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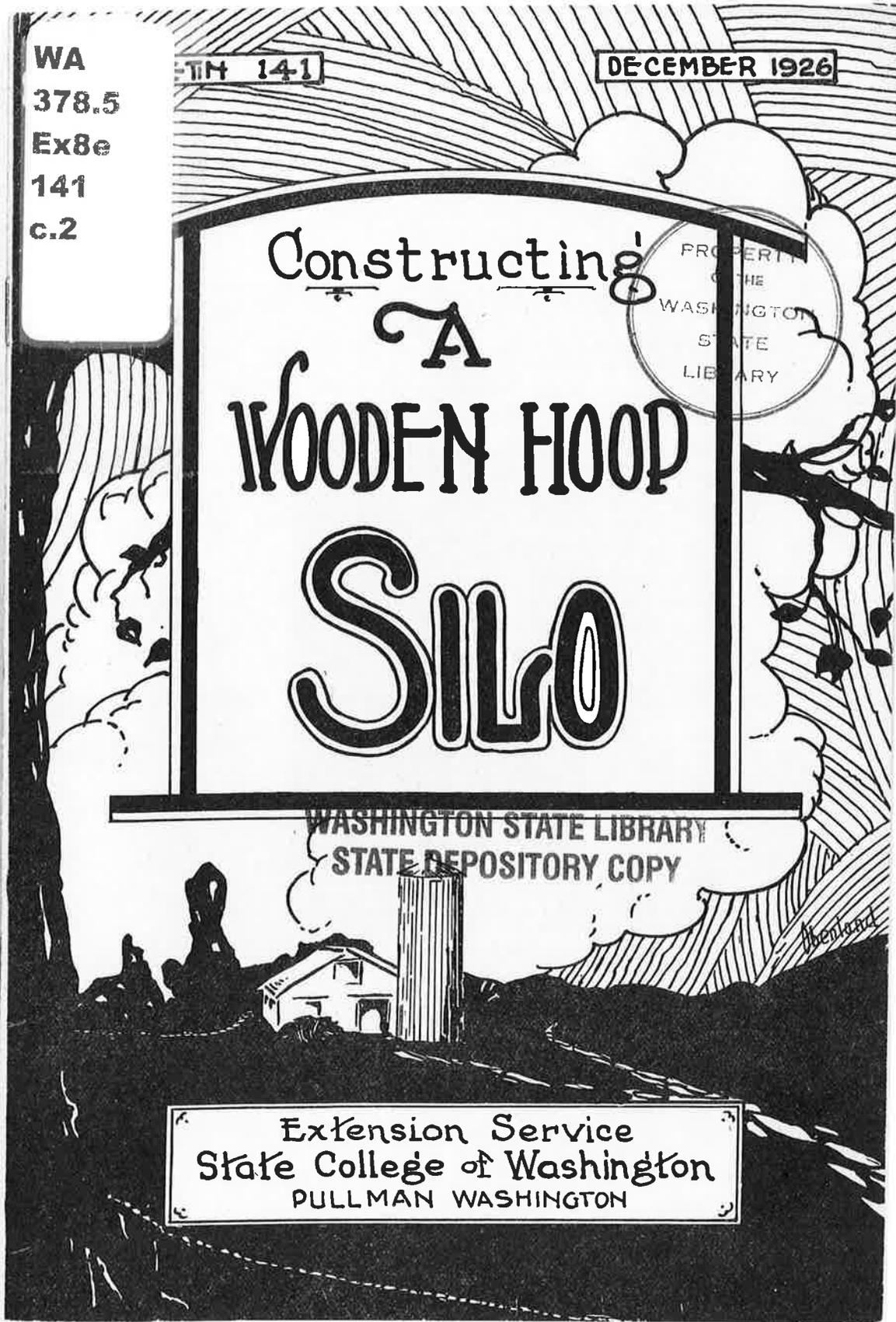
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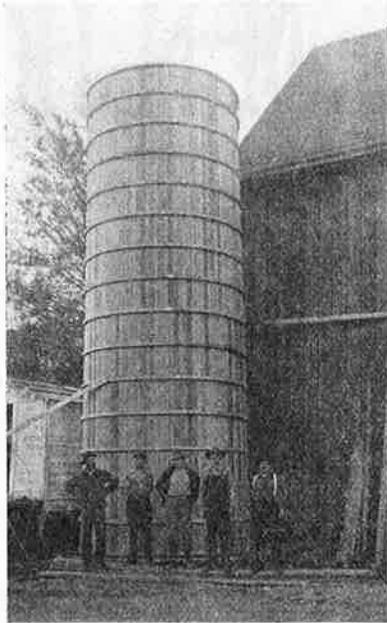
Constructing
A
WOODEN HOOP
SILO

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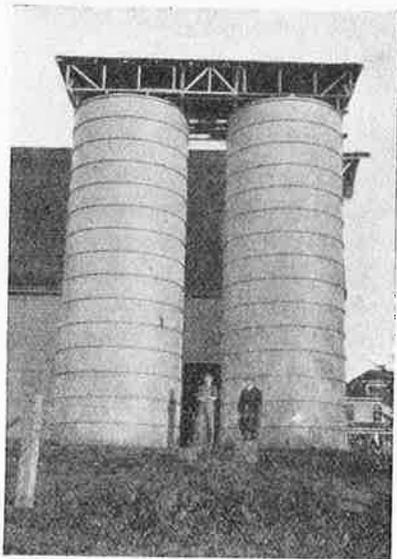
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CONSTRUCTING A WOODEN-HOOP SILO

by

A. B. Crane, Extension Specialist in Agricultural Engineering
and W. W. Henry, King County Extension Agent

The silo as a means of storing and utilizing the full nutritive value of feed and providing succulence for cattle, especially during the winter months, has proved its worth and is now recognized as an essential addition to the farm equipment. The concensus of opinion of Washington farmers is that feed put up and fed as silage goes from 33 per cent to more than 40 per cent farther than the same provender fed in its dry state, with a saving of from one-third to one-half on hay and grain. This alone makes the silo a paying investment.



Two silos under one roof make a neat appearance.

The growing use of the silo has awakened interest and a demand for information on the construction of serviceable, home-made silos that can be built at a cost that will justify their construction. The cost of filling machinery, added to the cost of the silo, must not be too high in relation to the size of the herd as this adds to the general overhead expense and increases the cost of production of the milk or meat.

This bulletin describes the construction of a serviceable silo that can be built with little trouble by a farmer and

a few of his neighbors, at a cost that will be well within his reach when the saving on feed is considered.

Kind of Silo

While there are many kinds of silos, namely, the concrete, concrete block, brick, pit, iron hoop stave and wooden hoop, the latter has been developed and is now being constructed as one the best, cheapest and most efficient types. This wooden-hoop silo will be described in this bulletin.

Requirements For a Good Silo

The walls should be durable so it will not rot or get in disrepair for a good number of years. This will make it a profitable investment.

The walls must be strong, to resist bulging when the silage is packed. They must be smooth, so that the silage will slide down freely and pack readily. They must be tight so as to exclude all air. The silo should also be water-tight.

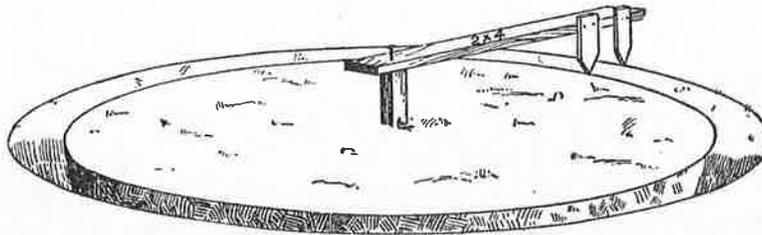
It should be simple in construction, easy to keep in repair, handy to fill, in a convenient location, and of a neat appearance in order to add to the general attractiveness of the farm. Its first cost and upkeep should be reasonable and consistent with the size of the herd.

Construction of the Wood Hoop Silo

The circular shaped silo has been found to be the best, as it is easiest to fill, can be packed evenly and is easily constructed without any framing. It also has the greatest capacity for a given amount of material. Locate it close to the barn, preferably outside except under special conditions, and readily accessible from the feeding alleys of the barn. Have the filling door at the top accessible from the cutting and filling machinery so as to be as conveniently filled as possible. Place the doors next to the feeding alley.

Foundation

The foundation of the silo may be of solid concrete forming the entire floor; or if the ground is hard and dry, it may be just a ring about one foot wide and the hard ground may form the floor. Level the ground below the foundation and make its top perfectly level so



The foundation is marked out on the ground.

the silo will be plumb when setting square on its base. If a solid concrete floor is made, slope it to the center a few inches and insert a small drain pipe, leading out to the low side of the ground. The foundation need not be more than a foot above the ground surface.

Details of Construction

The details of construction will be for a single wall wood-hoop silo, ten feet in diameter, thirty feet high, with continuous door, holding approximately 47 tons. This will last 15 cows 180 days, allowing 35 pounds per day per cow.

The following details should be carefully noted:

Bill of materials for silo 10 feet diameter, 30 feet high:

118 pieces flooring $1\frac{1}{4}$ " x 4", 10 feet long	} No. 2 grade or better
76 pieces flooring $1\frac{1}{4}$ " x 4", 14 feet long	
76 pieces flooring $1\frac{1}{4}$ " x 4", 16 feet long	

16 pieces 1" x 6", 18 feet long, fence boards, selected straight for temporary uprights.

12 pieces $\frac{1}{2}$ " x 6", 18 feet long, for form for foundation

2 pieces 2" x 4", 16 feet long } selected straight and planed

2 pieces 2" x 4", 14 feet long } on four sides, for door posts

70 bats, $\frac{3}{8}$ " x 3", 18 feet long } No. 1, perfectly straight grained

70 bats, $\frac{3}{8}$ " x 3", 16 feet long } and not over $\frac{3}{8}$ " thick for hoops

Hardware:

10 pounds 10d common nails

5 pounds 16d common nails

8 pounds 5d box nails, cement coated

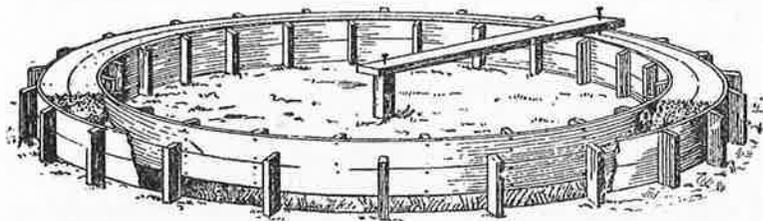
25 pounds 8d box nails cement coated

- 3 pounds shingle nails
- 34 pieces galvanized iron strips 3" x 8", 30 gauge
- 1 piece iron pipe, 5'-8" long, for drain
- 4 pieces strap iron, $\frac{3}{8}$ " x 2", 3'-6" long, for anchor rods.

These should have a 6" angle at lower end and a $\frac{3}{8}$ " hole one inch down from the top and another $\frac{3}{8}$ " hole exactly 20½ inches down from the first hole toward the angle.

Concrete foundation, 11' diameter, average 13½" thick, 1:3:6 mixture:
 10 sacks Portland cement
 2 cubic yards of clean sand
 3½ cubic yards of screened gravel

Note: Materials for roof are not figured.



The form is filled with concrete for foundation. Concrete floor may be put in if desired.

Laying Out the Foundation

Drive a stake at the center of the foundation with a nail partly driven in the top at the exact center. With a measuring board or a string at an exact length of 5 feet 6½ inches, drive 2" x 4" stakes with their inner edge 5'-6½" from the nail in the center post. Set these stakes opposite each other and practically two feet apart. There will be 18 stakes.

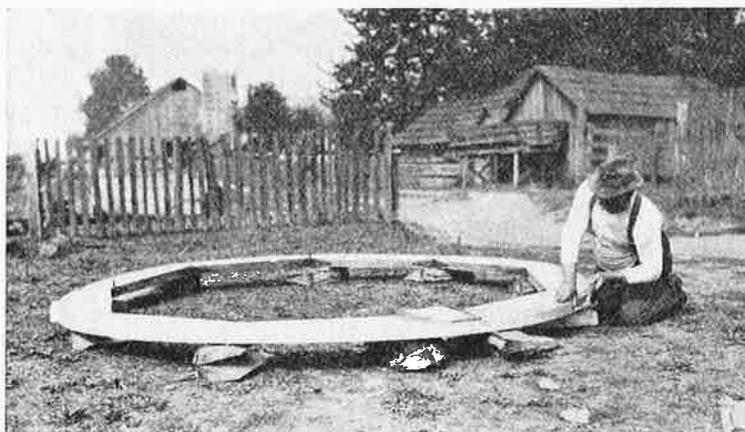
Use ½" x 6" boards for the form. If the ground is firm cut square down to a level base, and use the ground as a form using the ½" form-boards above the ground to the top of the form. Have the top of the form level all around so that when filled, the concrete will be level on top, ready for the wall of the silo. Level the inner floor down to 6 inches below the top of the form. Fill this entire floor with a 6 inch bed of concrete, 1:3:6 mixture, slightly depressed

in the center, with a small pipe leading from the lowest point out through the wall to the lowest side of the ground. This is for a drain.

Place the anchor rods at points 4'-4" each side from the center of the door, the other two 8'-8" away from the first two, measured around the curve of the silo. These anchor rods must be not less than 5'-3" from the center of the silo, and set so the lower $\frac{3}{8}$ " hole is exactly 6 inches above the top of the concrete. They must be placed flat-wise so as to fit over the hoops and be bolted after the silo staves are placed. Pack the concrete firmly in the floor. Let the foundation set a week or more before building the silo.

Building the Superstructure

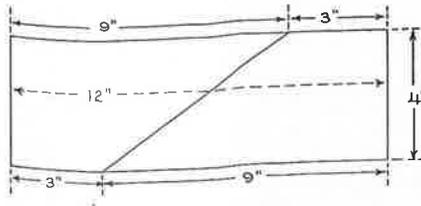
While the concrete foundation is setting the hoops and other materials may be made ready.



The hoop is built around the form. There are four layers of $\frac{3}{8}$ " x 3" battens 1 $\frac{1}{2}$ " thick when finished.

Making the Hoops. A level floor, such as a barn floor or level platform is needed, on which to construct a temporary form for the hoops. Some blocks made of 2" x 4" pieces about 1 foot long, cut diagonally across as shown in the diagram on page 8, are needed.

Each foot of 2" x 4" will make two blocks. Twenty-seven pieces of these "form blocks" will be needed. They should be placed 1'-2" apart around the circle.



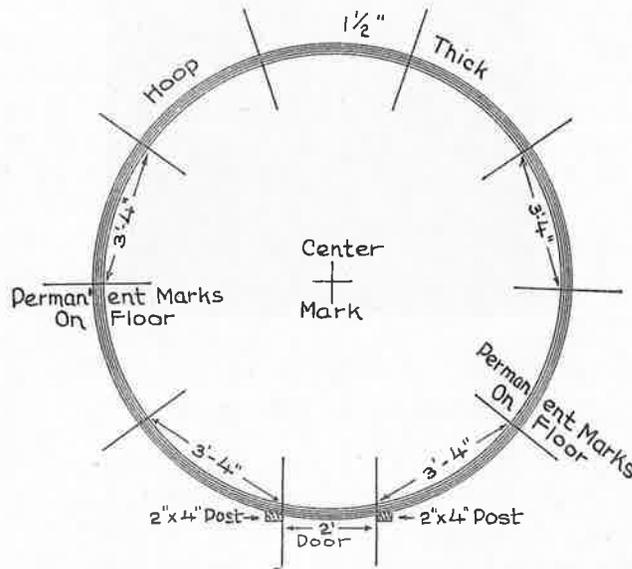
Select a place on the level floor where you will make the hoops, placing a chalk or pencil mark at the center. Take a piece of 1" x 4" or similar board, drive a nail in one end, driving the nail into the mark at the center of the form so that the board can swing around the nail as a pivot. Measure 5'-1 $\frac{1}{4}$ " from the center of the pivot nail and cut the board off at that length. Now with the chalk or pencil, mark a circle with the end of the board at the outer edge. This circle will mark the inner edge of the hoops. Now nail your 2" x 4" "form blocks" with the square end just flush with the circle mark and with the point toward the center of the circle. Nail them down at the beveled end and toe-nail them at the square end so they will remain firm. These blocks should be 14 inches apart. Twenty-seven of them will be needed. When these blocks are all nailed around the circle the form is ready.

The $\frac{3}{8}$ " x 3" battens are for the hoops. They will be built up with four layers. Square one end and nail it to one of the form blocks with two shingle nails; bend it around the next block, tacking it lightly to a block occasionally if necessary to make it fit against each block and keep it touching the floor. Bring the batten around as far as it will go, and cut the end square and so it will fit to the middle of the last block. Nail it just strong enough to hold it in place. Proceed on around with another batten until you meet the block where you began. Saw the batten to fit here and nail. Your first layer is done.

Now, starting at another point so that no two joints will come on the same block, proceed in the same way with the next layer, tacking it lightly to the first layer. Build up in this manner until all four layers are placed. The outside layer should now be nailed firmly every five or six inches, with a 5 penny, cement coated nail, driving through all four layers. It is well to "stagger" the nails,

driving them alternately near the upper and lower edges of the hoop instead of at the middle. The two joints of the outside layer will now be covered with the strip of galvanized sheet iron brought around the hoop and nailed tightly on the inside.

Now mark on the floor, inside the hoop, selecting any place to represent the door, a space of 2 feet to mark the location of the inner edges of the 2" x 4" door posts. Carry these lines up the outside of the hoop and over the top. Let these marks be plain so they can be readily seen when placing the hoops. Measure 3'-4" intervals each way from these marks, carrying the lines up and over the top of the hoop as before. Make the marks on the floor permanent so they can be used as guides for marking each hoop, thus:



When these guide marks are made the hoop is ready to take off and clinch all nails that stick through to the inside, leaving it perfectly smooth so the wall boards will fit firmly against it. Proceed in this manner with all the hoops until sixteen are made, which is the number for a 30 foot silo. Do not forget to mark each completed hoop with the guide marks. As fast as made take each hoop off

the form and pile them on the silo foundation, one on top of the other with the door marks at the proper place.

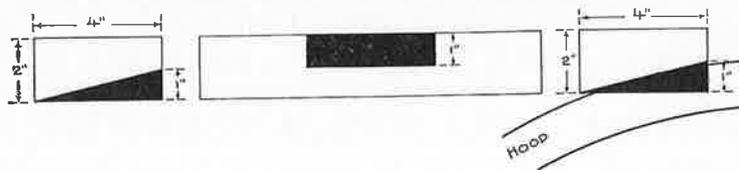


The hoops are placed on the foundation, ready to be lifted into place.

Framing the Door Posts

The 2" x 4" pieces, sized four sides 14 and 16 feet long, are for the door posts. They must be framed as follows:

Measure up two inches from the lower end which sets on the foundation and cut in a notch to fit over the hoop. This notch should be 3 inches wide, just to fit the hoop. It should be cut as shown:



The lower edge of the first hoop is two inches from the bottom end of the post. The notch for the second hoop will be $22\frac{1}{2}$ inches from the end of the post, which brings its center just two feet above the foundation. All the other notches will be two feet apart, center to center, except the last one which will be cut so the top of the hoop will be flush with the top of the staves. Make the other door-post exactly the same except that the notches must be made facing each other, deep parts opposite. One 16 foot and one 14 foot $2" \times 4"$ will be needed for a 30 foot silo. In joining them, cut the ends square and splice them on the middle of the hoop at the 16 foot height. The rest of the structure will hold it firmly when finished. The notches serve to hold the hoops in proper position. This is the only framing necessary in the silo.

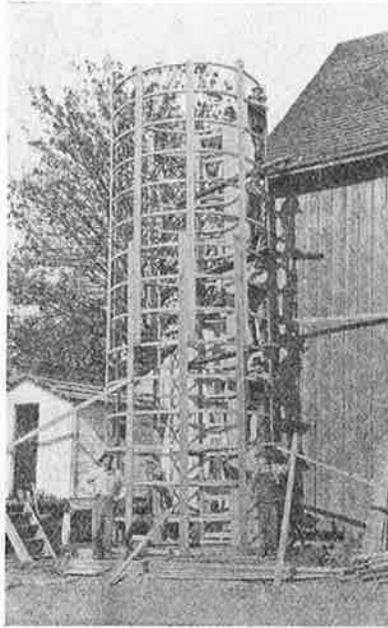
Nail together the 16 foot door posts with about four pieces of $1" \times 4"$ or scrap lumber, holding them exactly two feet apart and braced diagonally to prevent twisting. The two 14 foot ones should be nailed and braced in the same manner. The 16 foot section is now placed on the foundation where the hoops are marked "door", made perpendicular by the use of the carpenter's level and braced in position at bottom, middle and top.

Supports for the Structure. The $1" \times 6"$ fence boards are for the support of the hoops and should be marked off to correspond to the door posts. There are eight for each section. Nail cleats of $1" \times 4"$ or scrap material on these boards at the correct intervals for the hoops to rest on. Do not nail on the cleats for the three lower hoops as these three go on last and the cleats would interfere with placing the supports.

Allowance must be made for a 6 foot splice on the upper set of $1" \times 6"$ supports. These are not fastened to the lower set but the two bottom cleats are so placed that they will rest on the tops of the hoops at the 12 and 14 foot points. The cleats above the 18 foot mark are placed as usual except for the top cleat which is set down half the width of the hoop to correspond with the doorposts and allow the top of the hoop to come flush with the top of the staves.

After the door-posts are framed and the supports prepared, the wall boards or staves can be got ready. These are the pieces of $1\frac{1}{4}"$ flooring. They must be cut truly square on each end, exactly to 10,

14 and 16 foot lengths so they will fit when placed, without further trimming. Be sure to have all pieces turned the same with reference to the tongue and groove when piled.



The hoops are placed on the outer supports.

Raising the Silo

The proper place for the door was selected when the hoops were piled. This should be accessible to the feeding door of the barn. Raise the two 16 foot door-posts previously framed and braced two feet apart, into their place. They must be plumbed and securely braced as they control the shape of the silo.

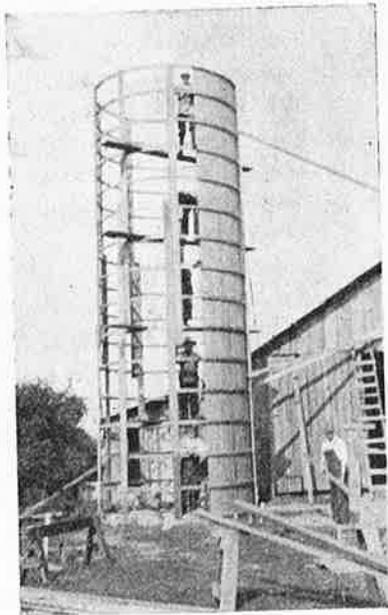
From this point, until the walls are all up, six men are required on the job.

The first section of the door-frame is now in place, the hoops are properly stacked on the foundation and the lower set of 1" x 6" supports are distributed at the marks on the hoops ready to be raised. Each man, armed with a hammer and 8 penny cement coated nails, raises a 1" x 6" support and the hoop from the top of the pile is raised to the cleats at the 6 foot level. The hoop is nailed securely into place, first at the door post then each man, keeping his support at the left of the mark on the hoop and flush with it, drives a nail through the support from the outside into the hoop to hold it in place. The remaining supports are then put into place and the next hoop is raised to the 8 foot level and so on up until all the hoops are in place to the top of the 16 foot section. Some 2" x 12" boards may be placed across the lower hoops for the men to stand on while working on the upper structure. Brace the support opposite the

door-posts well, so the structure will not have a tendency to corkscrew due to the weight of the men not being evenly distributed over the work.

A rope about 30 feet long is handy in pulling the hoops up into position, one man staying on the ground to send them up to the others.

When the top of the first set of supports is reached the second set is drawn up and put into position, this time placing the supports on the right side of the hoop marks with the lower cleats resting on the twelfth and fourteenth hoop as planned. When two hoops above the 16 foot door-posts are in place the 14 foot section of the door posts is drawn up and nailed in position. When the top of the silo is reached the three remaining hoops at the bottom are nailed into place and the frame made perpendicular by use of a plumb bob and braced in position.



Six men are needed in nailing the wall to the hoops.

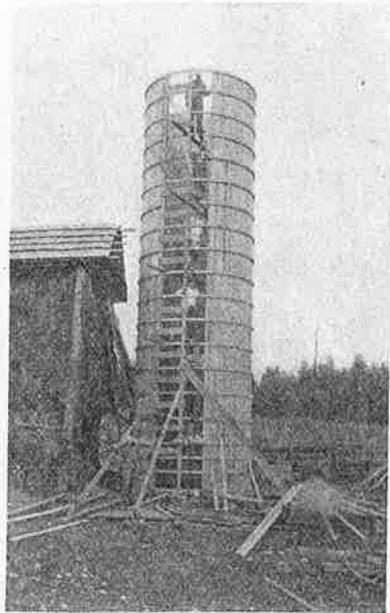
A strip of 1" x 4" cut diagonally so that it is feather edge on one edge and full thickness of the board on the other edge, is then nailed in place from top to bottom on the inside of the hoops and on the right side of the door as you look out, using the door frame as a guide and setting it in 1½ inches from the inside of the door-post. A similar piece will go on the opposite side of the door with the last stave. These pieces are necessary to make the ends of the door fit flat against the staves. This will leave the actual opening for the door just 21 inches.

Placing the Silo Wall

Five men are used in the silo, one on the floor and one each at the 6, 12, 18, and 24 foot levels. The 2" x 12" foot-planks are used for the men to stand on. One man passes the flooring into the silo and the others nail it on the same as if they were laying a floor. Each man nails three hoops except the man on the floor, who takes care of four.

Place the boards with the thick part from the tongue and groove next to the hoops. The first board up should have two nails at each hoop straight through the board and the feather edged strip beneath it. All the others will have one nail each at the tongue edge as in flooring, with no nails showing on the inside.

Different lengths of flooring can be used in making the walls, but two joints should never come in the same place. Ten, 14, and 16 foot lengths work nicely though other even lengths can be used.



The continuous door is made last. The hoops form the ladder.

A sequence of a 16 foot board down, a 14 foot above, then a 14 foot board down and a 16 foot above, then three 10 foot boards makes quick work and helps to keep the boards running even. Use a plumb bob as a check.

As the walls are put up remove the 1" x 6" supports before passing on. When the walls are laid two boards past the half way mark opposite the door, some pieces of 2" by 4" about 1½ feet long may be nailed to the inner wall opposite the door and the ends of some of the foot-planks should be toe-nailed to these with the other end sticking out through the door

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space. Short pieces of 2" x 12" plank can then be used for the men to stand on, one end on the main scaffold board, the other on the hoop. This makes it much easier to put up the last half of the wall.

When the last stave is to be put on, the piece of 1" x 4" diagonally cut to feather edge, is put on first in the same manner as for the first board on the opposite side of the door. The last stave is then ripped to come flush with the outer edge of the diagonal strip.



Details of Door, Posts and Staves

The Door

The door is continuous and is made in sections of one thickness of the flooring as used for the wall, 2 feet wide and approximately 2 feet high. The boards when in position in the door are at right angles to the staves and lap over 1½ inches on either side. Each section is nailed together with two pieces of flooring running parallel with the staves, on the outside of the door and extending a little over the edge of the door where the tongue occurs. These doors are all made exactly alike so they will fit anywhere. Some 1" x 4" diagonally cut strips are nailed to the inner wall just 1½ inches back from the edge of the opening on each side and will make shoulders to hold the doors in place. A board 2 feet long cut with square ends may be used to space these strips so they are the same all the way up and will take in any door any place. The pressure of the silage from the inside holds the door in place.

Bolting the Anchor Rods

The anchor-rods had ⅜" holes drilled and were set so these holes would come one inch above the first and second hoops. Flat-headed bolts, with the head inside should now be put through, bolting the structure firmly down to the foundation. The silo is now complete except for roof and paint.

Roof and Paint

No special design is given for a roof but it should be of a design to conform to the architecture of the barn and other buildings. It may be placed directly on the silo or raised a foot or more on supports, with screen netting to keep the birds out. The silo needs no paint on the inside but should be thoroughly painted with two or three coats on the outside to preserve it. The colors should conform to the rest of the paint on the barn in order to present a pleasing appearance.

Size of Silo

The silo described above will hold approximately 47 tons and is enough to last 15 cows 180 days allowing 35 pounds per day per cow. For a larger or smaller herd, the size should be made to correspond as it should be just enough so that a layer of between two and three inches will be removed and fed each day. The following table will give sizes, capacities and feeding periods for other silos:

Table, Based on 35 Pounds Per Cow Per Day

Size of Silo	Approximate Capacity	Number of Cows	Number of Months
8' diam. x 20' high	14 Tons	7	4
10' diam. x 20' high	21 Tons	10	4
10' diam. x 24' high	26 Tons	12	4
10' diam. x 30' high	47 Tons	15	6
12' diam. x 30' high	55 Tons	17	6
14' diam. x 30' high	75 Tons	24	6
16' diam. x 30' high	100 Tons	32	6

Note: In general, it is not economy to build a silo for a herd of less than ten head.