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EC713 Revised 1933 The Trench Silo in Nebraska

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The Trench Silo in Nebraska

A Large Trench Silo in Dakota County

THE TRENCH SILO AS DESCRIBED IN THIS CIRCULAR, UNLESS LINED WITH SOME PERMANENT MATERIAL SUCH AS BRICK, CONCRETE OR STONE, MUST BE CONSIDERED A TEMPORARY STRUCTURE WHICH WILL SERVE FOR A FEW YEARS ONLY AND THEN MUST BE DISCARDED OR REBUILT. IN AN EMERGENCY IT WILL SAVE A CROP EVEN THOUGH THE FARMER HAS LITTLE CAPITAL TO EXPEND OTHER THAN HIS OWN LABOR.

The University of Nebraska Agricultural College Extension Service
and United States Department of Agriculture Cooperating
W. H. Brokaw, Director, Lincoln

FOURTEEN TRENCH SILO FEATURES:

1. Quickly and cheaply built for emergency use.
2. Can be built with unskilled labor and with machinery easily procured on the farm.
3. Any desired capacity can be had by increasing length of trench.
4. Can be built any place where drainage is sufficient for a house basement.
5. Not easily destroyed by storm or fire.
6. Little danger from poison gases.
7. Little trouble from frozen ensilage.
8. Can be filled without a blower.
9. Machines for cutting ensilage in field can be used without extra blower or elevator
10. No hoisting apparatus required. Ensilage easily removed in wagons, feed carriers on tracks or feed carts.
11. Is better adapted than other silos to preservation of whole corn bundles, when ensilage cutter is not available.
12. Unless trench is lined, caving will result after first year. Open trench is dangerous and unsightly unless roofed.
13. If made too wide, the percentage of spoiled ensilage will be large.
14. It preserves ensilage with relatively small amount of spoiling if corn is cut at proper time, packed and covered with earth.

The Trench Silo in Nebraska

BY IVAN D. WOOD AND E. B. LEWIS

The original idea of using a trench for the storing of ensilage seems to have been the outgrowth of the practice long used in several European countries of storing clover and beet tops in pits. Shortly after the World War, western Canada followed by Montana and North Dakota began to use the trench silo. In Nebraska the true trench silo made its appearance about 1925 or 1926.

Agricultural statistics for 1930 show that only about 48 per cent of the farms in Nebraska are operated by the owners, eastern Nebraska showing about 45 per cent and the western districts about 51 per cent. Many farm owners and most of the renters have felt that most all silos were too high in first cost per ton capacity. The very low first cost of the trench silo seemed to offer a partial answer.

During September 1930, two trench silos were dug at the Agricultural Experiment Station Farm, University of Nebraska, Lincoln, one at the agronomy farm and one at the sheep barn on the main campus. Both of these when finished had cross-sections very closely conforming to that illustrated in Figure No. 1.

Pick Well-Drained Location Near Lots

It is exceedingly important that flood water from rains does not enter the trench silo. A muddy floor may cause difficulties in feeding and caving of the side walls may result

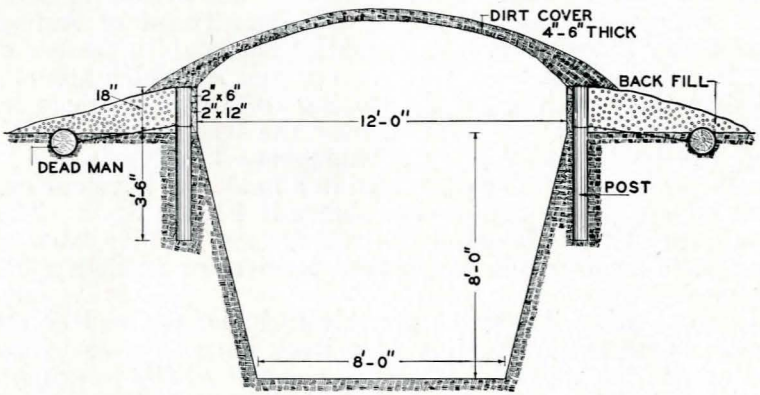

FIG. 1.—Typical cross-section of the type of trench silo built at the College of Agriculture Experiment Farm. Here posts and plank are indicated to hold the back fill of earth at the sides. Logs were used in the experimental silos but not found very satisfactory, due to spoilage of ensilage near them. Experience in 1931 indicates that a 4 inch layer of dirt laid directly on the ensilage gave good results.

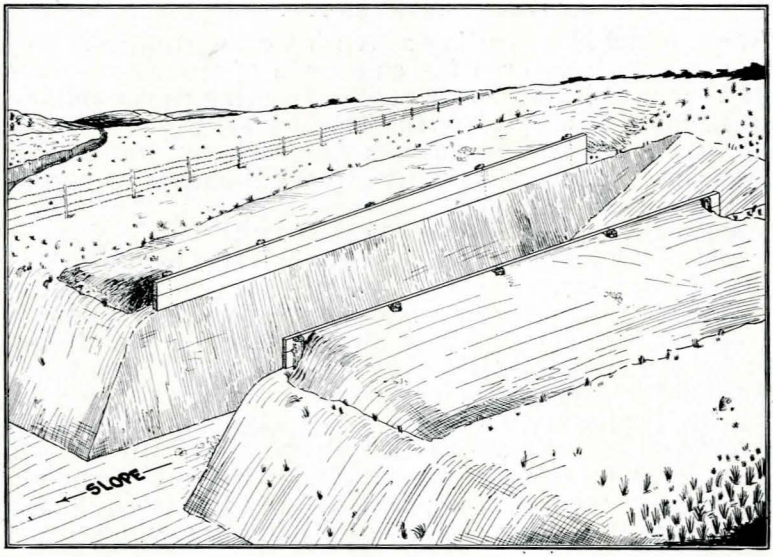

FIG. 2.—Location of a trench silo in a bank with one end opening on a lower level. This makes for easy removal of ensilage where feed carriers and carts are used. It also gives good drainage and permits easy removal of snow.

from water pouring over them. The importance of good drainage may be realized when seventy out of one hundred men who were interviewed by the Department of Animal Husbandry indicated that the greatest handicap in the use of the trench silo was mud, water, snow and ice which accumulated in the trench or on the sloping runways. In most instances a well drained location near the feed lots and buildings can be found. A very advantageous location is one in which the trench can be excavated in a bank, yet have one end open on a lower ground level as shown in Figure No. 2. This arrangement permits excellent drainage and reduces labor of feeding to a minimum, where feed carriers or ensilage carts are used.

In some cases it may be possible to bring one end of the trench up to the foundation of a bank barn or even to use one foundation wall of the barn as one side of the trench silo as shown in Figure No. 3. In most instances, it is necessary to make the excavation on fairly level ground and in this case the trench is dug with a sloping runway at either end. Even though no convenient location near the buildings can be found, it may pay well to have available the excellent feed that good ensilage provides. Wagons can be easily loaded by

backing them down into the runway of the trench and the ensilage transported to the feed bunks wherever they may be located.

Where sand or gravel beds or rock ledges may be encountered, it is well to investigate the proposed location to a depth of 6 or 7 feet with a soil auger. Most of the sub-soil formations in the uplands of Nebraska stand well if some slope is given to the side walls of the trench. Where sand is present in considerable quantities, it will probably be necessary to line the side walls as described elsewhere in this bulletin.

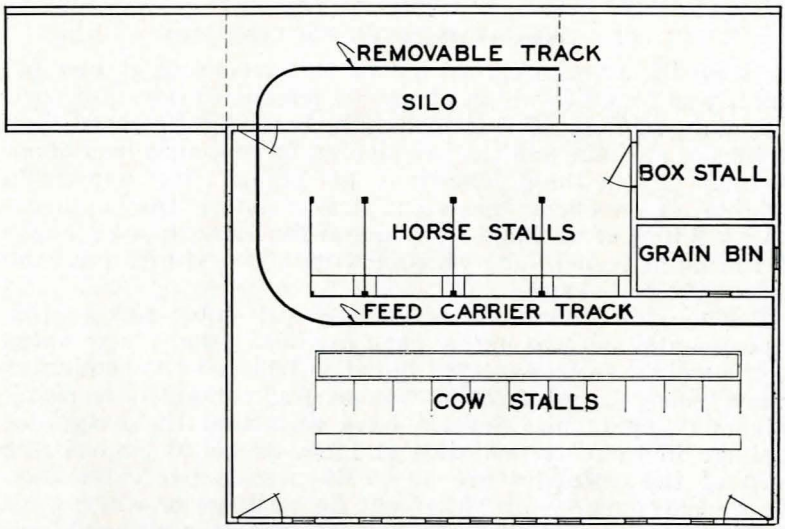

FIG. 3.—Suggestion for using one wall of the basement barn as one side of the trench silo. This places the feed near the point of consumption.

Details About Filling the College Trench Silos

As previously mentioned both silos built on the Experimental Farm had cross-sections conforming to Figure No. 1. The deep section of one silo was 40 feet in length, the other was 75 feet in length, and each had 20 feet of sloping runway at each end.

The silo with 40 feet of main section was built near the sheep barns. When this silo was filled September 23-25, 1930 all of the green fodder was weighed and moisture samples taken. A tractor was used to pack the ensilage. Some water was added the full length of the trench on one side. The reason for adding the water to one side only was to note whether

the dry condition of the side of the trench would draw moisture from the ensilage and cause spoilage.

The trips of the tractor the length of the trench averaged one per ton of ensilage. The average per cent moisture of the ensilage was 72.9. (This was about 4 per cent drier than most of the ensilage cut for silos on the Experimental Farm the fall of 1930.)

Measurements were taken 5 hours after filling operations ceased and showed the rounded ensilage to be 2 feet higher than the top of the logs at the sides of the trench. With these conditions at filling time the ensilage when settled completely filled the trench shown in Figure No. 1.

Silage Weighed 45 Pounds Per Cubic Foot

All ensilage was weighed out of this trench as it was fed and it was found to weigh almost 45 pounds to the cubic foot. The main section, 40 feet in length, held slightly more than 80 tons of ensilage and the two sloping 20 foot ends held about 26 tons. From these conditions at filling time and from weights of ensilage taken out it was shown that approximately 2 tons of ensilage were stored for every foot in length of the main trench, and about 0.6 of a ton stored for each foot of the end slopes.

The number of pounds of ensilage per cubic foot in this experimental silo was higher than has been generally accepted as the weight to be expected but it is believed the conditions under which the information was secured can easily be duplicated on any farm. Several have estimated the weight of ensilage in these trench silos at from 30 to 40 pounds and most of the estimates are 30 to 35 pounds per cubic foot. Where the fodder is dry when cut for ensilage or where poor packing is done or both conditions are true, it is probable that 30 to 35 pounds per cubic foot is all that should be estimated. Where filling conditions are similar to those met at the Agricultural College in the fall of 1930 it is felt that 45 pounds per cubic foot can be depended upon.

How Much Will Stock Eat?

The following table may be used to determine the approximate amount of ensilage required for any farm. The amounts shown are figured for a full allowance of ensilage and would be reduced if supplemented with considerable quantities of other feeds.

Approximate Daily Ration

KIND OF STOCK	Pounds fed per day	KIND OF STOCK	Pounds fed per day
Beef Cattle			
Cows	50 to 60	Work Horses	10
Weanling Stock Calves	30 to 40	Colts	5
Yearling Stockers	40 to 45	Breeding Ewes	3 to 5
Fattening Calves	20	Fattening Lambs	2
Fattening Yearlings	25	Dairy Cows	40 to 50
Fattening Two Year Olds	35	Yearling Dairy Heifers	25 to 30

If it is desired to feed ensilage to 10 head of dairy cows and 20 head of fattening calves the requirements per day would be:

10 cows, 40 pounds each..... 400 pounds
20 fattening calves, 20 pounds each 400 pounds
Total..... 800 pounds per day or

24,000 pounds per month

When an average of 800 pounds of ensilage per day was taken out of the two experimental trench silos at the Agricultural College no waste occurred. The table on the next page is given to aid in determining the dimensions best fitted to a farm.

These data are based on 45 pounds per cubic foot. In the main 40 foot section of the trench near the sheep barns the ensilage weighed out 80 tons or 2 tons per foot of length. The weight of the ensilage in the deep section with quality considered good enough to feed sheep was 50 pounds per cubic foot. This included none of the discolored or burned out ensilage on top which was light in weight.

Dig Silo With Farm Tools and Labor

A trench silo is well adapted to emergency use because it can be quickly constructed when a corn crop is drying up or has been frosted before maturity. The tools and equipment necessary to construct one may be found on most every farm. One man with a plow, slip scraper and a spade could do the job if the time element were not important. Two men and two teams can work to good advantage, one plowing while the other runs the scraper. A crew of three men, using four horses on a Fresno and two on the plow also make a good working unit. The four horses on the Fresno will move big loads of dirt. The extra man holds the plow or scraper or trims up the side walls with a spade in spare moments.

CAPACITY OF TRENCH SILOS

			Tons of Ensilage for Various Lengths							
Depth	Top Width	Bottom Width	30 feet	40 feet	50 feet	60 feet	70 feet	80 feet	90 feet	100 feet
6 ft.	8 ft.	6 ft.	28.35	37.8	47.25	56.7	66.15	75.6	85.05	94.5
6 ft.	10 ft.	7 ft.	34.42	45.9	57.37	68.85	80.32	91.8	103.27	144.75
6 ft.	12 ft.	8 ft.	40.5	54.0	67.5	81.0	94.5	108.0	121.5	135.0
7 ft.	8 ft.	6 ft.	33.0	44.0	55.0	66.0	77.0	88.0	99.0	110.0
7 ft.	10 ft.	7 ft.	40.1	53.5	66.9	80.3	93.7	107.0	120.4	133.8
7 ft.	12 ft.	8 ft.	47.2	63.0	78.7	94.5	110.2	126.0	141.7	157.5
8 ft.	10 ft.	6 ft.	43.2	57.6	72.0	86.4	100.8	115.2	129.6	144.0
8 ft.	12 ft.	8 ft.	54.0	72.0	90.0	108.0	126.0	144.0	162.0	180.0
8 ft.	14 ft.	10 ft.	64.8	86.4	108.0	129.6	151.2	172.8	194.4	216.0
10 ft.	14 ft.	9 ft.	77.4	103.2	129.0	154.8	180.6	206.4	232.2	258.0
10 ft.	16 ft.	11 ft.	90.6	120.8	151.0	181.2	211.4	241.6	271.8	302.0

These figures do not include ensilage in the runways.

Neighbors Might Pool Equipment

Where several neighbors contemplate digging silos it will pay to pool equipment and operate on a larger scale. For speed and ease of operation a crew of three men operating two light tractors, two 5 or 6 foot Fresnos, one two-bottom plow and a 6 foot wheel road grader will usually make excellent headway unless the ground is too hard. For extremely hard ground it may be necessary to use a road plow or even to resort to explosives.

FIG. 4.—Fresno scrapers handled large loads but could not be used near the walls.

Stake Out Dimensions

The first step in excavating the trench silo built near the sheep barn at the Agricultural College in 1930 was to stake out the size of the ground. The silo proper was to have been 12 feet wide at the top, 8 feet wide at the bottom, 40 feet long, and 8 feet deep. At each end was a 20 foot runway making a total length of 80 feet. Stakes were set at all corners and at points where runways were to join the main part of the silo. The top soil was plowed and immediately removed with one 5 foot Fresno grader and one common slip scraper, each pulled by light tractors. As soon as dirt was removed the plowing was resumed and the scrapers started again as shown in Figure No. 4. A two-way plow was found better than the common variety as plowing operations could start at one side and continue to the other side without the necessity of making rounds.

It was not possible to plow and scrape near the side walls so a light wheel road grader was used to remove the shoulder which remained as shown in Figure No. 6. In the absence

FIG. 5.—Starting the excavation for the trench silo at the sheep barn. The ground was plowed with a two-way plow and removed in Fresno scrapers drawn by tractor power.

of a road grader it would be possible to get much nearer to the side walls by using one slip scraper with a chain hitch and one Fresno, the slip scraper being used along the walls and the Fresno near the center. A plow can be used nearer the walls when hitched about 4 feet behind the doubletrees.

Figure Actual Time and Expense

Very little difficulty was encountered in getting up and down the runways with tractors and machinery. The side walls required a slight amount of trueing up with a tile spade when the excavation was finished. The actual time required for various operations is shown in the following table: (Size of silo 15½ foot top width, 8 foot bottom, average 7 foot excavated depth, two 20 foot sloping runways at ends).

Item	No. of Hours
Road Grader	2
Plow	6
Fresno (5 foot)	21.5
Slip scraper	16.5
Killefer (deep tillage tool)	1
Two-way plow	2.5
Man labor	116
Tractor	60
Fuel	62 gallons
Oil	4.5

Advantages of Sloping Side Walls

The side walls of the trench silo are generally sloped about one foot inward for each four feet of depth whether or not

FIG. 6.—A small wheel type road grader proved very useful in removing dirt near the walls. Very little hand work was necessary in finishing the walls.

a permanent lining is used. Several instances have come to attention where one side of the silo was made straight and one sloping. Without exception the greater amount of spoiled ensilage was found next to the straight wall. The advantages of the sloping walls are:

1. Packing of the ensilage is more easily accomplished because tractor, team or truck can get closer to the edge than with perpendicular walls.
2. As the ensilage settles there is less likelihood of air pockets forming, to cause spoilage.
3. There is less likelihood of destructive caving when dirt walls are used without any type of lining.
4. Gives greater stability where masonry or other types of lining are constructed.

Building on Bottom Land or in Sandy Locations

It is not always possible to make excavations to depths of 6 or 7 feet due to high water table or sandy conditions of the soil. Even under these circumstances the trench silo can be constructed with a fair degree of satisfaction. In sandy soils the slope of the side walls may be made much flatter than those shown in the drawing. Successful silos have been built

with walls which sloped one foot or more inward for each foot of depth.

In river bottom lands the excavation might be made 2 feet or less in depth but dirt could be brought in and piled along the sides of the silo to give height to the walls.

Temporary Linings

In one experimental silo a section of the side wall was lined with tough waterproof paper and another section lined with 1 inch boards placed vertically. As far as could be determined neither of these linings could be called worth while. In fact, near the logs at the top of the trench more spoilage resulted from pockets formed when the settling ensilage forced the temporary linings to give way. This was especially true where paper linings were used. The results would, no doubt, have been different had heavier plank been used as described later in this circular.

May Use Unlined Walls For a Year or Two

The unlined, dirt walls of the two trench silos at the College of Agriculture, University of Nebraska, are in good condition after having been filled three times. Some caving has resulted, however, and each year it has been necessary to increase the width by trimming the sides. The trench at the Agronomy Farm can be filled for the fourth time by expending a few hours labor with spades and a slip scraper. At the time it was built this silo had an average top width of 12′ 6″ and a bottom width of 8′ 6″. In July 1933, the bottom width had not changed materially but due to the character of the soil, the top width had increased to 16′ 6″. Almost identical conditions were found at the sheep barn silo.

When unlined, dirt walls are used some slaking and caving may be expected. Before filling time each year, the sides are trimmed to a new cross-section by removing from 3 inches to 6 inches of soil with sharp spades. This increases the size and capacity of the silo but exposes a new layer of earth which will resist the action of the elements for a time.

The answers to a questionnaire sent out by the Department of Animal Husbandry to 68 trench silo users in twenty-one counties indicate that the amount of caving depends largely on the character of the soil. In some instances no trouble was experienced while others reported the removal of as much as 24 inches from the side walls each season in sandy sections. The average thickness removed per season was 6 inches. Of 51 men reporting, 33

found it necessary to trim the walls before each filling while 18 did not. Twenty of these men said that the trench was becoming too wide, while 31 reported that the cross-sectional area was not yet so great as to cause undue spoilage of feed.

Due to difficulty in holding the side walls, trenches built in sandy soils should be lined immediately or after one year's use. If the soil stands well in caves and other excavations about the farm, it should be satisfactory in the walls of the trench without resorting to permanent linings, for several years.

Permanent Wall Linings Eventually Needed

Permanent wall linings are desirable if the trench silo is to be used over a period of years. Constant trimming and straightening soon widens the trench to such an extent that the area of exposed ensilage is so great that it cannot be fed immediately and spoilage results.

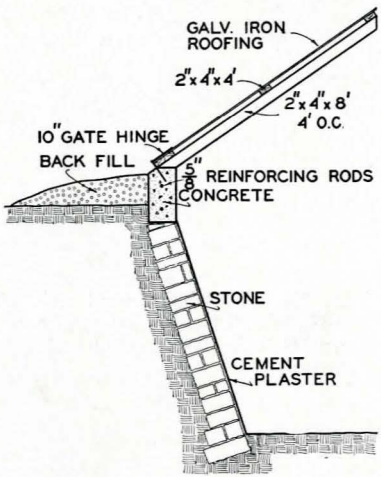

FIG. 7.—If stone walls are used the thickness should be about 12 inches. Two or more coats of cement plaster will give the walls a smoother finish.

There are many advantages to lining the trench immediately after it has been excavated. If the work has been carefully done the walls will then be true and of uniform slope. The cross-sectional area may be made suitable to the needs of the livestock kept on the farm and any additional capacity obtained by adding to the length of the silo.

Too much emphasis cannot be placed on the importance of choosing a location where flood water from higher ground will not cause difficulty. Since proper drainage is so important, it is suggested that all wall linings be carried from 12 inches to 27 inches above natural grade as shown in Figures No. 9, No. 10, No. 11 and No. 12. As dirt is excavated it may be backfilled against the wall to prevent surface water from entering.

As a temporary precaution in the case of unlined trenches, logs or old telephone poles may be staked down to hold the fill as shown in Figure No. 6. A better method

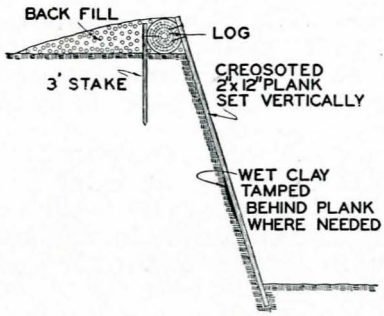

FIG. 8.—Heavy plank linings have met with success, if care is used to exclude the air behind the plank by tamping the space full of damp clay. The plank should be creosote treated.

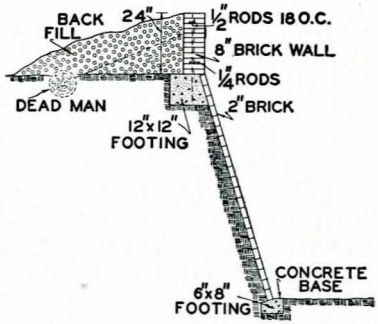

FIG. 9.—A 2-inch brick wall below grade, 8-inch wall above. If reinforcing rods are not used, dead men should be buried at 8-foot intervals.

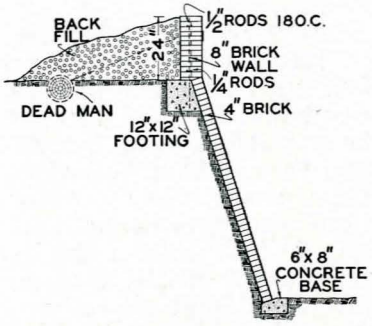

FIG. 10.—A 4-inch brick wall below grade with 8-inch wall above.

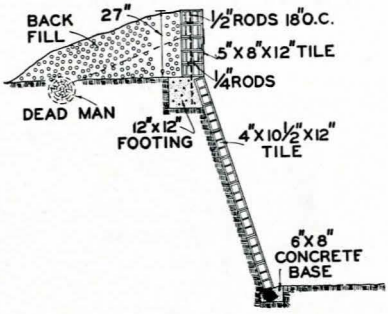

FIG. 11.—A 4-inch wall of 4"x 10½"x12" tile below grade and an 8-inch wall of 5"x8"x12" above.

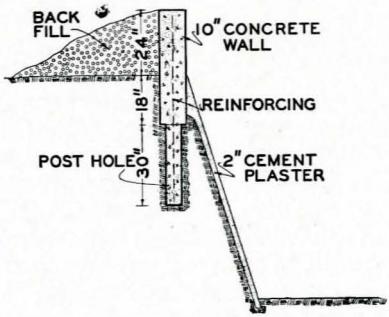

FIG. 12.—A 2-inch plastered wall with 10-inch reinforced concrete wall above.

is shown in Figure No. 1 in which 2"x4" plank are nailed to posts set along the trench and anchored to "dead men" placed under the fill.

Two Inch Plank Lining

While a lining of 1-inch boards, set vertically, did not prove satisfactory in the experimental silos, there is reason to believe that heavier material would serve the purpose very well. The type of construction shown in Figure No. 8 has been used with some degree of success by several farmers in this state. After the excavation is finished and the side walls trimmed to a uniform cross-section, old telephone poles are laid along the top of the trench and attached to heavy stakes. One side of the log is hewn flat to permit a nailing surface for the planks which are set vertically with the lower end buried in the ground.

After the logs are in place, a plank is nailed on with 60d. spikes. If any space remains between the plank and the dirt wall it must be filled with wet clay and thoroly tamped. This treatment is necessary as an air space here will result in spoiled ensilage. After the next plank is in position more wet clay is placed behind it and so on until the wall surface is covered. Cracks between planks must be filled with clay each year at filling time or covered with light bats.

Since the wood is exposed to alternate wetting and drying, decay will soon result. Material which has been thoroly treated with creosote should last many years, however. The logs at the top will also decay unless similarly treated.

Rough Rock Linings Impractical

A number of trench silos with rough rock walls have been constructed in the state but the results have not been encouraging. The rock walls caused too many air pockets during the settling process and too much waste ensilage resulted.

If after the rock walls are laid, two or three heavy coats of cement plaster were applied as shown in Figure No. 7, this difficulty would largely be avoided. The rock lining might well be used up to the ground surface and above that solid concrete would be more likely to give good results.

Plastering Directly on the Earth of Side Walls

Cement plaster applied directly to the dirt has been successfully used for many years in the lining of cisterns and pit silos. Where it is applied in two or more coats to a total thickness of 1 to 2 inches little trouble has been experienced

in well drained soils. It should be remembered, however, that there is a bracing action in round structures which tends to hold the plaster in place which does not exist in long, straight walls of trenches.

No experience has been had with concrete linings of any type at the Agricultural College but the following suggestions are given for those who may wish to try them. Figure No. 12 shows one method of plastering the side walls of a trench silo which has been successful in parts of the state where well drained soils stand well without caving. The plaster is applied in two or more coats until a total thickness of 2 inches or more is obtained. One part of Portland cement, 2½ parts of clean sand and a little lime will give about the right mixture. When the dirt of the wall is dry it should be moistened before the plastering process is attempted and the finished work must be kept wet and protected from the sun for at least a week. Undoubtedly a stronger job of plastering could be had by covering the wall with fine mesh poultry netting but the troweling will be more difficult. There are one or more patented processes of applying cement plaster with a compressed air gun which gives promise of success in the lining of trench silos since the method has given good results when used in large irrigation ditches.

Referring again to Figure No. 12, it will be noticed that a solid, concrete wall 8 to 10 inches thick is used above the ground to retail the back-fill. A wall of this type is constructed at either side of the proposed trench before any excavating is done, by digging a trench 18 inches deep with a tile spade and setting up forms for the part above ground. The wall can be made more stable by digging post holes in the bottom of the trench at intervals of 8 feet and filling these with concrete as the trench and forms are filled. Reinforcing rods made of one or more 1-inch pipes extending from the bottom of the post hole into the wall add to the strength of the whole structure. After the walls have set and the forms have been removed, the trench is excavated and the side walls plastered as described above.

Plastered walls, however, are thin and easily broken if hit with a tractor lug or wheel hub while packing. In some cases the plaster has been carried to the ground surface but has always resulted in failure due to action of frost and damage by stock and machinery.

In event the trench has been used for some years the walls are trimmed and an excavation is made near the top of the dirt wall. A form is set up and the footing and above ground wall run in at the same time.

Experimental Walls in Silo at Sheep Barn

During the spring months of 1933, a portion of the north wall of the silo at the sheep barn was lined with four types of experimental linings. See Figure No. 14. The rough, caved walls were carefully trimmed to a uniform slope as shown in Figure No. 15. Up to the present four sections have been completed, two of brick, one of clay tile and one of monolithic concrete. A fifth section consisting of cement plaster applied directly to the dirt will be in place before filling time. Each section covers a portion of the wall approximately 7 feet long and extends from the footing to a point approximately 24 inches above natural grade.

These wall sections will be watched for several seasons to determine the effect of pressure upon them, how the ensilage settles over each surface, amounts of spoilage on each surface and resistance to weather and mechanical damage of each type of wall. During construction many observations were made. Following is a brief description of each type of wall:

Wall No. 1. See Figure 9.
The sloping surface is covered with brick laid on edge giving a thickness of 2¼ inches. Above grade the wall is 8 inches thick to resist damage. It is reinforced with four ¼-inch rods placed horizontally in the mortar joints and ½-inch vertical rods spaced 18 inches apart.

Wall No. 2. See Figure 10.
This wall section is in all ways similar to No. 1 except that the sloping surface is covered with brick laid flat, giving a wall thickness of 3¾ inches. Reinforcing is the same as above.

Wall No. 3. See Figure 11.
The sloping surface of this wall is laid up with 4″x10½″x12″ clay tile giving a wall thickness of 4 inches. That part above grade is of 5″x8″x12″ clay tile laid flat, giving an 8-inch wall. Reinforcing same as in walls No. 1 and No. 2.

Wall No. 4. See Figure 13.
This wall is of concrete approximately 7 inches thick, reinforced with ⅝-inch rods, 18 inches apart both ways.

Concrete Footings for Masonry Walls.—The construction work on the experimental walls indicates that a concrete footing should be placed at the base as shown in Figure No. 10. It should be noted that this footing has a sloping

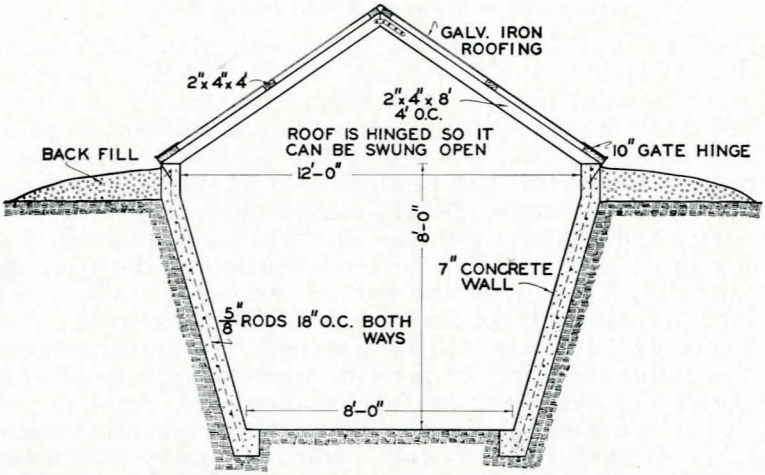

FIG. 13.—Reinforced concrete and other masonry construction give smooth trench linings and prevent caving of the side walls.

surface on top so that the brick work starts at the proper angle. A second footing of about the dimensions shown should be used at the ground surface to support the portion above grade. Either of these footings could, of course, be made of brick or tile. The concrete wall needs but one footing as shown in Figure No. 13.

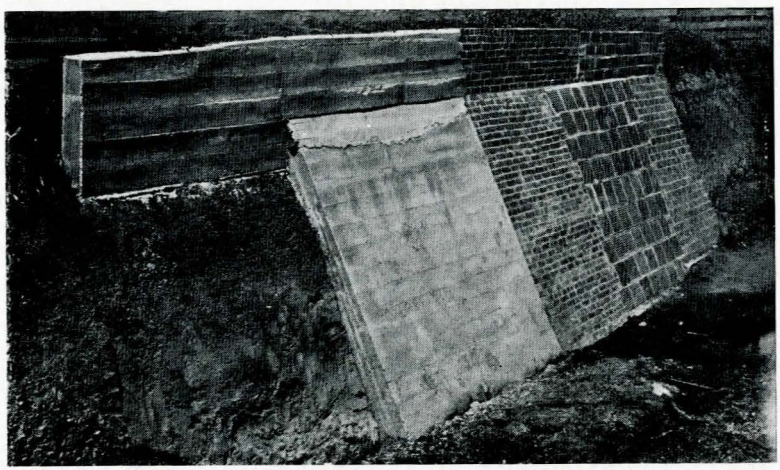

FIG. 14.—The four experimental linings on the north wall of the experimental silo at the sheep barn at the Agricultural College.

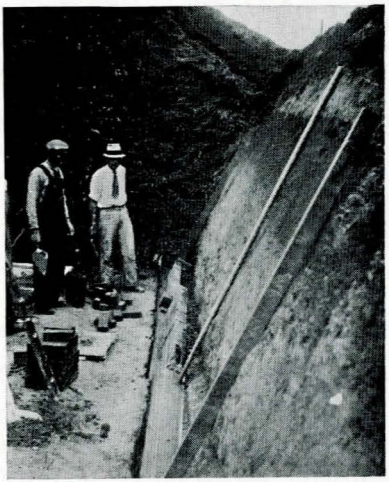

FIG. 15.—A piece of 2″x4″ was used at either side of work to hold the guide strings while laying the experimental walls. Note the sloping concrete footing at base.

Laying Brick and Tile Walls.—If smooth brick and tile walls are to be made, it is necessary that the dirt be trimmed to a smooth surface and uniform cross-section. Figure No. 15 shows the concrete footing and a portion of the wall during construction at the sheep barn silo. Pieces of 2″x4″ at either side were used to hold the guide string while laying brick and tile.

Care should be taken to make the mortar joints carefully to secure a bond entirely around the masonry unit. Smooth walls will allow the ensilage to settle more uniformly.

Even with the most careful job of trimming there will be some uneven places in the dirt wall. As the brick wall was carried upward, wet clay was tamped behind it to fill any hollow spots. Experience indicates that some precautions must be taken to keep rats from working behind the linings.

In laying thin masonry walls the quality of mortar used is very important. In laying the experimental walls, a quantity of hydrated lime was mixed with water to form a putty, just plastic enough to work easily. The mortar was made by mixing this putty with Portland cement and clean, sharp sand in the proportion of **1 part lime, 10 parts cement, and 50 parts sand.**

Reinforced Concrete Walls.—When all or a portion of the wall is to be reinforced concrete, it will be necessary to use forms. It is probable that a thickness of 4 to 5 inches is sufficient for the part below grade but thin walls are not easy to make due to difficulty of tamping concrete in the forms.

It is not necessary that the entire side wall be run at one time. It may be built in sections 8 feet, 10 feet, 12 feet, or 16 feet long, after which the form lumber is moved to the next section. The 2″x4″ uprights are spaced 2 feet apart while shiplap or sheathing is nailed on horizontally with the

smooth side to the concrete. That part of the form below grade must be well braced to prevent spreading. Temporary spacing blocks should be placed between the form and the dirt to preserve the proper wall thickness. That part above grade must be well braced and tied with No. 12 wire every 2 feet of height and at each 2"x4" upright. If the wire twist is made at the corner of the 2"x4" it will hold more securely.

If smooth walls, free from air pockets, are to result. continuous spading is necessary while placing the concrete. A hoe with a straightened blade or a piece of 1"x4" with beveled end is used for this purpose.

For reinforcing, ⅝-inch bars spaced 18 inches apart both ways were used in the experimental wall. This reinforcing was placed before the form construction was started and the vertical and horizontal bars were securely wired together with No. 12 wire so that neither set could shift out of position. As concrete was placed care was used to keep the bars in the center of the wall.

A mixture of one part cement and 5½ to 6 parts sand-gravel was used in the walls. For uniform results which will insure a good wall the following instructions may be followed:

It is known that the amount of water used in mixing greatly effects the strength and water tightness of concrete. For perfectly dry sand-gravel mix 6½ gallons of water with each bag of cement and add enough of the sand-gravel mixture to make a plastic, workable concrete which will easily go into the forms. For moist sand-gravel add 5 gallons for each sack and for wet sand add 4½ gallons per sack.

Trench Silo Linings, Agricultural College, University of Nebraska—1933

BRICK

Wall Thickness	No. Bricks per 100 Sq. Ft.	Material for Mortar 1:10:50 Mix—100 Sq. Ft.*					
		Mortar per 100 Sq. Ft.	Sand lbs.	Hydrated Lime Sacks or Lbs.		Cement Sacks or Lbs.	
2"	450	2.2 cu. ft.	300	.13	6.0	.66	60
4"	616	7.5 cu. ft.	810	.30	15.3	1.70	153
8"	1,232	19.5 cu. ft.	2,100	.81	40.5	4.50	405

* Special Mix for mortar for silo walls or any construction where acid may remove lime from mortar resulting in crumbling. This exposes reinforcing rods to acid action.

CLAY TILE

Wall Thickness	No. Clay Tile per 100 Sq. Ft.	Material for Mortar 1:10:50 Mix—100 Sq. Ft.*					
		Mortar per 100 Sq. Ft.	Sand lbs.	Hydrated Lime Sacks or Lbs.		Cement Sacks or Lbs.	
		5"x8"x12"					
5"	150	4.3 cu. ft.	475	.20	.10	1.00	90
8"	240	9.4 cu. ft.	1,030	.43	2.17	2.17	195
		4"x12"x12"					
4"	100	2.8 cu. ft.	300	.13	6.0	.66	60
		4"x10½" x12"					
4"	105	2.7 cu. ft.	290	.10	5.1	.60	54

* Special Mix for mortar for silo walls or any construction where acid may remove lime from mortar resulting in crumbling. This exposes reinforcing rods to acid action.

MONOLITHIC CONCRETE

Materials Necessary for 100 sq. ft. of wall of various thicknesses.

Wall Thickness	Proportion			
	1 part cement, 5 parts sand gravel		1 part cement, 6 parts sand gravel	
	Cement	Sand Gravel	Cement	Sand Gravel
4"	8.6 sacks	1.6 yards	7.3 sacks	1.60 yards
6"	12.0 sacks	2.4 yards	10.3 sacks	2.43 yards
8"	17.2 sacks	3.2 yards	14.6 sacks	3.25 yards

Trench Silo Filling Not Hard Work

Hard work seems to have connected itself to most silo filling methods. This was undoubtedly true when the heavy green corn bundles were lifted on and off wagons by man power. Corn binders with elevators to place the bundle on the rack have helped this situation somewhat but the appearance of a field type ensilage cutter has removed much of the hard work of silo filling. This machine which cuts the green stalks, chops them into ensilage and delivers it to a wagon drawn behind a tractor, the power take-off of which drives the cutting and elevating mechanism. The field cutter is well adapted to use with trench silos since the loads of cut ensilage can be driven directly into the trench and unloaded. Often strips of woven wire are laid in the bottom of wagon or truck boxes in such a way that the entire load can be rolled out at once by hooking a solidly anchored chain into the

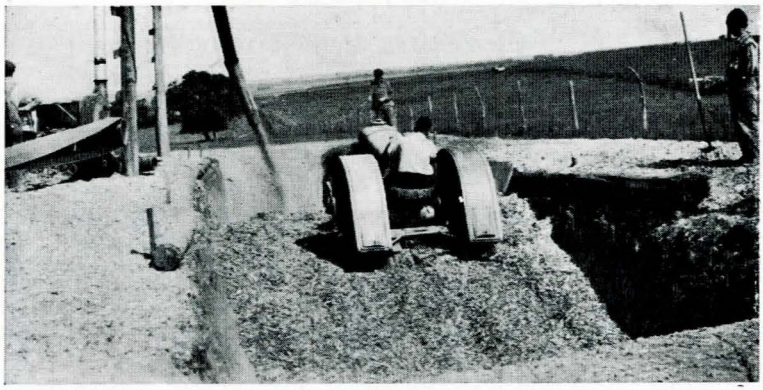

FIG. 16.—Running a light tractor over the ensilage during the filling process proved an effective means of packing.

wire at the front end of the wagon and then driving ahead until the load has rolled clear. Tractors, horses, wagons and trucks are all used to do the packing.

Many farmers are trying to lighten filling costs and lessen the housework of feeding a large number of men by filling over a longer period and using smaller crews. With a small crew the farmer does not need to work early and late doing chores, nor bother with a large amount of exchange labor nor wait too long before filling because all his neighbors are busy. Also, the ensilage has more time to settle and more can be placed in the silo and the corn need not be cut so far in advance of filling as is often true when large crews are used.

FIG. 17.—The cutter may remain in one place. The ensilage is then spread out with a team and scraper.

Whole Bundles May Be Used

During the 1931 crop season several farmers filled trench silos with whole corn bundles and reported that good ensilage resulted. In an emergency the man with no equipment other than a corn binder could store whole corn bundles by packing them cross-wise of the trench in the center but lengthwise near the side walls. The packing and covering must be well done as described for cut ensilage.

Packing Ensilage With Tractor, Truck, or Horses

It has been previously mentioned that a tractor was used to pack the ensilage in the two experimental silos. When care is taken trucks, wagons, horses or combinations of any of these serve very well. Even packing over every part of the trench is to be strived for and the more solid the packing the greater amount of feed stored. Two or three trips along the length of the silo for every load of fodder will do a very good job of packing provided a light weight tractor or equivalent weight is used.

Of the 53 men who answered the previously mentioned questionnaire regarding trench silos, 33 said they used tractors for packing with success, while 10 used teams. In answer to the question as to how they would proceed differently this year from last, 23 of 51 said they would pack the ensilage better and use more water at filling time.

Filling The Silo With Stationary Cutter

When the field cutter is not available the green bundles are ordinarily hauled in and cut with a power operated stationary cutter set at one side of the silo. The ensilage is delivered by means of a distributor pipe to the trench but it may be necessary to set the machine several times in filling a long silo unless some additional means of distribution is used. The entire trench may be easily filled at one setting by placing the machine near the center and using a team with a Fresno scraper to distribute the cut corn. It is allowed to pile up under the distributing pipe until a considerable amount has collected when the team and scraper are used to remove it first in one direction and then in the other. Many farmers who did not have field or stationary cutters used feed choppers and even shredders rather than do without the use of the silo.

Watering Side Walls Did Not Help

When the trench at the sheep barn was filled the suggestion was offered that the soil was too dry on the sides of the trench, that much of the moisture in the ensilage would be absorbed

into the bank and cause undue spoilage. For this reason about 8½ tons of water were added to one side of the feed during the filling process. When the ensilage was removed about the only difference noted was in the per cent moisture content. Very little spoiled ensilage was found on the trench sides except near the top in either experimental silo.

Experience of trench silo users in dry sections of the state indicate that use of water on side walls is beneficial when the dirt is dry at filling time.

Dry Stalks Cannot Be Used

During the 1932 season many farmers were disappointed in the quality of ensilage obtained because dry stalks were cut and put in the silo without the addition of sufficient water. It is important that corn be cut at the right stage if high quality ensilage is to result. When the kernals are just beginning to dent stalks usually contain enough moisture without using additional water. When the stalks and leaves are dry, however, water must be added in great quantities either at the cutter or uniformly sprayed upon the ensilage during the filling process.

Dirt Is The Best Cover

During the past two seasons a covering of from 3 to 4 inches of dirt, placed directly on the ensilage, was used on the silos at the Agricultural College. This earth was placed with a slip scraper and was easily removed as the ensilage was fed. Almost no waste occurred and better satisfaction resulted where dirt alone was used than where a layer of straw was placed between it and the ensilage. Observa-

FIG. 18.—Covering the large silo at the Agronomy Farm with 4-inch layer of dirt after filling in 1932. The edges are first covered to prevent injury to top of wall while scraping.

tions from the field indicate that dirt covers are giving universal satisfaction and are to be recommended. When using slip scrapers care should be taken not to destroy the top of the silo walls. Dirt can be piled over them first to form a protection as shown in Figure No. 18.

Wet Straw or Hay Used for Cover

During the 1930 season, different thicknesses of straw, a single thickness of tough waterproof paper under a layer of straw and straw under a three or four foot depth of alfalfa were used as a covering for the two experimental silos at the Agricultural College. The most spoilage occurred where the paper was under the straw and the least amount was found where the three or four feet of alfalfa was stacked over 12 to 14 inches of straw. Water was thrown on all the straw covering. Probably less spoilage would have occurred at the sides of the top if the straw cover had extended out further. That is, if the top of the trench is 12 feet wide then the covering should be 15 feet or more in width. It often happens that hay is fed at the same time as the ensilage. This hay can often be stacked on the trench as a cover with very satisfactory results.

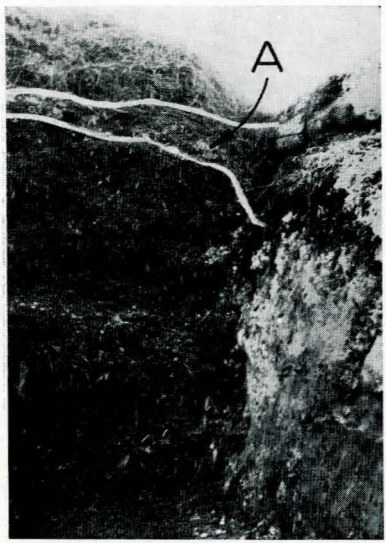

FIG. 19.—Between the two white lines is the zone of spoiled ensilage. It was thickest at "A" due probably to air pockets near the logs and also insufficient cover at this point.

During the 1931 season a 3 to 4 inch dirt cover placed directly on the ensilage was used on one of the silos at the Agricultural College. This earth was placed with a slip scraper and was easily removed as the ensilage was fed. The results were extremely satisfactory as almost no waste was observed, in fact, all of the ensilage of the top was successfully used.

During the season of 1930-1931 when the straw covers were used on the two silos at the Agricultural College, the silage was fed from the end, the thickness of the slab depending on the amount used per day. In each silo the men attempted to work from top to bottom about two times in five days. From 600 pounds to 4,000 pounds were taken out with the only waste being

the spoilage at the very top when the original straw was removed. This waste on the top varies from 4 inches at the middle to 18 inches near the logs at the sides as shown in Figure 19. The total waste can best be shown in the following summary table:

Summary Table

Trench Silo near Sheep Barn, 1930-31

Excavated depth 7 ft., depth from top of logs 8 ft., top width 15½ ft., bottom width 8 ft., two 20 ft. inclines at ends.

Tons ensilage put in silo	114.84 tons
Tons water used	8.66 tons
Total tonnage into silo	123.50 tons
Tons good ensilage taken from silo	99.26 tons
Tons waste ensilage taken from silo	7.19 tons
Total tons taken from silo	106.45 tons
Volume of total ensilage when packed	4,806.9 cu. ft.
Weight per cu. ft. of ensilage taken out	44.29 lbs.
Total cost per silo *	$96.43
Weight per cu. ft. of waste	13 pounds
Weight per cu. ft. of good ensilage	50 pounds
Waste in percentage of tonnage taken out	6.76%
Shrinkage in percentage	13.81%
Average moisture of ensilage put in	72.9 %
Average moisture of ensilage taken out	72.7 %
Average moisture of waste ensilage	63.97%
Average moisture of good ensilage	75.64%

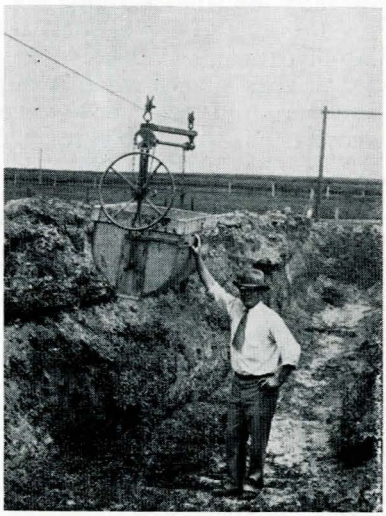

FIG. 20.—A litter carrier may be used to pull the ensilage out of the trench.

Easy to Get Ensilage Out

One great advantage of the trench silo is the ease with which ensilage can be removed. No hoisting equipment is necessary. Where sloping runways are used, it is possible to back a wagon down the incline, fill it with ensilage and haul it to the desired location for feeding. If the trench can be located in a bank as shown in Figure No. 2 it is very practical to use a feed carrier on an overhead track. The track into the silo can be supported on temporary cross pieces which are laid in place as the ensilage is fed further and further back. Another successful method used where the trench

* In finding the total cost of this silo man labor was figured at 35 cents and charges made on all equipment on an hourly basis.

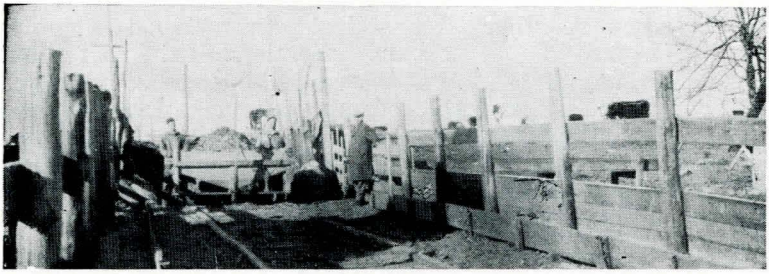

FIG. 21.—Car coming out of the large trench silo in use on the W. A. Apperson farm near Tecumseh. The car runs on rails of 2" x 4" material. It holds 750 to 800 pounds and is eased down the slope with a rope snubbed about a post. The scheme was developed by W. A. White, Apperson's manager and partner.

silo is built in a bank, consists of the construction of a car from the wheels such as are used on a handcar trailer. This car should have sloping sides and hold 700 to 1,000 pounds of ensilage. It can be pushed into the silo, filled and shoved out into the feed lot as shown in Figures No. 21 and No. 22.

Roof Keeps Out Rain and Snow

The use of a roof has certain advantages which cannot be well overlooked. During the warm season rain water can be kept out and the floor kept dry. In winter drifting snow is often a nuisance and a good roof will prevent it from entering where it is not wanted. A cheap and temporary roof for the trench silo can be made by laying poles across, placing brush over the poles and then using a heavy coat of straw or a lighter coat of straw with some earth over it.

Any type of roof to be most convenient should be removable so as to permit driving into the silo with teams at filling

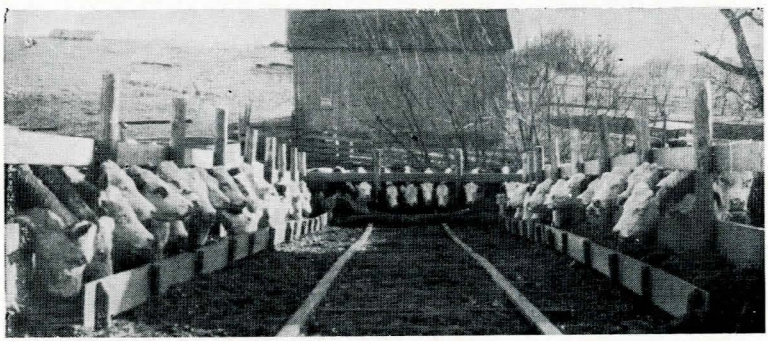

FIG. 22.—The track leads down into the feed lot where 168 head of white faced cows found the silage to their liking in the winter of 1930-31.

time or when feeding. A practical type of construction is shown in Figure No. 13. This shows sections of the roof about 8 feet long hinged at the top of the wall lining and so arranged as to open at the ridge of the roof and lay back on the ground at filling time. Another type is so arranged that whole sections of the roof can be lifted off in 6 foot sections at filling time. For portable roofs where lightness is a factor, frame construction covered with corrugated, galvanized metal is popular.

Snow Fence

Reports from the field indicate that trouble was experienced from snow in many sections. This has been overcome by planting trees or hedges along the north and west or by erecting 6 or 7 feet of solid fence and in some cases by using ordinary slat, snow fence at a distance of 100 feet north and west of the trench.

H. J. Gramlich, Chairman of the Department of Animal Husbandry, adds this comment about—

Quality of Ensilage From Trench Silos

"Trench silos have been used rather extensively for several seasons in Nebraska. Observations made on the quality of the ensilage, together with actual results in feeding the same, have indicated that there is no appreciable difference between the product produced in these silos and that from above-ground units. There doubtless is slightly more waste; however, the quality of the larger part of the ensilage in a trench silo may actually be better than that from an above ground one due to the fact that so thorough a job of packing has been done.

"The past winter has been one which very forcibly brought to the realization of Nebraska stockmen the value of ensilage. With a great deal of snow in corn fields, it was practically impossible to graze stalks to advantage. Likewise, it was very difficult to haul fodder. The problem of getting ensilage out of the silo was relatively simple compared to the handicaps experienced where trying to utilize the products from the field. One big advantage of the silo lies in the fact that ensilage can be fed over a long period. A trench can be opened the first of October and ensilage fed therefrom continually until May 1. If there is some left when pasture becomes available, it would be comparatively simple to cover the exposed surfaces with earth and keep ensilage over the summer.

"The trench silo is not an object of beauty and must look for approbation on a basis of utility. Many Nebraska farmers are experiencing their first use of ensilage as a result of the construction of trench silos. When prosperity again comes to the state, folks will know the value of ensilage and may then consider constructing more permanent and attractive structures in which to preserve their roughage in the form of ensilage.

TWELVE ESSENTIAL FACTS

1. Trench silos can be cheaply and easily built for any desired capacity with tools and labor to be found on most any farm. They are not easily destroyed by storm or fire and there is little danger from poison gases or frozen ensilage.

2. Location should be such that flood water cannot enter and where there is no danger from ground water.

3. Ensilage weighed out of an experimental trench silo at the University of Nebraska Experimental Farm in 1930 weighed 45 pounds per cubic foot. The silo was 8 feet deep, 12 feet wide at top and an 8 foot bottom width. The freshly cut ensilage contained 72.9 per cent moisture and was packed with one trip of a light tractor over the surface per ton capacity.

4. Ensilage is removed from a trench silo from the end in layers like slicing a loaf of bread. If exposed to air too long some spoilage will occur. The cross section of trench should be kept small enough to permit an average of about 2 to 3 inches per day to be fed.

5. Trench silos can be dug with small amount of equipment but for ease of operation and quick construction neighbors may well pool equipment and use two Fresno graders, one plow, small wheel type road grader and two tractors or eight head of horses.

6. One experimental silo with 7 feet of excavated depth, 12 foot top width,8 foot bottom width, the main part of the trench 40 feet long and with a 20 foot incline at each end, was built at the University of Nebraska Experimental farm at a cost of $96.00 figuring 116 man hours of labor at 35 cents per hour and making a charge for all equipment used. The actual cash outlay to a farmer would have been for 62 gallons of gasoline and 4½ gallons of oil.

7. A slope of one foot inward for each 4 feet of depth is recommended for the side walls as it permits ease of packing, eliminates danger of air pockets and prevents caving where dirt walls are used.

8. Temporary lining of plank and tough water proof paper in experimental silos did not prove worth while from the standpoint of preventing spoilage of ensilage. Unlined walls stand well in certain soils. Under other conditions a lining of plastered rock, concrete, brick or clay tile may be necessary.

9. Filling may be accomplished with the least effort by using a field cutter, hauling the ensilage in and dumping it into the pit by driving down the inclines. The unloading may be accomplished by putting woven wire strips on the wagon before loading and pulling these strips out by hooking a rope to them and driving ahead. A cutter and blower may be used at the pit.

10. In so shallow a silo as the trench type, packing is essential to increase the capacity and eliminate the danger of air pockets along the edges. Either teams, trucks or light tractors may be used to good advantage.

11. Coverings of wet straw over which two or three feet of alfalfa hay was stacked gave good results at the experimental silos. Most spoilage occurred where a tough water proof paper was placed over the ensilage and covered with wet straw.

12. A covering of 3 to 4 inches of dirt directly on the ensilage gave excellent results. No spoilage was noted where it was used.

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