4-1923

EC720 Pit, Semi-pit and Bank Silos

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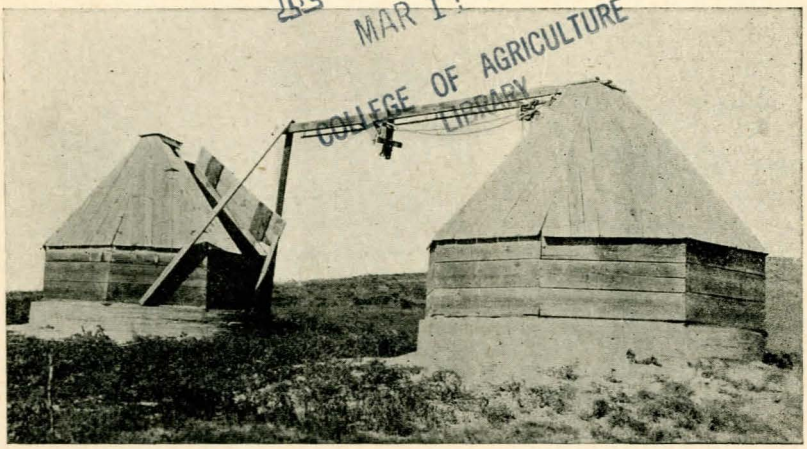
THE UNIVERSITY OF NEBRASKA
AGRICULTURAL COLLEGE EXTENSION SERVICE

April, 1923 Extension Circular 720

PIT, SEMI-PIT AND BANK SILOS



TWIN PIT SILOS IN RED WILLOW COUNTY

UNITED STATES
DEPARTMENT OF AGRICULTURE
COOPERATING

PIT, SEMI-PIT AND BANK SILOS

L. W. CHASE

Probably Nebraska is the home of the pit silo with plastered walls, Fillmore and York counties being the first to use this type of construction. On the Kale farm northeast of Exeter is a silo of this type which was first constructed in 1894 and is still in use. Mr. Kale obtained his idea from neighbors who had been using similar silos for several years previous.

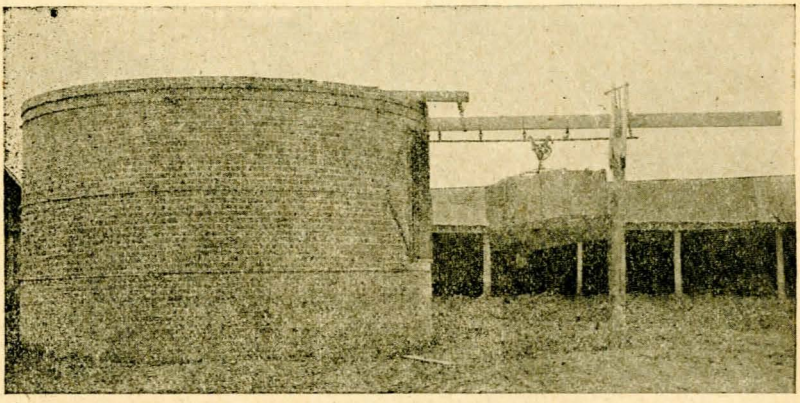


FIG. 1.—C. P. Shoef's pit silo, Beatrice, Nebraska.

Pit silos are cheap, durable, cost practically nothing for upkeep, and silage does not freeze in them. Further, they require a less expensive cutter and a small engine for filling, since the silage need not be elevated in filling.

Their greatest disadvantage is the inconvenience in removing the silage. In large areas of Nebraska the soil is peculiarly adapted to pit silos. Wherever water cisterns can be made by plastering directly against the earth, pit silos can be made in a similar manner. Such silos should not enter water-bearing soil, and whenever a stratum of soil is passed thru which is apt to collect water the walls of the silo should be built much heavier or the top of the silo kept so tight that the water in such stratum will not freeze and force the plaster off.

GAS IN PIT SILOS

The claim is made that carbon dioxide gas collects in the bottom of the pit silos and makes it dangerous to enter them. In conversation with several owners of pit silos they stated that nothing of the kind had ever occurred in their silos.

The temperature of a pit silo is much higher in winter than the surrounding air, and because of this higher temperature in the silo, air currents are formed that carry off all dangerous gases. If the top of these silos be left open, the currents of air set up by the wind are sufficient to keep the air circulating so that gases will be removed.

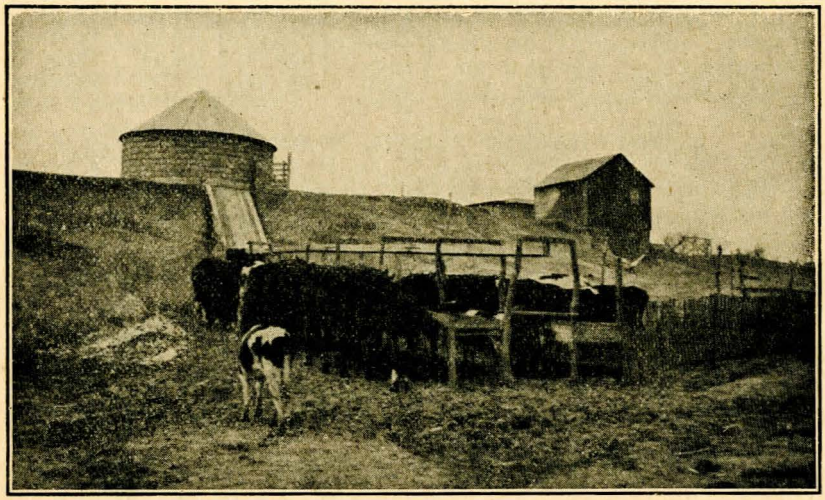


FIG. 2.—The bank silo of Peter Bergquist, Atlanta, Nebraska. Doors are provided up and down the side of the silo opposite the passage, so the silage can be thrown from the silo into the common litter carrier which runs out over the feed bunks, as shown in the cut.

Greater quantities of gas form within a day or so after the filling begins; hence, if the silo is partially filled and then permitted to stand for a few days, it is best to run the cutter a few minutes before the silo is entered. The falling silage will force all dangerous gases from the silo. If one desires to test the condition of the air in a partially filled pit silo, he may do so by lowering a lighted lantern to the bottom. If the lantern continues to burn, there is no danger to a man entering the silo. If the light is extinguished by the gas, the silo should not be entered.

TABLE 1—*Capacity of Round Silos in Tons*

Inside height of silo, in feet	Inside diameter of silo, in feet					
	10	12	14	16	18	20
20	22.78	32.75	44.60	58.28	73.80	91.10
24	29.50	42.45	57.80	75.48	95.53	117.95
26	33.08	47.66	64.80	84.64	107.22	132.30
28	36.78	53.00	72.10	94.10	119.25	147.10
30	40.60	58.50	79.50	103.80	131.60	162.30
32	.....	64.12	87.20	113.80	144.35	178.00
34	.....	69.82	95.10	124.20	157.35	194.10
36	.....	.....	103.20	134.70	170.70	210.60
38	.....	.....	111.30	145.30	184.20	227.20
40	.....	.....	119.60	156.20	198.10	244.30
44	.....	.....	.....	178.60	226.30	279.10
48	.....	.....	.....	201.80	255.65	315.40

ESSENTIALS OF A WELL-DESIGNED SILO

The essential features of a well-designed silo can be summed up briefly as follows:

1. The walls should be practically air-tight.
2. The inner surfaces of the walls should be smooth and perpendicular.
3. The inner surfaces of the walls should be free from corners. Round silos are more efficient and economical than other types.
4. The walls should be sufficiently non-conducting to prevent excessive freezing,—especially so when the silage is to be fed during cold weather.
5. The walls should be sufficiently firm or sufficiently well anchored to prevent cracking due to settling or racking due to wind.
6. The doors should be so designed that a minimum amount of silage has to be removed before they can be opened.
7. A good ladder should be provided with steps from 15 inches to 18 inches apart and at least 3½ inches away from the silo or walls of the chute.
8. The foundation should be heavy, well made, and reach below the frost line.
9. A good roof makes the silo more durable, adds greatly to its appearance, and if tight assists materially in keeping the silage from freezing.

Silos which have the above features will be found convenient, cause little trouble, and when properly filled will keep the silage in perfect condition.

TYPES OF SILOS

There are two general types of silos—

1. Pit silos, or silos built partially or wholly below ground;
2. Silos above ground, built of wood or of masonry.

TYPES OF PIT SILOS

There are three types of pit silos:

Plain holes in the ground, where the walls are plastered and the silage is dropped in and lifted out at the top;

Holes in the ground, but with the silo extended above the ground from 4 to 12 feet, the roof placed above this, and the silage removed thru the side of the upper part;

Silos built similar to either of the other two, but set in the bank so that retaining walls which act as a chute are placed up and down beside a line of doors. If there is a bank barn and the retaining walls connect the silo to the barn, the conditions are ideal.

Of the three types of pit silos mentioned above, the last is the most convenient, also the most expensive. The first is the cheapest and likewise the least convenient.

CONSTRUCTING PIT SILOS

Most silos are constructed by commencing at the bottom and building up, but a pit silo can be constructed by commencing at the top and building down. By building a silo in this manner, the ground acts as a staging and no lumber or labor is required for that purpose.

Build all of that part of the silo which stands above the ground before very much excavating is done. The roof can be put on at this time or after the silo is filled. First dig out a trench, similar to the one shown in figure 3. Fill this with concrete and let it set. The ring of concrete formed in this manner will serve as a border to protect the rim of the plain pit silo or as a foundation for that part of the silo above the ground.

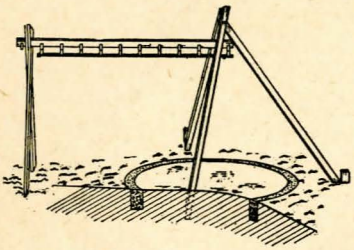


FIG. 3.—An illustration of the border of the pit silo; also one type of frame for hoisting the earth.

The plain pit silo will then be dug down about six feet, which is a convenient depth for easy

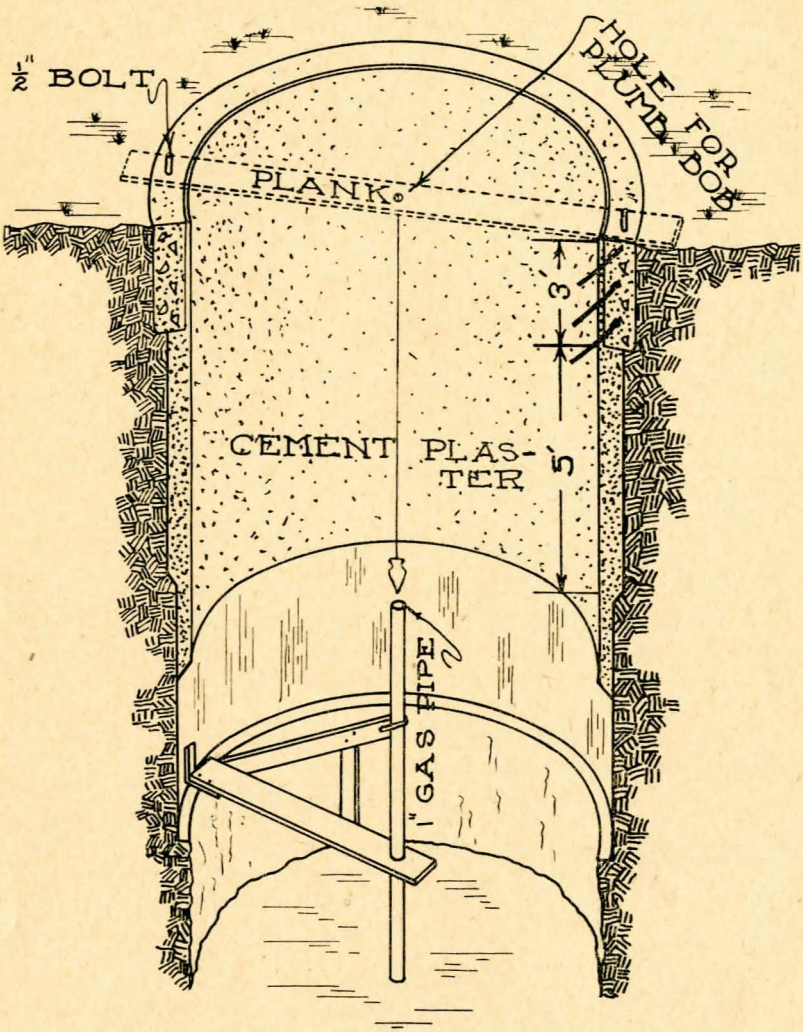


FIG. 4.—How to build the walls of a pit silo true.

plastering. This section will be plastered, another section dug down and plastered and so on until the proper depth is reached.

If it is desired to build part of the silo above the ground, it can be done in several ways. Staves may be purchased and a short stave silo be erected, or one may use solid concrete, concrete blocks, clay blocks, or concrete plastered onto metal lath.

If solid concrete is to be used, forms can be made by building up wooden hoops and lining them with 1x6 boards standing vertically. If forms are used in this way, they will necessarily be six inches apart to provide space for working the concrete and holding the reinforcing in place. The handiest reinforcing for such a silo probably is heavy woven wire fencing.

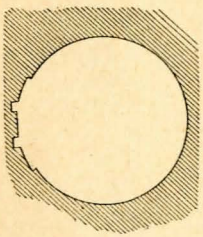


FIG. 5. — Showing how to cut away the earth to support a door frame and retaining walls for a bank silo.

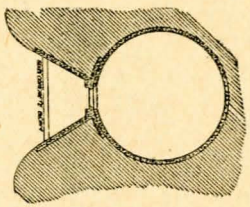


FIG. 6. — Showing how to build the door supports and retaining walls for a bank silo.

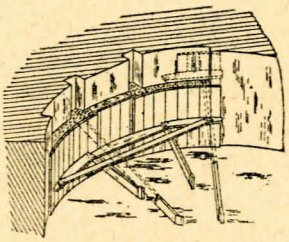


FIG. 7.—The form in place for holding the concrete for the heavy section about the doors of a bank silo.

A form of metal lath known as "Hy-Rib" can be purchased on the market in any diameter desired. This form of metal lath can be set up on the foundation and plastered with a sufficient number of coats of cement plaster to make a wall of concrete about three inches thick.

Another method of building the part of the silo above the ground is to set up two-inch by four-inch studdings about every two feet and nail metal lath to the inside of these. The lath should not be so firmly nailed but that the studding can be removed. Plaster several coats on the inside of the lath, then remove the studding and reinforce with heavy galvanized fence wire wound around the outside of the metal lath. Then put a few coats of cement plaster on the outside.

It is fully as easy to hoist the dirt out of the top of a bank silo as to remove it thru the doorway; so build the silo proper in the same manner as the other pit silos excepting that the

earth be dug away as shown by figure 5. By digging out in this manner, there is opportunity for building a heavy wall where the doors are and furnishing the supports as figure 6 for the retaining walls to rest against. In concreting this silo, a form must be used at the doors. This can be built as shown in figure 7. To use this form when the walls are concreted from the top down, the form must be dropped sufficiently far below the concrete of the previous setting to permit throwing the concrete into place. The gap thus formed between the two settings is then plastered full with a dry mixture of concrete.

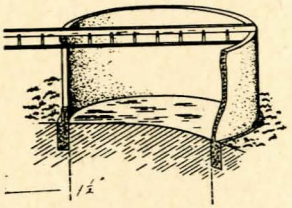


FIG. 8.—Showing a semi-pit silo ready for excavation.

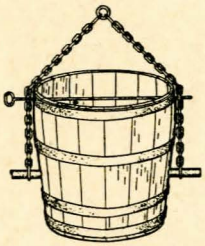


FIG. 10.—Barrel used for hoisting earth from silo pit.

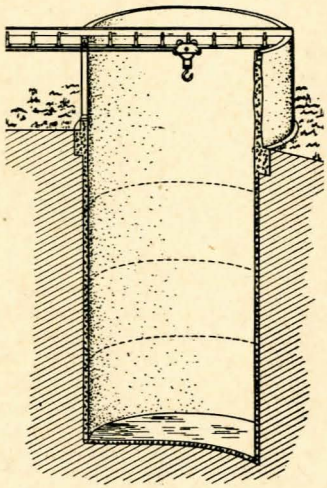


FIG. 9.—Illustrating the various stages of excavation of a semi-pit silo.

REMOVING THE EARTH FROM PIT SILOS

The most common method of hoisting the earth from the silo pit is to arrange a track support for a hay carrier car. The hoisting frame (fig. 3) as used by M. C. Anderson and his brothers of Cushing, Nebr., consisted of a tripod made of poles set up at one side of the silo and a scissor frame made of similar material at the other. The latter was set sufficiently far away so that a wagon could pass between it and the silo. A 2x12 was fastened between these supports, and an ordinary hayfork car attached to this which would elevate and carry the dirt. As a

means of carrying the dirt these men used barrels (fig. 10) which were two-thirds size and were made into buckets by boring a 1¾" hole thru the staves below the center. A 1½" pipe was put thru these holes and a chain fastened to each end of this to act as a bail. To hold the barrels from tipping while ascending, a wagon rod was put thru the upper part of the staves parallel with the pipe and one chain put on one side of this rod and the other chain put on the other side. When the barrel was dumped, the rod was pulled out far enough to free the chain on one side, and the barrel tipped itself. With this equipment Mr. Anderson says they arranged to fill a wagon in eight minutes. This would be about a cubic yard every five minutes. While removing the dirt from the pit, neighbors exchanged work so that a gang of seven men with two teams on the wagons and one on the hoist worked at once. Three men filled the barrels, one looked after the hoisting and returning of the barrels, and one drove the hoisting team.

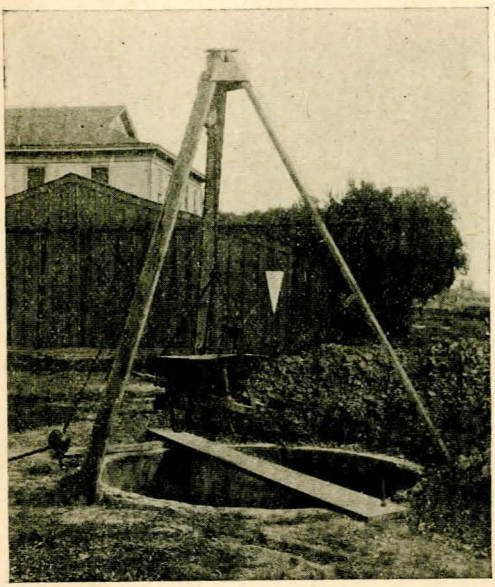


FIG. 11.—One method of removing dirt from a pit silo. When the wheelbarrow is being raised or lowered, the plank is slid to one side.

W. P. Bennett of Cambridge and the men on the Chase farm at Pawnee City used similar devices except that they used boxes instead of barrels for carrying the dirt. The bottoms of these boxes were hinged on one side and fastened with a catch at the other, which could be tripped, thereby letting the bottom drop down so that the dirt would fall out. These boxes were 20 inches wide, 20 inches deep, and 30 inches long. Mr. Bennett states that with five men digging in the pit he would take out four boxes every five minutes. This would be about a cubic yard every five minutes.

PLASTERING THE WALLS

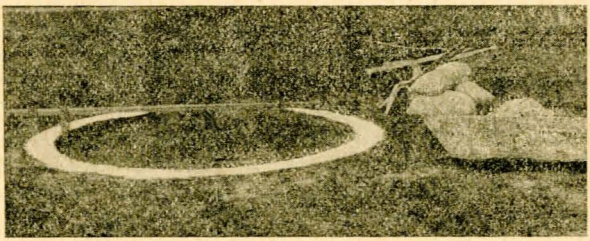


FIG. 12.—Heavy concrete collar in place for pit silo.

The plaster for the walls should be not less than one part Portland cement and two and one-half parts screened sand. The walls should be thoroly wet just before applying the plaster. The first coat should be left rough and then followed with a second coat before the first coat has had time to set. Some silos with three-eights inch plaster were inspected and found in good shape, but many were found to have chipped off at the end of one year's use. Where more than an inch and a half of plaster was used, the silos were always found in perfect condition.

COST OF PIT SILOS

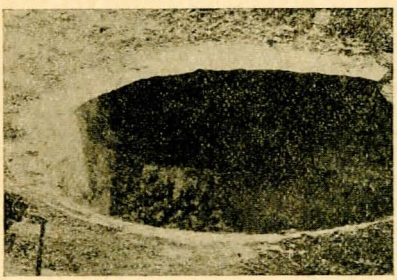


FIG. 13.—A pit silo in the making. The heavy concrete collar is shown exposed, and a part of the wall has been covered with the first coat of plaster.

At Cushing, Nebraska, five pit silos were built by one farmer and his four sons. A silo was dug on the farm of each of the sons and one on the father's farm. The digging for these silos was done during the coldest part of the winter and the plaster put on when the weather became warm enough to avoid freezing. To make the border of the silo, the men, by the use of a post hole auger, bored a series of holes adjacent to each other in a circle of the proper diameter, then trimmed the edges of the trench thus formed. The trench was then filled with concrete.

These men dug one silo without hauling the dirt away, but Mr. Anderson thought it took longer than to haul the dirt, as it took so much time to move the frame which supported the boisting apparatus.

Because of the cold weather they did not plaster their silos as they dug them. To support the men while plastering, they built a platform out of seven planks and supported these planks with four ropes, which were in turn fastened to planks lying across the top of the silo. These ropes were wrapped around the platform so that the men would untie the ropes and let the platform down as needed.

The work was all done with unskilled labor and at a time of year when little else could be done. Boys who had never touched

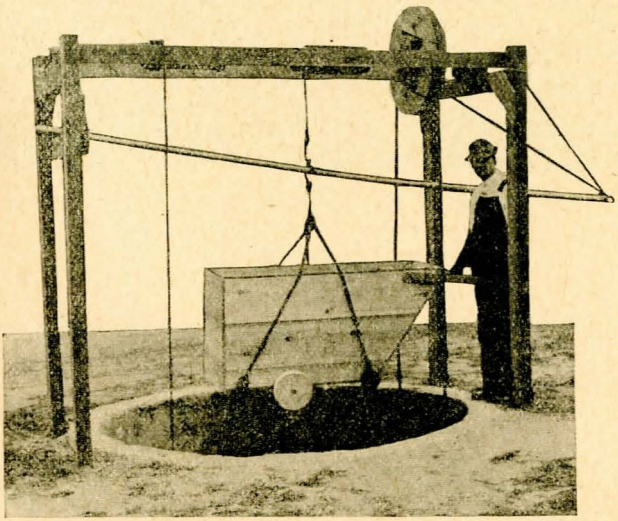


FIG 14.—Home-made hoist for pit silos.

a trowel before did a large part of the plastering. The following figures do not include the roof nor the hoisting apparatus. The latter would not amount to very much, as it would be divided among five men and nearly all of it used on the hayforks afterwards.

Mr. M. C. Anderson furnishes the following table of labor and material for the first silo and states that they made the others in less time:

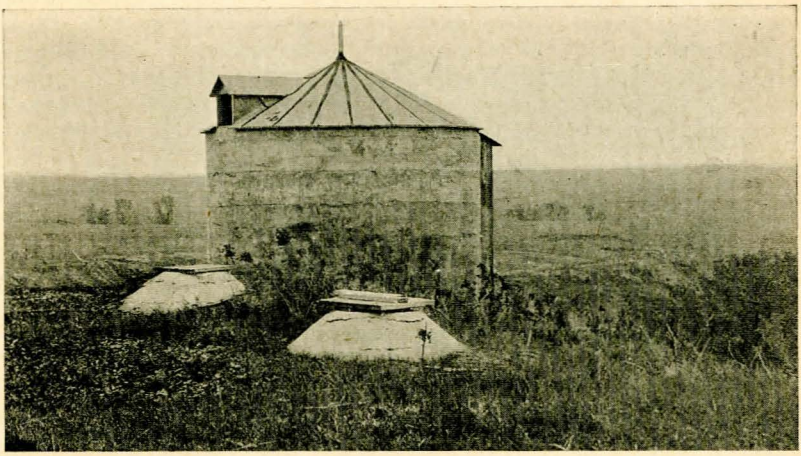


FIG. 15.—W. S. Corsa's bank silo at Daykin, Nebraska. Tops of water supply cisterns are shown in the foreground.

COST OF SILO ON M. C. ANDERSON'S FARM, CUSHING, NEBRASKA

14′x27′ full pit without roof

MATERIAL

Border		
2 loads sand, at 20c each	$0.40	
12 sacks cement, at 45c net	5.40	
Plaster for wall and floor		
20 sacks cement, at 45c net	9.00	
2½ loads sand, at 20c each	.50	
		$15.30

LABOR

Border		
Excavating, placing concrete, and hauling two loads sand; 5 men and 1 team, 6 hours	$7.50	
Silo proper		
Excavating, 5 men, 27 hours each, at 20c	27.00	
1 team, 27 hours, at 15c	4.05	
Hauling sand, 2½ loads	1.50	
Plastering, 24 hours, at 20c	4.80	
		44.85
Total cost of silo		$60.15

Cost per ton capacity $0.88

COST OF SILO ON W. P. BENNETT'S FARM, CAMBRIDGE, NEBRASKA

16'x30' full pit with roof and hoisting apparatus

Labor	$ 62.85
Board	18.00
40 sacks cement	20.00
8 loads sand	4.00
100 feet ½" wire cable	2.50
150 feet ¾" rope	4.00
Rope	4.00
Carrier for cable	4.00
Rope and post to erect cable	1.50
½"x12" bolts, top wall	1.00
Boxes to lift dirt	5.00
Lumber for roof	20.00
Total	$146.85

Cost per ton capacity.....$1.41

COST OF SILO ON CHASE FARM, PAWNEE CITY, NEBRASKA

12 feet in diameter, 13½ feet above ground, and 20 feet in the ground; walls 3½ inches thick below ground and 5 inches thick above ground.

	Labor, $2 per day	True cost, labor $1.50 per day
12 bolts	$0.30	$0.30
99 sacks cement for walls, 15 sacks cement for wall plaster, 3 sacks bottom, at 40c	46.80	46.80
31½ days digging and hauling	63.00	47.25
6 days team hauling	9.00	6.00
6 days elevating dirt	9.00	6.00
37 days constructing silo and hauling sand	74.00	55.50
3 days team hauling sand	4.50	3.00
5 days helping plaster	10.00	7.50
1¾ days plasterer, at $5	8.50	8.50
3 days on roof	6.00	4.50
Reinforcing, $3	3.00	3.00
220 feet of lumber in roof, 128 feet of lumber in rafters, at $26	9.05	9.05
10 pounds nails	.35	.35
Total	$243.50	$200.75

Mixture of concrete for walls
1 part cement to 5 parts bank run sand

Mixture for plaster on walls
1 part cement to 2 parts screened sand

Capacity.....78 tons
Cost per ton capacity.....$2.68

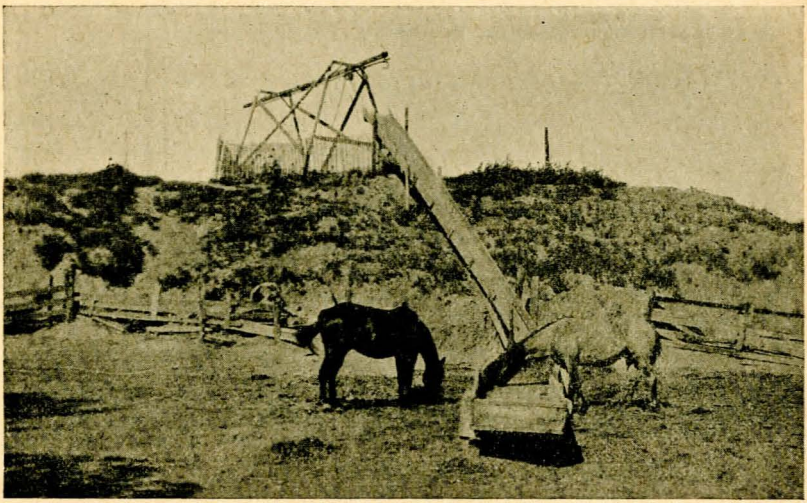


FIG. 16.—Pit silo in Republican Valley where the silage is hoisted and then conveyed to the feed bunks thru a chute.

COST OF 16'x30' FULL PIT SILO, USING THE COST OF M. C. ANDERSON'S 14'x27' SILO AS A BASIS OF COMPUTATION

MATERIAL

Border		
Sand, 2.25 loads, at 20c each	$0.45	
Cement, 14 sacks, at 45c each	6.30	
Plaster for wall and floor		
Cement, 25.6 sacks	11.52	
Sand, 3.14 loads, at 20c	.63	
		$18.90

LABOR

Border		
Excavating, placing concrete, and hauling 2½ loads of sand	$8.50	
Excavation		
5 men, 39½ hours each, at 20c	39.50	
2 teams, 39½ hours each, at 15c	11.85	
Plastering, 30.6 hours, at 20c	6.12	
		$65.97
Grand Total		$84.87

Cost per ton capacity.....$0.82

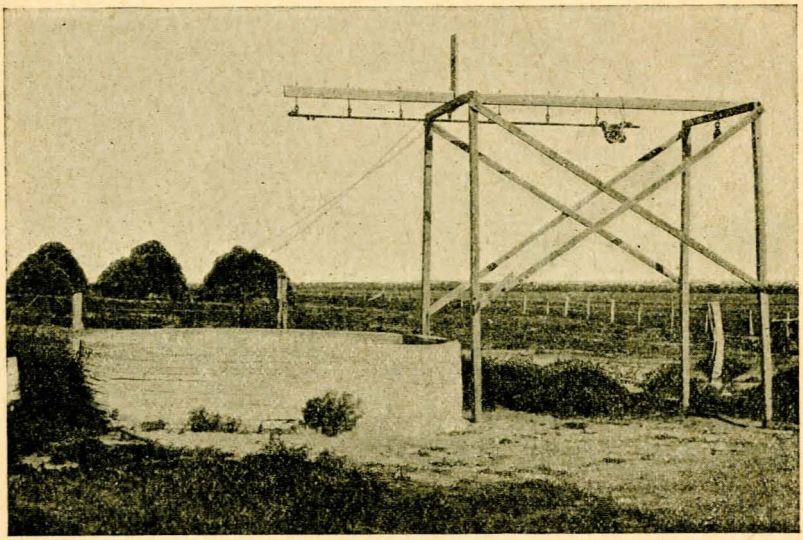


FIG. 17.—Pit silo and hoist near Holbrook in southwest Nebraska.

INSPECTION OF PIT SILOS

A number of pit silos have been inspected which have been used, some one year, some two years, some six years, and one for eighteen years. This inspection demonstrates the success of the pit silo, so far as the principle involved is concerned. These silos are giving universal satisfaction. Because, however, of the method of construction, one was being remodeled. One which was built with square corners required considerable time and expense in tramping the silage in the corners and around the rough stone wall while filling.

The pit silo which has been used 18 years was made by plastering the lower earth with natural cement and protecting the upper walls with brick. The cement had peeled from the walls in places, but the owner did not consider this sufficiently detrimental to make repairs necessary.

Another pit silo, which had been used six years, was made by building the upper walls of brick and leaving the earth bare below the brick. This silo was in a perfect state of preservation and giving excellent satisfaction.

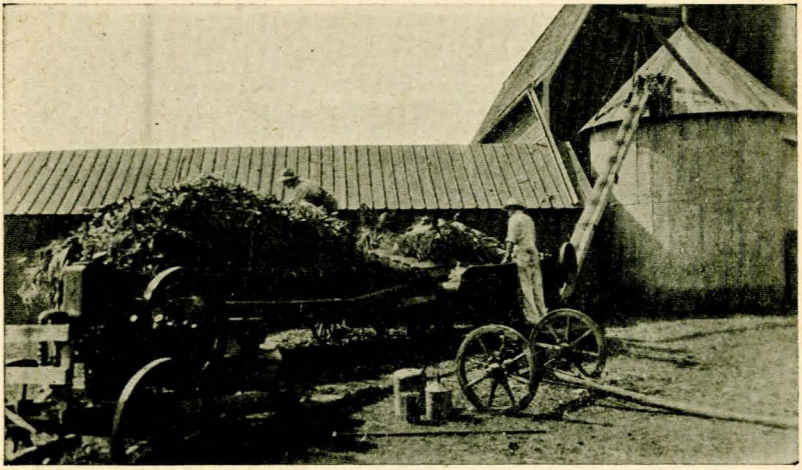


FIG. 18.—Filling a semi-pit silo with 5-horsepower gas engine on the Chase farm.

As a result of this inspection, the following recommendations are offered:

All pit silos should be built round, with the wall perpendicular and smooth. The wall should extend at least three feet above the surface of the ground. The concrete wall or border should extend at least three feet below the surface. Below this point the walls should be plastered with not less than three coats of rich cement mortar, and in loose sandy soil more coats should be added, giving a thicker and stronger surface. In the silos visited, where the plaster was from five-eights of an inch to one inch thick, of Portland cement mortar, the walls were in perfect condition, regardless of the length of time the silo had been in use.

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(Bul. 39—11-16-10M; Cir. 720—4-23-10M)