A BUNKER SILO

of farm treated native posts & rough cut lumber for Alaska dairy farms

A simple drive-through bunker silo built of treated posts and rough-cut lumber. Materials cost estimate for this 100-ton storage is estimated at less than $500.

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Farm storage of silage is essential in Alaska. Weather conditions make it nearly impossible to dry hay after early July. Economy of construction without sacrificing structural stability has been achieved in this bunker type silo. Locally available materials and simple construction techniques are all that are needed to produce an adequate bunker silo. Braced poles support the walls and absorb lateral loads, with the floor being subjected to simple vertical loading. Silos of this type serve the beginning dairy farmer until he is financially able to provide more convenient storage wherein less spoilage may be anticipated.

A BUNKER SILO FOR ALASKA FARMS

THE silo described here is one of several at the Matanuska Experiment Station Farm. It is a low-cost, horizontal, above-ground bunker of approximately 100 tons capacity, built in 1955 and used every year since then.

The structure is essentially two parallel rows of braced posts sided with 2-inch planks. All wood was cut locally. A sufficient number of poles were sawed at a local mill to obtain the required amount of 2-inch rough lumber. Local mills will commonly saw timber for half of the rough lumber yield. All posts were cut green and treated immediately with water soluble chemicals to prevent deterioration.

BASIC DESIGN—The silo consists of 22 sets of posts and braces. Posts were originally cut 12 feet long and set in the ground 2½ to 3 feet to provide an 8-foot sidewall. Their tops were later marked with a chalk line and cut off even. Four-foot spacing of posts eliminated additional bracing and support for the 2-inch rough lumber walls.

Walls slope outward two feet on each side making the top width 20 feet, for a floor width of 16 feet. This greater than normal slope is allowable in this design since all overturning forces on the walls developed in packing or settling are carried easily by the braces.

A minimum top diameter of six inches is required for posts and five inches for braces. Braces may be attached to posts by spikes or bolts. No foundation or footings are needed since the post and brace design is self supporting. It has a high safety factor so that construction methods or materials are not critical. Either cottonwood or spruce may be used for sidewall materials. Cottonwood is recommended for posts and braces since it is generally considered a lower value wood for other structural uses and is easier to treat with chemical preservatives than spruce.

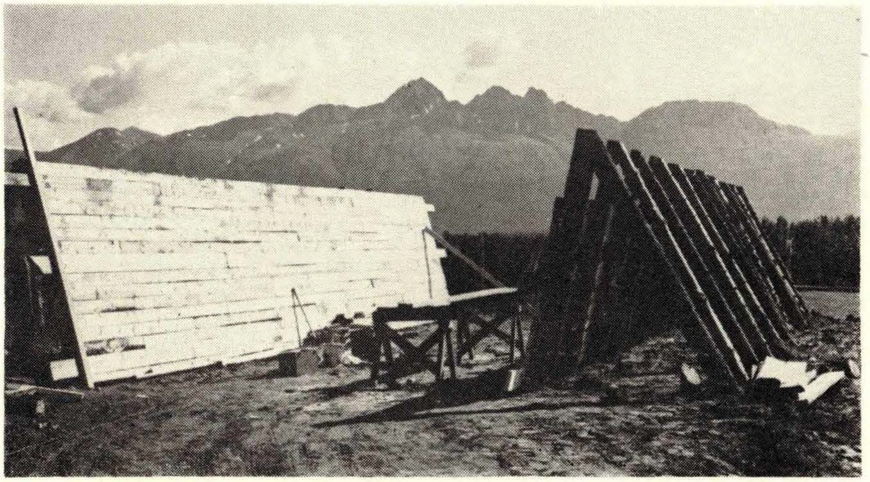
Chemical preservation of posts and braces is essential if the silo is to have a reasonable service life. Commercially pressure treated posts and poles are not yet readily available in Alaska, and even when they can be purchased they are relatively expensive. The cost of pressure treated poles is from 75c to $1 per linear foot while the cost of chemicals for treating the poles at home is only 10 to 15 cents per foot. For the 528 feet of poles in the silo a considerable savings can be realized by home treatment. An explanation of a farm method for treating freshly cut green poles is appended.

SELF FEEDING—Time and effort are saved by allowing cattle to feed themselves. Feeding from the bunker is easily accomplished with a self-feeding gate.

While self feeding on an earth floor causes considerable mess and waste in the bottom of the silo it is a possible temporary expedient. A concrete floor can be installed later when funds are available. Silage quality is not impaired by an earth floor but feeding or mechanical removal of the silage is wasteful and difficult. Self-feeding a milking herd on an earth floor is unsatisfacory because of excessive dirt picked up by the cows' udders. Fewer problems are encountered when feeding young and dry stock.

CONCRETE FLOOR & APRON.—Silo floor slabs should be 4 inches thick and contain 6 x 6 welded wire mesh of number 9 gauge in both directions to prevent cracking. Even though thickened margins are not a structural requirement of the slab, its life will be lengthened by increasing the thickness to about 8 inches near the edges. A 12-inch wide thickened area around the outer edge of the floor slab requires an additional 1⅓ yards of concrete over the 8 yards needed for the entire floor.

At least six inches of compacted gravel fill is needed under the slab to provide drainage and to aid in maintaining uniform thickness during pouring.



Construction view showing arrangement of posts, braces, and rough lumber sidewall.

The silo floor must slope a half inch per foot downward towards the feeding end, and a quarter-inch per foot from the center toward the walls. Many floors are built with a small drainage groove down each side of the silo, made by imbedding a beveled 2 x 4 in the concrete when poured. The 2 x 4 is removed while the concrete is green. A dry well can be provided to catch silo drainage collected by these grooves.

A feeding apron at one or both ends of the silo protects the area from heavy cattle traffic and prevents development of mud holes. It also provides a solid place for cattle to stand when the silo is first opened. A 4-inch 10 x 24 foot slab with thickened edges requires 3.7 cubic yards of concrete.

Concrete estimates listed are exact amounts for the slab thickness specified. If all dimensions are not accurately controlled more concrete may be required.

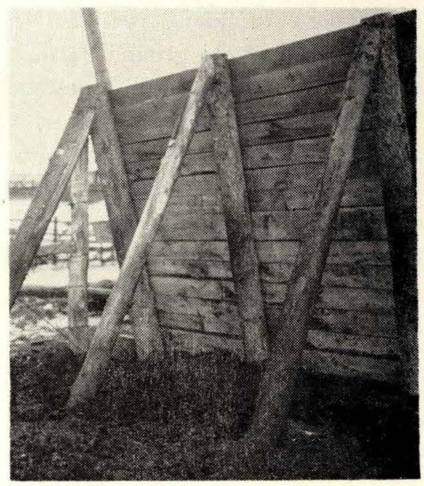
SILO CAPACITY.—Farm silo needs are determined by the size of the herd, the amount of silage fed daily, method of feeding, and length of the feeding season. Silo width is governed by filling methods and equipment, and method of feeding. For uniform packing with a tractor the silo must be at least twice the tread width of a four-wheeled tractor or 1½ times the width of a three-wheeled tractor. If silage is to be self-fed with free access, allow at least six inches of silo width per head of stock. Feeding from both ends of a silo is often practical.

Walls less than six feet high increase the proportion of spoilage because of the shallow depth. Silos with walls higher than 8 feet are more difficult to fill and feed.

Well packed grass silage weighs between 30 and 40 pounds per cubic foot. A high producing cow may consume as much as 80 pounds or two cubic feet a day when it is the only roughage. When some hay is fed throughout the winter the required silo capacity is proportionately less. A feeding season of about 240 days is common in Alaska. Average seasonal needs are therefore about 10 tons per head, the required volume ranging from 480 to 570 cubic feet per animal. Lighter milking breeds than Holsteins and young stock need somewhat less.

In warm weather it is best to feed at least four inches from the silage face each day to prevent spoilage. Very little warm weather occurs during the winter feeding season in Alaska so a smaller amount can usually be fed. About two inches per day is a practical minimum.

For the 240-day feeding period a 40-foot long silo will furnish 2 inches per day, and an 80-foot silo will furnish 4 inches per day. Somewhere in this range is probably the best length for most Alaskan dairy farms. Long narrow silos must be fed from both ends because of the requirement for 6 inches of feeding width per animal. Wider silos are more economical on a cost of materials per ton basis. Greater depth is also a relatively inexpensive way to reduce silo building costs. In the pole design longer sidewall poles can be used to allow a 10-foot wall. The braces should not contact the posts any higher than in the 8-foot silo. Farmers who can overcome the



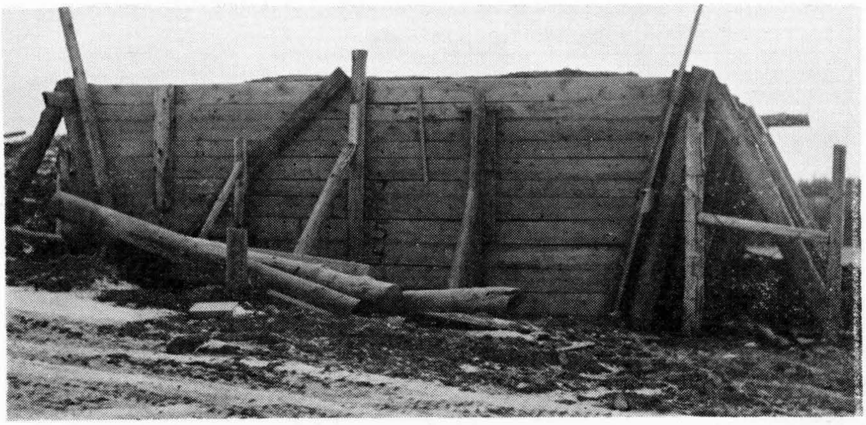
Supporting members are simple and sturdy.

additional loading and feeding problems resulting from greater depth will find it initially more economical.

Things to remember when deciding silo size are these—

- It must be at least 40 feet long for all year feeding.
- An 8-foot depth is best unless there are good reasons for choosing differently. A 6-foot depth reduces the cross section for small herds, and a 10-foot depth is more economical to build.
- The width in feet must be at least half the herd size for self-feeding. Extremely wide widths present problems in filling and in self-feeding but are more economical to build.
- When silage weighs 35 pounds per cubic foot, 57 cubic feet weigh a ton. Ten tons or 570 cubic feet are needed by a typical Holstein cow. Available space as well as management practices and economics of each individual farm must be considered before the best size can be determined.

Green rough lumber shrinks to form wide cracks (arrow). Cracks are sealed by lining walls with plastic or moisture proof paper.



End walls are removed so trucks can drive through silo during first part of filling. Boards are numbered so they can be replaced in the same position each time.

Suggested silo sizes for various herd sizes are listed below. Other combinations of dimensions can be used to give an equivalent capacity. Examples in the table are not recommendations of the best size but merely show possible solutions to a given problem.

ENLARGING A BUNKER.— Bunker silos can easily be adjusted to changes in herd size, although space limitations may demand a second silo in another location rather than adding to an existing structure. With certain management practices or larger herds it is often advantageous to feed from two silos at one time. It is often desirable to keep young and dry stock in different locations than the milking herd so that two silos are a definite asset. On the other hand one large silo is more efficient from a standpoint of losses than two smaller ones. Additional capacity, can be gained by adding length or width to an existing structure.

Depth of silage in any bunker should not be less than the wall height since the extended walls catch snow and rain which leach out nutrients. Bunker silos must always be sufficiently filled so that the settled silage is slightly higher than the walls. Partial filling is best arranged by reducing the length.

FILLING. — Filling is most efficiently done with dump trucks or hydraulic dump wagons unloading inside the silo. It is possible also to adapt equipment for filling vertical silos if it is available and dumping equipment is not.

A wheel tractor with front end loader or small crawler with dozer is ideal for continuous packing. A considerable amount of additional packing is attained by having the silage trucks or tractors drive through the silo each time they are unloaded. Too much packing is unlikely. Driving over the silage is faster than backing into the silo for dumping.

In 1959 excess earthfill from a building site was placed along one side of the experimental silo so that trucks can dump directly over its sides. This aids in final filling and packing near the ends of the silo because full-depth end walls can be used and even the final packing can be done with a tractor. Under most conditions it is more practical to leave one end sloped so the tractor can be driven off the silage.

Suggested dimension of 8-foot deep bunker or trench silo for herds of various sizes to be fed from this storage.

Number of cows	Width of — Bottom	Top	Length	Face area	Feeding rate
		Feet		Feet²	In/day
10	16	20	40	144	2.0
	12	16	52	112	2.4
15	12	16	76	112	3.8
20	16	20	80	144	4.0
25	16	20	100	144	5.0
30	16	20	120	144	6.0
	24	28	84	208	4.1
40	16	20	160	144	*4.0
	20	24	132	176	6.6
	24	28	108	208	5.4
50	16	20	200	144	*5.0
	24	28	136	208	6.8

***Silage removed from both ends each day.**

SEALING—Proper sealing is essential for satisfactory preservation. Several suitable materials are readily available. Black polyethylene plastic 4 mills thick in wide widths is probably the most adaptable material. Asphalt filled paper or other similar water resistant products are also suitable if available at lower cost than plastic.

Sheets are placed vertically on the walls and held in place with wooden strips. These sheets are cut long enough that they reach from the floor to the top of the wall and then drape over the top 2 or 3 feet on the outside. This extra length at the top is later folded over the silage to make a lap seal with the covering material. Walls are ordinarily made from green wood which dries leaving cracks, making a good sealing job mandatory.

MANAGEMENT.—It is possible to make excellent silage in a bunker. In any silo some spoilage is expected. In a horizontal silo spoilage can be reduced by good management, keeping in mind the following requirements—

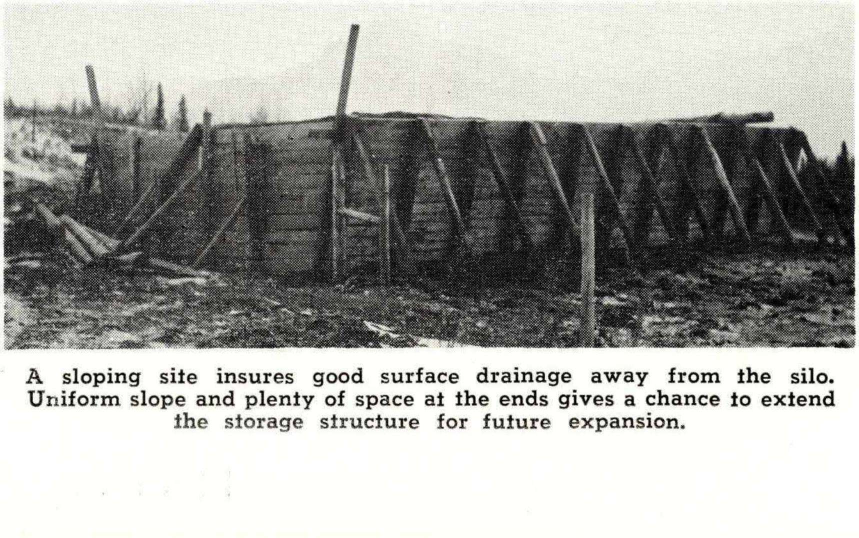
- The silo must be well lined with an airtight waterproof material and silage must be covered to permanently exclude air.
- The silo must be so situated and constructed that seepage can drain away.
- Materials placed in the silo must be of good quality, that is at the proper stage of maturity, free from excessive dirt, sticks, weeds and other foreign material.
- All silage must be properly packed to exclude air and reduce internal spoilage.

The top cover may be the same as the lining material. It need not be heat sealed, but all sheets must overlap sufficiently to prevent air leakage. The cover must be weighted to keep it from blowing away or otherwise being damaged. Several inches of wet sawdust is recommended, but four inches of soil has been used with reasonable success. Frozen soil is difficult to remove. Sawdust may blow away when it dries. Piling material such as old tires, bales of spoiled hay, planks or logs on top of the sawdust keeps it in place. Surplus military camouflage netting is also useful for several years.

CHOOSING A SILO—Horizontal silos have a lower first cost than upright silos, although the annual cost of sealing materials and the loss of silage from spoilage must be considered. Availablility of capital is a controlling factor in a farmer's choice. Assuming adequate amounts of capital, the labor requirement of a system is then most likely to dictate the choice of a storage structure. Advantages and disadvantages of building a bunker silo compared to other types of silos are listed below.

ADVANTAGES OF BUNKERS

- Bunkers can be located with less regard to terrain and sub-surface drainage than trench silos.
- Bunkers can be built almost entirely with farm materials and labor.
- Their cost is less than for an upright silo.
- Bunker silos are adaptable to self-feeding when this management practice can be used.

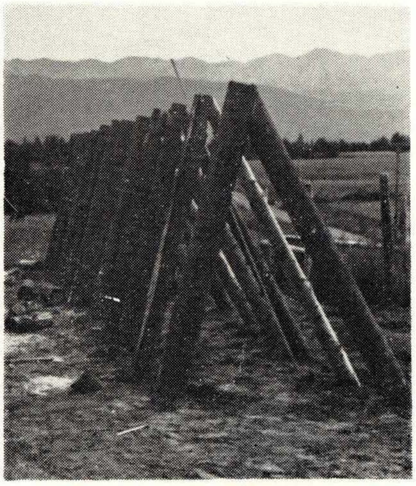


A sloping site insures good surface drainage away from the silo. Uniform slope and plenty of space at the ends gives a chance to extend the storage structure for future expansion.

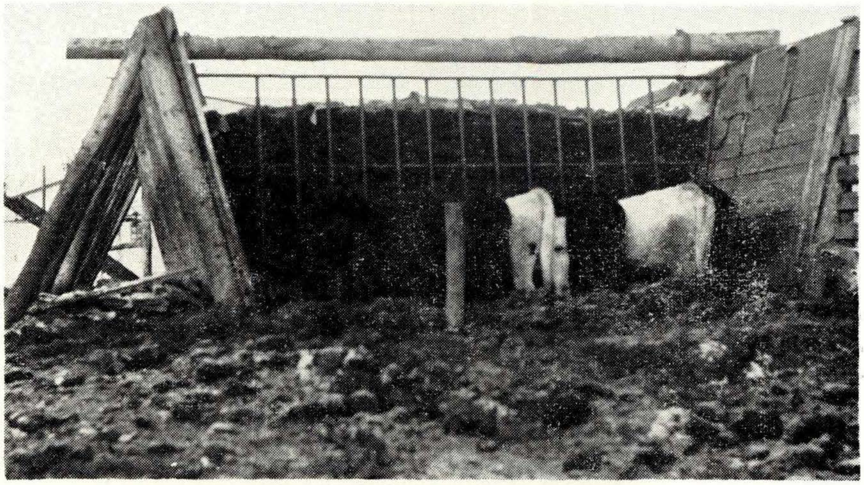
- Bunkers are also adapted to mechanical feeding with a tractor mounted front-end loader, or a horizontal silo unloader and self-unloading wagon.
- They are readily adjusted to changes in herd size.
- A major portion of the eventual cost can be deferred by adding the concrete floor at a later date.
- Footings and foundations are not needed.
- Less expensive equipment can be used for filling and feeding than for upright silos.
- When constructed with treated materials a long service life can be expected with minimum maintenance except for annual sealing.
- All materials are available locally so that construction can start shortly after the decision to build.
- Farm labor can be used in constructing a bunker silo, allowing a farmer to effectively utilize any excess labor to reduce cash costs.

FAULTS OF A BUNKER SILO.

- Top spoilage in bunker silos is greater than in upright silos.



Close-up of post, brace and side-wall details.



Young stock self-feeding through a welded $1\frac{1}{2}$-inch movable pipe gate. Heavy pole keeps stock from pushing the gate ahead. Pole is moved each day to ration out feed.

- Removing the top cover and spoiled silage is a continuing operation while silage is being fed.
- Because of their shallow depth, silage must be carefully distributed and packed to prevent excessive spoilage.
- The cover must keep out rain and melting snow to prevent leaching, and air to prevent spoilage.
- Unless a roof is provided or the silo is self-fed, feeding is disagreeable during inclement weather.
- Bunker silos are not adapted to to completely automatic push button feeding.
- There is an annual expense for the cover and lining materials.
- Some freezing will occur next to the walls and at the surface.

REQUIREMENTS FOR ANY SILO.—Regardless of the type of silo certain general requirements must be satisfied. These apply to the characteristics of the building site and determine the labor needed for filling and feeding. Here is a partial list of the most important—

- Building site must be well drained. A paved feeding area improves the utility of the silo.
- The silo must be accessible both to feeding areas and to fields.
- Space is needed for maneuvering machinery during filling and unloading.
- A silo should be chosen that has the lowest yearly cost over its expected service life and yet has a first cost within the financial means of the farm.

Arrow shows top of silage above top of wall. Filling above walls keeps snow from collecting on top.

- Annual cost of spoilage in a poor silo must be considered.
- The silo should be sized to meet anticipated needs. Horizontal silos can more easily be enlarged at a future date than vertical silos.
- An approved plan assures structural soundness.
- The cost of additional farm equipment that must be purchased should be considered in deciding on the type of silo.
- Materials and labor costs should be calculated before a decision is reached.

MATERIALS LIST.—All materials used in the bunker silo are locally available. Material costs must be calculated for each individual silo on the basis of the actual farm situation. A column for actual cost is included in the materials list so it can serve as a work sheet. Cash costs can be reduced by cutting and treating poles on the farm, trading logs for rough lumber at a local sawmill, and by mixing concrete at home.

Chemicals, nails and 2-inch rough siding costs about $250. Cost of poles must be figured by the individual who obtains them. Cutting poles on the farm is advantageous because only that number easily treated in one day need be cut.

Lining and covering material costs depend on the material selected. Black polyethylene makes a good seal and can be used for both sidewalls and the cover but it must be replaced every year under ordinary usage.

TREATING POSTS

Unprotected cottonwood and spruce posts rot at the ground within five or six years. Their life

MATERIALS FOR AN 18 x 20-foot BUNKER SILO 40 feet long

Number	Item	Total cost for item: Estimated	Actual
POSTS & LUMBER			
22 each	Posts 12-feet long with 6-inch tops, 262 feet	$ 26.20	$ ________
22 each	Posts 12 feet long with 5-inch tops, 262 feet	23.58	________
1230 fbm	2-inch random width rough lumber @ 100/m	132.00	________
320 fbm	2-inch rough lumber in 10-foot lengths, ends	32.00	________
NAILS & CHEMICALS			
15 lbs	10-inch spikes	3.75	________
30 lbs	20 penny nails	7.50	________
100 lbs	copper sulfate (blue virtriol)	35.00	________
100 lbs	sodium chromate	40.00	________
SEALING MATERIAL			
1 roll	20 x 100 feet of 4 mil black polyethylene*	34.00	________
TOTAL for materials excluding concrete floor and aprons		$334.03	$ ________
CONCRETE FLOOR & APRON			
7.9 yds	concrete (640 square feet 4 inches thick) @ $33	$260.70	$ ________
1.3 yds	concrete (12-inch thickened strip around edges))	42.90	________
640 sq ft	6 x 6 number 9 welded wire reinforcing mesh	40.00	________
3.7 yds	concrete (10 x 24-foot feeding apron)	122.10	________
240 sq ft	6 x 6 number 9 welded wire reinforcing mesh	15.00	________
TOTAL for floor and apron		$480.70	$ ________
GRAND TOTAL for concrete-floored bunker		$814.73	$ ________

*This is an annually recurring item. Sidewall lining takes 640 square feet while top cover requires 800 square feet. Remainder is needed for overlap. Other lengths and widths may be used.

Labor cost ranging from $200 to $400 may not require cash-out-of-pocket expenses if the farm operator does all the work himself.

can be doubled and sometimes trebled by treating them with chemical preservatives, at a cash outlay of about 20c a linear foot. This is much cheaper than pressure creosoted timbers. In situations where spring and summer labor needs are slack, some farmers may earn a good wage by treating their posts at home. Many others are already overwhelmed by work. To them the necessity of cutting posts is an added chore, unless they can hire cheap dependable labor or divert some family labor to the task.

Cheap chemical preservatives are water soluble. A neat trick to get an effective amount inside the wood is to let capillary activity suck it in. Capillarity in a growing tree is most active when its spring sap flows. To take advantage of this force, posts must be cut after late April and immersed in preservatives the same day, while their wood cells are alive. Posts cut in the summer soak up solution more slowly.

One of the best methods of insuring long life is to dunk the posts first in a solution of copper sulfate, then in a second solution of sodium chromate. As the second chemical is drawn into the wood, it reacts with copper sulfate to form an insoluable compound that is only slowly leached away. Here is one method for treating fifty 12-foot posts—

- Knock the tops out of two 55-gallon steel drums, one for copper sulfate the other for sodium chromate. Bury them in the ground at a convenient spot near where the bunker is to be built. Set up a sturdy A-frame or tripod suspending a husky block about 10-feet above the top of the barrels so that 12-foot posts can be raised and lowered into the drums with tractor rather than muscle power. All this can be done in the fall.

Paint the inside of the drum to contain copper sulfate with roofing tar to keep the sulfate solution from corroding through the steel.

- Suitable posts may be located and marked during the winter. A total of 50 will be needed, each 12-feet long. Half should measure six inches at the top, the other half five inches. Butts measuring 8 or 9 inches are satisfactory.

- When spring sap starts flowing the posts are cut each day and carried to the treating site. Peel the bark from the bottom two feet of their butts. They must be immersed in copper sulfate the same day to take ad-

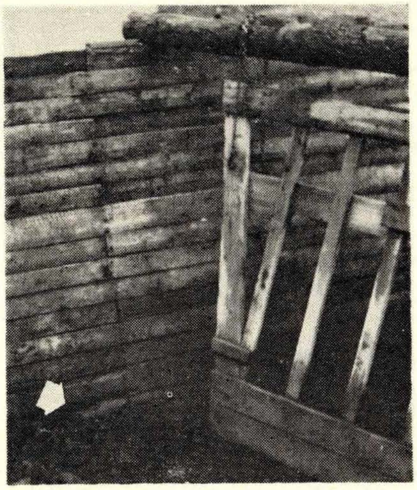
MEASURING CHEMICALS

Easiest way to measure chemicals is by volume. Since quantities are usually specified in pounds and the volume weight of bulk chemicals differs with their physical characteristics, a handy means of converting pounds to volume is needed. Here is one way to do it—

1—Cut the top out of a No. 3 fruit juice can. Remove label, wash and dry can.
2—Place on household scale and note weight.
3—Fill with exactly one pound of copper sulfate.
4—Shake surface level and mark position of surface on outside of can.
5—Mark around can with scotch tape and cut can off at this height.
6—Check by scooping up level canfull of copper sulfate and weighing. With a little practice, each canfull will weigh one pound.

Because sodium chromate is a little heavier, it requires its own measuring can. Label each with a crayon or wax pencil so they can be easily reidentified. Volume measures for any other quantity may be similarly prepared. For best exactness, the height of the volume measure must equal or exceed its diameter.

Arrow points to snow accumulation on top of silage, caused by settling after filling below top of walls. Filling to greater depth helps shed snow. Concrete floor and feeding apron eliminates soggy footing.



Arrow points to rotting boards at bottom of wall caused by excessive moisture. Muddy floor can be improved by pouring cement slab.

vantage of capillary activity in the live wood. In an emergency, butts may be covered with damp burlap for not more than a day before treating.

- Dump 9 pounds of copper sulfate into the tarred drum. Add 12 gallons of hot water and stir until the crystals are dissolved. If only cold water is available, the sulfate may need a day to dissolve with frequent stirring.
- When the copper sulfate has dissolved, three freshly cut posts, their butts peeled, are immersed in the solution. The tripod supports them so they do not topple and uproot the drum.

The bottom half of these posts have an average volume of about two cubic feet. Each cubic foot needs a half pound of each chemical for good protection. Most cottonwood or poplar posts will absorb $1\frac{1}{3}$ gallons of solution (or a pound of chemical for each two cubic feet to be preserved) in one or two days in early spring. Two days are needed in summer. Spruce soaks up chemicals more slowly.

- Nine pounds of sodium chromate are slowly poured into 13 gallons of cold water with constant stirring in the second drum until dissolved.
- After the batch of three posts has soaked up a total of four gallons of copper sulfate perhaps 24 to 48 hours after first immersing them—they are transferred to sodium chromate solution where they remain another day. Each must soak up about $1\frac{1}{3}$ gallons of chromate. They are then removed and leaned butt end up against a building for a few days.
- While the first three poles are soaking in chromate, another three freshly cut unpeeled posts are immersed in copper sulfate. The solution is replenished by adding 3 or 4 gallons of fresh solution made up in the same proportions.

By continuing this process of treating three posts a day, 50 posts may be preserved in four weeks or less. More time is required in summer when life processes within the wood have slowed. Treatment time can be halved by doubling the drum capacity, using two drums of sulfate and two of chromate at the same time.

Another way of treating posts may prove easier in some situations. Instead of standing them upright in a drum, small individual rubber containers can be fastened to the butts of posts inclined in a more-or-less horizontal position. Individual containers can be improvised from old truck tire inner tubes large enough to slip over the post butt. Here is a brief explanation of this method—

- Eight or ten freshly cut posts are laid out with their tops on the ground and with their butts supported and elevated on another post lying at right angles.
- Eight inches of bark must be peeled from the butt of each

Poles supported in a rack for treating by the "tire-tube" method. Oil drum holds treating solution. Bucket and scales are for measuring chemicals.

post. The exposed peeled wood is heavily greased, half of an inner tube is slipped over it, and a watertight joint is made by wrapping the tube with several turns of soft iron wire. The loose end of the tube is suspended with wire to a rack or horse and serves as a container for preserving solutions.

- Pour in each tire tube container 3 gallons of copper sulfate solution, made by dissolving one pound of copper sulfate in $1\frac{1}{2}$ gallons of hot water. Most spring cut posts will absorb a gallon of this solution in one day.

- After 3 gallons of sulfate have been absorbed, empty any excess remaining in the tube—it can be saved for the next set of posts. Then pour in 3 gallons of chromate solution made by dissolving one pound of sodium chromate in $1\frac{1}{2}$ gallons of cold water. A gallon of chromate is usually absorbed the second day. Save the remainder for the next set of posts.

When the preservative treatment is completed, treated posts may remain where they are to dry. In the meantime a second battery of 8 or 10 can be prepared and treated.

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