A BOOK ON SILAGE

By

F·W·WOLL

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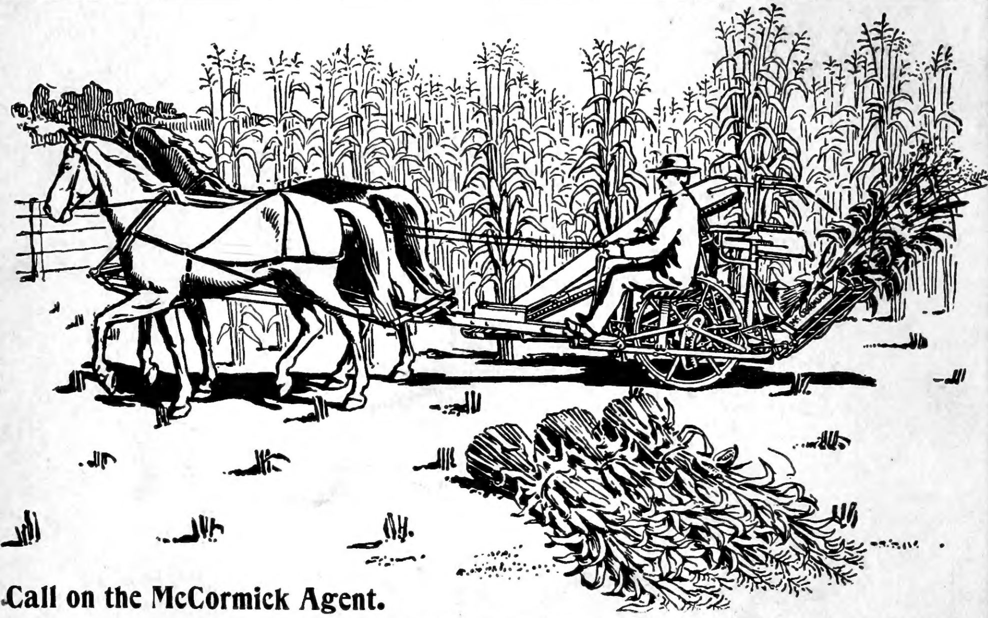

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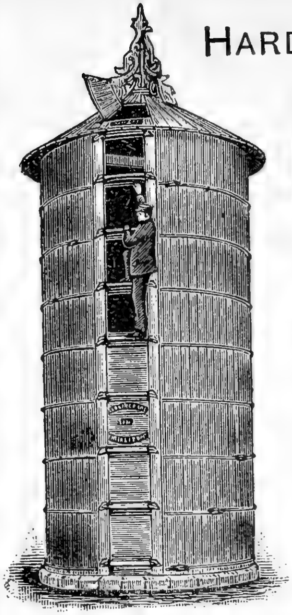

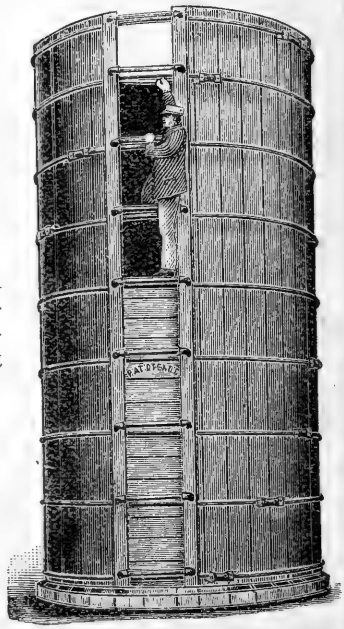

A BOOK ON

SILAGE

BY

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WITH ILLUSTRATIONS.

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INTRODUCTION.

The history of the silo dates back to antiquity. Ancient writers speak of the practice of burying grain in underground pits to save it for future use or to hide it from their enemies, and the evidence at hand goes to show that semi-barbaric peoples in the different parts of the world have known and practiced this method. Green forage was preserved in the same way in the early history of the races of Northern Europe, notably in Sweden and the Baltic provinces, where the uncertainty of the weather and the low summer temperature rendered difficult the proper curing of the hay. It was not, however, until toward the middle of the present century that the practice of preserving green fodder by means of pits in the ground became more known. The method was especially practiced in central Europe, where large quantities of green leaves and tops were available every fall in the sugar-beet districts; also green forage, such as Indian corn fodder, green clover, grass, etc., was treated by this method; the fodder being placed in pits ten to twelve feet square, or larger, and as many feet deep; these were often lined with wood, and puddled below and at the sides with clay. The fodder was spread evenly in the pits, and well trampled down; when the pit was full the whole was covered with boards and a layer of earth one to two feet thick; such pits would hold nearly ten tons when full. It is stated that the silage thus obtained "remained green and was well liked, even by sheep." This practice slowly spread; in the sixties over 2000 tons of Indian corn was thus made into silage annually in a single small German province where dairying is an important industry.

One of the earliest advocates of the practice was M. Reihlen of Stuttgart, Germany. His communications on the subject gave an impetus to a large amount of experimentation and study along this line, both among German and French farmers. The French farmer, Auguste Goffart, whose name by most writers has been connected with the origin of silage, in 1877 published his book, "Manual of the Culture and Siloing of Maize and other Green Crops," which book is the first monograph on the subject ever published, and embodies the experience and results of twenty-five years' study of the problem by the author. While Goffart has no claim to priority in inventing the method of siloing green fodders, he perfected and applied it on a large scale, and, in publishing the results of his experience, brought the subject to the general attention of farmers; he may, therefore, justly be called the "Father of Modern Silage."

The earliest mention of the subject in the United States was through accounts of European experience in our agricultural press; the first complete description of the system was given in a paper on "The French Mode of Curing Forage," published in the Annual Report of the United States Department of Agriculture for 1875. Goffart's book was translated in 1879, by Mr. J. B. Brown of New York; this translation, as well as Dr. J. M. Bailey's "Book of Ensilage," published in 1880, first made the subject of silos and silage more generally known among American farmers, and the system soon found its enthusiastic followers in the United States. Since that time a wave of silo discussion and silo building has spread over the whole continent, and, as a result, we find to-day silos practically in every State in the Union, thousands upon thousands being filled each year with green corn or clover, furnishing farm animals with a palatable, succulent feed, not only through the winter and spring, but in dairy districts through the whole year.

The first silo built in the United States is said to be that erected by Mr. F. Morris of Maryland, in 1876. The number of silos in this country at the present time can not be stated with certainty in the absence of official or other reliable statistics on the subject; but careful estimates—which, from the nature of things, are but good guesses—place the number at 300,000 or more. New York, Massachusetts, Pennsylvania, Wisconsin, and all other States where dairying is an important industry, have numbers ranging from several hundreds up into the thousands. We find silos in Maine and in California, in Washington and in Georgia, in the North and in the South. They are at the present most abundant where the dairy industry is of prime importance; but wherever stock raising is followed we may, in general, expect to find them. In England, where the silo was introduced a little later than in the United States, there were only six silos in 1882; but according to official statistics the number was 600 in 1884, 1183 in 1885, 1605 in 1886, and 2694 in 1887. No later statistics are available. English farmers have the reputation of being, and doubtless as a rule are, more conservative in the changing of old methods or in the adoption of new ones than their American cousins; we can not, therefore, consider the figures given an overestimate of the present number of silos in the United States.

Unwarranted claims for silage were often made during the early days of the silo movement by enthusiasts in this country and abroad. A German agricultural writer predicted the day as likely to come when dry hay would be obtainable only in drug stores. While no American writer or speaker, to my knowledge, was so carried away by his enthusiasm, excessive statements and reports were, nevertheless, often indulged in, which could not stand the light of further experience and investigation. The process of siloing forage, as we have seen, is practically as old as hay-making; but it is only during the last couple of decades that the process has been systematically studied and perfected. Thanks to the zealous work of the agricultural experiment stations in this and other countries, and to the mass of practical experience accumulated, our store of definite knowledge on the subject has now been greatly enriched, and many problems previously standing in the way of success have been solved. The siloing of green fodders is no longer an experiment; the results may be foretold with as much certainty as in case of any industry depending on the action of ferments. With our present knowledge of the subject, we therefore believe that we can place the silo where it belongs and give it its due importance.

The effort of the author will be to give, in the following pages, a plain and accurate account of the most important facts in connection with silage, and to furnish the beginner with such information concerning the building of silos, the making of silage, and its proper feeding, as will enable him to understand the important features of the method, and to adopt it in his system of farming.

A few definitions of the terms used in this book may be in order at this place.

In the modern meaning of the word, a *silo* signifies any air-tight structure used for the preservation of forage in a succulent condition. The feed taken out of the silo is *silage* (formerly and originally called *ensilage*). For the process of preserving fodders in a silo, several verbs are used by writers on agricultural topics and are given in our standard dictionaries; among these the author prefers the verb, *to silo;* we thus silo corn, clover, etc., and the product is corn silage, clover silage, etc. The term *siloist,* a person making and feeding silage, is occasionally met with, and has also sometimes been used in this book. The distinction made by some writers between *silage,* the feed, and *ensilage,* the process by which silage is made, is one rarely met with outside of books. By common usage, the prefix *en* has now been dropped in ensilage, the term *silage* having been generally adopted by farmers and agricultural writers.

According to American custom, the term *corn,* spoken of in this book, means Indian corn, or maize (*Zea Mays*), and *corn silage,* silage made from Indian corn; *fodder corn* means the whole corn plant grown for forage, and *corn fodder* or *corn stalks* (*stover*), the husked plant grown for the sake of the ears.

MAKING AND FEEDING SILAGE.

CHAPTER I.—SILAGE CROPS.

A. INDIAN CORN.

Indian corn is, above all other plants, the main silage crop in our country, and is likely always to remain so. A book on silage for American farmers is therefore of necessity largely a description of the preparation of the corn crop for the silo, and the feeding thereof. In view of this fact, we shall discuss in the following pages, first of all, the making and feeding of corn silage, and then take up other silo crops, according to their importance.

Development of the Corn Plant.

In order to obtain a correct idea of the corn plant, it is necessary to examine its life history somewhat in detail. A kernel of corn, planted in a sufficiently moist and warm soil, will sprout within four to six days, sending out the radicle, growing downward, and the plumule, from which the different organs of the plant gradually develop. The starch, albuminoids, and ash materials in the corn germ, and in the rest of the kernel, furnish the young plant with nourishment until it is sufficiently developed to draw upon the soil and the air for the elements required for the upbuilding of its structure and of the various organs essential to its life and to the reproduction of the species.

The most exhaustive study of the life history of Indian corn has been conducted by the German scientist, Doctor Hornberger (published in 1882). We shall here briefly give some of the main results of his investigation, bearing directly on the growth of Indian corn from the early stages till maturity. Analyses were made once every week; the plants analyzed on June 18th were 6 to 7 inches high; the last sample was taken on September 10th, when the corn was almost ripe. The percentage composition of the dry matter of the different samples was shown in the following table.

PERCENTAGE COMPOSITION OF DRY MATTER OF SAMPLES OF FODDER CORN.

Date.	Per Cent Water in Samples	Mineral Matter.	Crude Protein.	Crude Fiber.	Starch, Sugar, etc.	Crude Fat.	Amides.
June 18..	.....	9.49	30.83	.....	.....	....	9.80
" 25..	89.27	8.45	28.17	17.82	41.67	3.19	8.05
July 2..	90.27	7.74	27.21	21.06	40.72	3.02	8.94
" 9..	89.30	8.35	24.90	22.78	41.04	2.29	9.40
" 16..	89.44	8.15	22.94	22.92	43.34	2.26	8.18
" 23..	88.37	6.35	17.32	24.43	49.60	2.03	6.05
" 30..	88.09	6.02	15.14	24.95	51.41	2.07	5.26
Aug. 6..	88.25	5.58	13.12	26.23	53.23	1.55	5.05
" 13..	88.07	5.31	12.16	26.26	54.55	1.28	4.06
" 20..	86.02	4.83	10.71	25.62	57.33	1.18	4.08
" 27..	.....	4.72	10.45	25.19	58.15	1.05	4.57
Sept. 3..	.....	4.30	10.08	23.37	60.45	1.43	3.89
" 10..	80.45	4.29	9.67	22.63	61.52	1.60	2.80

We notice from this table that the composition of the dry matter of the fodder corn varies greatly with the season. The young plant is relatively rich in mineral matter, crude protein, amides, and crude fat; it is relatively poor in crude fiber and in nitrogen-free extract (starch, sugar, etc.). The nitrogenous (flesh-forming) constituents predominate in the early stages of growth, and the non-nitrogenous (heat-producing) in the latter stages; the nutritive ratio (i. e., the proportion between flesh-forming and heat-producing nutrients), therefore, widens with the development of the plant.

The percentages of water, ash, protein, and amides decrease, and those of nitrogen-free extract and crude fiber increase as the plant grows older. The changes occurring in the composition of plants during their growth, in the majority of cases, follow this general law; it will, therefore, not be necessary to give results as to the changes in the composition of other silage crops with increasing age of the plants.

Considering next the total quantities of food materials found in fodder corn by Hornberger, at the different stages of growth, we have the following table:

YIELD OF FOOD INGREDIENTS, IN GRAMS.*

DATE.	Green Wt. of one plant.	Dry Matter.	1000 Plants Contained					
			Ash.	Crude Protein	Crude Fiber.	Starch Sugar etc.	Crude Fat.	Amides.
June 18...	......	.16	14.8	48.1	......	......	.....	15.3
" 25...	4.7	.50	42.6	142	89.8	210	16.1	40.6
July 2...	21	2.1	161	566	438	847	62.8	186
" 9...	39	4.1	342	1020	933	1681	94.	385
" 16...	78	8.3	674	1898	1896	3585	187	677
" 23...	161	18.8	1190	3249	4581	9301	380	1136
" 30...	276	32.8	1978	4972	8194	16884	679	1727
Aug. 6...	468	55.0	3069	7215	14420	29266	851	2780
" 13...	565	67.4	3576	8192	17692	36746	865	2735
" 20...	591	82.6	3991	8848	21164	47357	974	3369
" 27...	......	108.7	5131	11369	27394	63232	1143	4970
Sept. 3...	......	121.2	5215	12218	28311	73247	1729	4722
" 10...	611	119.4	5120	11554	27023	73473	1906	3245

*1,000 grams equal 2.2 lbs. avoirdupois.

Professor Ladd, in 1889, in a very exhaustive study of the corn plant, analyzed fodder corn cut at five different stages of growth, from full tasseling to maturity. The results obtained will nicely supplement the preceding data.

CHEMICAL CHANGES IN THE CORN CROP.

YIELD PER ACRE.	Tasseled, July 30.	Silked, Aug. 9.	Milk, Aug. 21	Glazed, Sept. 7	Ripe, Sept. 23
	Pounds	Pounds	Pounds	Pounds	Pounds
Gross Weight	18045	25745	32600	32295	28460
Water in Crop	16426	22666	27957	25093	20542
Dry Matter	1619	3078	4643	7202	7918
Ash	138.9	201.3	232.2	302.5	364.2
Crude Protein	239.8	436.8	478.7	643.9	677.8
Crude Fiber	514.2	872.9	1262.0	1755.9	1734.0
Nitrogen-free Extract (starch, sugar, etc)	653.9	1399.3	2441.3	4239.8	4827.6
Crude Fat	72.2	167.8	228.9	260.0	314.3

The data given in the preceding tables show how rapidly the yield of food materials increases with the advancing age of the corn and also that the increase during the later stages of growth comes largely on the nitrogen-free extract (starch, sugar, etc.). A number of American experiment stations have determined the increase during the stages previous to maturity, with the average results shown in the following computation:

INCREASE IN FOOD INGREDIENTS FROM TASSELING TO RIPENESS.

EXPERIMENT STATION.	Variety.	Stage of Maturity.		Gain in per cent between first and last cutting.			
		First Cutting.	Last Cutting.	Dry Matter.	Crude Protein.	Crude Fat.	Carbohydrates
Cornell, N.Y.	Pride of the North	Bloom	Mature	150	90	129	169
"	Pride of the North	"	Nearly mature	217	134	374	300
Geneva, N.Y.	King Philip.	Tasseled	Mature	389	183	335	462
New Hamp.	Av. of 4 Var.	"	Glazed	112	50	84	130
Pennsylvania	Av. of 10 Var.	"	Mature	155			
Vermont.	Av. of 2 Var.	"	Glazed	122	50		
"	"	Bloom	"	204	81		
Averages of	all trials			193	98	230	265

We thus find that the largest amount of food materials in the corn crop is not obtained until the corn is well ripened. When a corn plant has reached its total growth in height it has, as shown by the results given in the last table, attained only one-third to one-half the weight of dry matter it will gain if left to grow to maturity; hence we see the wisdom of postponing cutting the corn for the silo, as in general for forage purposes, until late in the season.

The tables given in the preceding, and our discussion so far, have taken into account the total, and not the digestible components of the corn. Early German digestion work goes to show that the digestibility of plants decreases as they grow older; the following average digestion coefficients for green corn, obtained in American digestion experiments, embody all work done by our experiment stations on this point up to date; the computation is made by Professor Lindsey of Massachusetts experiment station.

DIGESTION COEFFICIENTS FOR GREEN DENT FODDER CORN.

STAGES OF GROWTH.	No. of Trials.	Dry Matter.	Crude Protein	Crude Fiber.	N-free Extract	Ether Extract
Immature	11	68	66	67	71	68
In milk	9	70	61	64	76	78
Glazing............	9	67	54	51	75	78
Mature.............	4	65	51	55	72	73

It will be noticed that there is a slight decrease in the digestibility of the dry matter and a marked decrease in that of crude protein and crude fiber with the greater maturity of the fodder. The preceding trials were made with different lots of fodder, so that they can only be compared on account of the fairly large number of trials made in each group.

Results of other trials corroborate the conclusion drawn that older plants are somewhat less digestible than young plants. There is, however, no such difference in the digestibility of the total dry matter or its components as is found in the total quantities obtained from plants at the different stages of growth, and the total yields of digestible matter in the corn will therefore be greater at maturity, or directly before this time, than at any earlier stage of growth. Hence we find that the general practice of cutting corn for the silo at the time when the corn is in the roasting stage, is good science and in accord with our best knowledge on the subject.

Another reason why cutting at a late period of growth is preferable in siloing corn is found in the fact that the quality of the silage made from such corn is, as we shall see later on, greatly better than that obtained from green immature corn.

Varieties of Corn to be Planted for the Silo.

The varieties to be planted for the silo must differ according to local conditions of climate, soil, etc. The ideal silage corn, according to Shelton, is a variety having a tall, slender, short-jointed stalk, well eared, and bearing an abundance of foliage. The leaves and ears should make up a large percentage of the total weight, and the yield per acre should be heavy. The lower leaves should keep green until the crop is ready to harvest, and it is desirable to have the plant stool well and throw out tall grain-bearing suckers. A silage variety should mature late, the later the better, so long as it only matures, as a long-growing, late-maturing sort will furnish much more feed from a given area than one that ripens early.

In the early stages of siloing corn, in our country, the effort was to obtain an immense yield of fodder per acre, no matter whether the corn ripened or not. Large yields were, doubtless, often obtained with these big varieties, although I doubt that the actual yields ever came up to the claims made. Bailey's Mammoth Ensilage Corn, "if planted upon good corn land, in good condition, well matured, with proper cultivation," was guaranteed to produce from forty to seventy-five tons of green fodder to the acre, "just right for ensilage." We now know that the immense Southern varieties of corn, when grown to an immature stage, as must necessarily be the case in Northern States, may contain less than ten per cent of dry matter, the rest, more than nine-tenths of the total weight, being made up of water. This is certainly a remarkable fact, when we remember that skim-milk, even when obtained by the separator process, will contain nearly ten per cent of solid matter.

In speaking of corn planted so as to be cut for forage at an immature stage, Professor Robertson of Canada said at a Wisconsin Farmers' Institute, "Fodder corn sowed broadcast does not meet the needs of milking cows. Such a fodder is mainly a device of a thoughtless farmer to fool his cows into believing that they have been fed, when they have only been filled up." The same applies with equal strength to the use of large, immature Southern varieties for fodder, or for the silo, in Northern States.

In comparative variety tests with corn in the North, Southern varieties have usually been found to furnish larger quantities per acre of both green fodder and total dry matter in the fodder, than the smaller Northern varieties. As an average of seven culture trials, Professor Jordan thus obtained the following results at the Maine experiment station.

COMPARATIVE YIELDS OF SOUTHERN CORN AND MAINE FIELD CORN AS GROWN IN MAINE, 1888–1893.

	Southern Corn.					Maine Field Corn.				
	Green Fodder.	Dry Substance.		Digestible Matter.		Green Fodder.	Dry Substance.		Digestible Matter.	
		Per Cent.	Lbs.	Per Ct.	Lbs.		Per Cent.	Lbs.	Per Ct.	Lbs.
Maximum	46,340	16.58	6,237	69	3,923	29,400	25.43	7,064	78	4,945
Minimum	26,295	12.30	3,234	61	2,102	14,212	13.55	2,415	70	1,715
Average..	34,761	14.50	5,036	65	3,251	22,269	18.75	4,224	72	3,076

It will be noticed that the average percentage digestibility of the dry substance is 65 per cent for the Southern corn, and 72 per cent for the Maine field corn, all the results obtained for the former varieties being lower than those obtained for the latter. It is of importance to examine the detailed results of digestion experiments with these two kinds of fodder. The average digestion coefficients obtained in trials at the Maine station are as follows.

COMPARATIVE DIGESTIBILITY OF VARIETIES OF CORN GROWN UNDER SIMILAR CONDITIONS.

	Dry Matter. Per Cent.	Organic Matter. Per Cent.	Ash. Per Cent.	Crude Protein. Per Cent.	Crude Fiber. Per Cent.	Nitrogen-free Extract. Per Cent.	Crude Fat. Per Cent.
Field Fodder Corn and Silage, 7 samples, 17 trials	72.3	74.6	36.8	65.1	76.5	75.5	74.9
Southern Fodder Corn and Silage, 5 samples, 12 trials	64.6	66.5	39.7	59.6	71.0	65.2	66.3
Difference in favor of field corn	7.7	8.1	....	5.5	5.5	10.3	8.6

As a result of the lower digestion coefficients for the Southern varieties, the difference in the yield of digestible matter—the real important factor to be considered—is less marked. While the general result for the five years is slightly in favor of the Southern varieties, as far as the yield of digestible matter is concerned, the fact should not be lost sight of, as called attention to by Professor Jordan, that an average of 6¼ tons more of material has annually to be handled over several times, in case of these varieties of corn, in order to gain 175 pounds more of digestible matter per acre; we therefore conclude that the smaller, less watery variety of corn really proved the more profitable.

At other Northern stations similar results, or results more favorable to the Northern varieties, have been obtained, showing that the modern practice of growing only such corn for the silo as will mature in the particular locality of each farmer, is borne out by the results of careful culture tests.

Methods of Planting Corn.

Thickness of Planting.—The thicker the stand of a crop, the larger the proportion of stalks and foliage to grain; with corn we thus find that thin planting will produce perfect plants, with well-developed, large ears, while close planting will produce much fodder and only few ears, a large proportion of which will be nubbins. The reason for this will be easily understood at a moment's reflection: Plants need a great deal of light, heat, and moisture to reach perfect development. Where the stand is too thick, one plant will shade another, and the supply of sunshine and moisture (in our climate perhaps particularly the latter) will be insufficient to bring each plant further than to the formation of rich foliage and a small proportion of ears of an imperfect size; the greater part of the food materials of the plant elaborated will, therefore, in this case, remain in the stalks and foliage. In planting corn for the silo we want the largest quantities of food materials that the land is capable of producing. This, evidently, can be obtained by a medium thickness of planting. If too thin or too thick planting be practiced, the total yields of food materials obtained will be decreased—in the former case, because of the small stand of plants; in the latter, because of insufficiency of light, moisture, and other conditions necessary to bring the plants forward to full growth.

A single experiment may be given to show the effect of the distance of planting on the quantity and quality of the corn crop. White dent corn was planted on six one-twentieth-acre plats at the Connecticut experiment station, as follows: One, two, and four stalks every four feet in the row, and two, four, and eight stalks to the foot. The following yields of cured fodder and dry matter were obtained from the different plats.

YIELD OF FIELD-CURED CROP.

Plat.	DISTANCE OF PLANTING.	Gross Weight	Dry Matter.	Water-free Substance in		
				Kernels	Cobs.	Stover.
		lbs.	lbs.	lbs.	lbs.	lbs.
A	One stalk in four feet...	168.0	104.3	50.5	11.8	42.0
B	Two stalks in four feet..	320.0	201.6	102.2	20.4	79.0
C	Four stalks in four feet..	457.5	307.2	**145.3**	**32.1**	129.8
D	Two stalks to one foot..	491.0	**317.6**	105.4	21.1	191.1
E	Four stalks to one foot..	522.0	297.2	70.4	19.1	**207.7**
F	Eight stalks to one foot..	**532.0**	260.3	48.4	13.5	198.4

The highest yield of the field-cured crop was obtained with the thickest planting, while most dry matter was obtained by growing two stalks to a foot. The highest yield of water-free kernels was at one stalk to a foot, and of stover at four stalks to a foot. The following table shows the proportions of kernels, cobs, and stover in the different plats.

PROPORTION OF KERNEL, COBS, AND STOVER IN CORN CROP, IN PER CENT.

DISTANCE OF PLANTING.	Kernels	Cobs.	Stover.	Water Content of Crop.
One stalk in four feet.........	48.4	**11.3**	40.3	37.9
Two stalks in four feet.........	**50.7**	10.1	39.2	37.1
Four stalks in four feet.........	47.3	10.4	42.3	32.9
Two stalks to one foot..........	33.1	6.6	60.3	35.3
Four stalks to one foot.........	24.0	6.4	69.6	43.1
Eight stalks to one foot.......	18.6	5.1	**76.3**	**51.0**

We notice that the water content of the field-cured crop increased as the distance of planting decreased; that is, thicker seeding gave more watery fodder.

The fact that thin seeding favors the perfection of well-developed, strong plants is illustrated by the following results, obtained in the same experiments, showing the yields of different parts of the corn plant from 1,000 seed kernels for each of the distances named.

YIELDS OF DIFFERENT PARTS OF CORN PLANT FROM 1,000 SEED KERNELS, IN POUNDS.

DISTANCE OF PLANTING.	Field cured Crop.	Water-free Substance.			
		Kernels.	Cobs.	Stover.	Total.
One stalk in four feet....	**1,236**	371	**87**	**309**	**767**
Two stalks in four feet..	1176	**376**	75	290	741
Four stalks in four feet..	841	267	59	239	565
Two stalks to one foot...	451	97	19	176	292
Four stalks to one foot...	239	32	9	96	137
Eight stalks to one foot..	122	11	3	46	60

It would not be safe to conclude that similar results as those given in the table would be obtained in all kinds of soils and seasons. The number of plants which can be brought to perfect development on a certain piece of land depends upon the state of fertility of the land, the character of the season and other factors, and is therefore subject to considerable variations. The results given in the table plainly show, however, that the practice to be followed in planting Indian corn for fodder must differ from that used in planting for ear corn. The distance in planting corn for the sake of the grain, differs greatly in different localities. The old Indian way of planting in hills, four feet both ways, dropping four to five kernels in each hill, has been followed generally in the corn belt. In the New England States corn is, according to Professor Morrow, usually planted in hills three feet apart, with three kernels to the hill, while in some Southern States it is planted in hills five feet apart, with only one stalk in the hill. The ordinary Southern practice is, I believe, to plant in rows three to four feet apart, with stalks every twelve to eighteen inches in the rows. These methods will secure a large proportion of perfect ears, but not the maximum crop of dry matter and its constituents in the total plant, which is wanted in growing corn for the silo. Numerous experiments have shown that under ordinary conditions in our country, better results in this direction may be obtained by planting the corn in hills three or even two feet apart, or in drills three or four feet apart, with plants six to eight inches apart in the row. We find that the practice of our best farmers is in accordance with the teachings of these experiments. In growing corn for the silo, it is therefore generally recommended to plant in hills or drills in the manner mentioned, which will give about a square foot of ground to each corn plant.

Since the conditions of moisture, temperature, and fertility of the land, as well as other factors influencing the growth of crops, are not exactly alike in any two succeeding years, it is evident that any definite practice of thickness of planting adopted will not necessarily produce the best results every year, but such a practice should be followed as will be apt to produce the best average results for a number of years in each particular locality.

PLANTING IN HILLS OR IN DRILLS.—Experiments conducted at a number of experiment stations teach us that it makes little if any difference, so far as the yield obtained is concerned, whether the corn be planted in hills or in drills, when the land is kept free from weeds in both cases. The yield seems more dependent on the number of plants growing on a certain area of land than on the arrangements of planting the corn. Hills four feet each way, with four stalks to the hill, will thus usually give about the same yields as hills two feet apart, with two stalks in the hill, or drills four feet apart, with stalks one foot apart in the row, etc. The question of planting corn in hills or in drills is therefore largely one of greater or less labor in keeping the land free from weeds by the two methods. This will depend on the character of the land; where the land is uneven, and check-rowing of the corn difficult, or when the land is free from weeds, drill planting is preferable; while, conversely, on large level fields, as on our Western prairies, the corn may more easily and cheaply be kept free from weeds if planted in hills and check-rowed.

When the corn is to be cut with a corn harvester or with a sled cutter, it should be planted in drills, so as to facilitate the cutting.

Sowing Corn Broadcast.—Corn should be planted in hills or drills, and not broadcast. The objection to sowing corn broadcast is that the land cannot be kept free from weeds in this case, except by hand labor; that more seed is required, and that plants will shade one another, and therefore not reach full development, from lack of sufficient sunshine and moisture. As a result, the yield will be greatly diminished. In an experiment conducted at the Geneva (N. Y.) experiment station in 1889, the average yield of green fodder per acre from

King Philip corn was 12,780 lbs., against 14,077 lbs. and 16,967 lbs., for drills and hills, respectively; the average weights of single plants were: Broadcast, 0.73 lbs.; drills, 1.06 lbs.; hills, 1.24 lbs.; the average number of quarts of seed per acre used was 25 1-3, 14 4-9, and 10 2-9 quarts, for broadcast, drills, and hills, respectively.

Preparation of Corn Land.

Corn will give best results coming after clover. The preparation of the land for growing corn is the same whether ear corn or forage is the object. Land intended for corn should be in good condition; in fact, it can hardly be too rich. Fall plowing is practiced by many successful corn growers. The seed is planted on carefully prepared ground at such a time as convenient and advisable. Other things being equal, the earlier the planting the better. "The early crop may fail, but the late crop is almost sure to fail." After planting, the soil should be kept pulverized and thoroughly cultivated. Shallow cultivation will ordinarily give better results than deep cultivation, as the former method suffices to destroy the weeds and to preserve the soil moisture, which are the essential points sought in cultivating crops. The cultivation should be no more frequent than is necessary for the complete eradication of weeds. It has been found that the yield of corn may be decreased by too frequent, as well as by insufficient, cultivation. The general rule may be given to cultivate as often, but no oftener, than is necessary to kill the weeds, or to keep the soil pulverized. In the majority of cases one cultivation a week until the corn shades the ground will be found sufficient.

B. CLOVER.

Clover is second to Indian corn in importance as a silage crop. We are but beginning to appreciate the value of clover in modern agriculture. It has been shown that the legumes, the family to which clover belongs, are the only common forage plants able to fix the free nitrogen of the air; that is, convert it into compounds that may be utilized for the nutrition of animals. Clover and other legumes, therefore, draw largely on the air for the most expensive and valuable fertilizing ingredient, nitrogen, and for this reason, as well as on account of their deep roots, which bring fertilizing elements up near the surface, they enrich the land upon which they grow. Being a more nitrogenous feed than corn or the grasses, clover supplies a good deal of the protein compounds (flesh-forming substances) required by farm animals for the maintenance of their bodies and for the production of milk, wool, or meat. By feeding clover, a smaller purchase of high-priced concentrated feed stuffs, like flour- or oil-mill refuse products, is therefore rendered necessary than when corn is fed, and on account of its high fertilizing value it enables the farmer feeding it to keep up the fertility of his land.

When properly made, clover silage is an ideal feed for nearly all kinds of stock. Aside from its higher protein content it has an advantage over corn silage in point of lower cost of production. The late A. F. Noyes, of Dodge County, Wis., who siloed 1200 tons of clover during his last eight years, estimated the cost of one ton of clover silage at 70 cents to $1, against $1 to $1.25 per ton of corn silage.

His average yields per acre of green clover were about twelve tons.

Clover silage is superior to clover hay on account of its succulence and greater palatability, as well as its higher feeding value. The last-mentioned point is mainly due to the fact that all the parts of the clover plant are preserved in the silo, with a small unavoidable loss in fermentation, while in hay-making, leaves and tender parts, which contain about two-thirds of the protein compounds, are often largely lost by abrasion.

In spite of the fact that there have been many failures in the past in siloing clover, it may easily and cheaply be placed in a silo and preserved in a perfect condition. The failures reported are largely due to a faulty construction of the silo. Clover does not pack as well as the heavy green corn, and therefore requires weighting, or greater depth in the silo, in order to sufficiently exclude the air.

Time to Cut Clover for the Silo.—The yield of food materials obtained from clover at different stages of growth has been studied by a number of scientists. The following table giving the results of an investigation conducted by Professor Atwater will show the total quantities of food materials secured at four different stages of growth of red clover.

Yield per Acre of Red Clover — in Pounds.

Stage of Cutting.	Green Weight.	Dry Matter.	Crude Protein.	Crude Fiber.	N-free Extract	Crude Fat.	Ash.
Just before bloom.......	3,570	1,385	198	384	664	24	115
Full bloom....	2,650	1,401	189	390	682	33	107
Nearly out of bloom.......	4,960	1,750	230	528	837	31	129
Nearly ripe....	3,910	1,523	158	484	746	36	99

Professor Hunt obtained 3,600 pounds of hay per acre from clover cut in full bloom, and 3,260 pounds when three-fourths of the heads were dead. The yields of dry matter in the two cases were 2,526 pounds, and 2,427 pounds, respectively. All components, except crude fiber, yielded less per acre in the second cutting. Jordan found the same result, comparing the yields and composition of clover cut when in bloom, some heads dead, and heads all dead, the earliest cutting giving the maximum yield of dry matter, and of all components except crude fiber.

The common practice of farmers is to cut clover for the silo when in full bloom, or when the first single heads are beginning to wilt, that is, when right for hay making, and we notice that the teachings of the investigations made are in conformity with this practice.

C. OTHER SILAGE CROPS.

A large number of crops, besides corn and clover, have been siloed successfully in this and other countries. All are, however, of less general importance as silage crops, compared with these, being cut for the silo only in certain localities, or occasionally and in small quantities, as a matter of experiment.

We shall in the following give a brief mention of the main crops adapted for siloing purposes, aside from the two crops already mentioned.

Alfalfa (lucern) is the great coarse forage plant of the West, and in irrigated districts will yield more food materials per acre of land than perhaps any other crop. Three to four cuttings, each yielding a ton to a ton and a half of hay, are common in these regions, and the yields obtained are often much higher. While the large bulk of the crop is cured as hay, alfalfa is also of considerable importance as a silage crop in dairy sections of the Western States. As with red clover, reports of failure in siloing alfalfa are on record, but first-class alfalfa silage can be readily made in deep, modern silos, when the crop is cut when in full bloom. In the opinion of dairymen who have had large experience in siloing alfalfa, sweet alfalfa silage is more easily made than good alfalfa hay.

What has been said in regard to the siloing of clover refers to alfalfa as well. Alfalfa silage compares favorably with clover silage, both in chemical composition and in feeding value. It is richer in flesh-forming substances (protein) than clover silage, or any other kind of silage, and makes a most valuable feed for farm animals, especially young stock and dairy cows.

Sorghum is sometimes siloed in the Western and Middle States. It is sown in drills, 3½ inches apart, with a stalk every six to ten inches in the row, and is cut when the kernels are in the dough stage, or before. According to Shelton, the medium-growing saccharine and non-saccharine sorghums are all excellent silage materials. The sorghums are less liable to damage by insects than corn, and they remain green far into the fall, so that the work of filling the silo may be carried on long after the corn is ripe and the stalks all dried up. The yield per acre of green sorghum will often reach 20 tons, or one-half as much again as a good crop of corn. These considerations lead Professor Shelton to pronounce sorghum greatly superior to corn as silage materials, in Kansas, and generally throughout the Central Western States.

In Southern States, pea vines, soja bean, teosinte, and chicken corn are occasionally siloed.

Cow peas are to the South what alfalfa is to the West, and when properly handled, both crops make excellent and most valuable silage. The cow peas are sown early in the season, either broadcast, about $1\frac{1}{2}$ bushels to the acre and turned under with a one-horse turning plow, or drilled in rows about two feet apart. They are cut with a mower when one-half or more of the peas on the vines are fully ripe, and are immediately raked in windrows and hauled to the silo where they are run through a feed cutter and cut into inch lengths. Instead of placing cow peas only in the silo, alternate loads of cow peas and corn may be cut and filled into the silo, which will make a very satisfactory mixed silage. The cut vines, or vines and corn, are carefully leveled off and trampled down in the silo, and about a foot cover of green corn, straw or cotton seed hulls placed on top of the siloed mass. It is safest to wet the cover thoroughly with about two gallons of water per square foot of surface. This will seal the siloed mass thoroughly and will prevent the air from working in from the surface and spoil a considerable depth of the top silage.

Cow-pea silage is greatly relished by farm animals after they once become accustomed to its peculiar flavor; farmers who have had considerable practical experience in feeding this silage are of the opinion that cow-pea silage has no equal as a food for cows and sheep. It is also a good hog food, and for all these animals is considered greatly superior to pea-vine hay. In feeding experiments at the Delaware experiment station 6 pounds of pea-vine silage fully took the place of 1 pound of wheat bran, and the product of one acre was found equivalent to two tons of bran.

Soja beans (soy beans) are another valuable silage crop. According to the U. S. Department of Agriculture "the soy bean is highly nutritive, gives a heavy yield, and is easily cultivated. The vigorous late varieties are well adapted for silage. The crop is frequently siloed with corn (2 parts of the latter to 1 of the former), and like other legumes it improves the silage by tending to counteract the acid reaction of corn silage."

Professor Robertson of Canada has recommended the *Robertson Ensilage Mixture* for the silo; it is made up of cut Indian corn, sunflower seed heads, and horse beans in the proportion of 1 acre corn, ½ acre horse-beans, and ¼ acre sunflowers. The principle back of this practice is to furnish a feed richer in flesh-forming substances (protein) than corn, and thus avoid the purchase of large quantities of expensive protein foods like bran, oil meal, etc. Feeding experiments conducted with the Robertson Silage Mixture for cows at several of our experiment stations have given very satisfactory results, and have shown that this silage mixture can be partly substituted for the grain ration of milch cows, without causing loss of flesh or lessening the production of milk or fat. Fifteen pounds of this silage may be considered equivalent to three to four pounds of grain feeds.

In Northern Europe, especially in England, and in the Scandinavian countries, meadow grass and aftermath (rowen) are usually siloed; in England, at the present time, largely in stacks; in the sugar-beet districts of Germany and Central Europe, diffusion chips and beet tops are preserved in silos in large quantities.

In districts near sugar beet factories, where *sugar-beet pulp* can be obtained in large quantities and at a trifling cost, stock feeders and dairymen have a most valuable aid in preserving the pulp in the silo. As the pulp is taken from the factory it contains about 90 per cent of water. The pulp packs well in the silo, being heavy, finely divided and homogeneous, and a more shallow silo can therefore be safely used in making pulp silage than is required in siloing corn, and especially clover and other crops of similar character. If pulp is siloed with other fodder crops, it is preferably placed uppermost, for the reason stated. Beet tops and pulp may also be siloed in alternate layers in pits 3-4 feet deep, and covered with boards and a layer of dirt.

Beet-pulp silage is relatively rich in protein and low in ash and carbo-hydrates (nutr. ratio 1:5.7). Its feeding value is equal to about half that of corn silage.

Occasional mention has furthermore been made in our agricultural literature of the siloing of a large number of plants, or products, like vetches, small grains (cut green), cabbage leaves, sugar beets, potatoes, potato leaves, turnips, brewers' grains, apple pomace, twigs and leaves, and hop vines; even fern (brake), thistles, and ordinary weeds have been made into silage, and used with more or less success as food for farm animals.

At a recent convention of the Cal. Dairy Association, the president, Mr. A. P. Martin, stated that the best silage he ever made, besides corn, was made of weeds. A piece of wheat which was sowed early, was drowned out, and the field came up with tar weed and sorrel. This was made into silage, and when fed to milch cows, produced most satisfactory results.

Alvord says that a silo may be found a handy and profitable thing to have on a farm even if silage crops are not regularly raised to fill it. There are always waste products, green or half-dry, with coarse materials like swale hay, that are generally used for compost or bedding, which may be made into palatable silage. A mixture, in equal parts, of rag-weed, swamp grass or swale hay, old corn stalks or straw, and second-crop green clover, nearly three-fourths of which would otherwise be almost useless, will make a superior silage, surprising to those who have never tried it.

The following description of the contents filled into a New York silo, which was used as a sort of catch-all, is given by the same writer: 1, 18 in. deep of green oats; 2, 6 in. of red clover; 3, 6 in. of Canada field peas; 4, 3 in. of brewers' grains; 5, 2 feet of whole corn plants, sowed broadcast, and more rag-weed than corn; 6, 5 in. of second-crop grass; 7, 12 in. of sorghum; 8, a lot of immature corn cut in short lengths. The silage came out pretty acid, but good forage, all eaten up clean.

A peculiar use of the silo is reported from California, viz., for rendering foxtail in alfalfa fields harmless in feeding cattle. The foxtail which almost takes the first crop of alfalfa in many parts of California, is a nutritious grass, but on account of its beards, is dangerous to feed. By siloing the crop the grass is said to be rendered perfectly harmless; the alfalfa-foxtail silage thus obtained is eaten by stock with great relish and without any injurious effects.

CHAPTER II.—SILOS.

GENERAL CONSIDERATIONS.

Several important points have to be observed in building silos. First of all, *the silo must be air-tight.* The process of siloing fodders is largely a series of fermentation processes. Bacteria (minute plants or germs), which are practically omnipresent, pass into the silo with the corn or the siloed fodder, and, after a short time, perhaps at once, begin to grow and multiply in it, favored by the presence of air and an abundance of food materials in the fodder. The activity of the bacteria is soon discernible through the heating of the mass and the formation of acid in the fodder. The more air at the disposal of the bacteria, the further the fermentation processes will progress. If a supply of air is admitted to the silo from the outside, the bacteria will have a chance to continue to grow, and more fodder will therefore be wasted. If a large amount of air be admitted, as is usually the case with the top layer of silage, the fermentation processes will be more far-reaching than is usually the case in the lower layers of the silo. Putrefactive bacteria will then continue the work of the acid-bacteria, and the result will be rotten silage. If no further supply of air is at hand, except what remains in the interstices between the siloed fodder, the bacteria will gradually die out, or only such forms will survive as are able to grow in the absence of the oxygen of the air.

The biology of silage has received but very little attention from our scientists up to the present time, and we do not know which forms of bacteria are favorable, and which are unfavorable to the proper run of the siloing process, or in how far the making of silage is dependent on bacterial action, and how far on the natural dying-off of the plant tissues (*intermolecular respiration*), or how many of the various conditions of siloing affect the final result. We know this, however, that no silage fit to be eaten can be made in the presence of air. The silo must therefore be air-tight, and the fodder well packed in it, so as to exclude the air as far as practicable.

In the second place, *the silo must have smooth, perpendicular walls,* which will allow the mass to settle without forming cavities along the walls. In a deep silo the fodder will settle several feet during the first few days after filling. Any unevenness in the wall will prevent the mass from settling uniformly, and air spaces in the mass thus formed will cause the surrounding silage to spoil.

The walls must furthermore be rigid, so as not to spring when the siloed fodder settles, on account of the lateral pressure in the silo (see p. 47), air would thereby be admitted along the silo walls, causing decay and loss of silage.

Other points of importance in silo-building, which do not apply to all kinds of silos, will be considered as we proceed with the discussion of the various forms of silos in existence. We shall now take up the different phases of the subject of silo building.

Size of Silos.—In planning a silo the first point to be decided is how large it shall be made. We will suppose that a farmer has a herd of twenty-five cows, to which he wishes to feed silage during the winter season, e. g., for 180 days. We note here, at the outset, that silage will not be likely to give best results for milch cows, or for any other class of farm animals, when it furnishes the greater portion of the dry matter of the feed ration. As a rule, it will not be well to feed over forty pounds of silage daily per head. If this quantity be fed daily, on an average for a season of 180 days, we have for the twenty-five cows 180,000 pounds, or ninety tons. On account of the fermentation processes taking place in the silo, there is an unavoidable loss of food materials during the siloing period, amounting to perhaps 10 per cent; we must therefore put more than the quantity given into the silo. If ninety tons of silage is wanted, about one hundred tons of fodder corn must be placed in the silo. Corn silage will weigh from thirty pounds, or less, to toward fifty pounds per cubic foot, according to the depth in the silo from which it is taken, and the amount of moisture which it contains. We may take forty pounds as the average weight of one cubic foot of corn silage. One ton of silage will accordingly take up fifty cubic feet; and 100 tons, 5,000 cubic feet. If a rectangular one-hundred-ton silo is to be built, say 12x14 feet, it must then have a height of 30 feet. If a square silo is wanted, it might be given dimensions 12x12x35 feet, or 13x13x30 feet; if a circular silo, the following dimensions will be about right: Diameter, 16 feet; height of silo, 25 feet, etc. In the same way, a silo holding 200 tons of corn or clover silage may be built of the dimensions 16x24x26 feet, 20x20x25 feet, or, if round, diameter, 25 feet; height, 32 feet, etc.

Since the capacity of round silos is not as readily computed as in case of rectangular silos, we give below a table, which shows at a glance the approximate number of tons of silage that a round silo, of a diameter from 10 to 26 feet, and 20 to 32 feet deep, will hold.

TABLE GIVING THE APPROXIMATE CAPACITY OF CYLINDRICAL SILOS FOR WELL-MATURED CORN SILAGE, IN TONS.

DEPTH OF SILO, FEET.	INSIDE DIAMETER OF SILO, FEET.												
	10	12	14	15	16	18	20	21	22	23	24	25	26
20	26	38	51	59	67	85	105	115	127	138	151	163	177
21	28	40	55	63	72	91	112	123	135	148	161	175	189
22	30	43	59	67	77	97	120	132	145	158	172	187	202
23	32	46	62	72	82	103	128	141	154	169	184	199	216
24	34	49	66	76	87	110	135	149	164	179	195	212	229
25	36	52	70	81	90	116	143	158	173	190	206	224	242
26	38	55	74	85	97	123	152	168	184	201	219	237	257
27	40	58	78	90	103	130	160	177	194	212	231	251	271
28	42	61	83	95	108	137	169	186	204	223	243	264	285
29	45	64	88	100	114	144	178	196	215	235	256	278	300
30	47	68	93	105	119	151	187	206	226	247	269	292	315
31	49	70	96	110	125	158	195	215	236	258	282	305	330
32	51	73	101	115	131	166	205	226	248	271	295	320	346

The following table, which has been reproduced from a trade publication, will show at a glance how much silage is needed for dairy herds of six to fifty heads, the size of silo needed and amount of land to be planted to corn in each case. The table is based on the assumption of an average feeding season of 180 days, and of a daily allowance of 40 pounds of silage per head.

SIZE OF SILO NEEDED—(*Harder*).

Number of Cows.	Estimated Consumpt'n of Silage Tons.	Size of Silo Needed. Diam. Height.	Average Acres of Corn Needed.	Number of Cows.	Estimated Consumpt'n of Silage Tons.	Size of Silo Needed. Diam. Height	Average Acres of Corn Needed
6	20	9 x 20 **10 x 16**	1 to 2	30	108	13 x 38 14 x 34 **15 x 30** **16 x 28** 17 x 26	8 to 9
9	30	**10 x 22** 11 x 20	2 to 3	35	126	15 x 35 **16 x 31** 17 x 29	9 to 10
13	45	10 x 29 11 x 25 **12 x 22** 13 x 20	3 to 4	40	144	16 x 35 **17 x 31** 18 x 29	10 to 11
21	74	11 x 37 12 x 32 **13 x 29** **15 x 24** 16 x 22	5 to 6	45	162	**18 x 32** 19 x 29	11 to 12
25	90	12 x 38 13 x 33 **14 x 30** **15 x 27** 16 x 25	6 to 7	50	180	17 x 38 **18 x 34**	12 to 13

FORM OF SILOS.—The first silos made in this country or abroad were rectangular, shallow structures, with a door opening at one end. Goffart's silos (see Fig. 1 and 2) were 5x12 meters wide, and 5 meters high (16.4x 39.4x16.4 feet). Another French silo, one of the largest ever built, belonging to Vicomte de Chezelles, was 206x21½ feet, and 15 feet high, holding nearly 1,500 tons of silage. Silos of a similar type, but of smaller dimensions, were built in this country in the early stages of silo building. Experience had taught siloists that it was necessary to weight the fodder heavily in these silos, in order to avoid the spoiling of large quantities of silage. In Goffart's silos, boards were thus placed on top of the siloed fodder, and the mass was weighted at the rate of 100 pounds per square foot.

It was found, however, after some time, that this

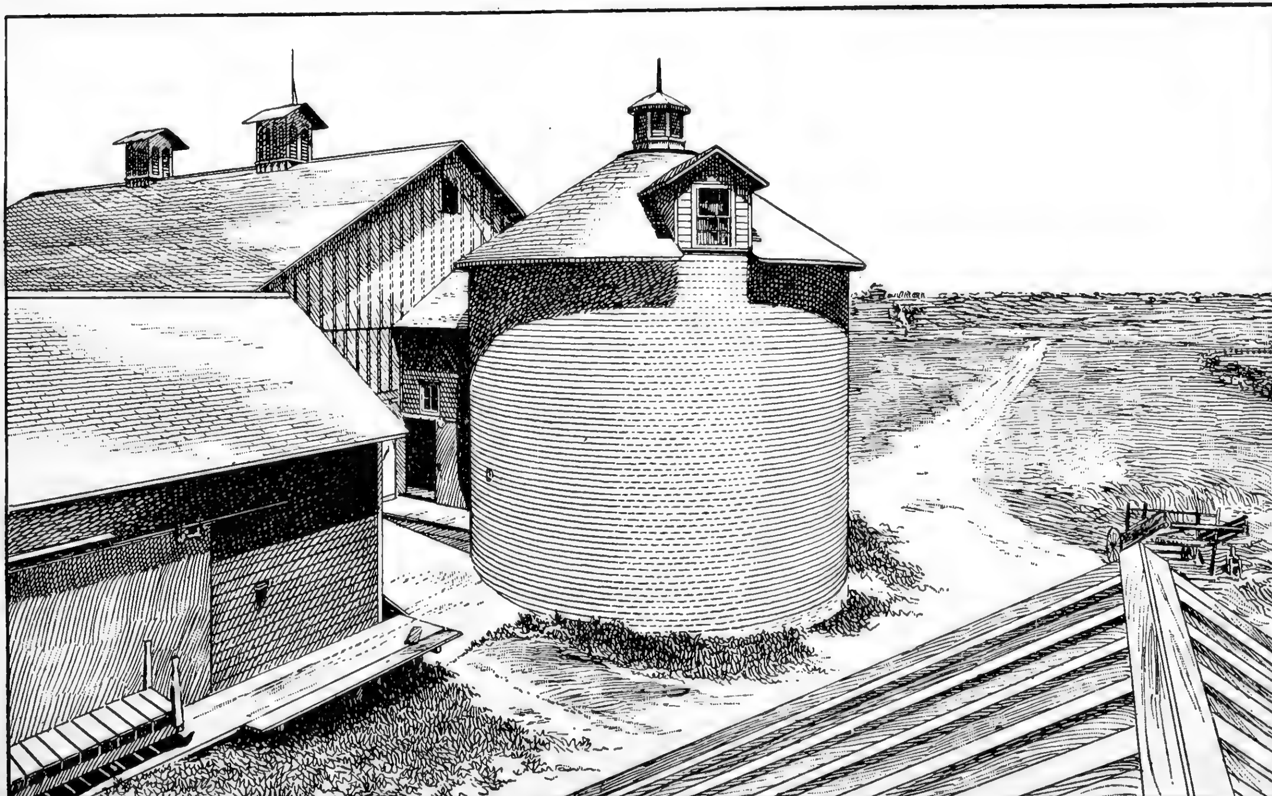


FIG. 4. ROUND WOODEN SILO, KENOSHA COUNTY, WIS., DIAMETER, 30 FEET; HEIGHT, 24 FEET; CAPACITY, 300 TONS.

heavy weighting could be dispensed with by making the silos deep, and gradually the deep silos came more and more into use. These silos were first built in this country in the latter part of the eighties; at the present time none but silos at least twenty to twenty-four feet deep are built, no matter of what form or material they are made, and most silos built are twenty-four to thirty feet deep.

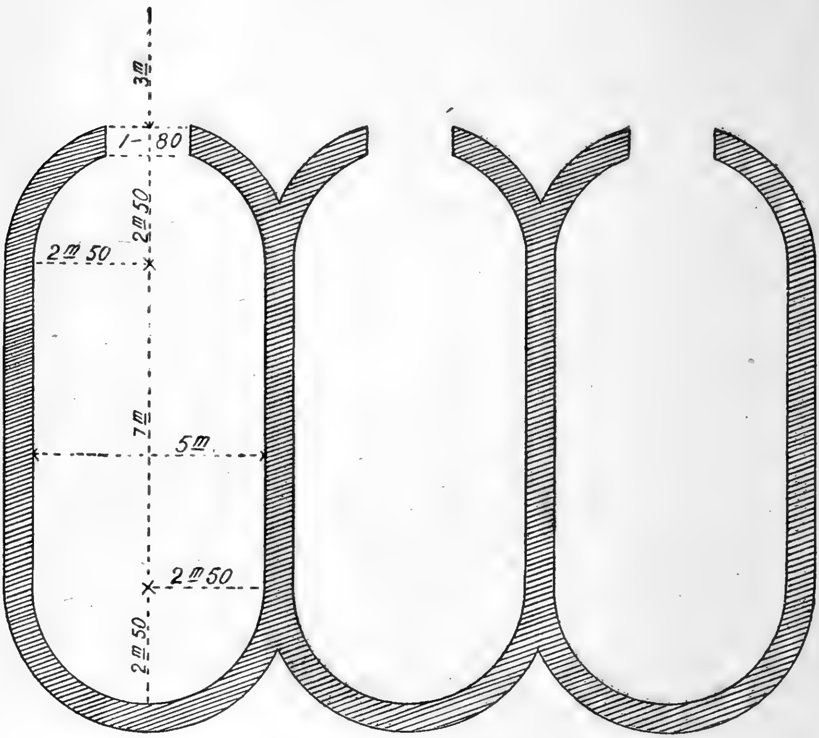


FIG. 2.—PLAN OF GOFFART'S SILOS.

Since 1890 the cylindrical form of silos has become more and more general. These silos have the advantage over all other kinds in point of cost and convenience, as well as quality of the silage obtained. We shall, later on, have an occasion to refer to the relative value of the various forms of silos, and shall here only mention two points in favor of the round silos.

One of the essentials in silo building is that there shall be a minimum of surface and wall exposure of the silage, as both the cost and the danger from losses through spoiling are thereby reduced. The round silos are superior to all other forms in regard to this point, as will be readily seen from an example: A rectangular silo, 16x32x24 feet, has the same number of square feet of wall surface as a square silo, 24x24 feet, and of the same depth, or as a circular silo 30 feet in diameter and of the same depth; but these silos will hold about the following quantities of silage: Rectangular silo, 246 tons; square silo, 276 tons; circular silo, 338 tons. Less lumber will, therefore, be needed to hold a certain quantity of silage in case of square silos than in case of rectangular ones, and less for cylindrical silos than for square ones, the cylindrical form being, then, the most economical of the three types.

Round silos can furthermore be built cheaper than square ones, because lighter material may be used in their construction. The sills and studding here do no work except to support the roof, since the lining acts as a hoop to prevent spreading of the wall.

Silage of all kinds will usually begin to spoil after a few days, if left exposed to the air; hence the necessity of considering the extent of surface exposure of silage in the silo while it is being fed out. In a deep silo there is less silage exposed in the surface layer in proportion to the contents than in shallow silos. Experience has taught us that about two inches of the top layer of the silage must be fed out daily during cold weather in order to prevent the silage from spoiling; in warm weather about three inches must be taken off daily. The form of the silo must therefore be planned, according to the size of the herd, with special reference to this point. Professor King estimates that there should be a feeding surface in the silo of about five square feet per cow in the herd; a herd of thirty cows will then require 150 square feet of feeding surface, or the inside diameter of the silo should be 14 feet; for a herd of forty cows a silo with a diameter of 16 feet will be required; for fifty cows, a diameter of 18 feet; for one hundred cows, a diameter of $25\frac{1}{4}$ feet, etc.

Locating the Silo.—The question, where to build the silo, is most important and has to be settled at the start. The feeding of the silage is an every-day job during the whole winter and spring, and twice a day at that. Other things being equal, the nearest available place is therefore the best. The silo should be as handy to get at from the barn as possible. The condition of the ground must be considered. If the ground is dry outside the barn, the best plan to follow is to build the silo there, in connection with the barn, going four to six feet below the surface, and providing for doors opening directly into the barn. The bottom of the silo should be on or below the level where the cattle stand, and, if practicable, the silage should be moved out and placed before the cows at a single handling. While it is important to have the silo near at hand, it should be so located, in case the silage is used for milk production, that silage odors do not penetrate the whole stable, at milking or at other times. Milk is very sensitive to odors, and unless care is taken to feed silage *after* milking, and to have pure air, free from silage odor, in the stable at the time of milking, the milk will have a decided silage flavor. So far as is known this odor is not discernible in either butter or cheese made from silage-flavored milk, nor does it seem to affect the keeping qualities of the milk in any way.

Bottom of Silo.—The bottom of the silo may be clay, or, preferably, a layer of small stones covered with cement. In some silos considerable damage has been done by rats burrowing their way into the silo from below, and destroying a great deal of silage, both directly and indirectly, by admitting air into the silo. The silo may be built four to six feet down into the ground, if this is dry. It is easy to build the silo deep by this arrangement, and there will be no need of extra length of carrier. By means of a ten-inch plank, provided with a number of cleats, the underground portion of the silo may easily be emptied, the feeder walking up the plank with the basket filled with silage. Stave silos are built entirely above ground, and also in case of other silos the tendency of late years seems to be toward not going so deep down as was generally done in the early period of silo construction.

Foundation and Wall of Silo.—The silo should rest on a substantial stone foundation, to prevent the bottom of the silo from rotting and to guard against spreading of the silo wall. The foundation wall should be 18 to 24 inches thick. Professor Cook recommends making the bottom of the silo one foot below the ground, so that the stone wall on which it rests may be sustained by the earth on the outside, as shown in Fig. 3.

In building rectangular silos sills made by two 2x10 planks (P) rest on the inside ten inches of the foundation wall; one of these projects at each corner. The studdings (S), which are 2x10 planks, and as long as

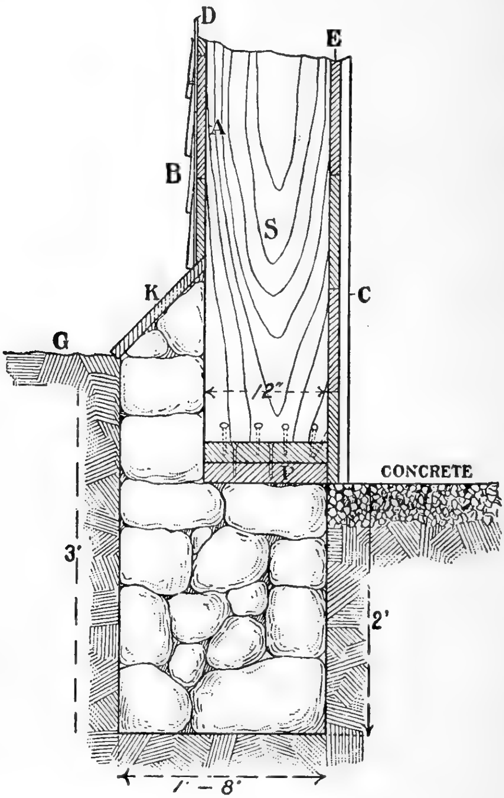


FIG. 3. FOUNDATION OF SILO.
Bottom of silo one foot below ground. (Cook.)

the silo is high, or two lengths toe-nailed together, are placed 12 to 16 inches apart, large silos requiring the smaller distance.

As there is a considerable lateral pressure in the silo before the fodder has settled, it is very important to make the walls rigid and to place the studdings sufficiently close together to prevent spreading of the wall. Professor King found that the lateral pressure in a silo on the average amounts to 10.94 pounds for every foot in depth of silage; that is, at a depth of 20 feet there is a pressure of about 218 pounds per square foot; at 30 feet, 328 pounds, etc. Mr. James M. Turner states that it was found necessary to use 2x12 studding, 22, 24, or 26 feet in length, for the outside wall, as well as for the cross-partitions in his first silo. In addition to this, three courses of bridging in each side-wall were inserted. In spite of all, the pressure, when the silo was full, frequently forced out the sides from two to six inches in places, and on some occasions the air thus admitted caused large quantities of the silage to rot and greatly impaired the value of the silo.

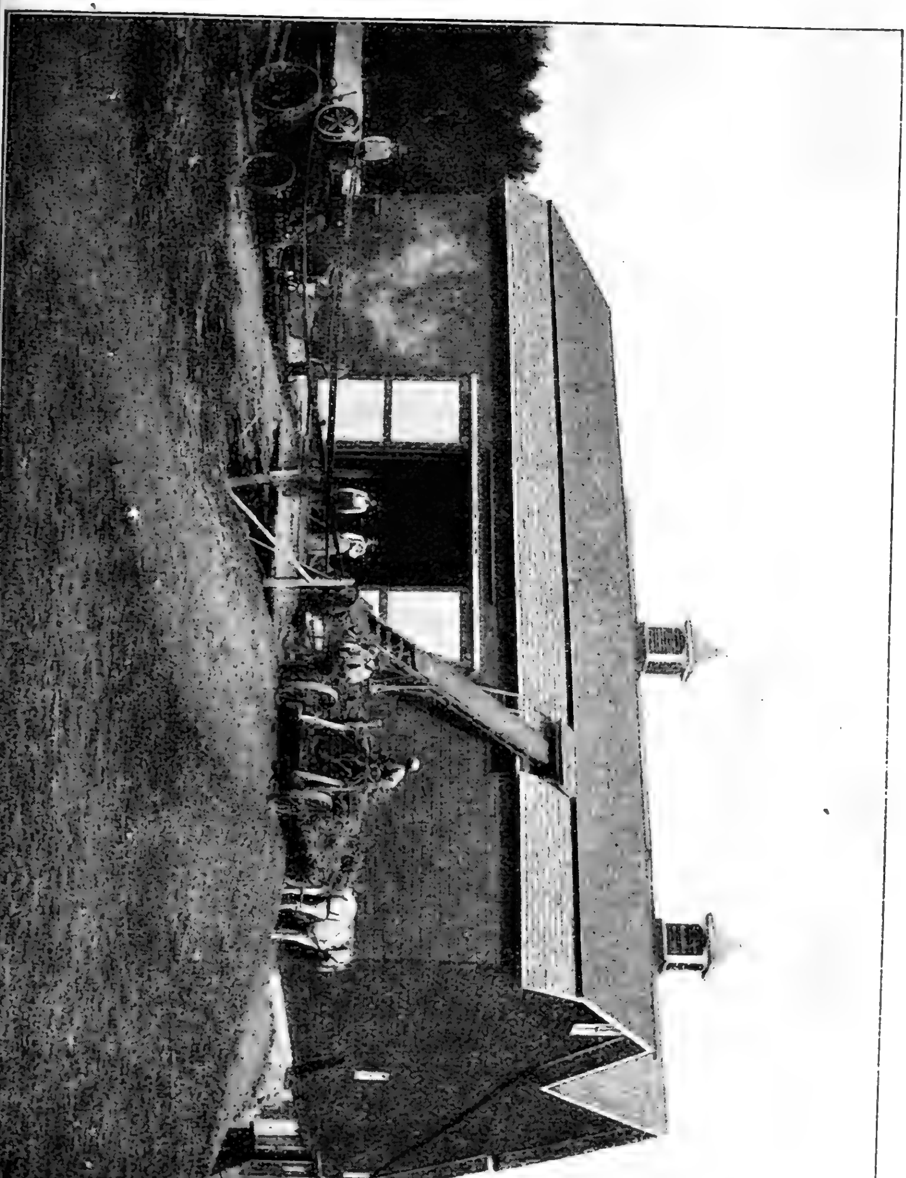
When the silage has settled there is no lateral pressure in the silo; cases are on record where the silo has burned down to the ground with the silage remaining practically intact as a tall stack. While silos provided with partitions must be filled simultaneously on both sides of the partition to avoid bulging or even breaking of the partition, the silage in one compartment can be completely removed before that in the other is uncovered, without causing the partition to spring.

To insure ventilation in rectangular wooden silos, the sills may be two inches narrower than the studding, so as to leave air spaces between the sills and the lining; in the same way the plate is made narrower than the studding to provide for an escape at the top. The same end may be reached by boring a series of holes at the bottom of the outside wall between every two studs, leaving an open space of about two inches on the inside, at the top of the plate. Wire nettings should be nailed over ventilation openings to keep out rats and mice.

Roof of the Silo.—Where the silo is built in the bay of a barn, there will be no need of making any separate roof, which otherwise generally will be the case. The roof may be either board or shingle, and should be provided with a cupola, so as to allow free ventilation in the silo. In extreme cold weather this should be shut, to prevent freezing of the silage.

Material for Silo Building.—Silos are at the present built almost exclusively of wood, stone, or concrete, or partly of one, partly of another of these materials. The material used will largely be determined by local conditions; where lumber is cheap, and stone high, wooden silos will generally be built; where the opposite is true, stone silos will have the advantage in point of cheapness, while concrete silos are likely to be preferred where cobble-stones are at hand in abundance, and lumber or stone are hard to get at a reasonable cost. So far as the quality of the silage made in any of these kinds of silos is concerned, there is no difference when the silos are properly built. The longevity of stone- and concrete silos is usually greater than that of wooden silos, since the latter are more easily attacked by the silage juices and are apt to decay in places after a number of years, unless special precautions are taken to preserve them. A well-built and well-cared-for wooden silo should, however, last almost indefinitely.

Painting Silos.—It is not strictly necessary to paint the silo on the outside, any more than is the case with



barns or other farm buildings, but painting preserves the woodwork from the action of wind and rain, and greatly improves the appearance of a silo as well as of other structures. If a farmer thinks much of his silo or of his farm, he will therefore be likely to paint the silo. Two good coats of pure linseed oil and white lead, with the same color as is used for the other farm buildings, should be put on. This will add greatly to the appearance of the silo, and make it a very attractive structure.

We shall now consider somewhat in detail the various types of silos, and shall give directions for their building in each case. More round wooden silos have been built than other kinds of silos during late years, and such silos, built either of uprights lined inside and outside with several layers of half-inch boards, or built of one thickness of staves, will doubtless be the main silo type in the future. We shall therefore first of all describe round wooden silos and stave silos, and shall then briefly consider other silo types.

DESCRIPTION OF DIFFERENT KINDS OF SILOS.

I. Round Wooden Silos.

Round wooden silos (see fig. 4) were first described in 1892 by Professor King, of Wisconsin Experiment Station, who strongly urged the advantage of these silos over other silo types. In the tenth annual report of the Wisconsin station, complete directions will be found for the construction of these silos, and illustrations are given elucidating the manner of procedure. The plans and specifications given in the following pages are largely based on the directions for building round silos published in the report referred to, but such modifications and additions have been included as have been considered advisable in the light of the practical experience in silo construction gained during late years. The plans and specifications were furnished for the writer and under his direction by Claude and Starck, Architects, Madison, Wisconsin. The specifications call for a silo 30 feet deep, inside diameter 26 feet, capacity about 300 tons. By changing the figures for the height and the diameter, round silos of any desired capacity may be readily built according to these specifications.

SPECIFICATIONS FOR A 300-TON ROUND WOODEN SILO.

MASONRY.

Excavation. Mason to excavate for all trenches and the entire inside of the building as far as bottom of gravel, as indicated on the section. Bottoms of all trenches shall be level. Excavated material shall be disposed of as directed by the owner.

Footings. Footings shall be good sound sand- or lime stone, extending through the wall in one piece, or brick; in either case the footing shall be bedded and laid up in cement, one (1) part cement, to three (3) of sand.

Wall above footing. Wall above footing shall be laid up in lime mortar richly gauged with cement. All brick shall be thoroughly bonded every fourth course.

Brick, lime, sand and cement. All brick shall be good sound hard-burned brick. All lime and cement shall be fresh and undamaged; cement shall be any standard brand of hydraulic cement, subject to the approval of the superintendent. All sand shall be clean, coarse and sharp.

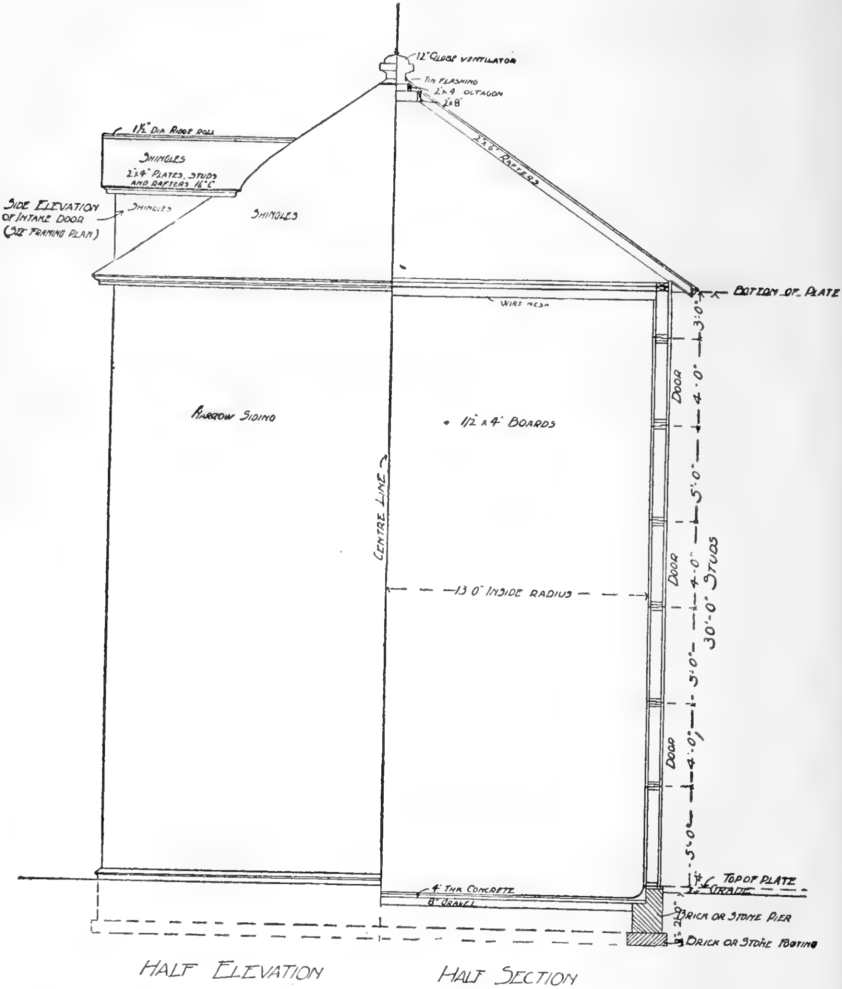


FIG. 5. ELEVATION AND SECTION OF ROUND WOODEN SILO. SCALE INCH 12 FEET.

Asphalting. This contractor shall cover the top of wall and bed sill (furnished by other parties) in at least ½ inch thick of hot coal-tar asphaltum.

Concreting. After the roof is on, the mason shall cover the floor with 8 inches of good gravel or coarse sand well tamped down, and on this he shall lay three inches of concrete composed of 1 part of cement to 9

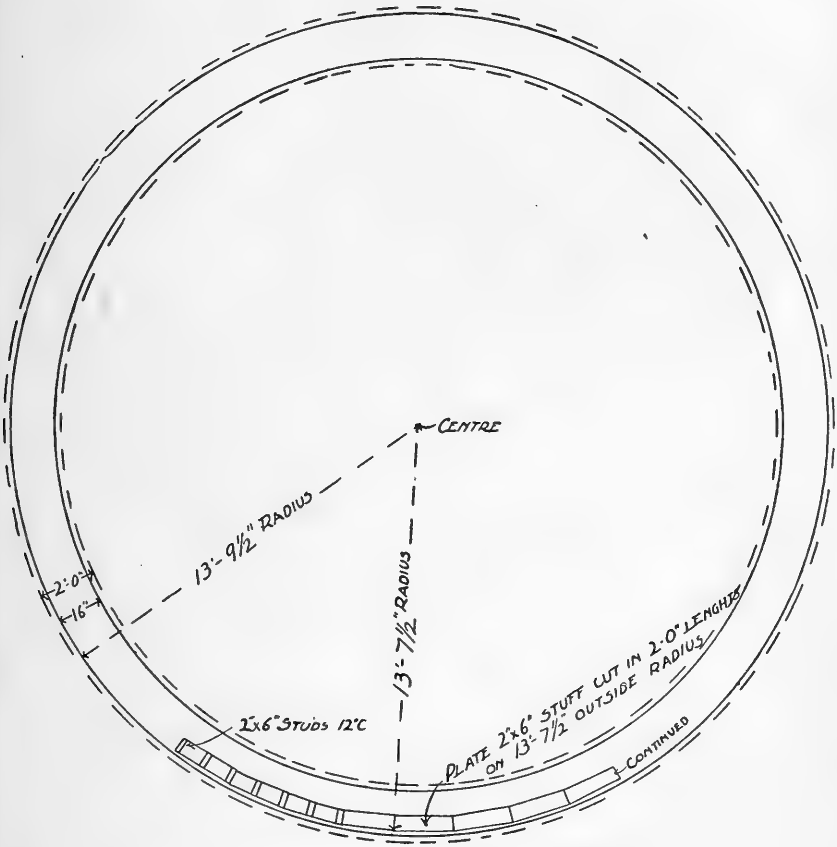


FIG 6. FOUNDATION PLAN OF ROUND WOODEN SILO.

parts of good clean sand and gravel, thoroughly mixed and tamped in place with a heavy tamp. On this base, and before it has time to set, he shall spread 1 inch of Portland cement and sand, one part of cement to one of sand, well mixed, and troweled off to a perfectly smooth surface. The concrete shall be dished 2 inches to the center and brought up against the sill as shown on the sectional drawings. Especial care must be taken with the asphaltum and concreting

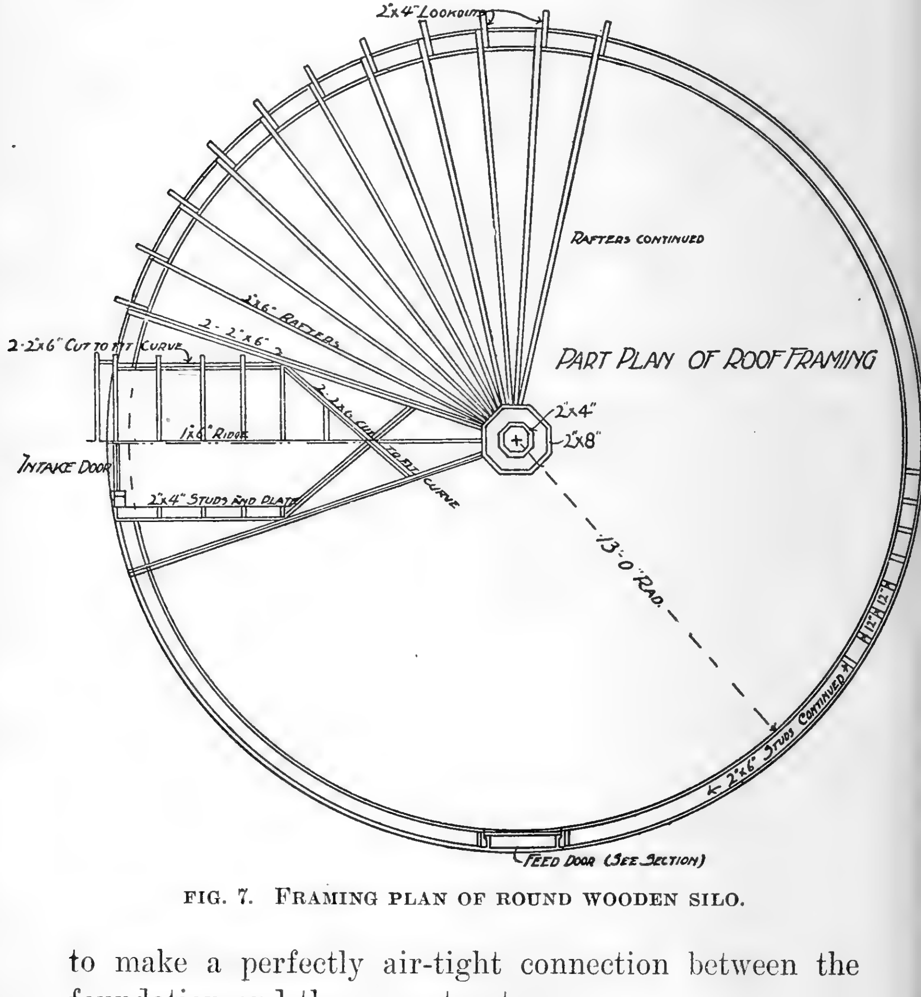


FIG. 7. FRAMING PLAN OF ROUND WOODEN SILO.

to make a perfectly air-tight connection between the foundation and the superstructure.

Finally. After the building is completed, but before acceptance, the mason shall repoint and repair all imperfections or injured work, whether caused by himself or other parties, and leave the entire job complete and to the satisfaction of the superintendent.

SHEET METAL WORK.

This contractor shall furnish and set one 12-inch diameter Globe ventilator, and he shall properly flash around ventilator, and at least 8 inches over the shingles, with stamped I. C. roofing tin.

CARPENTERING.

This contractor shall furnish all carpenter material and perform all labor necessary to leave the entire building complete and ready for use to the satisfaction of the superintendent.

Framing. Plates shall be cut from 2-inch by 6-inch stuff, 2 feet long, cut to fit together to an outside radius of 13 feet 7½ inches; these shall be bedded in asphalt, furnished by the mason. On the plates he shall then set sound hemlock or pine studs of 2x6 inches, 30 feet long, not over 12 inch-centers. Top plate shall be made in the same manner as bottom plate, and studs and plates shall be thoroughly spiked together. The rafters shall be put up as indicated on roof-framing plan, and thoroughly spiked to plate and octagon form at apex of roof; lookouts shall be well nailed to rafters.

Lining and sheathing. The lining shall be made of two thicknesses of sound, clear fencing split in two, i. e., ½ inch thick. [Some authorities recommend three

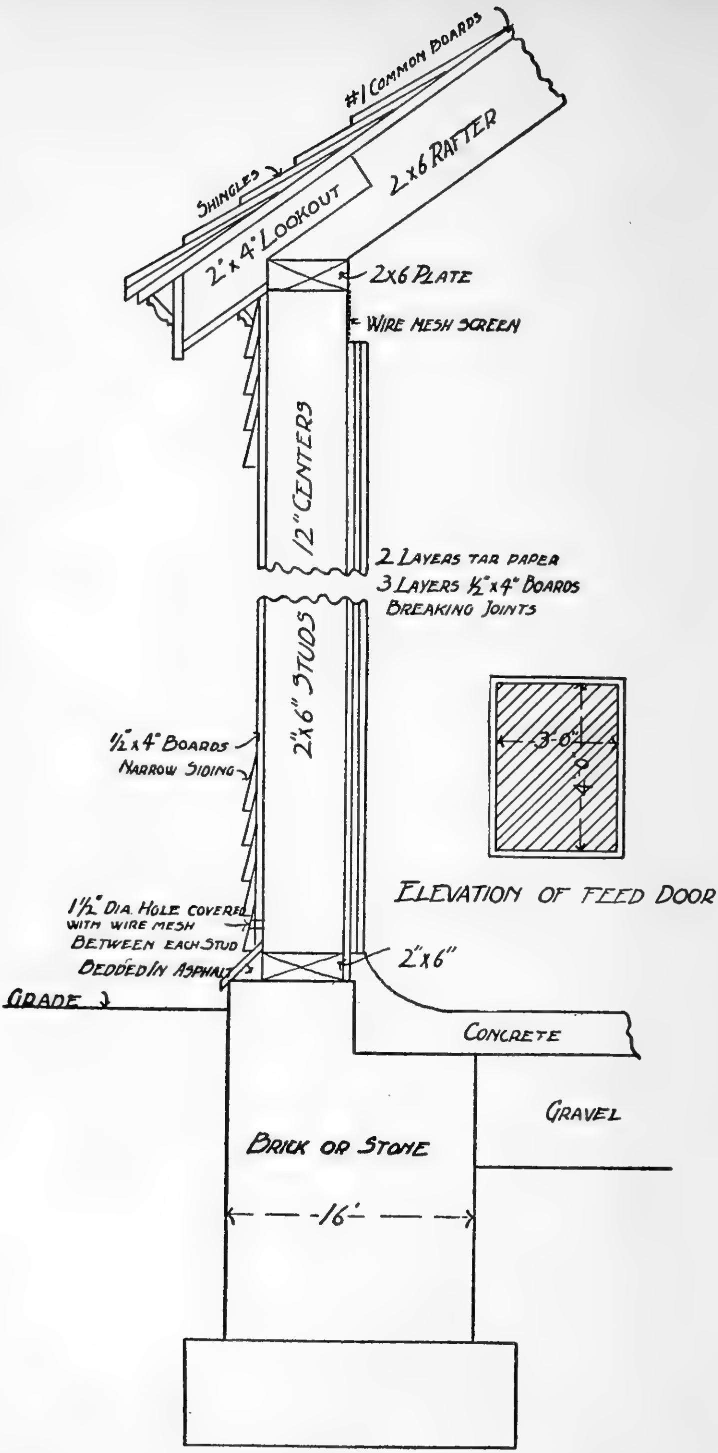


FIG. 8. SECTION THROUGH WALL OF ROUND WOODEN SILO.

thicknesses of $\frac{1}{2}$ inch fencing.] All lining and sheathing shall be sized on one side to an exact width; the layers of lining shall be made to break joint, and between the layers the carpenter shall furnish and lay one (1) thickness of good quality of tar paper. [Two layers, if three thicknesses of boards are used.] The first layer shall be laid with 8 d. nails and the last layer with 10 d. nails. Outside sheathing shall be of same material and laid in the same manner as inside. All tar paper used between lining boards of silo shall be 2-ply Giant P. & B. paper, or its equal, on approval of the superintendent.

Siding. The siding shall be perfectly clear pine, basswood or Washington cedar narrow siding well nailed to each stud.

Roof sheathing. The sheathing for the roof shall be of No. 1 fencing lapped around the rafters from eaves to top in spiral form. All well nailed to rafters with 10 d. nails. The sheathing shall be tapered in such a manner as to work out evenly to conical roof, and where ends of boards abut, they shall be dressed off with a jack plane.

Cornice. Cornice facia shall be $\frac{1}{2}$ inch 2d clear pine. Mouldings shall be 2d clear pine. Soffit shall be $\frac{7}{8}$ inch thick second clear pine cut to a radius of the outside of the building and cornice, all securely nailed to lookouts.

Doors. Intake door shall be made of two thicknesses of No. 1 fence flooring laid diagonally and well nailed together; it shall be hung with two strong 3x3-inch japanned iron butts, and fastened with a strong japanned iron combination latch, handle and hasp;

provide with 2-inch oak sill. Feed doors shall be made as indicated on details, with 2-inch double beveled edges made to fit snugly into 2-inch double beveled jamb, at the middle of the break between bevels. Jambs

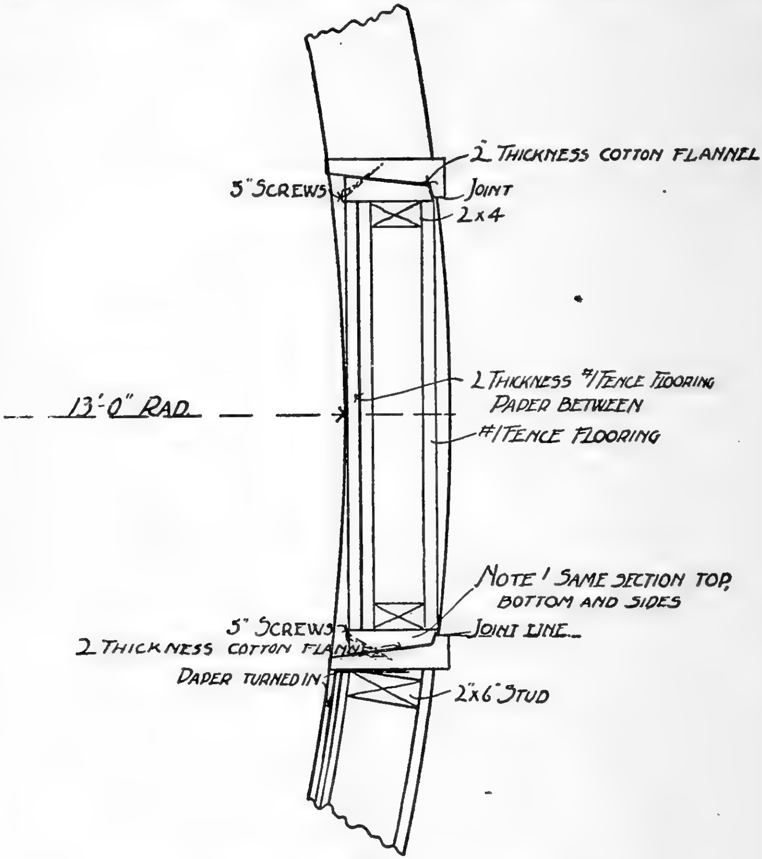


FIG. 9. SECTION THROUGH FEED DOOR OF ROUND WOODEN SILO.

shall be covered with 4-ply cotton flannel, or a heavy strip of rubber, in such a way as to make the door perfectly air-tight when closed. These doors shall be opened from the inside, and held in position by six $\frac{3}{8}$-inch diameter, 6-inch long wood screws. Door casings shall be $\frac{7}{8}$x3-inch second clear pine. Fit around jambs with tar paper and have perfectly air-tight.

Ventilation. Between each stud near the bottom bore $1\frac{1}{2}$-inch diameter holes through siding and sheathing and cover with heavy gal. iron screen $\frac{1}{8}$-inch mesh. Cover studs on inside from top plate 4 inches down with same kind of wire screen tightly tacked to plate and studs.

Finally. All work shall be done in first-class workmanlike manner to the entire satisfaction of the superintendent.

PAINTING.

The entire outside surface of the woodwork except shingles shall be painted two good coats of pure linseed oil with white lead, color selected by the superintendent. The entire inside surface walls of the silo shall be painted with asbestos paint or hot coal-tar, some of the oil in the tar having been previously burned off, care being taken to fill in all cracks and joints and jambs of feed doors. Feed doors shall be painted inside and on the edges in the same manner.

BIDS.

The owner reserves the right to reject any or all bids.

Chute for round silos.—Instead of providing a number of feed doors for taking out the silage at different heights of the silo, a door may be placed at a bottom extending up from it to the top, where there is another door for one to enter in getting out the silage. The following description of the chute and the accompanying illustration (fig. 10) is taken from Bull. No. 14, Washington Exp. Station:

Two pieces of 2x8 or 2x10 are nailed to the inside of the silo wall before the second layer of the wall is put on, one on either side of the door, and extending from top to bottom of the silo. Boards are nailed to these so as to project about two inches beyond their edges (see fig. 10). As the silo is filled, the board forming the wall of the chute next to the silage are laid in in two layers, with a layer of tarred paper between them. As the silage is removed in feeding these boards are taken out. The paper between them should be in rather small pieces, in order that it may not be in the way in taking out the silage.

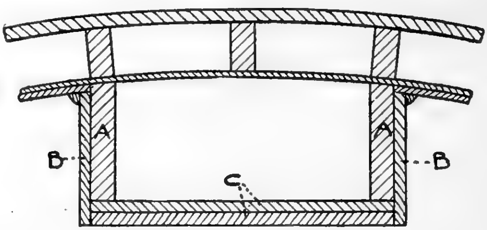


FIG. 10. SILAGE CHUTE FOR ROUND SILOS. (SPILLMAN.)

Descriptions are given in the following of round wooden silos built at the agricultural experiment stations in New Jersey, Wisconsin, Missouri and South Dakota, according to a similar plan as that explained in detail in the preceding. The descriptions will be useful to farmers living in the states mentioned or in the regions represented by these, and will also serve to show how local conditions will determine details of construction, as well as the cost and kinds of materials used in the building of the silos. The publications of the respective experiment stations have been followed closely in describing the different silos.

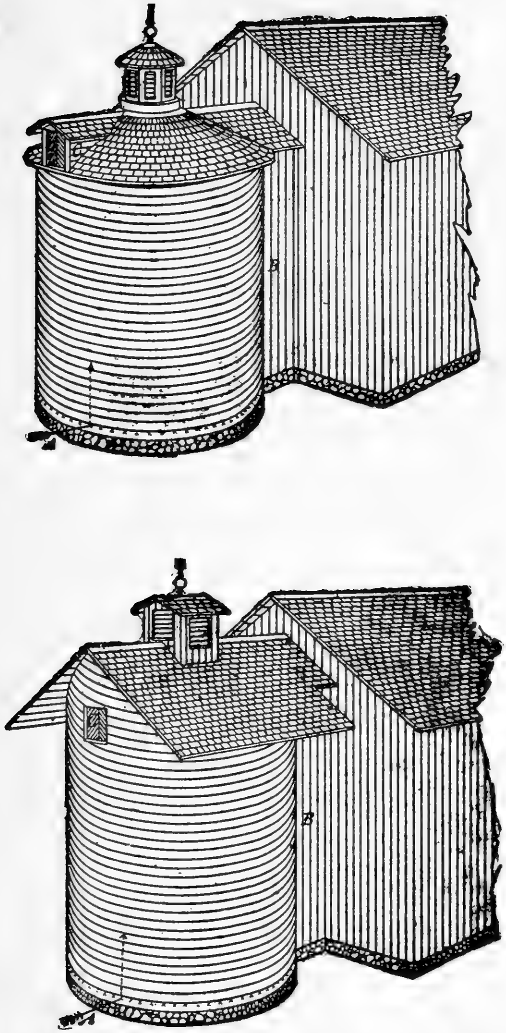


FIG. 11. TWO METHODS OF ROOFING ROUND WOODEN SILOS AND THE MANNER OF CONNECTING THEM WITH A BARN.

A, Shows where air is admitted between the studding to ventilate behind the lining. B, Feeding chute; C, Filling window. The cupola is essential to perfect ventilation (King).

FIG. 12. INSIDE VIEW OF ROUND WOODEN SILO SHOWN IN FIG. 4, LOOKING UPWARD.
From a photograph.

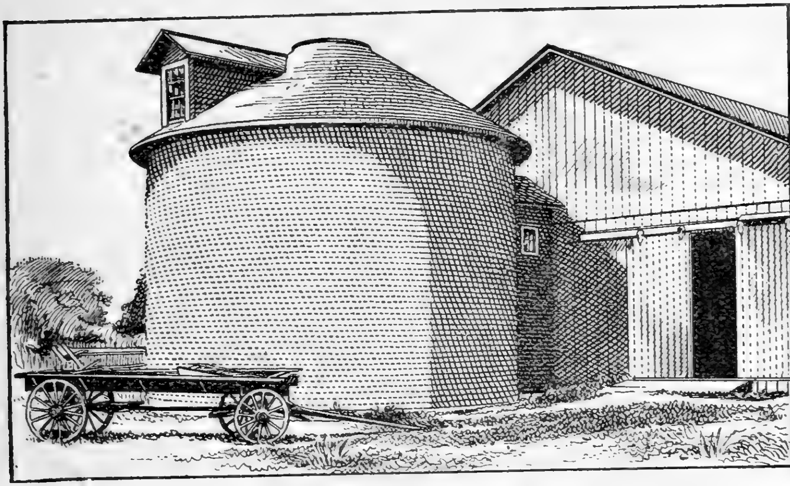


FIG. 13. ROUND WOODEN SILO.

Dormer window kept open for ventilation when silo is in use.

THE NEW JERSEY EXPERIMENT STATION SILO.
(See Fig. 14.)

The silo has a capacity of 150 tons; it is 21 feet inside diameter, and 24 feet deep, with a brick foundation 1 foot wide and carried 2 feet below the surface of the ground; the bottom is cemented and is 1½ feet below the sills. The sills are made from 2x6 studding, cut on the slant of a radius of the silo circle, bedded in mortar and toe-nailed together; the plates are made in the same way and spiked to studs which are 2x4 inches, and 1 foot apart. The lining consists of two thicknesses of half-inch spruce boards with tarred paper between. The siding consists of one layer of boards as above, covered with cedar shingles; holes bored between each stud and covered with wire netting permit a circulation of air between the siding and lining, which aids in the preservation of the lining. The structure is roofed, as shown, with dormer windows for filling and with ventilating cap and is joined to the barn with a passage and floor 6x8 feet, also roofed. Four doors, 2½ feet square are cut in the siding for

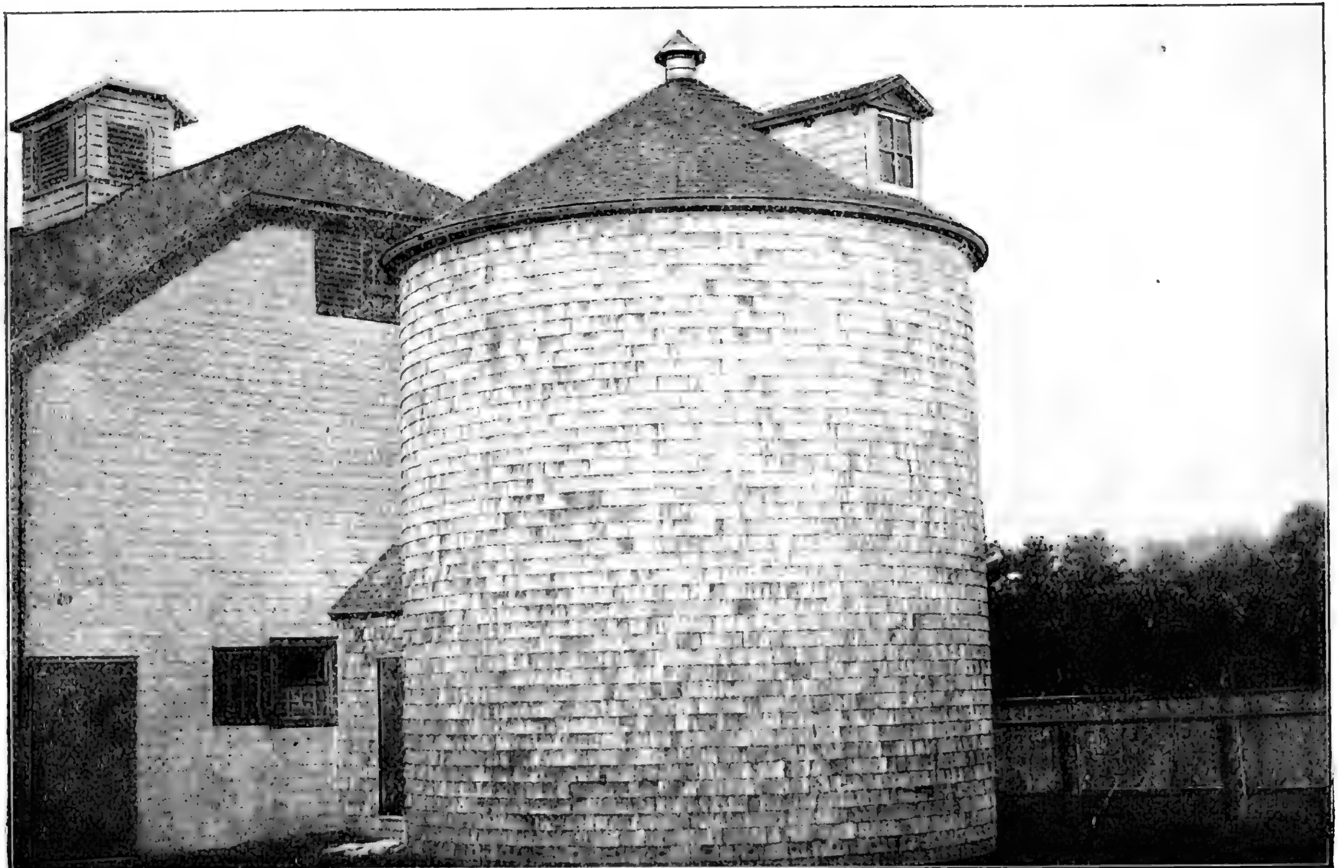


FIG. 14. SILO AT NEW JERSEY EXPERIMENT STATION.

emptying the silo, the silage dropping through a chute, 2 feet square, upon the floor of the passageway which is connected by a door with the feeding floor of the barn.

COST OF MATERIALS REQUIRED IN BUILDING SILO.

(Not including labor.)

Foundation—2,500 brick, 5.50 per m.	$ 13.75
Cement—7¾ barrels ordinary, $1.35 per bbl.	10.46
Cement—1¼ barrels, Portland, $4.00 per bbl.	5.00
Sand—4 loads, $1.50 per load	6.00
Studding—2x4x24 (704 feet), $20.00 per m.	14.08
Plates and sills—2x6x12 (260 feet), $20.00 per m.	5.20
Studding for passage—2x4x16 (85 feet), $20.00 per m.	1.70
Siding and lining—5,200 feet, $17.50 per m.	91.00
Shingles—14,000, $4.00 per m.	56.00
Nails—2 kegs, $3.25 per keg	6.50
Boards for roof—325 feet, $17.50 per m.	5.69
Paper—6 rolls, $1.50 per roll	9.00
Total	$224.38

The cost of labor is not included as this item is likely to be more variable than the materials, besides a large amount of the work can be performed by the farmer himself, or his regular laborers. The items are given solely as a guide as to the probable maximum outlay for materials which it is necessary to buy for a structure of this form and capacity. (See Fig. 14.)

THE 90-TON ROUND SILO, WISCONSIN EXPERIMENT STATION.

The silo has an outside diameter of 16 feet and is 27 feet deep. It has a stone foundation, 3 feet high and 18 inches thick, laid in Louisville cement and plastered on the inside with two coats. The sill is a single 2x4 cut beveled on the radius of the circle in 2-foot lengths, and toe-nailed together after being laid upon the wall, then bedded in mortar. For studding 2x4's were used, 1 foot apart, 12 and 14 foot pieces being lapped 2 feet and spiked together before setting in place. For lining and outside sheeting, 6-inch fencing was split in two and nailed on horizontally, taking care to break joints. Three layers were put on for lining, with two layers of tar paper between. For siding ordinary half-inch beveled siding was used, rabbeted as shown in Fig. 16.

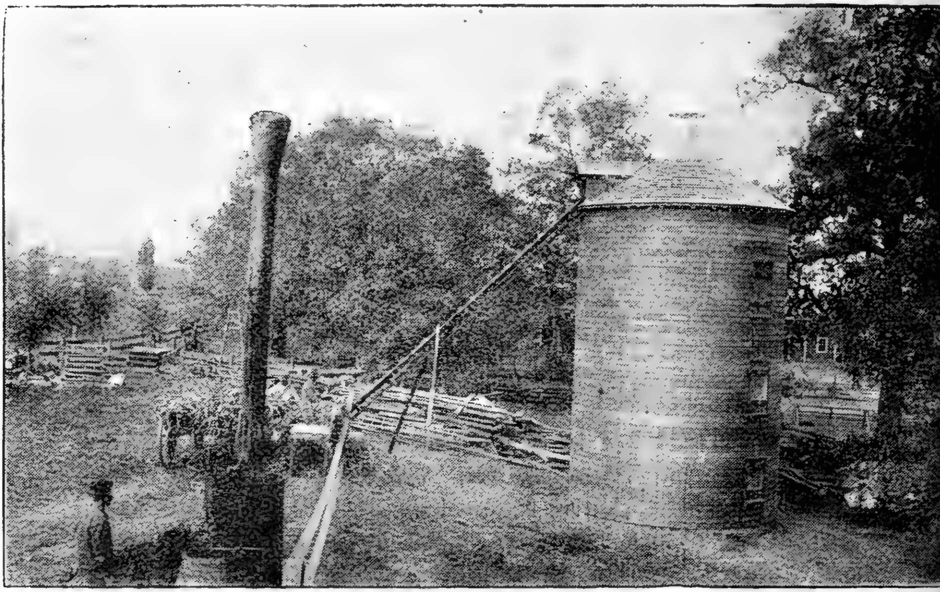


FIG. 15. ROUND WOODEN SILO AT WISCONSIN EXPERIMENT STATION.

Diameter, 16 feet; height, 27 feet; capacity, about 90 tons.

The plate was made like the sill, out of 2x4's cut in 2-foot sections and spiked down to the tops of the studding after the sheeting and siding had been carried up and the last staging built.

The roof was built without rafters by having a circle made by sawing pieces of 2x8's to the curve of a circle five feet in diameter and spiking two layers of these together, breaking joints so as to form a circle. This was supported in place so as to give about one-quarter pitch to the roof, and the roof boards were then nailed one end to this circle and the other to the plate. The roof boards consisted of fencing cut the desired length and sawed diagonally from within one inch of one corner to within one inch of the opposite corner. The roof was shingled and a galvanized-iron ventilator was nailed to the roof after the shingling was done.

The filling window was 3½ feet high and 3 feet wide. Three feeding doors 4 feet high, 2 feet wide, were cut out after the siding and lining was put on. The doors are made of three layers of ⅞ inch matched flooring, 4 inches wide, nailed to two cleats sawed so as to have the

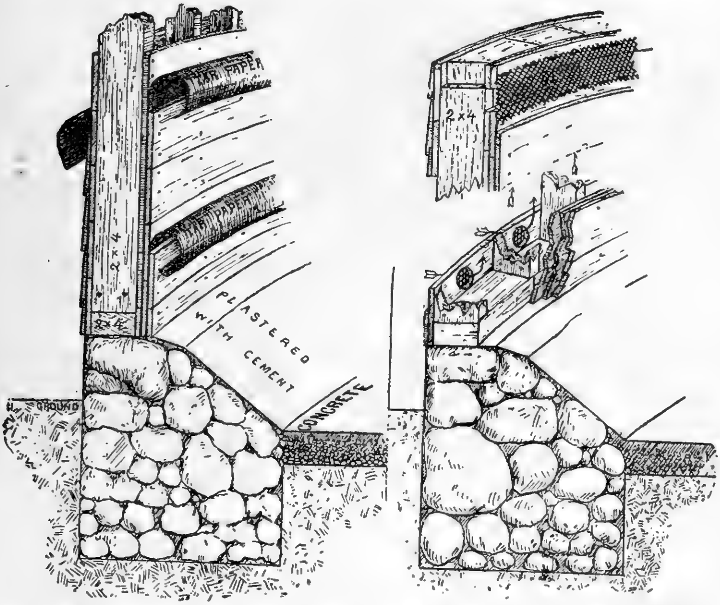


FIG. 16. CONSTRUCTION OF ROUND WOODEN SILO. (WHEELER.)

curvature of the silo wall, and of a similar thickness as that of the silo wall. The two sides of the door are beveled, and the inner corner of the swinging edge of the door is rounded a little to permit it to open and close readily. The doors are fastened by a pair of carriage bolts put through the studding opposite the ends of the cleats in the door and strips of band iron, 2 inches wide and ¼ inch thick bolted to the door along each cleat and provided with a long hole which shuts over the bolt in the studding when the door is closed. The door is held shut by handle nuts like those used on the rods for the end boards of lumber wagons.

For ventilation one 2-inch hole is bored through the siding and sheeting at the bottom between each pair of studs, and the hole covered with wire netting on the inside before the lining is put on (see Fig. 16). At the top the lining does not quite reach the plate and wire netting is nailed over the opening to prevent the silage from falling in. Provision is made for closing the lower openings in freezing weather. (See Fig. 15.)

The bill of materials for the silo was as follows: 57 2x4's 12 feet long; 57 2x4's 14 feet long; 2,500 feet fencing, 16 feet sized and split for sheeting and lining; 320 feet fencing, 16 feet cut 8 feet, and sawed diagonally for roof boards; 720 feet siding rabbeted; 120 feet flooring; 3 M. cedar shingles; 1 circle frame for roof; 500 pounds tar paper; 7 barrels Louisville cement; 2½ cord of stone; 1 keg of 10d. wire nails; 3 kegs of 8d. nails; 1 keg of 20d. nails; 50 pounds 6d. wire nails; 25 pounds 4d. wire nails; 3 pairs 6 inch T hinges; 1 pair 4 inch T hinges; 1 hook and staple; 12½x7 inch carriage bolts; 6⅜x7 carriage bolts; galvanized iron cupola; 25 pounds band iron for door fasteners.

Total cost of materials	$175.99
Mason labor	29.14
Carpenter labor	42.89
Total	$248.02

THE SILO IN THE DAIRY BARN, WISCONSIN EXPERIMENT STATION. (See Fig. 17.)

The silo is circular in form, 18 feet inside diameter and 33 feet deep. It is a frame structure lined inside and outside with brick. On 2x6 inch uprights, two wrappings of ⅜ inch stuff, 6 inches wide, are put, breaking joints, with no paper between. Brick is laid tight against this lining, and on the brick surface is a heavy coating of Port-

FIG. 15.—DAIRY BARN, WISCONSIN AGRICULTURAL EXPERIMENT STATION. SILO IN FOREGROUND.

land cement (1 part cement, 1 part sand). On the outside brick is laid up against the lining with a small open space between (about ½ inch). The silo is filled from the third floor of the barn, the loads of corn being hauled directly on to this floor over the trestle shown to the right in fig. 17, and there run through the feed cutter. When the silage is taken out for feeding, it falls through a

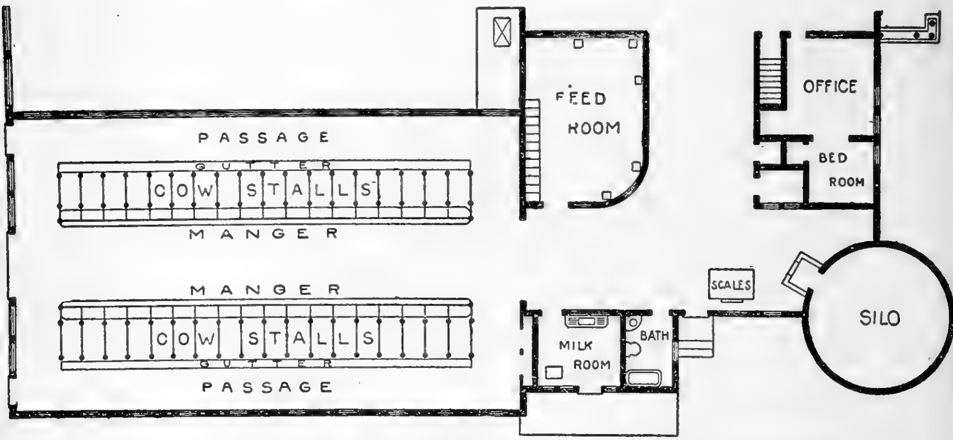


FIG. 18. PLAN OF EASTERN HALF OF FIRST FLOOR OF DAIRY BARN, WISCONSIN EXPERIMENT STATION.

box chute to the main floor where it is received into a truck (fig. 61) in which it is conveyed to the mangers of the animals.

THE MISSOURI EXPERIMENT STATION SILO. (115 TONS.)

The sill is a single thickness of 2x4 stuff, three or four feet long, cut on the arc of the silo circle, bedded in mortar, and the sections toe-nailed together. The plate is made in the same manner and nailed to the top of the studding. The studding is 2x4 stuff, placed one foot apart, and toe-nailed to the sill. In silos 30 feet deep, two 16-foot studs are lapped together. The lining is made of good fencing boards split in two, making them one-half inch thick by six inches wide, tarred and laid with the tarred faces together, with tarred paper between the same, taking care to break all joints in both directions. A line of doors from bottom to top one above the other, 3 feet wide and 4 feet high, at intervals of about 4 feet, are provided, and closed with pieces of boards made to fit. The studding on each side of the doors are doubled. Sheet steel was used

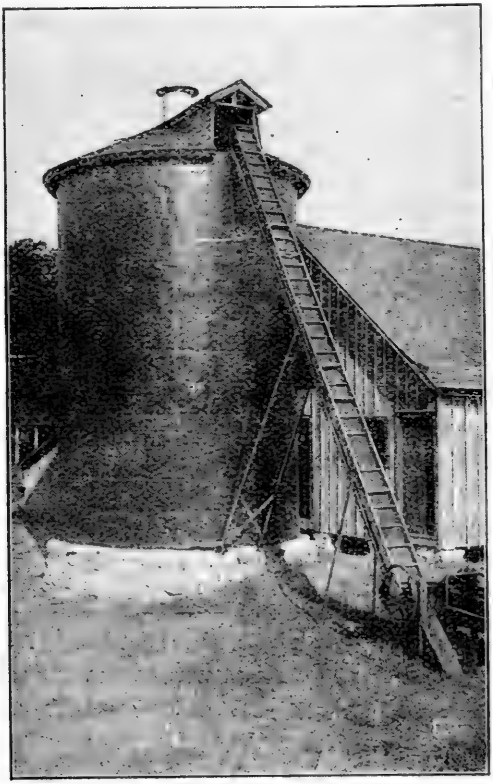


FIG. 19. ROUND SILO AT MISSOURI EXPERIMENT STATION. (FROM PHOTOGRAPH.)

for siding, painted inside and out. This was cheaper in cost of material and in labor of putting it on than the drop siding, and really cheaper than weather boarding or clapboards. A conical roof with dormer window completed the construction of the silo. (See Fig. 19.)

Cost of round silo holding 115 tons (16 feet diameter, 30 feet deep):

Foundation—10 perches at $1.50	$ 15.00
Sills and plates—10 pieces 2x4, 12 feet long, 80 feet at $15	1.20
Studdings—100 pieces 2x4, 16 feet long, 1,066 feet at $15	16.00
Rafters—25 pieces 2x4, 10 feet long, 166 feet at $15	2.49
Roof boards—300 feet at $15	4.50
Lining—1,600 feet clear fencing at $17	27.20
Shingles—3 m. at $2.25	6.75
Siding—18 squares of 27-pound steel	28.00
Tar paper—3 rolls at $4	12.00
Coal tar—1 barrel	4.50
Nails—155 pounds	6.45
Cementing floor	4.00
Paint	6.00
Labor	40.00
Total cost	$174.09

It is not necessary to employ skilled labor and the cash outlay may therefore be reduced by the amount charged to labor in the foregoing estimates.

THE SOUTH DAKOTA EXPERIMENT STATION SILO. (125 TONS.)

The silo (see fig. 20) was built in 1896; it is 16 feet in diameter and 30 feet from sill to plate; its capacity is 125 tons of green fodder, as it comes from the field. It is built at the west end of the dairy barn and there is a chute, 4x4 feet, between it and the barn. This chute extends the entire height of the silo and terminates in a ventilator about six feet above the ridge of the dairy barn. Into this chute the four feeding doors of the silo open. There are also two doors from the dairy barn opening into it, one at the bottom from the feeding alley which runs between the two rows of mangers, and one from the floor above. This chute makes it very convenient feeding the silage as it can be thrown from any of the doors into the chute and it will drop very close to the place where it is needed for feeding. A car and tramway could be put in at a small cost, so arranged that the silage would drop into the car when it was run into the chute, and when it was filled the silage could be distributed by running the car along in front of the feeding mangers. This chute also acts as a ventilator for the cow stables. In giving bill of materials and estimating the cost of the silo this chute is not included.

FIG. 20. ROUND WOODEN SILO, SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION.

The foundation is of native boulders laid in Yankton cement. The wall is 3½ feet high and 2 feet thick at the base, narrowing to about 8 inches at the top. The mortar used for laying the wall was made by mixing one-third Yankton cement and two-thirds sand, while that used for the plastering after the stone work was finished was mixed two-fifths cement and three-fifths sand. The bottom was made by putting in a layer, 8 inches deep, of broken stone, and pouring over it cement mixed very thin so that it would fill all the open spaces between the stones. After this had hardened the whole inside surface was plastered over with mortar so as to entirely cover all the stone work.

The sill was made by cutting 2x4 pine into sections 2 feet and 1 inch long at the outer points, and cut at 7 degrees and 30 minutes angle. Forty-eight of these were required to make a double sill. They were spiked together with 20d. nails, so as to break joints.

The studdings are 2x4, 16 feet long, lapped 2 feet and nailed together, making a total length of 30 feet between sill and upper rim. They are set 12½ inches apart from center to center on their outer faces, and each one comes directly over a joint in either the upper or lower section of the sill. The lower ends of the studding were saturated with hot tar and toe-nailed to the sill. After setting the studding the sheathing was started on both the outside and inside. Cement mortar was run in on top of the sill between the studding to the depth of about 2 inches. This unites with the cement of the wall and makes an air tight connection between foundation and superstructure.

The upper rim was made exactly the same as the sill and nailed on top of the 30-foot studding.

The inside lining is made of two thicknesses of ½-inch No. 1 fencing, 6 inches wide, neither planed nor matched. The first thickness was put on, then painted with a coat of hot coal tar, a layer of tarred felt was then applied, then another thickness of ½-inch fencing made to break joints with the first, and this second or inside lining was given two coats of hot coal tar, the last coat having been boiled until it made a hard, glossy surface.

The outside sheathing and siding are of one thickness of ½-inch fencing and one thickness of rabbeted lap siding with tarred felt between. It was found necessary not only to have the siding rabbeted, but it also had to be cut into pieces not exceeding 8 feet in length in order to get it to lie flat against the sheathing without "crimping."

The Roof.—Plates 8 feet long, made of two 2x4's nailed together, were spiked on top of two opposite sections of the upper rim. Upon these were erected five pairs of rafters carrying a 2x6 ridge pole 19 feet long. To the lower ends of these rafters two 2x4's were spiked to take the place of the fascia of the cornice. Three shorter pairs of rafters were then attached to the ridge pole at each side of the first ones and held in place by stays, and other 2x4's were spiked to the end of these. The roof sheathing was then put on and the short studding were fitted in between the upper rim and the roof boards, or the rafters, as the case might be. The stays which had supported the rafters were removed. The gables were then sided up with ⅜-inch ceiling and the roof was shingled.

Doors. There are four feeding doors, each 2 feet by 3 feet 10 inches, made of matched flooring on a framework cut on the same radius as the silo, and with a hollow space of 4 inches on the inside. These doors are hung on heavy T hinges, and are each provided with two ½x2 inch hasps extending the full width of the door, and projecting beyond the front edge about 2 inches. When these doors are closed for filling the hasps are fastened with a ⅜-inch carriage bolt through the silo wall and the projecting end of the hasp. In this way the doors can be so tightly closed as to make the wall nearly air-tight.

A door, 3x4 feet, for filling, made of 1-inch flooring, was put in the gable.

Ventilation of Silos.—Three ¾-inch holes were bored through the outer walls of the silo between each pair of studding, and the inside sheathing was not continued quite to the upper rim, but a space of about two inches was left between the top of the sheathing and the bottom of the upper rim. This arrangement allows a free passage of air between the outer and inner walls of the silo during warm weather when decay is liable to occur. In cold weather these holes through the outer wall are covered by tacking a piece of thin siding over them.

The silo was finished by giving it two coats of paint.

Below is given a bill of material and labor. It is believed that the price of some of the material is too high, and that anyone having the cash to pay for it could make a considerable saving on this bill. The conditions under which this material was purchased were not so favorable to economy as they might have been. The prices given are, however, those paid; and all material, except the stone, which we had in abundance close at hand, and all the labor is included. It is also believed that the foundation of this silo is more expensive than would be necessary in most locations. The silo is located on the lower side of the barn between two stable doors. In the spring the drainage from the higher ground, and the tramping of the cattle often make the ground around the silo quite soft and muddy. On this account it was considered advisable to make the foundation quite substantial. For a silo of the same size located on a high, well drained site, a much cheaper foundation would do equally as well.

BILL OF MATERIAL.

100 2x4 16-foot long studding....	1067 feet	
41 2x4 12-foot long rafters, sills, rim, etc.	493 "	
18 2x4 10-foot rafters and plate..	120 "	
1 2x6 20-foot long ridge plate.....	20 "	
	1700 feet @ $18.00 $	30.60
1900 feet No. 1 lap-siding, rabbeted @ $27.50......		52.20
4500 feet ½-inch fencing, sheathing @ $15.00.......		67.50
120 feet flooring, for doors @ $25.00...............		3.00
375 feet boards, for roof @ $18.00..................		6.75
200 feet ⅜-inch ceiling, for gable @ $30.00........		6.00
1 barrel coal tar..................................		7.50
621 pounds tarred felt @ $2.00.....................		12.40
3 m. shingles @ $3.00..............................		9.00
6 barrels cement @ $5.00...........................		30.00
400 pounds nails @ 3 cents.........................		12.00

Hinges and hook		1.50
Heavy hasps and bolts for doors..................		6.20
Labor and Paint—		$ 244.65
Paint and painting	$10.00	
Carpenter work @ $3.00 per day.......	60.00	
Mason work @ $3.50 per day..........	10.50	
Common laborers @ $1.00 per day.....	8.00	88.15
Total		$ 332.80

FIG. 21. CYLINDRICAL BARN, SHOWING MAIN ENTRANCE TO FIRST AND SECOND STORIES.

Round silo, 23 feet diam., 34 feet high, in center. From a photograph. (King.)

Round Wooden Silos may conveniently be built inside of large, round barns in a similar manner, as described in the Seventh Report of the Wisconsin Experiment Station, in case of a three-hundred ton silo at Whitewater, Wis. The dimensions of the silo, which is in the center of the barn, are 23 feet inside diameter, by 34 feet high. It was built from 2x6 studdings, sided up by two layers of fence boards, sawed in two. For explanations as to the details of the construction of barns of this kind the reader is referred to the report mentioned. Other methods of connecting round wooden silos with barns will be shown at the close of the discussion of stave silos.

II. Stave Silos.

The stave silo is the simplest type of the various separate silo buildings, and partly for this reason, partly

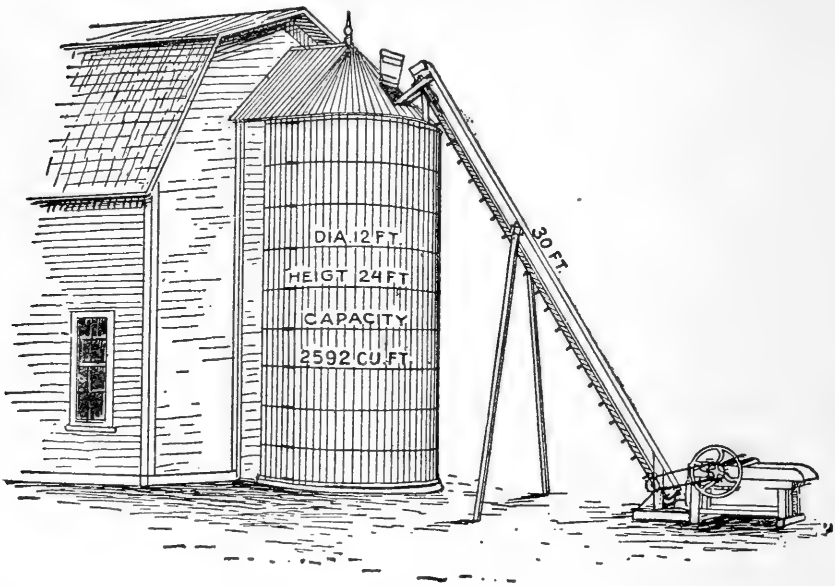


FIG. 22. STAVE SILO.

12 ft. diameter, 24 ft. high; capacity, 50 tons. (Elias.)

also on account of its cheapness of construction, more silos of this kind have been built during the past few years than of any other silo type. Stave silos are, generally speaking, similar to large railroad- or fermentation tanks, and to make satisfactory silos should be built at all events equally well as a No. 1 water tank. The first stave silos were built in this country in the beginning of the nineties; they soon found some enthusiastic friends, while most people, and certainly nearly all writers and lecturers on silo construction, were inclined to be skeptical as to their practicability. It was objected that the staves would expand so as to burst the hoops when the silo was filled with green fodder; that they would shrink, after having been left empty during the summer months, so that the silo would fall to pieces, or at least so that it could not again be made air-tight; and finally, that the silage would freeze in such silos, and its feeding value thereby greatly lowered. In addition to this, it was claimed that a substantial stave silo would cost as much as a first-class ordinary all-wood silo of the same capacity, and that this would not have the objectionable features of the former.

In spite of these objections the stave silo has, however, gained more and more ground until of late years it has been adopted quite generally in preference to other kinds of silos, particularly in the Eastern and Central Eastern states. This being a fact, it follows that the objections previously made to the stave silos are not valid, that the staves do not swell so as to burst the hoops, or shrink so as to cause the silo to fall to pieces or become leaky. As regards the danger from freezing of the silage, the criticisms of the stave silo are in order, as the silage will freeze in cold weather in any of the Northern states or Canada, if the silo is built outdoors, but according to the unanimous testimony of farmers who have had experience with frozen silage, this is more an inconvenience than a loss. The freezing does not injure the feeding value of the silage, or its palatability. When the silage is thawed out, it is as good as ever, and eaten by cattle with a relish.

The main reasons why stave silos have been generally preferred by farmers of late years and are likely to become the silo type of the future are, I take it, first, they can be put up easily, quickly, and cheaply, and the expense for a small silo of this kind is comparatively small, so that many a farmer has built a stave silo who could not afford to build a high-priced silo, and others have preferred to build two small silos for one large one, or a small one in addition to an old, larger one they may already have. Secondly, manufacturing firms have made a specialty of stave-silo construction and pushed the sale of such silos through advertisements and neat circulars. Having made a special business of the building of stave silos, and having had several years' experience as to the requirements and precautions to be observed in building such silos, these firms furnish silos complete with all necessary fixtures, that are greatly superior to any which a farmer would be apt to build according to more or less incomplete directions.

It follows as a corollary that the stave silos sent out by manufacturing firms will generally be more expensive than such as a farmer can build himself, because they are built better. The writer believes that it does not pay to build a poor silo except to bridge over an emergency. Poor, cheap silos are a constant source of annoyance, expense and trouble, whether built square, rectangular, or round. The cheap silos described in other places of this book have not been given for the purpose of encouraging the building of such silos, but rather to show that if a farmer cannot afford to build a *good* silo, he is not necessarily barred from the advantage of having silage for his stock, since a temporary silo may be built at a very small cash outlay.

We can therefore consistently, in most cases, recommend that parties intending to build stave silos patronize the manufacturers who have made silo construction a special business; their advertisements will be found in any of the standard dairy or agricultural papers. These firms furnish all necessary silo fittings, with complete directions for setting up the silos, and, if desired, also skilled help to superintend their building. Perhaps a large majority of the farmers of the country cannot, however, patronize manufacturers of stave silos because the expense of shipping the lumber and fixtures would be prohibitory. For the convenience of such parties and others who may prefer to build their own stave silos, directions for their construction are given in the following. The specifications for a 100-ton stave silo, printed below, were furnished at the request of the author by Claude & Starck, architects, Madison, Wisconsin:

SPECIFICATIONS FOR A 100-TON STAVE SILO.

MASONRY

Excavate the entire area to be occupied by the silo to a depth of six inches; excavate for foundation wall to a depth of 16 inches; in this trench build wall 18 inches wide and 20 inches high, of field stone laid in rich lime mortar. Level off top and plaster inside, outside and on top with cement mortar, 1 part cement to 1 part sand.

Fill inside area with four inches of good gravel, thoroughly tamped down; after the woodwork is in place coat this with 1 inch of cement mortar, 1 part cement to 1 part clean sand. Cement shall be smoothly finished, dished well to the center and brought up at least 2 inches all around inside and outside walls.

CARPENTRY.

All staves shall be 26 feet long in two pieces, breaking joints, and made from clear, straight-grained cypress 2x6 inches, beveled on edges to an outside radius of 8 feet, mill-sized to the exact dimensions and dressed on all sides. There shall be three doors in the fifth, eighth and tenth spaces between hoops, made by cutting out from staves 28 inches long cut to a 45 degree bevel sloping to the

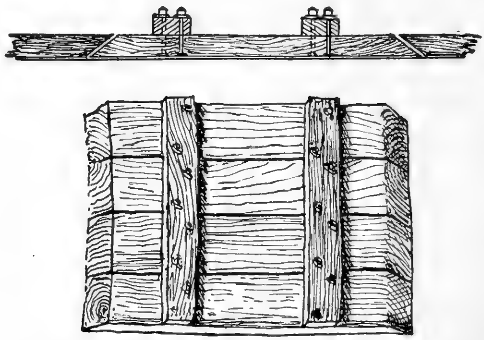


FIG. 23. APPEARANCE OF DOOR IN STAVE SILO AFTER BEING SAWED OUT, AND SIDE VIEW OF DOOR IN PLACE. (CLINTON.)

inside. (See fig. 23.) The staves shall then be fastened together with two 2x4 inch battens cut on inside to an 8-foot radius and bolted to each stave with two ¼-inch diameter carriage bolts with round head sunk on inside and nut on outside. The staves between the doors shall be fastened together, top and bottom, with ¾-inch diameter hardwood dowel pins, and abutting ends of staves shall be squared and toe-nailed together.

Bottom Plates.—Bottom plates shall be made of 2x4 inch pieces about 2 feet long, cut to a curve of 7 feet 10 inches radius outside. They shall be bedded in cement mortar and the staves shall then be set on the foundation and well spiked to these plates.

Hoops.—Hoops shall be made from two pieces of ⅝-inch diameter round iron with upset ends, threaded eight inches, with nut and washer at each end; as a support for the hoops a piece of 4x6-inch shall be substituted for a stave on opposite sides and holes bored in it and the ends of hoops passed through these holes and tightened against the sides of the 4x6-inch. The hoops shall be twelve in num-

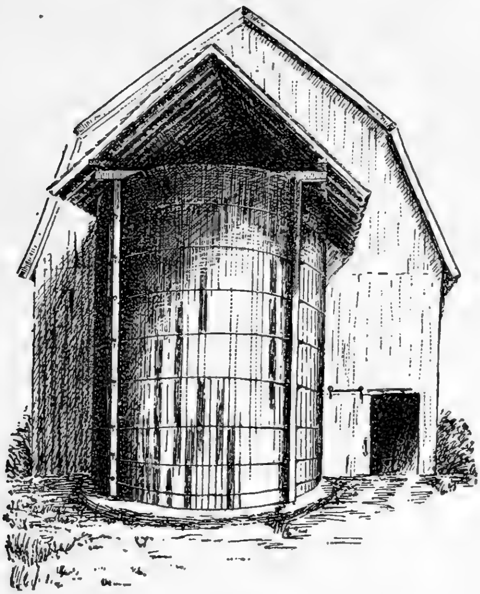


FIG. 24. A CHEAP ROOF OF STAVE SILO. (CLINTON.)

ber starting at the bottom 6 inches apart and increasing in distance 6 inches between each hoop until a space of 3 feet 6 inches is reached; from this point up this distance shall be preserved as near as possible to the top.

Roof.—Roof shall be made to a half-pitch of 6 inches clear siding lapping joint, nailed to 2x4-inch rafters, 2 feet centers, 1-foot by 4-inch ridge, and 2x4-inch plates. These plates to be supported on two 4x4-inch pieces rest-ing on top of hoops (see fig. 24). Three 1x4-inch collar beams shall be spiked to end and middle rafters to tie side of roof together.

PAINTING.

The entire outside of the silo, including roof, shall be painted two coats of good mineral paint; the entire inside surface of staves and doors shall be thoroughly coated with hot coal tar.

Note.—Before filling silo, tar paper should be tacked tightly over doors and the entire inside of silo examined and all cracks tightly caulked.

The method of construction specified in the preceding may of course be modified in many particulars, according to the conditions present in each case, cost of different kinds of lumber, maximum amount of money to be expended on silo, etc. A few points in regard to the building of these silos may properly be discussed in this place.

Beveled vs. unbeveled staves. The question whether staves need to be beveled for use in the building of stave silos has been a subject of controversy in the agricultural press and elsewhere. The New York (Cornell) Experiment Station, which has made a systematic study of stave silos (the results of which are published in bull. No. 167 of this station, The Construction of the Stave Silo, by L. A. Clinton), as well as farmers who have had several years' experience with stave silos made of unbeveled staves, are of the opinion that "beveling is unnecessary with silos having a diameter of more than 12 feet, if the staves are not more than six inches wide, while silos having a diameter of 12 feet or less should have the staves beveled if these are six inches wide; if the staves are four inches wide, no beveling is necessary. With all stave silos, if the beveling could be guaranteed accurate for the silo to be constructed there is no objection to the beveling. But no beveling is preferable to too much beveling."*

According to the experience of the well-known writer and lecturer, John Gould, of Ohio, "unbeveled staves, well sized, will pinch together on inside edges so as to be in every way as good as a tongued and grooved stave, and will dry out and keep better than one where it can sap-soak so much in the grooves."

Although practical experience so far seems to confirm the correctness of the position stated, it is a fact that railroad water tanks and large fermentation tanks are always, so far as known, made of slightly beveled staves, and the staves in such tanks need to fit at least as tightly as those of stave silos. Another indication showing that beveled staves are preferable to unbeveled ones is the fact that all the various manufacturers who have made stave silo construction a specialty are using beveled staves. They are as interested as their customers in reducing the cost of their silos, but have still thought it unwise to vary from the plan of large water tanks. It is evident from the testimony on hand, however, that stave silos built of unbeveled staves have given good satisfaction for at least four seasons; and it is also evident that the beveling of the staves, if done at all, must be done carefully, so that too much is not taken off, which will prevent the making of a tight joint at the inner edge of the staves when the silo hoops are tightened.

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*Private communication from Prof. Clinton.

Wire fencing for hoops. In the place of round or flat iron hoops. ⅝-inch diameter, it has been suggested to use a band of 52-inch woven wire fencing cut of such a length that when each end is wrapped about a 4x4-inch oak scantling, and put round the silo, the end pieces will come within about 10 inches of each other and are tied together with two 1-inch bolts with double burrs. The bands are placed sufficiently far apart to admit of doors being placed at proper distances. The coil of the wire takes up all slack, as the silo shrinks when empty, and expands when the staves swell, so that the staves are under tension all the time.

By making the stave silo of plain unbeveled 2x4-inch scantling and using wire fencing for hoops, silo construction has been reduced to the lowest cost which it is likely to ever reach; a 50-ton silo of this kind (12 feet diameter, 24 feet high) of hemlock staves put up at Cornell Experiment Station cost $34 for materials. The materials may be obtained at any lumber yard and hardware shop, and a minimum of mechanical skill is required for putting up the silo. With the limited experience at hand at the present time concerning the longevity of silos built in the manner suggested we cannot feel certain that they will prove satisfactory structures in the long run—there are, in fact, good authorities that are skeptical even as to the value of such silos for a short period of time, but the evidence on record shows, as stated, that they have given good satisfaction for four seasons at any rate, first-class silage having been made in them during this time, and at present there are no signs of their giving out. It would seem therefore that stave silos built as suggested may be safely recommended at least as temporary structures and to bridge over to when more expensive and carefully built silos can be erected.

Foundation of stave silos. The method of making the foundation of a stave silo recommended by a New York manufacturer is shown in figures 25 and 26.

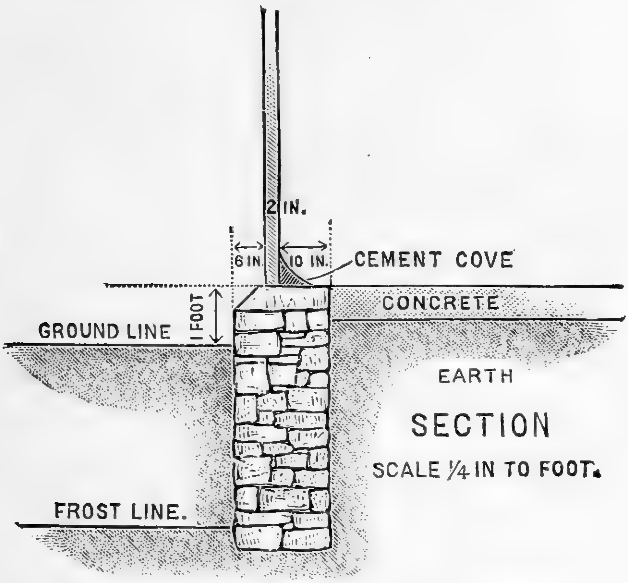

FIG. 25. FOUNDATION OF STAVE SILO. (HARDER.)

Setting up the staves. The method of setting up a stave silo recommended by the Cornell Experiment Station is shown in fig. 27. "Posts of 6x6 material (*a*), of the entire length of the silo, are set up vertically and stayed securely in place. The scaffolding may be constructed by setting up 2x4 scantling in the positions shown in the figure as *b*. Boards nailed from these 2x4's to the 6x6 posts will form a rigid frame, across which the planks for the scaffold platform may be laid. Before the scaffolding is all in place, the staves should be stood up within the inclosure, otherwise difficulty will be experienced in getting them into position. Some

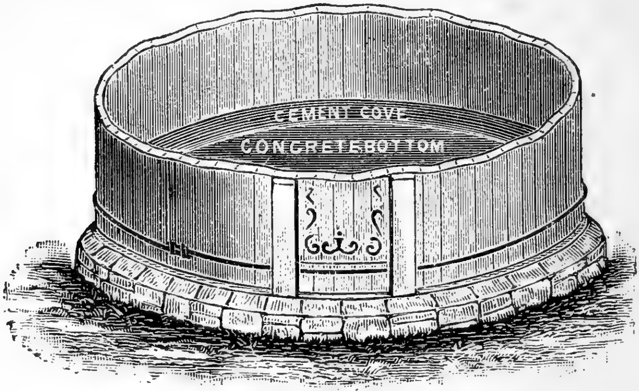

FIG. 26. BASE OF STAVE SILO. (HARDER.)

caution needs to be exercised in working on the scaffolding that the planks do not tip. The first stave set

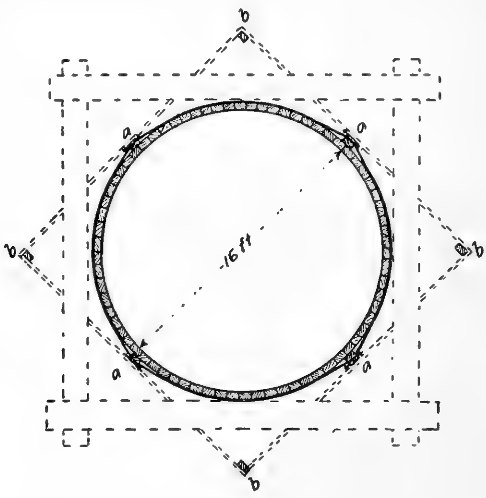

FIG. 27. CROSS-SECTION OF STAVE SILO. THE DOTTED LINES ARE TO SHOW HOW SCAFFOLDING MAY BE PUT UP. (CLINTON.)

up should be made plumb, and should be toe-nailed at the top to one of the posts originally set."

A good way of starting the building of a stave silo is illustrated in figures 28 and 29. Some manufacturers of stave silos furnish such silo fronts, all joined together and ready to set in place, at a small extra charge, with battens D, D, bolted on, and dowel-pinned together; after the front is up and braced so that it stands perfectly perpendicular every way, the silo is built by adding a stave at a time to this front, each stave being firmly fastened by cleats on the inside, one near the top, one in the middle and one near the bottom (fig. 30). According to Professor Clinton, old staves of sugar barrels are best adapted for a silo, 12 feet in diameter, while the flour barrel stave best fits the curve of a 16-foot silo, and staves of the cement barrel that of silos 20 feet in diameter or more. The staves are removed when the silo is all up.

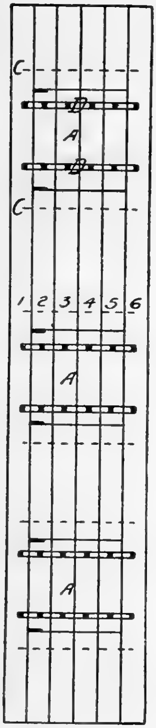

FIG. 28. SIX-STAVE SILO FRONT, READY TO BE PUT UP.

A, A, A, Doors; C, C, C, Dowell Pins; D, D, D, Door Battens (Cap. Lbr. Co.).

Doors. The arrangement of doors for stave silos illustrated in fig. 23 (see p. 82), will prove satisfactory if the work be carefully done. Manufacturers of stave silos have shown considerable inventiveness in constructing doors for such silos, some of which have some good features, while others are open to criticism in several ways. A couple of such patented doors, with stave silos of different manufacture, are shown in figures 31A-32. The difficulty with several of the patented silo doors is that they have iron parts which are apt to rust and wear out, or they weaken the silo, or after some time get out of shape and fail to close tightly. Fig. 33 shows a form of stave silos made by a New York manufacturer; instead of doors there are sections of staves put in horizontally across the opening; these sections are removable so as to form a continuous opening from the bottom to the top of the silo, through which the silage may be easily emptied; in addition the cross-bars supporting the sections form a ladder which may be used in ascending or descending the silo (see p. 93).

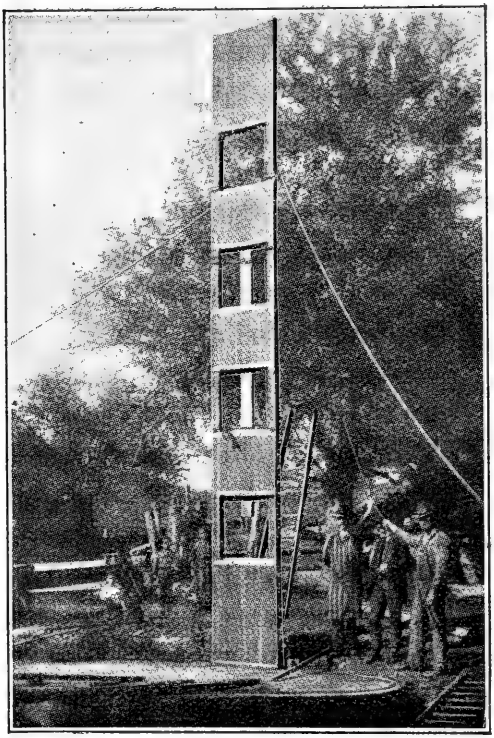

FIG. 29. SETTING UP THE STAVE SILO IN SECTIONS. (HARDER.)

Before filling the silo the hoops should be drawn somewhat tight, but not perfectly so, so as to allow for the swelling of the staves from the moisture which they will take up from the corn. The hoops should be watched closely for some days after the silo has been filled, and if the strain becomes very intense the nuts should be slightly loosened so that the hoops will not be broken or the thread stripped.

In order to prevent the collapse of the silo during

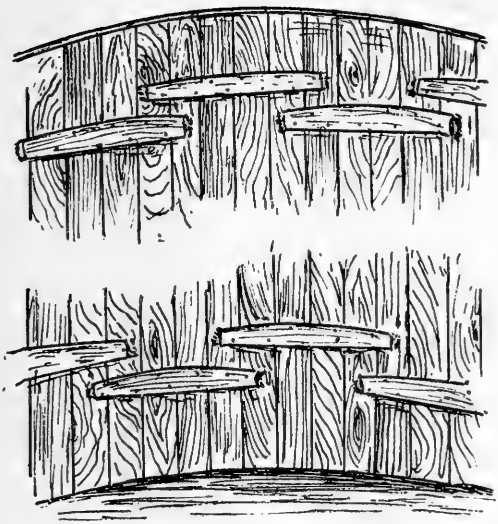

FIG. 30. USE OF BARREL STAVES IN SETTING UP A STAVE SILO; THEY SHOULD BE REMOVED BEFORE THE SILO IS FILLED.

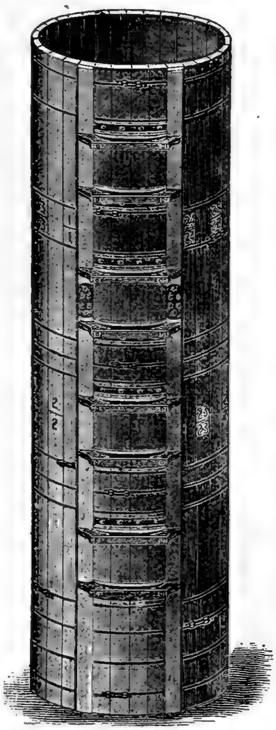

FIG. 31. STAVE SILO, "KALAMAZOO SILO." (WILLIAMS MFG. CO.)

the summer when it is empty and the staves have become thoroughly dried out, the hoops should be fastened with numerous staples; these will prevent the hoops from sagging or dropping down, and will also hold the staves in place.

Roof. If built inside a barn or another farm building, there will be no need of putting any roof on the

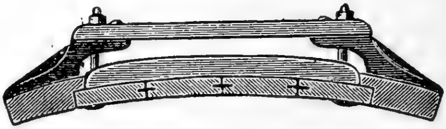

FIG. 31A. DOOR OF KALAMAZOO SILO.

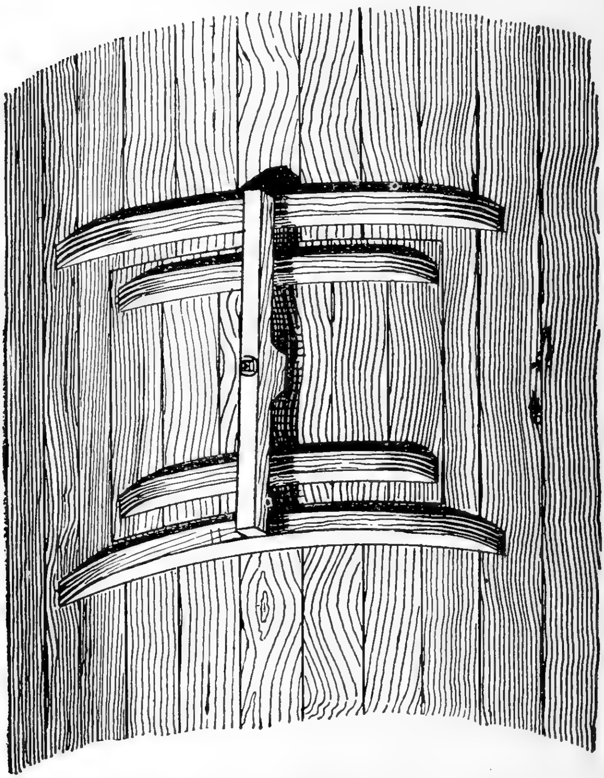

FIG. 32. DOOR OF STAVE SILO. (ELIAS.)

stave silo. If the silo is built out of doors as an independent structure, some sort of a roof should be put on to keep out rain or snow. The roof provided for in the specifications for a 100-ton silo on p. 83 is described in the New York bulletin previously referred to and may

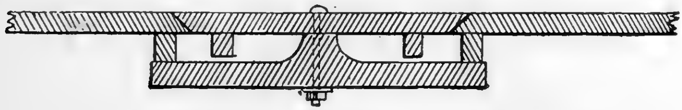

FIG. 32A. SIDE VIEW OF DOOR OF STAVE SILO. (ELIAS.)

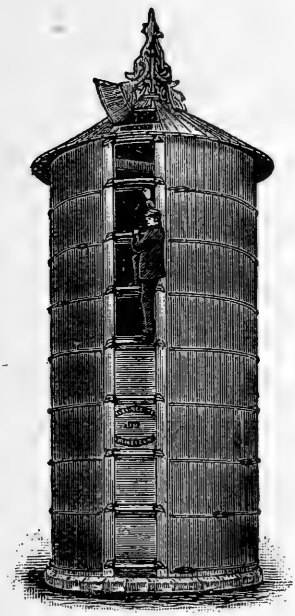

FIG. 33. STAVE SILO WITH CONTINUOUS OPENING IN FRONT. (HARDER.)

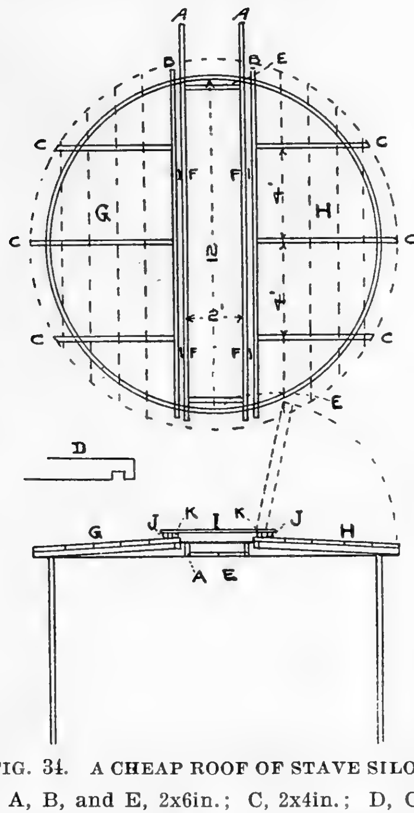

FIG. 34. A CHEAP ROOF OF STAVE SILO.

A, B, and E, 2x6in.; C, 2x4in.; D, C, Enlarged Outside End; F, Hinges; G, H, I, Sections of Roof; J, K, 2x2in. (Van Norman).

prove fairly efficient. Another construction of a cheap roof for a stave silo is shown in fig. 34. It was built at the Indiana Experiment Station at a total cost of $10.50, viz., lumber $4, tin put on and painted $6, and hardware 50 cents. Two 2x6 pieces (A,A) were placed on edge and toe-nailed to the top of the staves they rested on; the projection is for supporting the carrier at filling time. They are tied together by the short pieces E. The roof is in three sections, G, H and I. G and H

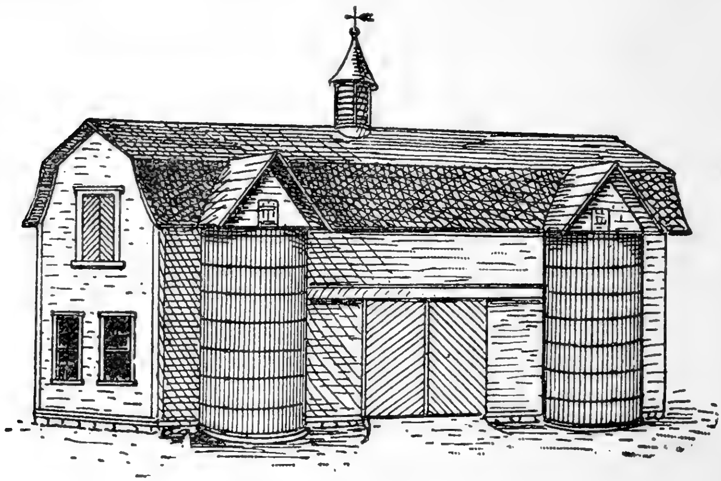

FIG. 35. TWIN STAVE SILOS BUILT IN CONNECTION WITH BARN. (ELIAS.)

are hinged to the frame A, A, and may be tipped up when the silo is nearly full, to allow filling to the top. The narrow middle section is light enough to lift off on either side, and leaves the opening for the carrier to deliver into.

On the framework B, B, and C, C, cheap sheeting boards are nailed. This is then covered with tin, soldered joints and painted. The sections should be fastened down by means of staples and hooks, or other device; the hooks are used on this one. On the inner edge of G and H, 2x2-inch strips, K, are nailed. Close to these are placed similar strips, J, to which the cross-boards are nailed, forming the section I of the roof. The tin on the section I should come over the edge on to J. On the other sections it should run up on the side of K, making a water-tight joint.

The sections G and H have a slope of nearly 3 inches, being the difference in height of A and C. C is notched one inch at the outer end. (VanNorman in *Hoard's Dairyman.*)

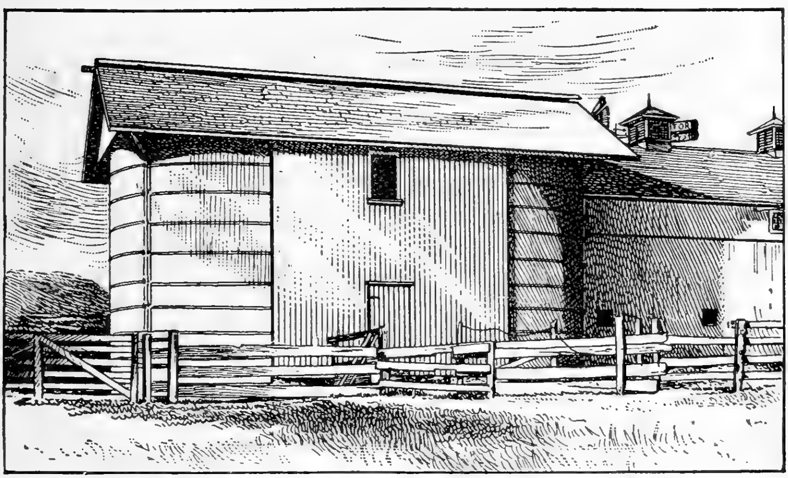

FIG. 36. TWIN STAVE SILO, KENOSHA COUNTY, WIS.

Protection against freezing. If the silo is built outdoors in any of the Northern states, it is necessary to provide some special means to keep the silage from freezing in case this is considered a very objectionable feature. The silo may be inclosed by a wide jacket of rough boards nailed to four uprights, leaving the section of the silo where doors are, easy of access; the space between the silo and outside jacket is filled with straw in the fall; this may be taken out and used for bedding in the spring, thus allowing the staves to be thoroughly dried out during the summer, and preventing the silo from rotting.

The plan of a stave silo given by Prof. King of Wisconsin Experiment Station is shown in fig. 37. It is made with tongued and grooved staves four to six inches

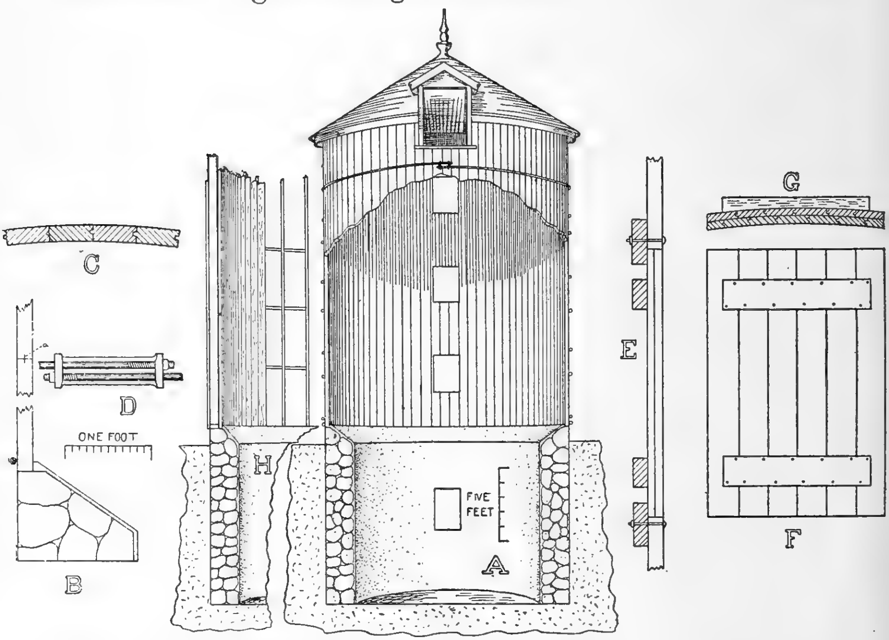

FIG. 37. CONSTRUCTION OF THE STAVE SILO, AND OF A MODIFICATION OF THE STAVE SILO (H.) (KING.)

wide, and is hooped with metal hoops and metal tighteners. In the figure, the construction of the silo is shown in A-G, while H shows the construction of an all-wood silo where matched flooring forms the lining and is put on in the manner of staves. The door, F, G, is made of two layers of 4-inch matched flooring with a layer of 2-ply saturated acid- and alkali-proof paper between ; it is held in place with large screws or lag bolts, and opens inside. The shoulder against which the door shuts, should be lined with 2-ply P. and B. Ruberoid paper, or its equivalent. The cleats for the doors are cut to the curve of the silo, as shown at G. The staves, C, are beveled to fit the circle. The hoops are $\frac{3}{4}$-inch round rods provided with iron tighteners, as shown at D, instead of wood as is being used by many. The wood is not durable enough, and is liable to give way in time when the silo is full. The iron

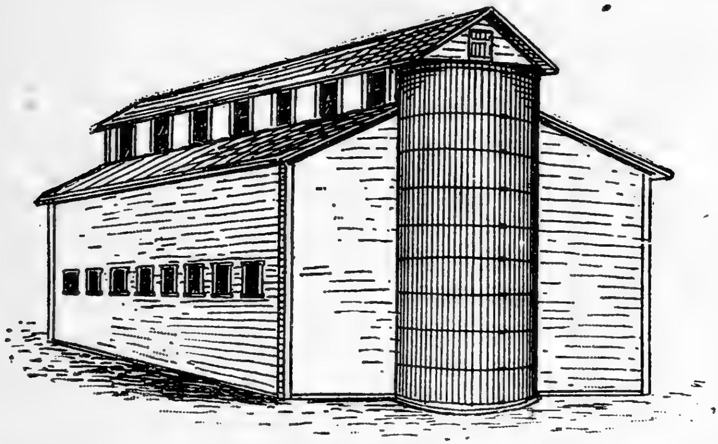

FIG. 38. STAVE SILO BUILT IN CONNECTION WITH A CHEAP AND EFFECTIVE DAIRY BARN. (ELIAS.)

tighteners are furnished by manufacturers of stave silos. If staves are spliced, the joint is made tight, as shown in B at a, by putting a piece of galvanized hoop iron in a saw-cut in the ends of the two staves where they meet.

In the substitute for the stave silo shown at H, the outside is much like the all-wood silo, and the lining consists of matched 4-inch flooring nailed to girts cut in between the studs as shown at H. In the opinion of Professor King, such silos, besides being warmer,

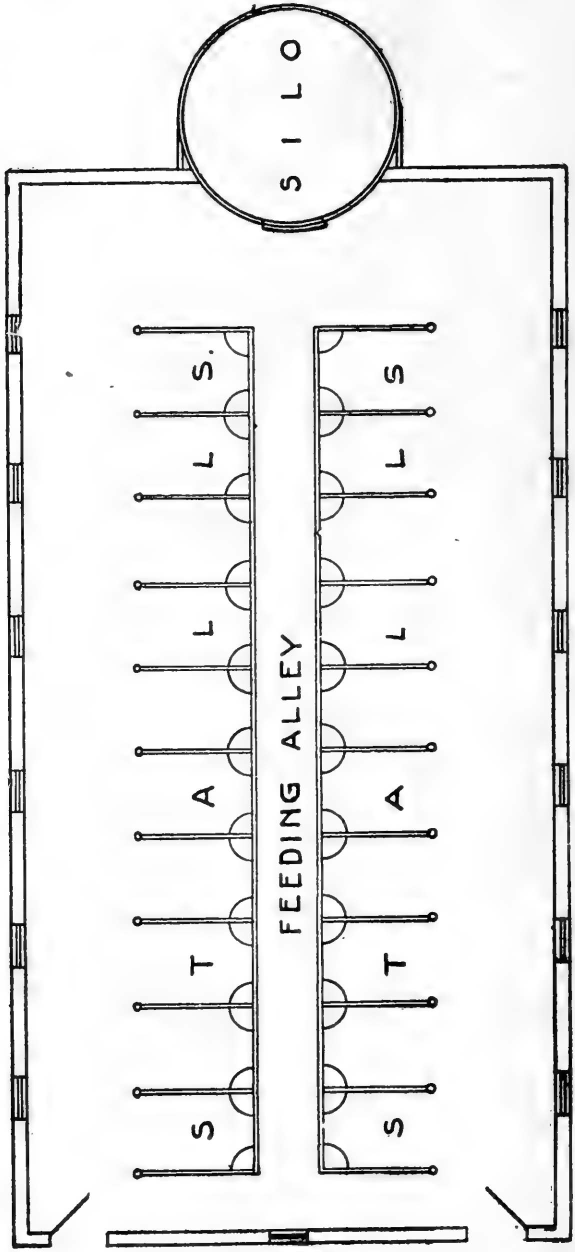

FIG. 39. INTERIOR OF BARN SHOWN IN FIG. 38.

more durable and tighter, may be built as cheaply as a first-class stave silo.

The manner of connecting stave, as well as other

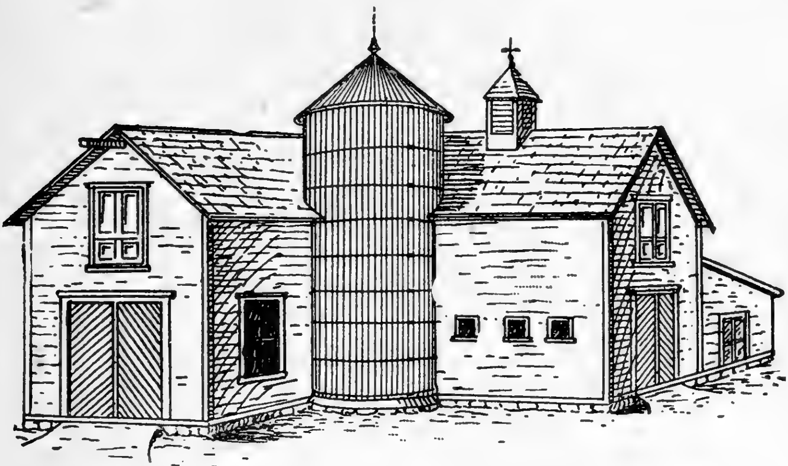

FIG. 40. STAVE SILO BUILT IN CONNECTION WITH A STOCK BARN. (ELIAS.)

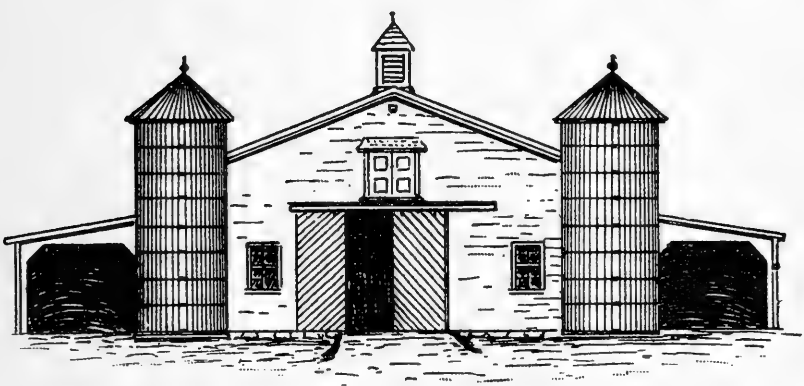

FIG. 41. TWIN STAVE SILOS LOCATED ON THE SIDES OF A STOCK BARN. (ELIAS.)

round wooden silos with stock barns is illustrated in many of the pictures of such silos given in this book; a few more illustrations are shown above which will suggest methods that may be adopted in building silos in connection with barns; see figures 38-41, inclusive.

Calculation of staves required for stave silos. The following table will be found useful in calculating the number of staves required for silos of different diameters, and the feeding areas which these will give:

CIRCUMFERENCES AND AREAS OF CIRCLES.

Diameter, Feet.	Circumference, Feet.	Area, Square Feet.	Diameter, Feet.	Circumference, Feet.	Area, Square Feet.
8	25.1	50.3	21	66.0	346.4
9	28.3	63.6	22	69.1	380.1
10	31.4	78.5	23	72.3	415.5
11	34.6	95.0	24	75.4	452.4
12	37.7	113.1	25	78.5	490.9
13	40.8	132 7	26	81.7	530.9
14	44.0	153 9	27	84.8	572.6
15	47.1	176.7	28	88.0	615 8
16	50.3	201.1	29	91.1	660 5
17	53.4	227.0	30	94.2	706.9
18	56.5	254 5	31	97.4	754.8
19	59.7	283.5	32	100.5	804.2
20	62 8	314.2			

To find the circumference of a circle, multiply the diameter by 3.1416.

To find the area of a circle, multiply the square of the diameter by 0.7854.

To find the cubical content of a cylinder, multiply the area of the base (floor) by the height.

Example.—A silo 16 feet in diameter and 26 feet high is wanted; how many staves 2x6 inches will be needed, and what will be the feeding area in the silo and its capacity?

The circumference of a circle 16 feet diameter is 50.3 feet; there will therefore be required 50.3÷½=101 staves, 2x6 inches, 26 feet high, or if staves of this height cannot be obtained, either 127 staves 21 feet long or 135 staves

20 feet long. The feeding area will be 15 2-3×15 2-3×0.7854=192.8 square feet, and the cubical content of the silo 192.8×26=5012.8 cubic feet. Estimating the weight of a cubic foot of corn silage at 40 pounds, 5012.8 cubic feet silage would weigh 200,512 pounds, or 100 tons, which is the approximate capacity of a round silo of the dimensions given.

III. Square or Rectangular Wooden Silos.

Nearly all silos built in this country prior to 1891 were square or rectangular, and were built either in bays of barns or as independent structures. As already stated, they were relatively shallow, while those built during late years have had considerable depth, like the round silos built during this period. Silos of this type differ in their construction according to whether they are built inside of barns or as separate buildings, and we shall therefore consider these two kinds under separate headings.

A. Silos in the Barn.

A large number of silos have been built in a bay of the barn. Where the necessary depth can be obtained and where the room can be spared, such silos can be built very easily and at less cost than a separate structure, since lighter materials in construction may be used in this case, and no roof will be required for the silo. Silos built in this manner have generally the advantage over other silos in being near at hand. This is a very important point; feeding time comes twice a day throughout the winter and spring, and a few steps saved in hauling the silage mean a good deal in the aggregate. Many farmers first made silos of this kind, and later on, when familiar with the process, built additional separate structures.

Bays of the barn may be easily changed into silos according to the following directions given by Professor Whitcher:

"Remove floors, and if there is a barn cellar, place sills on the bottom of this and set 2x8 scantling vertically, bringing up the inside edges even with the sills of the barn. The bottom may or may not be cemented, according as the ground is wet or dry. If to be cemented, three casks of cement and an equal amount of sharp sand or gravel will cover a bottom 16x16 and turn up on the sides two feet, which will give a tight silo. Common spruce or hemlock boards, square-edged and planed on one side, are best for boarding the inside of the silo; these are to be put on in two courses, breaking joints, and, if thoroughly nailed, will give a tight silo. No tonguing or matching is needed. Tarred paper may be put between the boarding, if desired, but I doubt if it is of great utility. At some point most easily accessible, an opening extending nearly the height of the silo must be made, to put in the corn and take out the silage. The courses of boards should be cut shorter than the opening, to allow loose boards to be set in, lapping on the door studding and making an air-tight joint. For all this work medium lumber is good enough, and a very limited amount of mechanical skill and a few tools, which all farms should have, will enable most farmers to build their own silo. A few iron rods, one-half inch in diameter, may be necessary to prevent spreading by side pressure, but this will depend upon the strength of the original frame of the barn. Narrow boards, from five to eight inches wide, are better than wide ones, as they are not likely to swell and split. Eight-penny nails for the first boarding and twelve-penny nails for the second course will hold the boards in place.

"A silo constructed as above outlined will cost from 50 cents to $1 for each ton of its capacity, according as all materials, including lumber and stone, are charged, or only labor and nails, rods, and cement."

JOHN GOULD'S $43 SILO.—The well-known agricultural writer and lecturer, John Gould, of Ohio, has described his one-hundred-ton silo built in one-half of a bay of his barn at a cost of $43. As it may be helpful to some farmers, we give below the full description of the silo. Mr. Gould says: "Having become convinced that cheaper material than that usually employed could be used, and even stone and cement discarded, I set out with this end in view. The barn has a basement of eight feet beneath it. This was utilized to make the silo deeper, making it twenty-two feet in depth and fourteen feet square inside.

"*Frame of Silo.*—On one side (E) I had the backing of my old silo, and on the opposite side (B) a stone wall of eight feet. On the two sides, B and C, the studding only had the center backing of the sill, and cross-beam at C, eight feet from the basement floor. The bottom of the silo was leveled off, and a footing made for the studs on the B and C sides by digging a trench, about 12 inches wide and 6 inches deep, under where the studding would come. Two sticks of timber, 6x12 inches, were thoroughly saturated with gas- or coal-tar, and laid in these trenches, and made solid by tamping them at sides. The studding, 2x6 inches, were hoisted in place and set about 18 inches apart, made perpendicular by the aid of a spirit level, and on the sills toe-nailed with 20-penny wire spikes. The studding against the wall were allowed to rest against it without a sill, and the studding of the old silo came in for double duty, its own wall becoming now a partition. On the A and B sides, false girths were added to those of the barn frame by building out with an 8-inch plank, so that they would be flush with the inside facing of the sill. This also lends additional strength to the barn frame, and makes three more back supports for the silo, and avoids at the same time 'cobbling' or bridging to connect barn and silo.

"The silo was then sheeted up inside with cheap, but good, sound, $8 per 1,000 feet, inch-lumber, taking 1,230 feet, costing $9.85. The whole inside was then papered up and down with a 3-inch lap with tarred building paper, costing 80 cents per roll, taking somewhat less than three rolls, or $2 more. The silo was then finished up by covering this inside again with inch cull pine lumber, single and unfaced, so put on that it half lapped the cracks of the first boarding, the second layer being tacked on with 10-penny wire nails. This lumber was not even jointed or matched, and all put on horizontally, so that there can be no up and down cracks for the escape or entry of air. If a board did not joint closely upon the one below it, a little of its round or concave was taken off with a draw-shave, and a nail or two driven 'toeing' to bring it down snugly. This coating of lumber cost, for 1,230 feet, at the rate of $13 per 1,000, making a bill of $16, and for surfacing $1 more; total, $17.

"*Painting the Lining.*—Six gallons of gas tar, costing 24 cents, and 2½ gallons of gasoline, costing 25 cents, were compounded, and the whole inside of the silo painted with it, the application being rapidly performed with a wash-brush. The gasoline causes the gas tar to strike in rapidly and dry quickly. After using hot tar and resin, and then this last, I greatly prefer it, and there is less danger of burning one's self.

"*Doors.*—Selecting the space between two studs at the middle of the wall C as the handiest place for taking out the silage, commencing at about three feet from the top, the boarding was sawed down close to each stud, eight feet. A strip was then made for three feet, to allow the center of the silo the full end strength of three boards. Another doorway was cut five feet and to within three feet of the bottom. An inch-by-four strip was then nailed on to each stud, on the outside and close up to the boards. The short lengths were all put back into their places in the order in which they were cut out, making a very close-fitting door. The boards were lightly fastened, and over each, on the inside, is hung a curtain made of a piece of tarred paper, two feet longer and a foot or more wider than the door. When the silo is filled the pressure of the silage against the paper makes an almost absolutely air-proof door, and it is the cheapest and best devised.

"*Floor of Silo.*—For the floor the original clay was used. Commencing in the center of the pit the clay was removed and thoroughly packed along the walls, making the bottom of the silo somewhat concave. This throws the great weight and pressure of the silage into this depression, and relieves the silo of so much strain. If the silo has natural drainage, and one is sure of reasonably dry footing, clay is in all respects preferable to a grout or cement bottom, and cheapens the cost of the silo by so much. I now have my silo complete. The lumber and labor bill is:

Sills	$ 1.00
Studdings	9.00
Inside facing	17.00
Nails	1.50
Sheeting	9.85
Paper	2.00
Paint	.50
Hired man	2.00
Total	$42.85

"This does not include my own labor for four and a half days."

Fig. 42 shows a small, square silo, built inside of a Michigan barn; dimensions, 8 feet square, and 22 feet

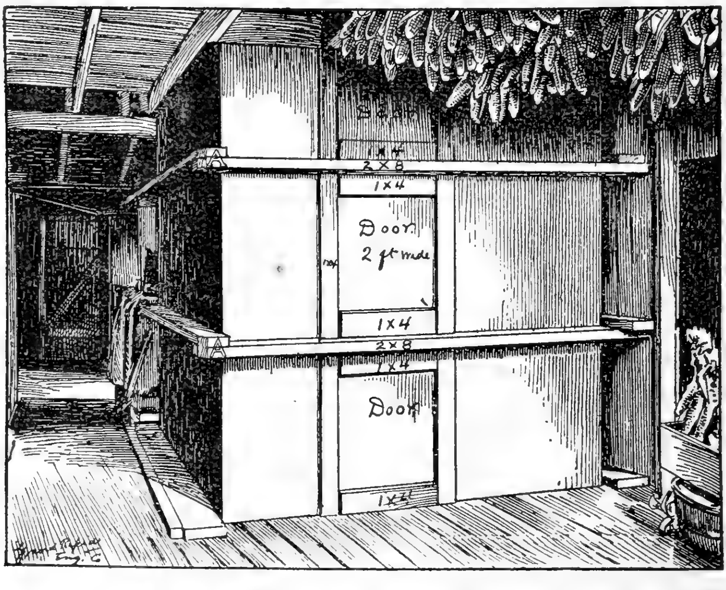

FIG. 42. VIEW OF A SILO, 8 FEET SQUARE, 22 FEET DEEP, BUILT INSIDE OF BARN. (SMITH.)

deep. The capacity of the silo is about 28 tons. It is built of 2x8 horizontal studding, placed lapped at the corners and held together with 5 twenty-penny nails, wire spikes, in each corner. The spaces between these frames, from the bottom to the top, are 2½, 2½, 3, 4, 5 and 5 feet. The siding consists of one thickness of matched white-pine flooring, six inches wide; it is nailed on vertically and painted on both sides with Venetian red and oil. No paper is used. The corners are filled out by 2x6 scantling properly beveled and nailed in vertically. Each door is 2 feet wide and made of sufficient length to lap an inch when placed between a certain pair of horizontal ribs; toward the bottom of the silo the doors are therefore 2½ feet wide, while toward the top they are 5 feet high. Battens of 1x4 pine are placed over the cracks on the sides of the doors and nailed to the wall of the silo. No hinges are used, the pressure of the silage keeping the doors in place.

The bottom frame, formed by the 2x8 studdings, rests on the clay bottom of the barn cellar. The silo has no foundation, but the hard clay bottom is cemented with Buffalo cement, one inch thick, to keep out rats. Cost of materials, $30.00. (Mich. Experiment Station, spec. bull. No. 6.)

B. Separate Square or Rectangular Wooden Silos.

Like other kinds of silos, square or rectangular silos built as outside independent structures may be made of wood, stone or grout. In most of the agricultural States in the Union wooden silos can be built cheaper than either stone or grout silos. While they may not last as long as the latter types, even with the best of care in both building and maintenance, they will last for a large number of years if the necessary precautions for their preservation are taken. The general directions for building silos of this type are similar to those given on p. 44. They may be built by placing 2x10 pieces as studding one foot apart, and boarding on the inside with matched boards or shiplap, or with two layers of siding with building paper between; and on the outside, building paper, over which common boards are nailed. If double lining is used, the first one is nailed on the studding horizontally, and the second vertically.

In building a square or rectangular silo more than 20 feet deep, Professor Plumb recommends making sills of 2x12-inch planks, in two layers, halved and spiked at the corners (Fig. 43). These sills are held in place by bolts, well anchored in the foundation wall (Fig. 44). The stud (1) should be blocked against a strip (2) nailed to the sill, and a bolt (4) driven through the sill (3, 3) into the wall (5, 5). The 2x12-inch studs are toe-nailed to the sills, 18 inches apart from center to center. The base of each stud is cut on the outside against a 2x4-inch piece spiked along the outer line of the sill, to prevent spreading.

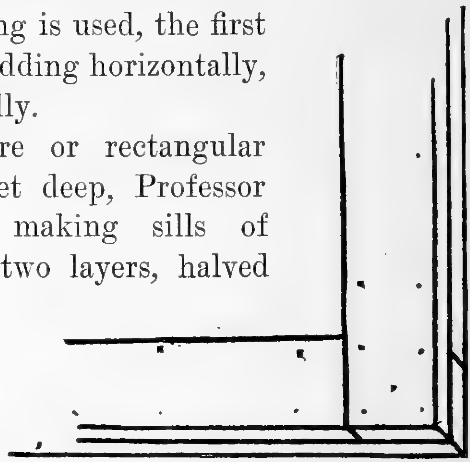

FIG. 43. FASTENING OF SILLS AT THE CORNERS. (PLUMB.)

There is a good deal of difference of opinion as to the silo lining, several observing farmers claiming that double boarding, with or without tarred paper between, will rot before a one-layer lining of sound matched lumber or shiplap, free from cracks and checks, put on horizontally. Mr. H. B. Gurler, the well-known Illinois dairyman, says on this point in a communication to the author: "My first silo was built with a single boarding on inside of studdings. This was a good quality of matched lumber, and it is still sound after having been filled eleven times; I cannot find any signs of decay, or at least could not before filling last fall. The second silo I built was with double walls inside, with paper between. I am confident that decay will sooner cause trouble with these walls, as I can see the effect of it now in some places, and this after nine fillings. I imagine moisture from the corn gets through the joints before it swells these tight, and saturates the paper, thus causing decay. I think if building now I should select sound, kiln-dried lumber for the inside and put on one thickness."

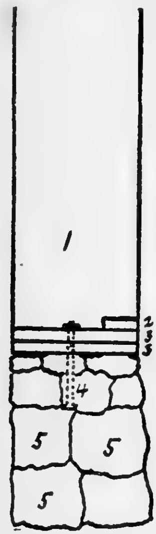

FIG. 44. FOUNDATION OF SQUARE SILOS.

1, stud blocked against a strip, 2, nailed to the sill, 3; 4, bolt driven through the sill into the wall, 5. (Plumb.)

Professor Robertson, the Commissioner of Agriculture of Canada, also recommends a single lining for wooden silos. He says: "I have found one ply of sound 1-inch lumber, tongued and grooved, and nailed horizontally on the inside of studs, 2 inches by 10 inches or 2 inches by 12 inches, to be sufficient. I did build silos with four ply of lumber and tar paper between them; and I could not keep the silage any better than with one ply of lumber, tongued and grooved or planed on the edges."

In a letter to the writer, Mr. John Gould, of Ohio, says on this point: "I suppose that within a few miles

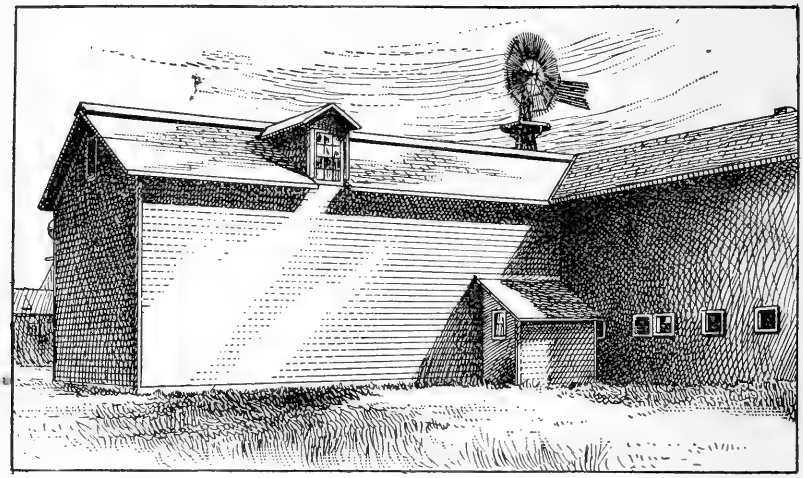

FIG. 45. RECTANGULAR WOODEN SILO.

Dimensions, 48x24 feet, 22 feet high.

of me there are 100 silos built with a single lining of inch Georgia pine flooring, all giving the best of satisfaction. I think them a great success."

Unless the lumber is very carefully selected, a single lining will not be likely to prove satisfactory. It would seem, however, that such silos, well built and cared for, may outlast silos having three or four-ply lumber for inside lining, which are poorly ventilated.

No filling material is necessary or desirable in the dead air spaces formed by the studding and the outside and inside facing; air is a better non-conductor of heat than sawdust, chaff, or any other material which has been recommended for this purpose.

As before stated, deep silos are better than shallow ones, and square ones better than rectangular, as they require less lumber. For the same and other reasons circular silos are to be preferred to either of these forms. Another point in favor of the round silo is the absence of corners in this type of silos, the whole inside forming a smooth, round wall; corners are always objectionable in a silo on account of the liability to loss of silage through spoiling, which may take place there from the difficulty of entirely preventing the access of air at these points.

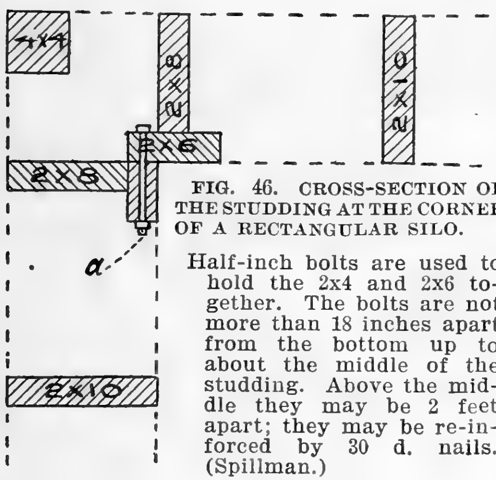

FIG. 46. CROSS-SECTION OF THE STUDDING AT THE CORNER OF A RECTANGULAR SILO.

Half-inch bolts are used to hold the 2x4 and 2x6 together. The bolts are not more than 18 inches apart from the bottom up to about the middle of the studding. Above the middle they may be 2 feet apart; they may be re-inforced by 30 d. nails. (Spillman.)

To avoid the loss of silage in the corners of square or rectangular silos they should be partially rounded off by placing a square timber, split diagonally, in each of the corners; another plan is to bevel the edge of a ten-inch plank and nail it in the corners, filling in behind perfectly with dry earth or sand; sawdust has been recommended, but it should not be used, as it will draw moisture and cause the plank and silo lining to decay; the space back of the plank may also be left empty.

The difficulty of excluding the air from the corners of rectangular or square silos may be obviated in the manner suggested by Spillman and shown in Fig. 46. The illustration, with legend, is self-explanatory.

Another arrangement for making the corners of a rectangular or square silo air-tight is shown in Fig. 47, taken from Geneva Experiment Station Bulletin No. 102, by Professor Wheeler. The corners are boarded up, as shown in the figure, a sheathing of paper going between the two courses of boards. The partitions at the corners can be put across after the first course of boards, instead of after the second lining is in place, as shown in the illustration. Still another arrangement is explained in *Rural New Yorker,* 1899, p. 478.

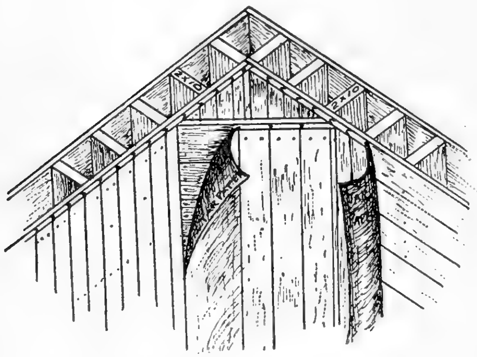

FIG. 47. CORNER OF RECTANGULAR SILO. (WHEELER.)

A Primitive Colorado Silo.—Professor Cooke gives an account of a wooden silo, made at the Colorado College Farm, which is still cheaper than Mr. Gould's silo, previously described—and also more primitive. "The climatic conditions in large sections of the West are such as to allow silos to be built very deep into the ground and render roof unnecessary. The silo was built on a slight slope; a hole, 21 feet square and 8 feet deep, was dug out with the plow and scraper. The only hand work necessary was in the corners and on the sides. Inside this hole a 2x6 sill was laid on the ground; 2x6 studding, 12 feet long, was erected every 2 feet, and a 2x6 plate put on top. This framework was then sheeted on the inside with a single thickness of unmatched, unplaned, rough boards, such as can be bought almost anywhere for $12 per 1,000.

"The inside was lined with a single thickness of tarred building paper, held in place by perpendicular slats. The floor was made by wetting and tramping the clay at the bottom, while the heavens above made an excellent and very cheap roof. The dirt was filled in against the sides, and banked up to within two feet of the top, except on the lower side, where were doors, reaching from near the top to within four feet of the bottom. All labor was done by the farm hands and teams, and could as easily be done by any farmer on his own farm.

"The bill for material stands as follows:

240	feet,	2 x 6, for sill and plate.	
528	"	2 x 6, 12 feet long, for studding.	
960	"	rough boards for sides.	
1,728	"	lumber, at $12 per M.................	$20.74
		Nails, lath, and building paper............	7.00
			$27.74

"Had the hole been two feet deeper, and the sides two feet higher, with one partition, the two pits would then have been each 10x20 feet, and 16 feet deep, with a total capacity of 100 tons of silage; while the cost of materials would have been $44. Thus, a silo can be built in Colorado for less than 50 cents for each ton capacity."

Silos with Horizontal Girts.

The illustration, Fig. 48, taken from Farmers' Bulletin No. 32 (Silos and Silage, by Prof. C. S. Plumb),

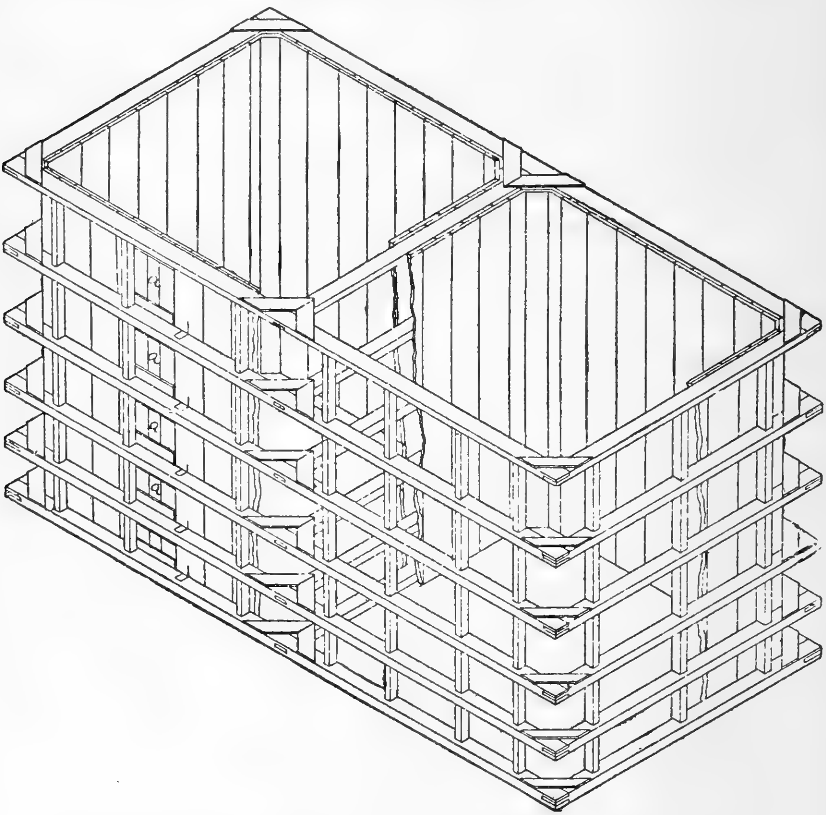

FIG. 48. CONSTRUCTION OF A DOUBLE SILO WITH HORIZONTAL GIRTS. (GULLEY.)

shows a double silo with a framing consisting of horizontal girts. This kind of silo has been tried with good results. "In the figure, *a, a* represents the door, of which the five sections extend from sill to plate. Each pit is 18 feet square inside and 20 feet deep. Each out-

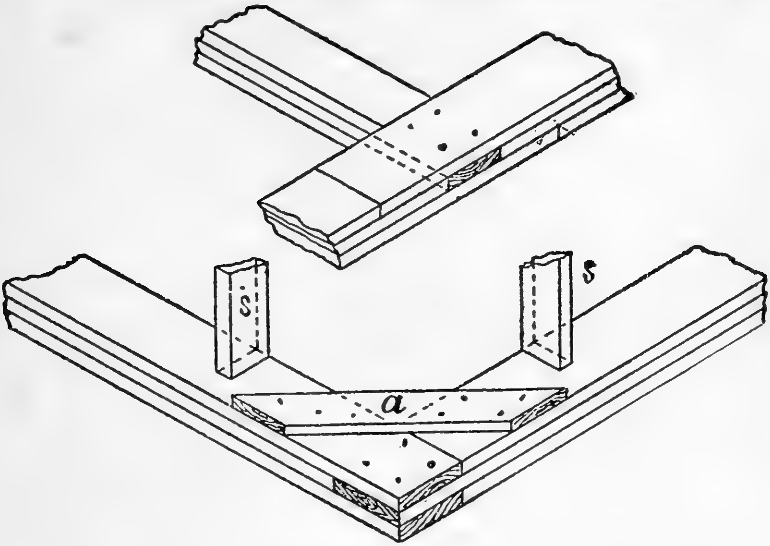

FIG. 49. CONSTRUCTION OF CORNER JOINT AND CROSS-WALL INTERSECTION OF HORIZONTAL GIRT SILO. (GULLEY.)

side girt is made of three planks, 2x10 inches, 20 feet long. The plate consists of two such planks. The girts of the

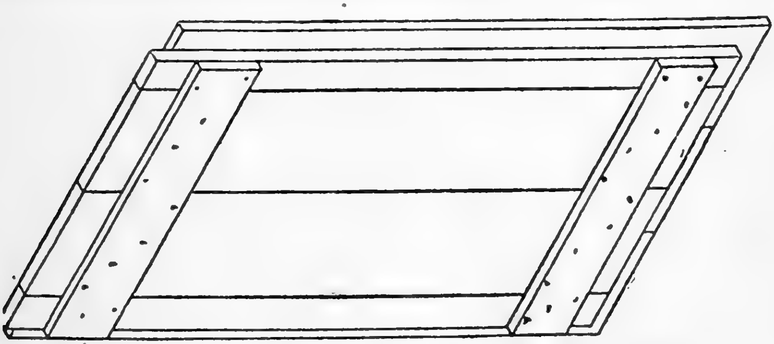

FIG. 50. CONSTRUCTION OF DOOR OF HORIZONTAL GIRT SILO. (GULLEY.)

cross-wall are made of 2x8 planks. The girts are nearer together toward the bottom of the silo where greater strength is required. The distances between these horizontal girts, measured from the upper surface of one to the lower surface of the next higher, beginning at the sill, are, respectively, 2′6″, 3′, 3′6″, 3′9″ and 4′5″.

Fig. 49 shows the details of the joint at the corner and at the intersection of cross-wall and outer girt. *s, s* are short supports of 2x6 plank between the different girts, *a*, a cross brace of 2x6 lumber, which, while strengthening the joints, dispenses with a right angle inside corner. Two half-inch iron bolts are used in each joint in addition to a number of 20d. and 40d. nails.

Fig. 50 shows details of the door, of which there is one section between each pair of girts. Where one section of the door joins another or touches the silo lining a lap-joint is formed.

The following shows the materials used for this double silo, omitting only the sheathing and battens, which serve as a protection against the weather.

	Feet.
105 pieces 2 by 10 inches by 20 feet, sills, girts, and plates	3,500
18 pieces 2 by 8 inches by 20 feet, sills, girts, and plates, cross-wall	540
35 pieces 2 by 6 inches by 18 feet, supports and cross corner braces	630
300 pieces 1 by 12 inches by 20 feet lining planks	6,000
44 pieces 2 by 4 inches by 14 feet rafters	462
1 by 4 inch roof sheathing	800
	11,932

3,000 square feet tarred building paper, 10,000 shingles, 75½ by 7 inch iron bolts, 150 ½-inch washers, 1 keg fortypenny nails, 2 kegs twentypenny nails, 2 kegs tenpenny nails, 1 keg eightpenny nails, 30 pounds fourpenny nails.

Brick foundation wall 12 inches thick, 18 inches high: 4,500 bricks, 2 barrels lime, 2 barrels cement.

IV. Stone or Brick Silos.

These silos are usually more expensive than wooden ones, but, in return, they will last longer when carefully built. Some of the first silos built in Wisconsin and other Northwestern states were made of stone, and are still in good condition, which can not be said about the earliest wooden silos made. Stone silos are easily built, being just like a cellar wall, if possible without any opening except the door, and provided with a roof like any other silo. The walls should be at least sixteen inches thick, and should be jacketed with wood on the outside, to prevent injury from frost, and to form dead-air spaces, which will insure perfect preservation of the silage clear up to the silo wall. The earlier stone silos built were not protected in this manner, and, as a result, the silage often spoilt several inches around the walls, the stone being more or less porous, and being a fairly good conductor of heat and cold. This applies still more to brick than to stone walls. With the outside covering nailed to studdings, 2x4, no trouble will, however, be experienced in either case. Ventilation of the silo frame must be provided for as in the case of wooden silos.

The following arrangement of constructing stone silos has proved very convenient, and will make good, substantial silos. The silo is built five to six feet into the ground, if it can safely be done; the foundation wall is made two feet thick, and at the level of the ground a 4x6 sill is laid on the outer edge of the wall and bedded in mortar; a wooden frame is then erected of 2x6 studding, sheeted on the inside with common flooring, and on the outside with ship lap boarding, with or without building paper on the studding. The stone wall is then continued on the inside of this wooden frame up to the plate, the corners well rounded off, and the whole inside cemented.

The stone or brick wall must be made smooth by

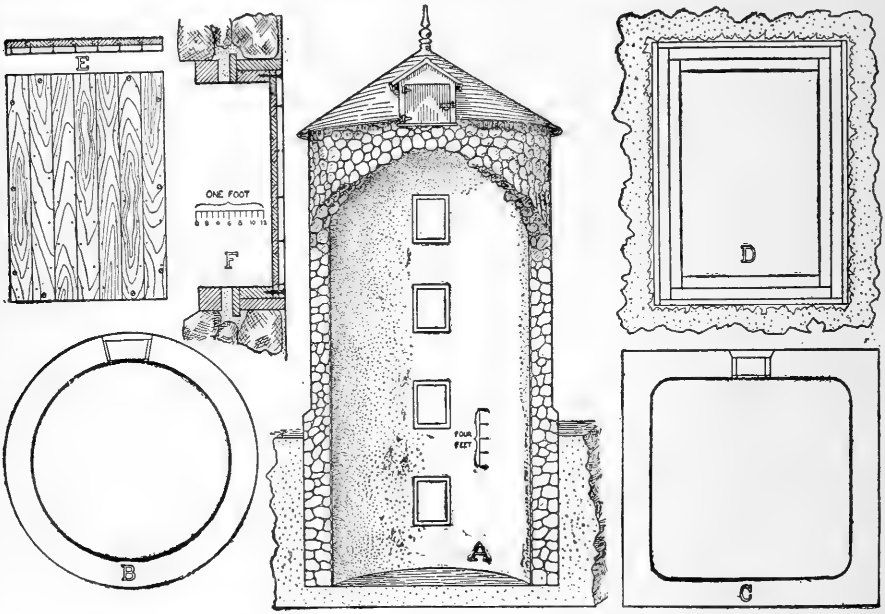

FIG. 51. CONSTRUCTION OF CIRCULAR ALL-STONE SILO. (KING.)

means of a heavy coat of a first-class cement. Since the acid juices of silage are apt to gradually soften the cement, it may be found necessary to protect the coating by a whitewash with pure cement every other year before the silo is filled. If this precaution is taken, the silo will last for generations; some of the earliest stone silos built in this country have now been filled every season for over twenty years without deteriorating perceptibly.

Like the wooden silos, stone silos may be rectangular, square, or circular; if built according to either of the first two forms, the corners should be rounded off so as to assist the settling of the siloed mass, and avoid loss through insufficient packing of the mass in the corners.

The construction of a round all-stone silo given by Prof. King is shown in Fig. 51. A shows a section of the silo, with conical roof, and the arrangement of filling, and feeding doors. B and C, are ground plans of circular and rectangular stone silos; D, E, F show construction of feeding doors. The construction of the door jambs, to make them air tight, will be seen in the illustration. The doors are made from 2 layers of 4-inch matched flooring, with a layer of 2-ply saturated acid- and alkali-proof paper, and are held in place with large screws or lag bolts, as shown in E and F. The face of the jambs should be lined with 2-ply P. and B. Ruberoid paper or its equal; this will act as a gasket to make the door perfectly air-tight.

V. Grout Silos.

Where stone is scarce, and lumber high, the best silo is made of grout. Grout silos may be made according to the following directions: "Having excavated for the silo, dig a trench all around the bottom, and fill it with cobblestone, and from one corner lead a drain, if possible, so as to carry off all water. The trench under the proposed walls of the silo being filled with cobblestones, place standards of scantling long enough to extend 12 inches higher than the top of the wall when it is finished. Place these standards on each side of the proposed wall, and if you desire the walls to be 20 inches thick, place the standards 23 inches apart, a pair of standards being placed every 5 or 6 feet around the entire foundation; be particular to have the standards exactly plumb, and in line; fasten the bottoms of standards firmly in the ground, or by nailing a strip of wood across at the bottom of the standards, and a little below where the floor of the silo will be; fasten the tops of the standards by a heavy cross-piece securely nailed, and fasten the pairs of standards in their plumb positions by shores reaching the bank outside. Planks 1½ inches thick and 14 inches wide are now placed edgewise inside the standards, 20 inches apart, thus forming a box, 14 inches deep, and running all along and around the entire foundation of the proposed wall. Fill this box with alternate layers of cobble-stone or any rough stone, etc., and mortar or concrete. First a layer of mortar, and then a layer of stones, not allowing the stones to come quite out to the boxing plank, but having concrete over the edges; the concrete must be tamped down solid.

The concrete is prepared as follows: One part of good cement is mixed thoroughly with four parts of dry sand, and then with six parts of clear gravel; make into a thin mortar, sprinkling with water over the same by means of a sprinkler, and use at once. Put an inch or two of this mortar into the box, and then bed in cobble-stones; fill in with mortar, again covering the stones, and again put in a layer of stone. When the box is filled, and the mortar "set" so that the wall is firm, raise the box one foot, leaving two inches lap of plank on wall below, and go around again, raising the wall one foot each day, or every second day, according to the amount of labor on hand. If no gravel is obtainable, use five barrels of sand to one of cement, and bed in all the cobble-stones possible. Stones with rough edges are better than smooth ones, as they bind the wall more thoroughly, but any flat stones found about the fields will do as well. A layer of loose cobble-stones should be placed against the outside wall before the earth is brought against it, so as to have an air space, and a free passage for water.

As in case of the stone silos, the inside walls of grout silos must be made perfectly smooth, and preserved from softening by means of occasional whitewashings with pure cement; they must also be protected from frost by an outside wooden lining nailed on the 2x4 studding.

VI. Metal Silos.

Solid steel silos have been put on the market, but it is not known what kind of results they have given in the limited number of cases where they have been tried in practice. They are built of homogeneous steel plate, lapped and double-riveted so as to make them perfectly air-tight. According to Professor Waters, the cost is about $4 per ton capacity, or more than three times the amount which will build a first-class modern wooden silo. It is difficult to see what advantage a steel silo on the whole would have over these; the danger of frost is far greater in a metal silo than in a wooden one; the silage juices will furthermore attack the steel, and slowly corrode the wall, in spite of any paint or preservative that may be put on the inside.

VII. Silo Stacks.

The practice of making stack silage has not been adopted in the United States, except as a matter of experiment on ranches in semi-arid regions. It met with great favor in foreign countries when the siloing method first became known, especially in Great Britain, where, according to official statistics, 1,362 persons in 1887 reported their intention of making silage stacks, against twenty-seven in 1886; the number given for 1887 is half of the total number of silos existing in that year. No official data are at hand during late years, but as far as we are able to judge, silo stacks have increased far more rapidly in England than other silos. The main objections to silage stacks in this country are the danger of frost and of excessive fermentative losses on account of the drying-out and spoiling of the fodder on top and the sides. Until practical experiments have been made, we can not, however, know definitely how silo stacks would stand our climate; judging from the experience of foreign siloists, they are not likely to ever become adopted here in preference to silo buildings of one kind or another, except, perhaps, on ranches in Western semi-arid regions, where silo building materials are high and forage cheap.

The stack system has been adopted, besides in Great Britain, in Sweden, on the European Continent, and in Australia with great success, if the reports of enthusiasts be credited. There are mainly two systems in use, the Blunt and the Johnson silage press; the fodder is stacked in both systems and the stacks pressed down by heavy weights or by means of ratchet drums. The capacity of the Blunt press is about 100 tons. The amount of waste under English conditions is stated to be about $1\frac{1}{2}$ per cent and not to exceed 2 per cent, which

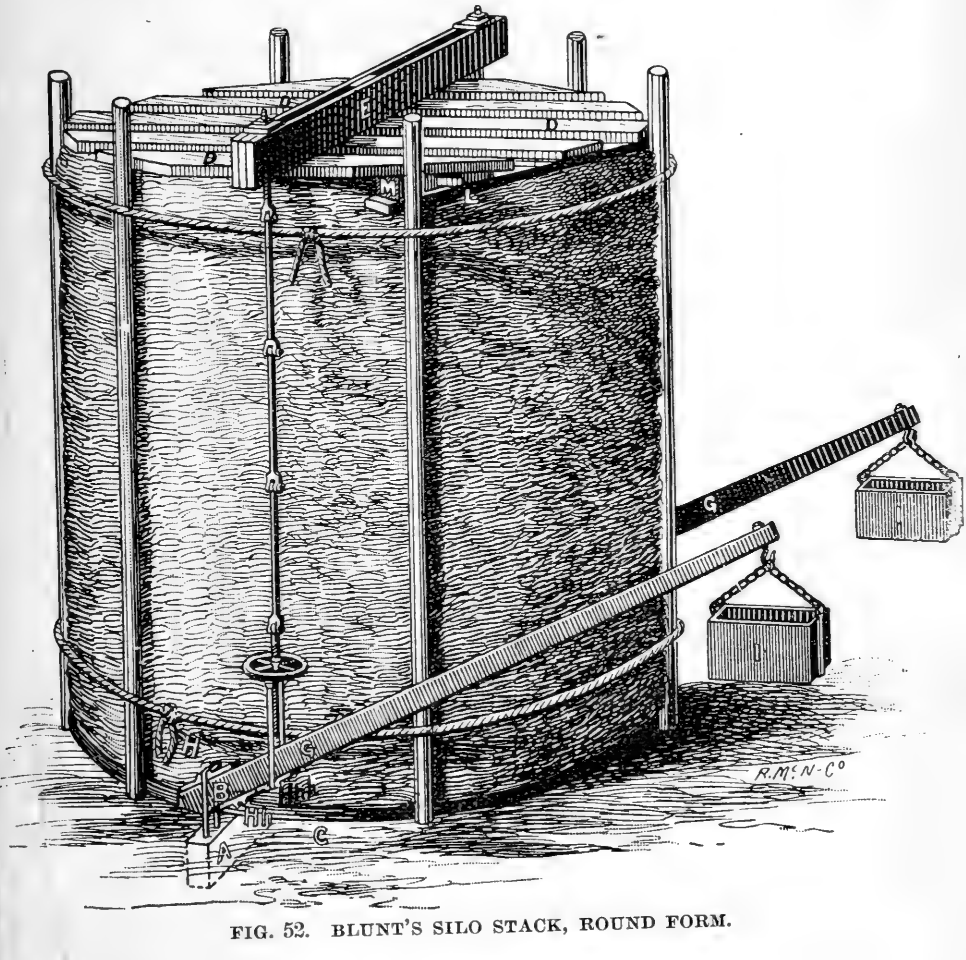

FIG. 52. BLUNT'S SILO STACK, ROUND FORM.

the advocates of the system claim is less than interest on the money that has to be put into a separate silo structure. Results of German experiments do not, however, show such small losses as those given above. Wolff placed forty-eight tons of meadow hay in a silo stack, from which quantity only twenty-four tons of good silage was obtained; forty tons was weighed back in all, so that sixteen tons or 33 per cent must have spoiled on the top and the sides of the stack. Müller obtained

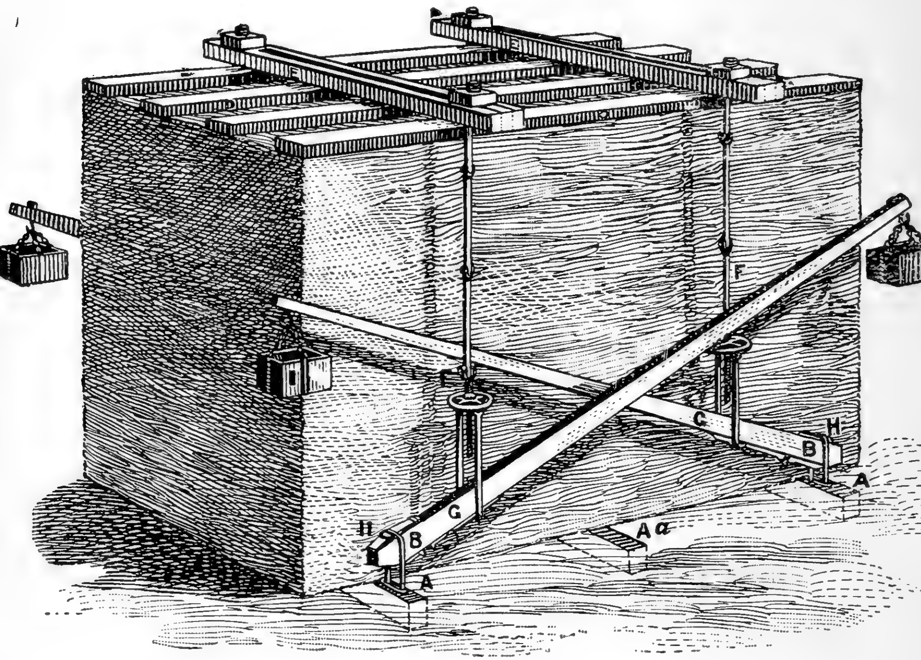

FIG. 53. BLUNT'S SILO STACK, SQUARE FORM.

somewhat better results; 132 tons of vetch fodder and sugar beet leaves were stacked in a Blunt's silage press; there was a loss on the outside and top amounting to about seven tons (5.4 per cent), while nearly 103 tons (77.9 per cent) of the silage was fed out to cattle.

Recent Swedish experiments, on the other hand, showed that 48.4 per cent of the whole mass spoilt in a

Blunt Press, and 35.7 per cent in another system of stack silos (Hermelin stack).

FIG 54. JOHNSON'S SILO STACK.

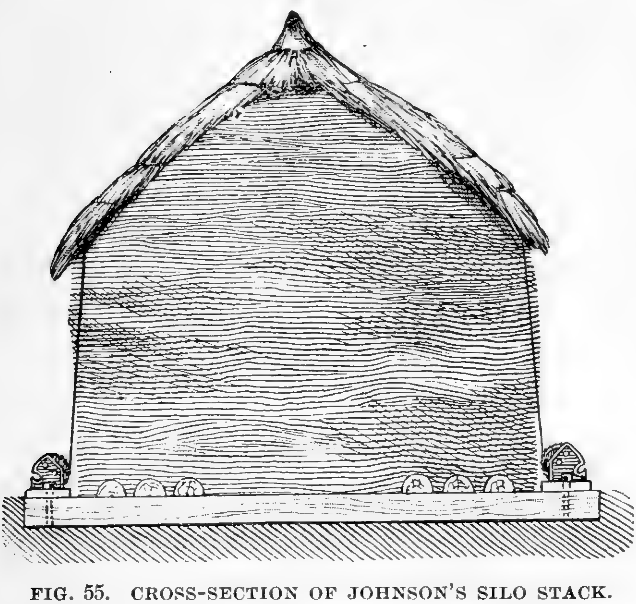

FIG. 55. CROSS-SECTION OF JOHNSON'S SILO STACK.

There are signs that the stack system of siloing fodders is on the wane in Europe, and that high silos of similar materials and types as built during late years by American farmers and dairymen will gradually take their place. The writer, during the past winter (Jan., 1899), received a letter of inquiry from a Swedish farmer, who has been making and feeding 1,000 tons

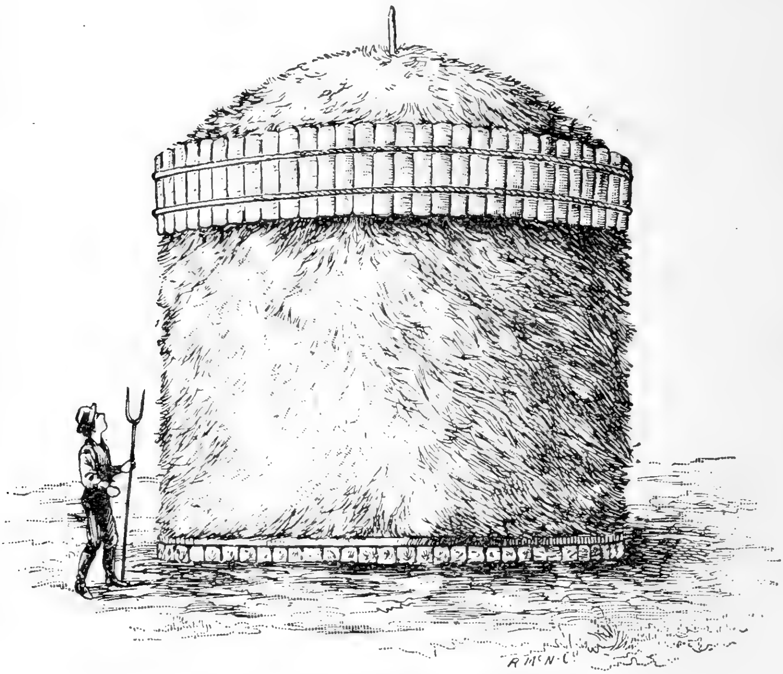

FIG. 56. RAMSTROM'S SILO STACK.

of stack silage or more annually for a number of years past. I quote from the letter: "The silage has been so far made by means of Blunt presses; the quality has always been good, but these press devices have a number of inconveniences which diminish the economic value of the method. The total loss of pressed fodder is quite considerable and amounts, according to my observations, to 25 to 35 per cent; this loss occurs partly through spoiling on the outside, partly through fermentation, and partly, not least, through the expression of plant juices which continue to run off during several months. The dark-brown juice which runs off contains, of course, considerable amounts of nutrients, especially albuminoids; this is confirmed by the fact that where a silage stack has been standing, the vegetation, even five to six years later, shows a rank growth, more so than if a compost heap had been in the same place. The siloing of fodder in a silo stack is furthermore very expensive, and takes a great deal of both labor and time, since the fodder must be raised high by hand, must be carefully spread out evenly, and thoroughly tramped down. I have, therefore, decided to change to the American method with tall silos, and intend to build a 150-ton silo this coming spring—the first one in Sweden."

VIII. Pits in the Ground.

We mention this primitive form of silos in this connection and last, because they are of no practical importance at the present time and have only an historical interest.

The first kind of silos made was simple trenches or pits dug in the ground, in which the grain or fodder to be preserved was buried, and covered with boards and a layer of earth. Sometimes the trench was cemented; in the earlier stages of underground silos, it was not. Immense quantities of sugar beet tops and beet pulp have been siloed in this way in Europe, especially in Germany and France. In this country, before silo structures proper became general, a few farmers, not wishing to risk much money on a system they knew only from hear-say, obtained their first silo experience in this simple way.

An excavation about 30 feet long, 15 feet wide, and 2½ feet deep was made in 1889, in a cornfield at the Kansas experiment station; the soil was dry and sandy; corn stalks with ears on were carefully piled in this pit in October, and the mass rolled with a heavy iron roller; the fodder was then covered with a four-inch layer of straw and twenty inches of earth. When the pit was opened late in December, the silage was found to be in a very excellent condition.

This rather crude method of preserving fodder will, however, always be accompanied by large losses on account of the excessive and faulty fermentations occurring during the siloing period. It can not, therefore, be recommended. Much the better plan to follow for the farmer intending to try silage, is to travel about a little before building and examine some modern silos; with the wide distribution of silos at the present date, he will usually not have far to go to find one or more of them.

Silo Literature.

The preceding descriptions of the various kinds of silos and the directions given for their construction will, it is believed, in general answer the purpose of most farmers and dairymen. The directions given are, however, necessarily to a certain extent general, and each farmer has to use his judgment when it comes to deciding both which kind of silo he had better build in his particular case and how a satisfactory, first-class silo can be built most cheaply under his conditions, as to the materials to be used, the details of construction, etc. Many of the various government experiment stations have issued publications describing silo construction, and farmers intending to build silos, who cannot consult with neighbors and benefit from their experience in this line, will do well to read what advice their own experiment station may have given as to the building of silos in their State. A list of station publications on the subject of silos and silage is given here to acquaint the reader with the literature of the subject published in this country. The experiment stations furnish their publications free of charge to residents of their respective States, upon request, and in some cases publications are sent to non-residents as well. Many of the bulletins given in the list are, doubtless, now out of print, but those that are still available may be obtained by addressing the director of the agricultural experiment station in the State in which the farmer resides.*

LIST OF EXPERIMENT STATION PUBLICATIONS ON THE SUBJECT OF SILOS AND SILAGE, 1889-'99.

(b. bulletin; r., report.)

Arkansas.—Silage, A. E. Menke; r. II., 1889, pp. 68-77.

Colorado.—An underground silo, W. W. Cooke and F. L. Watrous; b. 30, February, 1895, pp. 21-23.

Indiana.—The Silo and Silage in Indiana, C. S. Plumb; b. 40, June, 1892, pp. 65-81.

Kansas.—Silos and Silage, E. M. Shelton; b. 6, June, 1889, pp. 61-74.

Maryland.—Silos and Silage, A. I. Hayward; r, 1889-1891.

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* For a list of the agricultural experiment stations in the United States and Canada, with names of directors and post-office addresses, see Woll, Handbook for Farmers and Dairymen, 2d edition, New York, 1900, p. 409.

Michigan.—Silos and Silage, S. Johnson; b. 47, April, 1889, 45 pp.

—Building Silos, Clinton D. Smith, spec. b. 6, December, 1896, 17 pp.

Mississippi.—Silos and Silage, B. Irby; b. 8, August, 1889, 9 pp.

Nebraska.—Silos and Ensilage, Jared G. Smith; b. 17, June, 1891, pp. 7-22.

New Hampshire.—Silage in Dairy Farming, G. H. Whitcher; b. 14, May, 1891, 8 pp.

New York (Geneva).—Silage and Silos, W. P. Wheeler; b. 102, N. S., pp. 89-105.

New York (Cornell).—The Construction of the Stave Silo, L. A. Clinton; b. 167, March, 1899, pp. 473-488.

North Carolina.—Silos and Silage, F. E. Emery; b. 80, October, 1891, 17 pp.

Ohio.—Silos and Silage, J. F. Hickman; b. vol. II., No. 3, S. S., June, 1889, pp. 73-88.

Oregon.—Silos and Silage, H. T. French; b. 9, February, 1891, 8 pp.

Pennsylvania.—Silos and Silo Building, H. J. Waters; Pa. Board of Agr., r. 1894, pp. 232-237.

South Dakota.—Silos and Silage, E. C. Chilcott; b. 51, February, 1897, pp. 20-32.

Virginia.—Silos and Silage, D. O. Nourse; b. 53, pp. 53-80.

—Cheap Silos in Virginia, D. O. Nourse; b. 70, pp. 115-119.

Washington.—Silos and Silage, W. J. Spillman; b. 14, November, 1894, 19 pp.

Wisconsin.—Silo Building and Filling, L. H. Adams; b. 19, April, 1889, pp. 5-15.

—The Construction of Silos, F. H. King; b. 28, July, 1891, 16 pp.

—The Construction of Silos and the Making and Handling of Silage, F. H. King; b. 59, May, 1897, 31 pp.

U. S. Department of Agriculture.—Silos and Silage, C. S. Plumb; Farmers' Bulletin 32, November, 1895, 30 pp.

Ontario, Canada.—Ensilage, James W. Robertson; b. 32, August, 1888, 10 pp.

—Fodder Corn and the Silo, James W. Robertson; b. 42, May, 1889, 15 pp.

—The Silo and Corn Ensilage, C. C. James; b. 39 (Bureau of Industries), April, 1892, 8 pp.

Preservation of Silos.

A silo building will prove a rather short-lived structure unless special precautions are taken to preserve it. This holds good of all kinds of silos, but more especially of wooden ones, since a cement coating in a stone silo, even if only fairly well made, will better resist the action of the silage juices than the woodwork will be able to keep sound in the presence of moisture, high temperature, and an abundance of bacterial life. We have seen that the inside of the walls of stone silos should be given a whitewash of pure cement as often as found necessary, which may be every two years, and perhaps not as often. The degree of moisture and acidity in the silage made is, doubtless, of importance in this respect, as a very sour silage made from immature corn will be likely to soften the cement coating sooner than so-called sweet silage made from nearly mature corn.

In case of wooden silos it is necessary to apply some material which will render the wood impervious to water, and preserve it from decay. A great variety of preparations have been recommended and used for this purpose. Coal tar has been applied by a large number of farmers, and has been found effective and durable. It may be put on either hot, alone or mixed with resin, or dissolved in gasoline. If it is to be applied hot, some of the oil contained in the tar must previously be burnt off. The tar is poured into an iron kettle, a handful of straw is ignited and thrown into the kettle, which will cause the oil to flash and burn off. The tar is sufficiently burnt when it will string out in fine threads, a foot or more in length, from a stick which has been thrust into the blazing kettle and afterwards plunged into cold water. The fire is then put out by placing a tight cover over the kettle. The kettle must be kept over the fire until the silo lining has been gone over. A mop or a small whisk broom cut short, so it is stiff, may serve for putting on the tar.

Coal tar and gasoline have also been used by many with good success. About half a gallon of coal tar and two-thirds of a gallon of gasoline are mixed at a time, stirring it while it is being put on. Since gasoline is highly inflammable, care must be taken not to have any fire around when this mixture is applied. Asbestos paint has also been recommended for the preservation of silo walls, and would seem to be well adapted for this purpose.

I have not seen any silo walls in better condition than those of a number of Wisconsin silos, preserved by application of a mixture of equal parts of boiled linseed oil and black oil, or one part of the former to two of the latter. This mixture, applied every other year, before filling time, seems to preserve the lining perfectly. In building round silos, Professor King recommends painting the boards with hot coal tar, and placing the painted sides face to face. Ordinary red ochre and linseed oil have also been used by some farmers; others prefer to line the whole inside with building paper every time the silo is to be filled, in the manner explained by Mr. Gould. (See page 105.)

Lathing and plastering of the silo walls are used by some farmers; the method can not, however, be recommended, since the plastering is very apt to crack and break off, even if great care is taken to preserve the walls intact.

Manufacturers of stave silos and fixtures put up special preparations for preserving the silos, which they send out with the staves. These are generally simple compounds similar to those given in the preceding, and are sold to customers at practically cost prices.

Walls of wooden silos that have been preserved by one or the other of these methods will only keep sound and free from decay if the silos are built so as to insure good ventilation. Preservatives will not save a non-ventilated silo structure from decay.

Cost of Silos.

The cost of a silo will depend greatly on local conditions, as to price of labor and materials; how much labor has to be paid for; the size of the silo, etc. The author, in the spring of 1895, made some inquiries in regard to this point among farmers in different States of the Union who have built silos, with the following results:

The cheapest silos are those built in bays of barns, as would be expected, since roof and outside lining are here already at hand. Number of silos included, fourteen; average capacity, 140 tons; average cost of silos, \$92, or 65 cents per ton capacity.

Next come the square or rectangular wooden silos. Number of silos included, twenty-five; average capacity, 194 tons; average cost of silos, $285, or $1.46 per ton capacity.

The round silos follow closely the square wooden ones in point of cost. Only seven silos were included, all but one of which were made of wood. Average capacity, 237 tons; average cost, $368, or $1.54 per ton capacity. The data for the six round wooden silos are as follows: Average capacity, 228 tons; average cost, $346, or $1.52 per ton capacity. The one round cement silo cost $500, and had a capacity of 300 tons (dimensions: diameter, 30 feet; depth, 21 feet); cost per ton capacity, $1.67.

The stone or cement silos are the most expensive in first cost, as is shown by the data obtained. Number of silos included, nine; average capacity, 288 tons; average cost, $577, or $1.93 per ton capacity.

The great difference in the cost of different silos of the same kind is apparent without much reflection. The range in cost per ton capacity in the 25 square wooden silos included in the preceding summary was from 70 cents to $3.60. The former figure was obtained with a 144-ton silo, 20x18x20 feet; and the latter with a 140-ton silo, built as follows: Dimensions, 14x28x18 feet; 2x12x18 feet studdings, set 12 inches apart; two thicknesses of dimension boards inside, with paper between, sheeting outside with paper nailed on studding; cement floor. Particulars are lacking as regards the construction of the first silo, beyond its dimensions.

A good many figures entering into the preceding summaries are doubtless somewhat too low, if all labor put on the silo is to be paid for, for in some cases the cost of work done by the farmers themselves was not figured in with the other expenses. As most farmers would do some of the work themselves, the figures given may, however, be taken to represent the cash outlay in building silos. In a general way, it may be said that a silo can be built in the bay of a barn for less than 75 cents per ton capacity; a round or a good square or rectangular wooden silo for about $1.50, and a stone or cement silo for about $2 per ton capacity, all figures being subject to variations according to local prices of labor and materials.

I believe that cheap, poorly-constructed silos have done more to prejudice large numbers of farmers against silage, and impede the progress of the silo, than any other one cause; if it pays to build a silo at all, it pays to build a good one, and none but silos built to last should be put up, except to serve as a temporary relief until a good silo can be built. Many of the early wooden silos built were not made with an eye to the future, or rather, it was not then suspected that silos may be as easily destroyed as a few years' experience plainly showed. We now provide against the decay of the silo, as we have seen, by securing good ventilation, and by preserving the woodwork; in the cement or stone silo we whitewash with pure water-lime. In either case, it is generally found convenient and advantageous to put in a cement or concrete floor. All these matters increase the cost of the silo, but in return, silos thus built will last for an indefinite length of time, and will not require much outlay after first cost.

Professor King figures that round silos will cost about 14 cents per square foot of surface, and on basis of this figure arrives at the following cost of round silos of different dimensions.

APPROXIMATE COST OF ROUND WOODEN SILOS, THIRTY FEET DEEP, THEIR CAPACITIES AND COST PER TON OF SILAGE.

Outside Diam. of Silo.	Cap. in Tons.	Total Cost.	Cost per Ton.	Outside Diam. of Silo.	Cap. in Tons.	Total Cost.	Cost per Ton.
16 feet....	105	$239.26	$2.28	24 feet....	247	$379.96	$1.54
17 feet....	119	256.06	2.15	25 feet....	269	398.58	1.48
18 feet....	135	273.00	2.03	26 feet....	292	417.34	1.43
19 feet....	150	290.36	1.92	27 feet....	315	436.52	1.38
20 feet....	168	307.86	1.83	28 feet...	340	455.70	1.34
21 feet....	187	325.50	1.74	29 feet....	366	475.16	1.30
22 feet....	206	343.42	1.67	30 feet....	392	494.76	1.26
23 feet....	226	361.48	1.60	31 feet....	419	514.78	1.23

The data given in the preceding table show plainly that large silos are more economical than small ones. The expense per ton capacity of a 400-ton silo is thus only a little more than half of that of a 100-ton silo; the cost per ton capacity of the two silos being $2.28 and $1.23, for a 100- and 400-ton silo, respectively.

The following statements of the cost of the three types of silos were prepared by the same writer; comparisons are made with a stone silo of 200 tons capacity, costing $500; the silo is 14x24 feet inside, and 30 feet deep, 22 feet above ground. It is covered on the outside with dimension boards, battened, extending up and down, and nailed to 2x4 studding, held in place by hooked pieces of band irons laid in the wall.

Rectangular Silo, 200 Tons.

Foundation, 13.44 perch at $1.20	$16.13
Studding, 2x12, 28 feet, 8,736 feet at $20	174.72
Sills, etc., 2x10, 26 feet, 206 feet at $19	4.94
Sills, etc., 2x10, 16 feet, 426 feet at $14	5.96
Rafters, etc., 2x4, 20 feet, 400 feet at $16	6.40
Roof boards, fencing, 450 feet at $15	6.75
Shingles, 5 M at $3	15.00
Drop siding, 8 inch, 2,779 feet at $16	44.46
Lining, surface fencing, 4,256 feet at $15	63.84
Tarred paper, 426 lbs. at 2 cents	8.52
Coal tar, 1 barrel	4.50
Painting, 60 cents per square	15.00
Nails and hinges	10.00
Cementing bottom	5.00
Eighteen 3-4 inch bolts, 18 inches long	2.70
Carpenter labor at $3 per M, and board	41.16
Total	$425.08

Round Silo, 200 Tons.

20 feet inside diameter, 30 feet deep.

Foundation, 7.5 perch at $1.20	$9.00
Studs 2x4, 14 and 16 feet, 1,491 feet at $14	20.93
Rafters, 2x4, 12 feet, 208 feet at $14	2.91
Roof boards, fencing, 500 feet at $15	7.50
Shingles, 6 M at $3	18.00
Siding, rabbeted, 2,660 feet at $23	61.18
Lining, fencing, ripped, 2,800 feet at $18	50.40
Tarred paper, 740 lbs. at 2 cents	14.80
Coal tar, 1 barrel	4.50
Hardware	6.00
Painting, 60 cents per square	13.20
Cementing bottom	5.00
Carpenter labor at $3 per M, and board	33.17
Total	$246.59

"The three silos are outside, and wholly independent structures, except the entrance and feeding chute shown in Fig. 10, which connects with the barn. This method of connection for outside silos, while a little more costly, is, I feel confident, much the best in the long run."

It may be in order to state, in comparing the figures given in the preceding statements with the average data for the cost of the different silo types obtained by the writer, that the round silos in the latter summary were built uniformly better than the rectangular wooden silos included, and according to modern requirements, while many of the latter were old and of a comparatively cheap construction, so that the figures cannot be taken to represent the relative value of rectangular and round silos built equally well.

The cost of stave silos will of course vary with the kind of lumber used, cost of labor, and other expenses, as in case of other types of silos. It is evident that stave silos can as a rule be built cheaper than other kinds of silos, both from the fact that less material is used in their construction, and because the labor bill is smaller. One of the first stave silos described, built in Ontario, Canada, cost $75.00; capacity, 140 tons. Other and better built stave silos have been put up for $100 for a 100-ton silo, and this may be considered an average price for such a silo, made of white pine, hemlock or any lumber that is cheapest in the particular locality where the silo is to be built. If built of Southern cypress and complete with conical roof and doors, the price of stave silos will in the North come to about $1.50 per ton capacity, small silos being a little dearer, and larger ones a little cheaper than this average figure.

CHAPTER III.—SILAGE.

Filling the Silo.

Having built our silo, we proceed to fill it with the fodder grown for the purpose. Since Indian corn is our main silage crop, we shall first consider the siloing of corn, and afterwards take up other crops. We saw before that corn should be allowed to pass through the dough stage before cutting, *i. e.*, when the kernels are well dented, or glazed, in case of flint varieties. Where very large silos are filled, and in cases of extreme dry weather when the corn is fast drying up, it will be well to begin filling the silo a little before it has reached this stage, as the greater portion of the corn would otherwise be apt to be too dry. There is, however, less danger in this respect now than formerly, on account of our modern deep silos, and because we have found that water applied directly to the fodder in the silo acts in the same way as water in the fodder, and keeps the fermentations in the silo in the right track.

Cutting the Corn in the Field.—The cutting of corn for the silo is usually on small farms done by hand by means of a corn knife. Many farmers have been using self-raking and binding corn harvesters for this purpose, while others report good success with a sled- or platform cutter. If the corn stands up well, and is not of a very large variety, the end sought may be reached in a satisfactory manner by either of these methods. If, on the other hand, much of the corn is down, hand cutting is to be preferred. A number of different makes of corn harvesters and corn cutters have been placed on the market during the past few years; it is very likely that hand cutting of fodder corn will be largely done away with in years to come, at least on large farms; indeed, it looks as if the day of the corn-

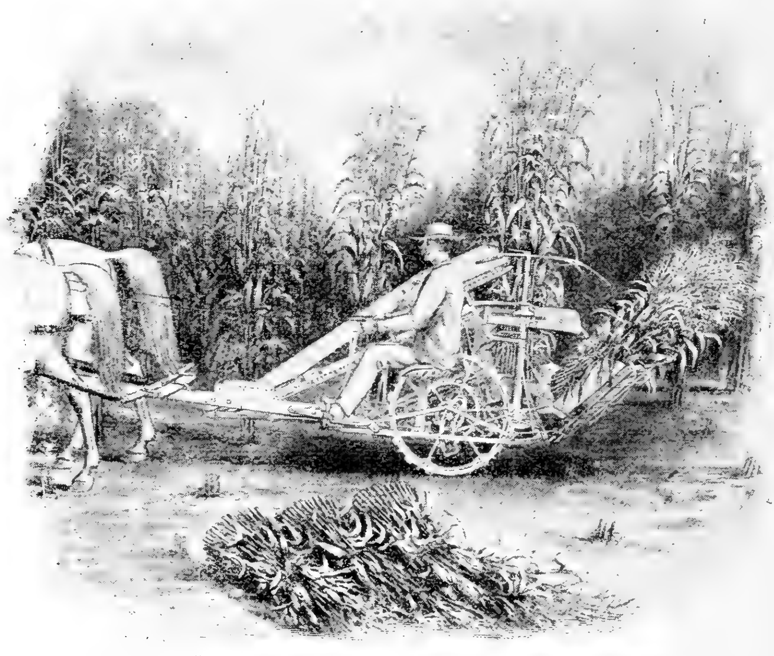

FIG. 57. A PRACTICAL VERTICAL CORN BINDER.

knife was passing away, and as if this implement that has figured so long will soon be relegated to obscurity with the sickle of our fathers' time.

Fig. 57 shows one of the latest and most improved machines that cuts corn and binds it into bundles of a convenient size, thus saving considerable of the work necessitated by handling loose stalks in the field and at the cutter. According to the testimony of the farmers who have in use the tens of thousands of machines of this kind that have been sold during the past half a dozen years, the corn harvester is a perfect machine for its purpose.

A platform cutter, which was used with great success, is described by a veteran Wisconsin dairyman, the late Mr. Charles R. Beach, in a communication to the author:

"We use two wagons, with platforms built upon two timbers, eighteen feet long, suspended beneath the axles. These platforms are about eighteen inches from the ground and are seven feet wide. The cutting-knife is fastened upon a small removable platform, two feet by about three and one-half feet, which is attached to the side of the large platform, and is about six or eight inches lower. One row is cut at a time, the knife striking the corn at an angle of about forty-five degrees. One man kneels on the small platform and takes the corn with his arm; two or three men stand upon the wagon, and as soon as he has gotten an armful, the men, each in turn, take it from him and pile it on the wagon. If the rows are long enough a load of one and one-half to two tons can be cut and loaded on in about eight to ten minutes. The small platform is detached from the wagon, the load driven to the silo, the platform attached to the other wagon, and another load is cut and loaded. None of the corn reaches the ground; no bending down to pick up. One team will draw men, cutter, and load, and I do not now well see how the method could be improved. With a steam engine, a large cutter, two teams and wagons, and ten men, we

FIG. 58. CUTTING CORN FOR THE SILO. TO THE LEFT, CORN HARVESTER; IN THE CENTER, EMPTY LOW-DOWN RACK FOR HAULING CORN; TO THE RIGHT, RACK LOADED.

filled our silo, 22x24x18 feet (190 tons), fast, in less than two days. Mr. —— owned the whole outfit, and filled his own and several silos for his neighbors, the same gang of men doing the work."

Professor Georgeson, late of Kansas Experiment Station, has described a one-horse sledge-cutter which has given better satisfaction than any fodder-cutter tried at that station. It is provided with two knives, which are hinged to the body of the sled, and can be folded in on the sled when not in use. It has been improved and made easier to pull by providing it with four low and broad cast-iron wheels. It is pulled by a single horse and cuts two rows at a time. Two men stand upon the cutter, each facing a row; as the corn is cut they gather it into armfuls, which they drop in heaps on the ground. A wagon with a low, broad rack follows, on which the corn is loaded and hauled to the silo.

Similar corn cutters have been made by various manufacturers of late years and have proved quite satisfactory, although they require more hand labor than the corn harvesters and do not leave the corn tied up and in as convenient shape for loading on the wagons as these do.

A low-down rack for hauling the cut corn to the cutter is shown in the accompanying illustration (Fig. 59). It has been used for some years past at the Wisconsin Experiment Station, and is a great convenience in handling corn, saving both labor and time. These racks not only dispense with a man upon the wagon when loading, but they materially lessen the labor of the man who takes the corn from the ground, for it is only the top of the load which needs to be raised shoulder-high; again, when it comes to unloading, the man can stand on the floor or ground and simply draw the corn toward him and lay it upon the table of the cutter, without stooping over and without raising the corn up to again throw it down. A plank that can easily be hitched on behind the truck will prove convenient for loading, so that the loader can pick up his armful and, walking up the plank, can drop it without much exertion.

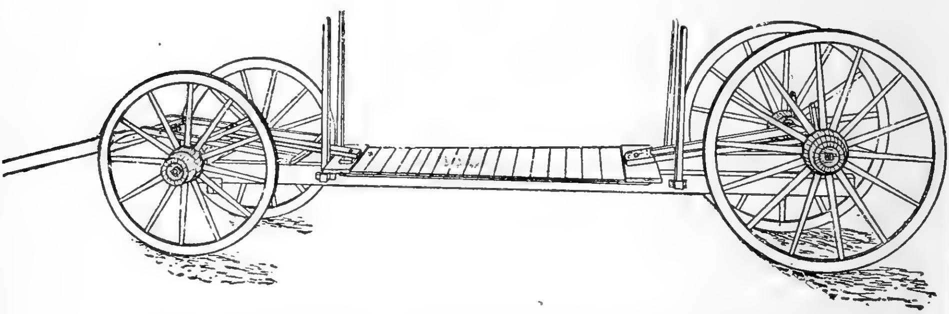

FIG. 59. LOW-DOWN RACK FOR HAULING FODDER CORN.

A very cheap and convenient sled for hauling fodder corn from the field has been recommended by Professor Hickman of Ohio Experiment Station; it is said to answer all purposes if the silo corn is not too far from the silo: The sled can be made out of a couple of 2x10 or 2x12 planks, say twelve feet long. Four 2x4 cross pieces, well mortised into the planks, and fastened by 20-penny nails, will finish the sled, except the trimming of the runners so that they will have a well-formed curve on the front end. Loose boards thrown upon this kind of sled will enable one to haul very easily a ton of fodder at a load; and by placing the butts of the fodder corn all one way and putting a 3x3 scantling under the tops the load can be unloaded when it arrives at the cutter by two hands taking each an end of the scantling, and raising that side of the load until the fodder corn is turned completely over. In hauling the fodder corn long distances a low-down rack similar to the one shown in Fig. 59 should be used.

If wilted fodder corn is to be siloed it should be shocked in the field to protect it as much as possible from rain before hauling it to the cutter.

WHOLE AGAINST CUT SILAGE.—One important matter to be decided at this point is whether or not the corn is to be cut before being filled into the silo. In the large majority of cases corn is run through a feed-cutter on being siloed. This is, however, not absolutely necessary, as it may be siloed whole with perfect success; in some localities and by some farmers, this practice is followed exclusively. The advocates of whole silage claim, with a good deal of plausibility, that there will be smaller losses from fermentations with whole than with cut silage, and that silos will be less subject to decay when corn is siloed whole than the other way. No direct proof of either of these statements is, however, at hand, and the practice followed must be decided by the greater ease of handling the fodder and silage, and the relative economy of one system or the other in the opinion of each farmer.

In experiments with whole and cut corn silage, conducted at the Massachusetts Experiment Station in 1884-85, the conclusion was drawn that the silage obtained from whole plants was in a better state of preservation than that which had been obtained from the same quality of corn previously cut into pieces of from

$1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length. The mechanical condition of the whole corn silage was less satisfactory for feeding purposes, so far as an economical consumption of the same weight of both is concerned, than that produced from corn previously cut.

The saving of machinery, cutter, and carrier makes an important point in favor of the whole silage, especially for small farmers, while the greater ease with which the cut silage may be placed in the silo as well as fed out, is in favor of the cutting of the corn crop. Professor Cook, late of Michigan Agricultural College, says on this point: "My silo, fifteen feet square and twenty feet high, cost less than $130, and my feed-cutter, with an eighteen-foot carrier, also costs more than $100. But the same tread-power enables me to cut all my dry corn stalks and oat straw at a great saving, and to grind all my oats and corn at a slight expense, with one of the excellent American grinders, while the cutter is also used as just indicated. For safety and convenience in feeding I prefer to run all the corn through a cutter. I believe that silos will soon be so common that engines and cutters will go from farm to farm, as threshers do now; then even the small farmers may cut the material for the silo, and yet not need to own the expensive machinery. I believe that it will pay even the small farmer to own the machinery, if he can purchase without incurring debt."

In siloing fodder corn whole, it is well to grow the smaller varieties and to plant rather thickly. One successful whole-silage farmer thus uses as much as twenty to twenty-four quarts of seed to the acre, which gives a stalk of corn nearly every inch in the row, with rows

$3\frac{1}{2}$ feet apart. We have seen that a maximum yield of food materials per acre can not ordinarily be expected from such close planting. Others use only half this amount and have equally good, or most likely even better, whole silage. Too close planting is to be avoided, both on account of the decreased yield of dry matter from the land and the large amount of acid found in silage made from very immature corn. A medium-thick planting, obtained by using, *e. g.*, ten to twelve quarts per acre, is preferable for whole silage, for two reasons—the corn may be handled more easily, both in filling it into the silo and in feeding it out, and there is no waste in feeding, since cattle will eat the slender stalks and leave nothing of the silage.

In siloing corn whole it is put into the silo in a systematic manner; beginning with a small armful in one corner of the silo, bundles of the same size are placed along the wall in a tier; then another tier is formed close up to the first one, being laid in the opposite direction, and successive tiers are formed in the same way until the whole bottom of the silo is covered. When the first layer has been formed, a second one is put on top of it, starting with bundles where the first layer was finished, and completing it where the first layer was begun; in the same way layer after layer is put on until the silo is full. Every time a corner is reached a number of stalks are bent in the middle and pressed down solidly in the corner, so as to leave no empty space. When the silage is to be fed out, the silo is emptied from the top in exactly the opposite direction from that in which it was filled; the different bundles and tiers will then separate from the rest of the silage without much trouble, although at best the process of feeding out whole silage must be considered back-aching work.

Farmers who can not very well afford to buy the machinery necessary for cutting corn for the silo should make whole silage until they find themselves able to invest in a cutter, if they should prefer a change, as they will be likely to. While siloing whole corn may not be any saving in the end, the first cost of making silage will be greatly lessened by following this method. Better whole silage than none at all; better cut silage than whole, in the majority of cases, at least.

Siloing Corn "Ears and All."—It is the practice of a great many farmers to silo the whole corn plant without previously husking it. If the ear corn is not needed for hogs and horses, or for seed purposes, this practice is in the line of economy, as it saves the expense of husking, cribbing, shelling, and grinding the ear corn. The possible loss of food materials sustained in siloing the ear corn speaks against the practice, but this is, as we shall see, very small, and more than counterbalanced by the advantages gained by this method of procedure. In proof of this statement it may be well to give here briefly the results of a somewhat extended feeding trial with milch cows, conducted by the author in 1891, at the Wisconsin Experiment Station.

Corresponding rows of a large corn field were siloed, "ears and all" and without ears, the ears belonging to the latter lot being carefully saved and air-dried. The total yield of silage with ears in it (whole-corn silage) was 56,459 pounds; of silage without ears (stover silage), 34,496 pounds, and of ear corn, 10,511 pounds.

The dry matter content of the lots obtained by the two methods of treatment was, in whole corn silage, 19,950 pounds; in stover silage 9,484 pounds, and in ear corn 9,122 pounds, or 18,606 pounds of dry matter in the stover silage and ear corn combined. This shows a loss of 1,344 pounds of dry matter, or nearly 7 per cent, sustained by handling the fodder and ear corn separately instead of siloing the corn "ears and all."

In feeding the two kinds of silage against each other, adding the dry ear corn to the stover silage, it was found that seventeen tons of whole-corn silage fed to sixteen cows produced somewhat better results than fourteen tons of stover silage, and more than two tons of dry ear corn, both kinds of silage having been supplemented by the same quantities of hay and grain feed. The yield of milk from the cows was 4 per cent higher on the whole-corn silage ration than on the stover silage ration, and the yield of fat was 6.9 per cent higher on the same ration. It would seem then that the cheapest and best way of preserving the corn crop for feeding purposes, at least in case of milch cows, is to fill it directly into the silo; the greater portion of the corn may be cut and siloed when the corn is in the roasting stage, and the corn plat which is to furnish ear corn may be left in the field until the corn is fully matured, when it may be husked, and the stalks and leaves may be filled into the silo on top of the corn siloed "ears and all." This will then need some heavy weighting or one or two applications of water on top of the corn, to insure a good quality of silage from the rather dry stalks. (See page 157.)

An experiment similar to the preceding one, conducted at the Vermont Experiment Station, gave results going in the same direction. The product from six acres of land was fed to milch cows; the results showed that corn siloed "ears and all" produced 3.3 per cent better results than siloed stalks and ground ear corn from the same; when the yield of milk and fat per acre of corn was considered in either case, the whole corn silage from an acre of land, fed with 4,313 pounds of clover rowen and 2,157 pounds grain, produced 8,113 pounds of milk and 333 pounds of fat; while in case of the stover silage fed with ground ears and the same quantity of other feed, 6,399 pounds of milk and 264 pounds of fat were produced; that is, it would have taken the product from 1.26 acres to give an equal amount of milk and milk products in the latter case as was produced by the silage from whole corn plant. This shows that husking, shelling, and grinding the corn, processes that may cost more than a quarter of the market value of the meal, are labor and expense more than wasted, since the cows did better on the corn siloed "ears and all" than on that siloed after the ears were picked off and fed ground with it.

The Filling Process.—If the corn is to be cut before being filled into the silo, it is unloaded on the table of the fodder-cutter and run through the cutter, after which the carrier elevates it to the silo window and delivers it into the silo. The length of cutting practiced differs somewhat with different farmers, and according to variety of corn to be siloed. The general practice is to cut the corn in one-half to one-inch lengths; a few cut in two-inch lengths. The corn will pack better in the silo the finer it is cut, and cattle will eat the larger varieties cleaner if cut into inch lengths or less. On the other hand, it is possible that fine cutting implies larger losses through fermentations in the silo; fine cut silage may, furthermore, not keep as long as silage cut longer after having been taken out of the silo. There is, however, not sufficient experimental evidence at hand to establish either of these points; the majority of farmers filling silos, at any rate, practice cutting corn fine for the silo.

The carrier should deliver the corn as nearly in the middle of the silo as possible; by means of a chute attached to the carrier, the cut corn may be delivered to any part of the silo desired, and the labor of distributing and leveling the corn thus facilitated. If the corn is siloed "ears and all," it is necessary to keep a man or a boy in the silo while it is being filled, to level the surface and tramp down the sides and corners; if left to itself, the heavier pieces of ears will be thrown farthest away and the light leaves and tops will all come nearest the discharge; as a result, the corn will not settle evenly, and the feeding value of different layers of silage will differ greatly. To assist in the distribution of the corn it is recommended to hang a pyramidal box in front and below the top of the carrier; this may be made about three feet square at the base and tapering to a point, at which a rope is attached for hanging to rafters. The descending mass of cut corn will strike the top of the box and be divided so as to distribute to all parts of the silo. Another simple device is to place a board vertically, or nearly so, in front of the top of the carrier, against which the cut corn will strike; or to tie a bag open at the bottom over the top of the carrier.

Powers and Cutters for Silo Filling.

The cutter used in filling the silo should have ample capacity to give satisfaction; a rather large cutter is therefore better than a cutter that is barely large enough. The size required depends on the rapidity with which it is desired to fill the silo and on the power at hand. Where a steam engine is available it is the cheapest power for filling a large silo, as the work can then be finished in a few days. For small farms and silos, engines come too high, however, and here a two- or three-horse tread will prove most economical. According to King, a three-horse tread will give about twice the power of a two-horse tread, and will nicely manage a No. 4 cutter, elevating silage 24 feet. During the past years large self-feeding cutters have been placed on the market, which will take whole bundles of corn as delivered by the corn harvester and as taken off the wagon, there being no need of cutting bands and feeding the corn a few stalks at a time. With one of these cutters as much corn can be cut as 3 or 4 teams can haul, if the corn field is at some distance from the silo. The machines also have a hopper-box under the carrier which mixes the grain and fodder and insures an even distribution of these in the silo at much less labor than was formerly required.

Pneumatic Elevators.

A new method of elevating the fodder in filling silos has been introduced by the use of pneumatic elevators ("blower silage elevators," "———'s Hummer," etc.) which practically fans or blows the cut fodder into the silo through a continuous pipe or spout. This machine therefore takes the place of an ordinary carrier elevator; they have been used in some sections of the United States and Canada, but so far only to a limited extent. The capacity of the machines may reach 12 tons an hour. Where steam power is available for cutting, there seems to be no difficulty in elevating the cut fodder 30 to 40 feet with these elevators when a 12-horse power engine is used. The pneumatic elevators have the advantage of ordinary carriers in some respects, but they require considerable power, and but limited practical experience as to their workings is as yet at hand.

Fast or Slow Filling.—The original practice in filling silos was to fill as rapidly as the conditions present would possibly admit; other outdoor farm work was therefore dropped at the time of silo filling, and all energies concentrated on completing this job. It was, however, found later on, perhaps by accident, that no harm will result if the filling be interrupted for some time, and the practice of slow filling gradually developed. The theory of the practice was worked out by the late Prof. M. Miles of Michigan, and he was one of the early champions of the slow-filling process in this country. The advantage claimed for the slow filling was, besides appreciably facilitating the work of filling the silo, the superior quality of the silage produced, viz., so-called sweet silage. We shall be able to discuss this subject more fully when we have considered the chemical composition of silage, and the changes occurring in the silo. (See page 170.) It will only be necessary here to state, concerning the slow or rapid filling of silos, that the silage produced by either method will be good, provided the corn is not too immature. It is, therefore, mainly a matter of convenience, which method proves preferable. Generally speaking, rapid filling has the advantage in point of economy, both of labor and of food materials. The fermentations are left to proceed farther in case of slow filling than when the silo is filled rapidly, being greatly aided by the oxygen of the air, which then has better access to the separate layers; this is plainly shown by the higher temperature reached in slowly filled silos. The rise in the temperature is due to the activity of bacteria, and a high temperature, therefore, means greater losses of food constituents. More silage can be obtained in the same silo by slow than by rapid filling, as the fodder will settle more in the former case than when the silo is filled at once, and refilled after a few days.

As there may be some farmers who still hold slow filling to be preferable, we give the directions for filling the silo in this way: When enough corn has been added to fill three to six feet of the silo, the filling is discontinued and the mass allowed to heat up to 120° to 140° Fahrenheit. This may take a day or two; the filling is then continued, and another layer of three feet or more filled in, which is left to heat as before. This method of intermittent filling is continued until the silo is full.

Danger from Carbonic-Acid Poisoning in Silos.

As soon as the corn in the silo begins to heat, carbonic-acid gas is evolved, and if the silo is shut up tight, the gas will gradually accumulate directly above the fodder, since it is heavier than air and does not mix with it under the conditions given. If a man or an animal goes down into this atmosphere, there is great danger of asphyxiation, as is the case under similar conditions in a deep cistern or well. Poisoning cases from this cause have occurred in filling silos where the filling has been interrupted for one or more days, the carbonic acid generated in the meantime having replaced the layer of air immediately above the corn, and men who have gone into the silo to tramp down the cut corn have been asphyxiated. If the doors above the siloed mass are left open when the filling is stopped, or at least the first door above the surface of the corn, and the silo thus ventilated, carbonic-acid poisoning cannot take place, since the gas will then slowly diffuse into the air. It is therefore most important in building a silo to place the doors not too far apart, and in filling it to leave the doors open when the filling is discontinued, and exercise care about going into the silo when the fodder has been settling for a time and become heated. Carbonic acid being without odor or color, to all appearances like ordinary air, it cannot be directly observed, but may be readily detected by means of a lighted lantern or candle. If the light goes out when lowered into the silo, there is an accumulation of carbonic acid in it, and a person should open feed doors and fan the air in the silo before going down into it.

After the silage is made and the temperature in the silo has gone down considerably, there is no further evolution of carbonic acid, and therefore no danger in entering the silo even if this has been shut up tight. The maximum evolution of carbonic acid, and consequently the greatest danger of carbonic-acid poisoning, comes during or directly after the filling of the silo.

COVERING THE SILOED FODDER.—A great many devices for covering the siloed fodder have been recommended and tried, with varying success. The original method was to put boards on top of the fodder and to weight them heavily by means of a foot layer of earth or sand, or with stone. The weighting having later on been done away with, lighter material, as straw, marsh hay, sawdust, etc., was substituted for the stone or sand. Building paper was often placed over the fodder, and boards on top of the paper. There is no special advantage derived from the use of building paper, and it is now rarely used. Many farmers run some corn stalks or green husked fodder through the cutter after the fodder is all in. In the South, cotton seed hulls are easily obtained and form a most efficient and cheap cover.

None of these materials or any other recommended for the purpose can perfectly preserve the uppermost layer of silage, as far as my experience goes, some six to eight inches of the top layer being usually spoilt. Occasionally this spoilt silage may not be so bad but that cattle or hogs will eat it up nearly clean, but it is at best very poor food and should not be used by any farmer who cares for the quality of his products. The wet or green materials are better for cover than dry substances, since they prevent evaporation of water from the top layer; when this is dry, air will be admitted to the fodder below, thus making it possible for putrefactive bacteria and molds to continue the destructive work begun by the fermentation bacteria, and causing more of the silage to spoil.

During the past couple of years the practice of applying water to the fodder in the silo has been followed in a large number of cases. The surface is tramped thoroughly and a considerable amount of water added. In applying the method at the Wisconsin Experiment Station, Professor King, a few days after the completion of the filling of the silo, added water to the fodder corn at the rate of about ten pounds per square foot of surface, repeating the same process about ten days afterwards. By this method a sticky, almost impervious layer of rotten silage, a couple of inches thick, will form on the top, which will prevent evaporation of water from the corn below, and will preserve all but a few inches of the top. The method seems to have worked very satisfactorily, and can be recommended in cases where the corn or clover goes into the silo in a rather dry condition, on account of drought or extreme hot weather, so as not to pack sufficiently by its own weight. While weighting of the siloed fodder has long since been done away with, it may still prove advantageous to resort to it where very dry fodder is siloed, or in case of shallow silos. Under ordinary conditions neither weighting nor applications of water should be necessary.

None of the different methods given in the preceding will preserve all of the silage intact, and the author knows of only one way in which this can be accomplished, viz.: by beginning to feed the silage within a few days after the silo has been filled. This method is now practiced by many farmers, especially dairymen, who in this manner supplement scant fall pastures.

By beginning to feed at once from the silo, the siloing system is brought to perfection, provided the silo structure is air-tight and constructed so as to admit of no unnecessary losses of nutrients. Under these conditions there is a very considerable saving of food materials over silage made in poorly-constructed silos, or over field-cured shocked fodder corn, as we shall presently see.

Before leaving the subject of filling and covering the silo it may be of interest to give an extract of an address by the well-known Ohio siloist, Mr. John Gould, in regard to these points, delivered in 1895: "I have flung aside all machinery for cutting the standing corn, and now have the crop hand-cut. I get it cut for about 80 cents an acre and the board of one man. A corn harvester costs $130, and will not last more than eight years, and $18 interest on money and wear of the machine yearly will cut my corn by hand twice over each year. A man cutting by hand can take three rows at a time, and a good man can cut three acres a day if he works alone. Never allow corn when cut to drop into the furrows. Let it be put crosswise of the rows, so that the man who comes along to take it up can do so without using his finger nails for a rake. In picking up the corn we do not use a low wagon, but an ordinary high one, and one man loads and unloads his own wagon. We have four men in the field—the cutter, a loader and two 'pick-me-ups.' A great deal depends upon careful loading. Get the driver to load his wagon seven bundles high, and keep it there until the wagon is loaded. Formerly in operating the cutting machine we had two men to feed it and one man to boss the job.

Now we have one man to feed the machine and no one to boss him. He must simply keep feeding the machine or get buried.

"We used to put two men in the silo when filling; now we find that one man can attend to that part of the work, look after the engine, and do odd jobs. A load of corn weighs more than a man, and that is why we do not do any tramping now. In filling a silo you should always aim to keep the highest portion near the walls. We place a sort of table or small platform over the center of the silo, run the ensilage on to it, making a pyramid; then the corn must fall toward the walls, and not to the center. Now and then it may take five minutes' work with the fork to make things even and level up. Do not cover your silo. Ten pails of water evenly distributed over the top, when the corn is all in and the top well tramped, is best of all. Then come away and put your trust in Providence. The moisture on top of the silo will quickly develop a fine mold, which is better than anything else by way of preserving that which is beneath. You will lose only about ten bushels of ensilage by the molding, and that costs less than would a day's work making an artificial covering."

The change that has taken place in the methods of silo filling during late years in this country has, however, modified the views of the well known siloist quoted in the preceding. In 1899, he writes in the *Rural New Yorker:* "The filling of silos about here (Northwestern Ohio) is taking on a radical change, and is being correspondingly cheapened; some farmers put it, by 33 per cent. The low-down corn harvesters have superseded hand cutting entirely; the gavels are tied in small compass, and are easily picked up and put on wagons, two men easily doing the work of three with untied ones." The greater efficiency of the modern silage cutters, with self-feeding arrangement, is also commented on.

"Dry" Silage.

The objection has been raised that we handle an unnecessarily large quantity of water in siloing green fodder corn, nearly three-fourths of the crop being made up of water, and it has been argued that some of this amount might advantageously be removed before placing it in the silo, by partially wilting or curing the fodder. The efforts to silo such wilted fodder have, however, often been unsuccessful, because of insufficient pressure in the silo; the wilted fodder will not pack sufficiently by its own weight to exclude the air, and as a result white, moldy spots are apt to appear in the silage, destroying large amounts of the contents. This may possibly be avoided in deep silos by weighting the fodder or by applying a liberal quantity of water to the well-tramped surface of the fodder corn. An experiment in siloing wilted fodder, made at Wisconsin Experiment Station in 1887, showed great losses of materials, more than half of the fodder being destroyed during the siloing process. The silage was dry and very light, with an odor similar to that of drying tobacco leaves. Chemical analyses made by the author showed the composition of the silage and the corresponding partly-cured fodder corn (yellow dent) to be as follows:

Percentage Composition of "Dry" Silage and Corresponding Partly Cured Fodder Corn.

	Water.	Ash.	Crude Protein.	Crude Fiber.	Starch, Sugar, etc.	Ether Extract.	Lactic Acid.	Acetic Acid.
Dry Silage	30.76	4.38	6.18	21.48	35.84	1.36	.14	...
Partly Cured Fodder Corn..............	34.77	3.52	4.87	23.37	32.51	.96	...	...

Scattered reports of success in siloing wilted corn fodder are at hand. Professor Sanborn, late director of Utah Experiment Station, reports very favorable results from silage prepared from such fodder. He says: "In seventeen years' experimental work in animal nutrition, during every year of which there has been some feeding trial or trials with fodder corn or corn fodder, and during the time several trials with methods of preserving the corn plant, I have never found a method of preserving this plant that has given so much satisfaction. Not the slightest change of the plant in Silo 3 was visible to the eye except that it was softer or more pliable. It was eaten better than I have ever known corn fodder to be eaten; fully as well as hay is usually eaten. I believe that no appreciable loss occurred under this system of storage, and I am sure that it is far less than by the regular silo system of green storage."

Mr. John Gould says in regard to dry silage: "While those who have tried this dry fodder silage are satisfied with it, none claim it as superior to putting up the green fodder. It is far more difficult to cut. The silo cannot restore to the dry fodder what it has lost, nor its original digestibility, but it does make it more palatable and easier fed, creating a large saving by having the coarser parts consumed. Instead of cutting fodder each day for the stock, the fodder is cut at one job and time economized. The chief point is, that it is possible by this process to save a big surplus corn crop, which otherwise would rapidly deteriorate."

Shredded Silage.

The practice of running the green fodder through a fodder shredder as it goes into the silo has become somewhat general in certain sections in the East, and very enthusiastic reports have been published as to the value of the silage thus obtained. The writer has not had any personal experience with the making or the feeding of such shredded silage, but from the testimony of disinterested and discerning parties who have had such experience the practice seems well worthy of further trial. The advantages claimed for shredded silage over silage from corn run through a feed cutter are, first, closer packing in the silo, about 20 per cent more going into the silo in case of shredded silage; second, a more fibrous texture of the silage, which enables it to be easily handled with a pitchfork, and third, on account of the finely comminuted butts and stalks, it will not make the mouths of cattle sore and all will be eaten up clean. As against these advantages we have the requirement for greater power in shredding fodder, the amount of which has not been determined.

The Director of Farmers' Institutes for the State of New York, Mr. F. E. Dawley, in recent letters to the writer, speaks as follows concerning shredded silage: "I am not apt to become very enthusiastic over any agricultural implement which I use, but I think the nearest I have ever come to it is over the shredder. I have had ten years' experience with silage, and two with the shredder, so I feel that I know a little something about the keeping qualities of corn silage. I am inclined to think that the idea which is probably correct scientifically, that the more you break down the tissues of the corn plant, thus exposing a large surface to the air, the more sour the silage will be, is generally also correct in practice. But I find by these two seasons' experience that the corn which is cut off finely by the shredder will pack in the silo very much more compactly, and in these two instances at least, the silage has been the sweetest we ever had. . . . The material packs more closely than even the shortest cut silage that I have ever put in, no matter how finely it was cut. The ears are all torn to pieces so that the grain is more thoroughly distributed through the mass than it is in cutting, and as the stalk is all torn to pieces, this and the leaves are more thoroughly intermingled. I have weighed corn into my silo and know from actual experience that I got practically one-fifth more corn in when shredded than when cut. . . . So far as the results in feeding are concerned I can see no particular difference, the advantage of shredding being in the finer cutting of the corn, compactness of the material in the silo, and the results in keeping which one would naturally expect from this condition. . . . The only disadvantage that I have ever noted is that a little more power is required. . . . As an indication of the favor with which shredded silage is received here I can say to you that from the small beginning which I made two years ago, three or four shredders have been purchased in this section, and if I wished to send my machine out with men to run it, I believe that nine-tenths of the silos in this community would be filled with shredded silage."

The corn is cut for shredded silage at the same time as when cut by square-cutting machines, viz., when it is beginning to glaze or dent. It is well to cut the corn the day before it is to be shredded so that it is slightly withered. The shredded mass is very carefully trodden down in the silo, and the filling continued till the silo is full; after the mass has settled for a couple of days, the silo is again filled to the top.

No accurate information is at hand as to the difference in the power required for shredding and for cutting, say 100 tons of fodder corn. Nor have the losses of nutrients in the silo been determined in case of shredded silage, or the comparative value of the two kinds of silage for the feeding of farm animals. Judging from the practical testimony at hand the method of making shredded silage is well worth looking into. Machines of great capacity are now on the market, shredding 12-15 tons of fodder per hour. In the better forms of shredders, the feed rolls are speeded at about 160 revolutions per minute, while the shredder head rotates at the rate of 1,500-1,600 revolutions. The manufacturers state that it requires 12 to 15 horse power to run the machine.

Clover Silage.

Green clover may be siloed whole or cut; when the former method is followed, it should be put into the silo in a systematic manner, in a similar way as explained in case of whole corn silage (p. 147). The silo may be filled by means of a hay fork, or by hand; the hay fork makes harder work of the feeding out of the silage, so that generally it is preferable to fill by hand. Since whole clover does not pack very solidly, most farmers either fill the lower half of the silo with whole clover, putting clover cut in two-inch lengths in the upper half, or cut all the clover put into the silo. The arguments for and against whole clover silage are the same as in case of whole corn, although whole clover silage is more easily handled than whole corn silage. The clover should not be left to wilt between cutting and siloing, and the silo should be filled rapidly, so as to cause no unnecessary losses by fermentations.

The different species of clover will prove satisfactory silo crops; ordinary red or medium clover is most used in Northwestern States, along with mammoth clover; the latter matures later than medium or red clover, and may therefore be siloed later than these. Alfalfa or lucern is, as previously stated, often siloed in the West. Under the conditions present there it will generally produce much larger yields than corn, and, preserved in a silo, will furnish a large supply of most valuable feed. Professor Neale and others recommend the use of scarlet clover for summer silage, for Delaware and States under similar climatic conditions.

By filling clover into the silo at midsummer, or before, space is utilized that would otherwise be empty; the silage will furthermore be available for feeding in the latter part of the summer and during the fall, when the pastures are apt to run short. This makes it possible to keep a larger number of stock on the farm than can be the case if pastures alone are to be relied upon, and thus greatly facilitates intensive farming. Now that stave silos of any size may be easily and cheaply put up, it will be found very convenient, at least on dairy farms, to keep a small separate silo for making clover silage that may be fed out during the summer, or at any time simultaneously with the feeding of the corn silage. This extra silo may also be used for the siloing of odd lots of forage that may happen to be available (see p. 35). It is a good plan in siloing clover or other comparatively light crops in rather small silos, to put a layer of corn on top that will weight down the mass below and secure a more thorough packing and thereby also a better quality of silage.

In several instances where there has still been a supply of clover silage in the silo, green corn has been filled in on top of the clover, and the latter has been sealed and thus preserved for a number of years. A sample of two-year-old clover silage which the author saw during the past season was perfectly preserved in the manner given, and, aside from being somewhat drier than ordinary clover silage (possibly due to exposure during transportation), it looked like first-class silage, of a uniform brown color, and of a sweet, aromatic odor. I may mention in this connection that corn silage will also keep perhaps indefinitely when left undisturbed in the silo. At the large Havemeyer dairy farm at Mahwah, N. J., there are twenty-four silos, ranging in capacity from fifty to seventy-five tons each; about 2,000 tons of corn silage are fed out each year and the practice has been to keep the silage for two years before feeding; I am informed by the manager that the best silage he ever had was seven years old. While it is difficult to see the advantages of this system, it shows that corn silage, once settled and left "sealed up," will keep for a series of years without suffering noticeable deterioration.

Freezing of Silage.

Freezing of silage has sometimes been a source of annoyance and loss to farmers in Northern States, and in the future, with the progress of the stave silo, we shall most likely hear more about frozen silage than we have in the past. As stated in the discussion of the stave silo, however, the freezing of silage must be considered an inconvenience rather than a positive detriment; when the silage is thawed out it is eaten with the same relish by stock as is silage that has never been frozen, and apparently with equally good results. If frozen silage is not fed out directly after thawed it will spoil and soon become unfit to be used for cattle food; thawed silage will spoil much sooner than ordinary silage that has not been frozen and thawed out. A feeding experiment conducted by Alvord at Houghton Farm with young cattle failed to give any evidence that silage which had been frozen and slowly thawed out, was less palatable or nutritious than silage of the same kind which had been kept free from frost.

The difficulty of the freezing of silage may be avoided by checking the ventilation in the silo and by leaving the door to the silo carefully closed in very cold weather. If the top layer of silage freezes, some of the warm silage may be mixed with the frozen silage an hour or so before feeding time, and all the silage will then be found in good condition when fed out. Professor Cook recommends keeping a layer of straw as a cover over the silage; this will prevent it from freezing, and may easily be cleared off when silage is to be taken out.

Cost of Silage.

Corn silage will generally cost $1 to $1.50 per ton, including cost of seed, preparation of land, interest on same, cultivation of corn, cutting, filling into the silo and ready for use. The cost will vary according to local conditions, yield, price of land and labor, facilities for work, etc. Professor King found that the average cost of cutting and putting corn into the silo on a number of Wisconsin farms was 58.8 cents per ton, when it was put in cut; adding to this amount the interest and taxes on the silo investment per ton and 2 per cent for insurance and maintenance, he finds that the cost of harvesting and feeding a ton of silage amounts to 73.2 cents. Various American experiment station men have given the cost per ton of the silage as put into the silo. Professor Henry, in a trial at the Wisconsin Experiment Station, put thirty-one tons into the silo at a net cost of 89 cents a ton. The late Professor Porter found the cost of one ton of silage to be 88 cents, according to Minnesota prices. Professor Whitcher gives $1.62 as the cost per ton in New Hampshire; this sum includes 55 cents paid for fertilizers and manure, an item considerably smaller for Western farmers. Professor Plumb of the Indiana (Purdue) Experiment Station states that "estimating on the cost of plowing, harrowing, planting, seed, manure, interest and taxes, cultivating, cutting and hauling from field, and placing in silo," a ton of silage will cost about $1.50. Dr. Goessmann obtained the same figure in siloing fodder corn at the Massachusetts Experiment Station.

Clover silage will usually cost less than corn silage on account of the smaller expense of growing the crop. The cost may be estimated at about $1 a ton. (See page 28.)

The yields of silage crops are of direct importance in determining the cost of the silage. Corn of Northern flint or dent varieties will seldom yield over eighteen tons to the measured acre, and yields over twelve tons may be considered satisfactory; fifteen tons will be counted a good crop by most farmers. The large Southern varieties, on the other hand, will yield toward twenty or more tons of green fodder per acre, ordinarily containing, as we have seen, somewhat larger quantities of dry matter than yielded by Northern smaller varieties under similar conditions. Green clover will yield toward fifteen tons per acre, twelve tons being a good yield.

Chemical Composition of Silage.

The chemical composition of silage will of course depend on the character of the siloed fodder and on the intensity of the fermentations occurring in the silo. The main components affected by the siloing process are starch and sugar (non-nitrogenous matter) and the nitrogenous bodies; carbonic acid, water, and organic acids are formed from the former, and from the latter, decomposition products of simpler constitution than the flesh-forming substances proper, the so-called amides. The percentage composition of silage will, as a result, differ somewhat from that of the siloed fodder. The following sets of analyses made by the author will illustrate the changes in the chemical composition of fodder corn before and after the siloing period.

CHEMICAL COMPOSITION OF GREEN AND OF SILOED FODDER CORN, IN PER CENT.

	Yellow Dent Corn.				Southern Ensilage Corn (B. & W.)			
	Green.	Siloed.	Composition of Dry Matter.		Green.	Siloed.	Composition of Dry Matter.	
			Green	Siloed.			Green	Siloed.
Water	71.00	70.62	......	......	82.30	82.67	......	......
Mineral Matter	2.22	2.59	7.65	8.82	1.59	1.83	9 00	10.58
Crude Protein	2.49	2.70	8.59	9.17	1.81	1.73	10 22	9.95
Crude Fiber	7 82	9.68	26.96	32.94	6.80	6.89	38.43	39.73
Starch, Sugar, etc.	15.98	13.69	55.12	46.63	7.22	6.23	40.75	36.00
Ether Extract	.49	.72	1.68	2 44	.28	.65	1.60	3 74
	100 00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Lactic Acid	.....	.40	.....	......	......	.85	......	......
Acetic Acid	.....	.08	...	......	......	.31	......	......
Total Nitrogen	.....	......	1.37	1.47	......	..	1.64	1.59
Amide Nitrogen	.....	......	.31	.55	......	......	.55	.68
Per Cent in Amide Form	.....	......	22.4	37.4	......	.. ..	33.8	42.5

RELATION OF MOISTURE AND ACIDITY IN SILAGE.—Silage will contain varying quantities of free organic acids formed during the siloing period, mainly lactic, acetic, and butyric acids. The amounts of acid in the silage will depend largely upon the water content of the siloed fodder, or, more correctly speaking, upon the intensity of the fermentation processes taking place in the silo, one important factor of which is the percentage of water in the fodder. I have prepared the following table showing the relation of the water in the siloed fodder, the temperature in the silo, and the acidity of the silage. The analyses and observations were taken by the author in silo experiments conducted at Wisconsin Experiment Station during 1887. Six one-inch gas pipes were placed in each of the six experimental silos; one set of three pipes, which went down, respectively, to within three, six, and nine feet from the bottom of the silo, was placed in the middle of the silo, and a similar set within two feet from one of the outside walls; observations of thermometers kept at the bottom of the closed pipes were taken three times a day during the first couple of weeks and later on twice or once a day. Only the maximum temperatures observed in the three silos are here given.

RELATION OF WATER CONTENT OF FODDER, ACIDITY OF SILAGE, AND TEMPERATURE IN SILO.

VARIETY OF FODDER CORN.	Per Cent Water in Fodder.	Lactic Acid in Silage.	Acetic Acid in Silage.	Max. Temp. in Silo.
		Per ct.	Per ct.	° F.
Stowell's Evergreen sweet corn	77.22	1.10	.21	125.6
Pride of the North, yellow dent corn	71.00	.40	.08	120.0
Same, partially cured	34.77	.14	......	153.0
B. & W. ensilage corn	82.30	.85	.31	129.5
Same, siloed whole	82.72	.36	.40	......
Stowell's Evergreen sweet corn	66.40	.82	.16	126.5
B. & W. ensilage and yellow flint corn, mixed	65.65	.80	08	122.0
Clover silage	61.39	.65	.03	......

We notice that, as a general rule, the more water in the fodder, the higher the acidity of the silage, and the lower the temperature. In case of the dry silage only a very slight acidity was found, and the temperature in the silo went up to 153° F. A high temperature, as we have seen, means a great loss of nutritive materials, and large losses have usually also been observed where the conditions favoring high temperatures have been present. The following analyses, made at Michigan Agricultural College, plainly show the relation of water content of siloed fodder, and acidity of silage. Different lots of corn were siloed from the time of tasseling till the ears were glazed.

RELATION OF WATER CONTENT TO ACIDITY.

DATE OF CUTTING.	Aug. 10.	Aug. 16.	Aug. 22.	Aug. 28.	Sept. 3.	Sept. 9.	Sept. 14.
Water content of corn, per cent..........	90.00	87.30	84.40	82.00	78.60	75.73	70.10
Acidity (calc. as acetic acid), per cent.....	1.26	.84	.76	.72	.72	.72	.70

The influence of the percentage of water in the siloed fodder and of methods of filling the silo is well illustrated in the following experiments, conducted by the Bath and West of England Society in 1886. The description of the experiments is taken from R. Henry Rew's treatise on Stack Ensilage (London, 1888). "The object was to obtain the comparative results, as ascertained by chemical analysis, from grass made into (1) hay, (2) sweet silage, (3) sour silage. Six small silos, each having a capacity of about 250 cubic feet, were carefully filled. The grass was all taken from the same meadow, and the conditions of making both silage and grass equalized with great pains. The following were the six different descriptions made:

"No. 1. Sour Ensilage—rammed and compressed as rapidly as possible. The temperature to be kept down to 50 degrees F., or as near thereto as possible. The silo to be filled and covered in one day. It is anticipated that the only acid present in this ensilage will be lactic, and perhaps a little butyric acid.

"No. 2. Sour Ensilage—temperature to be kept below 120 degrees F. This to be trodden and compressed as much as would be practicable in a general way. The filling of this silo may extend over a week. The acid in this ensilage, it is expected, will be both lactic and acetic.

PER CENT WATER, ACIDITY AND PROTEIN COMPOUNDS IN SAMPLES OF GRASS SILAGE.

	Grass.	Hay.	No. 1 Silage.	No. 2 Silage.	No. 3 Silage.	No. 4 Dry Silage.	No. 5 Silage.	No. 6 Silage.
Water.........	70.50	15.60	79.40	79.17	77.12	49.75	76.90	77.91
Lactic acid....	.....	.....	.26	.17	.14	.14	.26	.46
Acetic acid....	.....	.....	.32	13	.06	.04	.10	.31
Total nitrogen.	.42	1.45	.34	.32	.37	.86	.37	.35
Amide nitrogen.........	.08	.42	.14	.12	.10	.22	.15	.15
Per cent loss in gross weight.	.....	73.97	9.10	9.28	18.40	60.61	4.50	9.89

"No. 3. Sweet Ensilage—made by carting the grass as cut direct to the silo, treading it well in at the sides, but not in the center. Temperature regulated from 140 degrees to 150 degrees F. This should produce a fruity type of sweet ensilage.

"No. 4. Sweet Ensilage—the grass allowed to lie in the field one day after cutting, and then made in the same way as No. 3. Intended to produce an aromatic type of sweet ensilage.

"No. 5. Sour Ensilage—the grass to be chaffed and the silo filled at once and covered, as in No. 1.

"No. 6. Sweet Ensilage—the same as No. 3 silage, with the exception that the grass is to be chaffed."

We notice that the analyses by Doctor Voelcker, given in the preceding table, do not corroborate the predictions made concerning the acidity of the different kinds of silage. On the other hand, the largest amount of acetic acid was obtained in No. 1 silage, which was not expected to have any volatile acid, while No. 6 silage, made at a temperature from 140° to 150° F., contains the same amount of acetic acid as No. 1 and two-tenths of one per cent more lactic acid. The average losses of dry matter in the different kinds of silage were about 14 per cent.

Sweet and Sour Silage.—The analyses of silage given in the preceding do not show the differences between sour and sweet silage as we understand the terms. The former is rich in water and in volatile organic acids, while the latter is as a rule comparatively dry, only slightly acid, and contains especially but a very small quantity of acetic (volatile) acid. There has been a good deal of discussion on the subject of sweet and sour silage, and various theories have been advanced in explanation of the fermentations taking place in the silo at different temperatures.

Mr. George Fry was one of the earliest advocates of sweet silage; his book, "The Theory and Practice of Sweet Ensilage," published in 1885, has been translated into German, and has had a good deal of influence in England and on the European continent in spreading the siloing system and making its underlying principles better understood.

It may be stated in passing that the term *sweet silage*, correctly speaking, is a misnomer, since all kinds of silage will contain a quantity of acid. Acetic acid seems to be present in the sour silage in larger quantity than in sweet silage, and being volatile, will at once be noticed. The popular idea that there is no acid in sweet silage may come from the fact that it does not give off a strong acid odor like sour silage, the acid in this case being largely present as non-volatile acid which cannot be detected by the smell. The "optimum" temperature of the acetic acid bacteria lies lower than that of the lactic acid bacteria, and the temperatures at which these bacteria are killed, very likely stand in the same relation to one another.

The English have made careful observations concerning the question of temperature in silage making. In the silo stacks which are very common in England, the temperature of the mass may be closely followed without any difficulty, and may be largely governed by applications of greater or smaller pressure. Doctor Fream, in his "Elements of Agriculture," gives the following discussion of the appearance of silage in different layers, and of the relation of temperature to acidity in the silo:

"If an open-air silage stack is viewed in section from top to bottom, the lower layers will be seen to be greener than the upper, whilst the color gradually becomes browner toward the top, which will be almost of a burnt-coffee color. The bottom layers have been converted into green or sour silage, because the pressure of the material above has excluded the air, and fermentation has taken place at a low temperature, there not having been sufficient air to supply the oxygen for a high-temperature fermentation. As less weight was applied to the upper portion, there was freer access of air to it, and more air was retained among the mass, hence a higher fermentation. The color thus affords an indication of the temperature at which the fermentation took place. It is generally recognized that silage made at a temperature below 120° Fahrenheit is sour silage, whilst that which has not risen above 90° Fahrenheit is commonly spoken of as 'low-temperature sour,' and that which has exceeded 90° Fahrenheit as 'high-temperature sour.' Between 120° and 130° there are generally veins or seams of sweet and sour silage intermingled. From 130° to 140° a shade of brown is discernable. Between 140° and 160° it is decidedly brown, and above 160° it is over-heated and very similar in appearance to over-heated hay, whilst the flavor denotes burning. In any case fermentation ceases as soon as all available oxygen is used up, the air that exists amongst the herbage being then rich in carbonic acid gas."

In our modern system of siloing fodders in deep separate silo structures we rarely have low-fermentation silage, since the somewhat dry condition of the siloed fodder necessarily admits of considerable air in the silo, which gives the bacterial life a chance to flourish for a short time. On the other hand, our deep silos increase the pressure of the mass so as to hold the fermentations in check to a certain extent. The temperature in most of our silos will not be likely to exceed 130° Fahrenheit, at least not in the lower layers. While silage produced at this temperature would not be termed sweet silage according to the preceding definitions, the comparative absence of free volatile acids in it, its pleasant aromatic odor and not marked sour taste, properly bring it within the term as used by American writers. In the system of slow filling of silos, the various layers of silage have ample time to heat up and temperatures above 150° are reached. Silage produced at this temperature contains less acid than that produced below 150°, but the losses of food materials are at the same time larger.

Digestibility of Silage.

A considerable number of digestion experiments with various kinds of silage have been made. The author, in 1888-89, conducted a digestion experiment with corn silage and with corresponding field-cured fodder corn, feeding two cows exclusively on these feeds in two successive periods. The average digestion coefficients obtained for both cows were as follows:

DIGESTION COEFFICIENTS OF CORN SILAGE AND FODDER CORN.

	Dry Matter.	Ash.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Ether Extract	Albuminoids.
Corn silage.	63	20	54	47	72	82	24
Cured fodder corn.	60	19	49	56	65	69	30

This statement shows a somewhat lower digestibility of the dry matter, protein, nitrogen-free extract, and ether extract of the field-cured fodder corn, than of the corresponding components of corn silage, and a higher digestibility of the crude fiber and the true albuminoids.

As these data were obtained in a single trial with only two cows, too much importance should not be attached to the detailed results. We may only call attention to the fact that the digestibility of the corn silage proved fully equal to that of the dry fodder corn of the same origin.

Since this experiment was conducted, a number of digestion experiments have been made with different kinds of silage and fodder corn. The average digestion coefficients obtained have been computed by Jordan, and include the work done with twenty-four samples of fodder corn and seventeen samples of corn silage, fifty and thirty-seven single trials for fodder corn and corn silage, respectively, having been made. The average digestion coefficients for green fodder are also given, and include thirty trials, with fifteen different samples.

The digestion coefficients for dry matter are practically the same in all four cases, since the differences appearing may be considered within the limits of experimental errors; the same holds true for the coefficients for crude protein, except in case of immature fodder corn, the protein of which is more digestible (by at least 9 per cent) than that of any of the other feeding stuffs. The crude fiber and the ether extract of silage are more digestible than the same components in the corresponding silage. In case of ether extract, this is due to the fact that lactic acid is formed during the siloing period which would appear as wholly digestible. The nitrogen-free extract of corn silage is somewhat less digestible than that of fodder corn, although the difference in case of ripe corn is too small to be considered.

It may be said, in general, that so far as our present knowledge goes, there is no appreciable difference in the digestibility of corn silage and dry fodder corn made from ripe corn, and that both of these foods are somewhat less digestible than the immature fodder corn. The small differences found in the digestion coefficients for ripe fodder and corresponding silage are in favor of the latter. (For table see page 189.)

Losses of Food Materials in the Silo.

In the early stages of the silo movement in this country and abroad, a great deal was said about the losses of food materials in the silo, and scientific men were rather inclined to take a stand against the silo on account of the results of the investigations made on this point. Neither is this to be wondered at when we remember that chemical analyses had repeatedly shown that one-third to one-half of the total dry matter put into the silo had disappeared during the siloing period through the fermentation processes taking place in the silo. Later investigations with deep silos, where modern siloing methods were followed, have shown, however, that these results were due to the imperfect silo methods followed, and not inherent in this process of preserving green forage. It was furthermore not known at that time that similar, or, in fact, still greater losses take place in ordinary field-curing and handling of dry fodder corn.

Losses in Field-Curing Fodder Corn.—The experiments conducted at the Wisconsin Experiment Station in 1887 by Professor Henry and myself were, as far as I know, the first attempts to ascertain the amount of the loss of nutritive elements of fodder corn, on being field-cured in large shocks and stored during the greater portion of the winter. Corn fodder was left shocked in the field for a month, and then stored in a barn until fed out. By analyses of the fodder as it was shocked, and when fed out, it was found that a yellow dent corn had lost in the interval 18.55 per cent of the dry matter originally contained in it, while a large sweet corn, that had to be reshocked in the field on account of its beginning to heat, lost 36.61 per cent of dry matter. Nearly nine tons of green fodder was cut and shocked in each case.

These losses were surprisingly large, and the work was carefully repeated the following year in a similar way as before. The quantities of fodder corn shocked, and the losses of dry matter and protein obtained are shown below. At the same time that these shocks were put up, strictly comparative lots of the same varieties were cut for the silo, and the quantities of dry matter and protein put into and taken out of the silo determined as in case of the shocked fodder. The results obtained with both lots of fodder are shown in the following table:

LOSSES IN FIELD-CURING AND IN SILOING INDIAN CORN.—1887-88.

VARIETY OF CORN.	Field-Cured Fodder Corn.				Siloed Fodder Corn.			
	Green Fodder, lbs.	Cured Fodder, lbs.	Loss. Lbs.	Loss. Per Cent.	Green Fodder, lbs.	Silage, lbs.	Loss. Lbs.	Loss. Per Cent.
YELLOW FLINT....	11,401	3,847	7,554	....	....	....	....	....
Dry Matter.......	2,552.7	2,256	296.7	11.6	....	....	....	....
Crude Protein...	159	138	21	13.4	....	....	....	....
SHEEP'S TOOTH....	14,972	5,142.5	9 829.5	....	14,002	12,225	1,777	12.7
Dry Matter......	4,689 6	3,669	1,020.6	21.8	3,431.5	2,800.7	630.8	18.4
Crude Protein. ..	322.1	308.9	13 2	4.1	235.8	182.9	42.9	22.4
SMEDLEY YELLOW DENT	15,464	5,076	10,388	....	15.288	12,151	3,137	20.5
Dry Matter......	3,997.9	3,483	514.9	12.9	4,150.3	3,373.5	776 8	16.7
Crude Protein....	292.2	277	15.2	5.2	303 3	231.7	71.6	23.6
YELLOW FLINT....	14,890	4,358.5	10,531.5	.	17,218	14,540	2,677	15.5
Dry Matter......	4,197	3,357	840	20	3,844	3.355	489	12.7
Crude Protein...	343.4	282	61.4	17.9	314.4	258.3	56.1	17.8
AVERAGE LOSSES..								
Dry Matter......	....	....	....	16.5	....	....	....	15.9
Crude Protein...	....	....	....	10.1	....	....	....	21.3

As shown by the table, the average loss of dry matter in the shocked corn was but slightly higher than in the small experimental silo used (8x7, 14 feet deep; capacity about 12 tons), while the loss of crude protein was less than half as much.

These results led to a further study of the losses in field-curing and siloing fodder corn during 1889, when the problem was investigated in a more systematic manner and under a greater variety of conditions than before. We cannot here give the results in detail; suffice it to say that 149 shocks of corn, of nine different varieties, were put up in all, and the amounts of dry matter and protein contained in the shocks when fresh and when cured were determined in all cases; the shocks presented a large variety of conditions, small and large, husked and unhusked corn, shocks left in the field for different lengths of time, and shocks cured indoors, etc. The losses of dry matter found ranged from 6.9 per cent to 33.9 per cent. The former result was obtained in case of four shocks of Pride of the North yellow dent corn, and the latter in case of ten shocks of Stowell's Evergreen sweet corn, husked and left in the field for 2½ months, on the average. Eleven shocks of large sweet fodder corn, cured under cover, lost, on the average, 8.2 per cent of dry matter. The averages of the results obtained during this year at the Wisconsin Station are given below.

LOSSES IN FIELD-CURING AND IN SILOING INDIAN CORN.

	Field-Cured Fodder Corn.				Siloed Fodder Corn.			
	Green Fodder, lbs.	Cured Fodder, lbs.	Loss. Lbs.	Loss. Per Cent.	Green Fodder, lbs.	Silage, lbs.	Loss. Lbs.	Loss. Per Cent.
Av. for 9 Varieties, 149 Shocks.......								
Dry Matter..........	14,906	11,979.2	2,926.8	19.6	12,781	10,040	2,741	21.5
Crude Protein......	1,172.5	905.7	266.8	22.8	1,024.6	876.6	158	15.4

This investigation was continued during the season of 1890, on a larger scale than in previous years. Sixty-five tons of green fodder corn was siloed, and the same quantity was cut and shocked in the field. The resulting losses of dry matter and protein found in both cases are shown in the following table, with a summary of the work done in this line for four consecutive years.

Losses in Field-Curing and in Siloing Indian Corn.

	Field-Cured Fodder Corn.				Siloed Fodder Corn.			
			Loss.				Loss.	
	Green Fodder, lbs.	Cured Fodder, lbs.	Lbs.	Per Cent.	Green Fodder, lbs.	Silage, lbs.	Lbs.	Per Cent.
Av. for Two Var.. Total Weight.	129,014	31,738	....	....	129,014	105,824	23,190	18
Dry Matter.......	32,432	23,270	9,162	28.3	32,432	29,090	3,342	10.3
Crude Protein....	2,580.5	1,682	898.5	34.8	2,580.5	2,557	323.5	12.5
Results of Four Years' Work..								
Dry Matter.......	72,164	54,937	17,227	23.8	68,034	57,411	10,623	15.6
Crude Protein....	5,706.4	4,317.5	1,388.9	24.3	5,490.8	4,569.5	921.3	16.8

The results given in the preceding table show that 15.6 per cent and 23.8 per cent of dry matter were lost in the siloing and the field-curing of fodder corn, respectively, while the protein (flesh-forming substances) lost amounted to 24.3 per cent in the field-curing process, and 16.8 per cent in the siloing process.

Later researches have proved that these average figures must be considered rather low losses for the field-curing of fodder corn, and rather high losses for the silo. The results given in the last table concerning the losses in field-curing fodder corn have been corroborated by similar work at the New Jersey, Vermont, Pennsylvania, Colorado, and other experiment stations, where shocks of fodder corn were carefully kept in the field, or under cover, for a period of one to several months, and the dry matter contents at shocking time, and when the shocks were taken down, were carefully determined by chemical analysis. As the conditions described in the investigation at the Colorado Experiment Station will apply to most places on our continent, particularly in the Northwest and West, we quote rather fully from the account of the experiments given by Professor Cooke:

"It is believed by most farmers that, in the dry climate of Colorado, fodder corn, where cut and shocked in good shape, cures without loss of feeding value, and that the loss of weight that occurs is merely due to the drying out of the water. A test of this question was made in the fall of 1893, and the results obtained seemed to indicate that fully a third of the feeding value was lost in the curing. This result was so surprising that the figures were not published, fearing that some error had crept in, though we could not see where there was the possibility of a mistake.

"In the fall of 1894, the test was repeated on a larger scale. A lot of corn was carefully weighed and sampled. It was then divided into three portions: One was spread on the ground in a thin layer, the second part was set up in large shocks, containing about five hundred pounds of green fodder in each, while the rest was shocked in small bundles. After remaining thus for some months, until thoroughly cured, the portions were weighed, sampled, and analyzed separately. The table gives the losses that occurred in the curing.

	Large Shocks.		Small Shocks.		On the Ground.	
	Total Weight.	Dry Matter.	Total Weight.	Dry Matter.	Total Weight.	Dry Matter.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
When Shocked.....	952	217	294	77	186	42
After Curing.......	258	150	64	44	33	19
Loss in Weight.....	694	67	230	33	153	23
Per Cent of Loss...	73	31	78	43	82	55

"So far as could be told by the eye, there had been no loss. The fodder had cured in nice shape, and the stalks on the inside of the bundles retained their green color, with no sign of molding or heating. And yet the large shocks had lost 31 per cent of their dry matter, or feeding value; the small shocks, 43 per cent, and the corn spread on the ground, 55 per cent.

"On breaking or cutting the stalks, these losses were explained. The juice was acid, and there was a very strong acid odor, showing that an active fermentation was taking place in this seemingly dry fodder. We had noticed this strong odor the fall before and all through this winter. When the fodder corn for the steers is put through the feed cutter, that same strong smell is present.

"It can be said, then, that the dryness of the climate in Colorado does not prevent fodder corn from losing a large part of its feeding value through fermentation. Indeed, the loss from this source is fully as great as in the damp climate of New England.

"As compared with the losses by fermentation in the silo, the cured fodder shows considerably the higher loss."

In the experiments by the author during the fall of 1889, quoted above, eleven shocks cured under cover in the barn lost on an average over 8 per cent of dry matter and toward 14 per cent of protein. In a recent experiment at Maine Experiment Station, 14.13 per cent of dry matter was lost in the process of slow drying of a large sample of fodder corn under the most favorable circumstances. "It is interesting to note that this loss falls almost entirely on the nitrogen-free extract, or carbohydrates, more than two-thirds of it being actually accounted for by the diminished percentage of sugars."

Since such losses will occur in fodder cured under cover with all possible care, it is evident that the average losses of dry matter in field-curing fodder corn, given in the preceding, by no means can be considered exaggerated, but must, on the contrary, be too small, as a careful study of the conditions of the various experiments will readily show. Exposure to rain and storm, abrasion of dry leaves and thin stalks, and other factors tend to diminish the nutritive value of the fodder, aside from the losses from fermentations, so that very often only one-half of the food materials originally present in the fodder is left by the time it is fed out. The remaining portion of the fodder has, furthermore, a lower digestibility and a lower feeding value than the fodder corn when put up, for the reason that the fermentations occurring during the curing process destroy the most valuable and easily digestible part, *i. e.*, the sugar and starch of the nitrogen-free extract, which are soluble, or readily rendered soluble, in the process of digestion.

NECESSARY LOSSES IN THE SILO.—The losses of dry matter and protein during the siloing period previously given amounted to 15.6 and 16.8 per cent, respectively, as an average of four years' trials at the Wisconsin Experiment Station. There is, however, an abundance of evidence at hand showing that these figures are higher than those found in actual practice, and that they considerably exceed the necessary losses sustained in the silo. During the last half-dozen years our methods of siloing green fodder have been greatly perfected, mainly through improvements in the construction and form of silo buildings. The old silos were shallow, and the experimental silos in the experiments reviewed in the preceding, as well as elsewhere, were both shallow and very small. Under these conditions it is but natural that the losses found should be excessive, since two of the essentials in siloing fodders were absent—sufficient pressure to largely exclude the air from the siloed mass, and a minimum of wall space in proportion to the quantity of fodder siloed.

There are now plenty of cases on record showing that the results obtained by the author in the experiments of 1890 amply cover the necessary losses of dry matter in siloing fodder corn and that 10 per cent represents the maximum loss of dry matter in modern deep, well-built silos. The losses of dry matter obtained in siloing corn at the Wisconsin Experiment Station during the last eight years have come at or below this figure. It is possible to reduce this loss still further by avoiding any spoilt silage on the surface, which we saw may easily be done by beginning to feed immediately after the filling of the silo. Experiments conducted on a small scale by Professor King in 1894 gave losses of only 2 to 3 per cent of dry matter, on the strength of which results, amongst others, he believes that the necessary loss of dry matter in the silo need not exceed 5 per cent.

Summarizing our considerations concerning the relative losses of food materials in the field-curing and the siloing of Indian corn, we may say that far from being less economical than the former, the silo is more so, under ordinarily favorable conditions for both systems, and that therefore a larger quantity of food materials is obtained by filling the corn crop into a silo than by any other method of preserving it known at the present time.

NECESSARY LOSSES IN SILOING CLOVER.—Only a few siloing experiments have been made with clover, but enough has been done to show that the necessary losses in siloing this crop do not much, if any, exceed those of the green corn. Lawes and Gilbert of the Rothamsted Experiment Station, England, placed 264,-318 pounds of first- and second-crop clover into one of their stone silos, and took out 194,470 pounds of good clover silage. Loss in gross weight, 24.9 per cent. This loss fell, however, largely on the water in the clover. The loss of dry matter amounted to only 5.1 per cent, very nearly the same amount of loss as that which the same experimenters found had taken place in a large rick of about forty tons of hay, after standing for two years. The loss of protein in the silo amounted to 8.2 per cent. In another silo 184,959 pounds of second-crop grass and second-crop clover were put in, and 170,941 pounds were taken out. Loss in gross weight, 7.6 per cent; loss of dry matter, 9.7 per cent; of crude protein, 7.8 per cent pounds.

In a siloing experiment with clover, conducted at the Wisconsin Experiment Station, on a smaller scale, Mr. F. G. Short obtained the following results: Clover put into the silo, 12,279 pounds; silage taken out, 9,283 pounds; loss, 24.4 per cent; loss of dry matter, 15.4 per cent; of protein, 12.7 per cent.

There is nothing in any of these figures to argue against the siloing of green clover as an economical process. On the other hand, in view of what has been previously stated concerning clover silage, we conclude that this method of preserving the clover crop is highly valuable, and, in most cases, to be preferred to making hay of the crop.

No extended investigation has been made as to the losses sustained in the siloing of *alfalfa*, but there can be little doubt but that they are considerably smaller than in making alfalfa hay, if proper precautions guarding against unnecessary losses in the silo are taken. According to the testimony of Prof. Headden of the Colorado Experiment Station, the minimum loss from the falling off of leaves and stems in successful alfalfa hay making amounts to from 15 to 20 per cent, and in cases where the conditions have been unfavorable, to as much as 60 and even 66 per cent of the hay crop. Aside from the losses sustained through abrasion, rain storms, when these occur, may reduce the value of the hay one-half. The losses from either of these sources are avoided in preserving the crop in the silo, and in their place a small loss through fermentation occurs, under ordinary favorable conditions, amounting to about 10 per cent or less.

AVERAGE DIGESTION COEFFICIENTS FOR CORN SILAGE AND FOR GREEN AND CURED FODDER CORN.

	Dry Matter.	Ash.	Crude Protein.	Crude Fiber.	N. Free Extract.	Ether Extract.
Green fodder corn	68	35	61	61	74	74
Cured fodder corn	66	34	55	66	69	72
Corn silage ------	66	31	53	67	70	81

CHAPTER IV.—FEEDING OF SILAGE.

Silage may be fed with advantage to all classes of farm animals, milch cows, steers, horses, mules, sheep, swine, and even poultry. Neither does this enumeration finish the list of animals that take readily to silage. Kühn states that not only did the various European breeds of cattle in the herd of the Agricultural College of Halle (Germany) eat corn silage with a relish, but this was also the case with the long-horned Sanga, directly imported from Africa; the Yak, a native of the plains of Central Asia; and the crosses of Yak and Gayal. The corn silage was also eaten by all of the common breeds of sheep, and by the Asiatic and African breeds; the fine-wooled Electoral, Negrettis, and Rambouillet, especially, took to it kindly. The Mouflon crosses also ate it, but less readily. It was liked by goats, and especially by those of the Angora breed. The same was true of the asses and the mules bred at the Halle College.

Silage should not be fed as an exclusive coarse feed to farm animals, but always in connection with some dry roughage. The nearer maturity the corn is when cut for the silo, the more silage may safely be fed at a time, but it is always well to avoid feeding it excessively.

The silo should always be emptied from the top in horizontal layers, and the surface kept level, so as to expose as little of the silage as possible to the air. It should be fed out sufficiently rapidly to avoid spoiling of the silage; in ordinary Northern winter weather a couple of inch layer should be fed off daily. (See p. 44.) A convenient cart for hauling silage and a silage truck are shown in Figs. 60 and 61.

Silage for Milch Cows.

Silage is par excellence a cow feed. Since the introduction of the silo in this country, the dairymen, more than any other class of farmers, have been among the most enthusiastic siloists, and up to the present time we find a larger number of silos in dairy districts than in any other regions where animal husbandry is a prominent industry. As with other farm animals, cows fed silage should receive other roughage in the shape of corn stalks, hay, etc. The quantities of silage fed should not exceed forty or, at the outside, fifty pounds per day per head. It is possible that a maximum allowance of only 25 to 30 pounds per head daily is to be preferred where the keeping quality of the milk is an important consideration. The silage may be given in one or two feeds daily, and, in case of cows in milk, always after milking, and not before or during the same, as the peculiar silage odor will, in the latter case, be apt to reappear in the milk.

Silage exerts a very beneficial influence on the secretion of milk. Where winter dairying is practiced, cows will usually drop considerably in milk toward spring, if fed on dry feed, causing a loss of milk through the whole remaining portion of the lactation period. If silage is fed there will be no such marked decrease in the flow of milk before turning out to grass, and the cows will be able to keep up well in milk until late in the summer, or early in the fall, when they are to be

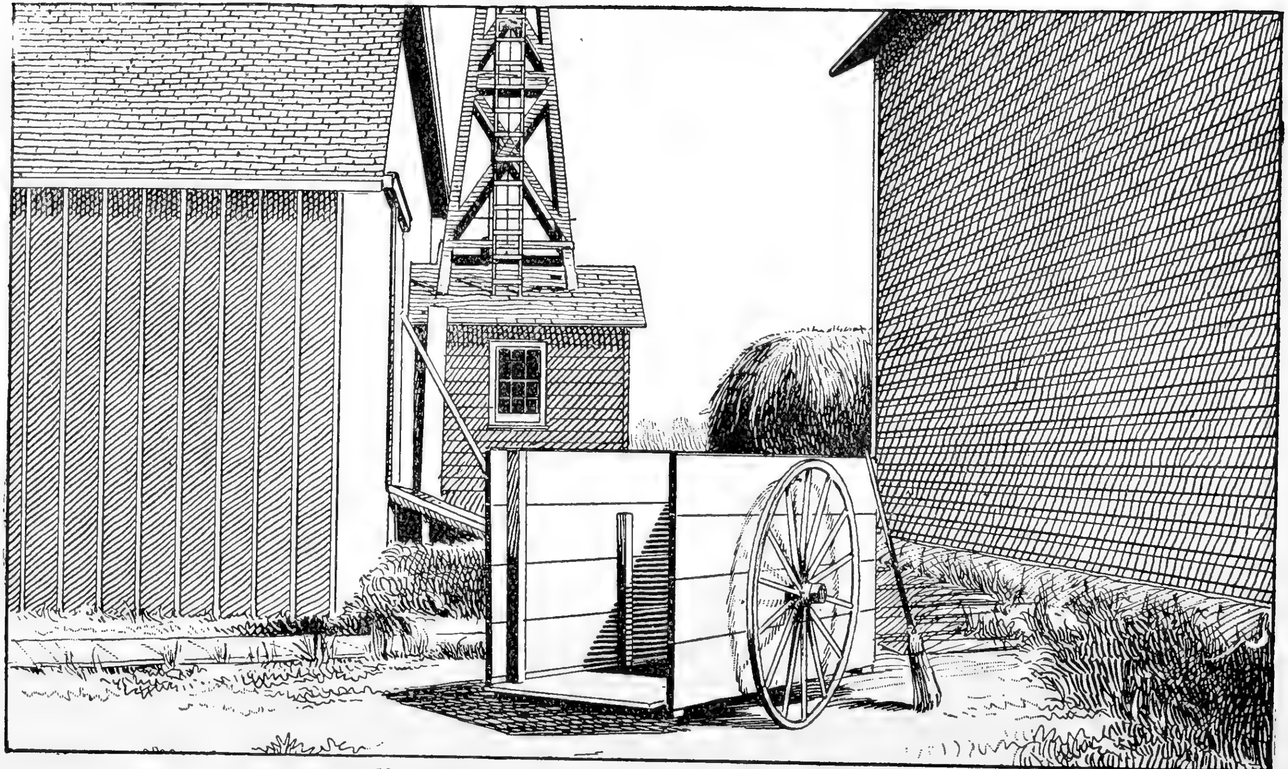

FIG. 60. CART FOR HAULING SILAGE. From a photograph.

dried up preparatory to calving. Silage has a similar effect on the milk secretion as green fodder or pasture, and if made from well-matured corn, so as not to contain an excessive amount of acid, is more like these feeds than any other at the disposal of the farmer.

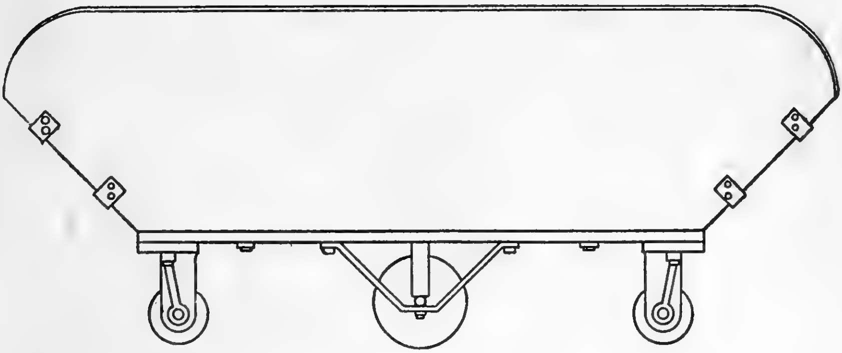

FIG. 61. SILAGE TRUCK.

The feeding of silage to milch cows has sometimes been objected to when the milk was intended for the manufacture of certain kinds of cheese, or of condensed milk, and there are instances where such factories have enjoined their patrons from feeding silage to their cows. When the silage is properly prepared and properly fed, there can be no foundation whatever for this injunction; it has been repeatedly demonstrated that Swiss cheese of superior quality can be made from the milk of silage-fed cows, and condensing factories among whose patrons silage is fed have been able to manufacture a faultless product. The quality of the silage made during the first dozen years of silo experience in this country was frequently very poor, being sour and often spoilt in large quantities, and, what may have been still more important, it was sometimes fed in an injudicious manner, cows being made to subsist on this feed as exclusive roughage. Under these conditions it is not to be wondered at that the quality of the milk should be lowered, and that manufacturers preferred to entirely prohibit the use of it rather than to teach their patrons to follow proper methods in the making and feeding of silage. There is an abundance of evidence at hand showing that good silage fed in moderate quantities will produce an excellent quality of both butter and cheese. According to the testimony of butter experts, silage not only in no way injures the flavor of butter, but better-flavored butter is produced by judicious silage feeding than can be made from dry feed.

The combinations in which corn silage will be used in feeding milch cows will depend a good deal on local conditions; it may be said in general that it should be supplemented by a fair proportion of nitrogenous feeds like clover hay, wheat bran, ground oats, linseed meal, cotton-seed meal, etc. To illustrate the quantities and combinations in which silage may be fed to milch cows, we give below a number of practical feed rations published in two bulletins by the author, viz.: Nos. 33 and 38, of the Wisconsin Experiment Station (October, 1892, and January, 1894). The former of these publications includes the rations fed to the herds of milch cows of fifteen Wisconsin dairymen, and the latter those fed by one hundred dairymen and breeders scattered over different parts of the United States and Canada. Only rations which include silage are given here; they are the outcome of practical feeding experience under varied conditions, and may be used as guides in making up feed rations for dairy cows. While they may not all be theoretically correct, they may easily be modified, if need be, so as to conform to our best knowledge on the subject.

It will serve as an illustration of the present general use of silage among progressive dairymen in our country to state that of the one hundred farmers furnishing the feed rations fed to their dairy cows, in the latter bulletin mentioned, sixty-four were feeding silage to their stock, this feed being used a larger number of times than any other single cattle food, wheat bran only excepted.

AMERICAN SILAGE RATIONS FOR DAIRY COWS.

1. Corn silage, 30 lbs.; hay, 6½ lbs.; corn and cob meal, 5 lbs.; ground oats, 5 lbs.; linseed meal, 3 lbs.
2. Corn silage, 27 lbs.; dry fodder corn, 8 lbs.; clover hay, 6 lbs.; oat straw, 1½ lbs.; wheat bran, 4 lbs.; linseed meal, 4 lbs.
3. Corn silage, 35 lbs.; hay, 5 lbs.; malt sprouts, 4 lbs.; wheat bran, 2¼ lbs.; cotton seed meal, 1½ lbs.
4. Corn silage, 30 lbs.; cut sheaf oats, 6 lbs.; mixed meadow hay, 10 lbs.; wheat bran, 4 lbs.; linseed meal, 2 lbs.
5. Corn silage, 30 lbs.; cut cornstalks, 12 lbs.; wheat bran, 3¾ lbs.; corn meal, 3 lbs.; oats, 3¼ lbs., with a sprinkling of peas.
6. Corn silage, 32 lbs.; clover silage, 22 lbs.; clover and timothy hay mixed, 5 lbs.; wheat bran, 6 lbs.; ground oats, 4 lbs.; cotton seed meal, 3 lbs.
7. Corn silage, 35 lbs.; hay, about 11 lbs.; wheat bran, 3 1-3 lbs.; ground oats, 2 1-3 lbs.; linseed meal (O. P.) 2 1-3 lbs.
8. Corn silage, 30 lbs.; hay, 8 lbs.; corn fodder, 5 lbs.; ground oats, 4 lbs.; pea meal, 2 lbs.
9. Corn silage, 40 lbs.; clover hay, 8 lbs.; wheat bran, 6 lbs.; pea meal, 2 lbs.

10. Whole corn silage, 25 lbs.; clover hay, 10 lbs.; wheat bran, 10 lbs.

11. Corn silage, 40 lbs.; clover hay, 5 lbs.; timothy hay, 5 lbs.; wheat bran, 4½ lbs.; middlings, 4½ lbs.

12. Corn silage, 45 lbs.; clover hay, 12 lbs.; wheat shorts, 8 lbs.; corn meal, 4 lbs.

13. Corn silage, 24 lbs.; corn fodder, 15 lbs.; clover hay, 5 lbs.; wheat bran, 5 lbs.

14. Corn silage, 40 lbs.; alfalfa hay, 15 lbs.; wheat bran, 4 lbs.; corn chop, 4 lbs.

15. Corn silage, 35 lbs.; hay, 10 lbs.; wheat bran, 3 lbs.; corn and cob meal, 3 lbs.; cotton seed meal, 2 lbs.; gluten meal, 2 lbs.

16. Corn silage, 50 lbs.; wheat shorts, 4 lbs.; grano-gluten feed, 4 lbs.

17. Corn silage, 30 lbs.; clover hay, 5 lbs.; corn fodder, 3 lbs.; straw, 2 lbs.; wheat bran, 5 lbs.; linseed meal, 2 lbs.; cotton seed meal, 2 lbs.

18. Corn silage, 40 lbs.; timothy and clover hay, 5 lbs.; wheat bran or shorts, 7 lbs.

19. Corn silage, 40 lbs.; English hay, 5 lbs.; clover hay, 5 lbs.; wheat bran, 2 lbs.; gluten meal, 2 lbs.; cotton seed meal, 1 lb.; linseed meal, 1 lb.

20. Corn silage, 40 lbs.; hay, 6 lbs.; gluten meal, 2 lbs.; corn and cob meal, 2 lbs.; wheat shorts, 2 lbs.

21. Corn silage, 50 lbs.; hay, 8 lbs.; wheat bran, 3 lbs.; wheat shorts, 2 lbs.; ground rye and oats, 3 lbs.; barley, 2 lbs.

22. Corn silage, 35 lbs.; clover hay, 10 lbs.; oat straw, 2 lbs.; corn meal, 5 lbs.; wheat bran, 5 lbs.; oats, 5 lbs.

23. Corn silage, 35 lbs.; hay, 7 lbs.; brewers' grains, 20 lbs.; gluten meal, 1½ lbs.; cotton seed meal, 1½ lbs.; wheat shorts, 1½ lbs.; linseed meal, 1½ lbs.

24. Corn silage, 24 lbs.; corn meal, 8 lbs.; wheat bran, 2 lbs.; oats, 4 lbs.; linseed meal, 2 lbs.

25. Corn silage, 40 lbs.; corn fodder, 10 lbs.; cotton seed meal, 2½ lbs.; N. P. linseed meal, 2 lbs.; wheat bran, 4 lbs.

26. Corn silage, 40 lbs.; timothy hay, 10 lbs.; wheat bran, 5 lbs.; corn meal, 3 lbs.; linseed meal, 2 lbs.

27. Corn silage, 50 lbs.; hay, 5 lbs.; wheat bran, 4 lbs.; linseed meal, 2 lbs.; cotton seed meal, 1 lb.; ground rye, 1 lb.

28. Corn silage, 40 lbs.; cotton seed meal, 3 lbs.; corn starch feed, 18 lbs.

29. Corn silage, 30 lbs.; clover hay, 12 lbs.; wheat middlings, 8 lbs.; linseed meal, 1 lb.

30. Corn silage, 42 lbs.; clover and timothy hay, 5 lbs.; corn and cob meal, 8 lbs.; dried brewers' grains, 1½ lbs.

31. Corn silage, 30 lbs.; fodder corn, 8 lbs.; corn meal, 3 lbs.; wheat bran, 3 lbs.; cotton seed meal, 1 lb.

32. Corn silage, 50 lbs.; clover hay, 8 lbs.; wheat shorts, 5 lbs.

33. Corn silage, 30 lbs.; corn stover, 8 lbs.; wheat bran, 5 lbs.; malt sprouts, 4 lbs.; linseed meal, 1 lb.

34. Corn silage, 50 lbs.; clover hay, 9 lbs.

35. Corn silage, 45 lbs.; mixed hay, 7 lbs.; wheat bran, 6 lbs.; cotton seed meal, 2 lbs.

36. Corn silage, 15 lbs.; sugar beets, 22 lbs.; hay, 10 lbs.; oats, 5.4 lbs.; corn meal, 7 lbs.

37. Corn silage, 40 lbs.; clover hay, 8 lbs.; coarse linseed meal, 6 lbs.

38. Corn silage, 30 lbs.; sorghum hay, 13½ lbs.; corn meal, 1.3 lbs.; cotton seed meal, 2.6 lbs.; cotton seed, 2.2 lbs.; wheat bran, 1.3 lbs.

39. Corn silage, 35 lbs.; mixed hay, 10 lbs.; wheat bran, 2 lbs.; corn meal, 3.2 lbs.; linseed meal, 1 lb.; cotton seed meal, .8 lbs.

40. Corn silage, 20 lbs.; hay, 14 lbs.; wheat bran, 3 lbs.; gluten meal, 2 lbs.

41. Corn silage, 30 lbs.; hay, 10 lbs.; corn meal, 2 lbs.; gluten meal, 2 lbs.; wheat bran, 2 lbs.

42. Corn silage, 48 lbs.; corn and cob meal, 2½ lbs.; ground wheat, 2½ lbs.; oats, 2½ lbs.; barley meal, 2½ lbs.

43. Corn silage, 40 lbs.; hay, 5 lbs.; straw, 5 lbs.; wheat bran, 4½ lbs.; oats, 4½ lbs

44. Corn silage, 15 lbs.; turnips, 45 lbs.; wheat chaff, 7 lbs.; oats, 2½ lbs.; pea meal, 2½ lbs.

45. Corn silage, 30 lbs.; hay, 12 lbs.; ground oats, 10 lbs.

46. Corn silage, 40 lbs.; turnips, 30 lbs.; clover hay, 8 lbs.; straw, ½ lb.; oats, 2 lbs.; wheat bran, 2 lbs.

47. Corn silage, 50 lbs.; clover hay, 10 lbs.; straw, 3 lbs.; pea meal, 5 lbs.; oats, 2 lbs.

48. Corn silage, 30 lbs.; hay, 7½ lbs.; straw, 6½ lbs.; turnips, 25 lbs.; pea meal, 1.3 lbs.; oats, 2.5 lbs.; barley, 1.3 lbs.

49. Corn silage, 35 lbs.; English hay, 8 lbs.; carrots, 30 lbs.; wheat bran, 1.2 lbs.; wheat middlings, 1.8 lbs.; cotton seed meal, 3 lbs.; oats, 1 lb.; wheat, 2 lbs.

50. Corn silage, 40 lbs.; clover hay, 7½ lbs.; straw, 3 lbs.; oats, 1 1-3 lbs.; barley, 1 1-3 lbs.; pea meal, 1 1-3 lbs.; wheat bran, 3 lbs.; cotton seed meal, 1 lb.

The rations given were fed in the following States: Nos. 1-13, Wisconsin; No. 14, Colo.; No. 15, Conn.; No. 16, Ill.; No. 17, Ind.; No. 18, Ia.; Nos. 19-20, Mass.; No. 21, Minn.; No. 22, Neb.; No. 23, N. H.; No. 24, N. J.; Nos. 25-30, N. Y.; No. 31, N. C.; Nos. 32-34, Ohio; Nos. 35-37, Penna.; No. 38, Texas; Nos. 39-41, Vt.; No. 42, W. Va.; and Nos. 43-50, Canada.

Silage for Steers.

Silage may be fed with advantage to steers, in quantities up to forty or fifty pounds a day. The health of the animals and the quality of the beef produced on moderate silage feeding leave nothing to be wished for. If the silage is made from immature corn, care must be taken not to feed too large quantities at the start and to feed carefully, so as not to produce scouring in the animals. Professor Henry says in regard to the value of silage for steer feeding: "As with roots, silage makes the carcass watery and soft to the touch. Some have considered this a disadvantage, but is it not a desirable condition in the fattening steer? Corn and roughage produce a hard, dry carcass, and corn burns out the digestive tract in the shortest possible time. With silage and roots, digestion certainly must be more nearly normal, and its profitable action longer continued. The tissues of the body are juicy, and the whole system must be in just that condition which permits rapid fattening. While believing in a large use of silage in the preliminary stages, and its continuance during most of the fattening period, I would recommend that gradually more dry food be substituted as the period advances, in order that the flesh may become more solid. Used in this way, I believe silage will become an important aid in steer feeding in many sections of the country. Results from Canada, Wisconsin, and Texas experiment stations show the broad adaptation of this food for stock-feeding purposes."

Young stock may be fed half as much silage as full-grown ones, with the same restrictions and precautions as given for steers. Experience obtained at the Kansas Experiment Station, suggests that corn silage is not a fit food for breeding bulls, unless fed only as a relish; fed heavily on silage, bulls lose virility and become slow and uncertain breeders.

Silage for Horses.

When fed in moderate quantities, not to exceed twenty pounds a day, silage is a good food for horses. It should be fed twice a day, a light feed being given at first and gradually increased as the animals become accustomed to the food. Some farmers feed it mixed with cut straw, two-thirds of straw, and one-third of silage, and feed all the horses will eat of this mixed feed. Some horses object to silage at first on account of its peculiar odor, but by sprinkling some oats or bran on top of the silage and feeding only very small amounts to begin with, they soon learn to eat and relish it. Some horses take it willingly from the beginning. Horses not working may be fed larger quantities than work horses, but in neither case should the silage form more than a portion of the coarse feed fed to the horses. Silage-fed horses will look well and come out in the spring in better condition than when fed almost any other food.

Professor Cook says in regard to silage as a horse food: "It has been suggested by even men of high scientific attainments that silage is preëminently the food for cattle and not for other farm stock. This is certainly a mistake. If we raise fall colts, which I find very profitable, then silage is just what we need, and will enable us to produce colts as excellent as though dropped in the spring. This gives us our brood mares in first-class trim for the hard summer's work. I find silage just as good for young colts and other horses."

Mr. James M. Turner, an extensive Michigan farmer and horse breeder, gives his experience in regard to silage for horses as follows: "Last winter we had nearly two hundred horses, including Clydesdales, standard-bred trotters, and Shetland ponies. They were wintered entirely upon straw and corn ensilage, and this in face of the fact that I had read a long article in a prominent horse journal cautioning farmers from the use of ensilage, and citing instances where many animals had died, and brood mares had aborted from the liberal use of corn ensilage.

"Desiring to test the matter to the fullest extent, our stallions and brood mares, as well as all the young stock, were fed two full rations of ensilage daily, and one liberal ration of wheat or oat straw. The result with our brood mares was most phenomenal, for we now have to represent every mare that was then in foal on the farm, a weanling, strong and vigorous, and apparently right in every way, with only one exception, where the colt was lost by accident. Of course there may have been something in the season more favorable than usual, but this was the first year in my experience when every colt dropped on the farm was saved."

Professors Thorne and Hickman give their experience in feeding silage to horses and to other farm animals at the Ohio Experiment Station: "Our silo was planned and filled with special reference to our dairy stock, but after opening the silo we decided to try feeding the silage to our horses, calves, and hogs. The result was eminently satisfactory. We did not find a cow, calf, horse, colt, or hog that refused to eat, or that did not eat it with apparent relish, not only for a few days, but for full two months. The horses were given one feed of twenty pounds each per day in place of the usual amount of hay, for the period above named, and it was certainly a benefit. Their appetites were sharpened, and the healthfulness of the food was further manifest in the new coat of hair which came with the usual spring shedding. The coat was glossy, the skin loose, and the general appearance was that of horses running upon pasture."

Doctor Bailey states that silage has as good an effect on work and driving horses as an occasional feed of carrots or other roots, and Rew informs us that there is a demand for silage in London and other large English cities, especially for omnibus, cab, and tram horses. According to the testimony of Mr. H. J. Elwes, the cart horses fed silage "looked in better condition and brighter in their coats than usual at this time of the year."

From experiments conducted at Virginia Experiment Station, Prof. Nourse concludes that "it would appear that silage would make a good roughage for horses, when used in connection with hay or stover or grain, but that these animals should become accustomed to the food by degrees, and that this is as important as when changing from old to new corn, or from hay to grass."

What has been said about silage as a food for horses will most likely apply equally well to mules, although only very limited experience has so far been gained with silage for this class of farm animals.

Silage for Sheep.

Silage is looked upon with great favor among sheep men; sheep do well on it, and silage-fed ewes drop their lambs in the spring without trouble, the lambs being strong and vigorous. Silage containing a good deal of corn is not well adapted for breeding stock, as it is too fattening; for fattening stock, on the other hand, much corn in the silage is an advantage. Sheep may be fed a couple of pounds of silage a day and not to exceed five or six pounds per head. Professor

Cook reports as follows in regard to the value of silage for sheep: "I have fed ensilage liberally to sheep for three winters and am remarkably pleased with the results. I make ensilage half the daily ration, the other half being corn stalks, or timothy hay, with bran or oats. The sheep do exceedingly well. Formerly I was much troubled to raise lambs from grade Merino ewes. Of late this trouble has almost ceased. Last spring I hardly lost a lamb. While ensilage may not be the entire cause of the change, I believe it is the main cause. It is positively proved that ensilage is a most valuable food material, when properly fed, for all our domestic animals."

Mr. J. S. Woodward, the well-known New York farmer and Farmers' Institute worker, who has made a specialty of early lamb raising, says, in an address before the New York Agricultural Society, regarding silage as feed for lambs: "In order to be successful in raising fine lambs it is imperative that the ewes and lambs both should have plenty of succulent food. Nothing can supply the deficiency. For this purpose roots of almost any kind are good. Turnips, rutabagas, mangolds are all good. Corn silage is excellent. Could I have my choice I would prefer both silage and roots. If I were depending on silage alone for succulent food I would give four pounds per hundred pounds live weight of sheep, all at one feed, at the forenoon feed; but when feeding both silage and roots I would feed silage in the morning and roots in the afternoon."

Mr. J. M. Turner of Michigan says concerning silage for sheep: "Of late years we have annually put up 3,200 tons of corn ensilage, and this has been the principal ration of all the live stock at Springdale Farm, our Shropshire sheep having been maintained on a ration of ensilage night and morning, coupled with a small ration of clover hay in the middle of the day. This we found to fully meet the requirements of our flock until after lambing, from which time forward we of course added liberal rations of wheat bran, oats, and old-process linseed meal to the ewes, with a view to increasing their flow of milk and bringing forward the lambs in the most vigorous possible condition. Our flock-master was somewhat anxious until after the lambs dropped, but now that he saved 196 lambs from 122 ewes, his face is wreathed in smiles, and he gives the ensilage system the strongest endorsement." Mr. Turner states that, after becoming accustomed to the silage, his horses, cattle, and sheep would all push their noses down through the hay, if there was silage at the bottom of the manger, and little or no hay would be eaten until the silage was first taken.

The following interesting experience illustrating the value of silage for sheep feeding is given by Mr. William Woods, a celebrated English breeder of Hampshire-Downs: "Last year, in August, I found myself with a flock of some 1,200 Hampshire-Down ewes, and about twelve or fourteen acres of swedes, on a farm of 4,000 acres, and these were all the roots there were to feed them and their lambs during the winter. Knowing how we should suffer from want of milk after lambing in January and February, I thought I would try (which no doubt has often been tried elsewhere, though not in this district) the effect of ensilage on ewes after lambing, having learned by hearsay that it increased the milk of cows nearly 30 per cent. I at once set to work to irrigate what water meadows I could spare, and in the month of October had a crop of grass that, had it been possible to make it into hay, would have made a ton of hay to the acre. I bought from the Aylesbury Dairy Company one of their Johnson's ensilage rick presses, and put some seventy to eighty tons of cut meadow grass under pressure. It must, however, be borne in mind that second-cut water meadow grass is some of the poorest stuff that is consumed, either green or in hay, and, therefore, my ensilage was not as good, and consequently not as favorable a trial, as if it had been made of better material.

"In January, when well into lambing, I opened the stack, and began to feed it to the ewes that had lambed. At first they hardly cared to eat it, but by degrees they seemed to like it more. They had a night and morning meal of best sainfoin hay, and a small lot of ensilage with the cake given at midday. After three weeks' trial, what the shepherd observed was this: That when best sainfoin hay, worth £4 a ton, was put in the cages, and ensilage in the troughs at the same time, half the sheep would go to the hay and half to the ensilage, although there was sufficient accommodation for the whole flock at either sort, and we now observe that with the ewes that are most constant to the ensilage, their lambs are nourished better than the others. We have not lost a single lamb from scour, and have some 470 lambs from 380 ewes lambed as yet, which I think proves the value of the experiment. As soon as the stuff arrives in carts the ewes are crazy for it, and almost come over the hurdles, so eager are they to get at this new sort of feed, which, as I have stated, is only water meadow grass ensilaged."

Silage for Swine.

The testimony concerning the value of silage as a food for swine is conflicting, both favorable and unfavorable reports being at hand. Many farmers have tried feeding it to their hogs, but without success. On the other hand, a number of hog-raisers have had good success with silage, and feed it regularly to their swine. It is possible that the differences in the quality of the silage and of the methods of feeding practiced explain the diversity of opinions formed concerning silage as hog food. According to Professor Cook, Col. F. D. Curtiss, the great American authority on the swine industry, states that silage is valuable to add to the winter rations of our swine. Mr. J. W. Pierce of Indiana writes in regard to silage for hogs: "We have fed our sows, about twenty-five in number, for four winters, equal parts of ensilage and corn meal put into a cooker, and brought up to a steaming state. It has proved to be very beneficial to them. It keeps up the flow of milk of the sows that are nursing the young, equal to when they are running on clover. We find, too, when the pigs are farrowed, they become more robust, and take to nursing much sooner and better than they did in winters when fed on an exclusively dry diet. We also feed it to our sheep. To sixty head we put out about six bushels of ensilage." Dr. Bailey, the author of "The Book on Ensilage," fed large hogs ten pounds of silage, and one pound of wheat bran, with good results; the cost of the ration did not exceed 2 cents per day. He states that clover silage would be excellent, and would require no additional grain. Young pigs are exceedingly fond of the silage. Feeding experiments conducted at Virginia Experiment Station show that silage is an economical maintenance feed for hogs, when fed in connection with corn, but not when fed alone.

In feeding silage to hogs, care should be taken to feed only very little, a pound or so, at the start, mixing it with corn meal, shorts, or other concentrated feeds. The diet of the hog should be largely made up of easily digested grain food; bulky, coarse feeds like silage can only be fed to advantage in small quantities, not to exceed three or four pounds per head, per day. As in case of breeding ewes, silage will give good results when fed with care to brood sows, keeping the system in order, and producing a good flow of milk.

Silage for Poultry.

Many farmers are feeding a little silage to their poultry with good success. Only small quantities should be fed, of course, and it is beneficial as a stimulant and a regulator, as much as a food. A poultry man writes as follows in *Orange Judd Farmer,* concerning his experience in making and feeding silage to fowls. Devices similar to that here described have repeatedly been explained in the agricultural press. "Clover and corn ensilage is one of the best winter foods for poultry raisers. Let me tell you how to build four silos for $1. Buy four coal-oil barrels at the drug store, burn them out on the inside, and take the heads out. Go to the clover field when the second crop of the small

June clover is in the bloom, and cut one-half ton three-eighths of an inch in length, also one-half ton of sweet corn, and run this through the feed cutter. Put into the barrel a layer of clover, then a layer of corn. Having done this, take a common building jack-screw and press the silage down as firmly as possible. Then put on this a very light sprinkling of pulverized charcoal, and keep on putting in clover and corn until you get the barrel as full as will admit of the cover being put back. After your four barrel silos are filled, roll them out beside the barn, and cover them with horse manure, allowing them to remain there thirty days. Then put them away, covering with cut straw or hay. When the cold, chilling winds of December come, open one of these 'poultrymen's silos,' take about twenty pounds for one hundred hens, add equal parts of potatoes, ground oats, and winter rye, place same in a kettle and bring to a boiling state. Feed warm in the morning, and the result will be that you will be enabled to market seven or eight dozen eggs per day from one hundred hens through the winter, when eggs bring good returns."

CHAPTER V.—COMPARISON OF SILAGE AND OTHER FEEDS.

I. Economy of Production.

We shall briefly consider in this chapter the comparative value of silage and feeds that may take its place in the feeding of farm animals. The first point to examine in this connection is the question of the cost of production of the different foods. Silage may be replaced by roots and by dry roughage, like hay of various kinds, dry fodder corn, corn stalks, straw, etc.

CORN SILAGE VS. ROOTS.—In our country, the comparison of roots and corn silage will come out more favorable to the latter feed than almost anywhere else, since corn is wonderfully well adapted to our climate, requiring a hot growing season and an occasional good supply of moisture for its perfection; roots, on the other hand, do best in a cool and moist climate, and yields obtained under such conditions are much larger than we can hope to reach here in normal seasons. This being true, it follows that, if roots are considered a more expensive crop than corn in countries where they will do best, they must be still more so with us.

R. Henry Rew discusses the relative value of the two foods from the standpoint of the English farmer, as follows: "The root crop has, for about a century and a half, formed the keystone of arable farming; yet it is the root crop whose position is most boldly challenged by ensilage. No doubt roots are expensive—say £10 per acre as the cost of producing an ordinary crop of turnips—and precarious, as the experience of the winter of 1887-8 has once more notably exemplified in many parts of the country. In a suggestive article in the *Farming World Almanac* for 1888 Mr. Primrose McConnell discusses the question: 'Are Turnips a Necessary Crop?' and sums up his answer in the following definite conclusion:

"'Everything, in short, is against the use of roots, either as a cheap and desirable food for any kind of live stock, as a crop suited for the fallow break, which cleans the land at little outlay, or as one which preserves or increases the fertility of the soil.'

"If the growth of turnips is abandoned or restricted, ensilage comes in usually to assist the farmer in supplying their place. . . . When one comes to compare the cultivation of silage crops with that of roots, there are two essential points in favor of the former. One is their smaller expense, and the other is their practical certainty. The farmer who makes silage can make certain of his winter store of food, whereas he who has only his root crop may find himself left in the lurch at a time when there is little chance of making other provision."

A number of our American experiment stations have furnished data for comparing the yields and the cost of production of corn silage and roots in our country. The Ohio, Maine, Pennsylvania, and Ontario Experiment Stations raised roots in comparison with corn for one or more years. The average yields of green substance and dry matter are shown in the following table.

YIELDS PER ACRE OF ROOTS AND FODDER CORN.

	Maine Station.		Pennsylvania Station.		Ohio Station.		Ontario College.	
	Green Substance.	Dry Matter.	Green Substance.	Dry Matter.	Green Substance.	Dry Matter.	Green Substance.	Dry Matter.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Rutabagas	31695	3415	......	......	......	......	42780	4877
Mangolds	15375	1613	16177	2382	31500	3000	55320	5034
Turnips	28500	2559	.....	..	......	.....	46120	4382
Sugar Beets	17645	2590	11436	2010	.....	......	32663	4737
Fodder Corn	21690	3110	.....	.....	......		......	.....
	39645	5580	18591	5522	.....	6000	41172	8135

In the Pennsylvania experiments a careful account of the cost of growing, harvesting, and storing the two crops was kept, with results as follows:

Cost for one acre of beets in the pit..........$56.07
" " " " " corn in the silo........ 21.12

These figures can only be considered approximations, but it is believed that the ratio between the cost for an acre of roots and of corn, expressed by them, is, at all events, not too unfavorable to the former. According to official statistics, the average cost of raising an acre of ear corn in the United States is $11.71. The siloing of the whole corn crop will not be likely to exceed much the expense of harvesting or gathering, housing, and marketing included in this estimate, and amounting to $2.98. On the other hand, the cost of raising a crop of beets has, in different States, been found to range from $31.36 to $60 per acre.

Corn Silage vs. Hay.—Two tons of hay per acre is generally considered a very good crop in humid regions. The average yield for a number of years will seldom exceed $1\frac{1}{2}$ tons with the best farmers. Since hay contains about 86 per cent dry matter, an average crop of $1\frac{1}{2}$ tons means about $1\frac{1}{4}$ tons of dry matter (2,580 pounds). Against this yield we have yields of 5,000 to 9,000 pounds of dry matter, or twice to three and a half times as much, in case of fodder corn. An average crop of green fodder will weigh twelve tons, of Northern varieties, and eighteen tons, of Southern varieties. Estimating the percentage of dry matter in the former at 30 per cent, and in the latter at 20 per cent, we shall have in either case a yield of 7,200 pounds of dry matter. The expense of growing the crop is, of course, higher in case of the corn, but by no means sufficiently so to offset the larger yields. It is a fact generally conceded by all who have given the subject any study, that the hay crop is the most expensive crop used for the feeding of our farm animals.

Sir John B. Lawes, of Rothamsted Experiment Station (England) says, respecting the relative value of hay and (grass) silage: "It is probable that when both (*i. e.,* hay and silage) are of the very best quality that can be made, if part of the grass is cut and placed in a silo, and another part is secured in the stack without rain, one might prove as good food as the other. But it must be borne in mind that while the production of good hay is a matter of uncertainty—from the elements of success being beyond the control of the farmer—good silage, by taking proper precautions, can be made with a certainty."

The amount of space required for storing one ton of hay or of silage speaks very strongly for the latter. One ton of hay stored in the mow will fill a space of at least 400 cubic feet; one ton of silage, a space of about 50 cubic feet. Considering the dry matter contained in both feeds, we have that 8,000 pounds of silage contains about as much dry matter as 2,323 pounds of hay, or 160 against 465 cubic feet, that is, it takes nearly three times as much room to store the same quantity of food materials in hay as in silage.

Corn Silage vs. Fodder Corn.—The cost of production is the same for the green fodder up to the time of siloing, in case of both systems; as against the expense of siloing the crop comes that of shocking, and, later on, placing the fodder under shelter in the field-curing process; further, husking, cribbing, and grinding the corn, and cutting the corn stalks, since this is the most economical way of handling the crop, and the only way in which it can be fully utilized so as to be of equal value with the silage. As an average of five Wisconsin farms, Professor King, as we saw, found the cost of placing corn in the silo to be 58.6 cents per ton, or, adding to this amount, interest and taxes on silo investment, and insurance and maintenance of silo per ton, 73.2 cents. The expense of shocking and sheltering the cured fodder and, later cutting the same, will greatly exceed that of siloing the crop; to obtain the full value in feeding the ear corn, it must, furthermore, in most cases, be ground, costing 10 cents or more a bushel. The advantage is, therefore, decidedly with the siloed fodder in economy of handling, as well as in the cost of production.

As regards the space required for storing dry fodder corn compared with silage, the former will take up still more room than the hay, since it can not be packed closely, but must be set up rather loosely in bundles, to prevent the fodder from heating. According to Professor Alvord, an acre of corn, field-cured, stored in the most compact manner possible, will occupy a space ten times as great as if in the form of silage. While hay will contain about 86 per cent of dry matter, cured fodder corn often does not contain more than 60 and sometimes only 50 per cent of dry matter; the quantities of food materials in fodder corn that can be stored in a given space are, therefore, greatly smaller than in case of hay, and, consequently, still smaller than in case of silage.

II. Comparative Feeding Experiments.

While the economy of production speaks decidedly in favor of silage as compared with roots and dry, coarse fodders, it might happen that the nutritive materials of the latter were sufficiently superior to those of silage to more than make up for their greater cost. Such is, however, not the case. In comparative feeding experiments with the various crops, silage has, as a rule, produced the better results, or practically no difference in the nutritive effect of the different feeds has been found. We shall briefly summarize some of the data at hand bearing on this phase of our subject.

SILAGE VS. ROOTS.—We previously gave the average digestion coefficients obtained for green and dry fodder corn and for corn silage (p. 178). Only a limited number of digestion experiments have been conducted with roots, but enough has been done to ascertain that they are highly digestible, the digestion coefficients for dry matter found ranging from 78 to 98, against about 66 for corn silage. Nevertheless, owing to the larger yields per acre of dry matter, the total quantity of digestible matter obtained from an acre of corn under our conditions is much larger than that obtained from an acre of roots. In the Pennsylvania experiments, as much digestible matter was produced on one acre when planted to corn, as was obtained from 1.91 acres of mangolds or 2.05 acres of sugar beets.

Feeding experiments have been conducted with milch cows, steers, sheep, and swine for the comparison of roots and silage.

In feeding experiments with *milch cows* at the Ohio Station, conducted for four consecutive years, the silage rations always gave somewhat the better results. The average gain in milk per 100 pounds of dry matter eaten amounted to 4 per cent in favor of the silage rations. The results of the different years are as shown below.

POUNDS OF MILK PRODUCED PER 100 POUNDS OF DRY MATTER CONSUMED.

Ration.	1889	1890	1891	1892	Av.
Beet ration..................	59	59	62	69	62
Silage ration................	62	60	66	76	66

Similar experiments conducted at the Pennsylvania and Vermont Stations gave corresponding results, the conclusion drawn being that "beets cost more to grow, harvest and store, yield less per acre, and produce at best no more and no better milk than corn silage."

Steer feeding experiments with roots *vs.* silage have been conducted at the Ontario Agricultural College, where six steers, divided into three even lots, were fed as follows: Lot 1, corn silage *ad libitum,* with about twelve pounds of corn meal; lot 2, thirty pounds of corn silage, about twelve pounds of corn meal, and hay *ad libitum;* lot 3, forty-five pounds of sliced roots, corn meal, and hay as in lot 2. The trial lasted 146 days; the average gains per day for the different lots were: Lot 1, 1.90 pounds; lot 2, 1.53 pounds; lot 3, 1.84 pounds. The total value of the animals at the close of the experiments was, $197.07, $188.24, and $189.67 for lots 1, 2, and 3, respectively, making the percentage gain on investment, calculated according to Canadian prices of feed and labor, 22.7 per cent for lot 1, 20.0 per cent for lot 2, and 15.0 per cent for lot 3.

The Ottawa Experiment Station in 1893 conducted experiments for the comparison of roots and silage as feed for fattening steers, and found that a daily gain of 1.05 pounds was made on a hay, root, and straw ration, and of 1.35 pounds on a corn silage and straw ration. The average cost per head per day was 13.78 cents on the former ration, and 9.26 cents on the latter; calculated per 100 pounds of increase, the cost was $13.35, and $6.95 for root and silage rations, respectively, *i. e.,* a difference of 92.08 per cent against the root ration.

Silage *vs.* roots for *fattening lambs* have been compared in several experiments at Michigan Experiment Station. Sugar beets proved superior to silage for lambs in the first year's experiment; the conclusion drawn was that either feed may enter largely into the fattening ration and may be fed with profit. In comparing rutabagas with silage for fattening lambs the same gain was obtained in both cases, viz.: seventeen pounds per week per head. Although the quantity of grain fed was the same, the lambs fed rutabagas consumed a considerably larger quantity of hay than those fed silage, and the amount of rutabagas eaten as compared with silage was very large. The profit on the root-fed lot was 22 cents on each lamb; that on the silage-fed lot, 63 cents. The silage, therefore, produced the same gain in fattening lambs at a greatly diminished cost, as compared with rutabagas.

Corn silage was compared with beets as foods for Merino ewes, at the Cornell Experiment Station. As the average of two experiments it was found that the ewes gained 3.33 pounds per week when roots were fed, and 3.49 pounds when silage was fed. "The ewes learned to like the silage as readily as they did the beets."

The relative feeding value of silage and roots for *swine* was studied in a single experiment at Ontario Agricultural College. The pigs fed silage and grain did not do very well, and gained less than those fed grain, or turnips and grain.

Silage vs. Dry Roughage.—A large number of experiments have been conducted with the various classes of farm animals for the study of the comparative feeding value of silage and dry roughage, either hay, fodder corn, or cornstalks. We can here only mention a few typical experiments.

In an experiment with milch cows conducted at the New Hampshire Station, where silage was compared with hay, the silage ration, containing 16.45 pounds of digestible matter, produced 21.0 pounds of milk, and the hay ration, containing 16.83 pounds digestible matter, produced 18.4 pounds milk; calculating the quantities of milk produced by 100 pounds of digestible matter in either case, we find on the silage ration 127.7 pounds of milk, on the hay ration, 109.3 pounds, or 17 per cent in favor of the silage ration.

In a feeding experiment with milch cows at the Maine Experiment Station, in which silage was compared with hay, the addition of silage to the ration resulted in a somewhat increased production of milk solids, which was not caused by an increase in the digestible food materials eaten, but which must have been due either to the superior value of the nutrients of the silage over those of the hay or to the general physiological effect of feeding a greater variety of foods. 8.8 pounds of silage proved to be somewhat superior to 1.98 pounds of hay (mostly timothy), the quantity of digestible material being the same in the two cases.

In another experiment, conducted at the same station, where silage was compared with hay for steers, a pound of digestible matter from the corn silage produced somewhat more growth than a pound of digestible matter from timothy hay. The difference was small, however, amounting in the case of the last two periods, where the more accurate comparison is possible, to an increased growth of only 15 pounds of live weight for each ton of silage fed.

Feeding experiments with milch cows were conducted for a series of years by the author and others, at the Wisconsin Experiment Station, in which the relative value of corn silage and corresponding field-cured fodder corn was investigated. The earlier of these experiments were made with only a couple of animals each, and no great reliance can, therefore, be placed on the results obtained in any single experiment. In later years a larger number of cows have been included in the experiments, and these have been continued for a sufficiently long time to show what the animals could do on each feed. In 1891 a feeding experiment with twenty cows was conducted by the writer, in which a daily ration of 4 pounds of hay and 7 pounds of grain, fed with corn silage or field-cured fodder corn *ad libitum,* was fed during sixteen weeks; a total quantity of 19,813.4 pounds of milk was produced during the silage periods, and 19,801.2 pounds of milk during the fodder corn periods. When the areas of land from which the silage and the fodder corn were obtained are considered, we find that the silage would have produced 243 pounds more of milk per acre than the dry fodder, or the equivalent of 12 pounds of butter, which is a gain of a little more than 3 per cent in favor of the corn silage. Similar results, or more favorable to silage, have been obtained in feeding experiments with which cows of a number of stations, notably New Jersey, Vermont, and New York (Geneva).

This may appear a very small difference to some, but it must be remembered that in this, as in all similar previous experiments, the fodder corn was handled in the most careful manner, so as to avoid losses by fermentations or abrasion. It was left in shocks in the field for about a month, then carefully transferred to the station barn, tied up in bundles, and cut before feeding.

The results, therefore, show what dry fodder can do under the most favorable conditions. In ordinary farm practice the loss of food materials in the silo would be no larger than found by us, if as large, owing to the small size of the experimental silo then used, while the fodder corn, most likely, would not be as well cared for, being often kept shocked in the field until needed for feeding; in a majority of cases not even cut and shocked, and often fed whole in the yard, with losses of food materials ranging from 30 to 60 per cent, according to data found at the Kansas Station. Cutting the corn fodder before feeding, according to Professor Henry's experiments, may save more than one-third of the food value of the fodder. We can not, therefore, hope to obtain equally good results with silage and field-cured fodder unless special pains are taken throughout to guard against deterioration of the fodder; precautions, it will readily be granted, more laborious and costly than making silage of the corn crop.

A few more experiments illustrating the value of silage as a stock food, may be quoted. Professor Henry fed two lots of steers on a silage experiment. One lot of four steers was fed corn silage exclusively, and another similar lot, corn silage with shelled corn. The former lot gained 222 pounds in thirty-six days, and the latter lot 535 pounds, or a gain of 1.5 pounds per day per head for the silage-fed steers, and 3.7 pounds per day for the silage and shelled-corn fed steers. Professor Emery fed corn silage and cotton-seed meal, in the proportion of eight to one, to two three-year-old steers at the North Carolina Experiment Station. The gain made during thirty-two days was, for one steer 78 pounds, and for the other 85.5 pounds, or 2.56 pounds per head per day.

The late well-known Wisconsin dairyman, Hon. Hiram Smith, in 1888 gave the following testimony concerning the value of silage for milch cows: "My silo was opened December 1st, and thirty pounds of ensilage was fed to each of the ninety cows for the night's feed, or 2,700 pounds per day, until March 10th, one hundred days, or a total of 135 tons, leaving sufficient ensilage to last until May 10th. The thirty pounds took and well filled the place of ten pounds of good hay. Had hay been fed for the night's feed in place of the ensilage, it would have required 900 pounds per day for the ninety cows, or a total for the one hundred days of forty-five tons.

"It would have required, in the year 1887, forty-five acres of meadow to have produced the hay, which, if bought or sold, would have amounted to $14.00 per acre. The 135 tons of ensilage were produced on 8½ acres of land, and had a feeding value, as compared with hay, of $74.11 per acre." As the conclusion of the whole matter, Mr. Smith stated that "three cows can be wintered seven months on one acre producing 16 tons of ensilage, while it required two acres of meadow in the same year of 1887, to winter one cow, with the same amount of ground feed in both cases."

Professor Shelton, formerly of Kansas Agricultural College, gives a powerful plea for silage in the following simple statement: "The single fact that the product of about two acres of ground kept our herd of fifty head of cattle five weeks with no other feed of the fodder kind, except a small ration of corn fodder given at noon, speaks whole cyclopedias for the possibilities of Kansas fields when the silo is called in as an adjunct."

The Ohio Experiment Station sums up the value of silage for stock food in the following words: "The logical conclusion of all this work is that the process of siloing adds nothing to the nutritive value of a feeding stuff. It does add to its palatability, however, when the method has been properly employed, and in consequence a larger proportion of the fodder will be consumed. In regard to the cost of this method, we do not consider it any greater than that of the ordinary method of cutting and husking and stacking the stover, and not so great as cutting, husking, and stacking and grinding the grain, and certainly all this must be done if the food materials are to be as thoroughly preserved and made as completely available as they are in well-cured silage."

CHAPTER VI.—THE SILO IN MODERN AGRICULTURE.

In closing our discussion of the making and feeding of silage, it may be well to consider briefly the main advantages of the system of preserving green forage in silos. In doing so, we shall summarize the conclusions previously arrived at, concerning the economy of the system, and shall call attention to some points that we have not before had an occasion to touch upon. The advantages of the silo enumerated below will not be apt to hold good simultaneously in individual cases; but it is believed that a majority of them will be of general importance, thus showing the decided superiority of the siloing method over other systems of preserving coarse fodders for the feeding of farm animals.

I. The silo enables us to preserve a greater quantity of the food materials of the original fodder, for the feeding of farm animals, than is possible by any other system of preservation now known. We have seen that the necessary losses of nutrients incurred in the siloing process need not exceed 10 per cent, and that by beginning to feed from the silo soon after it has been filled, the loss will be reduced to a minimum which may not be far from 5 per cent. In haymaking or field-curing of coarse fodders, there is an unavoidable loss of leaves and other tender parts, and in case of curing fodder corn there will be a fermentative loss of toward 10 per cent under the best of conditions, or about as much as is lost in the silo. The loss of dry matter will approach 25 per cent in ordinary farm practice, and will even exceed this figure unless special precautions are taken in the handling of the fodder.

II. Rainy weather is a disadvantage in filling silos as in most other farm operations, but when the silo is once filled, the fodder is safe, and the farmer is independent of the weather throughout the season.

III. Less room is required for the storage in a silo of the product from an acre of land than in cured condition in a barn. Hay placed in the mow will take up about three times as much room as the same quantity of food materials put into the silo; in case of field-cured fodder corn, the comparison comes out still more favorably to the silo, on account of the greater difficulty in preserving the thick cornstalks from heating when placed under shelter.

IV. Since smaller barns may be built when silage is fed, there is less danger of fire, thus decreasing the cost of insurance.

V. An acre of corn can be placed in the silo at less cost than the same quantity can be put up as cured fodder. To derive full benefit from the food materials in the field-cured fodder corn, it must be run through a feed cutter in small portions at a time; the corn must, in most cases, be husked, cribbed, and either ground, cob and all, or shelled and ground. In siloing the whole corn plant, the cutting is all done at once, thus economizing labor and doing away with the separate handling of the ear corn.

VI. The silo furnishes a feed of uniform quality, available at any time during the whole winter or year. This is of advantage to all classes of farm animals, but perhaps particularly so in case of dairy cows and sheep, since these animals are especially sensitive to sudden changes in the feed.

VII. Silage is of special value for feeding preparatory to turning cattle on to the watery pasture grass in the spring. The loss in weight of cattle on being let out on pasture in spring is often so great that it takes them a couple of weeks to get back where they were when turned out. When turned out in the spring, steers will be apt to lose weight, no matter whether silage or dry feed has been fed, unless they are fed some grain during the first week or two after they are let out.

VIII. Succulent food is nature's food. The influence of well-preserved silage on the digestion and general health of animals is very beneficial, according to the unanimous testimony of good authorities. It is a mild laxative, and acts in this way very similarly to green fodders. The good accounts reported of the prevention of milk fever by the feeding of silage are explained by the laxative influence of the feed.

IX. By filling the silo with clover or other green summer crops early in the season, a valuable succulent feed will be at hand at a time when pastures in most regions are apt to give out; then again, the silo may be filled with corn when this is in the roasting stage, and the land thus entirely cleared earlier than when the corn is left to mature and the corn fodder shocked on the land, making it possible to finish the fall ploughing sooner and to seed the land down to grass or to winter grain.

X. Crops unfit for haymaking may be preserved in the silo and changed into a palatable food. This is not of the importance in this land of plenty of ours that it is, or occasionally has been, elsewhere. Under silage crops were mentioned a number of crops which could not be used as cattle food in any other form than this, as ferns, thistles, all kinds of weeds, etc. In case of fodder famine the silo may thus help the farmer to carry his cattle through the winter.

XI. Where haymaking is precluded, as is sometimes the case with second-crop clover, rowen, etc., on account of rainy weather late in the season, the silo will preserve the crop, so that the farmer may derive full benefit from it in feeding it to his stock.

XII. More cattle can be kept on a certain area of land when silage is fed than is otherwise the case. The silo in this respect furnishes a similar advantage over field-curing fodders as does the soiling system over that of pasturing cattle; in both the siloing and the soiling system there is no waste of feed, all food grown on the land being utilized for the feeding of farm animals, except a small unavoidable loss in case of the siloing system incurred by the fermentation processes taking place in the silo.

Pasturing cattle is an expensive method of feeding, as far as the use of the land goes, and can only be practiced to advantage where this is cheap. As the land increases in value, more stock must be kept on the same area in order to correspondingly increase the profits from the land. The silo here comes in as a material aid, and by its adoption, either alone or in connection with the soiling system, it will be possible to keep at least twice the number of animals on the land that can be done under the more primitive system of pasturing and feeding dry feeds during winter. Goffart's experience on this point is characteristic. On his small farm, of less than eighty-six acres (thirty-five hectares), at Burtin, France, he kept a herd of sixty cattle, besides fattening a number of steers during the winter, and eye-witnesses assure us that he had ample feed on hand to keep one hundred head of cattle the year round.

According to the testimony of hundreds of intelligent, observing dairymen, the silo is next to a necessity in modern dairying in most sections of our country. It is also largely considered so by agricultural writers, and by farmers generally. It is, however, of no less importance where other branches of animal husbandry are followed more or less as a specialty. This, we think, is abundantly proved by the data and the results of practical experience and systematic investigations presented in the preceding pages. The building of the silo, therefore, should not stop, and will not do so, until dairy- and stock farmers in the width and breadth of our land have become acquainted with the siloing system, and are aware of its value. It is the hope of the author that this little book will, in some measure, help to make the system better known and understood among the mass of our farmers, and will assist them in their efforts to reduce the cost of production of their products, and thus enlarge the income from their farms.

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