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Silos and Silage

E. W. Sheets

G. L. Oliver

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DEPARTMENT OF ANIMAL INDUSTRY

SILOS AND SILAGE

A Good Silo Makes a Modern Cattle Feeding Shed Complete.

BY

E. W. Sheets and G. L. Oliver

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Silos and Silage

By E. W. SHEETS.

INTRODUCTION.

For many years the silo has been successfully used on large beef and dairy cattle farms for the storage of the corn crop for feeding purposes during the winter months. Not until recent years, however, has the need for a silo become so apparent on small farms carrying from ten to twenty-five or more mature cattle or their equivalent. Evidence that the silo is essential to the economical production of milk, beef, and mutton is obtained from the results of experiments carried on at different experiment stations and from the thousands of livestock farmers who have changed from the old to the new method of storing and feeding their corn crops.

ADVANTAGES OF SILAGE.

Utilizes Entire Corn Plant. One of the many reasons why the silo is of interest to West Virginia farmers is because hay has become so high in price that corn stalks are too valuable to lose. When harvested for silage the entire corn plant is taken from the field at a time when it contains approximately its greatest food value, and is preserved in as nearly the green state as possible. Analyses show that fully 37 percent of the digestible nutrients of the corn plant remains in the plant after removing the ear*, and when preserved and fed as dry stover or fodder at least one-half of this amount, or 20 percent of the entire food value of the corn plant, is lost by leaching and stalks not consumed by animals. The percentage of loss is even greater where shock corn or corn stover is fed to young cattle or sheep. Good silage properly fed is practically all consumed, thus eliminating the usual waste.

Provides a Succulent Feed. Silage is the cheapest and most palatable form in which a succulent feed can be provided for winter use. West Virginia is noted for its large acreage of bluegrass pasture. All kinds of livestock thrive upon it during the summer months. Silage, being a succulent

*Pennsylvania State College, First Annual Report.

roughage, in a large measure serves the same purpose in the winter ration that bluegrass pasture does in the summer ration.

Is Valuable as a Summer Feed. In many sections of the state there is urgent need for silage to tide stock over the dry season of August and September, when pastures become dry and parched.

Fig. 1.—Home-made Stave Silo.

By the use of silage, animals can be fed until the first of June instead of the first of May, and by beginning to feed in the middle of September instead of at the first of November it is evident that pastures would be greatly benefited and in a few years could carry much more livestock than they can at the present time.

Allows Use of Cheap Concentrates and Roughages. Silage is a succulent roughage and as such permits the use of cottonseed meal, which at the present time is the cheapest source of protein. Owing to the physical effect upon the animal and the inconvenience in feeding, cottonseed meal cannot be so successfully fed alone with any of the other roughages.

Owing to the nature and feeding value of silage, cheap roughages can be profitably fed with it to wintering animals. It has been found that wheat straw and cottonseed meal, when fed with silage, are superior to timothy hay fed with silage for wintering steers*. The cost of the ration is materially reduced by feeding silage to all classes of livestock. This reduction is due to its low cost, nutritive value, and beneficial effects upon the utilization of the remainder of the ration fed.

Is a Comparatively Cheap Feed. The claim is generally made that silage is a cheap feed. This, however, depends primarily on who compiles the figures. The agronomy department of a certain institution recently gave out figures

*West Virginia Agricultural Experiment Station, unpublished data.

showing the profits that could be derived from growing silage at $6.00 to $7.00 per ton. The department of dairy husbandry of the same institution had made calculations showing the profits to be derived from dairying, silage being valued at $2.50 per ton.

The principal factors which usually control the cost per ton of silage are: first, cost of raising the crop; second, cost of putting the crop into the silo; and third, yield per acre of the crop. All of these factors are considerably influenced by the personal capacity of the farmer, so that various costs are reported under very similar conditions. Figures compiled by the department of farm management* show that the cost of producing silage in different parts of the state varies from $23.43 to $35.60 per acre, while the yields vary from 10 to 10.3 tons per acre. The cost of producing timothy or mixed hay varies from $7.04 to $8.35 per acre, with a yield of 1.2 to 1.3 tons. Table I gives the average yield of silage and mixed hay, and the average cost of growing and harvesting the crops.

TABLE I.—Comparative Yield and Cost of Hay and Silage.

Average cost per acre to grow and harvest		Average cost per ton to grow and harvest	
Silage	Hay	Silage, yield per acre 10.15 tons	Hay, yield per acre 1.25 tons
$29.51	$7.70	$2.91	$6.16

One ton of mixed hay is equal in feeding value to three tons of silage. It is evident that while silage is a comparatively cheap feed, its greatest value is that it reduces to one-third the crop land necessary to feed or winter a given number of animals. The silo thus makes it possible, on the average, to put one-third of the present crop land in corn, one-third in soybeans or other crop for roughage, and to seed the other third of the roughest land now cultivated to permanent pasture, and at the same time to greatly increase the number of animals that can be wintered. By using only the more desirable land for crops and by carefully saving and applying the manure from the animals, the yield yer acre of forage can be greatly increased.

More Livestock Can be Kept. The silo makes it possible to put West Virginia agriculture on a sounder financial basis. Reports compiled by the West Virginia Agricultural Experiment Station* show that, on the average, the farms of the

*West Virginia Agricultural Experiment Station, unpublished data.

state which yield the largest incomes are those that maintain a relatively large number of livestock. It is evident, however, that there are many farms in the state where more livestock is needed, and the silo makes the keeping of more livestock possible.

ESSENTIAL FEATURES OF A GOOD SILO.

After deciding to build a silo, the question which puzzles many people is, "What type of silo should I build?" There probably is no one type of silo which is equally well adapted to local conditions in all sections of the state. The factors which usually determine the type of silo to be constructed on any farm are: initial cost, availability of material, durability, and ease and quickness of construction. Since all of these factors must necessarily be considered in each individual case it is impossible to recommend any one type of silo which will suit all conditions. There are, however, some features in the construction of all silos without which silage will not keep in perfect condition or otherwise be satisfactory. These should be considered before deciding to build any one type.

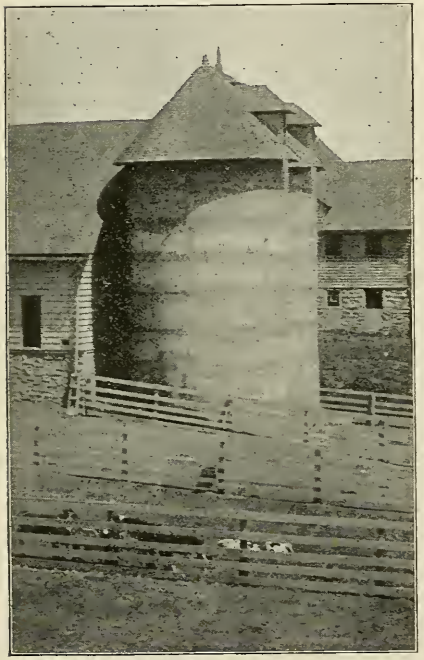

Fig. 2.—Home-made Concrete Silo.

Cost. The silo which will give the most and best service for the least money is, as a rule, the kind to build. While first cost is usually considered along with the cost of upkeep and the period of usefulness, there are no doubt cases where initial cost will be the deciding factor. In such cases it would seem to be the best policy to build a silo with the least possible outlay of money, even though its period of usefulness were comparatively short. In many instances it has been possible for individuals to build a silo of the home-made type where the construction of a more costly type was practically impossible.

Efficiency. There is one fundamental principle which must be observed in silage making. The green corn must be preserved in a form that will exclude all air. The silo with a wall most nearly airtight will keep silage best. It has been proved that practically airtight walls can be constructed from a variety of materials. The juice of the green corn or the water added aids in this exclusion of air and so the wall should be constructed in such a way as to make it not only airtight but also watertight. If the wall is constructed of materials which absorb large quantities of moisture from the silage it will allow mold to develop around it. Walls of concrete or plastered silos are oftentimes objectionable for this reason, unless treated with a cement wash, coal tar, or other preparation.

Durability. The wall should not only be efficient in keeping silage but should be durable. Any material used in the construction of a silo is expensive, so that the material which will last over the longest period of years and give satisfaction, when permanency is desired, will be cheapest in the end, even though the first cost will be slightly greater.

Convenience. The above-ground type of silo is more convenient than the below-ground type. It is much easier to throw silage down than to draw it up. The continuous door is also more convenient that the intermittent door, since the opening is always nearer the level of the silage. It is not desirable, as a rule, to go more than two or three feet below ground or to extend more than 18 feet in diameter, for convenience.

Attractiveness. Any properly constructed silo adds to the attractiveness of a farm and enhances its value. Like other farm buildings, if improperly or poorly constructed, it soon becomes dilapidated, is an eye-sore and a sign of shiftlessness, and shows poor judgment on the part of the owner. On the other hand, a silo which will be attractive and remain so with the least possible expense and effort is one that will be a thing of beauty and a satisfaction to its owner.

Shape. The only shape of silo to be recommended is a round one, this form being cheapest, most durable, and satisfactory for keeping the silage. The wall should be perpendicular and smooth on the inside so that silage will not adhere to it, and in order to permit even settling and packing without leaving air pockets in the outer edge of the silage.

Floor. A cement floor in a silo is not necessary under ordinary clay soil conditions, in fact it is not desirable. Where there is danger of seepage into the silo, or where the soil is very gravelly or sandy so that the drainage from the silo will be very rapid, it is always desirable to lay a floor.

Roof. A roof is not essential. It adds greatly, however, to the looks of the silo, giving it a more finished appearance. A roof probably helps to decrease freezing and adds to the comfort of the feeder during stormy weather.

Chute. A chute is necessary to prevent waste of silage in throwing it from the top of the silo. It also adds greatly to the convenience in feeding when the silo is near the barn, as it should be in most cases.

DIMENSIONS OF SILO TO BUILD.

Diameter. The inquiry is often made, "What size silo should I build?" The diameter depends upon the number and class of animals to be fed. To keep silage perfectly fresh, two to three inches should be removed daily from the entire surface during warm weather, and from one to two inches during cold weather. The depth of silage to be removed daily, however, will depend very largely upon the care used in taking the silage out. The surface in all cases should be left smooth, firm, and level. It is not considered practical to build a silo for less than 10 to 12 head of mature cattle, or their equivalent, as the amount which will be removed daily is too small to keep the silage in perfect condition. A mistake frequently made and a common cause of poor silage is building a silo too large in diameter for the number of livestock fed.

Fig. 3.—Patent Stave Silo.

The following table shows the number of animals that may be fed from silos of various diameters by removing an average of two inches per day when various quantities are fed:

TABLE II.—Relation of Herd to Diameter of Silo.

Diameter	Pounds Removed Daily	Number of Animals Fed Various Quantities per Head per Day						
		35 lbs.	30 lbs.	25 lbs.	20 lbs.	15 lbs.	10 lbs.	5 lbs.
8	320	9	10	12	16	21	32	64
10	523	15	17	21	26	35	52	105
12	754	21	25	30	38	50	75	151
14	1030	29	34	41	51	69	103	206
16	1340	38	44	53	67	88	134	268
18	1685	48	56	67	84	112	168	337
20	2100	60	70	84	105	140	210	420

The amount of silage fed varies with the class of animals to which it is fed. Silage should not comprise the only roughage fed to livestock. Some dry roughage such as hay or straw, depending upon the class of animals, should be fed with it. The following table shows the number of animals that may be fed by removing an average of two inches per day from a silo of a given diameter, when the amounts usually recommended are fed:

TABLE III.—Amounts of Silage to Feed Different Kinds of Animals.

Kind of Stock	Pounds to be Fed Daily	Number of Animals 2 Inches per Day will Feed from a Silo of a Given Diameter						
		8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
Dairy Cows	35	9	15	21	29	38	48	60
Beef Cows	35	9	15	21	29	38	48	60
Wintering Steers								
2 yrs. old	30	10	17	25	34	44	56	70
1 yr. old	25	12	21	30	41	54	67	84
Calves	18	17	29	42	57	74	93	116
Breeding Ewes	3	106	174	251	343	446	562	700
Fattening Sheep	3	106	174	251	343	446	562	700
Fattening Lambs	2	160	261	377	515	670	842	1050

Silage may be fed in very limited amounts to horses and mules, if only good silage, fed with great care, is used. Serious results, however, are frequently reported when apparently the best of care has been used.

Height. The height of silo to build depends upon the length of the feeding period. For wintering or growing animals a filled silo 30 feet in height is sufficient in most cases, as this will allow the feeding of two inches per day for 140 to 150 days, which is the usual length of the feeding period. A silo of greater height is recommended for feeding dairy cows or other animals where a longer feeding period is desirable.

Feeding Capacity. Knowing the amount of silage to be fed daily and the length of the feeding period, one can figure out the amount of silage which will be needed for the entire herd for the year. Practice has shown that the amount which can be fed from a silo is at least 10 percent less than the amount contained in it after settling, that is at the beginning of the feeding period. This loss usually consists of spoiled silage, waste, and shrinkage. The following table is not for the purpose of giving the capacities of silos of different dimensions, but shows the amount of silage which can usually be fed from a silo of a given diameter, with different depths of silage after settling:

TABLE IV.—Feeding Capacity of Silos.

Depth in Feet of Silage After Settling	Amount in Tons which can be Fed from a Silo Having an Inside Diameter of							
	8 ft.	10 ft.	12 ft.	14 ft.	15 ft.	16 ft.	18 ft.	20 ft.
24	20	31	44	.....	.....	.....	.....	.....
26	23	34	50	.....	.....	.....	.....	.....
28	25	38	55	75	.....	.....	.....	.....
30	29	42	60	82	95	.....	.....	.....
32	.....	.....	67	90	104	118	.....	.....
34	.....	.....	72	98	113	129	.....	.....
36	.....	.....	78	107	122	140	176	.....
38	.....	.....	.....	115	132	150	191	235
40	.....	.....	.....	.....	142	162	205	253
42	.....	.....	.....	.....	153	174	221	272
44	.....	.....	.....	.....	.....	186	236	291
46	.....	.....	.....	.....	.....	.....	252	311
48	.....	.....	.....	.....	.....	.....	.....	331

TYPES OF SILOS IN WEST VIRGINIA.

Owing to the many types of silos used in the state only those most commonly used and of approved types will be discussed at any length. The types of home-made silos which are recommended are the wooden-hoop stave silo, the wooden-hoop plastered silo, and the concrete silo; the patent silos recommended are stave and hollow tile block. Other types of both home-made and patent silos, however, have been used and in many instances gave entire satisfaction.

HOME-MADE SILOS.

Wooden-Hoop Stave Silo. Perhaps the first type of home-made silo to be built in the state was the wooden-hoop stave silo. The earlier silos of this type were built somewhat on the same order as those of the present day, although rather plain in structure. When the modern wooden-hoop stave silo is constructed of tongued and grooved material of good quality a good silo at a very low cost can be built. Including roof and foundation the average cost complete of a silo of this type varies somewhat in different parts of the state, but on the average a 60-ton silo will cost from $1.00 to $2.00 per ton capacity, depending somewhat upon the availability of material and the cost of labor. The cost per ton capacity decreases as the size increases.

Wooden-Hoop Plastered Silo. The wooden-hoop plastered silo is constructed very similarly to that of the wooden-hoop stave silo, having in addition a coat of plaster on the inside. One advantage of the wooden-hoop plastered silo is that rough and somewhat cheaper lumber can be used in its construction. The cost of this type of silo is about the same as that of the wooden-hoop stave silo.

The chief advantages of the wooden-hoop stave and plastered types of silos are low initial cost and availability of material in most agricultural communities. These silos are efficient and will last under ordinary conditions from six to fifteen years, depending upon construction and material used. Where capital is limited, material readily available and labor cheap, a silo of either of these types is recommended.

Concrete Silo. The concrete silo has the advantage of other types in permanency and stability. A well-constructed concrete silo will last indefinitely. For the man with sufficient capital who wants a silo for a long period of years, and who can obtain materials for concrete at a reasonable cost, the building of a concrete silo is advisable. The necessary repairs are reduced to a minimum, the first expense being practically the only expense. The chief objections to the concrete silo are its cost and its somewhat difficult construction. On the average, silos of this type will cost from $2.00 to $4.00 per ton capacity, depending upon the size of the silo, the availability of materials, the cost of forms, and the cost of labor.

Concrete Block and Brick Silos. These silos have been used to some extent and are entirely satisfactory when properly constructed. They are, however, expensive and have no advantages to recommend them over the concrete silo.

PATENT SILOS.

Stave Silo. Among the patent silos most commonly used is the stave silo. Silos of this type have become very popular in recent years because of their comparative cheapness, and ease and quickness of construction. Generally speaking the stave silo excels in these particulars, although there are many sections of the state where lumber or sand and gravel may be obtained at a nominal cost, and where the price of the stave silo is excessive. Under such conditions the home-made stave silo, the plastered silo, or even the concrete silo may be considerably cheaper and equally as satisfactory. Silos of this type will cost from $2.00 to $3.50 per ton capacity, depending upon the make and the material used.

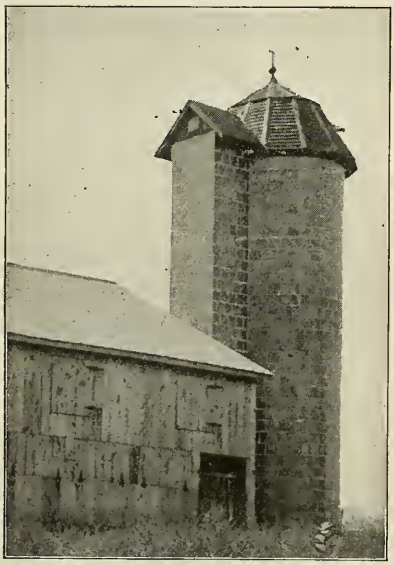

Fig. 4.—Hollow Tile Block Silo.

Tile Silo. A silo constructed of hollow tile blocks reinforced with steel is finding a place on many farms. The air space undoubtedly provides some protection against the freezing of the silage, although this is of relatively little importance. It is apparently durable when properly constructed, but owing to its rather recent introduction it is difficult to say how it compares in durability with other types. If good tiles adapted for the purpose can be secured at a reasonable cost there is no reason why this silo should not come into more general use. The cost of a silo of this type varies from $3.00 to $5.00 per ton capacity.

LOCATING THE SILO.

After having decided to build a silo of a definite size and type, its location is of considerable importance. If convenient, the silo should be located so as to shut off as little light from the barn as possible. The location of the barn, the approach to the proposed silo and other conditions being equal, the silo should be located on the north side. As a rule it should be so near the barn that the chute will open directly into the interior as near the place where it is to be fed as possible.

THE MAKING AND FEEDING OF SILAGE.

The making and feeding of silage to different kinds of livestock will be discussed in a separate publication, which may be secured free upon request to the Director of the West Virginia Agricultural Experiment Station.

Building Instructions for Home-Made Silos

By G. L. OLIVER,

In co-operation with U. S. Dept. of Agriculture.

Owing to the fact that complete plans for constructing patent silos are provided by the manufacturers, building plans, including bill of materials, are provided in this bulletin only for silos of the home-made type. The demand for more detailed information concerning the construction of silos of this type has made it necessary to rewrite Circular 8 of the West Virginia Agricultural Experiment Station, by W. D. Zinn, which gave instructions for building wooden-hoop silos. Acknowledgement is made to Mr. Zinn for his helpful suggestions in the preparation of these plans.

STAVE AND PLASTERED SILO.

Table V gives the approximate bill of materials for silos of different dimensions, including foundations. It does not, however, include a bill of materials for the roof.

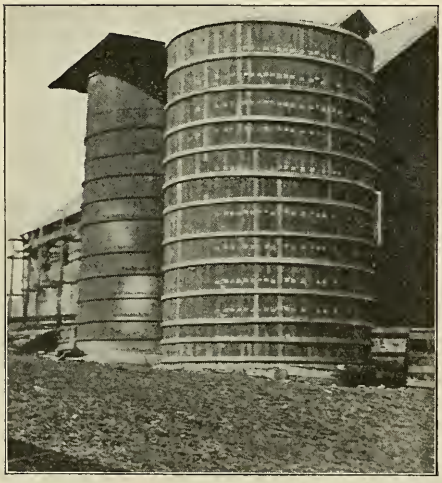

Fig. 5.—Home-made Silos on Farm of W. D. Zinn That Have Kept Silage for Fourteen Years.

Stave Material—Item* A. While not necessary it is advisable if a planing mill is convenient, to have the material for staves edged and planed on one side. Any lumber which is sound and straight can be used for this purpose. Although objectionable from the standpoint of appearance, knotty lumber, if sound, may be used for the plastered silo. If flooring instead of the material above is to be used for staves, be sure that it is of good

*For the amounts of materials specified in items A to I reference should be made to Table V.

quality and that it contains no holes of any kind. Use the smooth surface on the inside. Add about one-third to the bill for tongue and groove.

Hoop Material—Item B. In determining the length of material to be used for making hoops, find the circumference of the proposed hoop and match the length most economically. It is well to have this material cut ¾ of an inch thick and afterwards dressed to ½ inch if a planer is convenient. Otherwise insist upon having the material uniform, and not thicker than ½ inch. A thickness of ⅜ inch is sufficiently strong, as three thicknesses or layers will be used. Any pliable wood such as second-growth oak, white oak preferred, or elm may be used. Beveled weatherboarding of good grade or No. 1 ⅜-inch yellow pine ceiling may be used for the construction of hoops with good results.

Door Material—Item C. The material for the doors should be No. 1 yellow pine flooring with 3¼ inch face.

Plastering Laths—Item D. These should be made from material that will bend easily. Ordinary plastering laths 4 feet long are best. If somewhat dry when ready to use, soak in water. Sometimes chicken wire and metal laths are used but they are more expensive and not so satisfactory as wooden laths.

Door Facing—Item E. Quarter round may be used, but if it is not easily secured, 1 x 2-inch planed boards will answer, or a piece of flooring may be split to the desired size.

Cement—Item F. The quantity of cement given is for the plastering and is mixed 1 part cement, 3 parts clean, sharp sand, and 10 percent screened, hydrated lime. A 1 part cement, 3 parts sand, 5 parts crushed stone concrete mixture is used for the foundation. By using large stones in the bottom of the foundation the quantity of cement can be slightly reduced.

Sand—Item G. The sand includes the quantity required for plaster as well as that to be used in the foundation. This sand must be screened, clean, and sharp.

Stone—Item H. It is desirable to have this material broken up in pieces from 1 to 2 inches in diameter.

Anchor Irons—Item I. These can be made from old wagon tires, and should be about 4 feet long, with one end turned up about 2 inches to a right angle, so that they will not pull out of the concrete. The opposite end should have two ½-inch holes punched or drilled, one 2 inches and the other 24 inches from the end (see Fig. 7).

TABLE V.—Approximate Bill of Materials for Constructing Home-made Silos of Different Dimensions.*

ITEM	8 x 24 20 tons	8 x 30 29 tons	10 x 24 31 tons	10 x 28 38 tons	10 x 30 42 tons	12 x 24 44 tons	12 x 28 55 tons	12 x 30 60 tons	12 x 32 67 tons	14 x 30 82 tons	14 x 36 107 tons	15 x 30 95 tons	16 x 32 118 tons	Materials
A	576	720	720	840	900	864	1008	1080	1152	1260	1512	1360	1608	feet of 1 x 4" boards
B	367	454	468	520	576	520	600	640	680	736	856	768	884	feet B. M. ½ x 4" boards
C	152	190	152	176	190	152	176	190	204	190	228	190	204	feet of matched t. and g. flooring
D	950	1270	1150	1350	1450	1400	1650	1750	1900	2050	2550	2200	2500	plastering laths
E	48	60	48	56	60	48	56	60	64	60	72	60	64	feet quarter round
F	17	18	21	22	23	26	28	29	29	31	33	34	37	bags cement
G	2¼	2¼	2½	2½	2½	2¾	2¾	3	3	3¼	3¼	3¼	3½	cubic yards sand
H	3.2	3.2	3.8	3.8	3.8	3¾	3¾	3¾	3¾	4.4	4.4	4.7	5	cubic yards stone
I	4	4	5	5	5	5	5	5	5	6	6	6	6	pieces of old wagon tire
J	40	40	40	45	50	55	60	60	60	65	70	75	80	pounds nails, 4, 6, 8, and 10 d.

*The capacity given is the usual amount which may be fed from a silo of given dimensions.

Foundation. The first step to be taken up is the construction of the foundation. Having determined the diameter of the silo, the interior diameter of the foundation is laid off so that it will be 4 inches smaller than the inside diameter of the silo, the object being to have the silo rest near the inner edge of the foundation rather than in the middle or on the outer edge. The foundation is marked off by driving a stake in the ground at the center of the proposed silo. To this is fastened, with a 12-penny nail, one end of a straight strip long enough to reach from the stake to the outer edge of the foundation (see Fig. 6). The positions of the inner

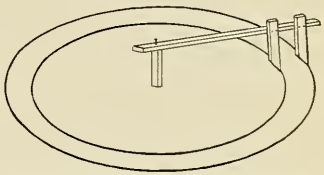

Fig. 6—Method of Marking Off the Foundation.

Fig. 7.—Anchor Irons Set in Foundation.

and outer edges of the foundation wall, which are 12 inches apart, are marked on this strip, and two short, straight-edged pieces are nailed on at right angles to the strip at these points. By keeping the strip level and using sliding markers two circles can be laid off on the ground, which will correspond to the inner and outer edges of the foundation. The soil can be

taken from between these lines to a depth of two feet, or below the frost line. Care should be taken that the walls of the excavation are perpendicular, as they will answer as a form for the concrete, which is mixed and poured in to the level of the ground. Place the anchor irons in the foundation while it is being made so that they will come on the outside of the hoop (see Fig. 7), and have the upper end of the anchor 30 inches from the proposed top of the foundation. When the cement has set, drive stakes in between the concrete and the earth about 2 feet apart on the inner and outer sides of the foundation, and tie together with strips across the top. Complete the construction of the form by bending ½-inch boards around and nailing to the stakes. Fill with the concrete mixture and smooth off. The outer edge should be about 1 inch lower than the inner edge.

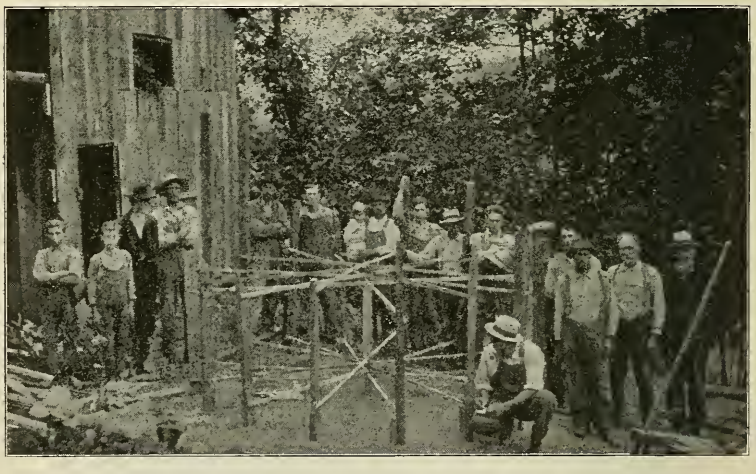

Fig. 8.—When the Uprights are Braced This Form will be Ready for Making the Hoops.

Construction of Hoops. The hoops are most easily made on a circular form about 6 or 7 feet high. The diameter of the form is to be made 2 to 4 inches greater than that of the inside diameter of the silo, depending upon whether a flooring or plastered wall is to be constructed.

With a 10-penny nail, fasten one end of a strip to a stake which has been driven in level ground. From this nail measure the radius or one-half the diameter of the form and saw off the strip at this point. Drive an 18-inch stake into the ground about 1 inch toward the center from the end of the strip. From this point sight across the center stake and similarly

locate another stake. Continue this operation so that a circle will be formed with an even number of stakes about 2 feet apart. Fasten in an upright position to the stakes of the circle straight-edged 2 x 4's about 6 feet long, so that their outer edges will be even with the end of the strip. These should be plumbed before fastening. When this has been completed tie the opposite 2 x4 uprights across the center with strips which are the exact length of the diameter of the form. Nail the tie pieces together in the center (see Fig. 8). The uprights or 2 x 4's should be plumbed in two directions before bracing.

The hoops are made as follows of three layers of the hoop material with broken joints: With 6-penny nails fasten the right end of the hoop material which is the inner layer to a 2 x 4 studding. Keep this level and bend around the form to the left. At the second or third studding begin the middle layer by nailing to the studding through the first piece of inner layer with three 6-penny nails. The outer layer of the hoop is started on the third, fourth or sixth upright. Do not allow the joints of any two layers to come within 12 inches of each other. Nail all the joints well with 6-penny nails. Use 8, 10, or even 12-penny nails in drawing the hoops to the studding. Do not hesitate to drive nails into the studding and nail every 3 to 6 inches between the studding. Complete the hoops by fitting the respective joints of the three layers.

Start the second hoop on the next studding to the left and continue as before. If the lumber is in good condition three men should build three hoops an hour. At least two men will be required to build the hoops, but a crew of three men is better. This work may be done in the spring and at odd times before building the silo. It is better to make the hoops when material is pliable. If the lumber dries out, it can be rendered more pliable by soaking it in water.

Slightly better hoops may be made by beveling the ends so that they will overlap. A foot adz may be used for this purpose.

When all the hoops have been completed, tear out the interior braces and tie pieces. The hoops should go on the foundation either in the order or in the reverse order in which they were made, and in the same position with respect to one another. In order to do this, number the hoops from top to bottom with a heavy pencil. Draw a vertical line in about five places around the form from top to bottom. These marks will be of use when the hoops are raised. With a crowbar, mattock or piece of heavy timber pry out all the studding and clinch all nails.

Constructing Scaffold. The scaffold can be constructed by splicing 2 x 4's together on the ground, making four uprights as long as the desired height of the silo. These uprights are raised and placed about 18 inches toward the center from the hoops and in such positions that they will be equally distant apart. They are then plumbed and braced. Scaffold floors are placed about every 7½ feet from the top of the foundation. Splice enough of the stave material so as to reach from the top of the foundation to the top of the proposed silo, and indicate on these pieces where the hoops are to be placed.

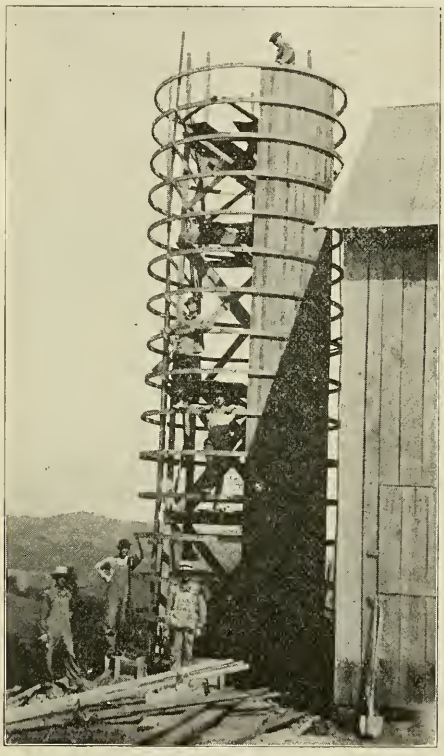

Fig. 9.—Nailing the Staves on.

Spacing Hoops. The hoops should be spaced as follows: Beginning at the foundation, the center of the first hoop should be located 6 inches above the foundation. The second and third hoops are spaced 22 inches on center, the fourth and fifth hoops 23 inches, and all others 2 feet apart, except the last two, which should be spaced 23 inches. This is done in order that joints in the staves may be made at any place where there is a hoop. By so doing, lumber 8 feet or more in length may be used. After the scaffold has been completed the first hoop is raised, using three ropes for this purpose. The first hoop is supported by nailing two sound 1 x 4's across the top of the scaffold where the pieces used for spacing the hoops indicate that the top of the silo is to be. These pieces are then fastened to the hoop, which has been raised, at the places indicated by the marks which were made while the hoops were on the form, and similarly fastened to the bottom hoop, which is resting on the foundation. The top hoop is then plumbed with the bottom hoop, and the

two 1 x 4's are raised or lowered as necessary in order to keep the top hoop rigidly in place. It is an easy matter to raise the remaining hoops and fasten them in their proper places by nailing to the pieces used for spacing. Plumb the hoops on one side, where the door is located, and brace well to the scaffold.

Nailing the Staves on. Begin on the side where the door is to be, drop a perpendicular line from top to bottom and mark on each hoop where the first stave is to be placed. Nail the first staves to the hoops, using two nails for each hoop. Continue breaking joints (see Fig. 9) and plumbing the hoops about every five feet until about one-half or two-thirds of the staves have been put on. Mark off the space for doors and door facings, beginning on the opposite side. Nail the staves on as before. This is recommended because of the fact that it is important to have the hoops at the doors as uniform as possible.

Fig. 10.—Doors are Constructed of Two Layers of Flooring.

Making Doors and Door Frames. For door frames use flooring which has a 1-16 inch bevel made so that the doors will fit into the frames from the inside of the silo and be continuous from top to bottom. By using eight pieces of 3¼-inch face flooring, taking off the tongue and groove of the outside pieces and beveling so that they will fit the bevel of the door frame, a door about 25½ inches wide can be made. The length of doors is determined by the spacing of the hoops from center to center.

The doors are made of two layers of flooring (see Fig. 10). the outer layer fitting into the bevel of the facing, while the ends extend from the center of one hoop to the center of the other. The inner layer overlaps the outer layer about 1¼ inches on each side, the ends being fitted 1¼ inches below the ends of the other layer. A piece of quarter round

fits against the inner layer on the sides. The two layers are then put into the opening, nailed together, and a batten nailed on. The doors may be made straight instead of assuming the curvature of the silo (see Fig. 11). In this event no batten will be needed. Instead of using batten the outside layers run in a horizontal position and the space between the door and the hoop is filled with a piece of wood cut to conform to the curvature of the hoop.

Lathing and Plastering. The laths if dry should be soaked in water so that they will bend easily. Begin at the top of the silo and nail the laths, from ⅜ to ½ inch apart, direct to the staves. Break joints as much as possible, as this will slightly strengthen the silo. One coat of a cement plaster is usually sufficient, using 1 part Portland cement and 3 parts clean, sharp sand by volume, to which is added 10 percent screened, hydrated lime. If dry, dampen the laths before applying the mixture, as dry wood absorbs the moisture from the plaster. The finished wall should be as smooth as it is possible to make it, since this will reduce friction and allow the silage to settle properly. The plastering may be done in a wet season. At any rate do not allow the wall to dry too rapidly. If it dries too rapidly, dampen with water. It is a good plan to go over the wall with a coat of cement wash mixed to the right consistency and applied as whitewash. A mixture of equal parts of coal tar and gasoline is also excellent. This can be applied over the cement wash.

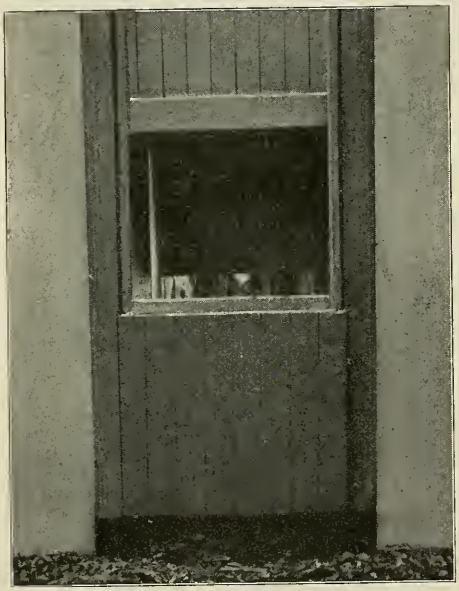

Fig. 11.—Straight Door Set in Door Frame.

Roof. The roof illustrated in Figure 12 is made of light material and the sections can be easily opened and closed. The chief advantage is that the capacity of the silo is in-

creased. If a gable roof is to be used it should be at least ½ pitch. The cost of a roof for a ten foot silo is about $15.00. A gambrel roof is still better (see Fig. 4) but will cost about 80 percent more.

Waterproofing Hoops. After the silo has been completed the hoops should receive a coat of creosote, applied hot. A mixture of equal parts coal tar and gasoline or a mixture consisting of 1 gallon of coal tar and 1 pound of pulverized rosin is sometimes applied, the latter mixture being heated and stirred over a slow fire. A little oakum should be added and the preparation applied to the hoops while it is hot. This forms a waterproof coat which greatly increases the durability of the hoops.

Fig. 12.—A Roof Which Increases the Capacity of the Silo.

Concrete or Other Types of Silos. Owing to limited space, building plans, including bill of materials, for concrete or types of silos other than those recommended are not given, but will be furnished upon request.