OREGON AGRICULTURAL COLLEGE
EXTENSION SERVICE

SILO CONSTRUCTION AND SILAGE FEEDING
By W. A. BARR and R. R. GRAVES

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SILO CONSTRUCTION
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Introduction

The primary object in constructing silos is for the preservation of green fodder crops in a succulent state. The silo that meets this aim is satisfactory from the standpoint of efficiency, but when the silo is considered from a practical standpoint, there are also considerations of economy, durability, and expense for upkeep. When material is made the basis of comparison, the silo that has a double initial cost over another often proves more economical throughout a term of years. In various parts of the country, we find in successful use silos constructed of wood, masonry, or iron, some of which are home-made and others the patented product of a manufacturer.

The home-made silo enters a field where competition is strong, and naturally some objection is offered; but as positive proof of its merits, we find that it has done excellent service in every state where silos are known. There is some detail work necessary in the ordering and assembling of materials for the home-made silo, and for the man who is in position to pay more for his silo and eliminate this detail work, the manufactured silo is best suited. The purpose of the information here given is largely to aid the man who desires to construct his own silo.

Kind of Silo for Oregon

Throughout the western portion of the State the stave silo is recommended. This is not only because of the comparative cheapness of lumber and the facilities for getting it, but because of the relative high cost of materials for the construction of the concrete silo, and because of the fact that the moist climate considerably reduces the amount of expense required for upkeep of the stave silo. Exceptions will occur where the builder desires a more durable silo than wood affords, and where sand and gravel can be obtained at a nominal cost for the building of the concrete
silo. In the eastern part of the State, where the atmosphere is drier and winds more frequent, the stave silo will not prove satisfactory unless a considerable amount of time is given to keeping the silo in good repair.

**Locating the Silo**

The first considerations in building a silo are its location, its size relative to the number of stock to be fed, and the length of the feeding period. As silage is a heavy feed, the first consideration in the location should be convenience for feeding. This as a rule will require the placing of the silo at one end of the barn, especially if the rows of cows face each other and there is a feeding alley between. Placing the silo in the barn is not advisable; for it is not always convenient to fill, and space is occupied that may otherwise be used to advantage. Silos should be so constructed and so cared for that they do not need the protection of the barn. Where there is a bank barn, a silo built into the adjoining bank will prove economical at filling time by placing the cutter on the bank, thus effecting a saving in the power required for elevating the silage.

**Size of Silo**

Perhaps no greater nor yet more common mistake is made than building a silo too great in diameter for the number of stock to be fed, which results in a loss of silage. The diameter of the silo should be determined by the number of stock to be fed, and the height by the length of the feeding period. If the height is great in proportion to the diameter, the surface area is small in proportion to the entire amount of silage, and spoilage is easily prevented. If the silo extends more than 36 feet in height, however, considerable extra power will be required to elevate the silage; and if the silo is more than 18 feet in diameter, or the bottom of the silo more than five feet below the door opening, inconvenience will be experienced in removing the silage when feeding. Where silage is fed all the year, it will generally be preferable to build two silos of smaller diameter than one large one; for it will be difficult to remove each day from the larger silo
enough to prevent spoilage during the summer. Table I shows the capacity of silos of various dimensions, with the minimum amount of silage that should be removed each day, the number of dairy cows, fattening cattle, or sheep, which can be fed from a silo of a given diameter, and the number of feeding days for each silo of stated capacity.

### TABLE I
Capacity of Silos

<table>
<thead>
<tr>
<th>Inside Diameter - Feet</th>
<th>Inside Height - Feet</th>
<th>Capacity - Tons</th>
<th>Number of Feeding Days</th>
<th>Minimum Pounds Removed Daily</th>
<th>Number of Stock That May Be Fed</th>
<th>Dairy Cows</th>
<th>Fattening Cattle</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>20</td>
<td>17</td>
<td>121</td>
<td>280</td>
<td>7-10</td>
<td>11</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>20</td>
<td>20</td>
<td>142</td>
<td>525</td>
<td>12-15</td>
<td>21</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>34</td>
<td>34</td>
<td>160</td>
<td>755</td>
<td>18-25</td>
<td>30</td>
<td>252</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>56</td>
<td>56</td>
<td>195</td>
<td>1030</td>
<td>20-30</td>
<td>40</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>91</td>
<td>91</td>
<td>175</td>
<td>1340</td>
<td>34-40</td>
<td>54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>131</td>
<td>131</td>
<td>230</td>
<td>1700</td>
<td>42-50</td>
<td>68</td>
<td></td>
<td></td>
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<tr>
<td>40</td>
<td>180</td>
<td>180</td>
<td>270</td>
<td>2100</td>
<td>53-65</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>231</td>
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<td>44</td>
<td>320</td>
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The above capacities are figured on the basis of the weight of silage per cubic foot 48 hours after filling. The silos will not have the given capacities unless refilled, as there will be four or five feet of settling.

### Amount of Silage in Partly Filled Silos

The amount of silage in silos partly full can be readily calculated when the cubic feet of silage and the mean weight per cubic foot are known. The number of cubic feet of silage can be determined by multiplying the surface area of the silo by the height of the silage 48 hours after filling. The surface areas of different diameter silos and the mean weight of silage per cubic foot are shown in Table II. For instance, if we wished to find the number of tons of silage in a silo 14 feet in diameter when the height of the silage was 20 feet, we should multiply the surface area, 153.94 feet, by 20, the height of the silage, and that product by the mean weight per cubic foot at this depth, which is 33.3 pounds; divide this
product by the number of pounds in one ton and the result is the desired number of tons.

TABLE II

<table>
<thead>
<tr>
<th>Diameter of Silo with Surface Area</th>
<th>Depth of Silage with Weight per Cu. Ft.</th>
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<tbody>
<tr>
<td>Feet</td>
<td>Sq. Feet</td>
</tr>
<tr>
<td>8</td>
<td>50.27</td>
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<tr>
<td>10</td>
<td>78.54</td>
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<tr>
<td>12</td>
<td>113.09</td>
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<tr>
<td>14</td>
<td>153.94</td>
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<tr>
<td>15</td>
<td>176.60</td>
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<tr>
<td>16</td>
<td>201.06</td>
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<tr>
<td>18</td>
<td>284.47</td>
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<tr>
<td>20</td>
<td>314.16</td>
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Essentials to Be Considered in the Construction of a Silo

1. The diameter of the silo should be limited.
2. The foundation should be of sufficient width to carry the weight upon it, considering the nature of the soil, whether firm or loose.
3. The inner walls of the silo should be smooth, perpendicular, and free from corners; other types of silos than round are not satisfactory.
4. The inside of the silo should be painted with tar pitch, melted or thinned with gasoline before applying.
5. The doors should be of such construction as to be easily removed.
6. A ladder should be provided, and should be placed at such distance from the silo wall as will allow easy climbing.
7. A window in the silo chute above the comb of the barn will afford light that is much needed in both the chute and the silo.
8. A good roof adds to the life of the silo, and adds greatly to its appearance.

CONSTRUCTING THE STAVE SILO

This type of silo can be made of either the plain stave or the tongue and grooved stave. The first is somewhat cheaper in original cost than the second, and if properly constructed will no doubt prove as satisfactory throughout a term of years. When a silo built of tongue and grooved staves is
emptied, and stands subjected to climatic conditions without proper attention or repairs, the staves shrink, and in shrinking cause the separation of the tongues and grooves; the staves also warp, and generally a number are drawn out of plumb, making it very difficult to match them again and properly tighten the silo. When the silo is constructed of the plain stave, as described later, the shrinkage will be no greater, and if the staves are spiked together, they will remain plumb.

_Laying Out Foundation._ A stake should be driven in the ground at a spot which marks the center of the proposed silo, the height of the stake after being set to be the same as the height of the foundation. On the top of this stake spike one end of a 2x4 sweep, the spike marking the exact center of the silo.

From the spike-head, measure off and mark on the sweep the distance to the outside and the inside of the foundation wall, allowing for a wall varying from 10 to 18 inches in thickness, depending upon the size of the silo, the nature of the ground, and the material of which the foundation is to be constructed. The distance from the center of the silo to the inside of the foundation wall must be three or four inches less than the radius of the silo, for the staves must not be placed closer than this distance to the inner edge of the foundation. Markers can then be nailed to the sweep, and circles described for the foundation as shown in Figure 1. By the use of a level and a longer marker, and the moving of the outer end of the sweep up or down, the foundation circles may be marked on ground that is not level. When the foundation is marked out, then dig out the trench that serves as a form for the underground part of the foundation. The trench may

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**Fig. 1—Laying Off the Foundation for a Silo**
be from six inches to one foot in depth, which, with the above ground portion, will give a foundation 12 to 24 inches in depth. The sides of the trench should be kept straight and the bottom left level. If the edge of the trench is inclined to cave, the trench should be filled with concrete and the forms may then be constructed for the above ground part of the foundation.

**Building Forms.** Stakes three feet in length should be driven into the ground, two and a half feet apart all the way around the inside of the lower foundation wall. These stakes should be one-half inch from the edge of the wall and driven down until they are the exact height the wall is to be built. Take green lumber, one-half inch thick and six inches wide, with straight edges, and bend around the outside of the stakes, nailing the boards to the stakes. The sweep and the level can be used to get the upper board the exact height. After the space has been boarded up, the outer form can be constructed in a similar manner. At several places nail slats across the tops of the forms, to strengthen them and keep them the proper distance apart.

**Preparing Concrete and Filling Forms.** For mixing the concrete, a platform 8x12 feet, or a box eight feet long, four feet wide, and one foot deep, may be used. A barrel with both ends out will serve to measure the concrete materials. The concrete should be made of one part of cement to three parts of sand and five parts of gravel. Broken stone, broken brick, or screened cinders may be used in place of the gravel. (For further details relative to handling concrete, refer to page 26, under constructing the concrete silo.)

While the forms are being filled, the concrete should be tamped thoroughly. A good tamper may be made of a piece of 4x6 inch lumber, two and a half feet in length, with a hole bored through the center of one end to receive a handle.

**Anchoring Bolts.** Anchoring bolts, one-half inch in diameter and 24 inches long, with an elbow on the lower end, should be placed between the forms about six inches from the inside of the foundation, and held in a vertical position by small boards across the top of the forms. These bolts, six to eight in number, should extend 10 inches above the foundation.
wall. The concrete will be filled in around them. After the silo is completed, the staves next to the anchoring bolts can be securely fastened to them. Two or three times during the process of filling the forms, a spade should be worked between the concrete and the forms to force the coarser materials away from the boards, in order to leave smooth-surfaced walls.

Reinforcing Foundation. That part of the wall above the ground should be reinforced by laying in the concrete strands of wire with the ends tied together. The top surface of the wall should be finished with mortar made of one part of cement to three parts of sand, and be leveled by the use of the sweep before referred to. Before the center stake is removed, mark a line around on top of the foundation to show where the inner edges of the staves should come.

Fig. 2—FORM FILLED WITH CEMENT, SHOWING EYEBOLTS AND SLATS IN PLACE AND CIRCLE TO MARK POSITION OF STAVES

Floor. The silo floor may be dispensed with when the ground on which the silo is located is very firm, but only under such conditions. The advantages of a floor are: The silo is easier to clean; rats cannot burrow into the silage; there is no loss from spoilage in the bottom of the silo. When a floor is contemplated, tile should be laid first for a drain, using three-inch vitrified sewer pipe. A small trench is dug from the center of the silo, extending below and beyond the foundation wall. The elbow tile is laid first, placing it so that the mouth opens into the center of the silo flush with the floor; to the other end of this tile is laid the second tile, etc. The outer end of the drain is plugged before the silo is filled and opened after the silo is empty. The mouth of the drain should be covered with a heavy wire screen of fine mesh, the edge of the screen being covered with concrete. The
drain will not only carry off water that tends to seep in, but any rain water that may collect on the floor, in case the silo is open. The floor should be made four inches thick, of concrete similar to that used in the foundation, and surfaced with mortar. It should slope to the center of the silo.

Silo Door. CONTINUOUS DOOR. The silo door is not as vital a part of the silo as it is often represented to be. It should be convenient to use, however, durable, and tight. The continuous door is preferable to the intermittent door, and is not difficult to construct.

DOOR FRAME. A very convenient method of constructing the door frame, is to use two pieces of 4x6 inch lumber, as long as the height of the silo. In each of these pieces two rabilds should be made the entire length of the pieces and on the same side. One rabild in each piece should be two inches by one and one-half inches, and the other rabild one inch by one and five-eighths inches. (Figure 3.) These rabilds should be made at a mill equipped for such work. If it is desired, the door posts may be beveled in place of cutting the two-inch rabilds, and the doors which close the silo may have an opposite bevel, so that the doors fit snugly when put in place. When such a plan is followed, the advantage is to make the removal of the doors easier after the silo doors may have swollen tight.

In putting the door frame together, it must be remembered that the deeper rabilds will come inside the silo door frame. The door frame is held together and the proper width secured by the use of half-inch bolts, 29 inches in length, which pass through the door posts and through one-inch, or three-quarters-inch diameter gas pipe, 20 inches in length, as shown in Figure 3. The gas pipes in the lower half of the door frame should be spaced 20 to 22 inches and in the remainder 26 to 30 inches. Within three inches of the ends of the door frame bore holes for the upper and the lower silo hoops. Holes for the remaining silo hoops should be bored in the door posts, so that the hoops will fall just below each gas pipe in the lower half of the door frame and midway between the remaining pipes.

Iron washers should be placed between the ends of the gas pipe and the door posts, to prevent the pipe from sinking
into the timber. Washers should also be used under the bolt-heads and under the nuts. When the door frame is completed, it should be placed on the foundation wall at the desired place for the silo door, with ledges between the rabilds, at the edge of the marked circle on top of the foundation wall. The frame should then be plumbed and securely braced.

The Intermittent Door. When using this type of door, it will be necessary first to decide on the number of doors the silo will have, allowing a distance of about two and a half feet between each door. Two staves are then selected and saw cuts made halfway through each one, on lines which mark the top and bottom of each door. These saw cuts are
for the entrance of the saw to complete cutting out the door after the staves are all erected and the hoops have been placed on the silo. The doors should be about 20 to 22 inches wide and 30 inches high. Two cleats, with one edge of each cut to the circle of the silo, should be bolted on the outside of each door, with the nuts on the outside and the boltheads sunk flush with the inner surface. Four bolts in each cleat (two in each end) will be sufficient; the cleat may be nailed to the other strips.

Preparing the Plain Stave. Only select lumber, sound, free from knots, and straight, should be used in silo construction. Staves 2x6 inches should be used for all silos larger than 10 feet in diameter. For silos 10 feet or less in diameter material 2x4 inches is preferable. The staves should be surfaced on both sides, the edges being left square, for when set in place the first point of contact will be the inner edge, and tightening the loops will make a tighter inner surface. Square the ends of each stave, and after doing this, bore holes one-half inch in diameter, three inches deep, perpendicular to one edge of the stave. The holes should be three to four feet apart, with one hole near each end of the stave. These holes must not be in line in adjoining staves. Their purpose is for spiking each stave to the preceding stave. Following this method makes the construction of the silo easier, gives a more rigid wall when finished, and tends to prevent the walls from getting out of plumb when the silo is empty. The spike is driven into the bottom of the hole in the stave, and, by the use of a drift-pin and hammer, is driven through the remainder of that stave into the adjoining stave. (Figure 4.) Care should be taken not to put any spikes in those portions of staves which are to be cut out for

Fig. 4—CROSS SECTION OF TWO STAVES, SHOWING METHOD OF SPIKING
doors. As a rule, lumber can be gotten long enough for one-piece staves, but where this is impossible, the staves should be of two pieces of unequal lengths, the shorter being not more than one-half the length of the longer staves. The two pieces should be joined together by the use of a sheet iron spline, after saw cuts have been made in the ends of the pieces. (Figure 5.)

**Erecting Staves.** When the continuous type of door is used, the door frame will first be erected, as previously described, and the first stave set up and spiked to one door post, with 40-penny spikes. Each succeeding stave will be set up and spiked to the preceding stave in a like manner. When the intermittent door is used one stave is erected and gauged, and the following staves set up adjoining the first, as shown in Figures 6 and 7.

**Tongue and Grooved Staves.** Silos constructed of the tongue and grooved stave are more commonly built than silos with the plain stave, and where sufficient care is given at the proper time to keep them in good repair, they will prove satisfactory for a long term of years. Material for the staves may be secured from the local lumber dealer or saw mill, or ordered from a company that makes a specialty of manufacturing lumber for such purposes. Staves with a half-inch tongue and groove will prove more satisfactory than will staves with narrower tongues and shallower grooves. Care should be taken that the staves are milled to fit. Lath should be soaked in water over night, or barrel staves may be used to hold the staves in proper position when erected. For a silo 30 feet in height, laths tacked at the top, bottom, and middle of the staves, will hold the staves securely. These may be removed after the silo is completed and the hoops properly adjusted.

The staves should be kept dry until erected; otherwise, difficulty will be experienced in fitting them because of tongue and groove swelling. While the hoops are being put on and tightened, tapping may be necessary where the matching is open.

**Scaffolding.** Unless the silo is more than 25 feet high, no scaffolding will be needed, as a ladder can be used very
Fig. 5—JOINING A TWO-PIECE STAVE BY USE OF SPLINE
satisfactorily. If scaffolding is constructed, six, seven, or eight posts may be set up around the outside of the foundation of the silo, bracing the posts by cross ties from one to the other. Planks are placed for walks at different elevations, these being chosen with reference to convenience in handling the hoops. Generally eight to nine feet is sufficient height between the walks. The work may begin at one side of the door and proceed around the silo until complete; or, a part of the staves may be set up working from one side of the door, and the remainder working from the opposite side, the work coming to completion opposite the door of the silo. The last stave can be put in place by spreading the adjacent staves out from the true circle, and after the stave has been inserted, crowding them back to the circle.

**Placing the Hoops.** The hoops may be made of rod iron, varying in size from three-eighths to seven-eighths inch in diameter, and in sections 8 to 15 feet in length, with the ends threaded about six to eight inches. These hoop sections are joined together by means of lugs; and by the adjustment of the nuts on the ends of the sections proper allowance is made for expansion and contraction of the silo. In silos of 12 feet diameter or less, the hoops on the lower half of the silo may be one-half inch rods, and the remainder a little smaller. In silos 14 feet in diameter or larger, and more than 30 feet high, the hoops on the lower half of the silo should be three-quarters to seven-eighths inch diameter. Place the bottom hoop on first, then the top hoop, and tighten both, after which the remainder of the hoops may be put on and tightened. Care must be taken to have the lugs come at various places on the silo, rather than in line, lest a sharp angle should be formed and the pulling brought on only a few staves, thus causing the silo to get out of shape. Measure across the top of the silo in several places, to see if the silo is round. Should it not be round, it can be trued by forcing planks of the proper length across the small diameter. If the silo is not true and is out of plumb, it will eventually cause a great deal of trouble. The hoops should be well stapled to the staves, each stave having three to four staples throughout its length.
Fig. 6—THE FIRST STAVE IN PLACE
Chute and Ladder

A chute through which the silage is dropped to the ground is a valuable addition to a silo, for feed is saved and convenience in feeding is augmented. The chute should be at least three feet square, preferably four feet square, and should enclose the doorway and ladder.

If the silo has the continuous type of door, the ladder will be formed of the gas pipe spacers in the door frame and the silo hoops. If it has the intermittent type of door, a ladder should be built onto the side of the chute and at right angles to the door.

Painting the Silo

Before the silo is filled, it should be painted with tar pitch, No. 7 soft, carbolineum or creosote. Repeating the process every few years will add to the life of the silo, and tend to fill any spaces between the staves, making the silo more nearly air tight. If painted outside its appearance will be improved. Painting may well be delayed until the second year, however, in order that the lumber may thoroughly dry out.

Care of the Silo

The silo is one farm building which must have attention at the proper time; if this is not given, it may mean the loss of the silo, or at least a great reduction in its efficiency. It is almost impossible to put sufficient emphasis on the necessity of keeping the hoops at the proper adjustment when the silo is empty. The hoops should never become so loose that they sag. They should be tightened, a little at a time, at intervals throughout the summer, and loosened when the silo is filled. If the hoops are tightened excessively when the silo is dry, there is danger of the staves buckling during a few days' continuous rain, or when the silo is filled the expanding of the staves may cause the breaking of the hoops or the lugs.

Sometimes the silo will get out of plumb, even though the hoops are tight and the silo is well anchored. In case this happens, the silo should be straightened before filling. This can be done with a heavy wire stretcher, or a block and tackle and a team of horses.
CONSTRUCTING THE CONCRETE SILO

While the concrete silo will not be built generally in this State, it can be recommended for the eastern portion of the State especially, for individual builders in other sections of the State that are so situated that sand and gravel can be had very cheaply, and for the man who desires a more permanent silo than wood affords.

Concrete Silo of Recent Development

Not more than 12 years ago it could have been said that the concrete silo was in the experimental stage. It has now been demonstrated by the success of numbers of concrete silos in different states, that concrete is one of the best building materials for the construction of permanent silos. Considering the fact that the general use of concrete has developed within the past few years, and that the majority of concrete silos have been built by men with little or no experience in concrete building, the success of this silo has been remarkable. In order to secure a first class concrete silo, it is necessary that good materials, well mixed, and in the proper proportions be used in preparing the concrete, and that the whole process of construction be given close attention. Of the several types of concrete silos now in use, the solid wall reinforced silo, the thin wall or metal lath plastered silo, and the concrete block silo are the most common types.

Advantages of Each Type

The solid wall reinforced silo has several points in its favor, among which are: the silo can be constructed without the use of skilled labor, thereby lessening the cost; there is little or no chance of error in erecting the walls; when complete, it represents a very durable type of silo. This type of silo is fireproof, vermin proof, will not blow over, and requires no repairs. Next to the solid wall silo from the standpoint of strength and economy, is the metal lath silo. This type has a wall three inches thick, and will prove cheaper, as a rule, where sand, gravel, and cement are expensive, although skilled labor is required in the construction and the chance for error
is greater than in the solid wall type of silo. The concrete block silo is more expensive than either of the other types and is difficult to reinforce properly. Its special advantages are the hollow wall, and more artistic appearance.
Cost

The chief factors in determining the cost of the concrete silo are: the availability of sand and gravel or rock; the kind of labor employed (contract or common), and the forms used in building. In general, the cost will range from $3.00 to $4.00 per ton capacity. By the use of home-made silo forms, and the employment of common labor, except a foreman who has a knowledge of handling concrete, a silo of this type can be constructed quite economically, considering its efficiency and durability.

Forms*

After determining the size and location of the silo, the next consideration will be the construction of the forms. The forms consist of two parts, circular in shape, one inside the other, the concrete being placed between them to form the wall. These forms are kept six inches apart by using 2x6 inch spacers, so that the silo walls, when complete, will be six inches in thickness. In silos 12 feet in diameter or less, a wall five inches thick is sufficient. The forms are three feet or more in height so that three feet of the silo wall can be built at one time without shifting forms. After the first three feet of concrete is in place, the forms are loosened by means of the adjusting bolts, raised, and again set. This operation is repeated until the silo walls are finished.

Inner Form

The inner form consists of a wooden supporting frame, which has an upper and a lower circle, with facing boards outside of and joining the circles; and around this frame is nailed sheet metal of 18 or 20 gauge. The supporting frame is made of 1x8 inch lumber. The circles of wood are made by cutting and nailing together segments cut to the circumference of the desired circles, using a diameter one and one-half inches

*The method given for the construction of forms and silo wall is that followed by the U. S. Dairy Division in the supervision of silo construction, where concrete silos are built.
less than the inside diameter of the proposed silo, which will allow for the thickness of the facing boards. The length of the segment is obtained by dividing the circumference of the wooden circles by 12, the number of segments used in circles of a diameter up to and including 14 feet. For silos of larger diameter, compute the length of segment by dividing the cir-
cumference of the circle by 16, the number of segments to be used. As the wooden circles are made by doubling the thickness of the segments, 48 or 64 segments will be required in all, depending on the diameter of the silo.

**TABLE III**

<table>
<thead>
<tr>
<th>Diameter of Silo</th>
<th>Radius of Circle</th>
<th>Length of Segment</th>
<th>No. of Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4 ft., 11 3/4 in.</td>
<td>2 ft., 7 5/16 in.</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>5 ft., 11 3/4 in.</td>
<td>3 ft., 1 5/8 in.</td>
<td>12</td>
</tr>
<tr>
<td>14</td>
<td>6 ft., 11 3/4 in.</td>
<td>3 ft., 8 in.</td>
<td>12</td>
</tr>
<tr>
<td>16</td>
<td>7 ft., 11 3/4 in.</td>
<td>3 ft., 2 5/8 in.</td>
<td>16</td>
</tr>
<tr>
<td>18</td>
<td>8 ft., 11 3/4 in.</td>
<td>3 ft., 9 3/8 in.</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>9 ft., 11 3/4 in.</td>
<td>3 ft., 11 3/16 in.</td>
<td>16</td>
</tr>
</tbody>
</table>

To cut the pattern segment, mark on a smooth floor the circle, and lay the segment on the circle so that the center point on the outer edge is on the circumscribed line. With the sweep that has been used to lay out the circle draw an arc on the segment in such a manner that it intersects the ends at equal distances from the outer edges. By the use of a straightedge from the center of the circle to the intersections at the ends of the segment, the lines can be drawn marking the end bevel of the segment. It is advisable to have the segments cut at a mill or shop, where a bandsaw can be used, thus saving time and avoiding mistakes. Two segments are then placed with ends together and with the curved edge on the described circle and on top of these is placed another segment, so that the center is directly over the junction of the lower segments, with the curved edges flush. Here it is nailed with sixpenny nails. The remainder of the
segments are placed in this manner and nailed, excepting two places on opposite sides of the circles, where, instead of nailing, carriage bolts 3-8x2 inches are used to join the upper and lower half segments. This plan is followed in order that the inner form may be taken apart in quarter sections and handled more conveniently, when building is completed, or when transporting the forms.

At two other places opposite each other, a section six inches in width should be sawed out of both circles, to allow for contracting the form, when it is to be raised. The ends of the sheet metal will lap at these places, and the lugs and adjusting bolts are here placed.

**Outer Form**

The sheet metal of which the outer form is made should not be lighter than 18 gauge for silos of 12 feet or less in diameter, and for silos larger than 12 feet in diameter, 16 gauge iron should be used. The outer form should be in two pieces of equal length. A straightedge should be used for lining up the metal sheets before marking for punching, otherwise the outer form will not set plumb, and a bulging outer wall will likely result. Angle-iron placed perpendicular, or lugs with an angle, may be used on the ends of each sheet, and holes should be drilled in the angle that will admit an adjusting bolt three-quarters of an inch in diameter. The lugs or angle-iron should be so placed that on one end of each sheet they are flush with the end, and on the other end of the sheet are placed back 12 inches to allow for the lap. Small lifting hooks should be placed near the top edge of the form, at the quarter sections.

![Fig. 9-b—MARKING SEGMENT](image-url)
Six adjusting bolts, 10½ inches in length, three-quarters of an inch in diameter, with five-inch right and left thread each, will be required to allow for expanding the form when it is to be raised, and contracting it after resetting.

Cost of Forms

If a few farmers cooperate in the construction of their silos, the cost of home-made forms will be proportionately very small, as a set of forms should be built for from $35.00 to $45.00. There are different types of commercial forms on the market, all of which cost in proportion to their convenience of operation, but these could be recommended only for a silo contractor, who would expect to use them repeatedly.

Door Forms

Continuous Door. The door form for the continuous door is built in sections of from eight to 12 feet in length, three sections being generally built where the silo extends more than 30 feet in height above the bottom of the door. Two pieces of full width 1x6 inches are used, with spacers 18 inches long between the pieces. The door form is notched one and a half inches deep at intervals of 22 inches, to admit the tie rods which join the perpendicular gas pipes on either side of the door, to which the wire reinforcement is tied. To the inside edge and outer side of the 1x6 pieces are nailed 2x2 strips, which form a rabild for the insertion of doors at silo filling time; a similar piece is also nailed on the bottom of

![Fig. 10—OUTSIDE FORM FOR BUILDING CONCRETE SILO](image-url)
the door forms. The door forms are set up between the wall forms when the wall has been built to the height of one to two feet above the ground level.

The Intermittent Door. Because of the simplicity in construction, and less chance for error, this type of door is preferred by many to the continuous door. In this type, a continuous course of the wall is built between each door, at distances of about two and one-half feet. The form for this type of door is a frame two feet in width by two and one-half feet in height, and has end pieces at both the top and bottom of the frame. A strip is nailed around the edges of the frame, which forms a rabild in the wall into which the door is placed when the silo is closed at filling time. In constructing the door form, it is cut tapering, with the wider side next to the inner form.

Excavation for Bottom of the Silo

In most cases, where the soil is firm, it is desirable and economical to have the silo proper extend from four to five feet below the ground level. This will insure protection from frost and increases the capacity of the silo at a minimum cost. In marking out the base, follow instructions given on page 7 (constructing the stave silo).

The excavation should have smooth perpendicular sides, and if the soil is not inclined to cave, the excavation should be six to eight inches greater than the diameter of the silo proper, when the earth wall may serve as the outer form for this height of the silo wall, requiring only the use of the inner form. If the soil is not firm, the diameter of the excavation should be one foot greater than the diameter of the proposed silo, and both the inner and the outer forms used from the start.

Footing

The trench for the footing should extend at least one foot below the base of the silo, 12 to 14 inches toward the center from the wall, and 6 to 10 inches under the wall. Upon completion the trench will then be 18 to 24 inches in width and 12 inches in depth. The footing should be reinforced
with wire in its construction, and on completion should be made perfectly level.

Preparing the Concrete

Amount of Cement. The amount of cement will vary with the kind and quality of coarse materials. The ideal proportions for silo walls are one part of cement to three parts of clean, sharp sand, and five parts of crushed rock or sharp gravel. Where ordinary pit run or river bank gravel is used, more cement is required, because of the larger proportion of sand and the fact that the sand and gravel are worn smoother, reducing the "holding" power. Where gravel alone is used, the mixture should be one to five, and with sand one to three and one-half.

Apparatus for Mixing. Among the essentials necessary is a tight mixing platform, ten feet wide and 14 to 16 feet long, with a two-inch strip bounding the outer edges to prevent the washing off of the cement. A measure should be used to secure the proper proportion of materials, since the shovel method of measurement leaves chance for error. A bottomless box, or barrel with side handles, makes a very good measure, and requires but slightly more time, while the accuracy of the work is made sure. The best shovels for handling concrete are those of the short handled, square nosed type. Water for mixing should be provided by whatever method is most convenient for keeping a supply ready when needed. All apparatus should be arranged as conveniently as possible, placing the mixing board and derrick near the silo, with the water tank near the mixing board. When hauling the sand and gravel, place these only far enough from the silo location to allow the mixing board to be placed between.

Mixing. The durability of concrete will be lessened unless care is given in mixing. The effects of careless mixing are easily noted in the appearance of particles of sand or rock not covered with cement. Hand mixing is usually practiced in building the home-made concrete silo, and can be done fully as well as power mixing. In preparing the concrete, the sand should first be measured, the cement added, and the mass turned until a uniform gray color results. This will require
turning three to four times—at least until the men become accustomed to handling concrete. The rock or gravel is then added, and the mass again turned and water added, when the mixture is again turned two to three times. Enough water should be used to make the mixture so plastic that it can easily be worked around the reinforcement.

**Precautions**

Make sure that the footing is sufficiently strong to carry the weight of the silo walls, and is level, before you begin the construction of the walls. A mixture of 1-3-5 does not mean a mixture of one to eight. The voids in the coarse material are but slightly more than filled when the sand and cement are added. When bank run material is used, the mixture should be tested by passing it over a quarter-inch screen, which will separate the sand and the gravel, allowing the proportions to be determined. A wide mixture is poor economy. Be sure that the material is clean. A test to determine whether sand is clean is to fill a two-quart glass jar with clear water and add sand to the depth of one-half inch. If the surface of the water shows considerable scum after the lapse of a few hours, the material should not be used unless washed. Thoroughly mix the cement and coarser materials. The concrete should be thoroughly tamped or spaded as it is placed in the forms.

**Erecting the Walls**

Upon completion of the footing and the floor, if a floor is constructed (refer to page 9), construction of the walls will begin. If excavation has been made as deep as the width of the forms, or deeper, the inner form should be placed on the footing and spaced equally distant from the earth wall all the way round. When the form is in place, sweep the footing space between the form and the excavation. Concrete may then be placed to the level of the form. No reinforcing is needed in this portion of the wall, excepting a few inches below the ground level.

**Reinforcement.** The reinforcement consists of hog-fencing or woven reinforcing wire, one-inch diameter gas pipe,
and three-fourths inch diameter rod iron for tie rods. The wire should be the same width as the forms, and in the first three courses above the ground level the wire should be doubled for silos exceeding 12 feet in diameter; for the bursting pressure on the silo wall will be far greater in the lower portion of the silo. The length of the wire will be determined from the outside diameter of the silo, as the wire is placed around the inner form and crowded to the outer form by the use of spacers 1x6 inches by three feet in length. Deduction should be made for the door, when the continuous door is used.

The one-inch diameter gas pipe is used on each side of the door form, parallel to the form and about two inches from the 1x6 pieces. The ends of the reinforcing wire are tied about these pipes, and the pipes are connected by the tie rods which conform to the circle of the silo wall and have an eye in each end, which is placed over the gas pipe. A common practice is to lay the door form on the ground, place the rods across the form, fitting them into the notches made in the door form, then placing the gas pipes by passing one end through the eyes of the tie rods until the lower end of the gas pipe is even with the bottom of the door frame. (Fig. 11.) The gas pipes are then fastened lightly, to hold them in place, and the door frame placed in position between the forms, after the silo wall has been built to the height at which it is desired to begin the door opening.

Scaffolding. The scaffolding for a silo not to exceed 12 feet in diameter, should consist of a center post of 4x4 inch material, with 2x6 quarter posts, set four or five inches from the inside of the silo form. The posts are most conveniently handled in lengths of 10 to 12 feet, or they may be long enough so that but two lengths will be required; for instance, two sets of posts each 16 feet in length, when a silo 30 feet in height is being built. At a height of six to eight feet above the top of the silo forms, cross arms of 2x4 should be placed for raising the forms. The length of these cross arms should be one foot more than the outside diameter of the silo. On the ends, which should be directly over the lifting hooks, are wired pulleys, through each of which is placed a one-fourth
inch rope, which will be used in raising the forms. In case of larger and heavier forms, four sets of block and tackle will be required, the double block being fastened to the cross arm and the single block to the lifting hook.

*Raising the Inner Form.* The inner form should always be raised first, to such a height that two inches of the lower part of the form remains lapped on the newly constructed wall. The inner form and working platform are supported by the use of 2x4 inch pieces, one end nailed to the center post, and the other end, extending below the silo form, nailed to a quarter post. These pieces should be leveled as they are put on, and the inner form then released and spread till in contact with the wall at all places. Short pieces of plank reaching from each quarter post to the next post will serve as a working platform.

*Raising Outer Form.* After the inner form has been raised and set, and the wire reinforcement placed, the outer form can be put in place and tightened about the spacers. When the outer form is being set, care should be taken to place it so that the lifting hooks will be in line with the
lifting hooks on the inner form. When the form is to be raised, first fasten the rope or lower pulley in the lifting hooks, then loosen the adjusting bolts so that the form can be easily raised, and raise to the height of the inner form and tighten the adjusting bolts.

**Hoisting Concrete.** The common method of hoisting the concrete is by the use of a gin pole, which is set about four and one-half feet from the base of the silo. A projecting arm of 2x6, five feet in length, should be fastened to the top of the pole and braced, and a one-inch pulley fastened to the end of the arm. The pole should be hoisted and guyed with the arm reaching over the silo wall. After the silo has reached a height of 10 feet a horse can be employed to advantage in hoisting the concrete, using a small carrying platform on which three buckets of concrete may be placed, or a wheelbarrow may be used instead. Where a small silo is being built, one of the cross arms may serve for hoisting the concrete.

**Chute Attachment and Construction**

Pieces of gas pipe, one-half inch in diameter, six inches in length, should be laid horizontally in the concrete, two inches from the gas pipes on either side of the door. These are placed in alternate courses of concrete and should be kept in line. When each course of concrete is completed and the forms raised, the pieces of pipe should be located and the ends opened, if concrete has lodged in them. When the silo is completed, seven-sixteenth inch bolts, eight inches in length, will be placed through these pieces of pipe, on which to bolt perpendicular pieces of 2x6, to which the remaining framework for the silo chute will be nailed.

The remaining part of the chute construction will depend on the barn construction. A window should be placed in the chute above the height of the comb of the barn.

**Roof Construction**

When the silo wall is almost complete, bolts 12 inches in length and one-half inch in diameter should be pushed down into the concrete, at intervals of four feet around the entire top of the silo, so that three inches of the bolts remain above
the concrete surface. The plate, which should be made of 2x6 pieces cleated together, with holes bored to admit these bolts, should be laid out on the ground, and the pieces put together on top and fastened to the top silo wall by nuts on the ends of the bolts. It is advisable to put on the plate before removing the inner form, as the liability of breaking off portions of the newly made wall is lessened. For silos not exceeding 14 feet in diameter, eight rafters should be cut from 2x4's. If an octagonal peak, made from a piece of 6x6 is used, the rafters may be cut uniform in length, making allowance on pattern rafter for one-half the thickness of the peak. The roof should be one-third pitch.

**Removal of Forms**

The outer form can be removed by loosening it and lowering it to the ground by the use of the pulleys and ropes. The inner form will be taken apart into sections, first dividing the form at the opposite sides, where the adjusting bolts are used; then at the opposite sides where the wooden circles were joined by use of carriage bolts. The form will now be in four sections, and one section at a time can be raised over the top of the silo wall, and lowered to the ground.

**Doors**

Doors for closing the silo can be made of 2x12 inch material, tongue and grooved; each door piece will be 24 inches in length, the distance across the door space, including the depth of the rabilds. The doors are put in place while the silo is being filled, and it is advisable to place a piece of tar paper perpendicularly in the rabilds, that the ends of the doors may be made air tight. The pressure of the silage will hold the door in place, and no fastening is necessary.

*Fig. 12—Door form, showing placing of gas pipes and tie rods as a part of the reinforcement*
Wall Finish

As the wall is built, slight rough spots are sometimes left, due to the concrete sticking to the forms. These can be made smooth by applying a coat of cement mortar, made of one part of cement and one part of fine sand, mixed with water to a creamy consistency, and applying with a whitewash brush. A coat of this mixture may be applied to the entire inner wall, which will close all pores and make the wall waterproof. The same results can be gotten by applying tar pitch, No. 7 soft, and while the tar is not so convenient to apply as the cement wash, the result is more lasting. The tar should be melted and applied while hot. A swab made from old sacks is very satisfactory for applying the tar.

There are a number of patented waterproofing compounds on the market, but, as a rule, their cost does not justify their purchase. The only point in their favor is convenience in applying, as they are sold ready for application. The wall finish should be applied as soon as construction is complete, after which the scaffolding may be taken down.

Bills of Materials

Bills of materials have been omitted from this bulletin, since it is impossible to include such as will cover the various sized silos that may be constructed without using a great amount of space. To those who make request, however, a complete bill of materials will be sent, together with such other information, not covered in this bulletin, as may be desired.

Silo Filling

Crew Required. The amount of help required at silo filling time will be determined by the capacity of the silage cutter, the distance to haul the corn, the size of the loads hauled, and other factors. As a rule, four to six men with teams will be required, and four to six additional men. The greatest economy in filling is secured when there is just force enough to keep the cutter running at full capacity.

Cutting Corn. The corn may be cut for the silo either by hand or by the use of the corn binder. The latter method is
preferable, and where the amount of silage put up each year does not justify the purchase of a machine by the individual, two or more farmers should purchase one in partnership. In using the corn binder, it will be found best to make the bundles rather small because of the ease in handling and in feeding into the silage cutter. One man with three horses should be able to cut six to eight acres per day. He should not cut faster, however, than the wagons can haul the corn to the cutter.

**Hauling the Corn.** The hauling should be done with low wheeled wagons; or a low down rack can be easily made by the use of two 4x6-inch pieces 18 or 20 feet long bolted together at one end to form a V, this end being suspended from the front axle by the use of a long kingbolt. The other ends are attached below the hind axle by U shaped clevises. End boards, built four feet high and flaring, will protect the wheels. The loads should be as large as possible or the expense is unnecessarily high.

**Silage Cutter.** In the purchase of a cutter, the considerations are: capacity of the machine, the amount of work to be done, and the power available. The power required will depend on the size of the machine and the kind of elevator used. The blower is more satisfactory than the carrier because of the difficulty in setting up the carrier, and the waste when used. The blower pipe should be as nearly perpendicular as possible in order to eliminate friction on the pipe and prevent clogging. As a rule one horsepower is required for each inch of length in the cutting cylinder for gasoline power, and at least two-thirds the same for steam power.

**Length to Cut.** As a rule the cutter should be set to cut lengths of from one-half to three-quarters of an inch. The finer the cut, the more solidly can the corn be packed into the silo. Cutting the corn finer reduces the capacity of the machine or requires an increase of power.

**Packing the Silage.** It is very important that the silage be thoroughly packed, in order to exclude the air. It is especially important that the silage around the walls be closely
packed, as this is where the air usually enters and where the silage spoils. While the silo is being filled, at least one man, and preferably two, should work in the silo, placing and packing the silage. The silage should be kept higher around the walls than at the center and should be constantly tramped about the walls. The silage in the center will pack itself.

**Distributing Silage.** The best results in evenly distributing the silage are obtained from the use of a distributing pipe which attaches to the end of the blower pipe. Uniform distribution is necessary for uniform packing and settling, which are essential to the preservation of the silage.

**Adding Water to Dry Corn.** If the corn has become very dry from being frosted or from getting over ripe, water should be added, as the silage goes into the silo. This is very effectively done by tapping the blower pipe at the base and inserting a half-inch hose, allowing a constant stream of water to enter the pipe.

**Covering Surface.** If feeding begins immediately after the silo is filled, surface spoilage is prevented; but usually feeding does not begin for a few weeks, and when such is the case, straw, chaff, or hay may be run through the cutter and thoroughly packed on the top surface, thus preventing spoilage. Oats are sometimes sown on the surface, which, as soon as sprouted, form a sod which excludes the air.
SILAGE FEEDING

By R. R. Graves

Silage is preeminently a feed for the dairy cow. While its use as a feed for beef cattle, for sheep, and, to a limited extent, for horses, is rapidly increasing, it has always been more widely used as a feed for dairy cattle than for any other class of stock. The dairy farm of today is not complete without a silo.

Silage, because of its palatability, succulence, low cost, as compared with other feeds, and its availability to supplement any feed or crop at any period of the year, or in any kind of season, is well adapted as a feed for the dairy cow.

Reasons why you should have silage:

1. Every ration needs some succulent feed.
2. Corn silage is probably the cheapest succulent feed that can be had.
3. A ton of corn silage contains more food nutrients than a ton of roots or kale.
4. An acre of corn can be placed in the silo at less cost than an acre of roots or kale can be harvested.
5. The crop is never too wet to put into the silo. Silage can be made in weather that could not be utilized in making or curing hay.
6. Many crops, especially in western Oregon, will be saved and utilized for feed, that would otherwise be a total loss on account of unfavorable weather for curing.
7. More feed can be stored in a given space than in the form of hay or fodder.
8. A well filled silo is a guarantee against shrinkage of milk when the pastures dry up.
9. Silage can be used for supplementing pastures more economically than can soiling crops; because silage is not only more palatable, but requires less labor.
10. When silage is the basis of the ration, more stock can be kept on a given area of land.
11. Silage is very palatable and has a beneficial effect on the digestive organs.
12. With the silo full, a good palatable feed is always at hand, no matter what the weather is, nor how busy the teams and men are in the field.
Silage vs. Other Sources of Succulence

The relative value of roots, kale, and silage, the usual sources of succulence for winter feeding, depends upon their composition, comparative feeding values, cost of production and yield, keeping qualities, and convenience in feeding.

Composition. The following figures, showing the digestible nutrients in 100 pounds, and the total digestible nutrients in one ton, of silage, roots, and kale, are taken from Henry's Feeds and Feeding, with the exception of those for kale, which are the result of analyses at this Station:

<table>
<thead>
<tr>
<th>Succulent Feeds</th>
<th>Dry Matter in 100 Lbs.</th>
<th>Crude Protein</th>
<th>Carbohydrates</th>
<th>Fat Nutritive Ratio</th>
<th>Total Digestible Nutrients in 1 ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Silage</td>
<td>26.40</td>
<td>1.40</td>
<td>14.20</td>
<td>0.70</td>
<td>1.11.3</td>
</tr>
<tr>
<td>Red Clover Silage</td>
<td>25.00</td>
<td>1.50</td>
<td>9.30</td>
<td>0.50</td>
<td>1.06.9</td>
</tr>
<tr>
<td>Apple Pomace Silage</td>
<td>15.00</td>
<td>0.70</td>
<td>9.60</td>
<td>0.50</td>
<td>1.15.3</td>
</tr>
<tr>
<td>Mangel</td>
<td>9.10</td>
<td>1.00</td>
<td>5.50</td>
<td>0.20</td>
<td>1.05.9</td>
</tr>
<tr>
<td>Sugar Beet</td>
<td>13.50</td>
<td>1.30</td>
<td>9.80</td>
<td>0.10</td>
<td>1.08.5</td>
</tr>
<tr>
<td>Rutabaga</td>
<td>11.40</td>
<td>1.00</td>
<td>8.10</td>
<td>0.20</td>
<td>1.08.5</td>
</tr>
<tr>
<td>Carrot</td>
<td>11.40</td>
<td>0.80</td>
<td>7.70</td>
<td>0.30</td>
<td>1.06.9</td>
</tr>
<tr>
<td>Kale</td>
<td>7.68</td>
<td>1.83</td>
<td>4.68</td>
<td>0.35</td>
<td>1.02.8</td>
</tr>
<tr>
<td>Parsnip</td>
<td>11.70</td>
<td>1.10</td>
<td>10.10</td>
<td>0.20</td>
<td>1.09.6</td>
</tr>
<tr>
<td>Artichoke</td>
<td>20.50</td>
<td>1.30</td>
<td>14.70</td>
<td>0.20</td>
<td>1.11.7</td>
</tr>
<tr>
<td>Turnip</td>
<td>9.50</td>
<td>0.90</td>
<td>6.40</td>
<td>0.10</td>
<td>1.07.3</td>
</tr>
</tbody>
</table>

It will be observed that the corn and clover silage contain the greatest percentage of dry matter, while the kale, mangels, and turnips contain more than 90% water. The corn silage and artichokes contain the greatest amount of carbohydrates, and with the apple pomace have the widest nutritive ratios. The kale contains the greatest amount of protein, and on account of its very low carbohydrate value, has a very narrow nutritive ratio. Corn silage contains the greatest amount of digestible nutrients per ton, with the artichoke ranking next. Kale, mangels, and turnips have the smallest amounts of total digestible nutrients per ton. All of these succulent feeds contain large amounts of water, and consequently are very bulky; for this reason they should always be fed with feeds that are richer in dry matter.

Comparative Feeding Values of Succulent Feeds. Comparing the total digestible nutrients contained in one ton of the various feeds as shown in Table I, we find that:

1 ton of corn silage is equal to 1.0 ton of artichokes.
1 ton of corn silage is equal to 1.4 tons of parsnips.
1 ton of corn silage is equal to 1.5 tons of sugar beets.
1 ton of corn silage is equal to 1.8 tons of rutabagas.  
1 ton of corn silage is equal to 1.8 tons of carrots.  
1 ton of corn silage is equal to 2.2 tons of turnips.  
1 ton of corn silage is equal to 2.4 tons of mangels.  
1 ton of corn silage is equal to 2.3 tons of kale.

All of these feeds are succulent, and all are relished by cattle. The computations comparing them are based only on the composition of the various feeds, and do not take into consideration the palatableness or the stimulation on milk secretion that any of these feeds might exert.

Cost of Production and Yield. The following table, showing the cost of production, is compiled from figures submitted by dairymen in the Willamette Valley and by the Agronomy Department of the Oregon Agricultural College:

| TABLE II.—Cost of Production of One Acre of Succulent Crops in Western Oregon |
|-----------------------------------|---------------------------------|---------------------------------|
|                                    | Kale                            | Roots                          | Corn Silage                    |
| Value of manure, at $1.00 per load | $12.00                          | $12.00                         | $6.00                          |
| Applying manure, at 30c per load   | 3.60                            | 3.60                           | 1.80                           |
| Double disking                     | .75                             | .75                            | .75                            |
| Plowing                            | 2.00                            | 2.00                           | 2.00                           |
| Preparation of seed bed            | 1.40                            | 1.40                           | 1.00                           |
| Seed                               | .25                             | 1.20                           | .50                            |
| Planting                           | 5.00                            | 5.00                           | .50                            |
| Cultivation                        | 2.00                            | 7.00                           | 2.00                           |
| Harvest—(corn in silo)             | 17.50                           | 16.00                          | 10.00                          |
| Depreciation and interest on machinery and storage | .60 | .60 | 3.75 |
|                                    |                                  |                                |                                |
| Average yield per acre (tons)      | 25                              | 20                             | 10                             |
| Cost per ton                       | $1.80                           | $2.20                          | $2.83                          |
| Average yield per acre digestible nutrients (pounds) | 3480 | 3440 | 3260 |
| Cost per hundred pounds digestible nutrients | $1.30 | $1.38 | $0.86 |

The above table shows the cost of preparing the seed bed, seeding, harvesting, and interest and depreciation on machinery, and storage to be as follows: for one acre of kale, $45.10; for one acre of roots, $44.05; and for one acre of corn, $28.30. The cost per ton of the kale is least, and that of the corn silage is greatest, but the cost per hundred pounds of digestible nutrients in the kale is 51 per cent more, and in the roots, 47 per cent more, than in the corn silage.

Based on these averages for yield, the roots and kale yield slightly more digestible nutrients per acre than the corn for silage. The digestible nutrients given for the roots are an average of the digestible nutrients of mangels, rutabagas, and carrots, the root crops most used in western Oregon.
**Keeping Qualities.** When preserved in an efficient silo, corn silage will keep for years without deterioration. If the silage is not all used during the winter, what is left below the spoiled portion on the surface will be just as palatable to feed, when the pastures get short during the summer, or during the following winter. Most root crops, harvested in the fall, will not keep in good condition for feeding after May 1, while kale gets very strong and fibrous and becomes undesirable for feeding early in April.

**Convenience in Feeding.** The silo is usually built to open into the feed room, or at some other point accessible from the barn, and where a silage truck is used, there is very little labor involved in securing and feeding the silage. Roots require cutting before feeding, and kale is perhaps the most inconvenient to feed of all, since it must be brought fresh from the field every few days, no matter what the weather is.

In these three crops there is probably not a great difference in the total yield of digestible nutrients. All three are very palatable to cattle. But the digestible nutrients in corn silage can be produced cheaper than those in the roots or kale. The silage has better keeping qualities, moreover, and is in a more convenient form to feed.

For a long time, the idea prevailed that corn could not be grown in this State, thus retarding the development of silage feeding. Now, it is not unusual for yields of from 12 to 14 tons of corn to the acre to be raised. Another factor that has retarded the general use of silage has been misinformation regarding the value of silage in the ration. The question is frequently asked, "Do we need silage when we have kale or roots?" Both kale and roots are valuable feeds. Roots are an especially valuable feed for dairy cattle, and every breeder who is doing Advanced Register work should have some roots on hand. In the coast counties, clover and oats and vetch are likely to become the principal silage crops, and in this case roots should continue to be used to some extent. In other parts of the State, it is more feasible to grow corn for silage than to use roots, because silage is more economical to produce, and because it may be had for summer feeding.
Corn silage and kale are very different in composition. The corn silage is rich in carbohydrates, and the kale contains a larger percentage of protein. On this account, they may be fed together with good results. Silage should not replace the kale altogether. It would seem advisable to have some kale even where silage is relied on for the greater part of the succulent feed. As stated before, the digestible nutrients in silage can be produced a great deal cheaper than in kale. Another advantage of silage is the fact that in this climate it will seldom be very cold when fed, while the kale is frequently fed when very cold and frosty, thus necessitating the expenditure of considerable energy on the part of the cow to warm it, besides retarding the functions of digestion and milk secretion.

In Oregon, many of the farm grown feeds, such as clover, vetch, alfalfa, and oats, are rich in protein, and, consequently, unless barley is fed, the home grown ration is likely to be deficient in carbohydrates and fat.

Corn silage, being rich in carbohydrates, in addition to being a succulent feed, will enable us to have a balanced ration from home grown feeds.

One of the greatest advantages of the silage over the roots and kale lies in the fact that what is left over from one feeding period can be preserved with very little loss until needed. Silage is invaluable as a feed with which to supplement pasture.

Where the herd contains less than ten cows, however, there is no question but that it is more economical to depend on roots or kale for succulent feed than on silage. The investment in the silo and the silage cutting machinery will offset the more economical production of the silage for a herd of this size.

**Crops for the Silo**

*Corn.* Corn is the principal silage crop; first, because it will produce more food materials to the acre than other crops; second, because corn is easier to harvest and put into the silo than such crops as clover, oats and vetch, and oats and peas; third, because corn makes a cleaner flavored, more palatable silage than other crops; and, fourth, because corn packs well
and contains the right amount of sugar to produce the proper amount of acid for the best preservation and for the best quality of silage.

The best variety of corn to use is that which will mature and yield the largest amount of grain to the acre, since the grain is the most valuable part of the corn plant, containing approximately 63 per cent of the digestible nutrients.

Corn should preferably be cut for silage when the kernels are past the milk stage and are glazed and dented, and when the lower leaves of the plant are turning brown. Besides making a sour, more acid silage, immature corn is not as nutritious as more mature corn. The New York Experiment Station found that corn in the silk stage contained 90 per cent more dry matter than when in the tasseled stage; 30 per cent more in the milk stage than in the silked stage, and 55 per cent more in the glazed stage than in the milk stage. Immature corn is poor feed, whether fed green or put in the silo.

When corn is frosted before it has reached the desirable stage of maturity, it should be put in the silo at once. If it is left standing in the field for any length of time after frostimg, water should be added to replace that lost by evaporation. The cut corn in the silo should feel moist to the touch. Very dry corn put into the silo without adding water is likely to mold or “fire-fang.”

*Sorghum.* Sorghum probably ranks next to corn as a silage crop. Sorghum silage is more acid, however, and not so palatable as corn silage.

*Clover, Vetch and Field Peas.* Where possible, it is advisable to cure legumes for hay, and grow corn for silage. It often happens in western Oregon, however, that the weather conditions are unfavorable for curing hay at the time when the crop is ready to cut. In this case, the crop may be put into the silo, and if it has been cut at the right stage, and is given a particularly thorough packing as silage, a very palatable feed will result. Owing to the high protein content of legume silage, such silage is difficult to keep. This difficulty can be largely overcome by adding to the legume some carbonaceous crop, such as rye, which contains sufficient sugar to afford the production of enough acid to prevent the protein
content of the legume from decaying. The rye should be mixed with the legume in the proportion of two-thirds legume and one-third rye. In this way, rye may be sown for fall and spring pasture, cut for silage and the ground plowed and used for some other crop. When clover or vetch is put into the silo, it should be cut at the same time as for making hay—when the clover is in full bloom and part of the heads are dead. It should be run through the cutter in order that it may be more thoroughly packed and more easily removed for feeding.

*Kale.* The latter part of the winter, kale gets very strong for feeding and that left after the early part of March is not relished by cattle. If eaten at this time, it is likely to taint the milk.

At the College this spring, eight tons of kale and two tons of mixed hay were run through the cutter and thoroughly packed in the silo. The resulting silage was very palatable to the cattle. Kale is not well adapted for a silage crop, however, on account of its high water content, and should only be put in the silo to avoid a loss in the spring.

*The Chemical Changes in Silage*

Soon after green corn is stored in the silo, fermentation starts and the temperature of the mass rises to a temperature of from 65° F. to as high as 125° F. The higher temperature is found only near the surface. Where the silage is properly packed and all air is excluded, the temperature rarely goes above 85° F. This is the most favorable temperature for rapid fermentation, which stops the growth of undesirable bacteria. As a result of this fermentation, the sugar in the corn is changed into acids and some alcohol. The acids formed are chiefly lactic and acetic. Lactic acid is found in sour milk and acetic acid in vinegar. The acetic acid is of a volatile nature, and it is the evaporation of this acid that gives the silage its pungent odor. The production of these acids lasts from two to four weeks.

The chief function of these acids is that of a preservative. The acids prevent the growth of putrefactive bacteria, which would cause the silage to decay. The acid destroying and
putrefactive bacteria require the presence of air. Hence, it is necessary to keep air from the silage. Silage that is kept air tight will keep indefinitely. Cases are known where silage has kept in good condition for five and six years. The exclusion of air can be obtained only by packing the silage very tightly in a silo with air tight walls.

When legumes, such as alfalfa, clover, vetch and peas, are put into the silo, they should be ensiled with some such crop as corn, rye, or oats. The legumes alone do not contain enough sugar to afford the production of sufficient acid to prevent the high protein content of the legume from decaying. The corn, rye, or oats, mixed with the legumes, would provide sugar for the production of sufficient acid to preserve both plants.

These silage acids not only preserve the silage, but probably partly digest the cellulose or fiber of the cell walls, causing the texture of the silage to become softer and rendering it more easily digested by the animal.

The acids of the silage act as an appetizer and a tonic, thus helping to keep the digestive tract healthy. This, together with the succulent nature of the silage, keeps the animal's bowels open and tends to give the animal a glossy coat and a pliant skin, such as the animal has when on good pasture, indicating that it is in the proper condition to make the maximum returns from its feed. In fact, silage lends to our winter ration that indefinable property which causes cattle to be at their best when on good pasture.

Feeding Silage

The silage may be fed as soon as the filling is completed, though at this time the corn has not fermented and has not the characteristics of silage. It is quite safe to feed, however, and if feeding is started immediately, there is no loss on account of spoiling. If feeding is not started at once, there will be a spoiled layer at the top, which, of course, should not be fed. From an inch and a half to two inches of silage should be removed from the surface each day after feeding has started, to prevent spoiling.
While silage is an excellent food, it is not a complete ration, since it contains a high percentage of water, is very bulky, and rarely contains protein, carbohydrates, and fat in the proper proportions. When corn silage is fed with a good leguminous hay, it forms a ration containing the proper proportions of food constituents for maintaining animals and for the growth of young stock. For a cow giving a good flow of milk, silage and hay alone would be so bulky that she would be unable to consume enough to supply the nutrients required for the secretion of a large amount of milk, and consequently she would lose in weight and her milk flow would soon drop to a lower level. For this reason, cows in milk should receive, in addition to the silage and hay, some more concentrated feed in the form of grain.

Silage is usually fed at the rate of from 30 to 40 pounds per day, depending upon the size and capacity of the cow. It is a good plan to feed the cow all of the roughage she will clean up well. Under average conditions, three pounds of silage are equal to one pound of hay, or, 15 pounds of silage would replace five pounds of hay.

A full feed of silage, together with a leguminous hay, is an excellent ration for the dry cow, and she will make some gain on this ration. If very thin, however, she should receive some grain in addition. The cow should be in good flesh when she freshens, if she is to do her best.

A ration of corn silage, and of clover, vetch, or alfalfa hay, is a splendid ration to keep the heifer in a thrifty, vigorous, growing condition, something that the Oregon farmer is inclined to neglect. Too many heifers in this State have to rough it through the winters, depending on a straw stack and a little washy grass for a living. Such care does not tend to develop heifers into profitable dairy cows. Calves may be fed some silage when from three to four months old.

During the months of July, August, and part of September, pastures often get very dry and short. If the cow that freshened in the spring is not given some additional feed at this time, she is very likely to shrink in her milk flow and no matter how well she may be fed later, she is not
likely to return to her former level. There is no better feed for supplementing pasture than silage, and the dairyman with a full silo will bring his cows over this period without any serious decrease in the yield.

The summer silo is growing in favor, and in many ways has advantages over the soiling system. As soiling is now practiced, a carefully planned rotation is necessary in order to have green feed always on hand. The acreage of each crop must necessarily be small, and frequent plantings at intervals of from 10 days to two weeks must be made. If a large field were planted and soiling was started at the proper time to get the maximum yield of food constituents and the greatest palatability, the greater part of the crop would soon be beyond this stage, as only a small part would be cut each day. By putting the crop in the silo, all could be cut at the proper stage of maturity, and all at the same time. This would do away with the daily chore of cutting small amounts.

The paramount question with the cow is plenty of good feed. The silo helps to solve the question. Silage is a cheap, palatable feed, relished by the cow, a feed that helps out the pasture, and cuts down the hay and grain bill.