4	4%	960	40	1041.6	.2483	-.0176
5	5%	950	50	1052.6	.2637	+.0154
6	6%	940	60	1063.6	.2649	+.0012
7	8%	920	80	1086.9	.2601	-.0048

These figures point to the same conclusions as do those in Table VI. The variation is less between cars and the range of the series is also less. A difference of .0176 kilowatts between two items of 1000 pounds is a difference of .00106 kilowatts between two bushels of 60 pounds each. In terms of money cost, such amounts of difference are absolutely negligible.

9. Explanation of Results.

The conclusion is contrary to the implication in paragraph five of this section, that increase in dockage content should result in increased cleaning costs. The reason is not far to seek. Oats, barley, stems and chaff are all appreciably lighter than wheat, and the more there is of them in the mixture, the lighter is a given bulk of the mixture. This being true one would expect power consumption to decrease progressively as dockage is increased, and the mixture becomes lighter and bulkier. But it does not do so, as is shown in Table VI. Clean wheat consumes the most, and the amount decreases until four per cent of dockage is reached. The addition of the next one per cent of dockage shows an increase, but this does not persist as at eight per cent the power consumed is again as low as it was at four per cent. The reason for this is that as foreign matter increases the grain will go thru the separator more slowly. The longer time consumed means an increase in power consumed. The change makes its appearance at the point where five per cent of dockage is present, but the downward trend sets in again and for the same reason.

Thus, it appears that there are two compensating forces, one of time and one of weight and friction. The benefit coming from lessened weight and friction is compensated by lessened cleaning capacity. If cleaners in terminal elevators were compelled to operate at utmost capacity at all times in order to get the work done, this might be a serious consideration. They are not so run, however, being idle a share of the time as a rule, save in exceptional cases.

10. Having determined to use power consumption as an index to relative cleaning costs, we have learned by experiment that this cost does not vary appreciably. We are justified now in applying our findings to cleaning costs in general. In the later sections of the study, when it is necessary to distribute total cleaning cost over product handled, such total cost will be distributed uniformly. As explained, the receiving separators used by terminal elevators and flour mills do not vary from a standard type to any extent. The separator used in this experiment is of this type. The results are applicable to all mills and elevators. Even tho the physical arrangements make absolute costs greater or less, relative costs will not vary.

Chapter III The Accounting System.

1. It is seen from the foregoing description of a Terminal Elevator that the business consists primarily in receiving grain for storage, cleaning it, and if desired, mixing it for the purpose of raising its grade. In a determination of costs, therefore, it is suitable to use these three divisions as the basis of the ultimate accounts, the titles to which would be Storing, Mixing, and Cleaning. Having decided on the names and content of the ultimate accounts, let us analyze each for the purpose of arriving at the nature of the penultimate or intermediate accounts.

2. Cleaning.

Let us take the ultimate account called Cleaning, and let us assume that the cleaning is done when convenient after the grain has been received into storage. Cleaning then implies moving from the bin to the elevating leg, elevating it and dropping it to the cleaners. After cleaning it is elevated to the upper conveying belt, and moved back again to the bins. Thus there are five separate steps in cleaning, namely;

Cleaning	(Conveying (Elevating (Cleaning Operation (Elevating (Conveying

This is true of the house which buys grain and stores it on its own account. The house which does custom cleaning varies this proceedure but slightly. The grain is unloaded and elevated to a small bin in the head-house from which it is dropped to the cleaners. Then elevated to another bin and finally loaded. The processes in the order in which they are performed are:

Custom-Cleaning	(Unloading (Elevating (Cleaning Operation (Elevating (Loading

The unloading and loading operations are thus substituted for the conveying of the grain twice. These costs are somewhat larger, as will be shown, and the accounting is explained in detail in the final section of this paper.

3. Mixing.

Mixing is done as found convenient,,after the grain has been placed in the bin and that is replaced in another bin after being mixed. The operations required are taking grain from two bins and letting it onto the belt at the same time (in order to mix it), elevating to the upper conveyor and moving back to the bin which is to hold the mixture.

Mixing	(Conveying (Elevating (Conveying

4. Storing

This function is more complex than the others embracing as it does the movement of the grain into the house and its discharge, weighing it (both in-coming and out-going), and moving it while in the house as previously described.

The chart of operations is then

Storing	Incoming	(Unloading (Elevating (Weighing (Elevating (Conveying	
	Moving (twice)	(Conveying (Elevating (Conveying	2 2 2
	(Outgoing	(Conveying (Elevating (Weighing (Loading	

5. Trans-shipment or transfer from car to car.

This operation consists of unloading the grain, elevating it to a small bin in the head-house and dropping it to another car. As suggested in Paragraph 2 these operations are very similar in nature to the conveying operation used twice. The cost of transfer is therefore not appreciably different from the cost of mixing explained in Paragraph 3. The relatively small amount of this work makes this classification satisfactory.

6. Intermediate Accounts.

It will be seen from these analyses that the component operations are these.-

Elevating
Conveying
Loading
Unloading
Weighing
Cleaning Operation

Let these, then, be the titles of the intermediate accounts of our proposed system. To them must be allocated all primary expense accounts.

7. Primary Expense Accounts.

The items which go to make up these accounts are the usual expense items which make up the costs of running the elevator. They may be listed thus,-

Power
Labor
Repairs
Interest
Insurance
Taxes
Depreciation Buildings
Depreciation Equipment

8. Chart of Accounts

The following is a graph of the flow of items from Primary to Ultimate Accounts.

Primary	Intermediate	Ultimate
Repairs)	(Elevating)	(Storing
Labor)	(Conveying)	(Cleaning
Power)	(Loading)	(Mixing
Interest)	(Unloading)	(
Insurance)	(Weighing)	(
Taxes)	(Cleaning)	(
Deprec.Bldgs.)	(Operation)	(
" Equip.)	( )	(
Superintendence)	( )	(

Let us now take up each of these primary and intermediate accounts separately, and discuss its distribution.

9. Repairs.

The items in this account may be allocated quite accurately from observation of actual requirements of the several types of equipment. The Repair man should keep a record of the hours expended on the different jobs and the supplies required for them. From this information the distribution can be calculated accurately. Keeping this record does not consume the repair man's time and it affords him and the company an insight as to the upkeep of the equipment.

10. Labor.

This account also is subject to a high degree of accuracy. The workmen should be required to keep time cards, on which would be shown the hours expended on the various jobs. From the information on these cards the foreman or accountant could distribute the labor to the proper intermediate accounts, e.g., moving the tripper would go to conveying, cleaning out a plugged elevator leg would go to elevating. The allocation of labor should be done each month even if the accounting period be a year or half-year.

11. Power.

If a high degree of accuracy were desired for this cost, it could be secured by attaching a current meter to each form of equipment requiring power. This would, of course, be absolutely accurate. If the meters were left for a stated period and an average of the power consumption for a week or a month determined, it would be nearly as satisfactory. However, if this method be impracticable, a close observation must be made of the power requirements of the various operations, and if this be done carefully, it may satisfy the requirements. If steam power is used, as is the case in some of the older elevators, the distribution would be the same, altho the costs would consist of different items.

12. Superintendence.

There are three possible ways for distributing the cost for superintendence to the intermediate accounts.

1. Total labor hours
2. Total labor costx
3. Number of employees

The first implies that the superintendent is required to oversee quite closely the work of his men and that, inasmuch as he puts in the same length of day, that his time is expended in the same ratio as theirs. The second is really similar to the first, but is superior in the case of a large organization with many departments where the labor cost of each department is known. The third is nearly the same as the second, using number of employees instead of labor cost. The latter two are not applicable to a Terminal Elevator, since it is not divided into well defined departments. The men, with the exception of the weigher, may work all over the house. The first, therefore, is used. The labor cost has already been distributed in Paragraph 10, and we will distribute superintendence on the same basis.

13. Administration.

Expenses of administration are not included. It is the usual custom for a company to own a number of elevators in various parts of the city, and administer them from a down-town office. There is often a line of country elevators in connection with it, and often the company owns membership on the Chamber of Commerce and does its own trading. The question of administration costs therefore resolves itself into a separate problem and the extreme degree of variation in the different offices makes a typical one nearly impossible. We will, therefore, leave these costs out of the elevator costs, and assume that they are deducted from the profits of the company.

14. Depreciation on Buildings.

A reference to the Cost of Reproduction Schedule discloses the fact that the typical head-house described therein has a capital cost of $100,000.00. It is abvious that the depreciation on the storage bins should be charged to the ultimate account. Storing and this depreciation need not be run thru an intermediate account. On this basis, 50% of the total depreciation is set over at once, and 50% is run thru the intermediate accounts. This proportion represents the capital cost of the head-house.

Since this contains the equipment for cleaning, elevating, conveying, loading and unloading, and since its bins are merely temporary storage places used in cleaning, loading, and unloading, in holding grain until it can be weighed and for similar short time purposes, and since all the grain that goes thru the head-house uses the services represented by each of the intermediate accounts, this portion of depreciation should be allocated to the six intermediate accounts on an equal basis. By this equitable division each bears 8-1/3% of building depreciation.

The depreciation on buildings should be figured on a forty year basis at least, owing to the substantial nature of the construction.

15. Depreciation on Equipment.

The Cost of Reproduction Schedule gives the capital costs of the items of equipment. From this can be calculated a table of the relative weights of these items. Depreciation on equipment would be handled similarly to the apportionment of its capital-cost, therefore this table may be used to distribute the depreciation on equipment. This item should be figured on not more than a ten year basis, because of the tendency to wear out.

16. Interest, Insurance and Taxes.

It does not require much argument to show that these accounts bear as close a relation to capital costs as do also the depreciation accounts. In fact capital-costs would be used as a primary basis for arriving at these amounts. The same schedule of distribution as is described in Paragraph 15 should be used for these accounts.

This completes the allocation of the primary accounts to the intermediate accounts. We will now turn to the distribution of these to the ultimate accounts.

17. Elevating.

The analysis of the Ultimate Accounts found in Paragraphs 2 to 4 shows that the elevating operation is used in performing the ultimate function.

Thus

Cleaning	2 times
Storing	5 "
Mixing	1 "

Thus mixing is chargeable with 1/8 or 12.5 %
Storing " " " 5/8 or 62.5 %
Cleaning" " " 1/4 or 25.0 %

The total cost of the elevating operation is allocated on the above basis.

18. Conveying.

The analysis of the ultimate accounts shows that the conveying operation is used in the following manner in performing the ultimate functions.

Cleaning	2 times
Storing	6 times
Mixing	2 times

Thus cleaning is chargeable with 2/10 or 20%
Storing " " " 6/10 or 60%
Mixing " " " 2/10 or 20%

19. Loading.

A reference to the analysis of ultimate accounts discloses the fact that the loading operation is used once only, and that in the case of storing, with the exception of custom-cleaning and trans-shipping. These cases are explained in Paragraphs 2 and 5. The charging of all loading costs to storing is explained in Paragraph 2.

20. Unloading.

The remarks in Paragraph 19 regarding loading apply alike in the case of unloading.

21. Weighing.

The analysis found in Paragraph 2 to 4 shows us that the operation of weighing is used twice, as the grain enters the house and as it leaves it. These weighings are both chargeable to Storing, and the entire weighing cost thus goes to Storing.

22. Cleaning Operation.

It is obvious that the entire cost of the cleaning operation goes to the ultimate account - Cleaning.

Repairs

Sal. Repairman	Elevating	20
Repair Supplies	Conveying	20
	Loading	10
	Unloading	18
	Weighing	10
	Cleaning operation	22
		100

Power (inc. Light)

Electric Current	Elevating	25
	Conveying	25
	Loading	
	Unloading	20
	Weighing	
	Cleaning Oper.	30
		100

Labor

Sal. Superintendent	Elevating	10
" Laborers	Conveying	10
	Loading	22
	Unloading	22
	Weighing	20
	Cleaning Oper.	16
		100

Interest

Interest at 4% on Capital cost of Bldgs. & Equip.	Storing	44.4%
	Elevating	9.6%
	Conveying	10.3 %
	Loading	8.3 %
	Unloading	8.7 %
	Weighing	9.2 %
	Cleaning Oper.	9.5 %
		100.0 %

Taxes

Taxes expense	As above

Insurance

Insurance Exp.	As above

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Depreciation Buildings

Depreciation on Head-house storage bins	Storing	50.
	Elevating	8.3 1/3
	Conveying	8.3 1/3
	Loading	8.3 1/3
	Unloading	8.3 1/3
	Weighing	8.3 1/3
	Cleaning Oper.	8.3 1/3
		100.00

Depreciation Equipment

Elevating	20
Conveying	26
Loading	8
Unloading	12
Weighing	16
Cleaning Oper.	18
	100

Elevating

Repairs	20%	Cleaning	25%
Power	25%	Storing	62.5 %
Labor	10%	Mixing	12.5 %
Interest	9.6%		
Taxes	9.6%		
Insurance	9.6%		
Deprec. Bldgs.	8.3 1/3%		
Deprec. Equip.	20 %		

Conveying

Repairs	20 %	Cleaning	20 %
Power	25 %	Storing	60 %
Labor	10 %	Mixing	20 %
Interest	10.3 %		
Taxes	10.3 %		
Insurance	10.3 %		
Deprec. Bldgs.	8.3 1/3 %		
" Equip.	26. %		

Loading

Repairs	10 %	Storing	100 %
Labor	22 %		
Interest	8.3 %		
Taxes	8.3 %		
Insurance	8.3 %		
Deprec. Bldgs.	8.3 1/3 %		
Deprec. Equip.	8.		

Unloading

Repairs	18 %	Storing	100 %
Power	20 %		
Labor	22 %		
Interest	8.7 %		
Taxes	8.7 %		
Insurance	8.7 %		
Deprec. Bldgs.	8.3 1/3%		
Deprec. Equip.	12. %		

Weighing

Repairs	10 %	Storing	100 %
Labor	20 %		
Interest	9.2 %		
Taxes	9.2 %		
Insurance	9.2 %		
Deprec. Bldgs.	8.3 1/3 %		
" Equip.	16. %		

Cleaning Operation

Repairs	22 %	Cleaing	100 %
Power	30 %		
Labor	16 %		
Interest	9.5 %		
Taxes	9.5 %		
Insurance	9.5 %		
Deprec. Bldgs.	8.1/3 %		
" Equip.	18.		

Storing

Interest	44.4 %
Taxes	44.4
Insurance	44.4
Deprec. Bldgs.	50.
Elevating	62.5
Conveying	60
Loading	100.
Unloading	100.
Weighing	100.

Cleaning

Elevating	25 %
Conveying	20 %
Cleaning Oper.	100%

Mixing

Elevating	12.5
Conveying	20.

Chapter IV The Application

This chapter consists of the application of the foregoing system to the cost of an elevator as actually incurred. The figures charged in the following accounts were taken from the books of a company operating several terminal elevators, and they apply to a house of the size and capacity described in the Cost of Reproduction Schedule. The figures for Interest were calculated on the "Opportunity Cost" basis, that is, the Interest account was charged at a rate which the company could earn on their capital invested if it were placed at any time in other lines. The rate is set conservatively low. Depreciation is figured on the Cost of Reproduction Schedule on a forty year term for the storage bins, and a ten year term for equipment.

Taxes include taxes paid both on real estate and on grain, the latter tax being paid at the rate of one half mill per bushel on wheat and flax and one quarter mill per bushel on other grain. Insurance includes premiums on the grain in the house and on the house itself, the forms of protection including "Use and Occupancy" (or insurance against being deprived of the use of the building for businesspurposes), and Explosion- (insurance against dust explosion). The other expense items are those usual to the terminal elevator business. The volume of business for the year August 1, 1920 to July 31st, 1921, was 2,126,338 bushels of grain.

Repairs

1200.00	746	Elev.
2530.00	746	Convey.
3730.00	373	Loading
	671.40	Unload.
	373.	Weighing
	820.60	Cleaning
	3730.00	

Power

3675.00	918.75	Elev.
	918.75	Convey.
	735.00	Unload.
	1102.50	Cleaning
	3675.00	

Labor

14,040.00	1404.00	Elev.
	1404.00	Convey.
	3088.80	Loading
	3088.80	Unload.
	2808.00	Weighing
	2246.40	Cleaning
	14,040.00	

Interest

9,000.00	3996.	Storing
	864.	Elev.
	927.	Convey.
	747.	Loading
	783.	Unload.
	828.	Weighing
	855.	Cleaning
	9,000.00	

Taxes

R.Est.	5817.	3054.70	Stor.
Grain	1063.	660.50	Elev.
	6880.00	708.65	Convey.
		571.05	Loading
		598.55	Unload.
		632.95	Weighing
		653.60	Clean.
		6,880.00	

Insurance

Grain	3435	3435.00	Storing
Gen'l	2830	1256.50	Stor.
		271.70	Elev.
		291.50	Convey.
		234.90	Loading
		246.20	Unload.
		260.35	Weigh.
		268.85	Clean.
	6265.	6265.00	

Deprec. Bldgs.

5,000.00	2500.00	Stor.
	416.65	Elev.
	416.65	Convey.
	416.65	Loading
	416.65	Unload.
	416.65	Weigh.
	416.75	Clean.
	5,000.00	

Deprec. Equipment

2500.00	500.	Elev.
	650.	Convey.
	200.	Loading
	300.	Unload.
	400.	Weigh.
	450.	Clean.
	2500.	

Elevating

Repairs	746.00	1445.40	Cleaning
Power	918.75	3613.50	Storing
Labor	1404.00	722.70	Mixing
Interest	864.00	5781.60	
Taxes	660.50		
Insurance	271.70		
Deprec. Bldgs.	416.65		
Deprec. Equip.	500.00		
	5781.60		

Conveying

Repairs	746.00	1212.51	Cleaning
Power	918.75	3637.53	Storing
Labor	1404.00	1212.51	Mixing
Interest	927.00	6062.55	
Taxes	708.65		
Insurance	291.50		
Deprec. Bldgs.	416.65		
Deprec. Equip.	650.00		
	6062.55		

Loading

Repairs	373.00	5631.40	Storing
Labor	3088.80		
Interest	747.00		
Taxes	571. 05		
Insurance	234.90		
Deprec. Bldgs.	416.65		
Deprec. Equip.	200.00		
	5631.40		

Unloading

Repairs	671.40	6839.60	Storing
Power	735.00		
Labor	3088.80		
Interest	783.00		
Taxes	598.55		
Insurance	246.20		
Deprec. Bldgs.	416.65		
Deprec. Equip.	300.00		

Weighing

Repairs	373.00	5718.95	Storing
Labor	2808.00		
Interest	828.00		
Taxes	632.95		
Insurance	260.35		
Deprec. Bldgs.	416.65		
Deprec. Equip.	400.00		
	5718.95		

Cleaning Operation

Repairs	820.60	6813.70	Cleaning
Power	1102.50		
Labor	2246.40		
Interest	855.00		
Taxes	653.60		
Insurance	268.85		
Deprec. Bldgs.	416.75		
Deprec. Equip.	450.00		
	6813.70		

Storing

Interest	3996.00	39,683.18	Main Office
Taxes	3054.70		
Insurance	4691.50		
Deprec. Bldgs	2500.00		
Elevating	3613.50		
Conveying	3637.53		
Loading	5631.40		
Unload.	6839.60		
Weigh.	5718.95		
	39,683.18		

Cleaning

Elev.	1445.40	9471.61	Main Office
Convey.	1212.51		
Clean. Oper.	6813.70		
	9471.61		

Mixing

Elev.	722.70	1935.21	Main Office
Convey.	1212.51		
	1935.21		

1. Some analysis and comparisons between our results and figures and rates now in use will now be made.

2. Storing.

We have seen in Paragraph 5, Section 1, that the terminal elevators of Minneapolis used their capacity 3.04 times in handling the 1919 crop, the public houses more times, and the private and tank houses less times than the average. Let us see how this compares with our results. If our volume is 2,126,338 bushels and our storage capacity 500,000 bushels, our capacity was used 4.25 times in handling the volume. From this figure can be calculated the average length of time the grain remained in the house, by dividing the year or twelve months by 4.25. The result is 2.82 months.

3. The total storing cost divided by total volume gives the cost of handling one bushel for the average length of storage. Thus $39,683.18 divided by 2,126,338 gives $0187, the cost of storing 2.82 months. Reduced, this figure is $.00663 as the cost of storage for one month, When the elevator is used to capacity. The legue rate for storage charges is one thirtieth of one cent per day or one cent per month. Thus the maximum margin for man office expenses, salaries and profits, would be $00337 or 33 1/3% of the income from storage charges.

4. It is obvious that the average terminal elevator is not full to capacity at all times. The grain crops are largely marketed in the fall, and during fall and winter the elevators are taxed to their full capactiy. During the summer this is not true. As wheat is

constantly being milled, the old crop is approaching exhaustion by the time the new crop is marketed. It would have been interesting and valuable if the facts could have been secured showing the actual amount of grain in storage in relation to total capacity. The officials of the Minneapolis Chamber of Commerce could not furnish this information, however, and it was not contained in a usable way in their annual report. This information is necessary, however, if the present findings are to be applied to the business of any specific elevator, or if they are to be used to determine the fairness of rate charged by Terminal Elevators. The per unit (per bushel) cost of handling grain is increased and the margin of profit is decreased when the quantity of grain handled in an elevator is decreased, either by using the capacity a portion of the year or by using only a portion of the capacity through the year.

Table VIII. Effect of degree of Utilization of Storage capacity on costs of storage grain.

Percent of Capacity utilized	Capacity in bushels	Number of times used	Average length in months	Relative costs per bushel
100	500,000	4.25	2.82	.00663
90	450,000	4.72	2.54	.00735
80	400,000	5.31	2.26	.00822
70	350,000	6.07	1.97	.00948
60	300,000	7.08	1.69	.01106
50	250,000	8.50	1.41	.01325

5. The above table is calculated on the capacity and volume of business used in the calculation in paragraph 3, and the capacity being utilized to different degree, but the house being operated the year around. This is the practice in terminal elevators, the

management of which attempts to keep some kind of grain in their bins at all times whatever will pay them their handling charge. The table points out the tendency of costs to increase rather rapidly as the degree of utilization of storage capacity decreases. It is therefore apparent that the degree of utilization becomes an important part of the application of this system to the amounts of specific companies. The records of the company would yield the desired information if the daily or weekly amounts of stored grain were averaged and the result compared with the total storage capacity.

6. It should be observed that in the above calculations the costs of operating the terminal elevator are regarded as fixed. This is substantially true. The practice is for the elevators to maintain a full or maximum crew throughout the year - by this means obviating the necessity of training men each fall in the busy season. Overhead expenses , such as depreciation, interest, taxes, etc., are constant throughout the year. The chief items of expense which vary with volume of business handled are power, insurance on grain in storage and taxes on grain in storage. A terminal elevator operates under decreasing costs and by reducing its storage activities,- it increases its per unit costs. However, in so far as the costs vary directly with the volume of business, they do not increase with a decrease in the quantity stored. In applying this system to the accounts of a specific company, no special calculation is necessary, as the actual expenses incurred and the actual degree of utilization are both determined.

7. Cleaning.

The total cleaning cost is $9,471.61 and we wish to know the cost of cleaning one bushel. We have already assumed that all grain is cleaned, and the amount is as before 2,126,338 bushels. The cost of cleaning one bushel is, therefore, $.00445 when grain is cleaned while in storage. Let us analyze this further.

Cost to clean	60 lbs.	$.00445
" " "	6000 "	.445
" " "	2000 "	.1483

Thus cleaning costs are 14.83¢ per ton.

8. Custom Cleaning.

This is more involved and a more expensive process since it comprises unloading and loading, elevating twice and cleaning. These costs are:

Unloading	$6,839.60
Loading	5,631.40
Elevating	1,445.40
Cleaning	6,813.70
	$20,730.10

Using the same volume of business as before. The average cost of handling one bushel in this way is $00975. As before

Cost to clean	60 lbs	$.00975
" " "	6000 "	.975
" " "	2000 "	.325

The cost to clean in this way is 32.5 cents per ton as compared to 14.83 cents for cleaning from storage.

Let us see how cleaning costs compare with value of dockage at different prices and different dockage content with the unit of comparison being the ton of mixture.

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Table IX. Value of dockage from one tom at different prices & percent of dockage.

% Dockage	Amount Dockage	Value @ $9.00 per ton	Value @ $20.00 per ton
2	40 lbs	$ .18	$.40
3	60 "	.27	.60
4	80 "	.36	.80
5	100 "	.45	1.00
6	120 "	.54	1.20

Cost of cleaning one ton of wheat (with dockage) is constant at $.1483, but the value of the by-product varies from eighteen cents to fifty-four cents at present prices.

The above costs do not include transportation of dockage from the elevator to the place of utilization. If the elevator retains the screenings as pay for cleaning, this cost should be included. When, in addition, main office expenses are considered as coming out of the margin between the prices of dockage and the cost of cleaning, the margin narrows.

Chapter V. - Conclusion.

It has been suggested in an earlier part of this paper that terminal elevators do not use cost accounting methods in the conduct of their business. This does not mean, however, that they are not applicable to the grain business. The system devised in this paper could be applied to any terminal warehouse. Slight modifications would doubtless be necessary to suit individual cases. The distribution of the primary accounts should be changed to meet requirements. The underlying principles, however, will apply to the business of all terminal elevators. It is the opinion of men in the grain trade that costs should be allocated over a crop year. The

The handling cost thus obtained would be an average cost. If it were desired to obtain monthly costs distributed over the volume of business handled during each month, there is no reason why it could not be done. Depreciation, interest, prospective taxes for the year could be divided into monthly parts. Current expenses, such as labor, power, repairs, etc., are easily gotten by the month. The volume of grain handled, the degree of utilization of storage capacity can be determined each month. The system thus is seen to be an elastic one, meeting the needs of the grain trade, lending itself to adjustment to meet varying conditions. The information obtained by a general application of cost finding to terminal elevators should prove valuable in the problem of putting a fair rate for storing, cleaning and other services of Terminal Grain Elevators.