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Why Build A Silo? —And How

Filling the monolithic concrete silos at the dairy barn of the Missouri College of Agriculture.

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Why Build A Silo? —And How

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ABSTRACT.—This bulletin briefly sets forth the advantages of a silo under the practical conditions to be met on Missouri farms, and gives defnite building instructions for each type of silo. To guide each builder in choosing the type of silo best suited to his own system of farming the authors enumerate the essential and desirable qualities of a good silo, and tabulate information on sizes of silos needed for different sized herds. Materials and details of construction are described for several types including monolithic, concrete block, concrete stave, stone, vitrified block, wooden stave and wooden hoop silos.

The purpose of this bulletin is to supply information on the following points: First, the practical value of a silo under Missouri farm conditions; second, the type and size of silo best suited to definite needs; and, third, some of the problems to be met in the erection of each type of silo.

WHO SHOULD HAVE A SILO?

The question as to whether or not it will pay to erect a silo is largely an individual farm problem, and the answer will depend largely upon the type of farming. There are doubtless certain conditions existing on individual farms under which a silo would not be profitable; but, on the other hand, there are many conditions under which the silo is practically a necessity.

Dairy farmers especially have appreciated the value of silage. Under Missouri conditions, it is seldom, if ever, possible to produce milk as economically without silage as with it. To make a profitable investment, however, a man should have at least ten cows and the usual complement of young stock, or the equivalent of this number in other stock. With smaller herds, the cost of the silo and the silo filling machinery constitute an excessive burden compared to the benefits obtained.

On farms where there is a great need for a succulent winter feed as a substitute for pasture, the silo is the most practical means of supplying it.

On farms where there is danger of a pasture shortage in summer, which will seriously affect the profit of operation, the silo may be used advantageously to tide over such a period.

On some farms the production of roughage limits the amount of livestock which can be fed. In such cases the livestock capacity of the farms can be increased by a silo. When the supply of roughage is uncertain and the success of operation depends largely upon it, a silo is often the only practical solution.

On farms where it is necessary to get the greatest possible amount of feed from each acre, a silo has very great value.

ADVANTAGES OF THE SILO AND SILAGE

1. Silage furnishes a succulent, readily available feed of uniformly good quality for any season of the year. It is cheaper than roots or any other succulent feed, excepting pasture grass. During the summer, when pastures are poor, it furnishes succulence at a cost less than that of soiling crops. Silage adds palatability to a ration, and thereby increases consumption.

2. The silo makes it possible to secure the largest amount of digestible nutrients from a given acreage. This is due to the fact that with such crops as corn the loss of nutrients in the silo is only about one-half as great as in field curing. Silage is eaten up clean, while 25 to 30 per cent of dry fodder is wasted.

3. Silage requires less room for storage than the same amount of feed in the form of hay or other dry forage, and is more readily accessible during bad weather.

4. The silo provides a plan for preserving crops when weather conditions do not permit field curing. It offers the most satisfactory method of saving an immature crop from untimely frost, or preserving frosted corn that would otherwise be ruined by rainy weather. Hay crops may be partially saved by storing in the silo.

5. Silage decreases the amount of grain required to produce milk or beef or maintain animals.

6. Silage makes it possible to put "bloom" or finish on animals in less time than can be done with most other rations.

7. Putting the crop in the silo gets it off the land earlier than otherwise, and the land may be fall plowed or fall sown.

8. Except in rare cases where filling costs are excessive, silage is one of the most economical carbohydrate feeds.

OBJECTIONS TO THE SILO AND SILAGE

1. Building the silo necessitates an initial investment which is usually an important item in farm expense, and involves an interest charge or credit arrangement sometimes difficult to meet.

2. Filling the silo requires an additional investment in farm machinery in the form of an ensilage cutter and the power to operate it.

3. The problem of getting and keeping a crew of men together for filling is more or less difficult and sometimes relatively expensive.

4. It is rarely practical to move a silo from one location to another.

THE ESSENTIAL QUALITIES WHICH MUST BE BUILT INTO ANY SILO

The sidewalls of the silo must be air- and water-tight. When the silo is filled, the silage should contain sufficient moisture so that when it is packed the air will be displaced and forced out. If this moisture is then allowed to seep out through walls or around doors, air will find its way in, and spoiled silage will result.

The inside of the silo walls must be smooth and plumb. Rough places on the walls prevent the silage from settling evenly and cause air pockets to be formed. Silage does not act wholly as a fluid, and, consequently, if the walls

are not plumb, the silage will settle away from them and allow air to find its way down between the walls and the silage.

The silo wall must be sufficiently strong to withstand the bursting pressure of the silage. The late Professor King of Wisconsin found that the side pressure produced by settled silage was 11 pounds per square foot for each foot of depth. Thus the pressure on the walls at the bottom of a 30-foot silo would be 330 pounds per square foot. If this silo is 14 feet in diameter, the pressure will cause a strain of 2,310 pounds on the hoop or reinforcement which holds the first foot of the wall above the foundation. Near the top of the silo, the pressure per square foot is less and the amount of reinforcement needed is not so great.

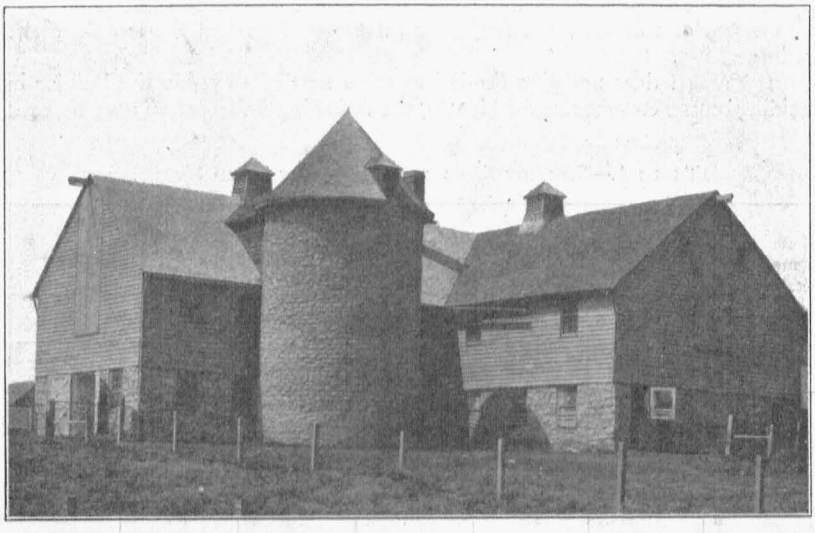

Fig. 2.—The stone silo at the horse barn of the Missouri College of Agriculture.

OTHER QUALITIES WHICH ARE DESIRABLE

The silo should be durable. While in most cases the silo will pay for itself in two or three seasons, one should build a silo that will last for a longer period of years. The silo requiring the least care and upkeep is usually the most practical.

Silage will freeze in any silo during severe weather. The double wall construction furnishing greater insulation may not allow the silage to freeze so quickly nor so deeply as single-wall construction; but, on the other hand, it will not permit it to thaw out so quickly. Freezing may be prevented to a great extent by locating the silo on the sheltered side of the building group. Much freezing may be prevented by removing the silage so as to keep the outer edge lower than the center. The amount of heat in the silage will ordinarily allow but little freezing.

THE PROPER SIZE FOR THE SILO

It is very important that the diameter of the silo shall be appropriate to the conditions under which it is to be used. If it is too small the cost per ton of silage stored in it will be excessive. If it is too large the silage will not be fed off rapidly enough to keep it from spoiling; and a more or less spoiled silage will be fed at all times.

The diameter to build depends upon two factors, the amount of silage needed per day and the season of the year that the feeding is to be done. Silage spoils when exposed to air for any great length of time. The rate of spoilage is much more rapid in warm than in cold weather.

It is necessary to remove at least 3 inches of silage daily in the summer, while 1½ inches will, in most cases, be sufficient to keep the silage fresh in winter.

The height to which the silo must be built depends upon three factors, the number of animals to be fed, their ration of silage and the length of the feeding period.

If Table 1 does not give the information needed to guide the builder in deciding on the correct size for his silo, the following information may be used

TABLE 1.—SIZES OF SILOS FOR DIFFERENT SIZED HERDS.

Number of mature cattle or their equivalent in other stock	Feed for a 200-day winter feeding period (30 to 35 pounds per day)			Feed for a 70-day summer feeding period (15 to 20 pounds per day)		
	Tons silage needed	Size of silo to build		Tons silage needed	Size of silo to build	
		Diameter	Height		Diameter	Height
10	34	10	27	--	--	--
12	40	12	24	--	--	--
15	56	12	30	--	--	--
20	66	14	28	--	--	--
25	80	14	32	22	10	20
30	100	16	30	24	10	22
35	116	16	34	26	10	24
40	121	16	36	28	12	20
45	145	16	38	32	12	22
50	152	16	40	36	12	24

as a basis for calculating silage needs. Dairy cows, dairy heifers, beef cows, feeder steers, and stock cattle, will consume under average conditions and with average rations 3 pounds of corn silage daily for each 100 pounds of live weight; beef cattle on full feed 1 pound to 2 pounds daily; sheep 1 pound to 1½ pounds and horses and mules 1 pound daily for each 100 pounds of live weight. More complete imformation on silo capacities may be obtained from Missouri Agricultural Experiment Station Circular 89, "Estimating Silo Capacities and Silage Weights".

The amount of silage needed for summer feeding is often secured by adding to the height of the winter silo; and, while this plan results in more or less waste from spoiled silage, it may still be more practical than to build the summer silo.

THE LOCATION OF THE SILO

The convenience of its location has much to do with the effectiveness of the silo as a part of the farm equipment. The question of where the silage is to be fed and how it is to be handled should be considered when the silo is located.

Figure 3 shows how two silos may be located conveniently at one end of the barn with space enough between them so that a wagon can be backed in and loaded directly for yard feeding or so that a feed carrier can be loaded when the silage is fed in the barn. Too often the silo is located so close to the barn that there is insufficient room for the silage that must be thrown down for each feed. When one silo is built with a possibility of a second in the future, the first silo should be located with this in mind.

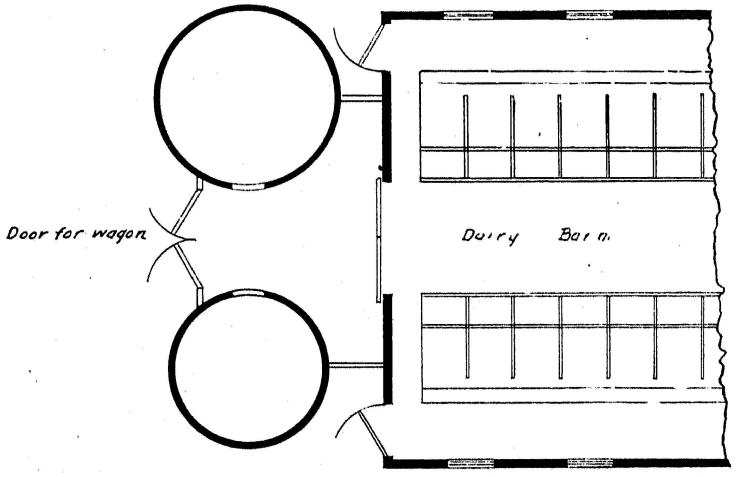

Fig. 3.—Ground plan of dairy barn and silos showing a very satisfactory arrangement.

Other factors which must be considered in locating the silo are the need for room at filling time, the kind of power used, the length of belt and the space required for teams and wagons.

THE FOUNDATION

The foundation for the silo must be made the proper size and of good materials, because the weight which it must carry is very great. The fact that the height is usually two and one-half to three times the diameter makes it imperative that uneven settling of the foundation be prevented. The silo foundation must always be laid below frost and should always be deep enough to have a good subsoil to serve as a base.

Figure 4 shows the wall of a pit which is undercut to provide room for a 20-inch footing and for a tile drain located just outside the foundation wall. A drain for the silo floor is desirable but not always necessary. These drains and the concrete floor are necessary only when the silo is located in wet, seepy land. The concrete floor may be found advantageous even if the silo is located on well-drained land as it will reduce the work of keeping the silo clean.

The trap or water-seal in the floor drain may be omitted if the inner end of the drain is closed before filling the silo. This will prevent air from entering through the drain.

Forms for the foundation of the round silo can be made from half-inch lumber bent around studding set to the proper curve as shown in figure 4. Inside braces (not shown) are necessary to hold studding in place.

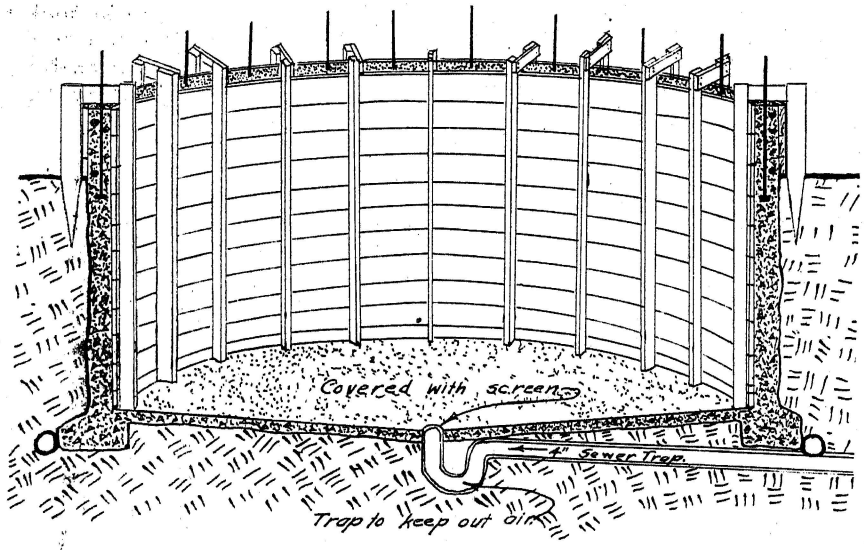

Fig. 4.—Detail of pit, wall, footing, drain and trap in foundation for silo.

Clean materials—sand, gravel, rock, etc.—must be used in order to insure a good concrete. A mixture of one part cement, two parts sand, and four parts crushed rock or screened gravel should be used. Any part of the foundation that is not backed up firmly by the soil should be reinforced. The amount of reinforcing needed will depend upon the diameter and height of the silo and can be determined from Tables 2, 3, or 4 on reinforcement.

TABLE 2.—LAYERS OF REINFORCING FENCE REQUIRED AT VARIOUS DEPTHS IN SILOS OF DIFFERENT DIAMETERS.

Distance in Ft. from top	Inside diameter			
	10 Ft.	12 Ft.	14 Ft.	16 Ft.
0 to 27	1	1	1	1
27 to 30	1	1	1	2
30 to 33	1	1	2	2
33 to 36	1	1	2	2
36 to 39	-	2	2	2
39 to 42	-	2	2	2
42 to 50	-	-	2	2

In a locality where stone is plentiful, a stone wall foundation may be made. In fact, the whole silo may be made of stone. Reinforcement should be imbedded in the wall as laid up in order to give the silo the proper strength. A coating of cement plaster on the inside of the wall is needed to make it smooth and air- and water-tight. It was found necessary to give the wall of the silo shown in figure 2 a brush coating of tar in addition to the cement plaster.

TABLE 3.—SPACING OF HORIZONTAL REINFORCING RODS FOR SILOS OF VARIOUS DIAMETERS.

Distance in ft. from top	10-ft. Diameter ⅜-inch round rods	12-ft. Diameter ⅜-inch round rods	14-ft. Diameter ½-inch round rods	16-ft. Diameter ½-inch round rods
0 to 15	24	24	24	24
15 to 20	18	16	24	18
20 to 25	16	12	18	16
25 to 30	14	10	16	14
30 to 35	12	9	14	12
40 to 45	9	7	11	9
45 to 50	8	6½	10	8½

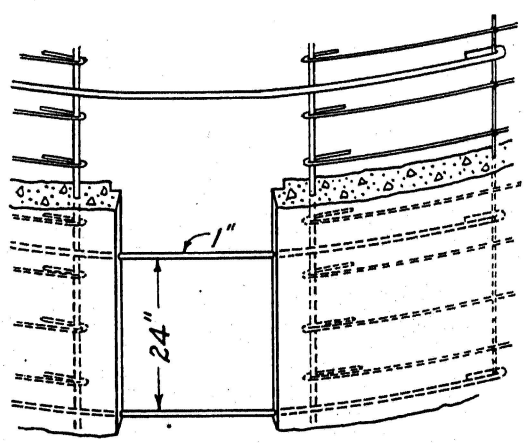

Fig. 5.—Spacing of reinforcement rods in building concrete silo with continuous doorway.

TABLE 4.—QUANTITIES OF CEMENT AND AGGREGATES FOR DIFFERENT SIZED SILOS FOR EACH FOOT OF HEIGHT. TO FIND QUANTITIES, MULTIPLY BY THE HEIGHT OF SILO DESIRED.

Inside diameter (in feet)	Sacks cement	Yards sand	Yards rock
10	2.8	.4	.7
12	4.7	.45	.8
14	5.5	.5	.9
16	6.3	.6	1.0

THE SOLID WALL CONCRETE SILO

The monolithic (solid wall) concrete silo is very popular in Missouri. It has been found to keep silage successfully, it is permanent, and the materials for its construction can often be obtained for a very reasonable outlay of time and money. Many farmers have constructed their own forms and erected their silos with the help available about the farm. Any man who can handle tools and who can make good concrete can build a silo of this type. If the help of a good contractor can be secured, however, it will frequently result in better work for less money.

If a number of farmers in a community wish to build their own silos, it may pay them to purchase a set of steel forms. The work can be done better

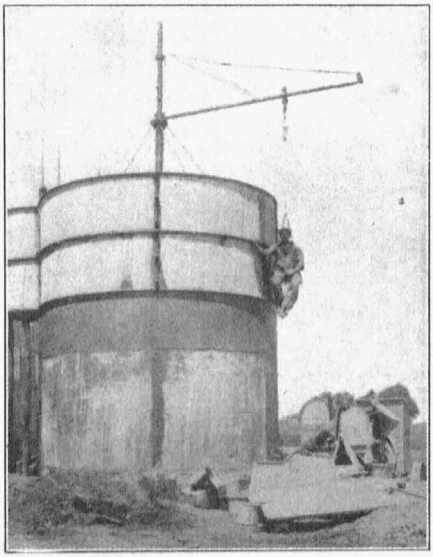

Fig. 6.—Steel forms in use in silo construction.

and at a more rapid rate when such forms are used. If forms are properly cared for when not in use, they will last indefinitely and can be made to serve a large number of farmers.

When the forms are raised, the wall should be rubbed smooth and a brush coat of cement and water mixed to a creamy consistency applied. This must be done as soon as the forms are raised. The steel form shown in figure 6 includes a form for the chute so that the chute becomes a part of the structure and is completed when the walls are finished.

The reinforcement for this type of silo is very important as it is absolutely necessary to give strength to the walls. The continuous doorway is more easily constructed and probably more convenient than any other type. One-inch rods anchored as shown in figure 5 are used to tie across the opening and

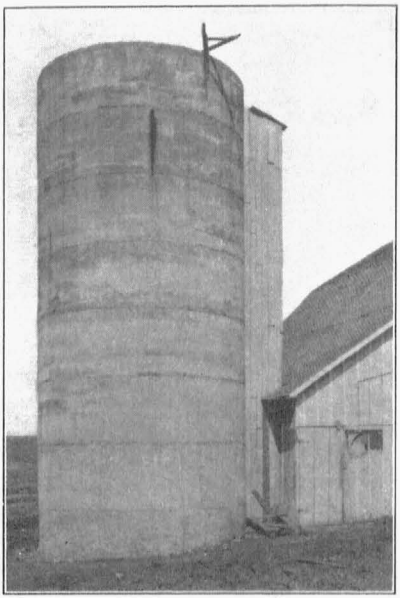

Fig. 7.—A monolithic concrete silo.

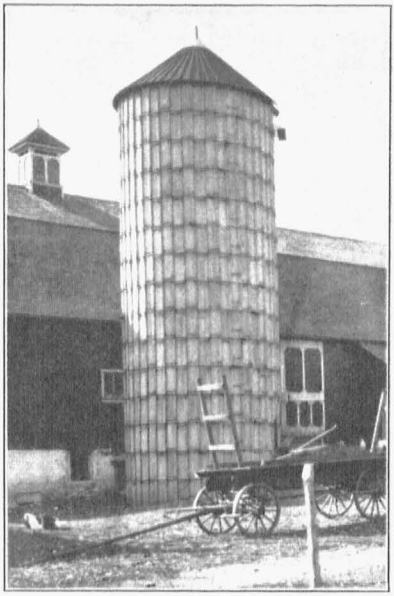

Fig. 8.—A concrete stave silo.

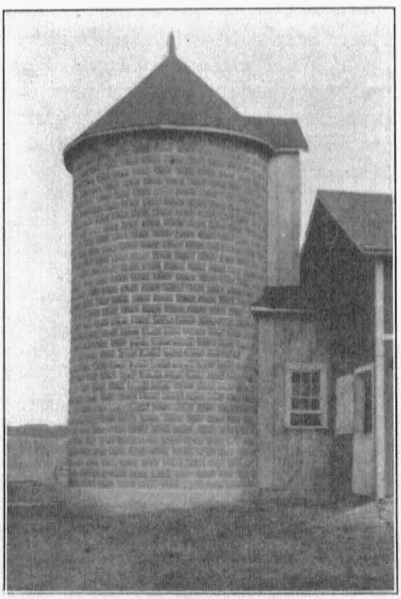

Fig. 9.—A concrete block silo.

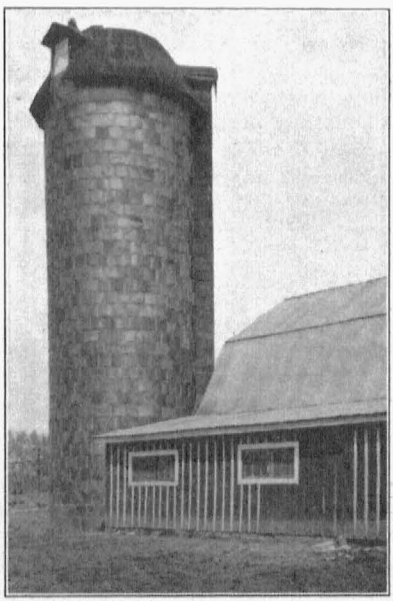

Fig. 10.—A vitrified tile silo.

to serve as steps. The free ends of the rods should be left at least 3 inches long to prevent them from straightening out under strain. A heavy grade of diamond or triangular mesh woven wire fencing can be used for reinforcing. When used it must be securely fastened to the vertical reinforcing rods at the door opening. The 36-inch width with No. 4 wires spaced 4 inches apart has been found to be satisfactory.

Steel reinforcing rods are in many ways more satisfactory than fencing for reinforcing the silo. They are shaped to give a good surface for bonding with the concrete. They are also more easily placed in the form and are of definite known strength.

If square rods are used, increase spacing 30 per cent, but in no case should spacing be greater than 24 inches.

Vertical reinforcement is needed in all monolithic concrete silos. This consists of ½-inch rods spaced 30 to 36 inches apart regardless of the diameter of the silo.

CONCRETE STAVE SILO

This type of silo has come to be very popular because it is permanent and because it can be built quickly. These silos are usually erected by the company which sells them, or by a contractor who is skilled in this line of work, as their construction is somewhat of a special job. The walls of this type of silo are thin and the silage will no doubt freeze to a greater depth than in most other types, but it will also thaw more quickly. In Missouri, the question of freezing is not so important, and consequently this type is very satisfactory.

THE CONCRETE BLOCK SILO

This is a very satisfactory type, if high-grade blocks are used in its construction. Silo blocks are made curving to correspond to the circumference of the silo and are usually 8 inches high, 8 inches thick, and 16 inches long. These blocks have a channel in the upper side so that the reinforcement can be imbedded in the mortar joint. Blocks made by the wet process are desirable because they are usually more impervious to water, and thus make possible an air-tight wall. Special care must be exercised in "pointing up" in order to prevent air leaks at the mortar joints.

THE VITRIFIED TILE SILO

The clay block (tile) silo has long been recognized as a very satisfactory type. The fact that the blocks are more or less permanent, coupled with the fact that they provide an insulating air space, makes them popular. These blocks are built to the proper curve for the silo wall, and are grooved to take the reinforcing which is imbedded in the mortar joints between the rows of blocks.

Adequate reinforcement is essential in the block silo. Any surplus of steel used increases the cost unnecessarily. Figure 11 shows the correct amount and placing of reinforcement for different sizes of block silos.

THE WOODEN STAVE SILO

Wood stave silos are more numerous in Missouri than any other type. This is because this type can be purchased complete from the local dealer and

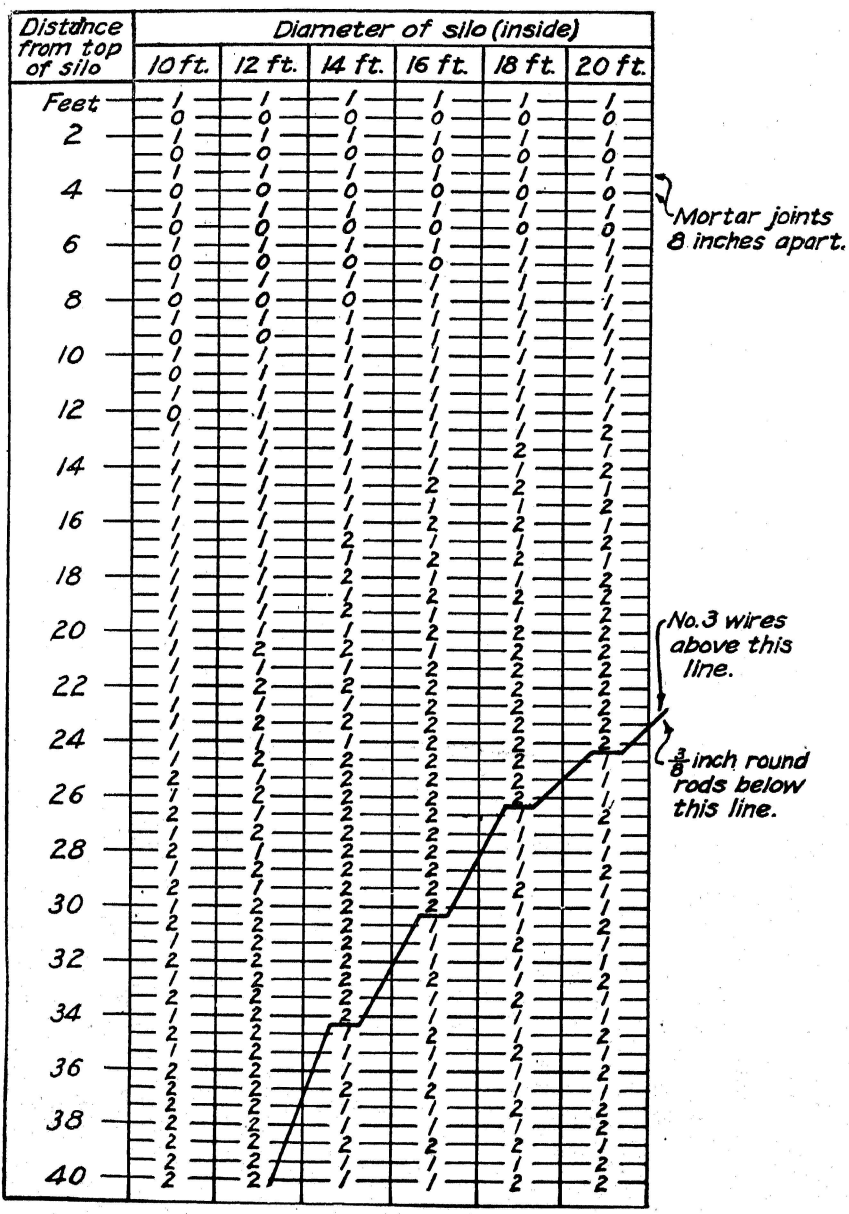

Fig. 11.—Diagram showing amount of reinforcement required by block silos of different diameters, at successive stages in their height.

can be erected quickly. This type of structure requires some attention during the dry season when it is empty. The hoops should be tightened at this time and then lengthened after the silo has been filled a few days. It is also necessary to guy the structure to make sure that it will not be blown down when empty. Some manufacturers use creosoted staves. Creosoting aids materially in preserving the wood and in preventing shrinkage. If the creosote is applied hot, there is no trouble with its being dissolved by the silage.

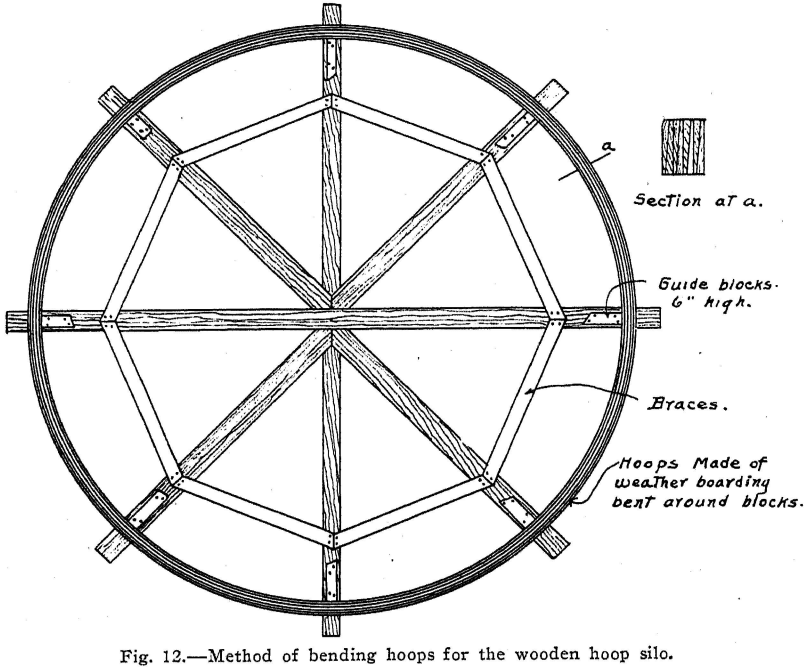

Fig. 12.—Method of bending hoops for the wooden hoop silo.

THE WOODEN HOOP SILO

The wood hoop silo has found favor in some localities because it can be built from stock materials by any carpenter. It does not require much attention; but, like the wood stave silo, it is not a permanent structure.

Figure 12 shows the method of bending the hoops to shape. The hoops are built up of weather boarding or half-inch lumber to a thickness of 3 inches, each layer being securely nailed to the ones inside it. These hoops are then raised into place and braced as shown in figure 13.

Bolts set in the foundation extend up through the second hoop. The inside is sealed with 4-inch tongued-and-grooved flooring. If the hoops are left exposed, they may advantageously receive a heavy coating of tar to keep them from taking moisture. The structure can be sided on the outside of the hoops if desired.

ROOFING THE SILO

A roof for the silo is not absolutely essential, but is in most cases desirable. It will keep out rain and snow and make the work of feeding easier; it adds to the appearance of the silo; and it retards freezing. The roof can be made of reinforced concrete or of any other kind of standard construction. There should be a door in the roof large enough to admit the blower from the cutter. A dormer window is preferable as this will give much more light in the silo.

There are patented roofs designed to increase the capacity of the silo. In one type, this is accomplished by sections of the roof opening out. This will provide additional capacity so that when the silage settles, the silo will be nearer full. Five or six feet of capacity can be gained in this way.

It is not possible to give detailed information on all types of silos in this publication. Anyone who desires more detailed instruction should write to the Missouri College of Agriculture at Columbia, Missouri stating the size and type of silo he wishes to build.

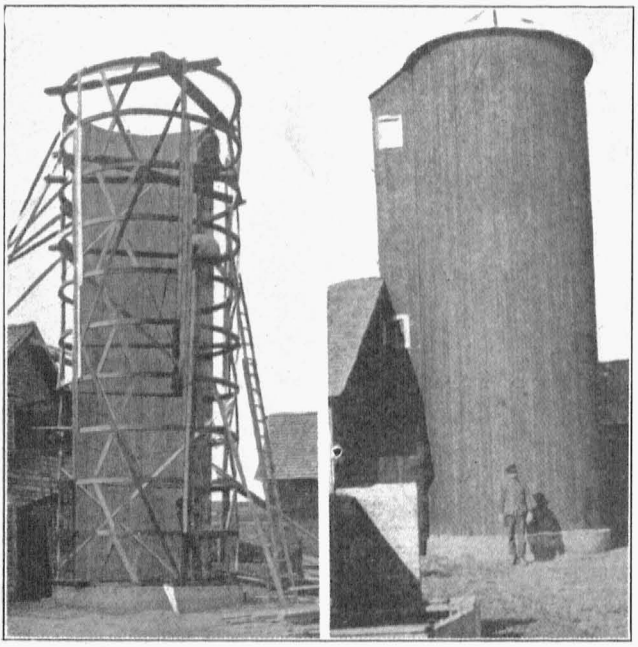

Fig. 13.—Wooden hoop silo, under construction (at left), and completed (at right).

THE ADVANTAGES AND DISADVANTAGES OF SILOS AND SILAGE

ADVANTAGES

Silage furnishes succulent, palatable feed of uniformly good quality for any season of the year.

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Filling the silo requires an additional investment in farm machinery in the form of an ensilage cutter and the power to operate it.

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