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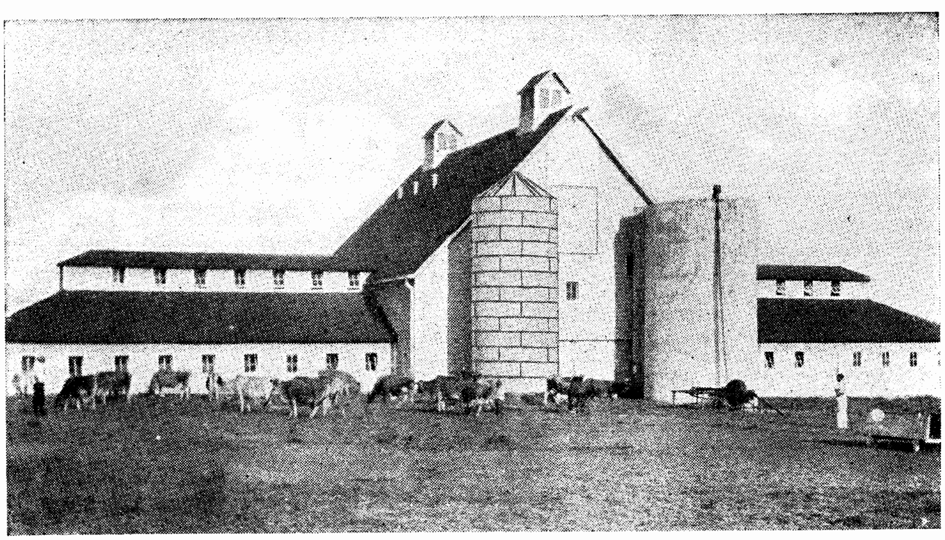
SILOS IN OKLAHOMA

BY C. I. BRAY AND D. R. FORRESTER
DEPARTMENT OF ANIMAL HUSBANDRY



DAIRY BARN, OKLAHOMA A. & M. COLLEGE
Concrete Silo on right, Metal Silo on left

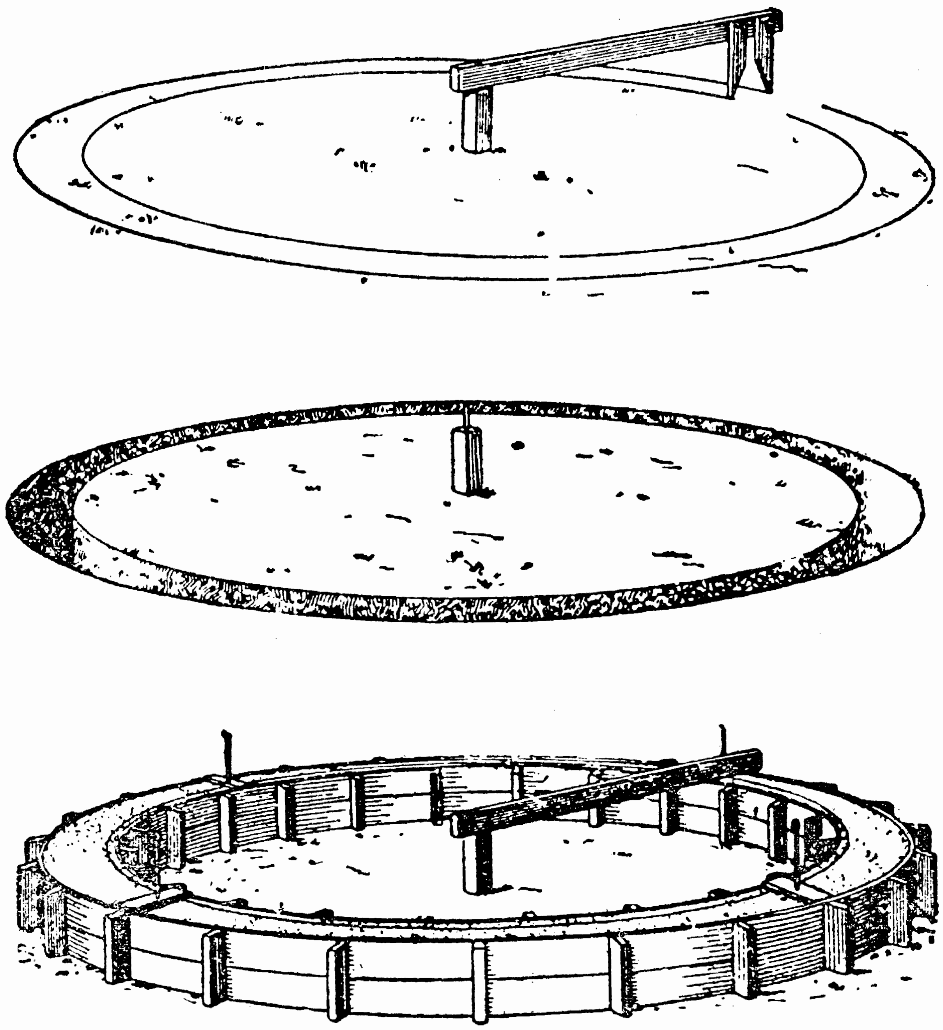


Figure 1 shows the best method of laying off the trench for the foundation of a silo or for collar of a pit silo. Middle section shows trench dug. Lower section shows foundation forms in place and filled with concrete. The foundation is leveled by a spirit level on the same sweep used in describing the first circle

ERRATA

Page.

8 Choice of Silo, second paragraph, fifth line, omit "or more".

26 Second line from bottom. The sentence, "The sections . . . bolted together" should come after the next sentence following.

30 Table IV, top line of figures, omit "1.11 (yds. gravel)".

30 Second line under "Reinforcing", as is "represented" by the hoops.

38 Second paragraph, second line, "see page 40".

38 Second paragraph, fifth line, "2-inchx5-16-inch strap iron".

39 Table VII, column A, figures represent "inches".

39 Table VII, two right hand columns, "sheet iron 3 feet wide".

40 Second line from bottom, " . . . inner form. Dimensions given for silo 16 feet in diameter."

41 Figure 36, "Form 4 feet high".

43 Under Figure 31, third and fourth lines, "levers like B are used for raising forms".

54 Last line, second paragraph, "buying and transporting them".

80 Last line, above Figures 86 and 87, "into the silo uncut".

Silos in Oklahoma

BY C. I. BRAY AND D. R. FORRESTER
Department of Animal Husbandry

INTRODUCTION

While the silo has been in use for centuries, and while thousands have been built in this country during the past thirty years, it has largely been within the last four or five years that silos have been recognized and appreciated as indispensible aids to success in the dry farming States, such as Kansas, Nebraska, Oklahoma and Texas. Probably more silos have been erected in Oklahoma during the past three years in proportion to its farming population than in any other State in the same period. The Oklahoma farmer has realized that livestock, in combination with drouth resisting crops, as kafir, milo, feterita, etc., and the silo are necessary to make profits certain with an uncertain rainfall. The fact that so many silos have been put up in the State during the past three years, and that thousands more are being planned, shows that silos have proved their value. Occasionally silo owners are disappointed because their silage is not the bonanza they expected, but those who have built and used silos have practically always been their strongest advocates.

The increased interest in silos has made it necessary for the Oklahoma Experiment Station to issue a bulletin on the subject that will give a fair description of the most common kinds of silos, their relative merits and methods of construction. Silo agents often exaggerate the faults of other types of silos to such an extent as to confuse the man who wishes to build or buy one. While it is hardly possible to give a complete description of all forms of silos now manufactured, it is hoped that this bulletin will answer most of the inquiries likely to be presented. By pointing out the essential features of a good silo and the most common defects of construction, it is hoped that builders of silos will thereby be helped to make their silos a success. The types of silos to be discussed range from the cheaper forms of homemade wooden or pit silos to the more expensive types, as concrete, tile or metal silos.

Advantages of the Silo

Silos are not luxuries, but necessities in Oklahoma. The silo preserves fodder in its best form for feeding and provides the cheapest of feeds for cattle and sheep, The whole corn, sorghum or kafir crop can be stored in the silo—butt, stalks and all—so that hardly any of the food value of the plant is lost. The silo stores feed in almost one-third the space that it can be stored in dry form in the barn, and the fields are cleaned up for other crops. No corn stalks are left in the way of the farm implements, neither are there any to be thrown out of mangers and feed racks. The loss of feed nutrients in curing is less in the silo than when corn is shocked in the field under the most favorable conditions, and many times less than when the stalks are allowed to stand in the fields through the winter. Corn stalk disease is avoided by the use of the silo. It is an improvement on the growing and cutting of green feed for dairy cows in summer, as with the silo the whole summer's feed can be planted at one time, cut and harvested at one time, and stored in a most convenient form for feeding. While the curing of hay is dependent largely upon the weather, the curing of silage takes place in the silo, regardless of weather, and, unlike a green fodder crop or soiling crop, is ready to feed at any time, regardless of bad weather, wet fields or pressure of work. With kafir or sorghum cane and enough silos, cattle can have the equivalent of good pasture all through the year, even in the regions where the rainfall is insufficient for good pasture and for ordinary farm crops. The saving of the corn stalks annually wasted and the converting of them into beef and mutton will mean an enormous increase to the wealth of the State.

One acre of kafir or sorghum can, by the use of the silo, be made to produce more succulent feed than several acres of pasture. The silo provides an efficient substitute for pasture grass in winter, insures the dairyman against drouth and short pastures in summer, and is more important and necessary than a hay barn.

Requirements of the Silo

The silo is nothing more than an enormous tank or preserving can for keeping green fodder in its natural, juicy condition without it molding or spoiling in any way so that it can be used lated in winter or dry weather. While the feed will heat, lose color and become somewhat acid, these changes will do little toward reducing food value. A good silo will keep feed for years in practically as good shape for feeding as when put in. To give satisfactory results, a silo should fulfill all the following requirements:

1. The walls should be airtight. Wherever air gets in through the silo walls or around the doorways, a considerable amount of feed will be spoiled and unfit for use.

2. The walls must be perpendicular and smooth. If they are rough or out of plumb, spaces will be left between the silo wall and the silage as the latter settles, allowing air to get down around the silage, which may spoil it for a foot or more around the edge. Ir-

regularities in the wall may also hinder the silage from settling evenly and the air will not be driven out as completely as it should.

3. The walls must be strong and rigid. A good deal of pressure develops on the inside of a silo, especially in high silos or where very juicy feed has been put in. Many silos have been cracked by this pressure, causing the loss of an investment of from $300.00 to $500,00. In wooden silos of square type, the walls may spring away from the silage near the top of the silo, owing to greater pressure farther down, and thus allow air to get in at the top. For this reason square wooden silos are rarely built, except in harns, where the walls are held in place by the framework of the barn.

4. A good silo should have a height of two to two and one-half times its diameter in order to get enough pressure on the silage to exclude the air. Very few silos are made less than twenty feet in height.

The Size of the Silo

The size of the silo to build will depend on the number of cattle or other stock and the length of time they are to be fed. The following table gives the usual amounts fed to various classes of stock per day, with the number of tons they may be expected to eat in six months of winter, November 1 to April 30:

TABLE I

Kinds of Stock.	Daily Ration in Pounds.	Tons Eaten. in 180 Days.
Calves, 8 months old	15 to 20	1½ to 1¾
Breeding cows (beef)	30 to 50	2½ to 4½
Fattening beef cattle, 18 to 20 months	15 to 30	1½ to 2½
Dairy cattle	30 to 50	2½ to 4½
Sheep	2 to 5	¼ to ½
Horses	5 to 15	½ to 1½

The diameter or width to build a silo will depend on the amount of silage to be fed daily, since a layer of silage at least two inches deep should be removed from the entire exposed surface of the silage each day to prevent molding. A man with twenty head of cattle to feed will require a silo of less diameter than if he had fifty to 100 head. If he is to feed the smaller number for a long period of time the increased silo capacity should either be obtained by extra height or by putting up two silos of smaller diameter rather than one large silo. For feeding silage in summer, when stock are not likely to eat as much as in winter, a silo of relatively small diameter is needed, especially as silage will spoil faster in hot weather, and a deeper layer must, therefore, be removed daily. As previously stated, the height of the silo should be two to three times the diameter. Table II suggests the best measurements for common sizes of silos, ranging from thirty-seven to 270 tons capacity. The table also shows the number of cows that these silos would feed for six months and the average acreage of cane or kafir required to fill them.

TABLE II

No. Cows.	Tons Silage for 6 months.	Diameter of Silo.	Height of Silo.	Acreage to Fill 10 Tons per Acre.	Acreage to Fill 6 Tons per Acre.
12	37¾	10	26	3	6¼
15	40½	10	28	4	6¾
20	54	12	27	5½	9
25	67½	14	25	7	11
30	81	14	29	8	13½
35	94½	16	26	10	16
40	108	16	29	11	18
45	121½	18	27	12	20
50	135	18	29	14	22½
75	202	20	34	20	34
100	270	20	40	27	45

The weight of silage in any given silo will vary greatly according to the dryness of the silage. The table of capacities given below is based upon heavy, green fodder, such as is usually put up in the corn belt. In Oklahoma our silage crops are not only more ripe and dry as a rule before being cut, but when left on the ground for even a few hours after cutting before being put into the silo lose still more moisture. The average weight of a cubic foot of silage is estimated at forty pounds. The chances are that a cubic foot of average Oklahoma silage will weigh from twenty-five to thirty-five pounds. This would reduce the actual weight of silage in the silo about one-third to one-fourth below the amount given in the table.

To estimate the actual amount of silage in a silo, take half the diameter of the silo, multiply it by itself, and multiply the result by 3 1-7. This gives the area of the cross section of the silo in square feet. If the silage was put in green and juicy, fifty to fifty-five square feet of silage one foot thick would weigh one ton, so that the number of square feet obtained above should be divided by fifty to get the number of tons silage per foot of height. To get the capacity of a silo in tons, multiply this result by the height of the silage in the silo in feet. Example: Given a silo 10 feet in diameter, containing twenty feet of silage, find the number of tons of silage per foot of height and the total silage in the silo as follows:

½ of 10=5=radius
5×5=25 feet= square of radius
25×3 1-7 = 78½ sq. ft., area of cross section of the silo
78½ divided by 50 equals 1.57, tons of silage in each foot of height
1.57×20=31.4, the number of tons silage in the silo

The weight of silage varies according to the depth down in the silo. The weight of the silage in the first ten feet at the top may weigh only twenty to twenty-five pounds per cubic foot, and forty to fifty pounds near the bottom of the silo, where it is under greater pressure. If thirty pounds is taken as the average weight of a cubic foot of silage, divide the number of square feet of surface in the above calculation by sixty-five instead of by fifty, to find the number of tons, before multiplying by the height. For example: In the above problem, 78½ divided by 65 instead of by 50 would give 1.2 tons silage in each foot, and this, in turn, multiplied by 20 would give only twenty-four tons, instead of thirty-one and four-tenths tons.

TABLE III

Capacity of Round Silos in Tons

For ordinary Oklahoma silage, somewhat dry, take two-thirds or three-fourths of amounts stated.

Inside Height of Silo	Diameter of Silo 8 Ft.	10 Ft.	12 Ft.	14 Ft.	16 Ft.	18 Ft,	20 Ft.	22 Ft.
20 feet	17	26	38	51	67			
21 feet	18	28	41	55	72			
22 feet	19	30	43	59	77			
23 feet	20	32	46	63	81	103		
24 feet	22	34	49	67	86	110		
25 feet	23	36	52	71	91	116	143	
26 feet	24	38	55	75	97	123	152	
27 feet	25	40	58	79	102	130	160	
28 feet	27	42	61	83	109	137	169	205
29 feet	28	44	64	87	114	144	178	216
30 feet	30	47	67	91	119	151	187	226
31 feet	31	49	70	96	125	158	196	237
32 feet	33	51	74	100	131	166	205	248
33 feet	35	53	77	105	137	174	215	260
34 feet	36	56	80	109	143	181	224	271
35 feet	37	58	84	114	149	189	234	282
36 feet	39	61	87	118	155	196	243	293
38 feet	41	66	94	128	167	212	262	316
40 feet	45	70	101	138	180	228	282	340
45 feet				165	215	269	330	399
50 feet						310	382	462

Table III gives the standard capacity of round silos in tons of silage. To contain these amounts of silage the silos must be full and the fodder put in must be fairly green and heavy. It is rarely advisable to build a silo more than forty feet above ground because of the extra power required to elevate the silage above that height. Neither is it advisable as a rule to have a silo of greater diameter than 20 feet on account of the large amount that must be removed daily. With a wider silo, the average man needs to handle the silage twice in getting it to the door from the further side of the silo. From two to eight extra feet may be easily and cheaply added to the depth of a silo by digging down that far in the ground. This extra capacity costs little and does not add to the power required in filling the silo.

Types and Forms of Silos

Silos may be round, square, or eight-sided, but probably nineteen out of twenty silos built are cylindrical in shape, as this form has proved most economical. The round silo requires less material to build for any given capacity. There are no corners in which silage can spoil, and the walls do not need to be so strong or rigid as in the case of the straight-wall silo.

Square silos are more likely to be found in the North where lumber is cheap, and where the silos are often built inside of a barn to avoid freezing. A concrete silo may be built in the square form if desired. The objections to a square silo are that a greater amount of material is necessary to build it, and that the walls (of a wood silo) are likely to spring out on account of the pressure of the silage, thus letting air in at the sides. The silage is harder to pack in the corners and is more likely to spoil. The octagonal silo has an advantage over the round silo in that it can be built of straight material, while corresponding closely to the round form and avoiding the defects of the square silo. This form is commonly found in wooden-frame silos or in the Commonsense Silo.

Choice of a Silo

Of the silos most commonly in use in Oklahoma, we have the following: Pit silos, homemade stave silos, wooden-frame silos, patent stave silos, the Commonsense silo, the Leitch silo and the Wisconsin or Gurler silo, the latter representing the more permanent type of wooden silo. Of the more permanent silos we have the following: Metal silos, solid-wall concrete silos, plastered cement silos, and cement stave silos, concrete block silos and brick or tile silos. The pit or underground silo is found principally in the western part of the State.

As a general rule the more expensive silos are the more permanent and durable, and consequently may ultimately give as good, if not better, value for money invested than the cheaper type. The man with little capital, however, especially if he has not a permanent location for his buildings, may well afford to put up a cheaper silo or more. If well cared for, a good wood silo may give him good service for ten to twelve years. Cost of materials may vary in different parts of the State. One man may be located, for instance, where sand and gravel are cheaply and easily obtained, and consequently he may profitably erect a cement silo, either solid-wall type or of homemade concrete blocks. It might cost a man in another locality two to three times as much to get the same materials, so that he might find some other type of silo preferable.

If the walls of a silo are airtight, strong and rigid, perpendicular and smooth on the inside, and if the silo is reasonably permanent and durable in proportion to cost, it will prove satisfactory, regardless of the material of which it is built. If a silo is lacking in any one of these particulars it can hardly be successful even if built of good materials and perfect in all other particulars. Practically all the commonly advised types of silos will give good results if properly erected and cared for. The choice of a silo or the materials from which to build one will be determined largely by questions of economy or permanency. The more expensive types of silos are usually more desirable for the man who has a permanent location for his buildings and who wishes a silo that will last a long while. The cheaper forms of silos, while not as lasting, may be as efficient for a few years and may prove a good investment for the man with little capital, or who is a renter on another man's farm.

Since there is little danger of silage freezing in this State, the natural heat of the silage affording sufficient protection, the matter of frost resistance is not important. The permanent silos are usually fire, wind and verminproof, and require less repairing than the cheaper types. The interest on the investment in an expensive silo will naturally be more than with the cheaper wood silos. The choice of a concrete silo may depend upon whether the owner has sufficient ability, or can hire some one with the ability to erect one properly. With the high priced silos there is more loss if the silo is unsatisfactory through faulty construction.

What Is the Best Silo

There is no best silo. Any one of the silos named above, if well constructed and well cared for, should give good satisfaction at least for a period of time proportionate to original cost. Almost any silo will pay for its original cost in at least two or three years, if not in one year. Since even the cheaper wood silos may last from six to ten years, the more permanent types being practically indestructible, a man has little to lose in choosing any of these silos.

Location of a Silo

Convenience should be the first consideration in locating the place to build. In cold climates it is customary to build a silo either in or close against the barn so that silage may be thrown directly into or approximately near some door of the room. In milder localities it is customary to put the silo near some door of the barn without connecting the two structures. In this case the silage will still be within convenient distance and the odor of the silage will not be as much in evidence in the barn. Stave silos may be built on such side of the barn as will protect them somewhat against high winds. Where cattle are fed in outdoor lots and the silage is fed from a wagon the exact location of the silo with reference to the feed troughs is not important, though it should be where the wagon can be conveniently driven under the chute to be filled. The location selected should be dry and well drained, since if water gets under the foundation it may cause the silo to settle to one side. Where farm buildings are already located, they will usually be on a fairly well drained location.

Foundation

Whatever material is used in the construction of a silo, whether wood, metal, brick or concrete, it is recommended that a concrete foundation be built extending at least three feet into the ground and one foot above the ground. It is economical and advisable to excavate three feet deep for the silo, as three feet in depth is thus added cheaply. The following plan of laying out a silo and of building the concrete foundation is recommended, particularly for stave or other wood silos:

A stake should be driven into the ground in the center of the proposed silo and sawed off squarely at the height to which it is planned to have the concrete foundation come. At the top of this stake, with a spike or bolt, fasten a 2x4 a little longer than half the diameter of the proposed silo in such a way that the scantling may be moved around to mark off the silo circle, as indicated in Figure 1. Level the ground first. By nailing on two markers, the inside and outside edges of the foundation are marked at the same time eight to twelve feet apart. These should be so placed that the inner circle, for a stave silo at least, will be about four inches inside of the circle of the silo itself. Where the silo is of a kind that can be fastened to the foundation solidly, as in the King silo, the inner edge of the foundation should be the same diameter as the silo. Having thus laid off the silo, the 2x4's should be removed and a trench dug for the foundation to the depth desired, as shown in Figure 1, 8 to 12 inches wide, according to the size of the silo and character of the ground. The inside wall of the ditch should be smooth and plumb. Do not remove any of the dirt from the center at this time. The concrete for the foundation may be made of one part cement, three parts sand and five parts broken rock. Fill the trench with concrete to the surface of the ground. In constructing a form for the concrete wall above the ground, drive 2x4 stakes one-half inch from the foundation, both inside and outside, and two feet apart all the way around. (See Figures 2 and 3.) Half-inch lumber or sheetiron may be bent around on the inside of these stakes. The top of this form should be made exactly

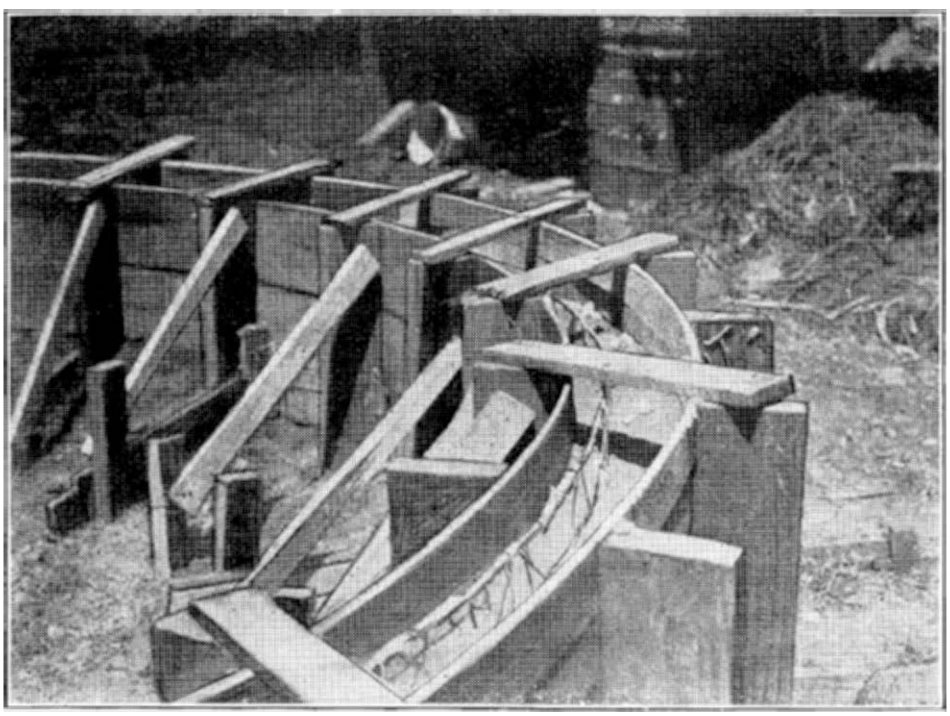


Figure 2—Concrete foundation for Stave Silo in process of construction, showing reinforcement of steel woven wire fencing. Note braces, which are necessary only on inside of form

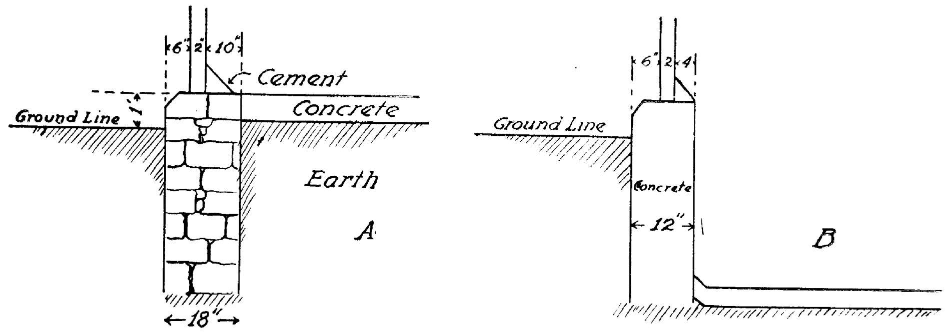


Figure 3—Types of foundations for wood silos. A. Masonry foundation silo floor level with ground. B. Concrete foundation. Earth excavated to bottom of foundation, giving six to twelve (6 to 12) tons additional capacity to silo at little cost

level. This is done by driving a longer stake in the center, the height the foundation is to be, nailing the 2x4 sweep back into place and using a spirit level on it as in Figure 1. When the foundation wall has been completed and is set, dig out the earth in the center to the depth of the foundation wall, and if desired lay a concrete floor. The chief advantage of such a floor is that it prevents rats from getting in and burrowing through the silage, causing it to spoil. If a sill is to be bolted on, as in the Commonsense or Wisconsin silos, 12-inch bolts may be bedded in the wall at regular intervals before the concrete fill is completed, so that the thread ends will project three or four inches above the foundation. If special anchors are to be put in (Figure 22) they must naturally be put in at this time. It is not advisable to have the foundation project much inside of the circumference of the silo, though with a stave silo this is usually necessary. An air pocket will be formed at this place as the silage settles and air will be drawn in between the bottom of the silo and the foundation, spoiling the silage. With concrete or brick silos the foundation of the silo is part of the silo wall. A foundation for a metal silo will be illustrated later. Other types of silo foundations are illustrated on pages 34 and 68.

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I—WOODEN SILOS

Wooden silos largely outnumber all other kinds at the present time and are built in many different ways. The first cost of wood silos is usually less than for other forms, and they can be erected by more or less unskilled laborers or by ordinary carpenters. It requires less experience to build these silos than such as the concrete silo. The principal objection to wooden silos is that they decay in from six to fifteen years, and that they are not fireproof. While it lasts, wood makes a good silo wall, because it swells, thus making it airtight. Stave silos, while the simplest to construct and set up, frequently blow down, though with proper foundation and sufficient anchoring at top and bottom they may go through almost any gale short of a tornado, even when empty, in comparative safety, providing the hoops are kept tight.

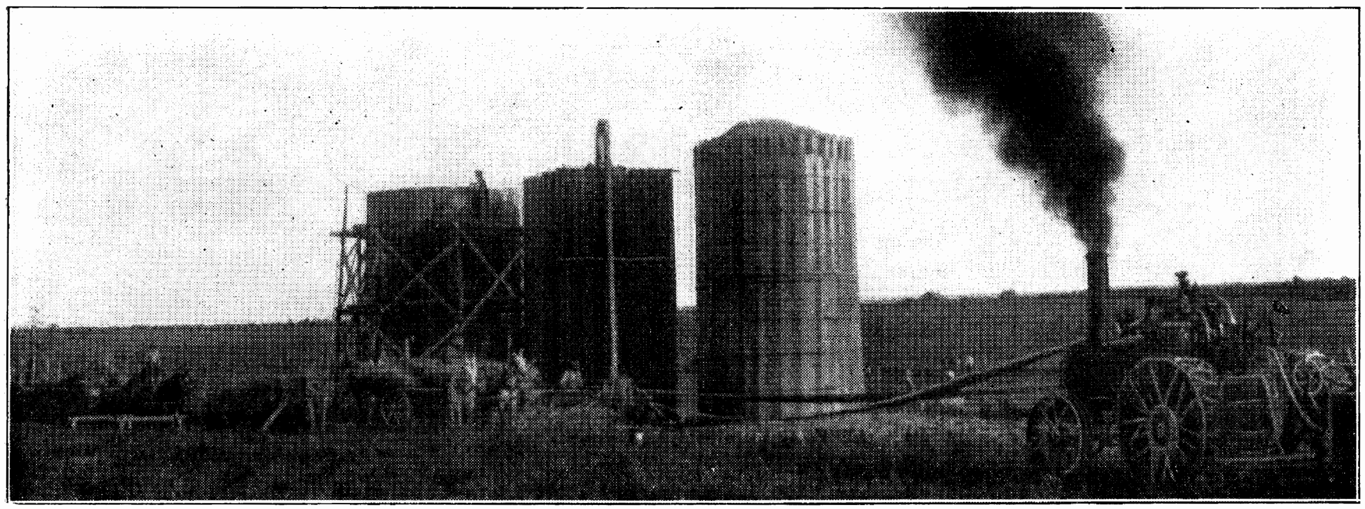


Figure 4—Three homemade Stave Silos on A. and M. College Farm, built of 2x6's

1--THE HOMEMADE 2x6 STAVE SILO

The homemade wood-stave silo, as used on the A. and M. College farm, is very cheap and efficient, costing only about $100.00 for seventy to eighty tons capacity. (See Figure 4.)

Material Needed

100 pieces of 2x6, common pine, 24 feet long, dressed edges
6 pieces of 2x4, 24 feet long
384 feet of ⅝-inch iron rods
24 ¾-inch tank lugs (Figures 19 and 20)
4 pounds of ⅝-inch hexagonal nuts
100 feet of 3-inch cypress bats.

The lumber in 24-foot length staves will make a silo 14 feet 9 inches in diameter by 24 feet high, holding approximately seventy-five tons of silage. Have the ⅝-inch iron rods cut into 16-foot lengths and threaded 6 inches at each end. Bend to the right circumference of your silo. This will make eight iron hoops, each hoop in three pieces, and joined together with tank lugs. Level the ground on which the silo will stand, and by means of a small sweep, 7 feet 4½ inches from center to circumference, lay off an exact circle for the bottom of the staves so that your circumference will be perfect.

Directions for Setting Up

Door Frame.—The doorway is a continuous opening from top to bottom, made of 4x6's (spiking 2x6's together). Pick out straight and sound pieces for the door frame and fasten together. Lay one side piece on top of the other and bore 1-inch holes through both pieces 2 inches from the inner edge. These are for the hoops to go through. Bore the first hole 12 inches from the bottom, the next one 2 feet above the first, the third 2 feet above the second, the fourth 2½ feet above that, the fifth 3 feet above the fourth, the sixth 3½ feet above the fifth, the seventh 4 feet above that, and the eighth and last one 5 feet above the seventh and 1 foot below the top of the silo. These holes will allow the continuous iron hoops to pass through the door frame, and these side pieces may now be fastened together in ladder form 2 feet apart. Spike a piece of 2x6 across the ends at top and bottom, and nail pieces of 1x4 across the front for ladder rungs, spacing them so that they will come in front of the hoops. Extra steps are put on near the top where the hoops are wide apart. Erect the door frame in place and anchor it firmly by means of temporary braces.

The six pieces of 2x4's (24-foot lengths) should have 1-inch holes bored to allow the hoops to pass through, and these holes must be spaced the same as the ones in the door frame. The 2x4's should be set up around the circumference of the silo and braced so that they will be approximately seven feet apart and will fit edgewise into the wall of the silo. Be careful to bore the holes so that the inside edge of the 2x4 will come flush with the inside wall when the staves are set in place. The iron hoops are then placed in position through the holes in the door frame and the 2x4 ribs and joined together by the lugs.

After the door frame and the 2x4's are up and braced, and the rods put through the holes, as described above, this skeleton framework is used in place of an outside scaffold. This method was not used in putting up the first silo. Put staves across to ride on the rods, making one footboard about seven feet from the ground, one half way up, and one near the top. Bend the hoops to the right curve before putting them through the holes. Beginning at the doorway, set up the first 2x6 stave and by means of small nails and a cleat tack this stave to the door frame. Laths soaked in water make good cleats for this work. Continue putting up the staves, being sure that they are plumb, and that they follow the right circumference, tacking each stave to the preceding one. When the first 2x4 rib is reached, jam this rib up firmly against the last stave, and tack a long brace from the door frame to this rib. This makes the wall strong, and as each section is filled in these braces should be placed from each rib to the door frame. As the wall is nearly completed it may be necessary to use a ladder or a light scaffold on the inside to put in the last staves. As the last stave is placed in position the hoops should be tightened gradually from bottom to top and the cleats on the inside knocked loose. The door is closed with short sections of the 2x6's as the silo is filled, using putty or white lead or clay between the boards. This silo is built right on the ground without foundation or anchoring and is taken down each summer as soon as empty and stored away. It is not much trouble to set up again in the fall.

Where the above system of erecting is not followed, the silo may be put up by means of scaffolding, as any other stave silo. The door frame is set up first, as before, and hoops put in place and held up by the scaffolding. Only the two top hoops and the two bottom hoops need be put in place at this time, having first bent them to the right shape on the ground.

The 2x6 staves can be readily put in place then and held together by toe-nailing the first ones on each side of the door frame. Then, at the upper and lower parts of the silo on the inside, tack barrel staves or lath or other thin lumber around to hold the staves together. On the outside the driving of 12-penny nails in each stave at one of the upper and lower hoops and hooking the nails over the hoops will help hold the staves in place until the hoops are tightened. If a man is kept on the inside to tap the staves into place while the hoops are being tightened, a good job can be made and the walls will be tight. The silo must be kept in an exact circle and the staves plumb. Two or three diagonal braces will keep the silo from twisting.

2—THE FLOORING SILO WITH WOODEN HOOPS

The flooring silo with wooden hoops is one of the very cheapest silos, and can be profitably used on farms where there is only a small herd of livestock, such as five or six milk cows and a team of horses. A silo 7 feet in diameter and 20 feet high will hold fifteen tons of silage. This is a very small silo, and ordinarily it is not profitable to erect one of such dimensions. However, with such cheap material this size of silo may prove profitable.

Materials for Wood-Hoop Silo 7x20, Capacity 15 Tons

530 feet of 6-inch hard pine flooring @ $30.00 per M	$	15.90
220 feet lapsiding for ten hoops @ $30.00 per M		6.60
Nails		1.00
Total	$	23.50

Bill of Lumber for 16x24-Foot Silo, Capacity 86 Tons

1440 feet 6-inch hard pine flooring @ $30.00 per M	$	43.20
600 feet ½x4-inch lumber for hoops @ $30.00 per M		18.00
Nails		2.00
Total	$	63.20

The total cost of this first-mentioned silo, outside of labor, will be about $1.60 per ton capacity. Two men can build it in one and a half days.

It is not advisable to build large silos of this type, since the length of flooring is not enough to get sufficient height for a large diameter silo. Twenty or twenty-four feet will probably be the greatest length of flooring on the market. Fourteen feet is about the maximum diameter for a silo of this height. By digging down in the ground from four to six feet and building a concrete foundation wall,

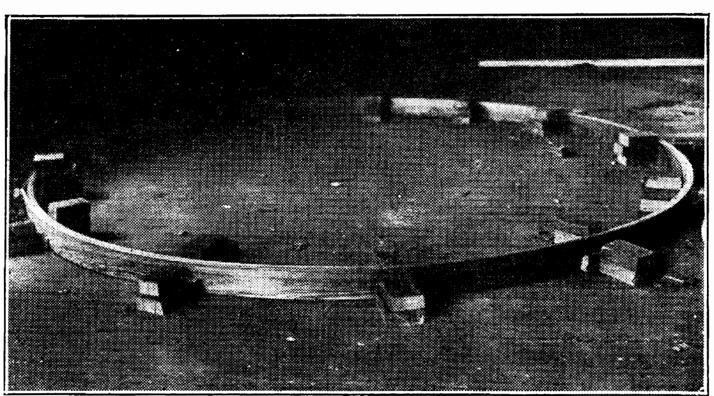


Figure 5—Wooden hoop for silo in process of construction. Note double circle of blocks, with wedges driven between hoop and outside blocks

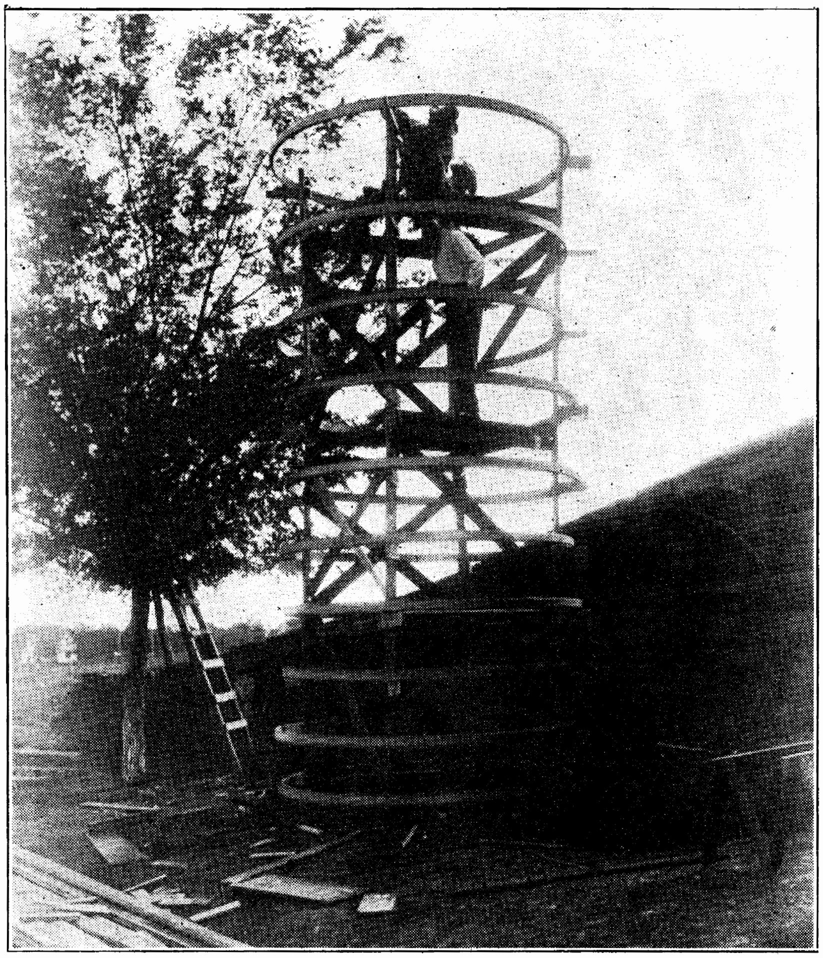


Figure 6—Model wooden-hoop Silo in process of construction. Scaffolding up and hoops in place

a depth of thirty feet can be secured, which will be sufficient for a silo 16 feet in diameter. The cost of excavating six feet, with the cost of cement, would make the total cost of this silo about one hundred dollars. A silo of this size will hold 120 tons and will not cost over one dollar per ton capacity, and possibly as low as seventy-five cents per ton capacity.

How to Build a Wooden-Hoop Silo

To build this silo, first make three-ply or four-ply hoops of wood. Where native lumber cannot be had, good batting or cypress lapsiding may be used, or any ½x6-inch stuff will do. The best way to make these hoops is to draw an exact circle of the right diameter on a barn floor or good, hard ground. If on a barn floor, nail blocks firmly on the inside of the circle, four inches high and eighteen inches apart, and nail other blocks two inches outside of these. If on the ground, drive good, square stakes instead of blocks. The hoops are made by placing the lumber between the two rows of blocks, wedging down firmly against the inside blocks, and nailing with 8-penny galvanized nails. (See Figure 5.) In setting up the silo the hoops are all placed one on top of the other on the foundation, then a four-legged scaffold is built on the inside as high as the proposed height of the silo. The legs of the scaffold are kept about one foot from the edge of the silo. Staging should be placed about eight feet apart. Beginning at the bottom, mark off on the uprights of the scaffold the place for the bottom hoop, making sure it is the same height on each upright. Then from this point measure eighteen inches higher for the next hoop and mark the place, twenty inches to the next, twenty-two inches to the next, and so on to the top. Draw the top hoop to the required height and hold in place by nailing on bracket arms to every scaffold leg where marked, letting the hoop lie loosely on top of these brackets. Continue in the same

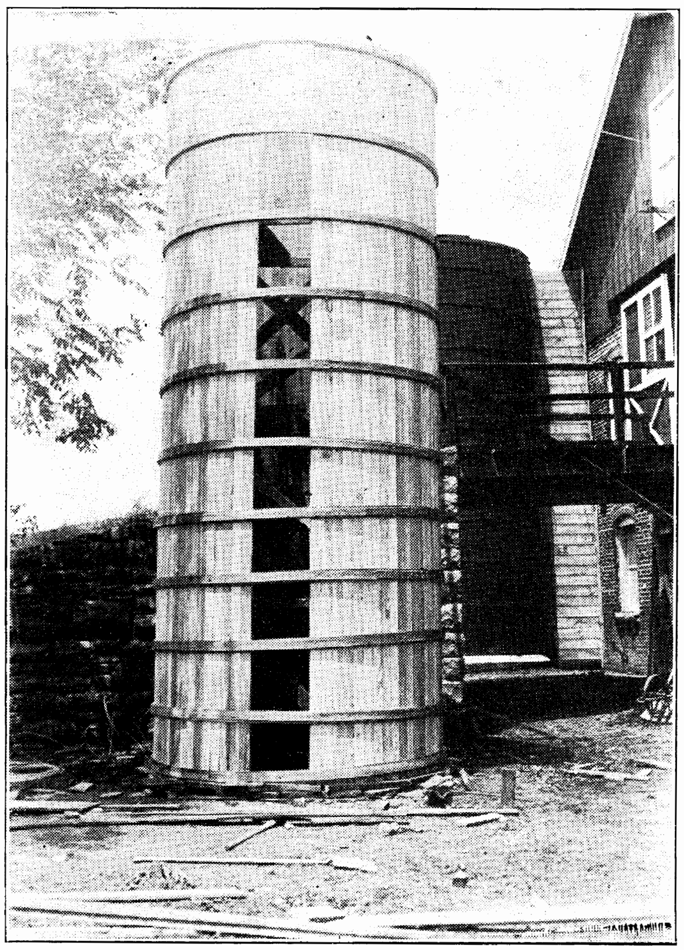


Figure 7—Model wooden-hoop flooring Silo at A. and M. College beef cattle barn. Lumber donated by Spurrier Lumber Company, Stillwater. Size 8x14 feet, capacity 17 tons; cost $23.00. Larger sizes cost less per ton capacity

manner until each hoop is in place. (See Figure 6.) Then begin putting on the hard pine flooring inside, commencing at one edge of where the doorway is to be. In putting on this lining, keep the groove ends of the board ahead. Double nail every other board on each hoop and single nail the others. Use 8 or 10-penny galvanized nails for this purpose. Drive the boards up close and draw tight, plumbing the hoops as you advance. Leave an opening for a continuous doorway about twenty inches wide. No door frame is needed. Simply cut off pieces of flooring 26 or 28 inches long and nail two or three pieces together so as to make narrow doors 7 to 10 inches wide and 26 to 28 inches long. Lay these one above the other across the opening as filling advances. (See Figure 7.)

One of the most important things to watch in building is to have the hoops the right distance apart and the wall plumb while the lining is being put on. Professor A. S. Neal of the Kansas State Agricultural College recommends that the hoops be treated with creosote or some wood preservative, and that the bottom hoop be bedded in a concrete foundation, building up the cement on the outside of the hoop. It is better to have a number of spikes driven through the hoops into the cement. These silos are good for at least eight years.

3—THE LINED FLOORING SILO

A more permanent type of wood-hoop silo may be made. Hoops are made of ½-inch stuff, as in the silo just described, but four thicknesses are used instead of three. One-inch flooring is nailed on perpendicularly as before, but by breaking joints at the third and ninth hoops the silo may be made 30 feet high instead of 24 feet. A lining of building paper, plain or tarred, is next put in, and then one thickness of half-inch lumber, which may be nailed on round and round or up and down as before. The latter is easier to put on, but the other way adds much to the strength of the silo. Green hardwood is recommended for making the hoops, but is not essential. With a good concrete foundation and sufficient anchoring at top and bottom there is no reason why this silo should not prove reliable and permanent. The door in this silo may be continuous or only in each alternate space between hoops. (See Figure 8.)

Wood silos should be well braced and anchored if they are left standing empty during the summer. In both the homemade stave silos and the flooring silo a strong wooden or iron hoop should be put at the top of the silo on the inside. This keeps the staves from blowing in and makes a good attachment for guywires. At least three guywires should be run from the top of a silo to some nearby trees or posts at equal distances around the silo. A log buried in the ground will do where there is nothing else to fasten to. Two strands of No. 9 or heavier wire may be used. Holes should be bored through the top of the silo in such a way that the guywires will go around or

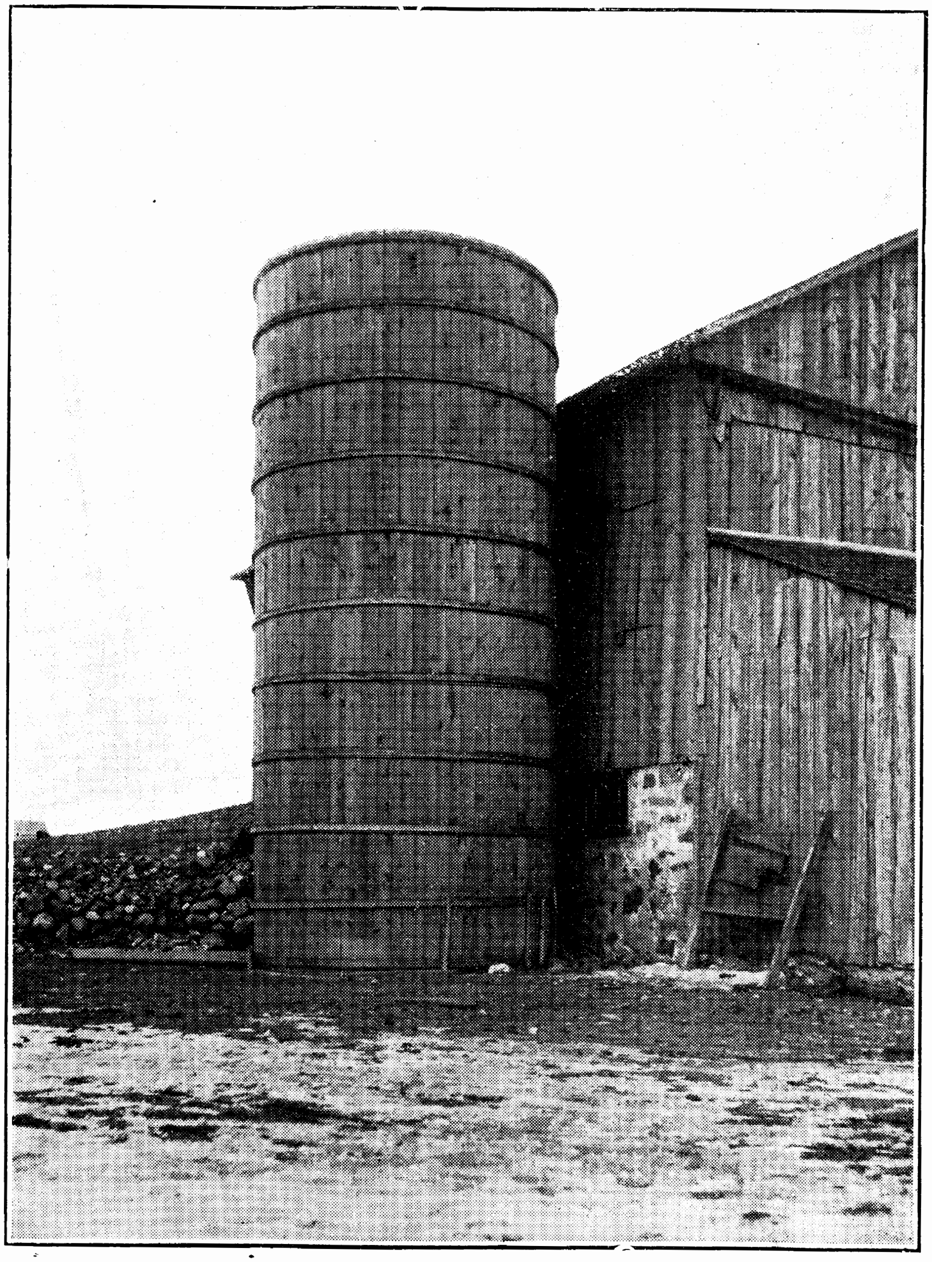


Figure 8—Wooden hoop flooring Silo, 30 feet high, lined with building paper, and half-inch lumber, nailed round and round on the inside. Four-ply hoops of half-inch green hardwood lumber. Staves spliced out of alternate 20-foot and 10-foot lengths

through the inner hoop at the top. After attaching to the anchor at the bottom the wires may be twisted together until tight.

4—OCTAGONAL SHAPED FRAME SILO

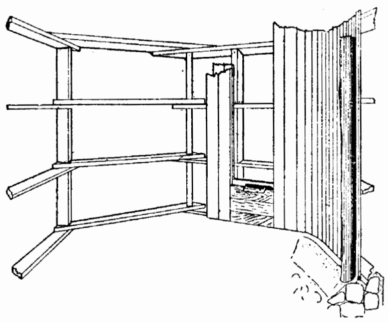


Figure 9—Detail of framework of octagonal wood-frame silo

An octagonal-shaped frame silo can be built on the same general plan as this one, using octagonal-shaped hoops of 2x8 lumber, fastened together at the corners with ten long spikes or with bolts. Detail of this silo is given in Figure 9. There is little advantage in putting up this type of silo as the hoops require more material than the round hoops, and they are not likely to be any stronger.

5—COMMONSENSE SILOS

The Commonsense silo is coming into a good deal of favor on account of the fact that it is more rigid and substantial than the stave silo. It requires, however, from twice to two and a half times as much lumber to build. These silos are possibly too well known to need much description. They are built of 2x4's nailed flat to each

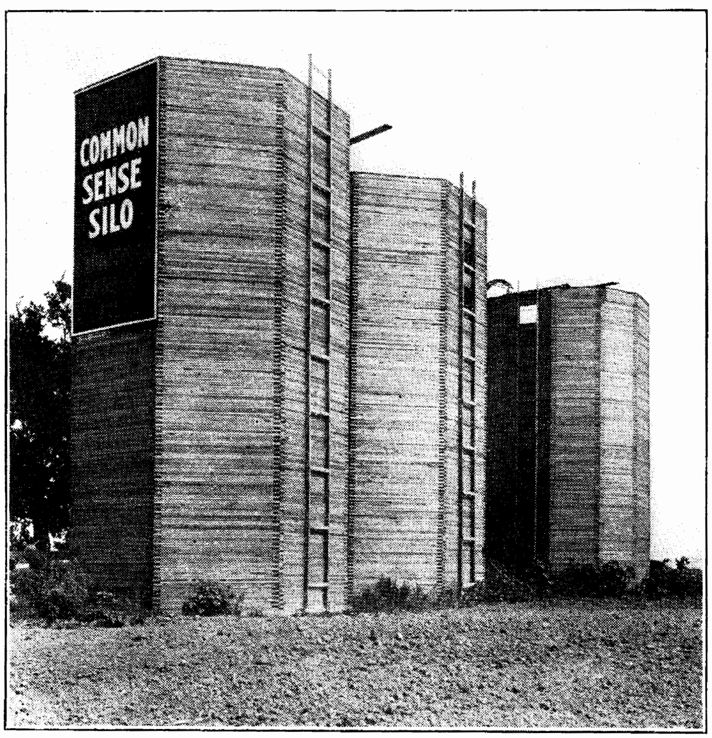


Figure 10—Three Commonsense Silos near Oklahoma City. Courtesy of Minnetonka Lumber Company

other so as make an octagon-shaped silo. They are perfectly rigid, and a man who builds, for instance, a 20-foot silo one year, can add another ten or fifteen feet to its height the next year if he so desires. They are made airtight in several ways. Waterproof pastes of asphalt or similar materials can be put between each layer of 2x4's as they are laid down, or the silo may be lined with ordinary rubber roofing. Some claim that this is pressed against the wood so firmly by the silage that it can hardly be detached later, while others have found the paper to tear off badly. A more expensive but more efficient way is to cover the outside with tar paper and nail on flooring or siding, thus giving a very finished appearance to the silo. Illustration No. 10 shows three Commonsense silos near Oklahoma City. The lumber for these silos is usually supplied already cut and at the right angles and lengths. One may build a homemade one himself if he so desires.

The Tung-Lok silo is a variation of the Commonsense silo, the timbers used being tongued and grooved. This is a new type of silo not very well known.

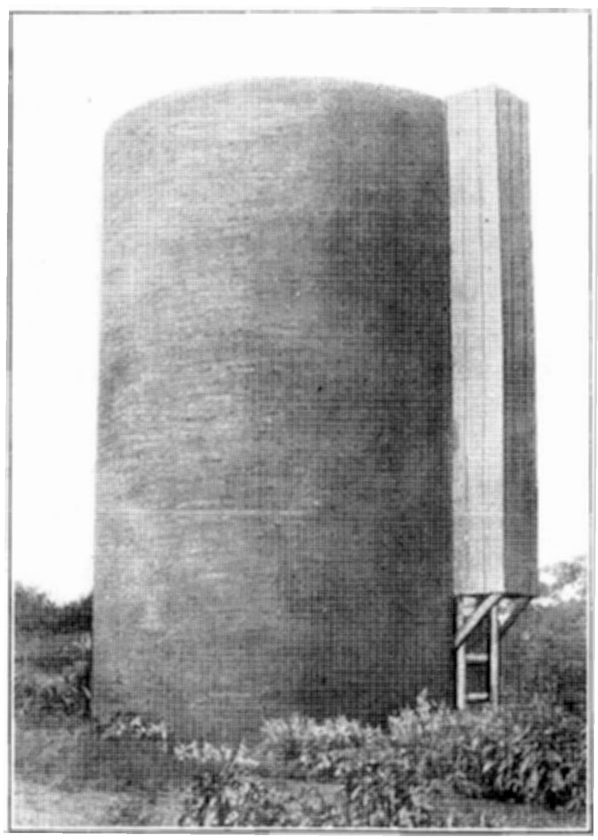


Figure 11—Leitch Hoopless Wood Silo. Built on farm of Mr. Schuler, McLoud, Oklahoma

6—THE LEITCH SILO

This silo is built and finished similar to the Commonsense silo, except that the lumber is cut in a circular form so as to make a perfectly round or cylindrical silo. The company making these silos operates at McLoud and Shawnee. Like the Commonsense silos, they require no tightening of hoops, can be bolted to good cement founda-

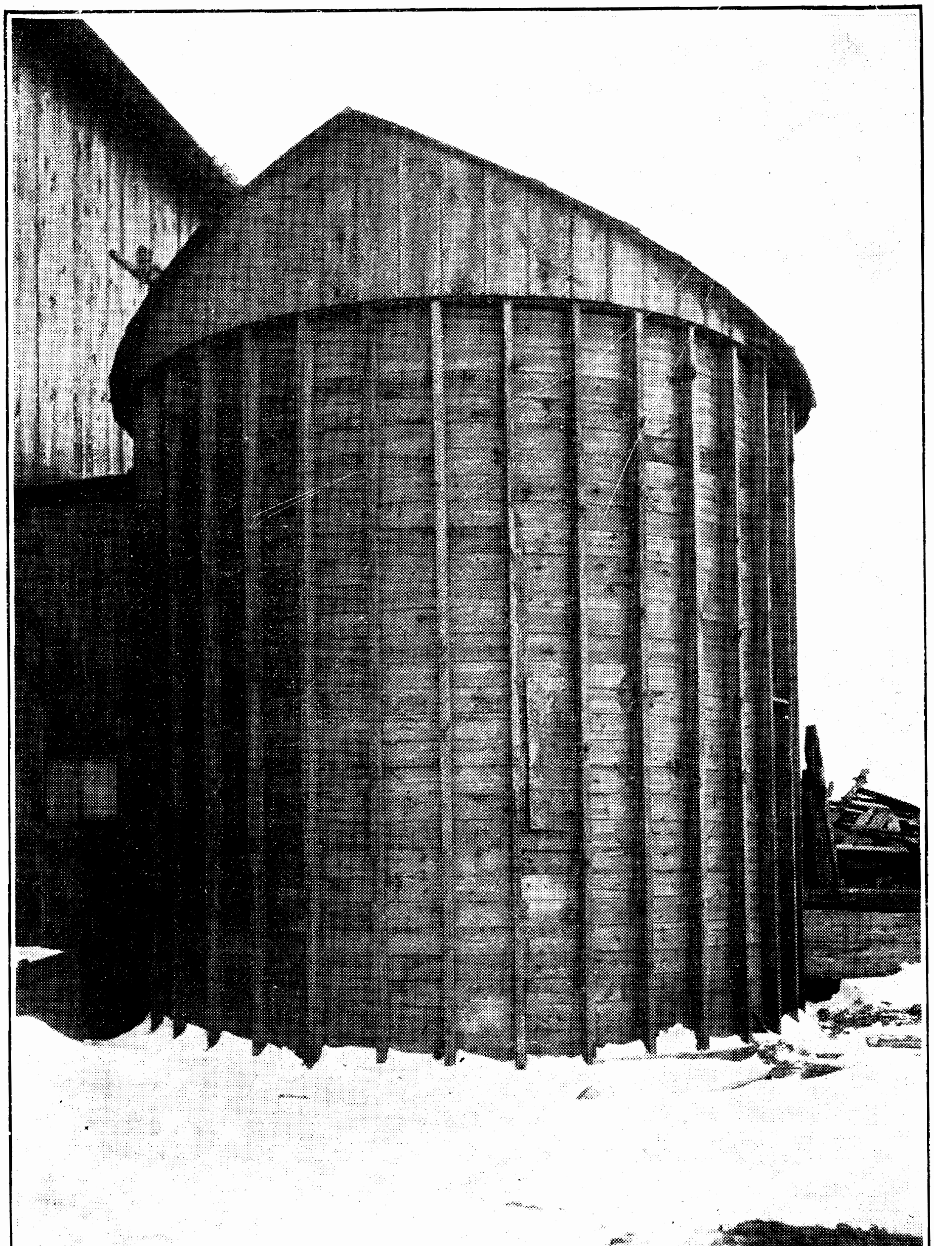


Figure 12—Unfinished Wisconsin or King Silo. In colder climates is usually sided up on outside of 2x4's, making a hollow wall

tions, and are solid and substantial. They are made airtight in the same ways as the Commonsense silo. (See Figure 11.)

7—THE WISCONSIN OR KING SILO

This silo is one of the strongest and best made wooden silos we have, and is illustrated in Figure 12. In most of the Northern States this silo is sheeted on the outside so as to provide a dead air space to prevent freezing. In this climate it is cheaper to leave this silo as shown in illustration. The outside sheeting adds a little to the strength of the silo, however, and a great deal to its appearance, but is not necessary in this climate. A sill is cut out in circular form, usually of two thicknesses of 1½-inch stuff 6 inches wide, and then 2x4's are set upright on these, twelve to fifteen inches apart and braced so as to be plumb from each side. Three thicknesses of ½-inch cypress 6 inches wide is then nailed on the inside with two layers of tar paper between. The pressure of the silage comes entirely on this cypress sheeting. The 2x4's have little strain on them, except to hold the sheeting in place. These silos should be well braced and wired in Oklahoma, as when empty they are easily blown over.

8—THE GURLER SILO

The Gurler silo is begun the same as the Wisconsin silo, but instead of the last layers of cypress sheeting and tar paper, beveled laths or metal lath is nailed on the wall and a cement plaster coat applied This protects the wood somewhat and cheapens the cost of construction. Ten or twelve wood hoops may be put around the outside of the 2x4's.

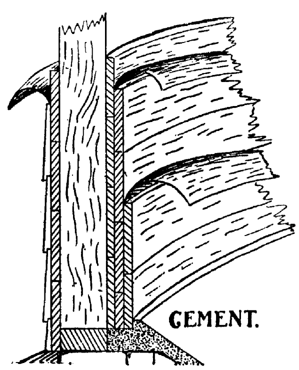
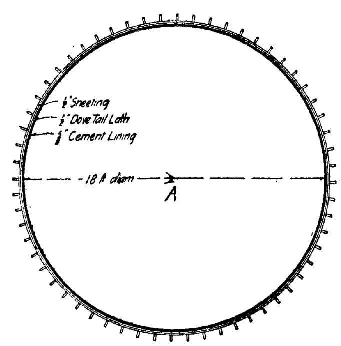


Figure 13—Detail of Wisconsin or King Silo

GURLER SILO



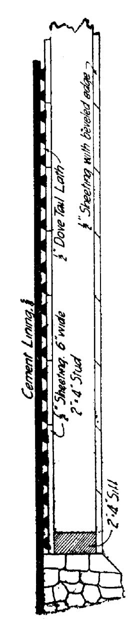


Figure 14—Detail of Gurler Silo. Cement plaster on dovetailed laths takes the place of two layers of one-half-inch lumber and tar paper in the King Silo

9—PATENT STAVE SILOS

The patent stave silo requires little discussion in this bulletin, even though an important type, as probably more silos of this type are in use in Oklahoma than any other kind. They are well known to

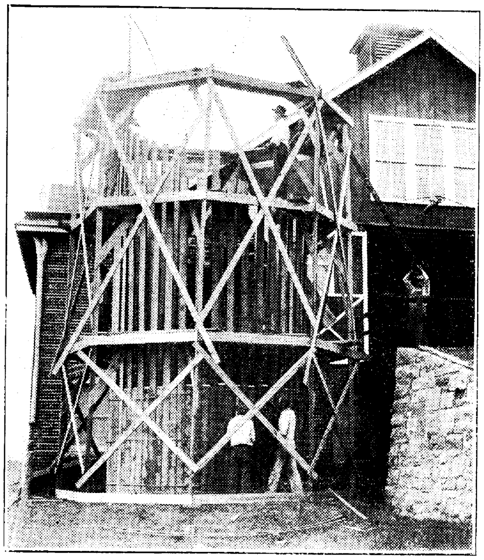


Figure 15—Scaffold erected for putting up Patent Stave Silo on foundation shown in Figure 2. Continuous door frame can be seen in place on the opposite side of the scaffold in front of the barn door. First staves are put in place and the three bottom hoops on

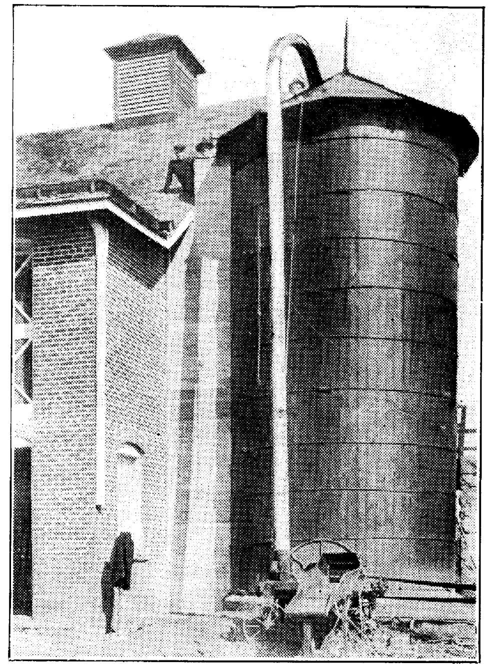


Figure 16—Same Silo completed and filled. Roof on. Located at brick barn, Oklahoma A. and M. College

every one, and call for little constructive knowledge on the part of the buyer. All materials are finished before the silos leave the factory, and the erection of the staves is more or less simple. Each silo company has its own bulletin giving details of construction and rules for erecting. The patent stave silo is made in various grades of wood

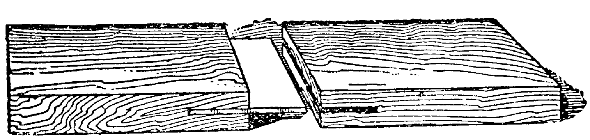


Figure 18—Stave splice

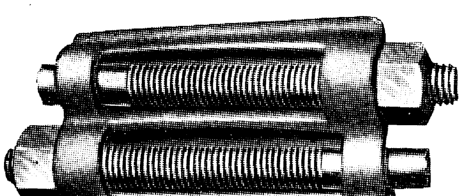


Figure 19—Malleable iron lug

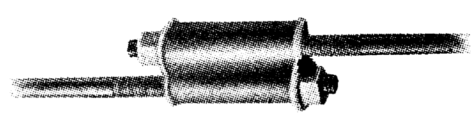


Figure 20—Cast iron lug

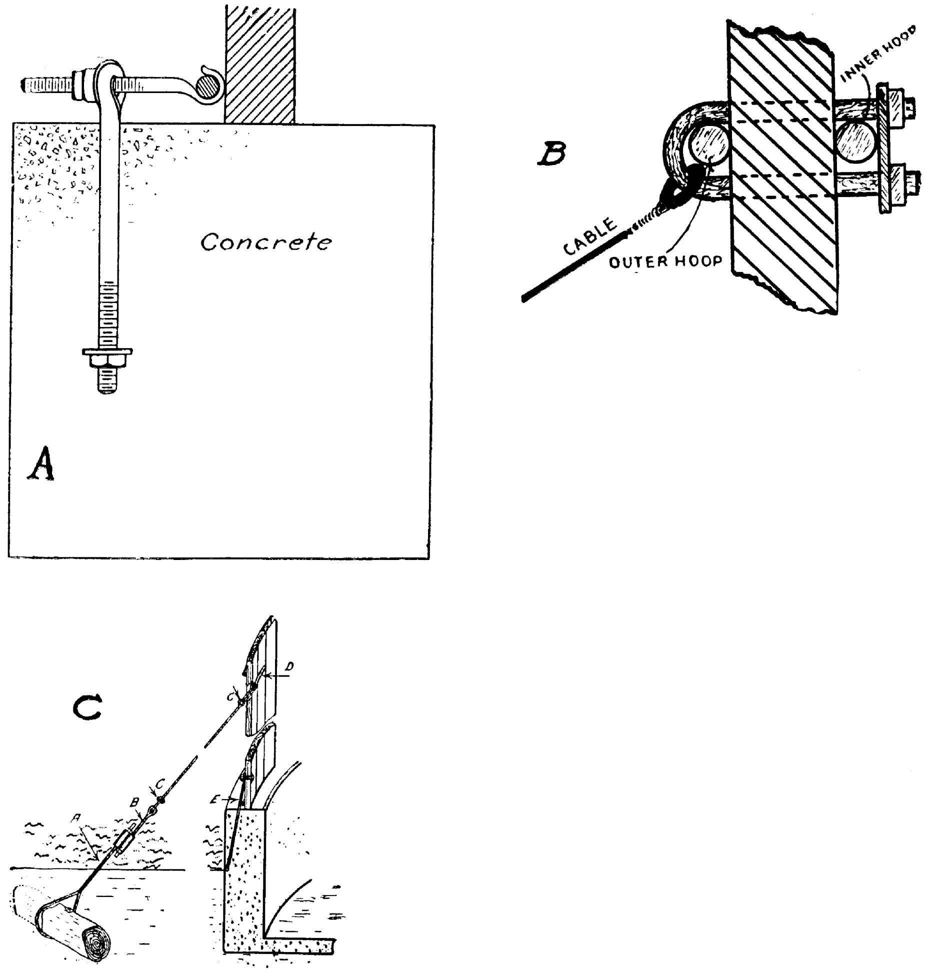
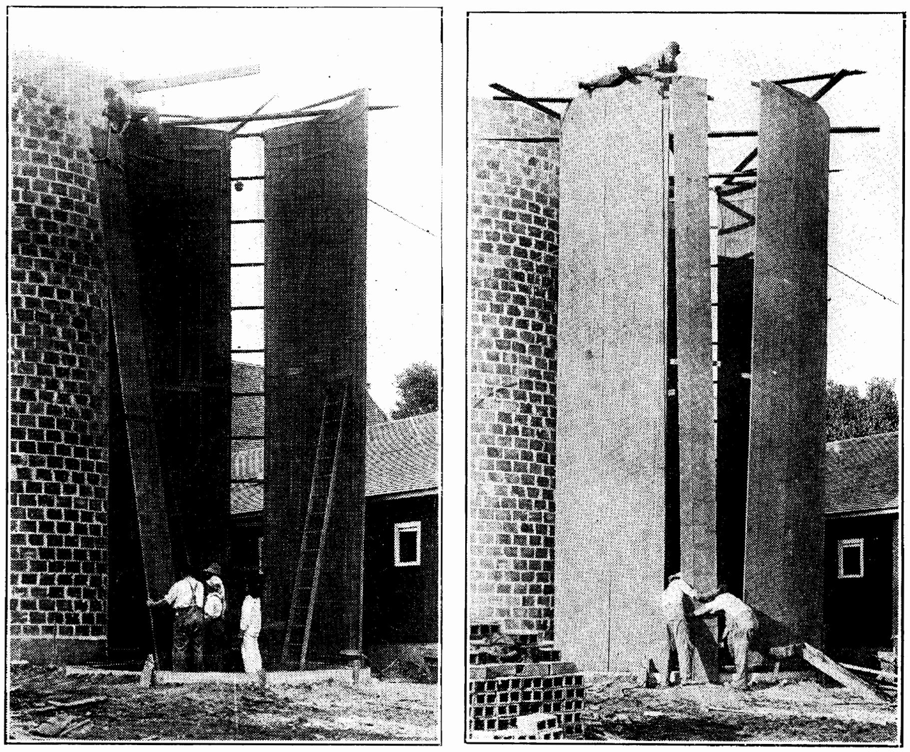


Figure 17—Types of anchoring and bracing for patent stave silo (Crown Silo). A. Bottom anchor set in concrete foundation. B. Attachment for guywires at top of silo. C. Anchor or "dead man" for lower end of guywire

ranging from common pine to douglas fir and cypress. Being factory-made, the staves fit more tightly than homemade staves. The door frames and doors are usually well braced and reinforced and tight-fitting. They are usually equipped with good roofs and with patent anchors and guy wires. If set on a good foundation and well anchored, top and bottom, these silos are practically as permanent and windproof as it is possible for wood silos to be. Most of the silos that blow down do so because of carelessness in not tightening the hoops, or because of insufficient wiring to hold the top steady. Guy wires should be attached to solid anchors, "dead men", as they are called (see Figure 17) a distance from the foundation equal to the height of the silo, thus giving the greatest strength. The patent stave silo at the A. and M. College beef cattle barn (Figure 16) has never blown down during four years of use, though many other such silos in the county have blown over once or twice. Many patent stave silos are creosoted or treated with patent oil preparations so as to make the wood as resistant as possible to moisture and rot. One-piece staves are more permanent than two-piece staves, as decay very often sets in where the staves join. These joints are made as solid and air-tight as possible through the use of steel or iron splices, as shown in Figure 18. Figure 17 shows types of anchoring; Figure 1 shows the foundation for a stave silo in process of making, and Figure 15 shows the erection of the staves at an early stage, using a scaffolding in-



Figures 21 and 22—Erecting a stave Silo without scaffolding. Door frame is raised first and braced well. Staves are tacked together with cleats, three at a time, and hoisted into place. They are then braced from the door frame at the top and held in place by barrel staves tacked on the inside of the Silo

Courtesy of Iowa A. and M. College

stead of the method suggested in putting up the homemade stave silo; Figures 21 and 22 show how to put up a silo without scaffolding.

10—THE TULSA SILO

A cheap and efficient form of flooring silo (Figure 23) is put out by a company which originated at Tulsa, now located in Kansas City. They supply angle-iron hoops through various lumber companies with which to make these silos. The boards are bolted onto these sections of hoops and drawn together in a special form made for the purpose. The sections are then erected and bolted together. A 100-ton silo of this type can be loaded onto a wagon and hauled from the lumber

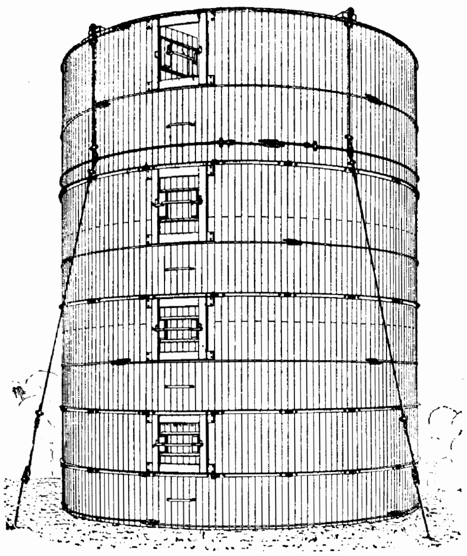


Figure 23—Tulsa Flooring Silo. Angle iron hoops to which the staves are fastened alternating with ordinary round hoops

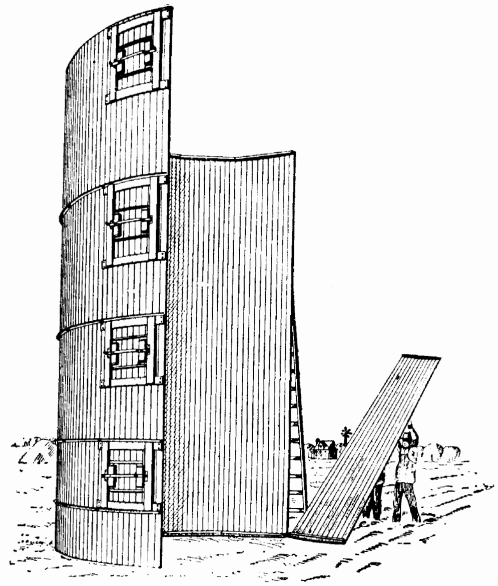


Figure 24 shows a Tulsa Silo in process of erection, one section being lifted into place at right

yards at one trip. Figure 24 shows the silo in process of erection. Being fastened to the hoops, it is claimed that the staves cannot be blown in in a high wind nearly as easily as in an ordinary stave silo. They can be made with either intermittent or continuous doors.

———o———

II—MASONRY AND CONCRETE SILOS

The masonry silos, whether of concrete, brick, stone or vitrified tile, are usually more expensive than the wooden silos as a class, but have a good many advantages which perhaps more than offset the differences in price. Their main quality is that of permanence. Well built masonry silos are practically everlasting, being fireproof and stormproof. Rats cannot burrow into them as into a wooden silo, and if properly plastered or glazed on the inside they are moistureproof also. Silage keeps as well in a well made concrete silo as in any other. Little moisture is lost through the walls of these silos.

There have been some failures with these types of silos, especially in the early days of silo building when the right methods of construction were not well understood. Failures have practically always been due to one or more of the following reasons: Lack of proper reinforcing; lack of sufficient cement (in the case of concrete silos), and insufficient or weak foundations. Since these silo structures are to be permanent, more care should be exercised in building them than in building the cheaper types. Because the cost is higher, the loss is, therefore, greater in case of failure, while if well constructed, permanent success is assured. The cost of these silos varies according to locality and transportation charges. In some cases these silos can be built for less than a wooden silo, while in other localities the cost of transportation of materials would prove excessive. The man who has sufficient ability to be his own construction boss and who has plenty of sand and gravel on his farm may find these silos the cheapest he can erect.

CONCRETE SILOS

Concrete structures reinforced with steel are characteristic of the twentieth century, the combination being practically indestructible. Many large office buildings, factories and school buildings are being made almost entirely of steel and concrete. It is not remarkable, then, that silos of these materials should also be in favor. The fact that concrete silos have been in use for fifteen years or more and show no signs of deterioration, coupled with the fact that many more are being put up in the same localities, is sufficient evidence that they are successful. Of the concrete silos, we have the solid-wall or monolithic silo, the cement block silo, the cement stave silo and the plastered or metal lath silo.

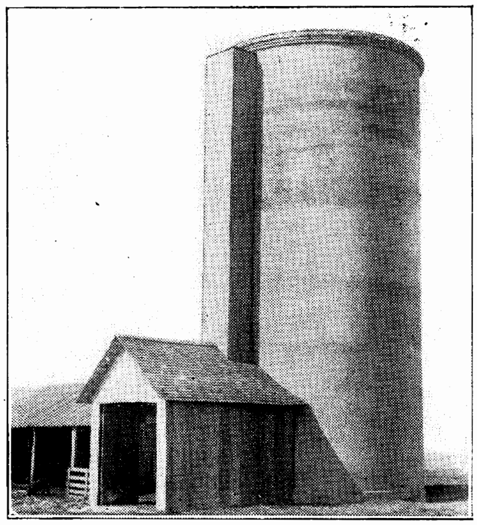


Figure 25—Solid Concrete Silo, 16x42 feet, built with forms as described in Figures 44 and 46. Owned by A. B. Campbell of Geary, Oklahoma

THE SOLID-WALL OR MONOLITHIC CONCRETE SILO

Of the various types of concrete silos the most popular is probably the solid wall silo. This is largely on account of its great strength and durability when well made. A good concrete silo may cost no more than the best stave silo or metal silo, especially when sand, gravel or rock may be obtained cheaply. Where these materials are near the farm and to be had for the hauling, where the cost of one set of forms is to be divided among several builders, where the farmer has sufficient ability to superintend the construction of his own silo, and where he has plenty of home labor, a 100-ton concrete silo should not cost more than $300.00. When sand and stone are to be purchased, where the entire cost of forms comes on one man, and where a good deal of labor has to be hired, some of it high priced, the cost will be between $400.00 and $500.00. It is not advisable for a man with little or no experience in handling concrete to attempt the construction of this kind of silo unaided. The materials are expensive, and if a concrete silo is once badly constructed it cannot easily be repaired or remodeled. It is generally advisable to get the assistance of some one who has worked with concrete. To the man who understands ordinary concrete work the making of a concrete silo is not especially difficult. The chances for mistakes are small where one will follow directions in handling the forms, mixing the concrete and placing the reinforcement. Where five or six farmers have clubbed together to build their own silos, the first silos built have sometimes been poorly constructed, but after one or two have been put up the others have generally been better built than a contractor would have built them. Farmers are usually more attentive to the details of construction of their own silos. With a cooperative agreement of this kind one set of forms will do for ten to twelve silos, thus reducing the cost for forms to $6.00 or $7.00 for each man. An expert need only be engaged for the first silo or two. In this way farmers may build their own silos at a very reasonable cost, possibly for as little as $275.00 for a 100-ton silo.

MATERIALS

Good concrete may be made from either of the following mixtures (see Table IV, page 30); A, crushed rock 4 parts, sand 2 parts and cement 1 part; B, gravel 4 parts and cement 1 part; or C, sand 4 parts and cement 1 part. Crushed rock, sand and cement in the proportion of 4, 2, 1 requires less cement to make good concrete than any other mixture. If these materials can be obtained at a reasonable figure these proportions should be used. Where hard stone can be obtained locally it may be used to advantage, as the stone can be broken up with hammers and will usually cost less than the crushed rock purchased. A good deal of rock can be broken each day while the latest concrete fill is setting, thus keeping the construction force going. Where a good grade of gravel is easily obtained and crushed rock is expensive the former may be used. Though more cement is required in the gravel mixture, the cheapness of the gravel may more than offset the difference in cost of concrete. In a few localities where sand is plentiful and stone and gravel are expensive, sand and cement alone may be used profitably. This requires more cement, however, than either of the former mixtures, and the finer the sand the more cement is needed. The distance the materials must be hauled and the cost of labor and forms all materially influence the price of the concrete silo. The various proportions to use of these different materials is given in Table IV. The sand and gravel used should be clean and free from trash. Nothing but a good grade of cement should be used, and it must have been kept perfectly dry.

TABLE IV

	Parts by Bulk.				Amount of Material required for Cubic Yard of Mixture.			
						Cubic Yards		
	Cement	Sand	Cruched Stone.	Gravel	Sacks Cement	Sand	Stone.	Gravel
Mixture for solid-wall concrete silo where crushed stone is available	1	2	4		6.28	.44	.88	1.11
Mixture for solid-wall or slush block where gravel is used*	1			4	7.92			1.11
Mixture for solid-wall or slush block where coarse sand is used	1	4			7.92	1.11		
Mixture to use for plaster mortar	1	2½			10.76	.95		
Mixture for silo foundation	1	3	6		4.44	.47	.94	

*Note that the same mixture is given here as that for coarse sand. Gravel varies, and the finer gravel the greater the requirement of cement.

To determine the number of cubic yards concrete in a silo wall: To find the circumference, multiply the diameter by 3 1-7; multiply the circumference by the height of the silo and then by the thickness of wall in fractions of feet. This will give cubic feet. Divide by 27 and get number of cubic yards. Then with Table IV, calculate amount of materials. Example: A silo 15 feet inside diameter, height 30 feet, thickness of wall 6 inches. Diameter from centers of wall is 15 feet 6 inches.

$$\frac{15\frac{1}{2} \times 3\ 1\text{-}7 \times 30 \times \frac{1}{2}}{27} = 27.06 \text{ cu. yds.}$$

Materials for solid-wall concrete silo 15x30, 6-inch wall, 1-2-4 mixture (see Table IV, page —):

27.06×6.28=170 sacks cement
27.06× .44= 12 yards sand
27.06× .88= 24 yards rock

Reinforcing

A concrete or masonry silo requires almost as much reinforcing as is required by the iron hoops on a stave silo. In the wooden silo the hoops have to withstand the pressure of the silage and also the swelling of the staves. The reinforcement in the masonry silo does not have this much strain on it, as the concrete itself will stand considerable pressure. The purpose of the refinforcement is to withstand the pressure of the silage and keep the silo wall from cracking. The bursting pressure of silage on the walls of a silo is estimated at

TABLE V

Spacing of horizontal reinforcing rods in monolithic silos in inches

	DIAMETER OF SILO IN FEET																				
	8 Feet.	10 Feet.		12 Feet.			14 Feet.			16 Feet.				18 Feet.				20 Feet.			
Diameter of rods in inches	¼	⅜	¼	½	⅜	¼	½	⅜	¼	⅝	½	⅜	¼	⅝	½	⅜	¼	⅝	½	⅜	¼
From Top Depth in Feet.																					
From - To	SPACING BETWEEN REINFORCING RODS IN INCHES																				
0 to 8	18	24	18	26	22	17	24	20	13	30	24	18	11	28	24	16	10	24	21	14	9
8 to 16	18	20	11	24	18	9	23	17	8	26	22	15	7	24	20	13½	6	22	18	12	5½
16 to 24	15	16	7	20	13	6	18	12	5	23	17	11	5	20	16	10	5	18	15	9	4
24 to 32	15	12	6	18	10	5	15	9	4	20	14	8	4	18	12	7	3	16	11	6	3
32 to 40	12	10	4	14	8	4	12	7	3	17	11	6	3	15	10	6	3	14	9	5	2½
40 to 50		9	4	13	7	3	12	7	3	15	10	6	3	14	9	5	2	12	8	5	2

eleven pounds per square foot for every foot of depth of the silage. That is, at the bottom of thirty feet of silage the pressure is 330 pounds per square foot. The following table gives the amount of reinforcing of different sized wires or rods as worked out according to this standard.

The most common kinds of reinforcement used are structural steel rods, round iron rods, smooth or barbed wire, or woven steel wire fencing. If old fencing is used, the amount put in should be double that of new material. As the strength of the wall depends largely on the reinforcement, it is best to buy new material as its strength is more certain. Where concrete walls are less than six inches in thickness, vertical reinforcing of ⅜-inch steel rods every thirty inches is recommended.

No. 9 wire has about one-third the strength of the ¼-inch steel rods. Two-strand barbed wire is about the same.

Example: To find the right spacing between the reinforcing rods in a silo at any particular distance from the top, find distance from top in column to left, follow along line to column indicating diameter of silo and kind of reinforcing used. The figures given are the inches of space between rods. Example given: A 32- foot silo, 16 feet in diameter, ⅜-inch reinforcing=rods 8 inches apart for first 8 feet, 11 inches apart for next 8 feet, 15 inches apart next 8 feet, 18 inches apart for top 8 feet.

Figure 32 shows method of straightening wire reinforcing to proper curve for laying between forms.

Mixing Concrete

Since the mixing and handling of the concrete is important, it may be advisable to make a few suggestions regarding the proper handling of materials before proceeding with the construction of the silo. The equipment needed includes hoes, wheelbarrows, buckets, water barrel, square-mouth shovels, two measuring boxes, a water-tight mixing board 9x10 feet made of smooth, grooved lumber, with a two-inch rib around the outside. While the sand and stone or gravel may be measured in wheelbarrows by those familiar with their use, it is advisable for the amateur to make bottomless measuring boxes (Figure 26).

Most cement companies put out complete instructions for mixing concrete. A very good bulletin is published by the Western States Portland Cement Company of Kansas City, Missouri. From this bulletin we summarize the following, illustrating the method of mixing what is known as the two-bag-batch of concrete of the 1-2-4 mixture of cement, sand and rock. This amount is the best to make where two or three men are at work. For a two-bag-batch, the sandbox may be 24x24 inches and 11½ inches deep, or 48 inches long 22½ inches wide and 6 inches deep. For gravel or stone a separate box may be made, twice as large; or the sandbox may be used twice. The sidepieces should project one foot at each end. These ends are made into handles as in Figure 26.

The following is one well recommended method of mixing concrete: Place the sandbox in the center of the mixing board and fill it from the wheelbarrow. When the box is level full lift it off and spread the sand over the board in a layer three or four inches thick. Empty the two bags of cement as evenly as possible over the sand. By shoveling this mixture to the ends of the mixing board and then back into the center twice the sand and cement will be thoroughly mixed together. Spread the sand and cement out level, measure the gravel or stone on top of the mixture, then remove the box, spreading the rock over the other materials. Add three-fourths of the required amount of water and turn as before, adding water to the dry spots as mixing goes on. After three such turnings the concrete should be well mixed and ready for use. Every particle of sand or stone must be moist and coated with cement. Accurate measuring and mixing of materials are necessary for best results.

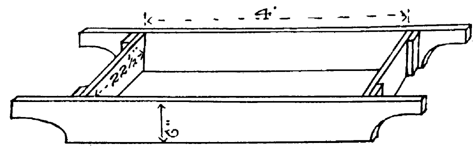


Figure 26—Bottomless measuring box for sand. Two-bag batch of concrete 1:2:4 mixture

This concrete will remain plastic for about one-half hour. After this time it will begin to set, so that it should be in position at least twenty to thirty minutes after it is first wet. If moved or stirred after hardening has begun the concrete loses strength, and if disturbed after setting has progressed to any extent the concrete is practically

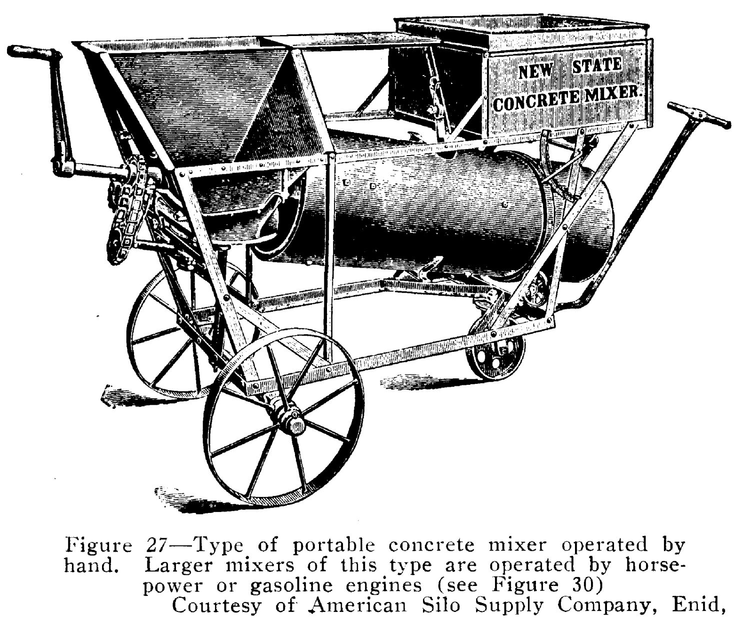


Figure 27—Type of portable concrete mixer operated by hand. Larger mixers of this type are operated by horse-power or gasoline engines (see Figure 30)
Courtesy of American Silo Supply Company, Enid, Oklahoma

useless. If work is delayed and a mixed batch sets, by all means do not use it. This may look like a waste, but it is much better to do so than to lose the whole silo. Where a batch is mixed and cannot be used immediately, the setting of the concrete can be put off by continually stirring. In most cases where farmers build their own silos the mixing of the concrete is done with shovels. Where labor is scarce it may be more profitable to use a concrete mixer. A mixer which can be run by a small gasoline engine or horsepower (Figure 30) will cost from $125.00 up. Figure 27 shows a small hand mixer with a capacity of four to five cubic yards concrete per hour. Convenient, cheap concrete mixers have been made from barrels. With another method of hand-mixing the stone is spread upon the platform first, the sand spread over the stone and the cement poured over this. The batch is turned over and over until it is all of the same color; that is, until the cement is thoroughly mixed with the sand and stone. Water is then added and the turning continued until a sloppy mixture is made. A wet, sloppy mixture makes a better wall than a dry mixture.

Foundation

The foundation of any silo is important, but a good foundation is especially necessary in a masonry or concrete silo because of the heavy walls. The foundation of the concrete silo usually answers the double purpose of foundation and silo wall. It is most economical where soil conditions permit to have the silo extend at least three feet below the surface of the ground. This not only puts the foundation on solid ground, but increases the capacity of the silo without increasing its height.

The excavation should be made about three feet larger in diameter than the diameter of the silo to give room for handling the outside

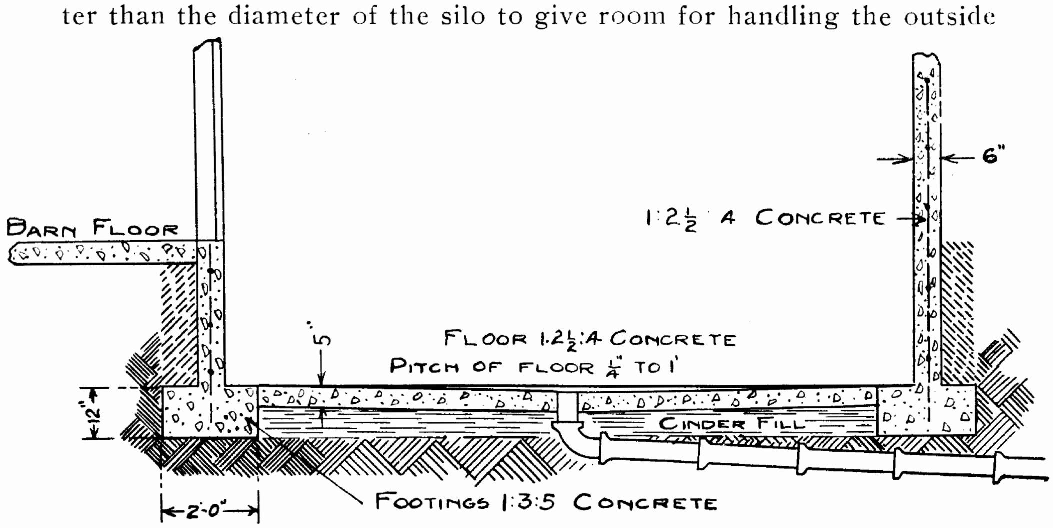


Figure 28—Type of foundation, floor and footings for concrete silo. Drain underneath
(Courtesy of Universal Portland Cement Company, Chicago)

forms in making the first fill. When the dirt is removed to the depth of the silo floor the trench for the footing must be dug. This trench may be 18 to 24 inches wide and from 18 to 24 inches deep. Then with the 6-inch silo wall in the center there is six to nine inches of footing on either side of the wall, as shown in Figure 28. When the trench is dug it is filled with concrete and this is allowed at least forty-eight hours to set before the wall is started.

TABLE VI

Materials for Silo Footings and Floors

		Footings. Quantities.				Floor. Quantities.			Footings and Floor Total Quantities.		
Inside Diameter in Feet of Silo.	1, 2½, 5 Concrete Cubic Yards.	Cement Bbls.	Sand Yards.	Gravel Yards.	4-Inch Base 1, 2½, 5 Concrete Cubic Yards.	Cement Bbls.	Sand Yards.	Gravel Yards.	Cement Bbls.	Sand Yards.	Gravel Yards.
8	1.5	1.8	0.7	1.4	0.5	.62	.25	.46	2.42	0.93	1.86
10	1.8	2.2	0.8	1.6	0.8	1.00	.37	.75	3.19	1.17	2.34
12	2.2	2.7	1.0	2.0	1.0	1.25	.46	.92	3.94	1.46	2.92
14	2.5	3.1	1.2	2.4	1.6	2.00	.75	1.50	5.08	1.94	3.77
16	2.9	3.6	1.3	2.6	2.2	2.75	1.00	2.03	6.33	2.31	4.62
18	3.2	4.0	1.5	3.0	2.8	3.50	1.30	2.58	7.47	2.79	5.58
20	3.6	4.4	1.6	3.2	3.5	4.35	1.60	3.22	8.74	3.21	6.42
22	3.9	4.8	1.8	3.6	4.3	5.33	2.00	4.00	10.13	3.78	7.56

(Courtesy of Universal Portland Cement Company, Chicago)

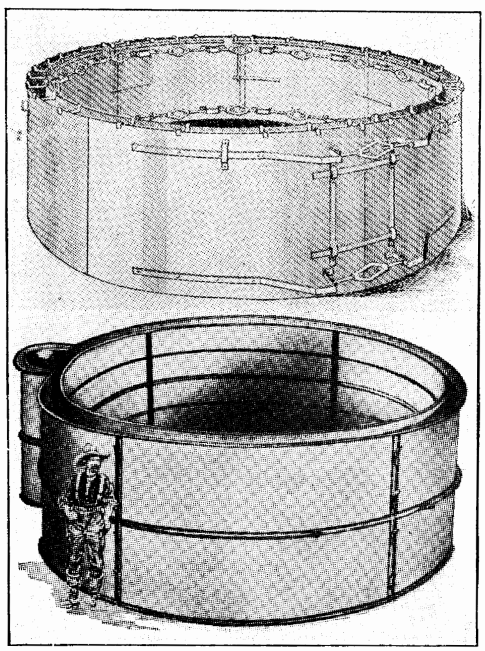


Figure 29
Two types of patent silo forms. Upper form is adjustable for different sizes of silos. Lower form has attachment for making a solid concrete chute attached to silo. (See also Figure 30)
Martin Concrete Form Company, Ottawa, Kansas
Monolithic Concrete Silo Company, Chicago

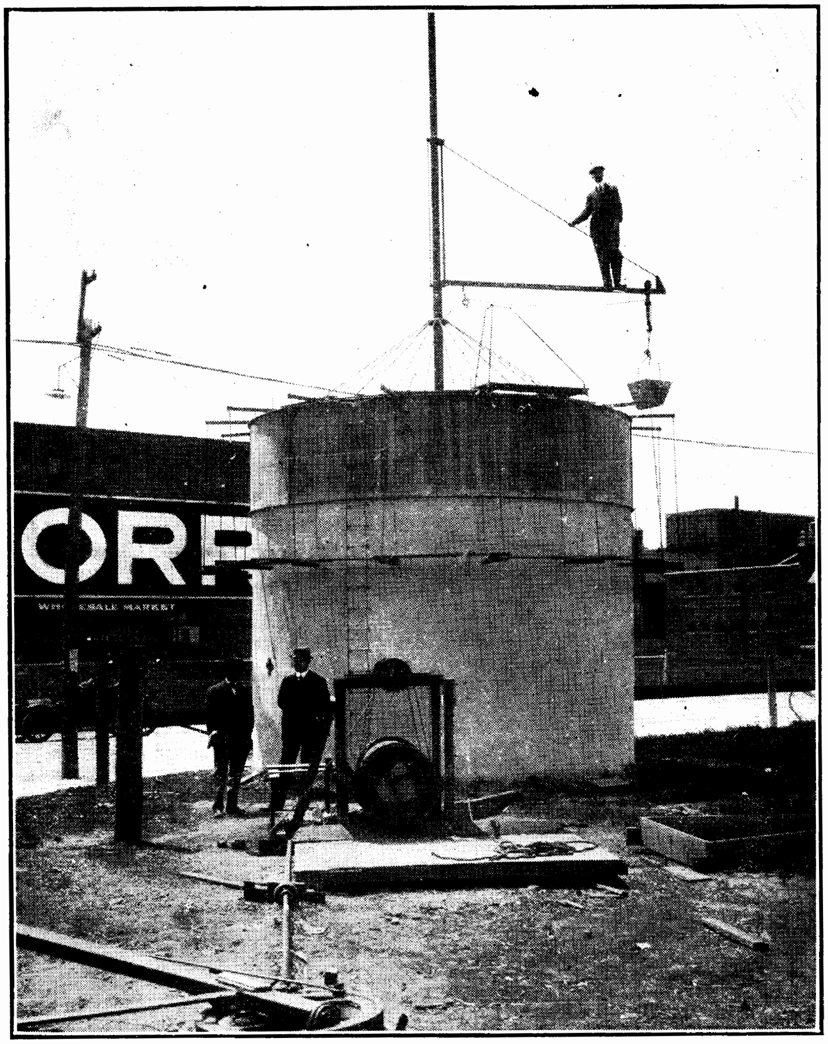


Figure 30—Concrete Silo built with steel forms and full equipment for hoisting. Cut also shows horsepower concrete mixer. Where several large silos are to be built in any community, contracting companies with these outfits may put up silos cheaper than individual farmers
Courtesy of the Oklahoma Concrete Silo Company, Oklahoma City

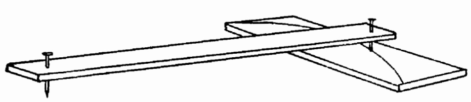


Figure 31—Marking off ribs for concrete silo forms, or for any other circular cuts requiring accuracy. Strings are not reliable

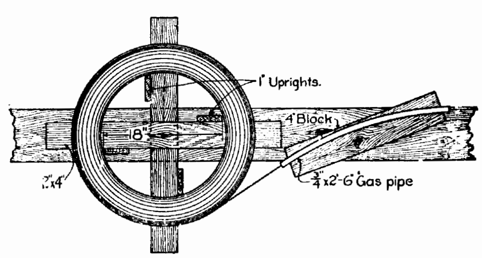


Figure 32—Device for straightening wire to the proper curve for placing in silo wall for reinforcing. (Iowa Agricultural College)

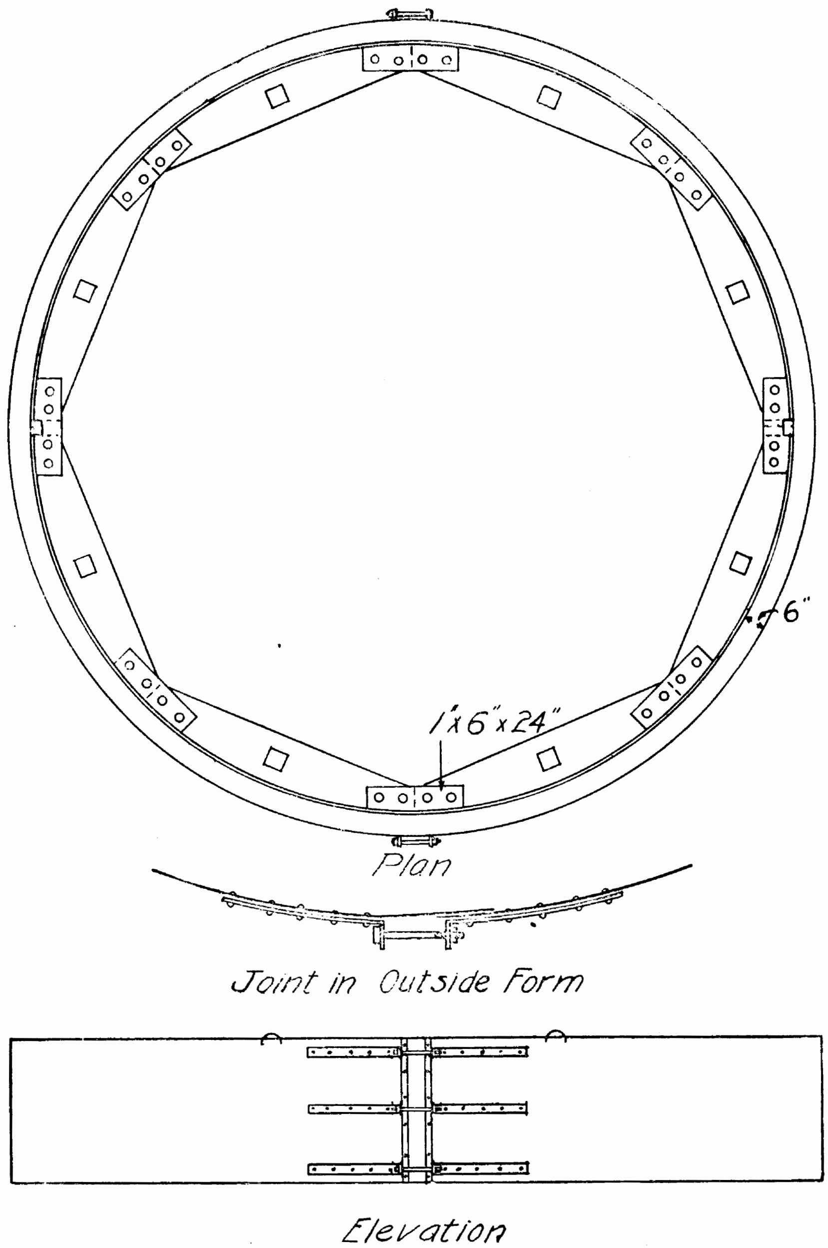


Figure 33—Diagram of homemade concrete Silo forms. Outer and inner forms shown together, six-inch space between. Lower diagrams show joint and elevation of outer forms.
Courtesy of Universal Portland Cement Company, Chicago

Forms

Patent forms may be purchased at a cost of from $150.00 to $750.00 per set, the latter price including all hoists, scaffold, etc., needed in putting up a silo (see Figure 30). Usually the person building only one or two silos will use homemade forms, as very efficient forms can be made at less cost. It is advisable for several farmers in

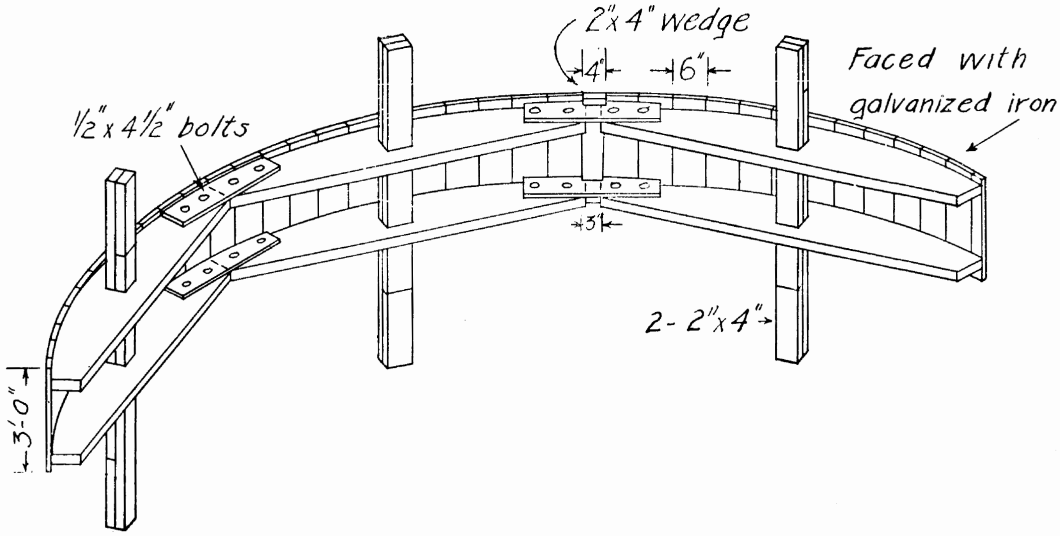


Figure 34 shows three sections of inner form in place. Note 4x4 supports, also place for wedge
Courtesy of Universal Portland Cement Company, Chicago

a community to make a set of forms together, since one set may be used in putting up ten to twenty-five silos. The life of the forms depends on the care used in handling them. There are several mothods of constructing homemade forms.

Forms used in constructing the concrete silo shown in Figure 25 may be made according to plans on page — Plate A. The outer form is made of sheetmetal divided in two equal lengths with a twelve-inch lap allowed at one end of each. This is 18-gauge galvanized iron 3 feet wide and of such length as may be necessary. (See Table VII for exact length.) The forms are fastened together by ⅝-inch bolts through lugs of 2x5 1-inch strap iron 12 inches long, bent to a right angle (see Figure C, Plate A). Lifting hooks of the same strap iron are spaced around the form. The inside form is made of wood with a facing of 28-gauge galvanized iron (Figure 33). These forms are constructed by making ribs of 2x12 plank sixteen in number, enough to make two complete circles around the silo (see Plate A). This form is faced with ¾-inch matched flooring before putting on the sheet steel. Figure 34 gives a view of three sections fastened together ready for use. Table VII gives the correct measurements for cutting out the ribs for any ordinary diameter of silo.

Materials for Homemade Silo Forms

For Silos With Inside Diameter 8 feet to 22 feet

16 2x2-inch plank, cut as per sizes given in table.
1x6-inch boards, for quantity see table.
16 2x6-inch cleats, 3 feet long, cut on radius "r".
2x4 studding planed. (Required quantity equal to 16 times the height of the silo.)
No. 22 gauge galvanized sheetiron 3 feet wide. (For quantity see table.)

No. 18 gauge galvanized sheetiron 3 feet wide. (For quantity see table.)

64 ½-inch bolts 4½ inches long (for cleats).
8 ½-inch bolts 6 inches long (under forms).
6 ½-inch bolts 12 inches long (for outer forms).
4 Iron straps ¼x2 inches 3 feet.
12 Iron straps ¼x2 inches 2 feet 6 inches.

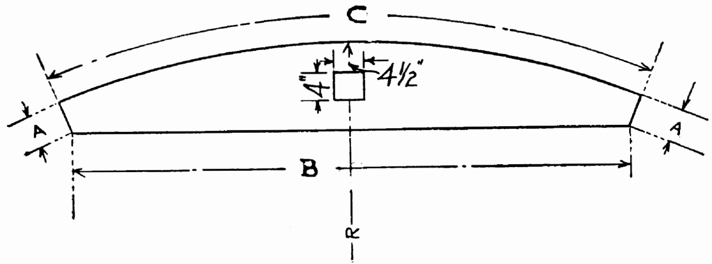


Figure 35—Diagram of rib for inner forms. (See Plate A and Figures 33 and 34 for use with Table VII)
Courtesy of Universal Portland Cement Company, Chicago

TABLE VII

Inner Form Ribs

Inside Diameter of Silo.	Dimensions of Inner Form Ribs: A (Ft. In.)	B Ft.	B In.	C Ft.	C In.	R Ft.	R In.	No. of 1x6-in. Boards 3 in. Long in Inner Form.	No. 18 Gauge Galvanized Sheetiron 3 in. Wide, Feet Needed. Ft.	In.	No. 28 Gauge Galvanized Sheetiron 3 in. Wide, Feet Needed. Ft.	In.
8 feet	9	2	5¼	3	0⅞	3	11	51	30	3	25	0
10 feet	8	3	3	3	10½	4	11	63	36	7	31	6
12 feet	6¾	4	1½	4	7⅞	5	11	75	42	10	37	8
14 feet	6	4	10½	5	5⅜	6	11	88	49	3	44	0
16 feet	5	5	9	6	2½	7	11	101	55	6	50	0
18 feet	4½	6	6½	7	0¼	8	11	113	61	9	56	6
20 feet	3	7	4¾	7	9¾	9	11	126	68	0	62	10
22 feet	2½	8	3	8	7¼	10	11	138	74	5	69	2

The radial cut is made as shown in Figure 31, using a radius one inch less than the required inside radius of the silo.

As noticed on Plate A (Figures 2 and 3) one end of some of these ribs is notched and the block connecting these sections is also notched. This is to permit driving in two oak wedges, one on each side of the silo, when the forms are to be tightened against the wall.

A 4½x4½-inch hole is cut through each rib; these are for the 4x4's to pass through on which the forms rest when in place. These 4x4's may be made by nailing two dressed 2x4's together and are one-half inch smaller than the hole to permit of easy raising. Holes are bored through these 4x4's and bolts stuck through underneath the forms when they are raised. The forms being heavy they have to be raised by four jackscrews. The face of the forms should be greased with

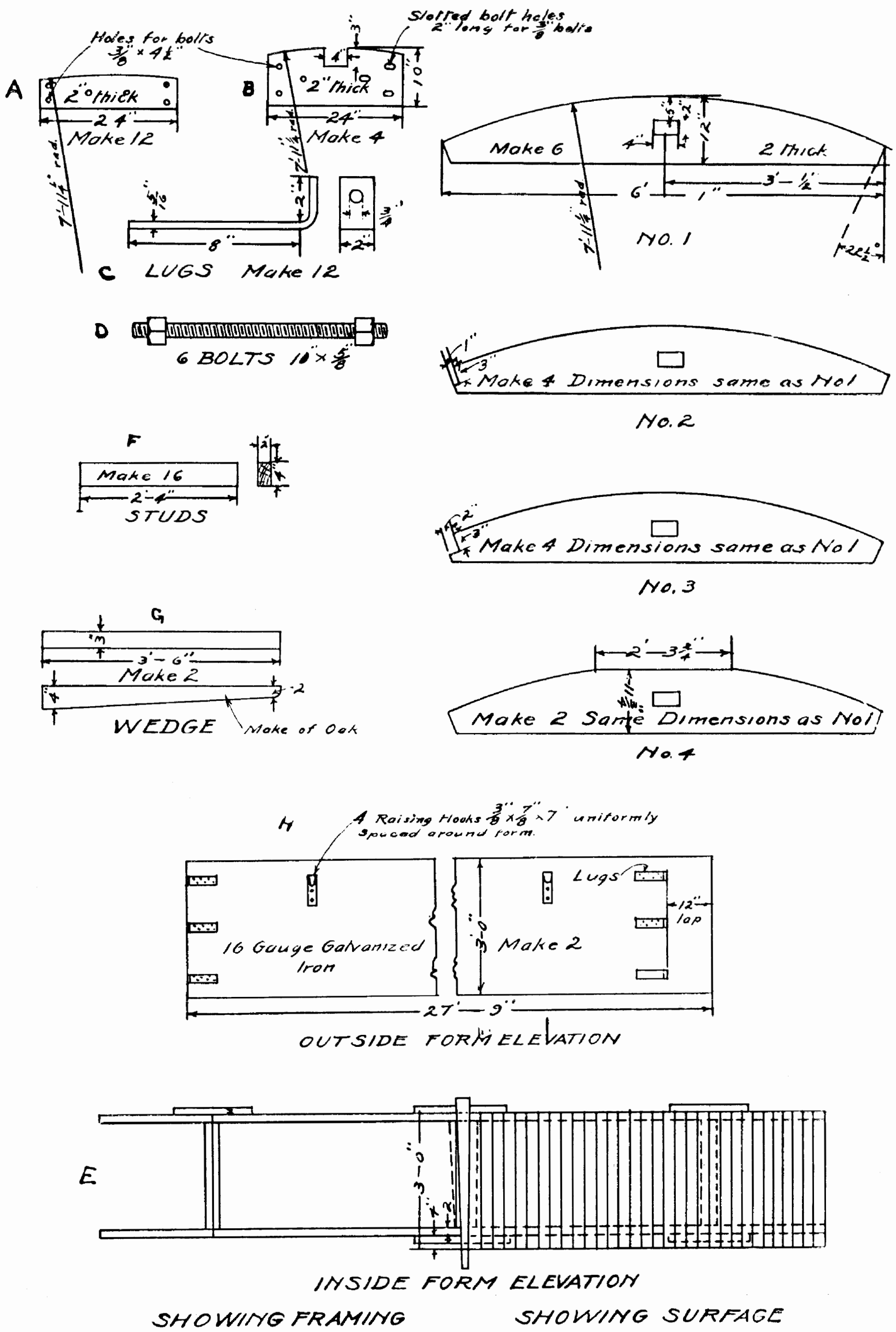


Plate A—Plan of homemade form for monolithic concrete silo. (See also Figures 33, 34 and 35.) No. 1 shows regular rib for inside forms. Nos. 2 and 3, ribs notched for oak wedges to go in. No. 4, ribs flattened to go next the door forms. A. Regular tie-plate for joining ribs together. B. Tie-plate for use at places where wedges are driven in. C. Strap iron lugs for connecting sections of outside forms. D. Connecting bolts. F. Upright studs. G. Oak wedges. H. Elevation of outside form. E. Elevation of inner form for silo 15 feet diameter. For other sizes see Figure 35 and Table VII. Courtesy of G. S. Hine, Manhattan, Kansas

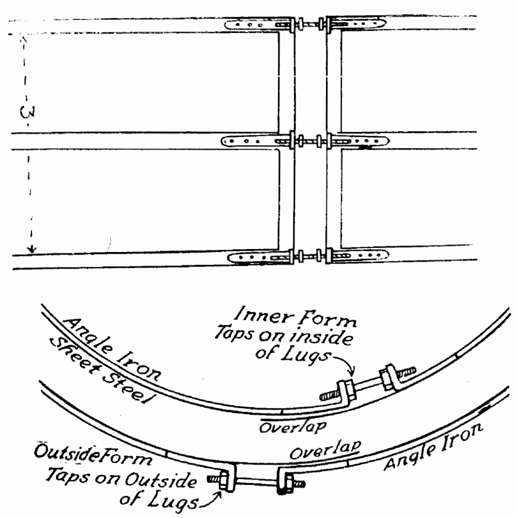


Figure 36—Diagram of homemade sheet steel forms. Note arrangement of connecting bolts and lugs. Upper part of cut shows elevation of inside form and position of angleiron ribs

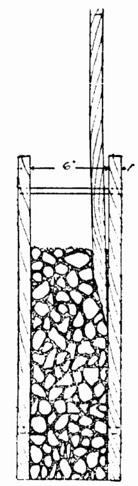


Figure 37 — Showing how to tamp concrete in forms to keep large pieces of rock away from the surface of the wall

axlegrease before being used so they will not stick to the concrete. The ribs shown by Figure 4, Plate A, are flattened for the door forms and Figure G shows plan of the wedges used. Plate B shows a form for an intermittent doorway.

An all-steel form has been in use in Kansas that is very practical and fairly cheap. It can be made by any local tinner or blacksmith. The material used is 18-gauge galvanized iron 4 feet wide, braced and held in shape by three angleiron bands riveted on, one at the top, one

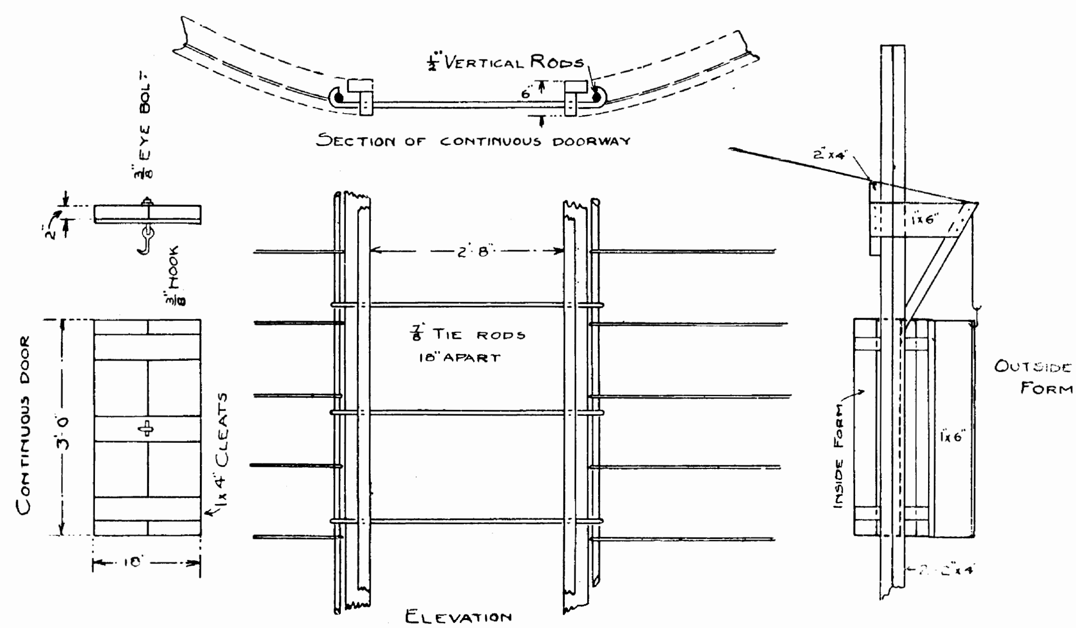


Figure 38—Plan of reinforcing for continuous doorway in a solid-wall concrete Silo
Courtesy of Universal Portland Cement Company, Chicago

in the middle and one at the botton of the forms. The inner and outer forms are made of the same material. The forms are made in sections, usually four inside and four outside. Hooks for raising are attached near the upper edge of the middle of each section. The sections are fastened together at each joint with three pairs of wrought-iron straps, with one end bent to a right angle (see Figure C, Plate A, and Figure 36) and furnished with long, threaded bolts. The outside forms are bolted together as in Figure 33. The inside forms are made practically the same, except that the taps are placed between the lugs so as to force the forms apart when the taps are tightened (see Figure 36). Both the inner and outer sections of the forms should lap six or eight inches (see Figure 40). Since in the forms previously described the outer form has been used with success without any angle-iron bracing, it is probable that at least two rounds of angleiron, one at the top and one at the bottom, might be sufficient for the outside form.

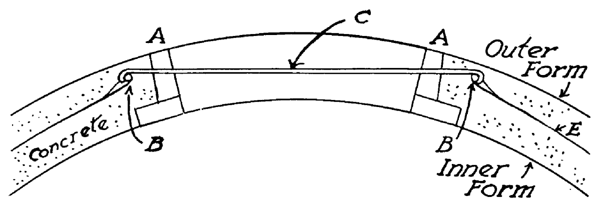


Figure 39—Forms for continuous doorway for concrete silo together with reinforcing. B. Upright 1-inch pipe. C. ⅝-inch iron rod. E. Wire reinforcing. A. Forms of 2x4's

The First Fill

When the foundation or footing has set, place the forms on the foundation and level them in the center of the footing. Spread the first batch of concrete so it will form a layer all around the silo and then place the first reinforcing. Smoothness is essential in the silo wall, and every precaution should be taken to make it so. The inside of the forms should be greased and kept clean. Any cheap oil, such as crude oil or axlegrease, may be used. It is important to tamp the mixture well as it is poured in. The best tool for the purpose is either a straight-handled spade or a paddle made by straightening the gooseneck of an old weeding hoe. This tool should be worked along the sides of the form as in Figure 37. This will not only work out the air and prevent what is known as honeycombing, but will work the larger particles of rock toward the center of the wall. This causes the finer portions of the concrete to settle next the forms and form the surface of the wall. The reinforcing should be kept to within about one inch of the outer edge of the wall.

Time for Setting

When the form has been filled long enough that the top portion of the concrete is just beginning to set, scrape off any concrete that is hanging over the top of the form. Then when the form is raised the top of the wall will not have to be broken before the forms can be raised. If the forms are not filled more than level full this will not be necessary. In dry weather only five to seven hours is required for the setting of a form, but in moist, cool weather twenty-four hours or sometimes longer may be required. It is better to allow plenty of time for setting than not enough. While the concrete is setting the section of the wall next below may be washed with cement and water, or whatever waterproofing is used to make it impervious to water and air. A cement wash can be put on easily while the scaffold is in reach and goes on best while the wall is moist. By getting the forms full of fresh concrete the last thing at night, the concrete sets during the night, thus allowing no waste of time. In dry, warm weather, and with a large working force, as many as three fills have been made in one day, beginning one at 7:00 a. m., one at 1:00 p. m. and one at 5:30 p. m.

Scaffolding for Use With All-Steel Forms

Build a four-legged scaffold using 4x4's for the legs, bracing horizontally with 2x6's and bracing diagonally with 2x4's (Figure 41). The scaffold should be put together with bolts if several silos are to be built so it may be easily put up and taken down, and so that the lumber will last longer. Twenty feet is the most convenient length of

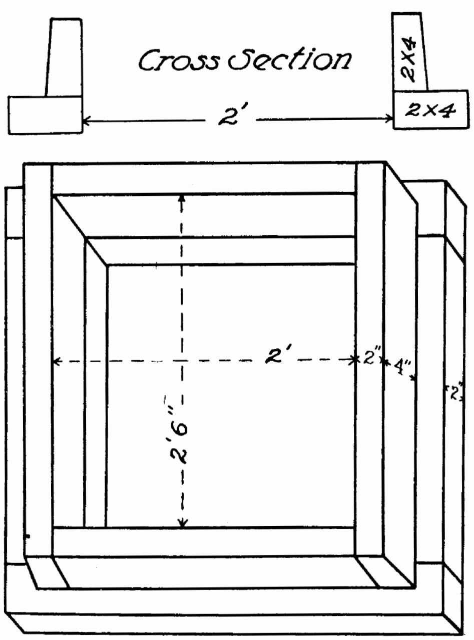


Figure 40—Form for intermittent doorway way in concrete silo. Made of two frames of 2x4's nailed together

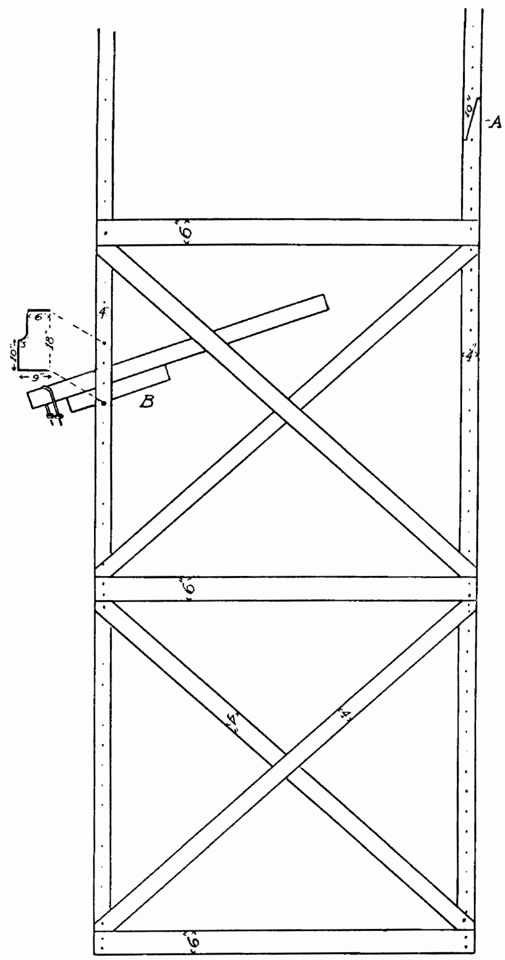


Figure 41—Scaffolding for use with sheet steel forms. Note method of making splice at A. Two pairs of levers at B. are used for inside forms, one for each upright. Clevis C. of ⅝-inch round steel rod holds B. to uprights of scaffolding. Short end of lever engages clevis D. attached to platform (Figure 42)

4x4's to use in the legs. In making splices, mark in one inch at the end on one side of the 4x4 and ten inches below on the other side, make a saw cut one inch deep, then connect the saw cut with the mark by sawing diagonally across the piece as at A in Figure 41. To provide for raising the forms, bore ⅝-inch holes every six inches up and down each leg. Additional holes will be required for bolting the braces on. The ends of the diagonal brace should be sawed diagonally at each end so that one side will fit on the horizontal braces and the other side will come even with the outside of the leg. There should be a hole in each end of these braces two inches from the end. All of the horizontal braces are made alike and all of the diagonal braces are made alike, thus making them interchangeable. It is very essential when setting the scaffold up to get it perfectly level and plumb, then there will be no trouble in keeping the silo wall plumb.

Platform

For a platform to work on and to support the forms use four pieces of 4x4's forming a square one-half inch larger on each side than the scaffolding. Bolt these together directly over the center of the silo wall and fasten the metal forms to them so when the platform is raised the forms will be lifted also (Figure 42). These pieces should be long enough to extend three feet past the silo wall at each end, then they can be used to support a scaffold all around the silo. It is best to use 2x10-inch lumber for this scaffold, bolting each piece down.

Plan for Raising Forms

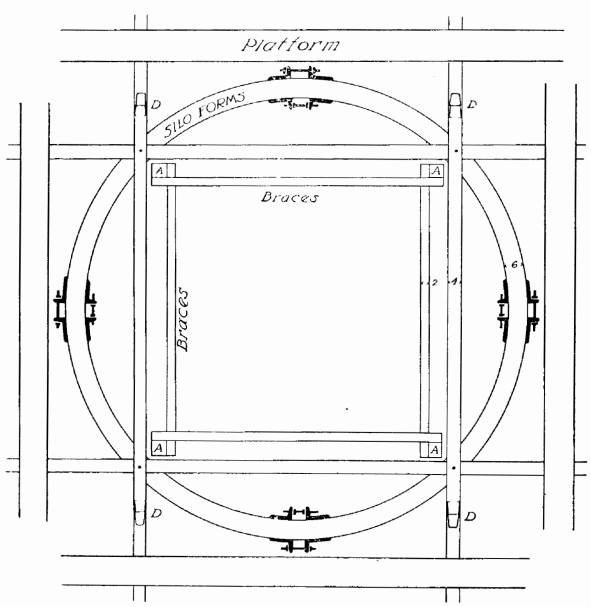


Figure 42—Shows steel forms in place, together with platform and scaffolding. (See Figure 41)

Make four levers of 2x4's 9 feet long, bracing each of these near one of the ends with 2x4's 3 feet long, as shown at B, Figure 41. Make special shaped clevices of 5.8-inch rods, as shown at C. The 9-inch prong of the clevices are placed in the hole of the derrick leg just below where the lever is to be placed. Regular shaped clevices are placed on the 4x4's of the platform to attach the lower ends of the levers. If two clevices are used at each place, one six inches longer than the other, the form may be raised one foot (two six-inch raises) without moving the special clevices (C) holding the levers to the derrick. When the levers are in position, one man stands on the high end of each lever. When the levers are down, one man can hold two levers while the other raises the stop bolts below. These are ⅝-inch iron pins placed in holes bored in the legs of the scaffold and project-

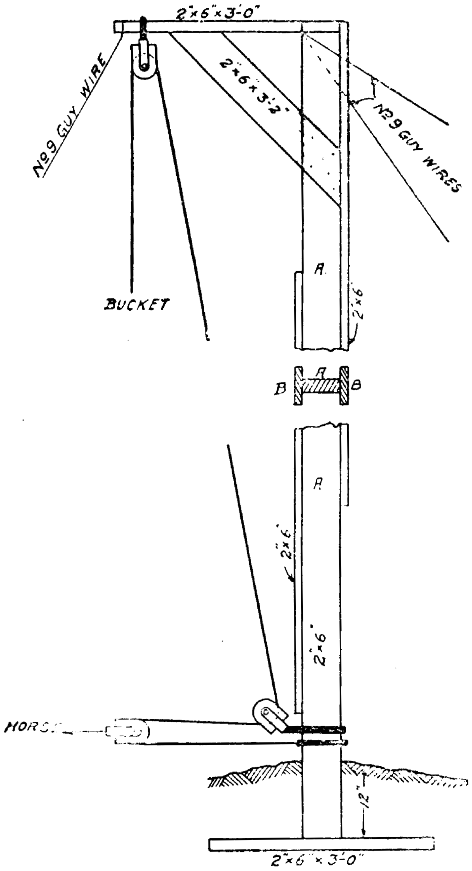


Figure 43—Stationary derrick for hoisting concrete. Courtesy of Universal Portland Cement Company

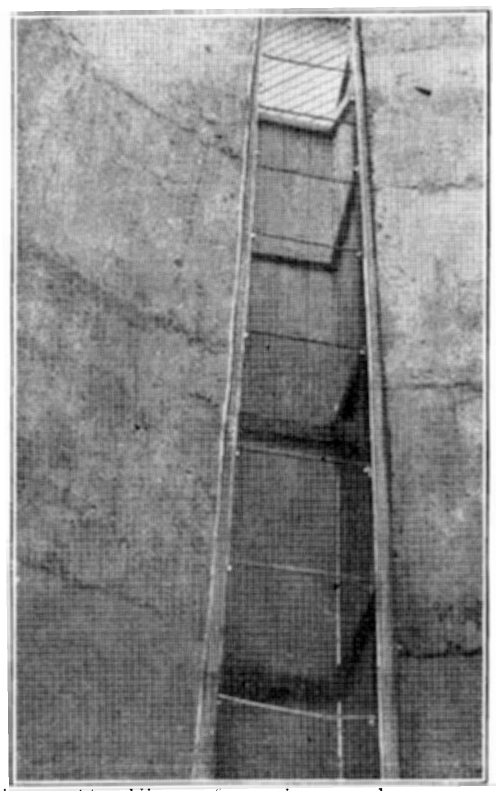


Figure 44.—View of continuous doorway in concrete Silo. Also shows rough wall, due to overhang of forms. Note construction of Silo chute

ing enough to support the 4x4's of the platform. A good hoist is shown in Figure 43. This stationary hoist is usually set outside the silo. A swinging derrick, pivoted at the top and bottom, may be set in the center of the silo to good advantage.

Bill of Lumber for Scaffolding for Silo, Dimensions 14x40 Feet Not Including Hoist

8 pieces of 4x4 20 feet long for legs of derrick.
24 pieces 2x6 9 feet 2inches long for horizontal braces.
40 pieces 2x4 12 feet 2 inches long for diagonal braces.
4 pieces 4x4 16 feet long to use as platform supports.
4 pieces 2x10 18 feet long to use in platform.
4 pieces 2x10 3 feet long to use in platform.
4 pieces 2x4 9 feet long for levers to raise form.
4 pieces 2x4 3 feet long as braces for levers.

Raising the Forms

The first thing to do in raising the forms is to loosen all bolts holding the forms against the wall. Then see that the forms are loose from the wall all the way around. Next raise the forms, keeping all sides about level. Ordinarily three inches is plenty to lap the forms over the walls, but if there is a break in the wall, brought about by the raising of the forms, take all loose pieces out and lap the forms enough to reach below the break. Always before starting the next fill, be sure that there is no space between the wall and form. This space is spoken of as an overhang, and one-fourth inch of overhang makes a very rough wall. (See Figure 44.) This can be prevented by tightening all bolts at the same time. It may be necessary to have one person pound the form where the overhang is worst while another tightens the bolts where the forms are binding. Be sure that the forms are level and plumb before the bolts are tightened. All roughness at joints should be plastered with cement plaster and well smoothed with a trowel. When this is gone over with cement wash the wall will be fairly smooth.

With the wood form (Figure 44) the wedges are driven out first, and the bolts in the slotted bolt holes loosened. Jacks are used to raise the inside forms, which slide up on the 4x4 uprights. Iron pins are put through the 4x4's to hold the form up when in place. The wedges are then driven in and the bolts tightened again. Do not wedge the inner form into place without having the outer form tightened as a support for the new concrete wall.

Doors

There are two types of doorways, the intermittent and the continuous kind. The intermittent door is the most popular in concrete silos because it is more simple of construction and there is less liability of weakening the silo than with the continuous door. In many concrete silos that crack the weakness occurs from faulty reinforcing around the door. Intermittent doors are openings between which there is a section of solid wall. These openings may be made of such size and distance apart as may suit the builder. (See Figures 45 and 46.) They are usually 2 feet wide and 2½ or 3 feet high, with a distance between them of three or four feet. With this type of door it is a little more laborious to get the silage out than with the continuous door.

Door Forms

A good door form for the intermittent type doorway is a simple frame of 2x4-inch lumber, as shown in Figure 40. Two frames are made, one with the 2x4's edgewise, and the other flat, both having the same inside measurements. The second frame is four inches longer

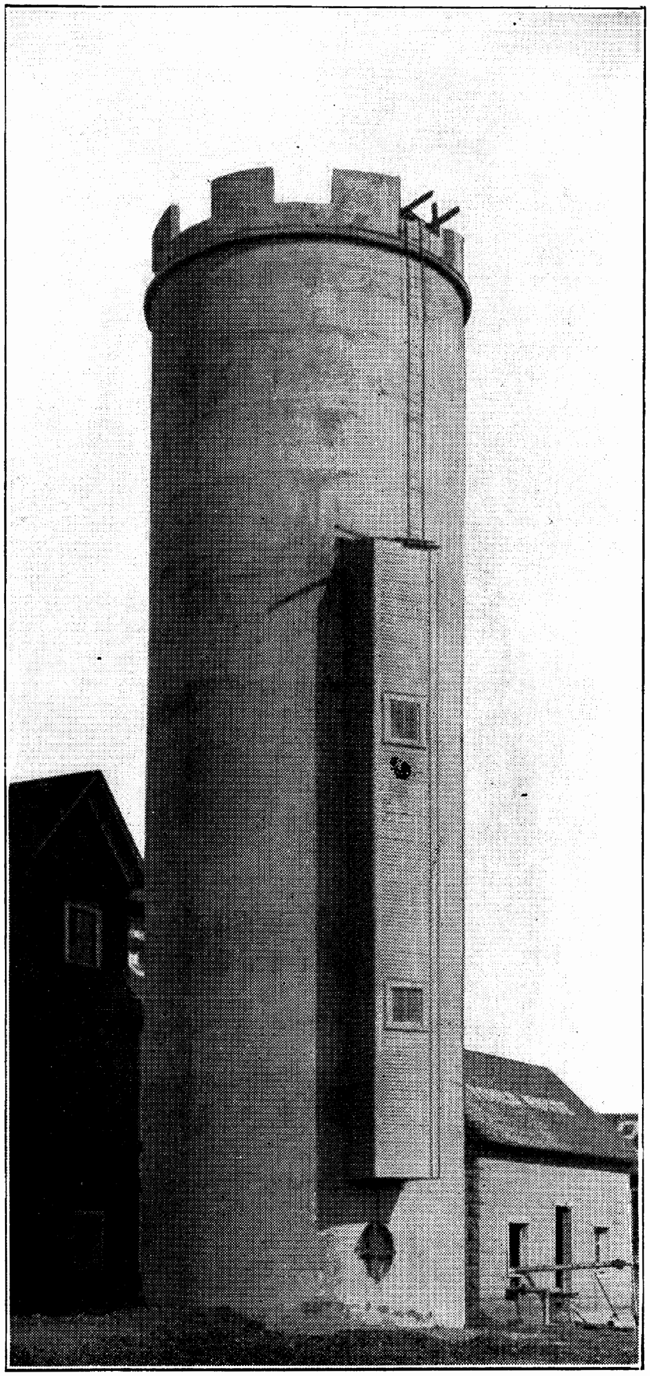


Figure 45—Water tower and Silo of reinforced concrete. The original of this was recently erected on Miller Brothers' 101 Ranch in Kay county, Oklahoma, by Oklahoma Concrete Silo Company, Oklahoma City (Polk System, see Figure 30)

and four inches wider outside measure than the first. Then nail the two together. This makes a frame 6 inches thick which will fit the space between the forms. When this is placed in the wall there is an offset in the concrete of two inches all around the opening.

When a continuous door is to be built it is usual to reinforce the silo with a sufficient number of ⅝-inch rods, extending all around the silo, to form the ladder rungs where they pass through the opening. These should be twenty-six inches apart and, if the ⅝-inch rod is used, this distance apart and enough No. 3 wire used between them to supply the requirements of reinforcing given in Table V, there is little or no danger of the continuous door weakening the silo.

In making the form for the continuous door, take two pieces of 2x6's 8 feet long. Placing one on the other, bore ⅞-inch holes two inches from one edge of the pieces and make the holes twenty-six inches apart. Rip these pieces through the center of the holes bored. Nail a 2x2 8 feet long on each side of the 4-inch sections to form the offset or jamb, as described in the intermittent door form. These pieces should be placed parallel, making the sides of the form. If they are braced apart with pieces of 2x4's 18 inches long the door proper will have a width of 22 inches. The door form should be placed in the silo form so that the reinforcing or ladder rungs come through the holes bored. Then place the 2-inch sections that were ripped off the 2x6's back in place and fasten with cleats. Brace so as to be perfectly plumb before making the first fill around door. When wall is up to top of forms take apart and raise for next fill. (See Figure 39.)

In order to provide bolt holes for bolting on a chute it is necessary to insert round, tapering, hardwood plugs in the concrete on either side of the doorway as the forms are being filled. One should be placed at each side of the doorway in each alternate fill. The measurements from the doorway should be exact so that when the silo is completed the bolt holes will be in a straight, perpendicular line on either side of the door. These plugs may be driven out, bored out or burned out. For illustration of how the chute is put on, see Figures 39 and 40. For reinforcing a continuous doorway, using wire fencing or other small wire around the silo, have ½-inch rods or iron pipes set perpendicularly on each side of the doorway. Attach the wire to these. Tie these together across the doorway by ⅝-inch iron rods bent at each end to go around the upright rods. (See Figure 39, also Figure 60.)

The Iola Portland Cement Company, Kansas City, Missouri, has recently published a complete book of plans for building a concrete silo by means of the forms shown in Figure 33. It should prove immensely valuable to any one intending to build a concrete silo. Another valuable bulletin is published by the Oklahoma Portland Cement Company of Ada. Other good publications are sent out by the Universal Portland Cement Company and Lehigh Cement Company.

Chicago, Western States Portland Cement Company, Kansas City, Oklahoma Concrete Silo Company, Oklahoma City, and American Portland Cement Manufacturers, Philadelphia.

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CONCRETE BLOCK SILOS

Concrete block silos have been used for a number of years. They give good satisfaction and make very substantial structures. However, there have been some failures in concrete block silos as there have been in solid-wall concrete silos. Failures, when such occur, have usually been due to lack of reinforcing or to faulty foundation. Concrete block silos may be made of ordinary building blocks, but there are a number of special silo blocks manufactured which are better suited to the purpose (see Figures 49 and 50). Where the cost of transportation of manufactured blocks is not too great and where sand and stone have to be purchased anyway, it is doubtful whether there is any advantage in making blocks at home. If sand or gravel are close at hand, blocks may often be made very cheaply. The more common method of making concrete blocks is to compress a slightly

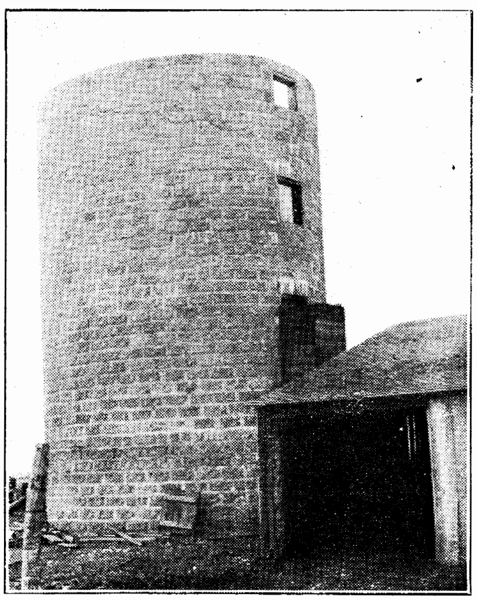

Figure 46—Concrete block Silo on the farm of J. W. Patton, Stillwater, Oklahoma. Manufactured blocks and intermittent doors. Built by Lawrence-Harvey Concrete Company, Stillwater

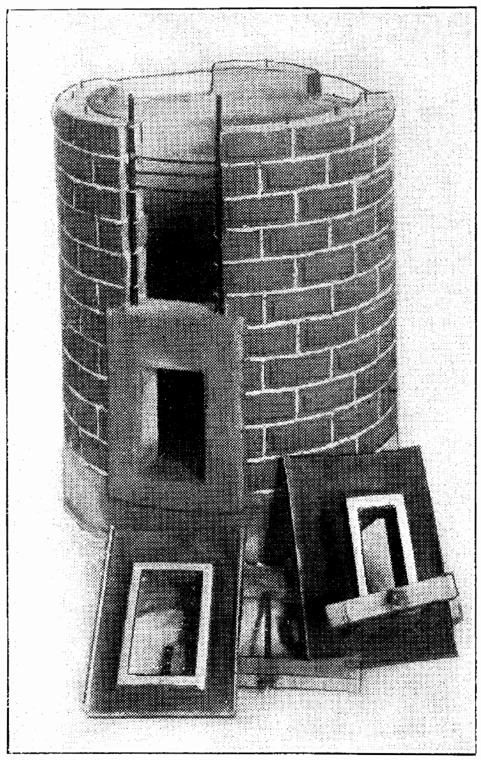

Figure 47—Concrete block Silo, showing reinforcing for intermittent doorway, with door frames of solid concrete. Dowel pins set in concrete in center of hollow blocks blocks act as vertical reinforcing

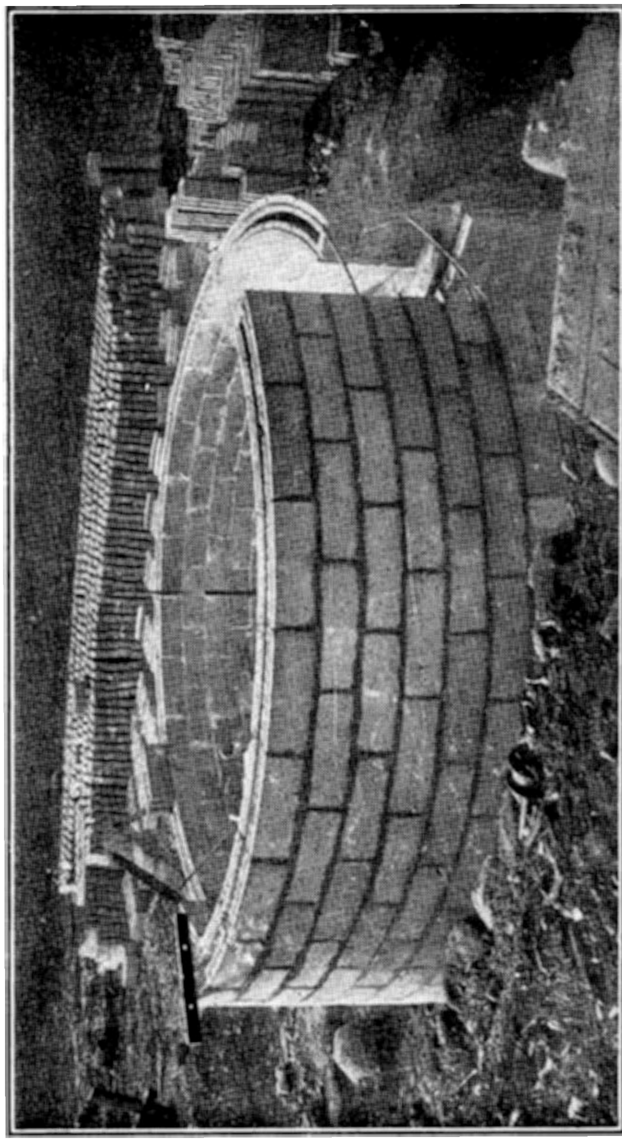

Figure 48—"PERFECT" cement block Silo in process of construction, showing how reinforcing rods form the ladder rungs for a continuous doorway
Courtesy of J. J. Coyne, Fon du Lac, Wisconsin

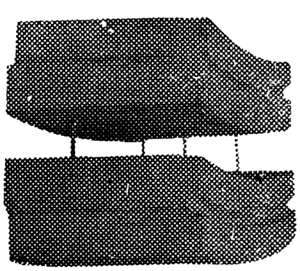

Figure 49 shows type of patent cement silo block with continuous air space through center. Same as is used in Figure 48

dampened concrete mixture in a mold, then remove it from the machine and covering it with wet straw or sacks for some time to allow it to harden. This makes a block that is more or less porous, which only makes a perfect silo wall when plastered. There are several brands of block machines on the market for making concrete blocks with a dry mixture. (See Figure 49.) Patent block machines are more or less expensive, but homemade forms may be made which answer every purpose.

Materials Used in Concrete Block Silo 16x32, Figure 46

2,000 blocks	$ 240.00
24,300 pounds sand	15.80
7,010 rock	9.70
126 sacks cement	56.70
Door caps	10.00
Waterproofing, 20c per pound	8.00
Laying blocks	120.00
Hauling	63.00
Reinforcing	8.00
Doors	15.00
Total	$ 546.20

TABLE VIII

Number of Concrete Blocks Required

Whole Block, 16 inches long (outside), 8 inches high
Half block, 8 inches long (outside), 8 inches high

Inside Diameter of Silo.	8 Ft.	10 Ft.		12 Ft.		14 Ft.		16 Ft.		18 Ft.		20 Ft.	
Size of Block. Height of Silo.	Whole.	Whole.	Half.	Whole.	Half.	Whole.	Half.	Whole.	Half.	Whole.	Half.	Whole.	Half.
20 feet	600	720	30	870	30	1020	30	1140	30				
22 feet	660	792	33	957	33	1122	33	1254	33	1419	33		
24 feet	720	864	36	1044	36	1224	36	1368	36	1548	36	1728	36
26 feet	780	936	39	1131	39	1326	39	1482	39	1677	39	1872	39
28 feet	840	1008	42	1219	42	1428	42	1596	42	1806	42	2016	42
30 feet	900	1080	45	1305	45	1530	45	1710	45	1935	45	2160	45
32 feet	960	1152	48	1392	48	1632	48	1824	48	2064	48	2304	48
36 feet	1080	1296	54	1566	54	1836	54	2052	54	2322	54	2592	54
40 feet	1200	1440	60	1740	60	2040	60	2280	60	2580	60	2880	60

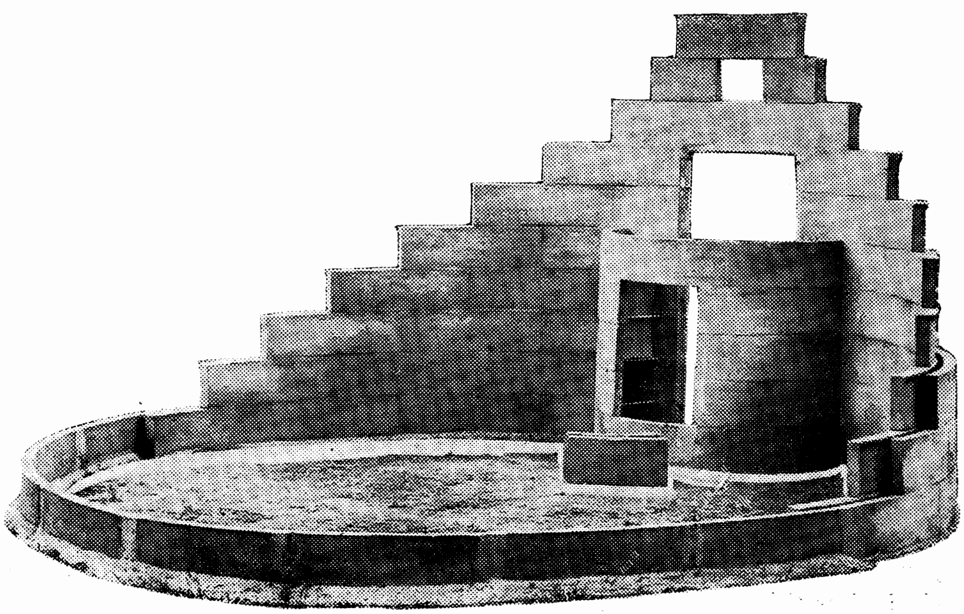

Figure 50—Circular block Silo, with chute on inside
Courtesy of Binning Cement Block Silo Company, Grand River, Iowa

2—SLUSH CONCRETE BLOCK SILO

A cheap and very desirable type of block is made by the slush method in simple, homemade forms, using a sloppy mixture of cement and sand or cement and gravel. Make long troughs of 2-inch lumber, 16 inches wide and 8 inches in depth. One side of these troughs is hinged or removable so that the blocks can be removed more easily. Clamps, bolts or other devices are needed to hold this side in place and to keep the sides from springing out when the form is filled. Sheet steel plates (16-gauge steel) 16½ inches by 8 inches, rolled to the curvature of the silo, are set in the trough as divisions. These plates are spaced in the trough by nailing blocks to the sides of the trough. Four-inch weatherboarding or lapsiding is used generally, as this makes about the right radial cut for the ends of the blocks, and makes a block four inches thick. This will make blocks 16x8x4, and ninety-one of these blocks can be made from one cubic yard of mixed con-

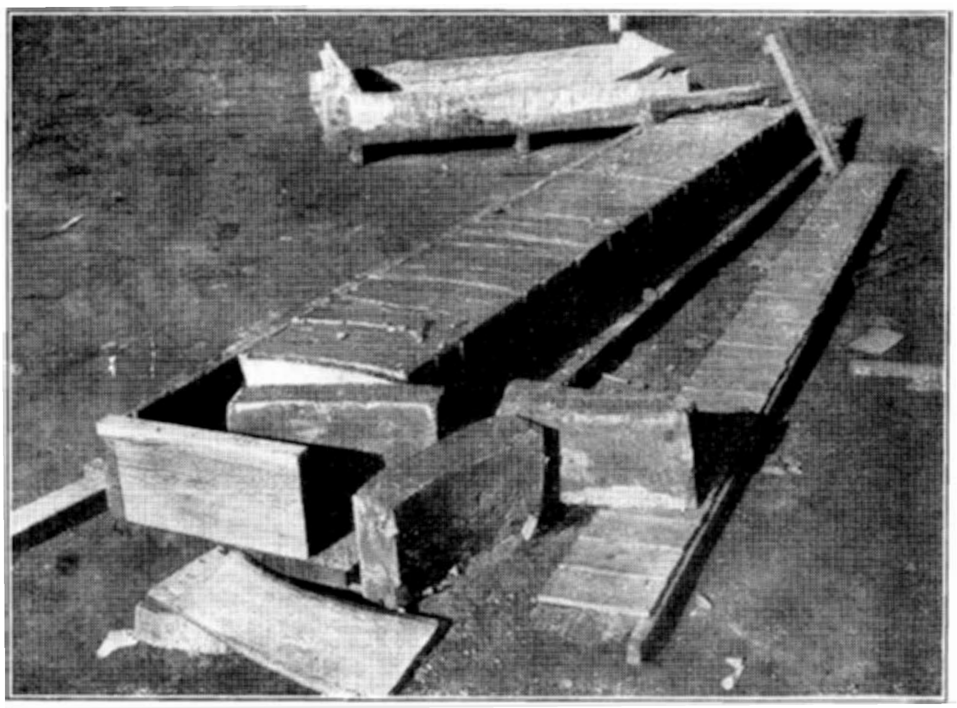

Figure 50A—Mold for homemade concrete silo blocks 16x8x4 inches. One side of mold removed showing spacing blocks. Model made at Oklahoma A. and M. College

crete (eight sacks cement and 1.1 yards sand or gravel). Sixteen hundred and thirty-two whole blocks and forty-eight half blocks are required for a 14x32 silo with continuous doorway. This equals eighteen and one-fourth yards concrete, or 146 sacks cement and twenty yards sand or gravel. (See Figure 50A.) Blocks can be made five or six inches thick if desired.

One set of these plates may be used in a number of forms by

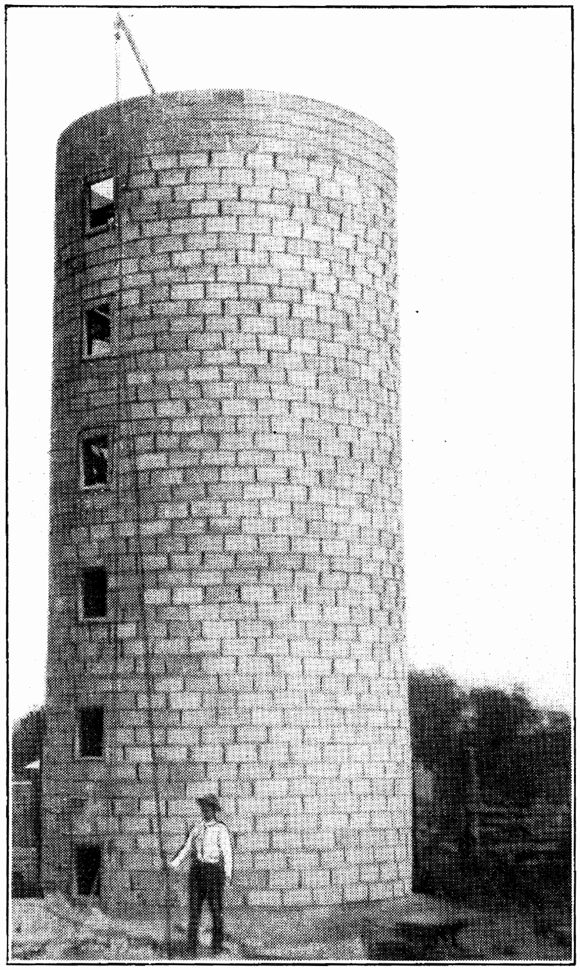

Figure 50B—Concrete block silo 18x40 feet. Built of homemade blocks made by J. M. Anderton, Okemah. Slush method. (See Figure 50A)

adopting the following method: The plates are covered with wrapping paper and placed in the form. When the form is filled with the soft concrete the paper is cut along the edge of the dividing plates, the plates are then taken out and rewrapped and used in another form. To make a trench in the blocks to hold the reinforcing rods or wire, nail strips of one-half-inch or three-fourths-inch doorstop in the bottom of the forms. These strips should have the same curve as the division plates and be placed directly half way between the plates. It is not absolutely necessary to have these trenches in the blocks, but they will help in placing the reinforcement, especially where the blocks are being laid by unskilled labor. Soak the trough or oil it before filling.

The Anderton Silo

A concrete block mold for making silo blocks by the slush method has been patented by J. H. Anderton of Okemah, Oklahoma. The silo shown in Figure 50B is 18x40 feet and built of blocks made in his molds. The blocks are slightly larger than those just described, being 18x9x4 inches. Mr. Anderton estimates that one-half yard of sand and one-half yard of gravel to six sacks of cement makes the best mixture to use. He reinforces his silo with No. 4 wire, which is a quarter of an inch thick. The top of the block is grooved and also the ends. The mortar used in laying these blocks is of one part cement and two parts sand. The grooves at the ends of the blocks are not filled with mortar, but are poured full of slush concrete after being laid. To make the foundation Mr. Anderton digs a trench 2 feet wide and 1 foot deep and fills this with concrete.

The doorway for this silo is of the intermittent type and the door frames are of poured concrete. The outfit for building a silo consists of one door frame mold and five block molds. Each of the block molds makes eighteen blocks or ninety in all at each fill. Mr. Anderton expects to rent these forms, and it is probable that there will be considerable demand for them.

Estimate of Material for Silo 18x40, Capacity 228 Tons, Figure 50B

Cement, 233 sacks @ 50c	$ 116.50
Sand, 35 yards @ $1.50	52.50
Crushed rock, 30 yards @ $1.50	45.00
Labor for making and laying blocks	131.00
Rent of molds, cost of reinforcing and iron chute, and cost of doors	195.00
Total	$ 540.00

For a 228-ton silo this is approximately $2.50 per ton capacity. Mr. Chester H. Nunn, Federal Demonstration Agent for Okfuskee county, was the first to call our attention to the fact that this silo was being built in Oklahoma. He claims that the silos made from these blocks appear to be first class in every way, and the people in that vicinity are well pleased with them. Mr. Nunn has tested these blocks in water and believes that they do not take up as much water even as vitrified brick.

This plan for making blocks was devised by Professor Davidson of Iowa and published in Bulletin No. 141 of that Station. With enough forms a man can make hundreds of blocks in a day. The blocks can be made on rainy days at half the cost of buying and transporting hand.

Reinforcing Concrete Block Silos

The requirements for reinforcing in the concrete block silo are practically the same as in a solid-wall silo. A ⅜ or ½-inch rod should be placed between every layer of blocks until a point fourteen feet below the top of the silo is reached. After this a rod of this size between every other layer of blocks is sufficient. The reinforcing around the door is important. If an intermittent door is desired, three or four layers of blocks are laid between each opening. The reinforcing rods at the doorway can be hooked around an upright rod at each side. (See Figure 47.) A steel or iron plate will be needed at the top of an intermittent doorway unless concrete door frames are used. With the continuous opening it is sometimes sufficient to use a heavier rod and put in every other mortar joint or every third joint and let it continue through the doorway as in Figure 49.

TABLE IX

Horizontal Reinforcement for Block Silos

Showing size wire and rods to be used between each course of blocks 8 inches high:

Feet from Top of Silo	Diameter of Silo.			
	8 Ft.	10 Ft.	12-16 Ft.	18-20 Ft.
0 to 8	No. 6	No. 6	No. 6	¼ in.
8 to 16	No. 6	¼ in.	¼ in.	⅜ in.
16 to 24	No. 6	⅜ in.	⅜ in.	⅜ in.
24 to 32	¼ in.	⅜ in.	⅜ in.	½ in.
32 to 40	¼ in.	⅜ in.	½ in.	½ in.
40 to 44	⅜ in.	⅜ in.	½ in.	½ in.

Materials

For slush concrete blocks for silo 16x32, blocks 16x8x4 (see Table IV, page 30):

Blocks required, 1,848. (See Table VII, page 51.)
Number of blocks in 1 yard of concrete, 91.
Yards concrete required for silo, 1,849÷90=21.

Material for 1 yard concrete, 1 part cement, 4 parts gravel (see Table IV).

7.92 sacks cement.
1.11 yards gravel.

Material for 21 yards concrete—
166 sacks cement @ 55c=$91.30.
23.3 yards gravel.

3—METAL LATH SILO

The metal lath silo is constructed by plastering with several coats of cement plaster on both sides of a metal lath form put on temporary staging in silo form. In this type of silo the wall is thin and the amount of materials used is less than that required in the block or solid-wall silo. However, more skilled labor is necessary and the cost will be nearly as great. The metal lath is not enough reinforcing in itself, so extra reinforcement should be used. This is done by wrap-

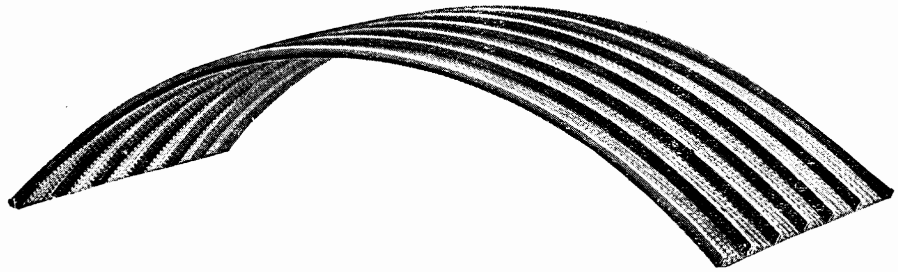

Figure 51—Section of Hyrib metal lath specially constructed for building plastered concrete Silos and tanks

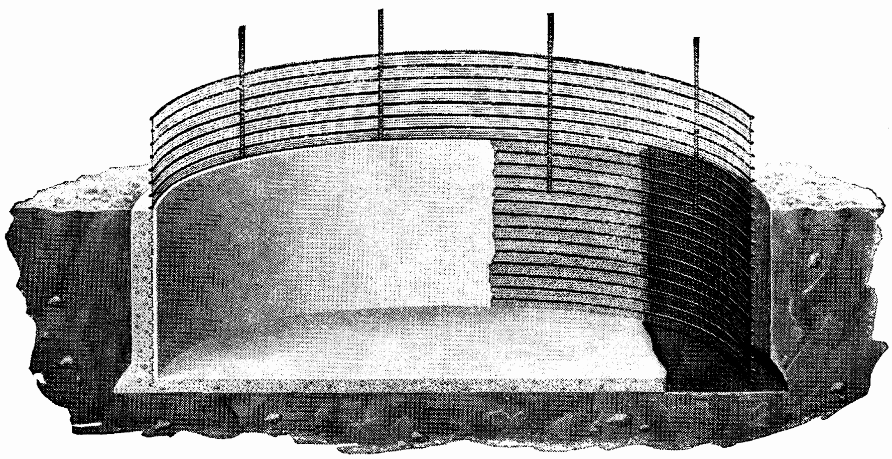

Figure 52—Foundation for plastered metal lath Silo showing detail

ping steel wire around the wall after the staging is removed. This should be placed horizontally just outside of the metal lath before the outside coat of plaster is put on. When this type of silo is well constructed it is very durable and one of the most handsome silos built. The walls are usually very smooth. Three or four coats of cement plaster are put on the inside of the silo and allowed to set. The staging is then removed and the wire reinforcing wound around the outside of the metal lath. The outside of the wall is then given two or three coats of cement plaster, making a strong, smooth wall about three to four inches thick. A continuous doorway may be built of reinforced concrete, or intermittent door frames may be used as in any other silo. This silo has been erected very successfully in Kansas during the past two years and gives good satisfaction. The cost of this silo does not exceed $3.00 per ton capacity in any case. A special type of metal lath made especially for silos is manufactured by the Trussed Concrete Steel Company of Detroit, Michigan. This is curved to the right shape and is easy to erect (see Figures 61, 62, 63, 64). There are few if any such silos in Oklahoma, but they are worthy of consideration. The Kansas bulletin on cement silo construction deals with the metal lath silo at some length.

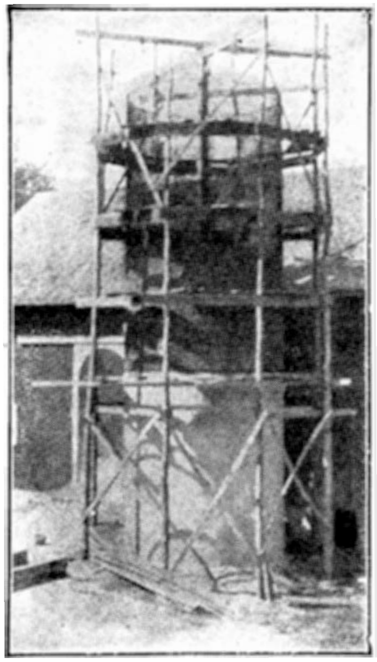

Figure 53—Plastered concrete Silo. Inside plastering completed and 2x4 falsework removed. Scaffolding in place for plastering outside

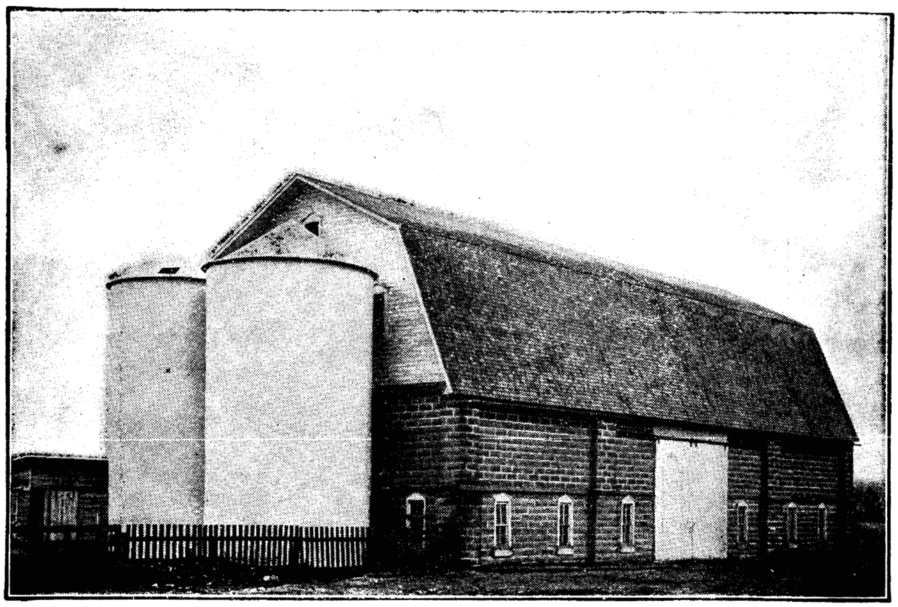

Figure 54—Twin silos of plastered metal lath. Built on Hyrib metal lath. Cuts 51, 52, 53, 54, courtesy of Trussed Concrete Steel Company, Detroit, Michigan

4—CONCRETE STAVE SILOS

A number of concrete construction companies are putting out concrete stave silos. These staves are usually about 8 or 10 inches wide, 2 to 3 feet long, and 2 to 2½ inches thick. Some are tongued and groved with a special tongue and grove on the sides and ends. The staves are reinforced with wires. Some of these silos are bound with special wroughtiron hoops. These silos have not been on the market long. If properly constructed they are durable and have the same advantage of being fire and windproof as the other types of concrete silos. They may range in price from $300.00 to $450.00 for a 100-ton silo. They are washed down inside with a waterproofing mixture of cement, lye and alum (see below).

There is no cost for forms with this type and the silo may be easily made in any diameter. They are generally erected by the companies selling the staves. Figure 56 shows a silo said to be the largest in Oklahoma, 60x30, capacity 840 tons. Doors are made on both sides to get the silage out easily. The staves of this type are rectangular.

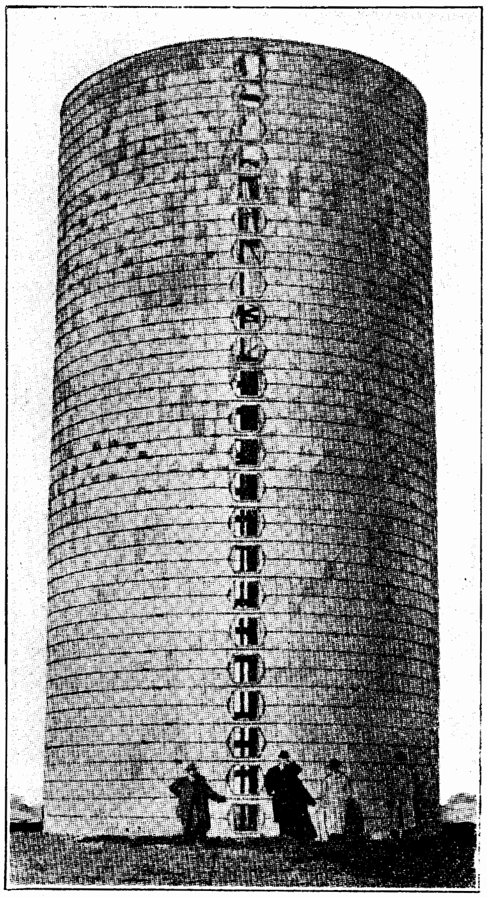

Figure 56—Concrete stave Silo. Size 60x30 feet; capacity 840 tons. Largest Silo in Oklahoma. Doors on each side. Owned by T. C. Harrill, Wagoner; manufactured by Oklahoma Concrete Stave Silo Company, Wagoner, Oklahoma

Figure 57 shows a stave silo of another type, using the diamond-shaped stave, and Figure 58 shows the interlocking stave silo with beveled ends and straight edges.

WATERPROOFING MIXTURES

One objection often made regarding concrete or masonry silos is that they draw some moisture away from the silage and evaporate it. While true to a limited extent, it has doubtless been overemphasized. A concrete wall made from a dry mixture is more porous than if a properly made mixture is used. It is recommended by some that silo walls should be moistened before putting the silage in. Green, juicy silage will keep well in spite of the small amount of moisture lost. It is usually dry silage that becomes moldy and spoils next the wall.

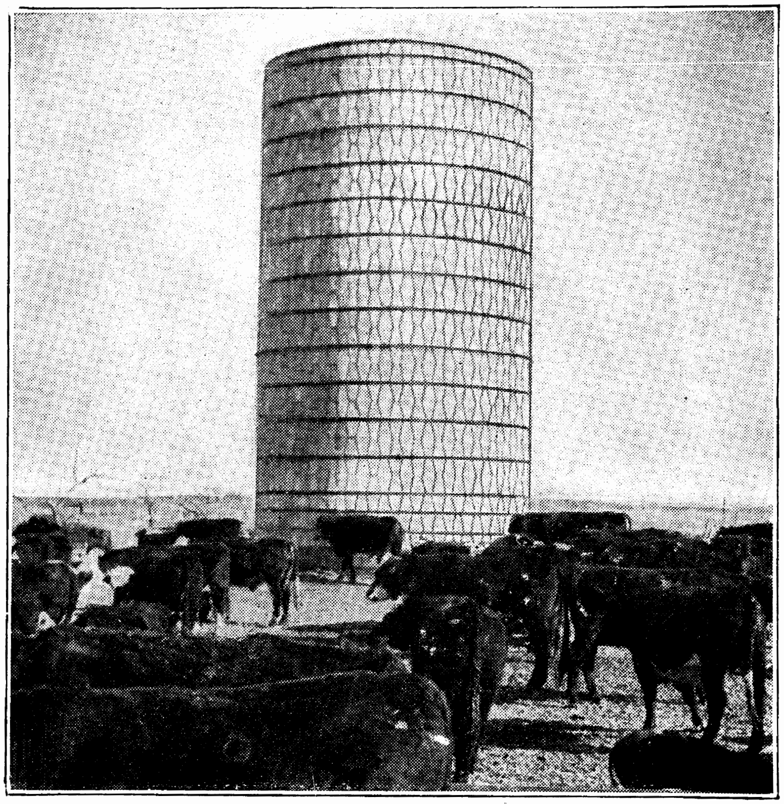

Figure 57—Diamond stave Silo on farm of D. H. Conley, Kingfisher, Oklahoma. Courtesy of Diamond Stave Silo Company, Kansas City, Missouri

There are several ways to waterproof the inside of a silo. A mixture of lye and alum, recommended by the Government, has been used successfully on the concrete silo at the College. Four parts of alum and one part of concentrated lye are mixed with a sufficient quantity of water to make a thick, creamy mixture. This applied to the wall with a whitewash brush will readily adhere to the walls after they are thoroughly dried out.

The Oklahoma Cement Stave Silo Company uses the following mixture to wash the inside of their stave silos: One pint pulverized, concentrated lye and two pints pulverized alum are used with one sack of cement. This is mixed in water just thin enough to spread nicely with a broom. The walls are thoroughly wet first and the wash applied, and then smoothed down with a smoothing brush. This is said to make the walls absolutely impervious to air, water or acid.

A waterproofing powder known as Medusa compound may be used to mix with cement plaster for coating the inside of cement or cement block silos. It costs about twenty cents a pound and two pounds are used to every hundred pounds of plastering. This prevents moisture going through the walls and does not cost much. This mixture was used in plastering the inside of the silo shown in Figure

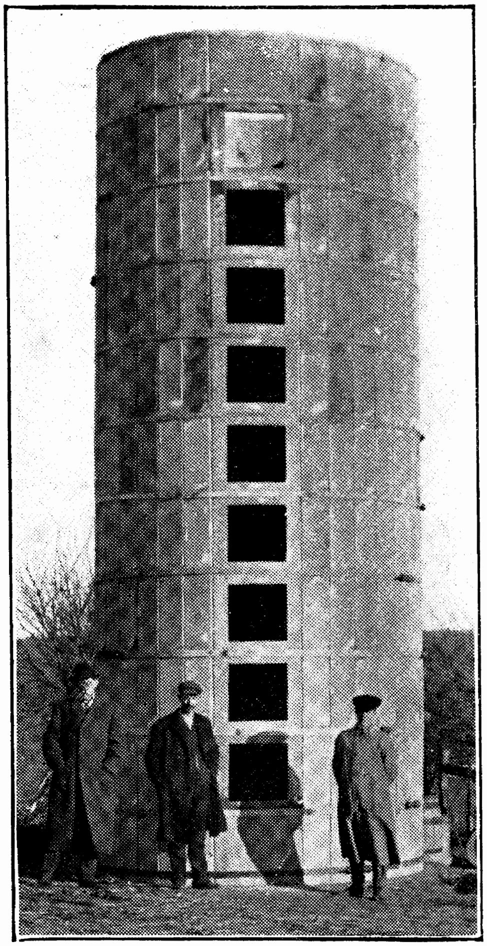

Figure 58—Interlocking cement stave silo Courtesy of Interlocking Cement Stave Silo Company, Oklahoma City, Oklahoma

46. The Trussed Concrete Steel Company, Detroit, Michigan, sells a waterproofing paste for the inside of cement silos or cisterns, or for use in the top coat of concrete roofs. If ordinary lead paint or building paint is used for the outside of a concrete silo it will prevent a considerable amount of evaporation. A coating of coal tar thinned with gasoline has been recommended for the inside of cement silos.

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4—BRICK SILOS

While brick silos are not much used in Oklahoma, there is no reason why more of them should not be used. Vitrified brick is less permeable to air and water than the average concrete, does not cost much more than concrete, if as much, and does not require forms to build. An experienced bricklayer who can build his walls plumb and smooth should have no difficulty in building a brick silo if he will put in enough reinforcing.

Brick silos that have failed have done so invariably on account of poor reinforcement or poor foundations. With strong reinforcement a brick silo set in a mortar made of one part lime to five parts cement with the proper amount of sand is sufficiently strong. The presence of a small amount of lime in the mortar makes it possible to move the bricks slightly while laying without destroying the bond, as would be the case with a pure cement mortar, yet will be practically as strong as pure cement after being set.

We describe below two types of brick silos. One was put up at the A. and M. College from vitrified brick donated by the Oklahoma Brick Manufacturers' Association, and the other the Atwood Brick Silo, put up at the Virginia Agricultural College.

1—THE A. & M. COLLEGE BRICK SILO (Figure 59)

This silo is 12x31 feet in dimensions, holding approximately eighty-five tons of silage and is built of two courses of common vitrified paving brick set in cement mortar, to which a little lime has been added for the sake of plasticity. It was reinforced with strips of woven wire fencing, together with some smooth No. 9 wire. The ground was dug out to a depth of two and one-half feet and wide footings were built, about two feet wide, tapering up gradually to a 9-inch wall. The reinforcing was not put in until about the level of the ground. Steel wire fencing, electrically welded was used for the most of the reinforcing, as it was a little easier to handle than single wires. This 14-wire fencing was cut into three strips of four or five wires each. (See Figure 60.) The outer wall of brick was built up five courses at a time. Then the reinforcing wires were put in place and

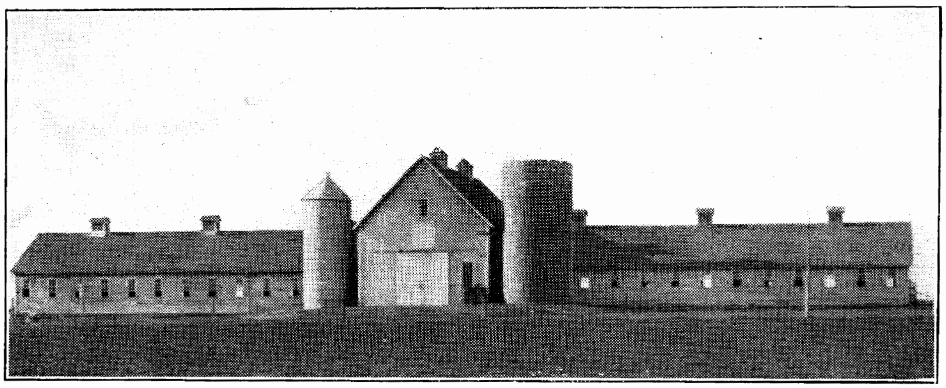

Figure 59—Brick Silo at the A. and M. College sheep barn; 12x30; capacity 85 tons. Also Perfection Metal Silo on left

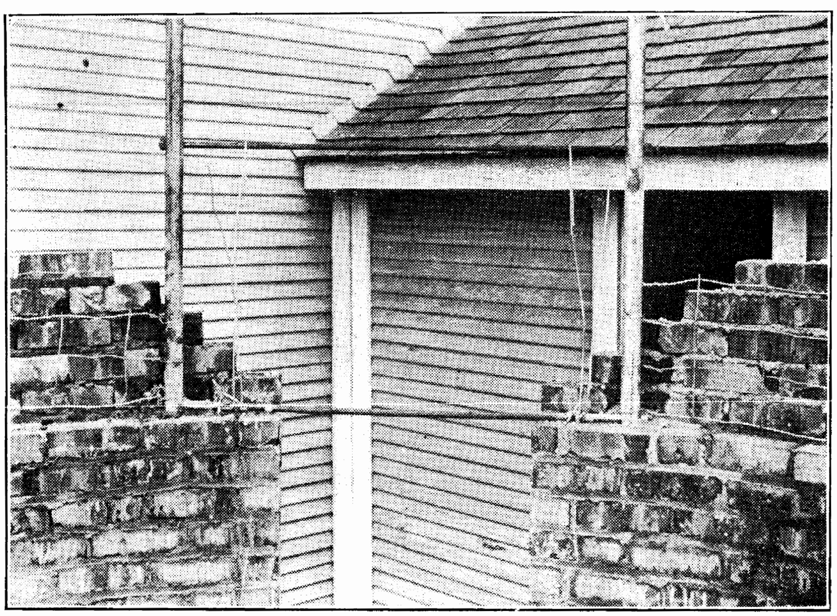

Figure 60—Brick Silo in process of construction, showing continuous doorway. Reinforcing of steel hog fencing attached to uprights of ladder. This type of ladder is adapted to the solid concrete Silo. (See also Figure 69)

fastened at either end to the iron pipe on each side of the doorway, as shown in Figure 60. This wire was pulled as tight as would allow the inner course of brick to be laid easily and was held in place by loose bricks until the inner course was laid. The inner wall was then built up five courses and a header course laid, that is, alternate bricks were laid crosswise in the wall to bind the two sides together. Before putting on the header course any spaces left in the center of the wall between the bricks were slushed full of sloppy cement so as to bed the reinforcing wire solidly in the concrete.

A continuous doorway 2 feet wide was made as follows: An iron ladder was made of two lengths of 2-inch water pipe, 26 feet long for uprights, with rungs of ⅝-inch iron rods. These were run through holes bored in the pipe every 2 feet, 4½ feet long, threaded and bolted at each end. Both upright pipes were cut into three parts to admit of easy handling and were fitted with threads and couplings so that they could be joined again as the silo went up. This iron ladder served two purposes. It provided a continuous ladder by which to climb to the top of the silo. It also served to complete the circle of reinforcement, making an unbroken circle with the wire (see Figure 60). The photo shows how the ladder was built into the wall and how the wires were attached. There was hardly as much wire put in this silo as we wished, but as the silo has done well after one year's filling, it is evidently strong enough. Eight-inch bolts were put in at intervals on each side of the doorway, the heads embedded in the mortar and the threaded ends projecting about three inches, making two rows, one on each side of the doorway, about eight bolts on a side.

After the silo was finished, strips of 2x3's with holes bored at the proper places, were fitted on over all these bolts and taps put on. Corrugated iron sheeting was nailed to these 2x3's (Figure 61) making a very good chute. When the top of the silo was reached, 16-inch bolts were set in the mortar at intervals around the top of the wall so that about four inches of the threaded ends projected from the top when the last course was put on. Sills were cut out and bolted on these so that the top bricks would not get knocked off during filling and so that a roof could be put on if desired. This silo should have been plastered on the inside, but it was decided to try it without plastering for one year as an experiment. It kept silage well, except where some of the fodder was too dry when put in.

The bill of materials for this silo follows:

15,000 bricks @ $12.00 per thousand	$ 180.00
75 sacks portland cement @ 55c	41.25
4 barrels lime @ $1.45	5.80
40,280 pounds sand	30.90
Iron ladder for silo	12.65
12 ⅜x7-in. bolts	.30
8 ½x16-in. bolts	.75
8 pounds nails	.25
15 rods 36-in. fencing	6.00
100 pounds No. 9 wire	3.75
1 man 8 days @ $4.00	32.00
2 men 8 days @ $1.50	24.00
(Lumber for scaffolding not included)	
Total	$ 337.65

Some of the bricks were used in putting a floor in the silo, which was then slushed with cement mortar, making a smooth surface. A silo near Guthrie built of one thickness of brick only, with No. 9 wires laid in each mortar joint is reported as giving good satisfaction.

2—ATWOOD BRICK SILO

The following description of a good brick silo, requiring only one course of brick is taken from a bulletin published by the West Virginia Station:

Method of Construction

An excavation was made about four feet deep to the underlying rock in order to secure a solid foundation. Then a cylindrical brick wall was laid up the width of a brick , or four inches thick, cement mortar being used. As the wall was laid 20-d wire nails, which previously had been annealed by heating them, were imbedded in the mortar with the ends projecting from the wall about two inches into the silo. About two nails were used per square foot of surface.

After the wall had stood a few days for the cement mortar to harden, Page woven wire fencing was cut into pieces of the proper length to go around the inside of the silo, lapping somewhat, and the projecting ends of the nails were clinched over the wires so as to hold the fencing close to the brick wall. Only fencing with straight, horizontal wires should be used, for if the fencing is not close to the wall in all places an unnecessary amount of cement is required for plastering. Two thicknesses of wire fencing were put on for about one-half the depth of the silo, and for the remainder only one thickness. Each strip of fencing as put on was lapped about two inches over the lower one. The top course of fencing was allowed to project about four inches above the top of the wall, and this was stapled to the plate, thus fastening the roof securely to the structure.

After the wires were in place the inside of the silo was plastered with cement mortar, thus covering the wire. The mortar consisted of one part cement and three parts sand.

Four openings were provided at convenient distances for removing the silage. These openings are each 25x30 inches in size. The door frames are of castiron, 1 inch in thickness, with a projection which laps a couple of inches over the brickwork on the inside of the silo. There is also a projection an inch high extending around the frame on the inside two inches from the face of the frame and against which the door presses when in place.

The doors were made of two thicknesses of ⅞-inch flooring with roofing paper between, and were held in place by being bolted to 4x4 pieces of timber extending across the door frames on the outside. The nuts on the bolts which pass through the doors and the pieces of timber are tightened from the outside, and in this way the doors can be drawn snugly against the jamb of the door frames.

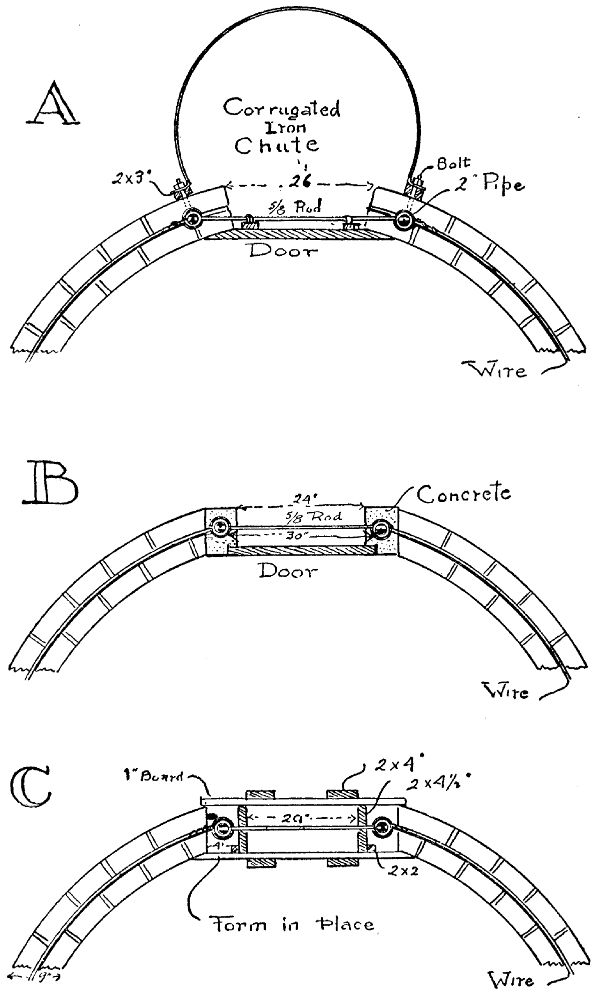

Figure 61—Plan of doorway for brick silo. A. Construction as shown in Figure 60. B. Suggested improvement, using reinforced concrete door frame and a narrower steel ladder. C. Forms in place for building concrete door frame after bricks are all laid and reinforcement all in place. (Oklahoma Farmer-Stockman)

6—TILE OR CLAY BLOCK SILOS

A type of silo that has become very popular in the North is what is known as the tile or clay block silo. These tiles are hollow and glazed or vitrified so as to be impervious to air, moisture and acid. When properly built the tile silo is both substantial and ornamental, and will give excellent satisfaction. The tile silo has not obtained much recognition in Oklahoma to the present date largely because the factories making these silos have been located altogether in the Northern States. Transportation charges have discouraged prospective silo builders. This past year the production of specially constructed vitrified silo tile has been taken up actively by some of the

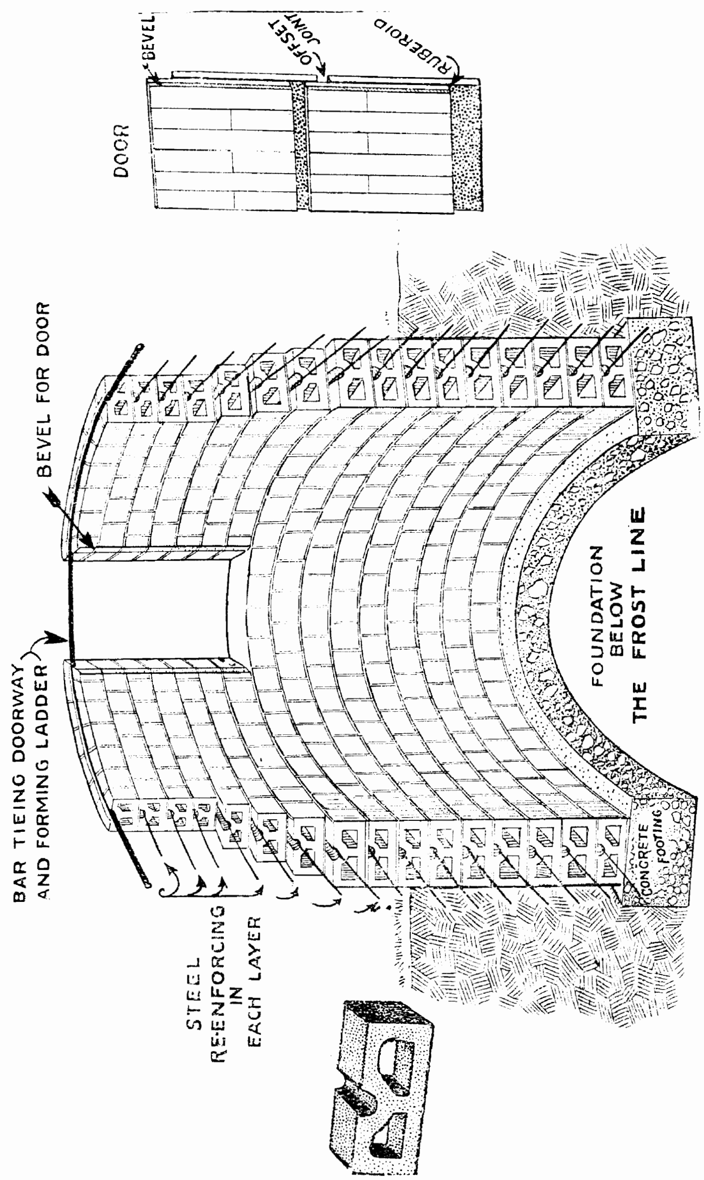

Figure 62 shows Silo tile manufactured by the Pawhuska Vitrified Brick and Tile Company, also section of wall. Shows intermittent doorway, placing of reinforcing and construction of door

brick manufacturers of Oklahoma, and two companies are manufacturing the hollow tile as illustrated in Figure 62. This tile seems to be an exceptionally good one, affording opportunity for plenty of reinforcing and being easy to lay. Two continuous dead-air spaces run clear around the silo in each course of tile, guarding against possible loss of heat. Reinforcing rods are laid in every course in the lower third of the silo, in every second course of the middle third, and in every third course of the upper third of the silo. A vertical iron bar on each side of the door opening extends clear through the steel plates at top and bottom, and the steel rods used for reinforcing fasten to this bar. The door is made of two thicknesses of wood with tar roof-

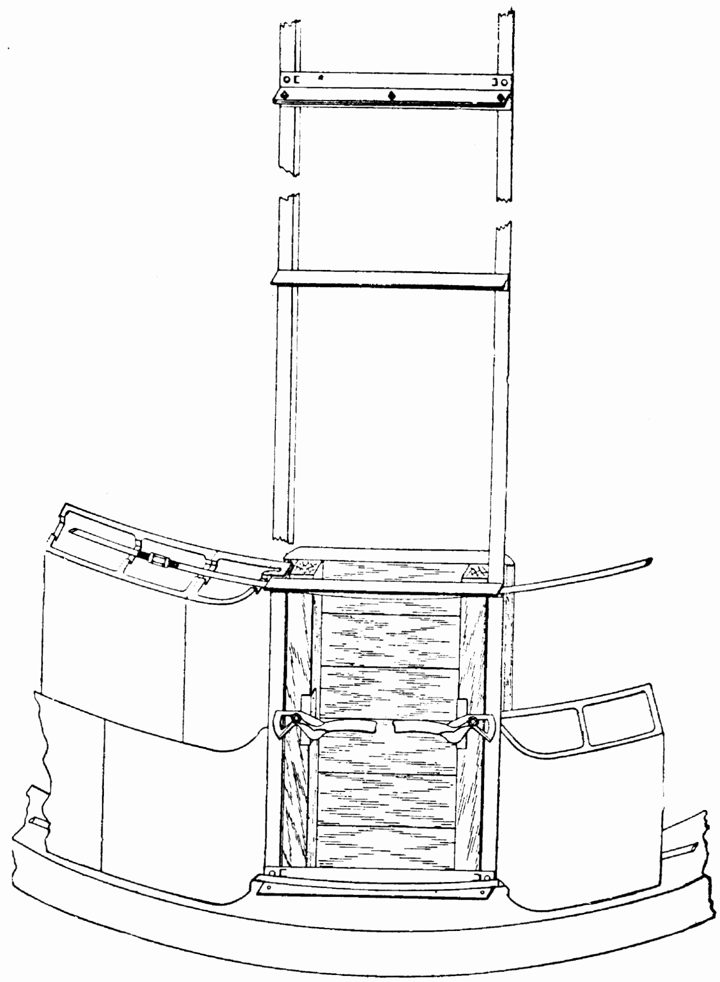

Figure 63 shows special doors, steel doorway detail of reinforcing, and view of hollow tile. (See Figures 64 and 65). Courtesy of Kalamazoo Tile Silo Company, Kalamazoo, Michigan

ing paper between. The blocks around the doorway are beveled on the inside corners, as shown in illustration, and the beveled door pressing against this makes a strong, tightly fitting joint.

Figure 64 shows the doorway of a different type of tile silo, the Kalamazoo silo. This type is built of somewhat larger blocks, has a continuous all-steel doorway with patent doors, and has flat steel reinforcing, as shown in Figure 65. This shows a Kalamazoo type of silo in the process of construction on the farm of L. A. Taylor, near Stillwater, and the completed silo is shown in Figure 65. Figure 64 shows the patent scaffolding supplied for putting up these silos and gives a good idea of how this silo is built. These tile silos will become popular as the demand for permanent silos becomes greater.

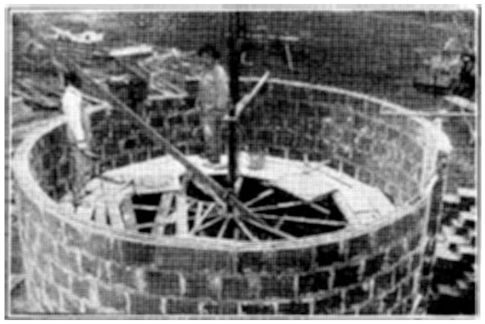

Figure 65—Kalamazoo tile Silo, shown in Figure 64, in process of construction. Note reinforcing; in foreground special blocks at doorway. The steel scaffold used is leased to parties building these silos, and is supported entirely by central steel mast. Note swinging arm at rear of mason, used to keep circle of wall correct

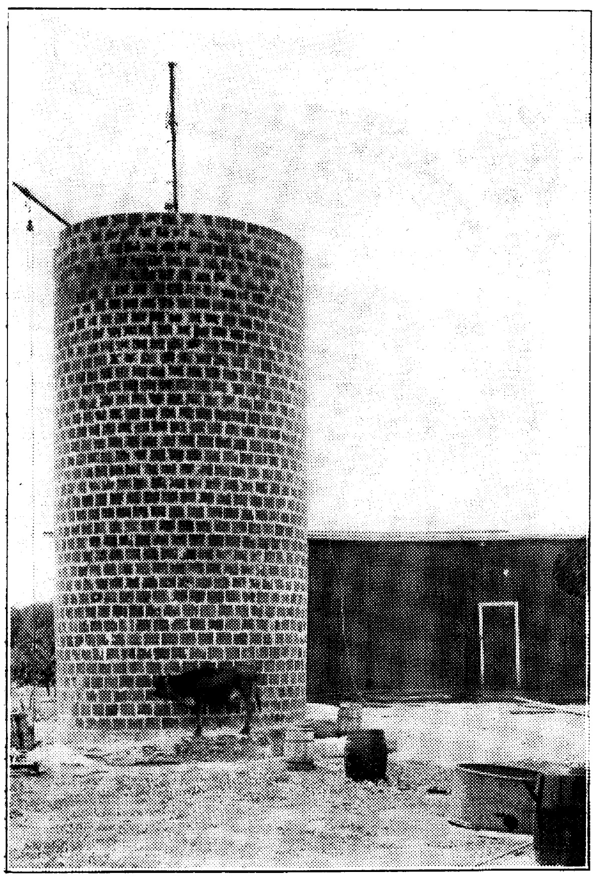

Figure 64—Kalamazoo tile Silo on farm of L. A. Taylor, Stillwater, Oklahoma

7—STONE SILOS

While silos built of stone are not likely to be built to any great extent in this State, it is possible that in an occasional district where rock or stone for building purposes is easily and cheaply obtained, the stone silo might be built to advantage. If such a silo is well reinforced and plastered with cement plaster on the inside there is no reason why it should not give good satisfaction. Many stone silos have been used in the past thirty years or more, and still give good satisfaction. Figure 69 shows method of reinforcing the stone silo.

III—METAL SILOS

Silos that have recently come into favor in Oklahoma are the steel or metal silos. These have been in use some six to eight years in other States. They have been objected to somewhat on the ground that the acid in the silage would rust out the steel and render the silo useless in a few years. We have not learned that this was the case in actual practice. Many of these silos are apparently as good as ever after five or six years of use and should give good service for

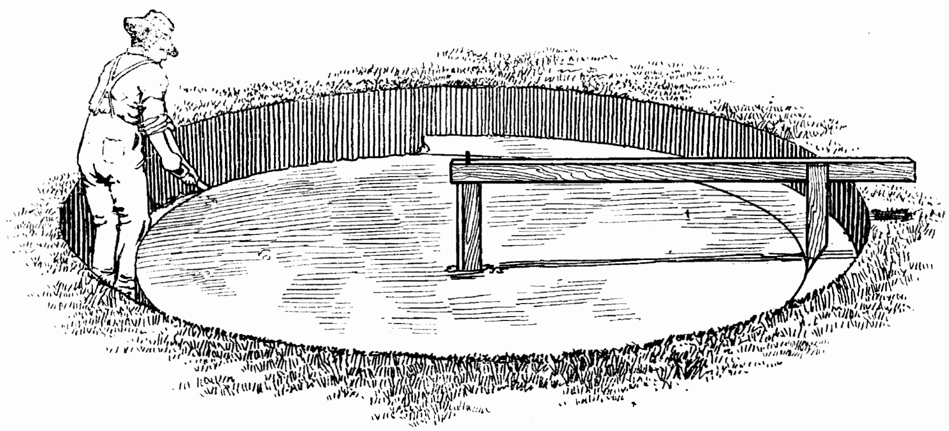

Figure 66—Digging trench for foundation for steel Silo

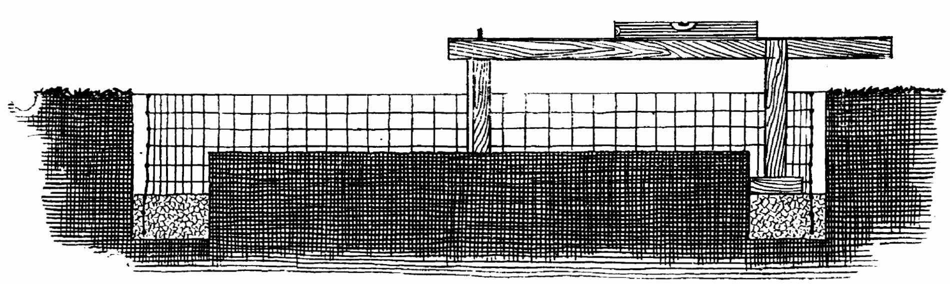

Figure 67—After trench is dug, the wire reinforcing is put in place and the concrete filled in to point shown. The leveling is very important. The first ring of steel is then bolted together and set in place inside of reinforcing

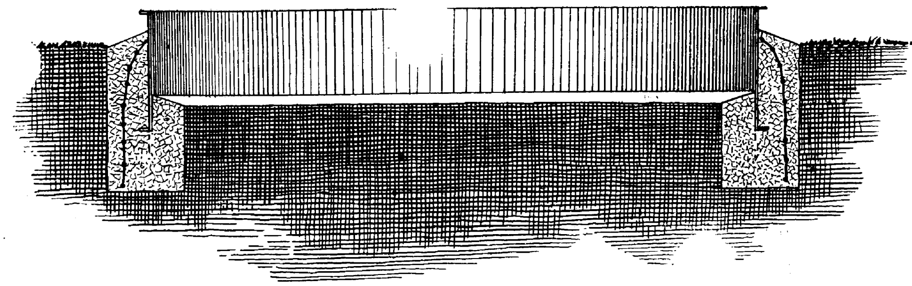

Figure 68—After ring is in place and concrete has set twenty-four hours, concrete is filled in on the outside and inside, holding it securely in place. The earth may then be dug out from center and a concrete floor put in. Cuts 66, 67, 68 and front page cut loaned by Perfection Metal Silo Company, Topeka, Kansas

from fifteen to twenty years. It is advisable to protect these silos by ordinary paint on the outside and by specially prepared asphalt paint on the inside. The concrete foundation illustrated in Figures 67 and 68 should protect all underground parts of the silos, coming up high enough on the outside to keep the steel from contact with the earth. The woven wire fencing used is advisable as reinforcement, as it keeps the concrete from cracking and letting water in around the steel. The cost of foundation will range from $20.00 to $50.00, according to size. The foundation as illustrated will take about four to five sacks of cement, six yards of sand or sand and rock and four rods of wire fencing for a 19-foot silo.

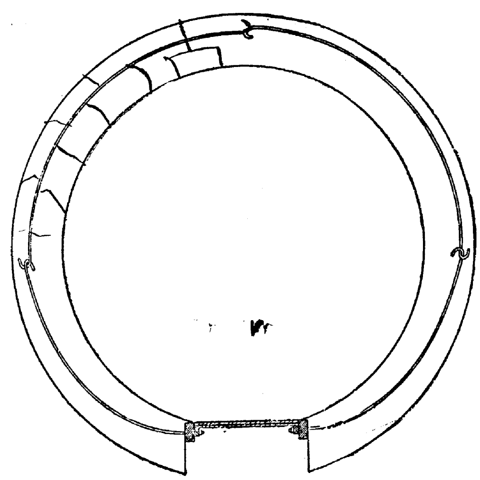

Figure 69—Diagram of reinforcing for stone silo. (Wisconsin bulletin)

In erecting these silos it is important to get the first ring of steel laid in an exact circle and perfectly level. If this is done the rest of the silo will go up plumb and regular, but if there are irregularities in the first ring these irregularities are likely to become worse as the silo nears completion, making it oval or egg-shaped rather than circular. Steel roofs and steel chutes are sold by these companies to go with them. Where no roof is used, it is recommended that the top of these metal silos be braced to prevent outside wind pressure from buckling the top rings.

Radiation of Heat

An argument often advanced against metal silos, as well as other types, that so much heat is lost through the silo walls when the silage is curing that it does not cure properly next the wall and is likely to spoil. We have not found that such is the case. It does not sound reasonable that there should be much spoiled silage from this cause in Oklahoma. Masonry silos and other silos of similar heat-conducting materials are satisfactory in much colder climates where there is a great deal more chance of heat being lost. The highest temperature found in silos by self-registering thermometers has been about 85° F. except where the silage is exposed to the air. If this be true, the outdoor temperature in July, August and September is more likely to be higher than the temperature of the silage rather than below. The steel silos at the College have kept silage well right to the wall.

Roofing the Silo

A roof on a silo is not a necessity in Oklahoma, and at least nineteen out of twenty silos are roofless in this State. There is no doubt but what a roof is some advantage. It braces the top of the silo to some extent and protects the silage from excessive rains. Such rains are probably no disadvantage, while the silo is fairly full and the silage more or less dry in nature, but when three or four inches of rain falls on the last ten or fifteen tons of silage in the silo it may easily make it too soggy and wet to be used to good advantage. We

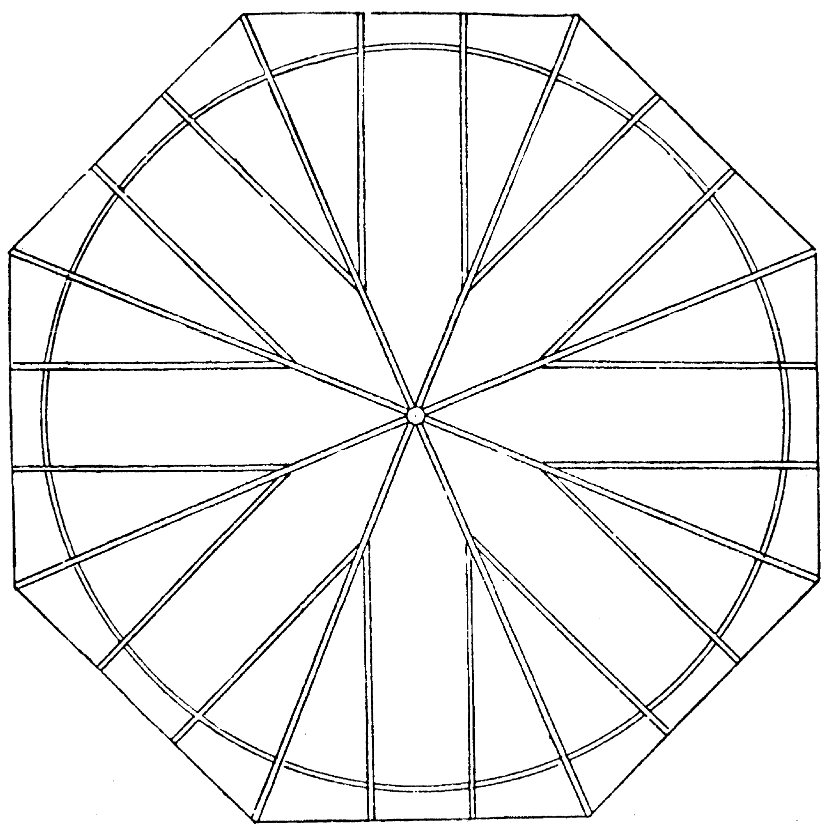

Figure 70—Framing for a roof for round Silo

believe that the main advantage of a roof is the preventing of excessive evaporation from the silage. If, for instance, a man is taking two inches of silage off each day and that upper two inches is exposed to the more or less direct rays of the sun for a day, especially in this dry atmosphere, that upper layer of silage will lose a great deal of its moisture from the air circulating around through the silo. It may not pay to roof a cheap wooden silo, but a good silo might as well have a roof on it. A method of framing the circular roof is shown in Figure 70. Concrete roofs may be built by the use of metal lath on a temporary framework. Wooden roofs, unless well bolted to the silo, are in danger of blowing off in high winds.

Chutes for Silos

To get the silage down out of a silo it is necessary to have some kind of chute to keep the wind from blowing the silage away. Figure 44 shows the construction of a wooden chute as used on concrete or stave silos. Masonry silos may have a chute made of galvanized iron, as on the brick silo (Figure 61). On some silos a concrete chute is built as the silo is erected and is of course permanent and strong, though slightly more expensive.

Doorways

The continuous doorway is much in favor in both homemade and manufactured silos, though considerable care is necessary in reinforcing around the door, else a silo may be weaker than if the intermittent doors are used. Figures 38 and 39 illustrate one way of mak-

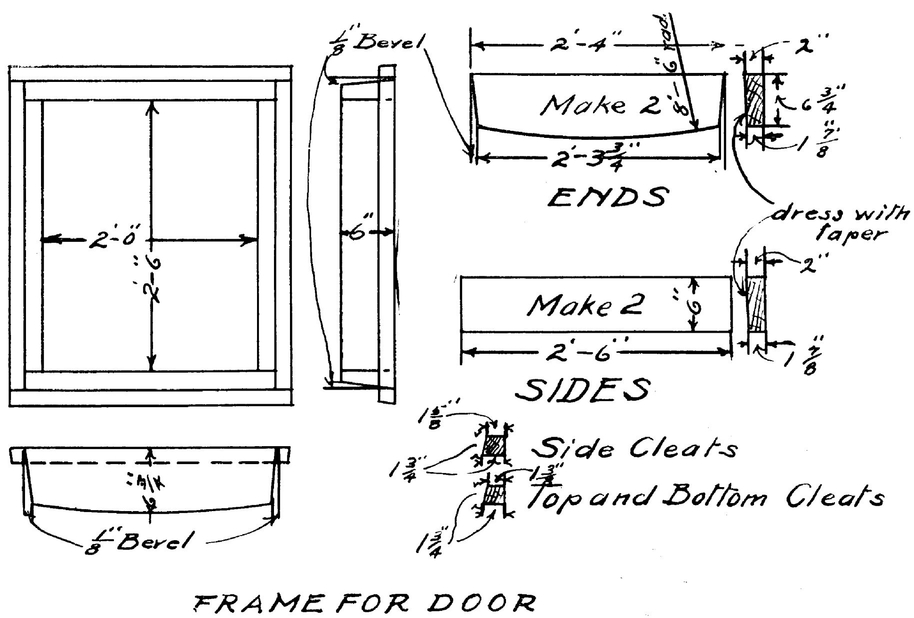

Plate B—Plan of door form for making intermittent doorway in concrete silo. (See also Figure 40.) Courtesy of G. S. Hine, Kansas A. and M. College ing a continuous door from 2x4's. The reinforcing rods in the silo are bolted through from the outside and the ladder rungs made of ⅝-inch iron rods bolted on the outside. In the College concrete silo these reinforcing rods are spaced about fifteen inches apart at the bottom and two inches further apart each succeeding ring until they are two and one-half feet apart near the top of the silo. Figure 44 shows how this appears from the inside of the silo. A cheaper form of continuous wooden doorway is used in the homemade stave silos. In these silos the reinforcing rods run clear through the uprights of the

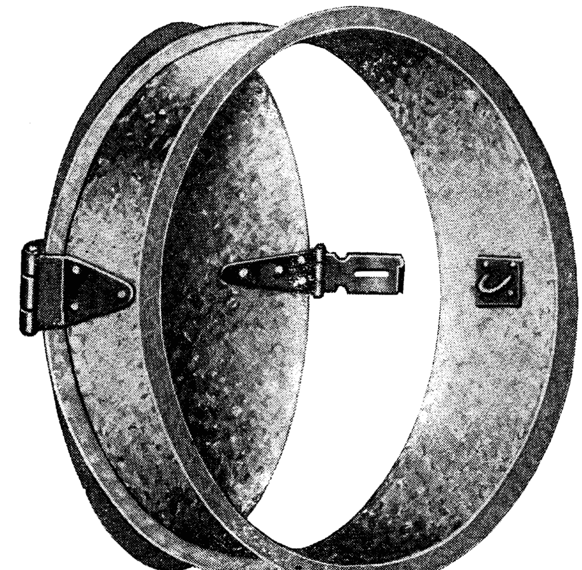

Figure 71—Galvanized steel door for cement or masonry Silos

ladder without needing separate bolts for ladder rungs. The sides of this doorway need to be braced apart by cross pieces of 2x4's.

In building a concrete or masonry silo it is better to use a reinforced concrete doorway rather than wood, as the wood will naturally decay in time, breaking the circle of reinforcing. In the concrete silo, Figure 33, where steel wire fencing was used for reinforcing, ¾-inch gas pipe was used for upright reinforcing on each side of the doorway. The woven wire fencing was wrapped around this pipe and then structural iron rods were placed at in-

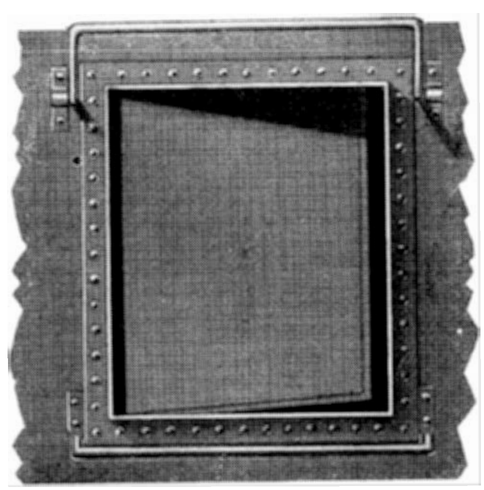

Figure 72—Iron door for silo. Intermittent type, shown on metal silo, could be used in concrete silo. Loaned by American Silo Supply Company, Enid, Oklahoma

tervals of eighteen inches across the doorway and the ends bent around the upright pipes. The concrete was built around these pipes so as to make a solid concrete door frame. (See Figure 38.) A similar idea is shown in the brick silo (Figure 60) where 2-inch water pipe is used for uprights and where the cross rods are run through holes bored in the pipe and bolted at each end. Diagram 61 shows a concrete door frame which could be used in this silo to good advantage. Figure 47 gives another method of applying this idea in tile or clay block silos, with intermittent doors. The reinforcement around the silo is continued between the door spaces, but could be spaced differently for a continuous doorway.

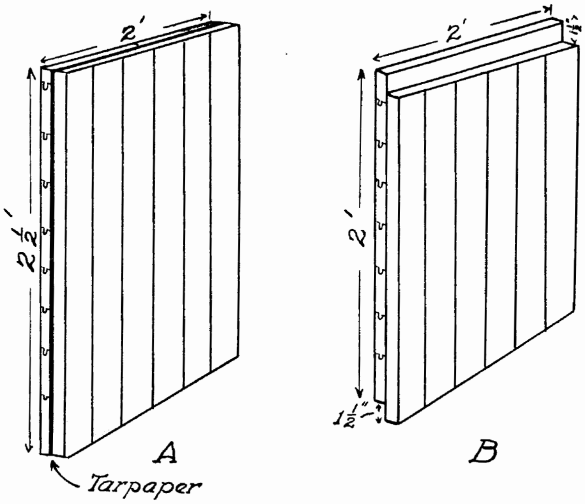

Figure 73—Silo doors made of tongue and grooved flooring. A. Door for intermittent doorway. B. Door for continuous doorway

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IV—PIT SILOS

Pit silos are cheaply constructed and require little attention after building. They can be filled with small machinery; the ensilage never freezes in them, and if well constructed they are nearer everlasting than any other silo. The greatest objection to the pit silo is the extra labor required in removing the silage. Other objections of minor importance are: The liability of stock falling in; danger of carbon dioxide gas forming; and the spoiling of the silage in wet seasons from seepage.

About twice as much time is required to remove silage from a pit silo as from an ordinary silo, but counting time at 20 cents an hour, the extra cost is only about $11.00 or $12.00 per year for a 100-ton silo, or less than the increased interest on a $400.00 silo. This estimate of the increased expense in removing the ensilage is also offset by the fact that much cheaper machinery can be used in filling the pit silo.

To prevent stock from falling in the pit silo, the silo walls are usually built up about four or five feet above ground. Suffocation from carbonic acid gas in pit silos, while possible, has, perhaps, been over-emphasized. The formation of gas in quantities large enough to be dangerous ceases in about ten days after filling the silo. A few bundles of fodder dropped in will stir up the air so as to render it safe to enter the silo. Gas can be detected by lowering a lighted lantern into the pit. If gas is present the light will go out. Where filling has been only partly completed and then discontinued for a few days, fill-

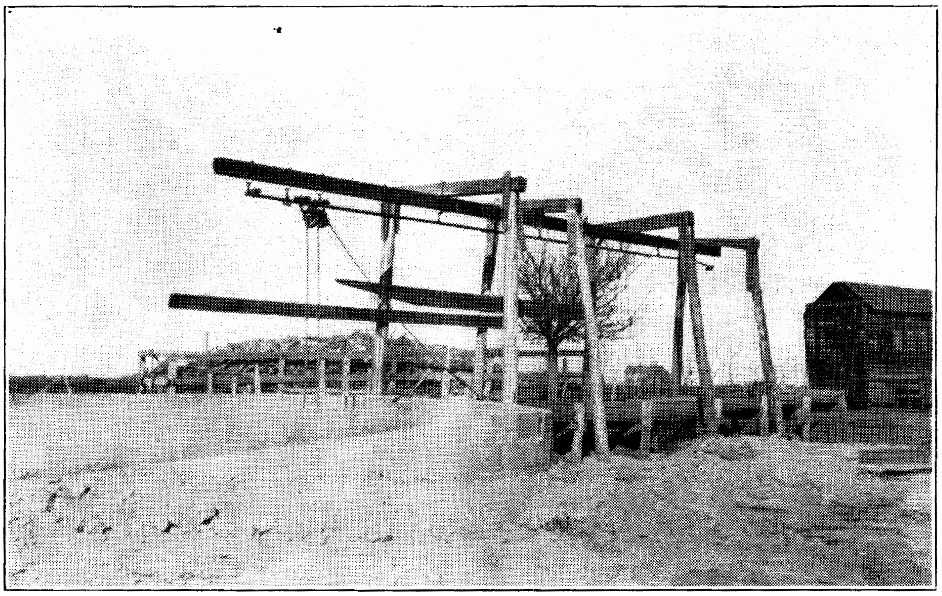

Figure 74—Pit Silo with hay carrier track to feed troughs

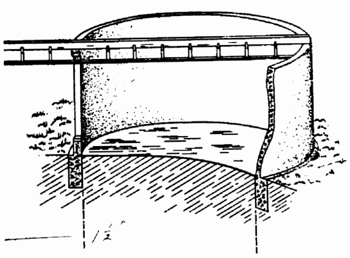

Figure 75

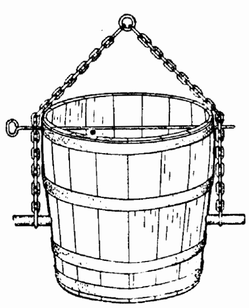

Figure 77

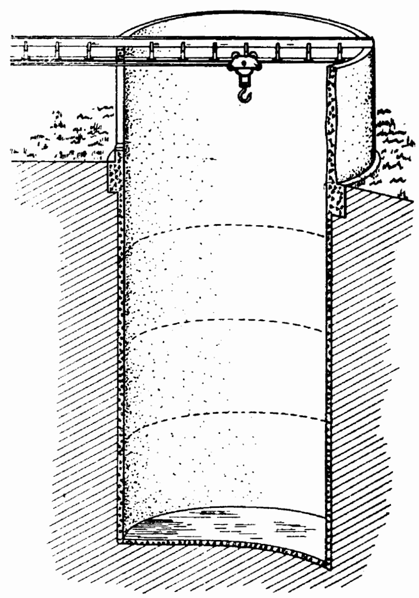

Figure 76

Figure 75 shows the beginning of a pit Silo, with concrete collar and wall built up five feet above it. Carrier track in place to carry away earth, also to take out ensilage. Figure 76—Section of completed, plastered pit Silo showing sections as dug and plastered. Figure 77 shows a barrel as arranged for raising earth. On removing the end-gate rod the barrel dumps itself. (Courtesy of Nebraska Experiment Station) ing should be started again for five or ten minutes before any one goes into the silo. The pit silo should never be built where the water level is not some ten feet or more below the desired depth of the silo. This is one reason why the pit silo is more popular in the semi-arid west than elsewhere. There are occasional rainy seasons when seepage water may give trouble. Thus far, however, we have not heard of much silage being destroyed in this way.

To build a pit silo, first lay out a circle on the ground the desired size of the silo, and outside of this circle dig a trench, which should be about two feet deep and about eight inches wide. (See Figure 75.) The inside wall of the trench should be smooth and perpendicular. Fill the trench with a concrete mixture of one part cement and five parts sand or gravel, well mixed and very wet. Old iron rods or old barbed wire can be used for reinforcing to keep the rim from cracking. When this concrete rim has set, go inside and excavate to a depth of about six feet below the rim. Keep the walls plumb and smooth so that it will not require too much mortar for plastering.

A good way to keep the walls smooth is to drill a perpendicular hole in the center of the silo and set a gas pipe in this hole to use as a pivot. If a long gas pipe is not at hand, a shorter bar may be used, if care is taken to keep it plumb. Bore a hole near the end of a 2x4 scantling and place it over the gas pipe. Saw the other end off so its length from the gas pipe will be the same as the radius of your silo. Bolt some heavy blade on this end. For this purpose an old plowshare is good. The walls can be trimmed perfectly smooth and perpendicular with this device, but with care the walls can be kept straight without it.

The trimming should be kept well up with the digging to prevent throwing the dirt out from a greater depth. After the silo is completed the collar at the top should be extended at least one foot above ground level to prevent surface water from running into the silo. This may be built up later with bricks, concrete blocks or solid concrete, as in Figures 74 and 75, to a height of four or five feet above the level of the ground. If the walls are made higher than this it will be difficult to take the silage out with a block and tackle. A lot of the dirt taken out of the pit may be graded up around the silo so as to bring the ground level up three or four feet.

Plastering

For best results, the walls of a pit silo should be plastered to prevent caving in. Pit silos can be used without plastering, but are not satisfactory after one year's use. The plaster should be made of one part cement and two and a half parts sand. Before it is put on the wall must be well dampened. A spray pump, sprinkler or old broom can be used for dampening the walls. The second coat of plaster can be applied immediately after the first, but in case more than two coats are to be put on, the first coat should set a few hours. Two coats are sufficient in heavy clay soil, but if the soil is sandy or gravelly, three to five coats should be used. The thicker the wall is plastered the nearer will the silo approach being everlasting. To save scaffolding and to avoid caving in of the walls before the pit is dug, it is best to plaster each section six feet deep before digging further. As soon as one section is plastered the next can be dug and plastered. It is not advisable to go more than twenty feet deep.

There are several good methods of removing silage from pit silos. For a small herd, and where the silo is near the place of feeding, a hand-over-hand pulley with a rope and two baskets is all that is necessary. Each basket should hold about enough silage for two cows. With a hook on each end of the pulley rope, one basket of silage can be raised while the empty basket is lowered. For a greater number of stock, a large box holding from 400 to 500 pounds of silage should be used. This must be raised by the use of block and tackle or windlass. The bottom of the box should open on hinges and let

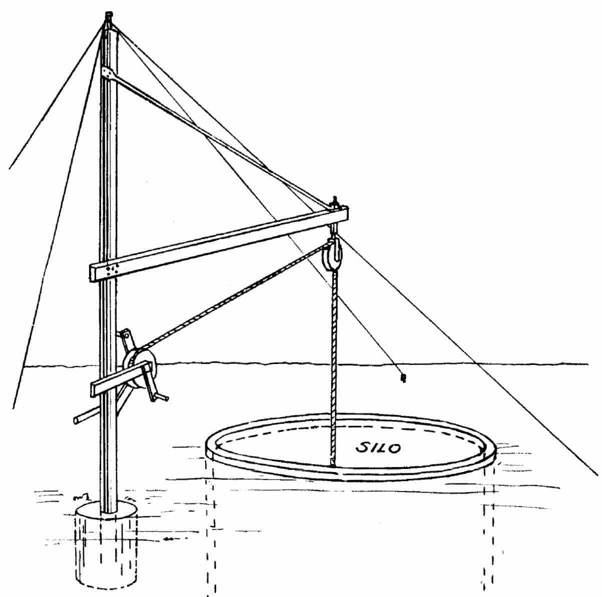

Figure 78—Swinging windlass for removing silage from pit silo

the silage fall in a trough or wagon. An elevated track, such as a hayfork track, can be arranged to carry the silage to the feed troughs. With either of these methods it will require little more labor to feed from a pit silo. Figure 76 shows a hayfork track and tackle erected over the pit as in Figure 74 and run from there out over the feed troughs. Figure 77 shows how a barrel can be used for lifting the silage. The box with hinged bottom answers the same purpose. By using the horse fork rope the silage is elevated by horsepower instead of by manual labor. These arrangements can, of course, be used for taking the dirt out of the silo when digging, as well as the silage.

The pit silo affords a good opportunity for the small farmer with few cows to own a silo at little cost, as it is the only silo that a small size is not much more expensive per ton capacity than a large one. A pit silo of fifteen tons capacity costs no more per ton, if as much, as one that holds 100 tons.

V—BANK SILOS

A bank silo is a pit silo constructed in the side of a hill or bank. The construction is the same as a pit silo on level ground except that it has a continuous door, the same as the upright silo. Figure 79 shows one such silo in use at Holdrege, Nebraska. The entrance is boarded over and the silage is carried on overhead tracks to the feed troughs on the left. Figures 80, 81 and 82 show the best methods of building the doorway. The bank silo is plastered the same as a pit

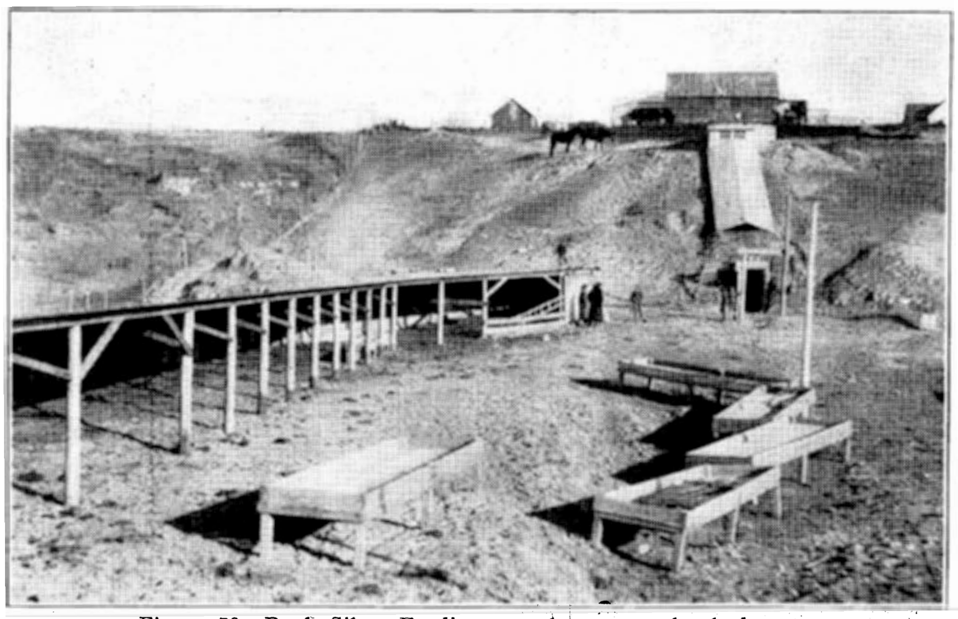

Figure 79—Bank Silo. Feeding troughs and cattle sheds

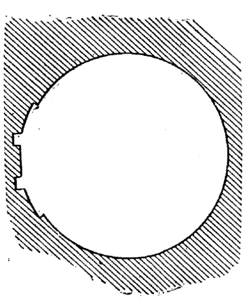

Figure 80

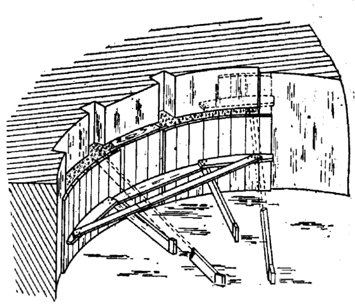

Figure 81

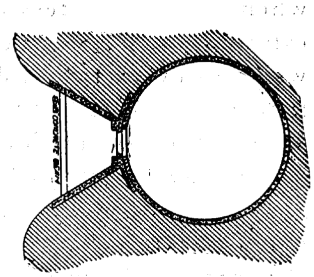

Figure 82

Figure 80 shows section of excavation for doorway of bank Silo. Figure 81 shows forms in place for making concrete door frame. Figure 82 shows section of completed bank Silo doorway. Wings held apart by concrete beam. (Courtesy of Nebraska Experiment Station) silo, but the doorway and adjacent walls are built with forms. Iron rods across the doorway serve as ladder rungs and strengthen the concrete columns. The wings at each side of the passageway are braced by a concrete beam. The door frame can be made of 2x6's with cross pieces for a ladder and the walls of the passageway boarded up instead of being plastered. This arrangement is more or less temporary. The continuous door lessens the cost of digging in that the dirt may be removed at the side instead of at the top. When complete the bank silo is one of the most desirable silos, as it has all the good features of the ordinary pit silo and the silage is as easily removed as from any upright silo. However, there are few banks so conveniently located that they can be used for this purpose.

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WHEN TO PUT CROPS IN SILO

To make good silage the crop should be as mature as possible without becoming too ripe and dry, or losing its green color. If put in too green the silage will be sour and watery, and there will not be the same amount of digestible food in it as when it is allowed to mature. If too dry the material will not pack down properly in the silo, consequently the air will not be driven out and the feed will mold. The woody or fibrous part of the plant will have developed to a greater degree than necessary and the feed will not be so palatable.

Corn should be put in when the grain is in the glazing stage, just before getting ripe. Kafir, milo and sorghum make good silage when the seeds are just ripe and the lower leaves just turning brown. The finely cut green feed being stored in the silo should be moist enough to dampen the shoes of the man tramping in the silage, otherwise water should be added.

Silage may be made from very dry fodder, but a great deal of water should be added to make it pack well and to drive out the air. Some farmers fill their silos twice during the season, putting in ordinary shocked fodder in February and March. They claim that by using plenty of water they make silage almost equal to that put in when fresh. Professor Chase of the Nebraska Experiment Station estimates that it is necessary to put in about two or three tons of water to every ton of dry feed in order to make it keep. The average failure in making fodder silage comes from not adding sufficient water. Where the farmer does not have regular water pressure at his barn, water may be pumped in with a force pump or hauled up in buckets. A hose may be attached to the water tank used to haul water to the engine, or to a barrel set up on a four or five-foot scaffold and water run into the blower.

Harvesting and Cutting Equipment

Since corn binders, ensilage cutters and engines or motors cost a good deal, and while the engine and cutter may be used to advantage on the farm at other seasons of the year, it will often be advisable for a number of farmers to club together and buy silage machinery in partnership. In many neighborhoods the owners of threshing outfits have an ensilage cutter and will do the work at a reasonable price. The man with a large farm and several silos may prefer to buy a complete outfit of his own. The man with one silo will find it more economical to make some other arrangement.

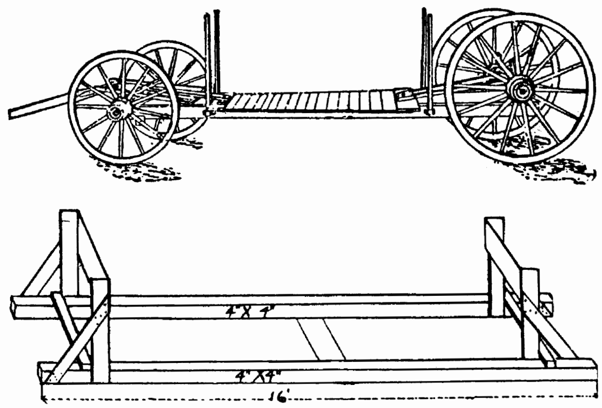

Figure 83—Type of corn racks. With low-hung racks larger loads can be hauled with less labor in loading and unloading. (Washington Station)

The corn binder can usually be used to good advantage, substituting horsepower for manpower, but good work can be done by hand. It is not necessary that the corn be tied by the binder, though tying will make unloading easier. It pays to have good racks for hauling corn, preferably flat and wide, and as low as possible. (See Figure 83.) A good type of rack is swung between the front and rear axles of a wagon, using no coupling pole. Being close to the ground, much labor is saved, especially in loading. These racks, if put under cover when not in use may be used for many years. A supply of corn knives on hand will make it possible to help out the binders in case they are not cutting fast enough.

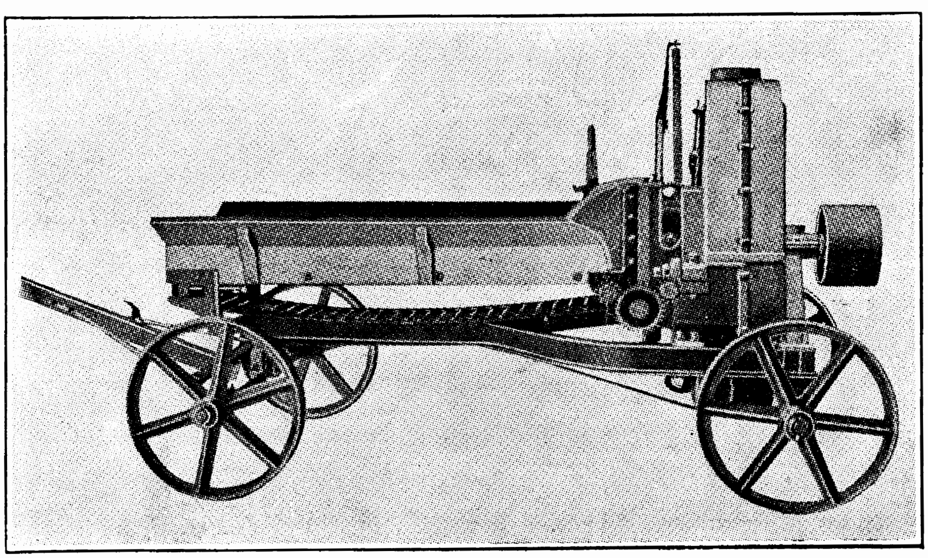

Figure 84—Ensilage cutter with blower combined

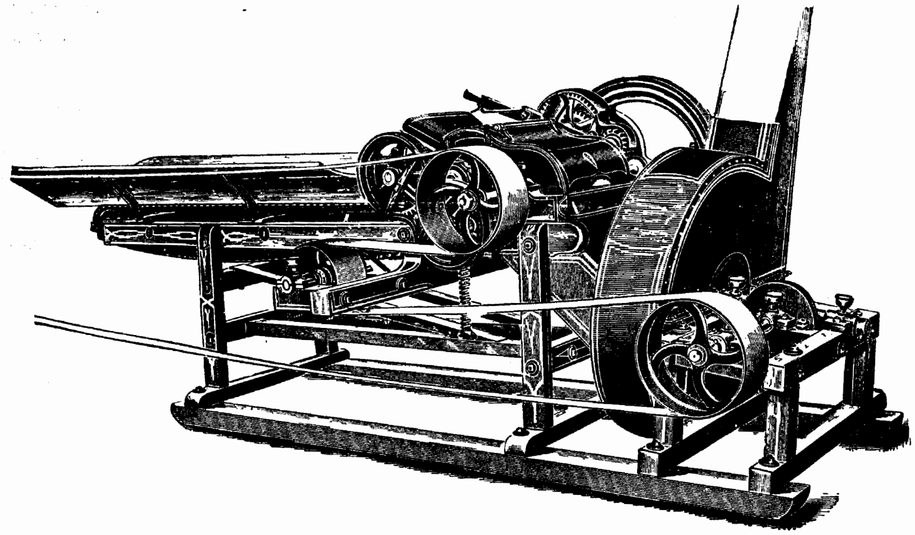

Figure 85—Ensilage cutter with separator blower

As a matter of economy, machinery of good capacity should be used. The engine should usually be several horsepower larger than the ensilage cutter needs under ordinary circumstances. A lot of power is required to elevate the cut feed, and much time may be lost if the blower pipe is allowed to choke up from lack of power, or where the cutter cannot be run to its full capacity for the same cause. It takes no more labor to run a large engine and ensilage cutter than small machines. Have plenty of hands and teams so that the cutter may be kept running steadily. (See two types of ensilage cutters, Figures 84 and 85.)

Filling the Silo

Silage has been made from corn in the bundle, and grass or legume silage has been made by filling the long hay into the silo chute,

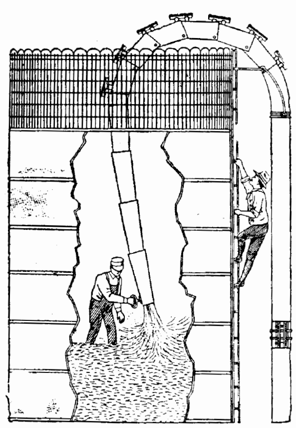

Figure 86 — Flexible silage distributer. Cut loaned by American Silo Supply Company, Enid, Oklahoma

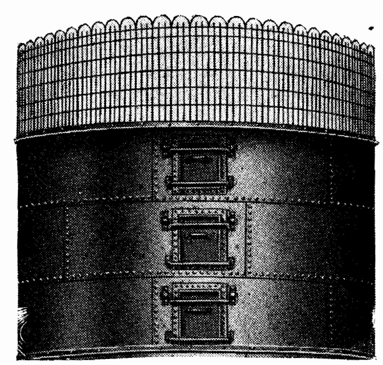

Figure 87—Extension top for silo. Permits several tons more feed being put in. Cut loaned by American Silo Supply Company, Enid

but this is not practiced for the reason that such feed does not settle well and is hard to get out again. The best and only advisable method is to cut the feed in short lengths, one-half to one inch, and elevate it by means of a blower. Carrier elevators are hardly ever used now.

In filling, it is important to have the cut feed evenly distributed and kept level, and it should be well tramped. With the old type of right-angled elbow at the top of the blower pipe it was necessary to put a shield of boards in front of the outlet so that the cut feed would come straight down in the middle of the silo. Without this the leaves

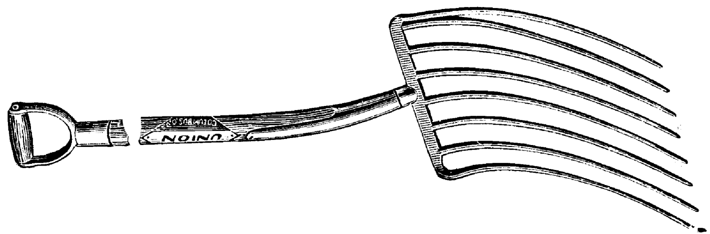

Figure 88—Ensilage fork. Cut loaned by American Silo Supply Company, Enid, Oklahoma

would blow to the far side of the silo and the pieces of ears and butt stalks would come down on the side next the cutter. This made an uneven mixture that settled unevenly and was not in good shape for feeding. With the curved and hinged distributors this difficulty was partly remedied, and with the flexible tube distributors now made (see Figure 86) one man may spread the cut feed around more evenly than two men without one. Even in a small silo two men can be used to advantage for spreading and tramping, and with a silo over eighteen feet in diameter three men will be needed, or two men with the flexible distributor.

After the silo is filled a few days it will settle considerably (five to eight feet in a forty-foot silo) and several more tons may be put in. If the silage is to be fed immediately, so much the better, as there will be no waste. If not, it is well to run a few loads of coarse fodder (straw or spoiled hay) through the cutter on top of the silage. Wet it well and tramp it thoroughly. Six or eight inches deep will heat and decompose on the top of the silo. This will not be fit for feeding and must be thrown away when the silo is opened, but will keep the good fodder from spoiling.

TABLE OF CONTENTS