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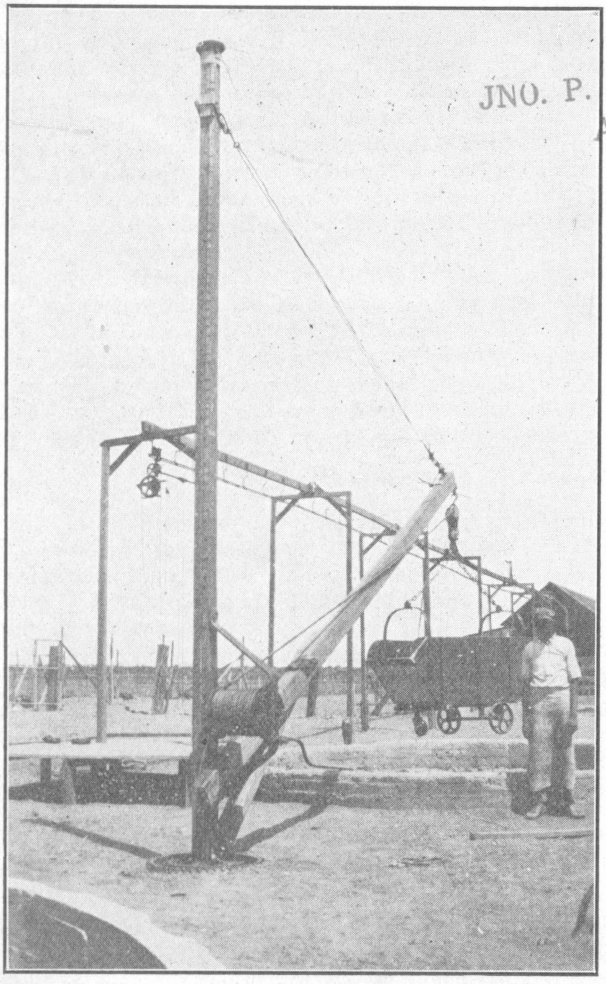

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The UNDER-GROUND SILO

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THE UNDERGROUND SILO.

By M. T. Payne

State Agent, Extension Service and U. S. Department of Agriculture,
A. and M. College of Texas.

INTRODUCTION.

The demand for information on the construction of the underground silo is steadily increasing. Every day some one makes inquiry of the county agent, or the Extension Service of the A. and M. College, for information on this subject.

It is not the purpose of this bulletin to discuss, at length, the value of a silo, the feeding of silage or discourage the construction of any other type of silo, but to give in detail the steps to take in the construction of the underground silo—for they have come to stay—and to point out the mistakes that may easily be made by those without experience, who want to build a silo of this type at a minimum cost. Many farmers would build a silo if it were not so expensive. By using the pit silo this objection is overcome.

With few directions any farmer, with ordinary hired labor, can construct a 100 ton underground silo at a cost, ranging from $75 to $150, in the ordinary type of soil. In some cases it may be constructed for a $60 cash outlay, or less, if a man does his own work and uses home-made hoisting apparatus. It has been demonstrated thoroughly by the farmers that silage keeps perfectly in a properly constructed silo of this type, and that they are entirely practical and permanent. A large per cent. of the silos in the Southwest are of the underground type.

Carrying Feed in Reserve.

The forage crops are the most easily produced and the most satisfactory way to dispose of them is to feed them to live stock, but with the ordinary methods of curing them dry, 50% or more of the crop is lost in shattered and bleached leaves, waste in feeding, etc. If made into silage the total loss of the crop should not exceed 10 per cent.

The silo in the semi-arid climates will be found very desirable, as a means of storing green feed to be reserved for use in drouthy seasons. Silage does not appear to deteriorate with age, hence the crops of heavy seasons can be carried over indefinitely. Thus, the farmer is more independent of the seasons, and is enabled to carry a larger herd upon the same amount of land. The crop is preserved in the most nutritious and palatable condition, and is the best supplement for short pastures during drouthy seasons.

The Two Types.

There are two types of the underground silos in use in Texas: First, the most common type is the one, in which a concrete collar is placed, extending from the firm subsoil, two to four feet below the surface, to two or three feet above the ground. The surface of the silo is then plastered from the bottom of the concrete collar to the bottom of the silo. Second, the type in which a concrete wall is constructed from the bottom of the silo to two or three feet above the surface of the ground.

Location of the Silo.

Convenience should be considered in locating the place to build the silo. It is usually best in a mild climate, not to locate the silo in the barn, as it will ob-

struct the free circulation of the air; also, it is more difficult to fill a silo in a barn than one on the outside.

The silo should be convenient to the place where the silage is to be fed, and should be situated especially with reference to future improvement about the premises. If the silo is constructed near the feed lot or barn the silage can be handled very conveniently and economically with a carrier, similiar to the hay carrier equipment, which is illustrated elsewhere in this bulletin. The water table should be below the bottom of the silo.

Size and Capacity of the Silo.

It is not advisable to construct underground silos of large size. Two small ones, having the total capacity desired, will give better results.

The expenses of digging and removing the silage increase as the depth increases. The smaller the silo in diameter the less surface exposure of silage while feeding. The silo, ordinarily, should not be more than thirty feet deep. The depth should be about twice the width.

The silage should be removed from the entire surface of the soil, while feeding, at a rate of not less than two inches per day in the winter and three inches per day in the summer. The diameter of the silo should not be larger than is necessary to accomodate the herd. The average weight of silage in a 30 foot silo is about 40 pounds per cubic foot. By knowing approximately the amount of silage to be fed daily it is possible to estimate the diameter of the silo needed to suit the herd, or if one has a silo and not a sufficient number of cattle to consume the necessary amount of silage per day, a very accurate estimate can be made, by using the following tables, of the number required to consume the necessary amount to prevent spoiling, both for winter and summer feeding.

"(Relation of size of herd to diameter of silo for winter feeding, on a bisis of 40 pounds of silage per cubic foot.)"

Inside Diameter of Silo.	Quantity of silage in depth of 2 inches.	Number of Animals that May be Fed Allowing			
		40 pounds per head.	30 pounds per head.	20 pounds per head.	15 pounds per head.
Feet	Pounds				
10	524	13	17	26	35
11	634	16	21	31	42
12	754	19	25	37	50
13	885	22	29	44	59
14	1026	25	34	51	68
15	1178	29	39	59	78
16	1340	33	44	67	89
17	1513	38	50	75	101
18	1696	42	56	85	113
20	2094	52	70	104	139

"A 900-pound cow will ordinarily consume 30 pounds of silage a day; a 1200-pound cow about 40 pounds; yearlings will eat about one-half as much as mature animals; fattening cattle, 25 to 35 pounds for each 1000 pounds of live weight; a sheep will take about one-eighth as much as a cow; horses should be limited to 15 or 20 pounds daily."

Great care should be exercised to see that no spoiled and moldy silage is fed to horses and mules, for even a small amount may cause serious sickness and often death. Begin by feeding a small amount and increase gradually to the amount suggested.

The practice of using silage to supplement pastures during the summer droughts and in the early fall should be encouraged. For such feeding the daily

ration may be as low as 10 pounds per cow, depending upon the amount and quality of pasture and other succulent feeds available. For the same herd, for summer feeding the silo should be of smaller diameter than the one used for winter feeding, since 3 inches instead of 2 are to be removed daily. In order to provide for this summer feeding an additional silo of smaller diameter should be constructed where the conditions demand it.

The following table shows the relation between the size of the herd and the diameter of the silo when 3 inches of silage are removed daily:

(Relation of size of herd to diameter of silo for summer feeding, on basis of 40 pounds of silage per cubic foot).

Inside Diameter of Silo.	Quantity of silage in depth of 3 inches.	Number of Animals that May be Fed Allowing			
		40 pounds per head.	30 pounds per head.	20 pounds per head.	15 pounds per head.
Feet	Pounds				
10	785	19	26	39	52
11	950	23	31	47	63
12	1131	28	37	56	75
13	1327	33	44	66	88
14	1539	38	51	77	102
15	1767	44	59	88	118
16	2011	50	67	100	134

Capacity of Silo.

Depth of silage (after settling) for a given capacity of silo with a given diameter.

Depth of Silage after Settling	Capacity of Silo Having Inside Diameter of—									
	10 Feet	11 Feet	12 Feet	13 Feet	14 Feet	15 Feet	16 Feet	17 Feet	18 eet	20 e et
Feet	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
24	34	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	38	46	55	.....	.....	.....	.....	.....	.....	.....
28	42	51	61	71	83	.....	.....	.....	.....	.....
30	47	56	67	79	91	105	.....	.....	.....	.....
32	....	62	74	86	100	115	131	.....	.....	.....
34	.....	.....	80	94	109	126	143	161	.....	.....
36	.....	.....	87	102	119	136	155	175	196	.....
38	.....	.....	.....	110	128	147	167	189	212	261
40	.....	.....	.....	.....	138	158	180	203	228	281
42	.....	.....	.....	.....	.....	170	193	218	245	302
44	.....	.....	.....	.....	.....	.....	207	234	262	323
46	.....	.....	.....	.....	.....	.....	.....	250	280	345
48	.....	.....	.....	.....	.....	.....	.....	.....	.....	368

The above figures were taken from U. S. Farmers' Bulletin No. 589.

Construction.

The first type mentioned in Figure No. 2, consisting of a concrete collar and plastered wall, is used most extensively in sections of the state where the water table is below the bottom of the silo.

After deciding upon the location and size of the silo to be built, the ground should be made perfectly level, as this will help in making the walls perpendicular in digging. If they are rough and out of plumb, space will be left between the wall and the silage, as the latter settles, allowing air to get down around the silage, which will cause it to spoil about the edge, for a foot or so. With irregular walls the silage will not settle evenly.

Marking Out Trench.

Drive a stake in the ground where the center of the silo is to be. To this stake nail one end of a board 1"x4" about 7 feet long for a marker. Assuming

that the silo is to be 12 feet in diameter, drive a large spike through the board at a point 6 ft. from the nail in the stake. Six inches out from this spike, then another nail is driven through the board. Wooden pegs, sharpened and nailed to the board, may be used instead of the spikes or large nails. By revolving the board around the center stake two circles will be made on the ground giving the width of the collar and the diameter of the silo, as shown in figure (2). Where the soil is firm and not subject to cracking, the wall of the collar may be made four inches thick.

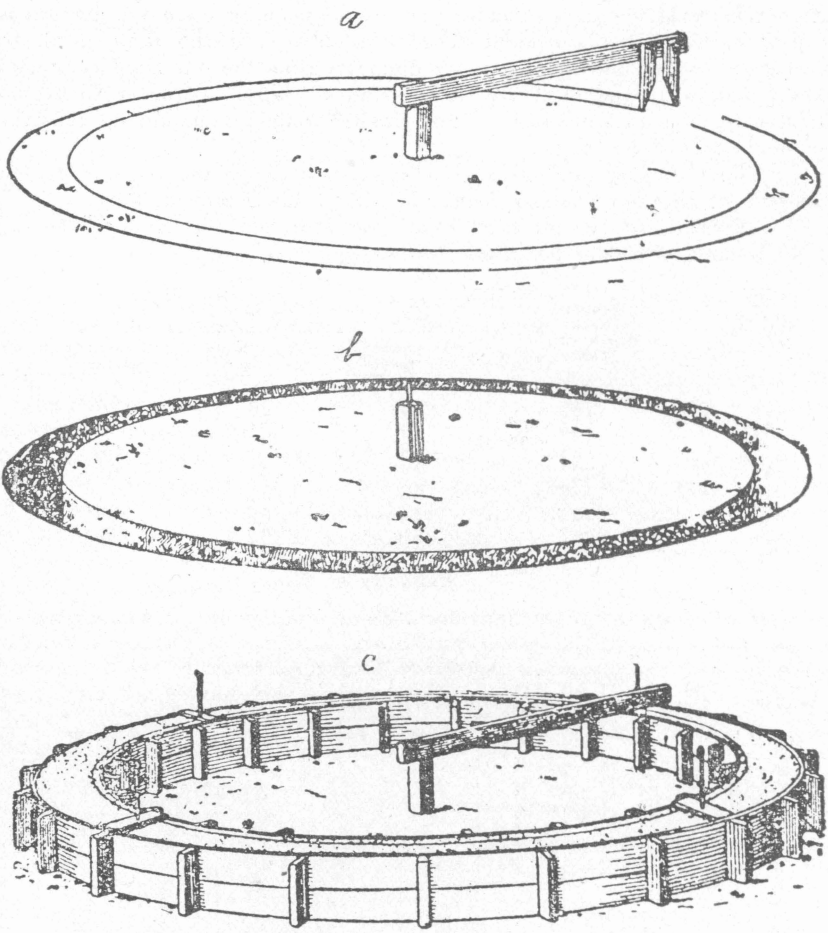

Figure 2.—(a) Shows the method of laying off the trench for the collar of the underground silo. (b) The middle shows the trench dug. (c) The lower section shows the forms in place made of horizontal strips filled with concrete.

The space between these circles is dug out to the firm subsoil, which is usually from 18 to 24 inches deep. The walls of the trench should be perpendicular and as smooth as possible, especially the inside wall, which will form the inside wall of the silo when filled with concrete. A sharp spade and spirit level should be used in trimming and plumbing the trench.

When the trench is finished it will be six inches wide and 18 to 24 inches deep. If the soil is light, the trench should be made wider at the bottom, so as to afford a better foundation. To do this the earth should be sloped back on the outside of the trench, as shown in figure 7.

Forms for Collar.

The bottom of the trench should be level and smooth. Some are made deeper than two or three feet. In most such cases it is found more convenient not to use

the trench. Mark the outside circle, remove all of the dirt from the inside of the silo to the desired depth of three or four feet. Then build a wooden form made of horizontal strips, nailed to upright pieces of 2"x4"; or make wooden hoops and line them with 6-inch boards, standing vertically well braced; or use metal forms for the inside wall and the dirt wall for the outside form, in which to mold the concrete

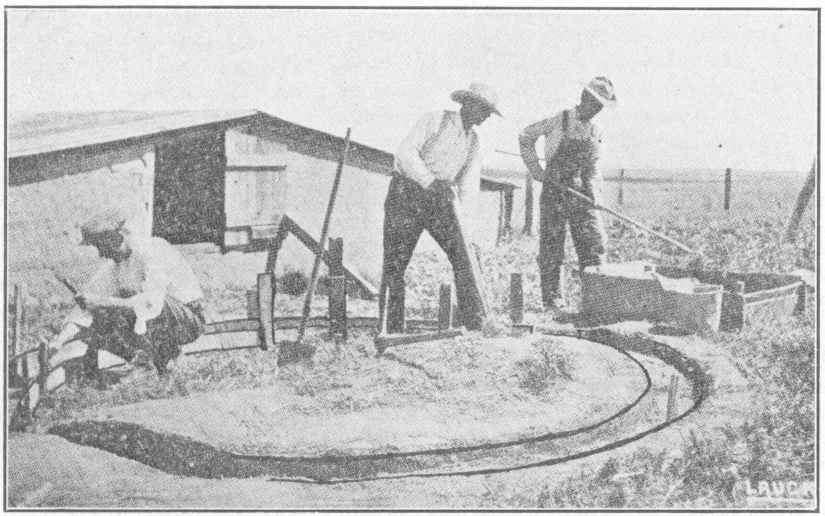

Figure 3.—An inexpensive method of building forms for concrete collar which does not extend far above the surface of the ground.

collar. In cases where only the trench is used as forms, the extension of the collar above the surface of the ground may be made of concrete or of brick and plastered on both sides. One farmer used a strand of hog wire around the brick, plastering over this, making it very durable. A stone wall may be used or concrete plaster on metal lath of about three inches thickness will be sufficient for this part of the collar. When lath is used the first round should be bedded in the concrete foundation in the trench, thus binding the parts of the collar together firmly.

In the construction of forms for the concrete collar to be built above the ground, where either sheet metal or wooden forms are to be used, the following suggestions, given by A. D. Melvin, in U. S. Farmers' Bulletin No. 589, have been found to be very helpful:

"For each form it is necessary to build two supporting circles (See Figure 5 c) to which the sheet iron or wood, as the case may be, is nailed. These circles are built out of 1 by 6-inch material, rough or dressed, of a length depending upon the diameter of the silo so that 16 pieces will exactly make the circumference. It is not an easy matter to compute these lengths of chords for the various diameters, so they are give nbelow. In Figure 4 the chord is the distance from A to B.

TABLE OF CHORDS

Diameter of silo.	Chord Measurement		Diameter of silo.	Chord Measurement	
	Ft.	In.		Ft.	In.
10 feet	1	1-⅜	15 feet	2	1
11 feet	2	1-¾	16 feet	3	1-⅜
12 feet	2	4	17 feet	3	3-¾
13 feet	2	6-⅜	18 feet	3	6-⅛
14 feet	2	8-¾			

Laying Out the Templets for Sheet-Iron Forms.

Figure 4 shows how to proceed to lay out the pieces to be used as templets, or patterns, by which to cut the pieces which, when laid end to end, are to form the supporting circles for inside and outside forms when sheet iron is used. For this part of the work use the barn floor or any clear space available. If there is no convenient place available, it will be advisable to build the concrete mixing board described later, and use this.

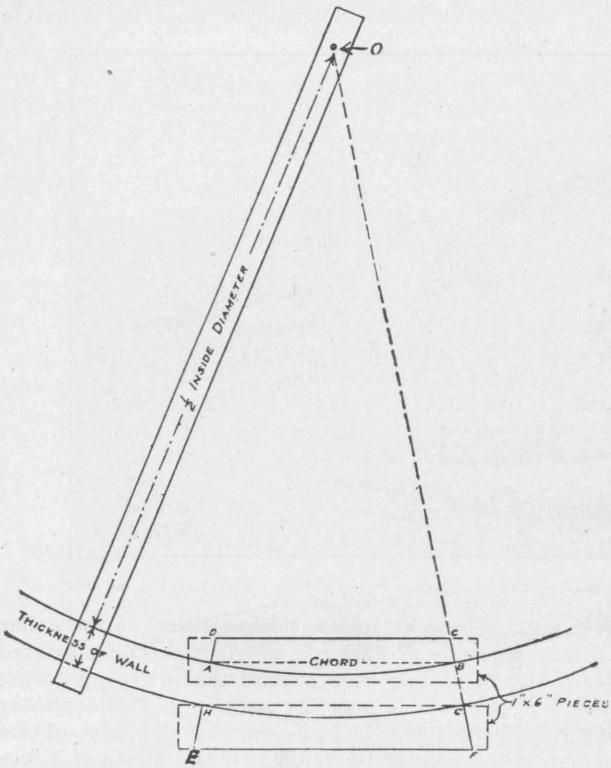

FIG. 4—Method of laying out templets.

Select a straight piece of 1 by 3-inch board about a foot longer than half the diameter of the proposed silo, and with a ten-penny nail tack one end to the floor so that the slat will be free to swing about. From this nail as the center of the silo, measure off on the slat one-half the length of the inside diameter. Here drive a nail, and 6 inches beyond drive another nail until the points extend through far enough to scratch clear marks on the floor as the slat is swung around on the center 0, as shown in figure 4. These circles represent the inside and outside faces of the wall. An arc equal to 1-4 of the circumference will be sufficient. From any point which has been determined to be A on the inside arc, measure off the length of the chord in Fig. 4 as given in the table of chords for the diameter of the proposed silo, and find point B. With a straight edge laid through the points A and O, and also through B and O, draw short lines on the floor from D to E and from C to F, respectively. On these lines measure inward 4 inches from points A and B, and locate points C and D. Similarly measure outward from points H and G 6 inches to find the exact location of points E and F.

Next take two pieces of the 1 by 6-inch board and lay one of them on the arc with the inside edge flush with points C and D, as shown in Figure 4. Lay the other on the outside arc with the outside edge flush with points E and F. Tack them to the floor with several small nails. Next lay off the arcs again on these pieces, and with the straight edge remark lines DE and CF. The pieces are now ready to be taken up and sawed. The resulting patterns, or templets, will serve to mark out the 64 pieces necessary to build the two inside circles and the 64 pieces to build the two outside circles.

The curved pieces can be sawed by hand, but if there is a mill or shop convenient that is equipped with a band saw, it will hasten and generally cheapen the job to have it done there.

Laying Out the Templets for Wooden Forms.

If the sheet iron for metal forms can not be obtained, or if for any other reason it becomes necessary to build wooden forms, then 1-inch flooring 3 inches wide and 3 feet long nailed on these supporting circles may take the place of the sheet iron. In working out the templets for wooden forms the nail used for marking off the inside circumference is driven one inche nearer the center to allow for the thickness of the flooring which is nailed on the circles instead of the sheet iron. In other words, the inner circle is described one inch nearer the center and the outer circle one inch farther away from the center in order to allow for the thickness of the flooring. As shown in Figure 5c the circles are raised one above the other, 26 inches apart, and the flooring is nailed on vertically with 8-penny nails. Before the flooring is nailed on it should be thoroughly soaked in water to prevent buckling later. Lugs are used similar to those used for sheet-iron forms. (See Figure 5c). Instead of riveting these lugs on the side, they are fastened on top of the circles with screws.

As shown in Figure 5c, each of the supporting circles is built two-ply, that is, the pieces are lapped so as to break joints. After cutting four or five pices, lay them out on the circles, so as to make sure they fit the curve. Before starting to nail the pieces together, mark out the whole circumference on the floor or on a level piece of ground with the slat as shown in Figure 4, and build the circles accurately by laying the pieces flush with the mark. It is important that the circles be well nailed with 8-penny nails driven through and clinched. While the circles are being built, approximate points of division into quarter circles can be marked, and those pieces nailed sparingly until after the circle is completed. It is generally safer to build the circles complete and then divide into quarter sections rather than to build each quarter separately. This division into parts is for the purpose of loosening and resetting the forms.

Dividing the Circle into Quarter Sections.

Remove the nails in one-half of every fourth piece in the top layer of each circle. This will divide each circle into four equal parts, with lapped joints.

Building the Inside Form.

A hole one inch wide and three inches long should now be cut through both layers in the center of each joint. (See Figure 5b). These holes are provided for wedges which are used in fitting or releasing the forms from the wall. The ends of the quarter sections should then be cut off at the outer edges of the wedge holes. This will allow the sections to slide together when they are to be removed from the wall.

When all the wedge holes have been cut and the work of dividing into quarter sections is complete, temporarily nail the quarter sections together at points of division and brace the top circle directly over 32 inches above the lower one. See that both circles are perfectly level and that the joints in the upper circle are directly above the joints in the lower circle, and then proceed to nail it securely, between the top and bottom circles, using 1 by 3-inch studding, 32 inches long carefully plumbing the studs and placing them from 12 to 18 inches apart as shown in Figure 5a to keep the iron from bulging.

In nailing on the sheet iron use 6-penny nails, and nail securely. Before starting to nail on the iron, however, see that it is cut to the proper length. The sheet for each quarter section should be just three inches longer than one-quarter of the circumference. If several sheets are required to make a single quarter section, they should be carefully riveted together with a double row of flat-headed rivets. Since the quarter sections lap 3 inches, and in removing need to slide together

several inches farther, it is necessary to leave one end of the sheets loose 8 to 10 inches from the end, while at the other end it should be nailed all the way.

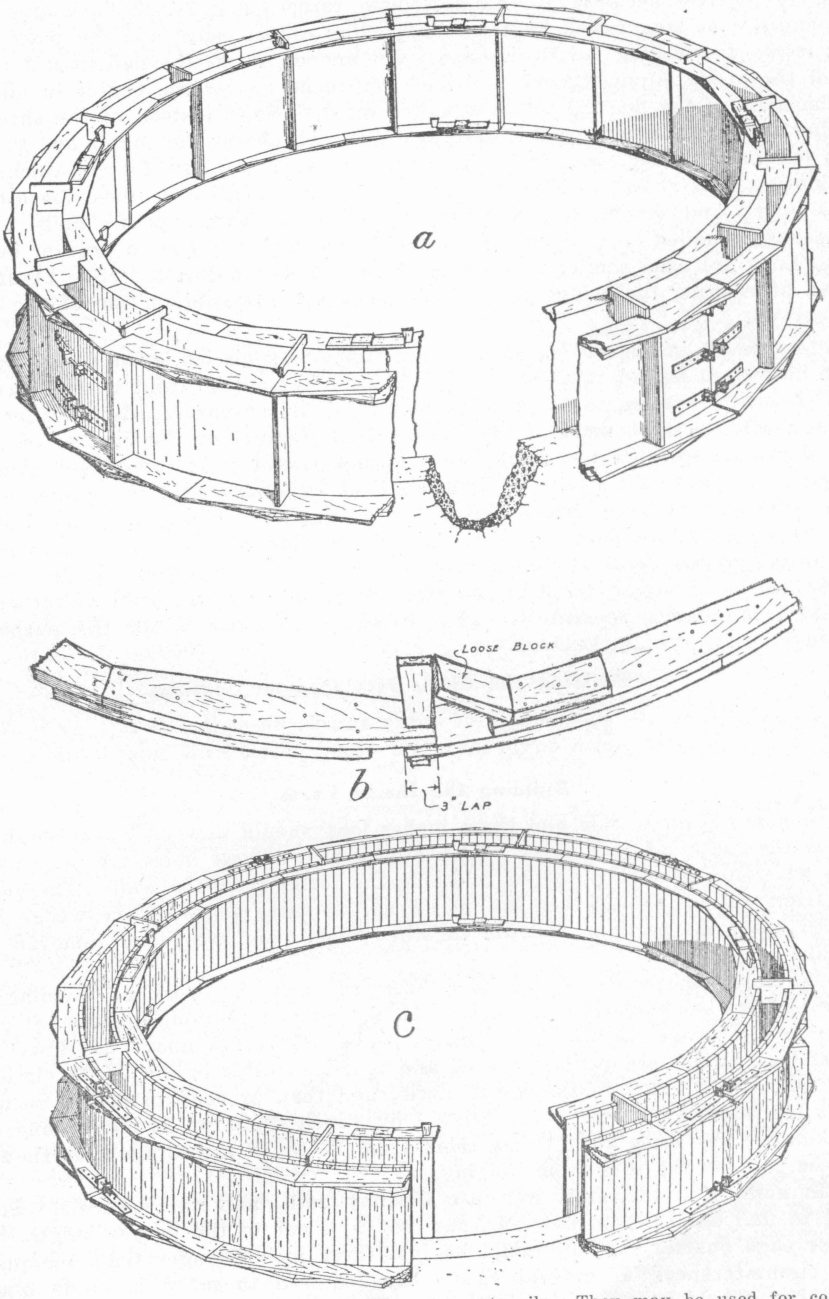

Figure 5.—Metal and wooden form for a concrete silo. They may be used for constructing concrete collar above or inside form may be used in putting in concrete wall from botton of pit silo to the top.

Wedges for Inside Form.—The wedges should be of hardwood, 8 to 10 inches long, 2 inches wide at the narrow end and 4 to 5 inches at the other. In order to make the wedges drive true and hold, it is necessary to put in loose blocks, as shown in Figures 5a and 5b.

Building the Outside Form.

The outside circles are built up and divided into quarter sections just as are the inside circles, but no provision is made for wedges. The sheet iron is made up in to quarter sections, three inches longer than one-quarter of the outside circumference, to provide for the lap.

Lugs and Bolts for Outside Form.—The quarter sections are joined and drawn together by means of bolts and lugs, the latter made from ⅜-inch tire steel and rivited on the forms as shown in Figure 5c. Note that on one end of the section the lugs are riveted on flush with the edge of the iron, while at the other end they are set in 5 inches from the edge to permit the lap. If preferred, the lugs may be put on the top of the supporting circles instead of on the sheet iron. The lugs should be made about 24 inches long to provide for several rivets. For drawing the sections together use ⅜-inch bolts, five inches long, with hexagonal heads and nuts and extra long thread. (See Figure 5c). The forms are now ready for use.

The experienced silo builder may leave off the supporting circles from the outside form. For the inexperienced man it is generally safer to provide these supporting circles, as they prevent the sheet iron from drawing at the top when the concrete is being placed."

As a rule such forms as described above should be made by the farmer who has several silos to build, or by a group of farmers in a community who centemplate building underground silos. Such forms are very substantial, and can be easily moved from place to place.

Where a farmer has only one or two small silos to build and no one to cooperate with him in building forms, he may use a little less expensive method of building the forms, such as are shown in Figures 2 and 3.

Proportion Material for Collar.

If the soil is very dry the walls of the trench should be wet; if the soil is of such nature that it will not crumble too badly, after filling the trench entirely full of water, this should be done. When the water has been taken up by the soil the trench is then ready to be filled with concrete. If the walls are not wet they may absorb too much moisture from the concrete and cause it to dry too quickly.

If hard flinty rocks or clean gravel is available a 1:2:2 mixture (one part cement, two parts sand and four parts crushed rock or gravel) should be used in making the collar. If no rock or gravel can be had a 1:4 mixture (one part cement and four parts sand) should be used; where the sand is coarse, containing considerable gravel, a 1:5 mixture (one part cement and five parts sand) may be used. The mixture should be made wet enough to pour, but not sloppy. With fine sand, more cement is required and in that case a 1:3 mixture may be used, but avoid using exceedingly fine sand. The concrete should be well mixed and carefully spaded, being careful not to mar the inner wall.

Reinforcing Concrete Collar.

Where the subsoil is firm and the surface soil not subject to cracking very little if any reinforcement will be necessary. If reinforcement is necessary, the farmer can usually find old scrap iron, and old wire about the place which can be used for this purpose. Hog wire makes a good reinforcing material. Allow the

concrete in the collar to set for 24 hours, before commencing the excavation of the silo. The farmer should also, make his elevator for elevating the silage, and use it in removing the dirt while digging. A device for removing the earth may be made of a half barrel, fixed up in the form of a bucket; or a trip bottom box, which is suspended from the hay carrier track or derrick.

The collar should extend two or three feet above the suface of the ground, to shed the surface water. If it is built higher than two feet above the surface of the ground, or higher than the end of the silage cutter, dirt should be banked up around the walls, so as to elevate the silage cutter, permittinfi the silage to drop from the cutter into the silo, doing away with an elevator or blower. The dirt bank will serve also in shedding surface moisture and prevent it from seeping in and softening the plaster on the wall below the collar.

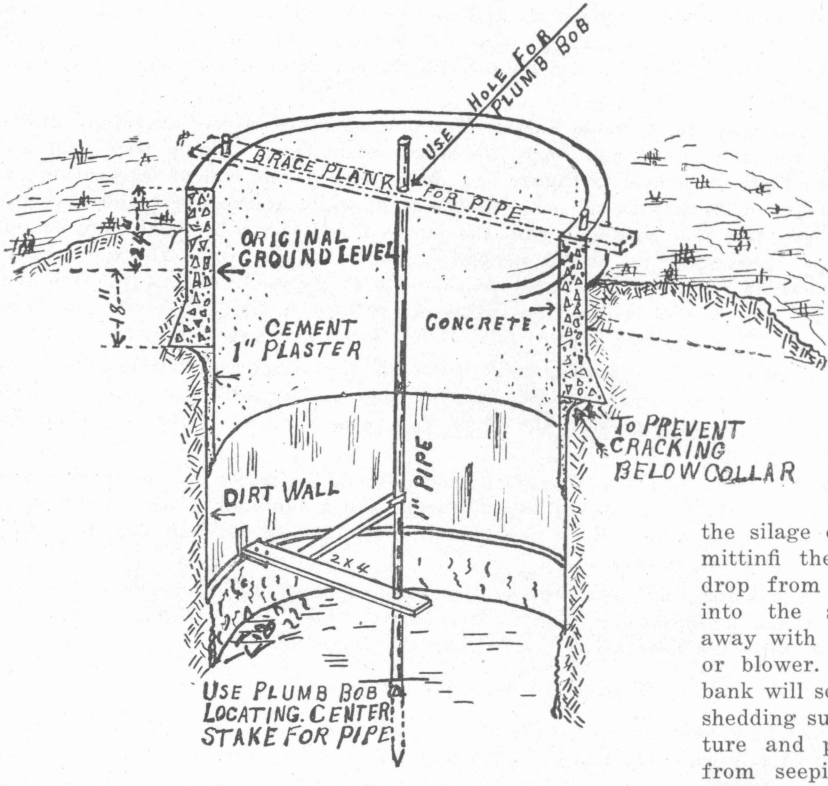

Figure 6. Showing one method of shaving walls in making an underground silo and other interesting points in construction.

Plumbing the Wall.

The inside diameter of the collar must be the same as the inside diameter of the silo, which should be uniform from top to bottom. It is very necessary that the walls of the silo be kept perpendicular. To do this one should use a plumb line, straight edge, or a piece of 2x4 and spirit level. Another simple method is to fasten a gas pipe in the center of the silo in a perpendicular position, after five or six feet of dirt have been removed. Saw off a 2" x 4", so it will revole in the silo, bore a hole through one end of the board and fit over the gas pipe. Bolt a heavy blade or cutting tool to the outer end of the 2" x 4". Beginning at the top revolve the 2"x4", causing the cutting tool to shave the wall smooth and plumb. This instrument will serve best where there is little or no rock encountered. The trimming should be kept well up with the digging. See Figure 6.

Plastering Below Collar.

After five or six feet of dirt have been removed below the bottom of the

concrete collar and the walls have been trimmed smooth, moisten the dirt wall, but do not make it soft and sticky. Plaster within one and one-half feet of the bottom with a 1:2 mixture, (one part cement and two parts clean, sharp sand) before digging deeper. Make the walls from one to one and one-half inch in thickness, depending upon the kind of soil in the silo and the diameter; as the diameter increases, the thickness of the plaster on the walls should increase. Apply the cement in three or more coats. Two coats will be sufficient in heavy clay soil, but if the soil is light more will be required. The thicker the wall the more permanent it will be. In order to prevent the cement from cracking immediately below the edge of the collar, remove the earth for two inches under the inner edge of the collar, allowing the trench to slope down two or three inches back to the edge of the wall; (See Figure 6) when applying the first coat of plaster fill the trench. If the collar is made of concrete, the plaster should come out even with the inner wall of the curb when finished, but if it is made of brick the plaster should extend to the top of the curb. The first coat of plaster should be left rough. As soon as the wall will stand brushing, use an old stiff broom to scarify it, and before the first coat has time to set, apply the next coat and repeat the brushing, as in the first, and so on until you have a sufficient thickness. After the last coat has been applied trowel down smooth and follow it with a cement wash made of cement and water of about the consistency of thick lime whitewash, and apply with a whitewash brush in the ordinary way. If the walls have had time to dry before applying the wash, wet the walls.

When the first course has been finished dig another five or six feet and plaster as before and so on. By doing this the silo may be finished without using a scaffold. If the walls are not plastered, they will eventually cave, also the soil will take up too much of the moisture causing the silage to spoil around the edge of the wall for a foot or so.

The cement plaster should be dampened twice a day for a week, as cement that dries slowly is tough, while if it is dried quickly it may crack or crumble. It is well to keep the silo covered during this period.

Unless the farmer has had some experience in handling cement, it is advisable that he employ an experienced man for a few days to show him how to do the cement work.

Painting Walls.

After the coat of cement has ben applied and has dried, the walls may be painted with coal tar, thinned with gasoline. The silage will keep without applying the coal tar, but it makes the wall more impervious, also protects it from the action of acids which develop in the silage. If necessary the wash may be renewed from year to year.

The following formula has been used in some cases for putting a glazed finish on the inside walls of the silos, making them considerably impervious and has been reported as giving good results.

Cement	100 lbs.	Water	16 gal.
Hydrated lime	10 lbs.	Concentrated lye	1 lb.
Mix thoroughly.		Powdered alum	2 lbs.

Thoroughly dissolve the lye and the alum in the water, then use same in mixing cement to about the consistency of thick cream.

Wet silo and wash off dirt, then apply cement mixture, rubbing thoroughly, filling all cracks and joints and rub smooth.

The Texas Experiment Station has had good results for the pest three years from painting the inside walls of concrete silos with gas-tar. The gas-tar is heated to a boiling point. While hot a small quantity of gas will form on top of the gas-tar. Touch a match to the gas and allow it to burn for a minute or so, then fan out the fire with an old sack or something similar. Then apply the gas-tar to the silo walls while hot with a stiff brush or broom.

Director Youngblood reports that the walls of a large reinforced concrete silo on the feeding and breeding farm at College Station, treated in this manner more than three years ago, is now in as good condition as when first treated.

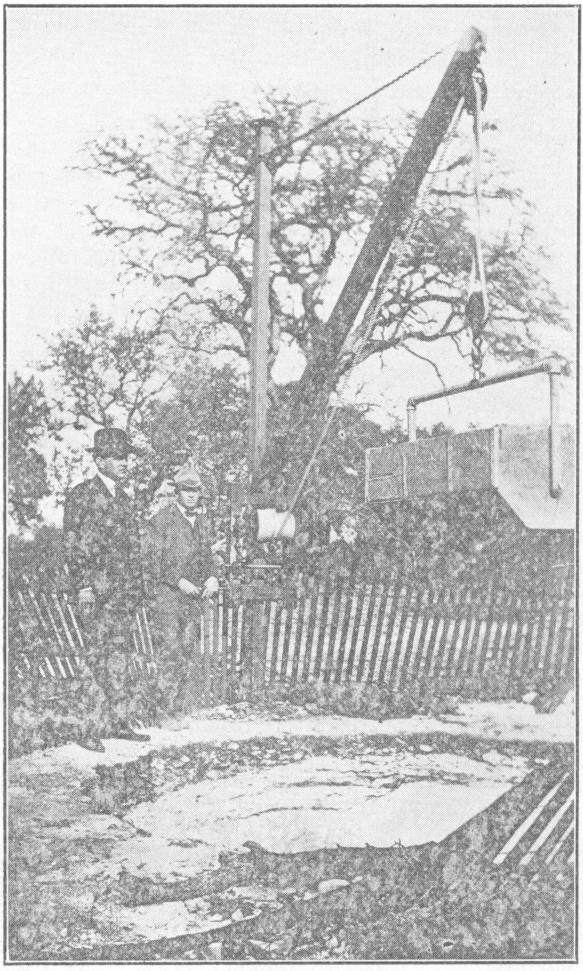

Figure 7.—Convenient hoist for removing dirt while digging, also may be used in removing silage.

Some prefer to use rosin with the gas tar, as it makes a better glazed surface. To do this mix thoroughly, 1 part well pulverized rosin, to 10 or 12 parts hot gas tar. Mix the rosin before heating the gas tar. Best results are obtained by heating the rosin before mixing, and then cooking the tar and rosin to a boiling point before applying.

Removing Soft Strata of Soil.

Should you come in contact with a strata of soap stone, lignite coal, loose sand or any substance to which cement would not adhere readily, remove this strata of soil just far enough to give room to lay a layer of brick to make it firm. When soft spongy spots are found in digging, hollow them out and fill with cement.

If this sort of soil is not removed in this way, the cement will be apt to crack at each such strata.

If the soil should be of such nature that the plaster could not be applied directly to the wall, use metal lath or close mesh rabbit wire, fastening it securely to the wall, and plastering as directed above. The bottom of the silos are usually not plastered, as the soil absorbs the excess moisture more readily.

Solid Concrete Wall.

Where the soil is very sandy or joint clay is encountered, it sometimes becomes necessary to use a three-inch wall of concrete from the bottom to top of the silo, if the walls will stand until excavation is completed. In that case the silo is dug and a sheet metal or wooden form, about four feet high, is used for the inner form and the earth wall for the outer form. The wall is built in sections from the bottom upward, the form being raised after each section has been completed or the walls may be lined with one thickness of bricks laid in cement mortar.

The concrete should be made of 1:2:4 mixture (one part cement and two parts sand, four parts crushed rock or clean gravel, or 1:4 (one part cement and four parts clean sharp sand.)

Concrete Collar on Black Wax Land.

The soil on black wax land, such as is found in sections of the gulf coast country and central Texas, cracks badly in dry seasons, and for this reason it is best to make the concrete collar thicker than usual. Probobly eight inches thick will be sufficient, with an extra amount of reinforcement of heavy hog wire and old rods.

In many sections of the gulf coast country the water table is of sufficient depth to permit the construction of the underground silo, without danger of water seeping in the silo. A method that has been used and proved satisfactory so far in the wax land to prevent the cracking of the ground from cracking the silo collar, is to use plow and scraper in beginning the pit silo, taking ofl the top surface for two or three feet in and around the silo. Upon reaching the desired depth mark out the circles as previously described and dig a trench as much deeper as necessary, preferably allowing it to rest on clay subsoil, then, build forms and extend them about two or three feet above the surface of the ground. By doing this you remove all the black wax soil from the concrete collar for several feet.

When digging use the clay from the bottom of the silo to fill in the excavation around the collar wall. This will prevent the soil from cracking so badly around the silo and eliminate, to a great extent, the danger of the cracking of the wall.

Quantity of Material Required.

The farmer is often at a loss to know how much material to arrange for before beginning the construction of his silo. The following suggestions are for the purpose of giving a general idea of the amount rejuired. For further information concerning the use of concrete on the farm, make request of the U. S. Department of Agriculture, Washington, D. C., for Farmers' Bulletins No. 461 and 481.

A silo 28 feet deep, 14 feet in diameter, having a four foot collar, six inches thick, and 24 feet of plastered wall below the collar of one inch thickness, will under ordinary conditions, require approximately 20.2 sacks of cement, 1.48 cu. yds. sand, 3 cu. yds. gravel for the collar, and 41.34 sacks of cement, and 3.1 cu. yds. of sand for the plastering, making a total of 61.54 sacks of cement, 4.58 cu. yds. of sand and 3 cu. yds. of gravel or crushed rock for the entire silo.

The following table applies to ordinary materials and covers the usual range of proportions.

By this table may be determined the quantities of materials required for the above silo, which contains 3.374 cu. yds. of concrete in the collar made of a 1.2:4 mixture, and 3.277 cu. yds. in the plaster wall below the collar made of a 1:2 mixture.

We find by the table that for each cubic yard of concrete (1:2:4 mixture)

there will be required six sacks of cement, .44 cu. yds. of sand and .89 cu. yds. of gravel. Then for 3,374 cu. yds. of concrete the quantities required will be 3.374x6—20.2 sacks of cement, 3.374x.44—1.48 cu. yds. sand and 3.374.89—3 cu. yds. of gravel.

We find by the table that for each cubic yard of plaster (1:2 mixture) there will be required 12.8 sacks of cement and .95 cu. yds. of sand.

Then for 3.277 cu. yds. of plaster the quantities required will be 3.277x12.8—41.34 sacks cement and 3.277x.95—3.1 cu. yds. of sand.

Quantities of Material Required for Various Mixtures of Mortar and Cement.

Mixture Materials for One Bag Batch				Resulting Volume in Cu. Ft.		Quantities of Cement, Sand and Pebbles or Stone Required for one cubic Yard of Compacted Mortar or Concrete.				
							Sand		Stone or Pebbles	
	Cement in Sacks...	Sand cu. feet ...	Pebbles or Stone cu. feet ...	Mortar ...	Concrete...	Cement in Sacks...	Cu. Ft.	Cu. Yd.	Cu. Ft.	Cu. Yd.
1:1½	1	1.5		1.75		15.5	23.2	.86		
1:2	1	2.0		2.1		12.8	25.6	.95		
1:2½	1	2.5		2.5		11.0	27.5	1.02		
1:3	1	3.0		2.8		9.6	28.8	1.07		
1:2:3	1	2.0	3.0		3.9	7.0	14.0	.52	21.0	.78
1:2:4	1	2.0	4.0		4.5	6.0	12.0	.44	24.0	.89
1:2½:4	1	2.5	4.0		4.8	5.6	14.0	.52	22.4	.83
1:2½:5	1	2.5	5.0		5.4	5.0	12.5	.46	25.0	.92
1:3:6	1	3.0	6.0		6.4	4.2	12.6	.47	25.2	.94

(Based on tables in "Concrete, Plain and Reinforced," by Taylor & Thompson).

Selecting Materials.

Cement.—Cement absorbs moisture from the atmosphere very readily, and if kept in a damp place it soon becomes caked or hardened, and should not be used in concrete work. Lumps, caused sometimes by heavy pressure in the storehouse, are not injurious, as they may be crushed readily between one's fingers with light pressure. Select a dry tight shed with floor raised from the ground, in which to store cement till used. In storing cement, wooden blocks should be placed on the floor and covered with boards; after piling the cement on boards cover with canvas, roofing paper, or other such material, and do not pile it against the outside wall. Much cement has been ruined by failure to observe these precautions. If it should contain lumps that are not very easily crushed they should be screened out and rejected. It is always wise to order a few extra sacks of cement if the dealer is at considerable distance, as by doing so one may avoid trouble caused by shortage. The left over cement, if any, may be used in repair work about the farm.

Sand.—Sand from the bank or creek should usually be screened before using in the concrete or plaster work. It should be clean, coarse and free from vegetable matter. Exceedingly fine sand should not be used. If it is of such fineness that over 50 per cent. of the bulk of sand will pass through a 40 mesh screen, when set at an angle of 45 degrees, it is generally unfit for concrete work. A 40 mesh screen means one with 40 holes to the lineal inch surface. Particles that will pass through a one-quarter inch screen are considered sand; coarser particles being considered gravel. If there is a large quantity of fine sand, get coarse sand and mix the two sands together in equal parts. If the sand is very fine increase the cement 10 per cent. The sand should not contain more than 10 per cent. of clay. To determine this the following test should be used:

A common method of testing sand for vegetable loam is to take a handful of the moist sand from the bank and rub between the hands. If the palm and fingers are covered with a film of pasty slime, the sand contains vegetable matter and should be washed before using.

The coarseness of the sand can be felt, or can be determined by a screen and the vegetable matter can be seen, but the amount of clay or loam can not be decided in either of these ways. Four inches of sand should be put in a pint preserving jar and when the jar has been filled with clear water to within an inch of the top, the lid should be fastened on and the jar shaken vigorously for ten minutes. The jar should then be rested up-right and the contents allowed to settle. The sand will settle in the bottom, leaving the clay and the loam on the top and the water above them. If more than one-half inch of clay or loam shows, the sand should be rejected or washed. The difference in color and fineness shows clearly the line of division between the clay or loam and the sand.

"If the sand must be washed, the simplest way is to build a loose board platform, from 10 to 15 feet long, with one end 12 inches higher than the other. On the lower end and on the sides and edges a piece two inches by six inches should be nailed to hold the sand. The sand should be spread over the platform in a layer three or four inches thick and washed with a three-fourth inch garden hose. The washing should be started at the high end and the water allowed to run through the sand and over the two-inch by six-inch piece at the bottom. A small quantity of clay or loam does not injure the sand, but any amount over 10 per cent. should be washed out.

Gravel.—The gravel should be cleaned, free from clay, loam and vegetable matter. The size for best results should range from one-fourth inch to one and one-half inch in diameter. In handling creek or bank material, first a one-fourth inch screen should be used to keep out the gravel and then the material which has passed through this screen should be screened again over a 40 mesh screen for the sand; all the material which passes through the 40 mesh screen should be rejected."

Dirty gravel should be washed in the same way as dirty sand. The dirt can usually be observed without making test.

Mixing Materials.

Mixing Board.—A water tight mixing board for two men should be about 9x10 feet made, preferably of 1x6 tongued and grooved plank to prevent the water from washing away the cement; two sides and one end of the mixing platform should have a strip nailed along the edge, projecting about two inches above the top of the platform to prevent materials from being washed off of the platform while mixing. The boards are so laid as to enable the shoveling to be with, and not against the cracks between the boards. The boards must be nailed close to prevent the cement grout from running through while mixing. Place the board level and locate it as close as possible to the forms in which the concrete is to be deposited.

Measuring Box.—A measuring box should be used whether or not the mixing is done by hand or machinery. A bottomless box can be made of one or four cubic feet capacity. If a four cubic foot box is made, marks on the inside of the box should be made to indicate capacities of 1, 2 and 3 cubic feet. In using the measuring box set it on the mixing platform, fill with the required amount of sand, then, raise the box and spread the sand out level over the board in a layer three or four inches thick; next add the cement, which need not be measured, as one sack (weight 94 lbs.) may be considered one cubic foot. Spread over the sand in an even layer, after which mix with square point shovel, turning the cement and sand two or three times or more, until the mixture is of a uniform color. When finally finished every

particle of sand and gravel should be coated with cement. In hand mixing do not make up a larger batch than can be placed in thirty minutes.

Wet the gravel thoroughly, then measure out and spread in a layer over the sand and cement, and mix all the material by turning with shovels, then add water while the mixture is being turned, until the desired consistency is obtained.

After water has been applied to cement it begins to harden or "set" in about thirty minutes. To disturb the concrete after this initial set has started or is well under way, means a loss of strength, or possible destruction of the concrete.

Water Required in Mixing.—When sand is moderately damp, a quaky jelly like mixture may be produced by using water in the proportion of one gallon to one cubic foot of concrete in place, or about five gallons of water to one sack of cement. The amount given is approximate. If the sand is dry or the gravel a little porous, more water will be required. The water should be measured carefully for the first batch. If the material contains a large amount of moisture, less water should be required. Do not use so much water as to make the mixture sloppy. The water used for concrete should be clean and free from strong acids and alkalies.

Placing Concrete.—Concrete should be deposited in a layer or layers of uniform depth, all around the trench or form, not deeper than the length of the blade of the spading tool being used. In placing the concrete in a trench where forms are not used, boards or planks should be laid around and across the trench for the workers to stand upon when dumping and spading the concrete, so as to prevent knocking down earth from the sides of the trench in to the freshly placed concrete.

Care of Fresh Concrete and Plaster.—After concrete has been placed, it should not be exposed to the hot sun for four or five days, especially during the hot summer months. During this period the concrete should be wet down by sprinkling water on the walls, both night and morning, or the walls may be covered with old burlap, canvas or other such material, placed so as to hang an inch or so away from the face of the concrete when wet. This will serve very well as a protection. It is also best not to allow a green cement mixture to freeze. If it should freeze after placing, and is not subjected to any load until it has thawed and allowed to "set" in the usual way, the binding qualities do not seem to be affected.

Stopping for the Day.

It often occurs that the work of placing the concrete is stopped before the forms are filled. In this case the concrete may suffer sufficiently so that the fresh concrete will not bond to it readily. This may take place, even in an hour or so, in warm weather. The concrete last placed should be roughened by scratching with a stick to prepare for a good bond with fresh concrete when the work is resumed. Immediately before resuming concreting, the surface of the old concrete should be washed off and painted with a mixture of cement and water to a consistency of thick cream, and applied just in advance of placing the fresh concrete.

Filling the Silo.

Packing Silage.—A silage conveyor connected to the cutter, is preferred by some. It may be made of galvanized iron in sections or of canvas. It is necessary to have two or more men in the silo, whether a conveyor is used or not; if not a hopper should be arranged to allow the silage to drop in the center of the silo, and the men with forks can distribute the silage and tramp it evenly both around the edge and the center of the silo. By tramping the center, as well as the edge the silage will settle evenly and toward the wall and not away from it. No silage has been lost by packing, but many have lost silage from lack of packing. After the silo is filled a few days it will settle five to six feet in a 30-foot silo, after which several more tons may be put in. When the silo is filled it is well to run a few

loads of straw, old hay or some less valuable feed on top of the silage for covering. Wet it well and pack thoroughly, or six or eight inches will decompose on the top of the silo.

Silage Cutter.—A six or eight horse power engine will furnish abundant power for a 12-inch cutter without a blower elevator which is not required with the pit silo. This is perhaps the most practical outfit for the average farmer. Where the elevator blower is required with the average above-ground silo it will take a twelve H. P. engine to pull a 12-inch cutter.

Watering Silage.—It may be necessary to run water in with the silage when cutting, if the crop has stood too long and become somewhat dry. A small stream turned on the silage as it leaves the cutter will wet each particle thoroughly as it goes into the silo, causing it to pack well, thus excluding considerable air, and prevent spoiling. The amount of water to use will depend upon the condition of the crop. There is not much danger of using too much water on a dry crop. Enough should be used to replace the water lost by the crop through drying. When the grain becomes a little glazed and the bottom leaves a little brown, the crop is in good stage for the silo. If perfectly green, the addition of water is usually not required. It is better to have the crop too ripe than immature. As the plant ripens the total weight of dry matter increases very rapidly, hence harvesting before time is wasteful and mature crops make a better grade of silage.

To avoid loss of space at the top of the silo caused by the settling of the silage, while filling, place a temporary picket fence, or such material, on the top of the collar flush with the inside edge of the wall. Fill this with silage and pack well. When the silage has settled, very little space will be wasted below the top edge of the curb. Then remove the temporary fence wall.

Precaution.

While filling the silo and for the first few days, after silage is put into the silo, carbonic acid gas is generated very rapidly. If the air is very still a sufficient amount may accumulate over the silage to make it impossible for a man to live in it. If the work is stopped for several hours or a day or two while the silo is being filled, or if it should stand empty or partly so far some time without being entered, care should be taken not to enter it upon resuming work until, the silo has been tested for gas. If gas is present the machinery should be started. The falling silage will stir the air up sufficiently to render it pure enough to work in, but it should be tested again before entering. One may throw in a few bundles of hay or loose sacks; this will create a current sufficient to displace any gas that may be present.

One can easily detect the presence of gas by lowering a lighted lantern or a chicken into the silo. If the light goes out, or the chicken dies, gas is present; but if undisturbed, there is no gas. By observing this precaution at the time of filling, by continual use after the silo is opened for feeding, and by having top ventilation, the trouble is eliminated.

The writer has made diligent inquiry for the past few years, but has failed to find any instance where gas has been found in an underground silo, but it must not be understood from this statement that gas may not occur. Since it may be present, the silo should be tested, as it takes only a minute.

With reference to gas forming in pit silos, C. I. Brady and D. L. Foster (Department of Animal Husbandry) in an Oklahoma Bulletin (Silos in Oklahoma) makes the following statement:

"Suffocation from carbonic acid 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."

Plenty of time should be given the cement to cure before filling the silo—possibly 10 or 15 days. One instance is known where a silo was filled four days after completion—the result was that the plaster cracked to the extent that the silo had to be replastered after removing the first silage.

Feeding Livestock.

For information on the subject of feeding livestock write to the Extension Service of the A. and M. College, College Station, Texas.

Removing the Silage.

The removal of the silage from the underground silo is often urged as an objection; however, the writer has never heard of a man having an underground silo who offered this as an objection. It is usually those who have not tried the underground silo. It should be remembered that the underground silo is very cheap. A blower is not required with the cutter and only one-half the engine power is needed to operate the cutter which is necessary when silage is elevated into a silo above ground. The saving of expense in the size of the engine, and the elimination of the blower, will pay for an underground silo in many cases.

Hoist and Derrick.—In hoisting the silage a number of devices may be used—the common hand windlass with system of double pulleys, proving very satisfactory.

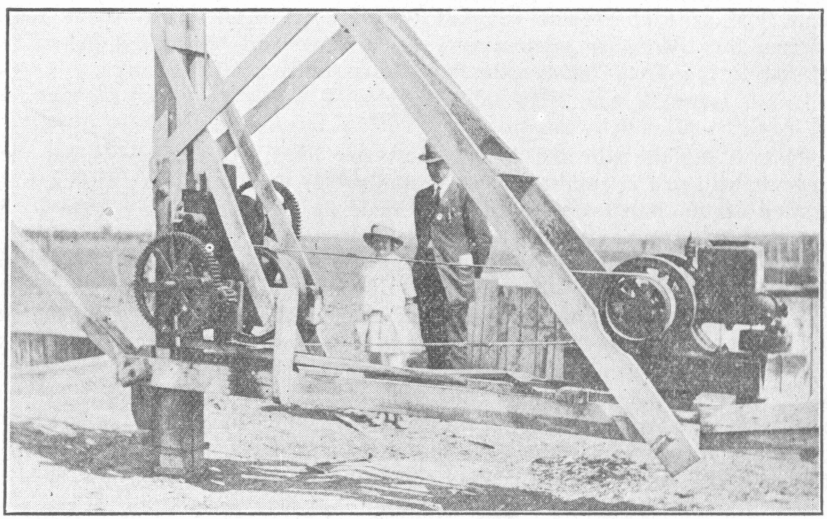

Figure 8.—A one H. P. gasoline engine placed on a revolving derrick, between a group of four underground silos, used for hoisting silage. It was also used in removing the dirt while digging the silos.

A swinging derrick, in connection with the windlass and pulley, or a block and tackle, may be used in raising silage by horse-power. Where a large silo and an extra large swinging derrick is used, an ordinary truck bed 10"x3½" can be used in removing the silage. Build the crane high enough to allow the bed to swing the truck wheels when lifting to and from the silo.

The common hay carrier and track may be used with, or without shed very conveniently. A hoisting frame may be made consisting of a tripod made of poles set up on one side of the silo and a scissor frame, made of similar material, on the other. The latter may be extended beyond the silo a sufficient distance to allow

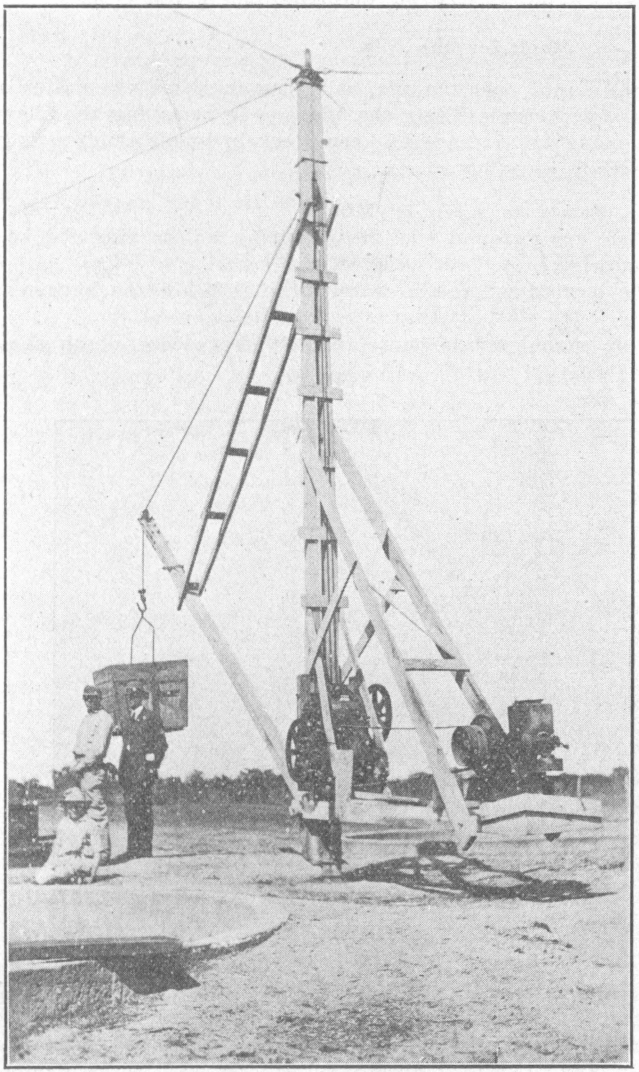

Figure 9.—Shows the same engine as figure No. 8, in addition in revolving derrick is placed between a group of four underground silos. The outfit has raised as much as 2000 pounds, the usual load is 1000 pounds. Total cost of the four silos, derrick and engine $886, each silo 15x25; encountered rock while digging, collar 4 1-2 inches by 20 inches and plastered walls.

a wagon to pass between it and the silo.A 2x12 may be fastened between these supports and an ordinary hay-fork-carrier-car attached to this will elevate and carry the dirt or silage. This track may be extended, as far as necessary, to the barn or feed pens.

In this way a trip bottom box, holding several hundred lbs. of silage may be handled with very little trouble, as it can be emptied from the hoisting box directly into the feed trough. The box may be conveniently pulled up by horse power or gasoline engine.

The hoist (Figure 11) is patented by W. J. Knorpp, Broom, Texas, and may be bought, or the farmer may rig up a home-made hoist that is probably not as efficient, but will answer the purpose.

The hoist is built over the silo and supported by a frame, or trestle made of 4x4's. The hoist works on the principle of a hand freight elevator.

The hoist consists of one large pulley wheel, about 24 inches in diameter on a short axle to which is keyed a 2-inch cog wheel. This small cog meshes with a large cog wheel about 20 inches in dameter, which is bolted or keyed to a long axle, or drum, on which the rope winds that lifts the feed box. An endless rope or chain runs over the large pulley wheel first mentioned and extends into the silo. By this arrangement the man doing the feeding rides on the box going down, controlling the speed of the descent by the endless rope. The box is filled with silage and the man rides the bux up, lifting both his own weight and that of the silage by pulling on the endless rope.

With the approximate back gear mentioned above, a man should be able to lift his own weight and at least 1500 pounds of silage, without great effort.

Roof for the Silo.

It is best not to build a roof over the silo, as it prevents free circulation of air and it is also in the way, both while filling the silo and in removing the silage. Some provisions should be made for a fence to keep stock or small children from falling in the silo if the curb is very low.

Points to Keep in Mind.

While constructing an underground silo the following points must be kept in mind, in order that it may give the best satisfaction:

1. The silo must be located where the water table is below the bottom of the silo.
2. The silo as a rule should not be more than 30 feet deep—depth about twice the diameter.

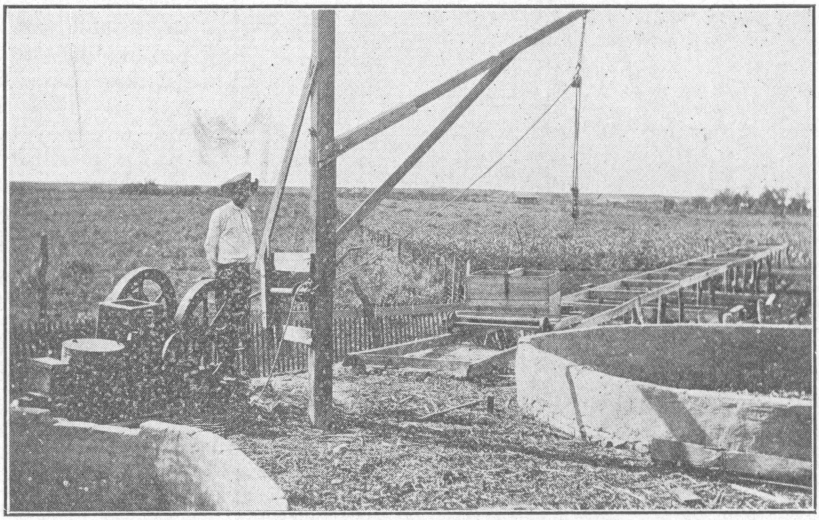

Figure 10.—A home-made track for carrying the silage box to feed pen.

3. The silo must have a collar extending about two feet, both above and below the surface of the ground, made of concrete 1:2:4 mixture.
4. The walls should be plastered with cement from one to one and one-half inch thick, with cement and sand (1:2 mixture). If dirt wall is dry dampen before applying cement.
5. Wash the walls with cement and water reduced to a consistency of thick cream; then paint with coal tar, thinned with gasoline, or with gas-tar as described.
6. Walls must be perpendicular and smooth.
7. Bank dirt up around the concrete collar, so as to shed surface water.
8. Wet cement collar and walls twice each day for a week after completion, keeping them covered during this time.
9. Remove soft strata and spongy spots, if any, in wall. Fill in with brick or cement.
10. Select clean, coarse sand and gravel for concrete and plaster work.
11. Do not allow dirt to fall in fresh concrete while placing.

Advantages of the Underground Silo.

The following are some of the advantages of the underground silo, briefly stated:

1. The expense of constructing an underground silo is very small, labor being the chief item.

2. The average farmer can construct one with the ordinary hired labor, as it requires little skill or outside help.

3. It will keep silage indefinitely, when well packed. Feed may be carried in reserve for droughty seasons.

4. The filling can be done with little cost; the cutter does not require a blower, hence only half the engine power is necessary to operate the cutter as required where a blower is used.

5. It is a permanent improvement; will not blow down ,burn up, and requires practically no repair.

6. Does not require expensive forms in construction.

7. Since they cost but little they are in reach of the farmer with limited means. He may have two—keeping a small one for summer feeding.

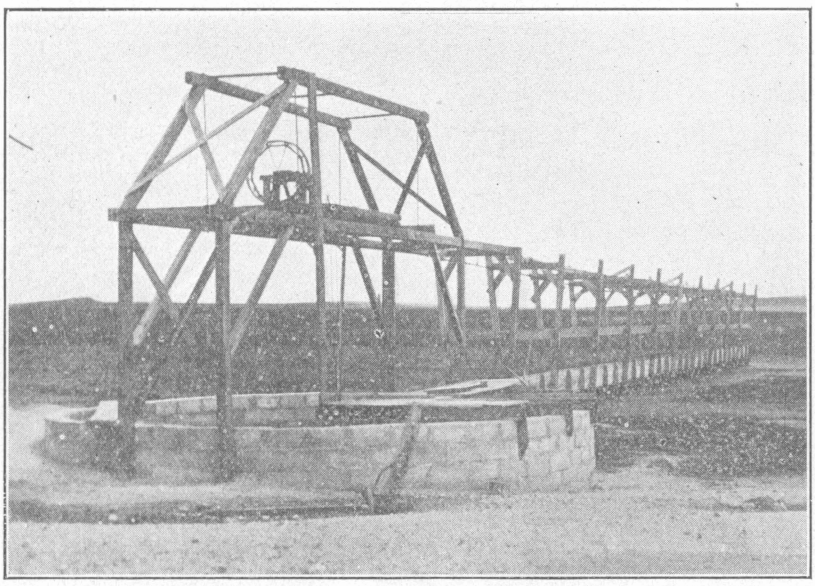

Figure 11.—The frame work and hoist above the silo as described above and carrier track extending over a continuous feed trough.