THAWING SILAGE IN UPRIGHT SILOS[1 2]

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In the September-October, 1955, issue of the Bimonthly Bulletin, a report was given on the use of flax straw as an insulating material to prevent silage from freezing in upright silos. As that report stated, the results of two years of work indicated that the insulation did not prevent the silage from freezing.

When these results became apparent, a study was started on other methods of controlling frost without insulating the silo. For the past several years many types of electrical heating devices for thawing frozen silage have been tested. An attempt has been made to develop a satisfactory device for thawing a layer of silage at the surface so it could be removed easily from the silo with a fork. Such a device could eliminate the use of a pick for loosening the silage and could reduce the time required to fork the silage down from an upright silo.

Heating Cable Covered With Loose Silage

The first attempt at thawing silage so it could be removed without using a pick was done with heating cables placed over the frozen silage at the edge of the silo and the cables then covered with loose silage for insulation.

Commercial 400 watt, 115 volt soil heating cables were used. One had a lead coating for protection, as shown in Fig. 1. It was enclosed in flexible conduit for these tests to reduce possible risks of fires. The second had a neoprene (rubber-like) coated cable of the type used for protecting water lines, as shown in Fig. 2. A 60 or 80 foot length of soil heating cable was laid along the outside 6 to 8 inches of the silo and doubled back so it would cover 12 to 20 feet of the circumference of the silo. This cable was then covered with 4 to 8 inches of loose silage, the heating element was turned on, and the frozen silage below the soil heating cable thawed.

The neoprene coated heating cable was difficult to manage. If doubled back across itself, the insulation would fail and the heating cable would short out. Insulated wire was used to form a series of spacers to produce a grid of neoprene covered wire as shown in Fig. 2, but even this grid was difficult to handle, the cable in this grid failed. The lead covered cable enclosed in conduit did not present this problem.

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[1] Progress report on the present North Dakota Research Project Hatch 4-3R, preceding North Dakota projects, and North Central Regional Project NC-23.

[2] Part of this report is based on a thesis entitled, "A Study of the Effect of Silo Wall Insulation on Silage Freezing and of Methods of Thawing Frozen Silage," submitted by Arthur H. Schulz to the graduate faculty in partial fulfillment of the requirements for the degree of Master of Science, North Dakota Agricultural College, June 1, 1953.

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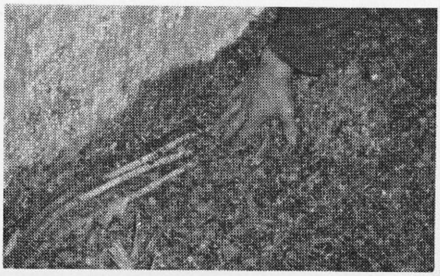


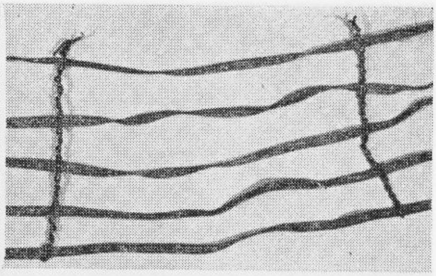


FIGURE 1.—*The lead covered cable installed within flexible conduit laid under loose silage for insulation.*

FIGURE 2.—*The neoprene covered heating cable held in a grid with twisted insulated wires.*

When the silage was warmed for a period of time, the silage around the cable would thaw and dry out. This dried silage then acted as an insulator and reduced the efficiency of the heating cable.

The results of the first of these tests, conducted in a silo without a roof where frost had penetrated 24 inches from the wall and under weather conditions of continuous below-zero temperature, were totally unsatisfactory. Later tests were conducted in a closed silo. Temperatures varied from below zero to about +5° F. and the frost had penetrated the silage to a thickness of 16 to 24 inches. A depth of thawing of silage of about three inches was produced.

At below zero temperatures there was little or no thawing along the outside wall. These later tests, although not successful, seemed good enough to warrant further study. It was felt that heating cables attached to the underside of blankets filled with commercial insulation would be more convenient to handle than cables placed under loose silage.

Flexible Insulated Blanket and Soil Heating Cable

Several types of flexible insulated blankets were assembled. These blankets consisted of an acid-proofed industrial fabric covering two double thick blankets of fiberglass insulation. A 400 watt, 115 volt neoprene covered soil heating cable was attached to the underside of the first blanket assembled. This neoprene covered soil heating cable failed in use and was later replaced by a 400 watt lead covered soil heating cable encased in flexible conduit.

The blankets were built to fit approximately a 15 foot sector of the outside 20 to 24 inches of the silage surface. They were designed to be moved around the circumference of the silo to provide thawed silage for each day's feeding. Figure 3 shows a blanket in position for thawing. The end of the blanket is turned up to show the soil heating cable.

FIGURE 3.—*The insulated blanket with the lead covered wires enclosed with flexible conduit and attached to the blanket.*

The heating units were left on continuously during the first part of the trial with the result that considerable drying occurred along the underside of the blanket. A 12-hour operating period per day reduced this drying effect and retained the same depth of thawing.

Tests were conducted using both soil heating cable covered with loose silage and the same type of cable attached to the underside of insulated blankets. The tests were run at the same time in the same silo.

Both assemblies gave similar results, thawing from three to five inches of silage per day.

The power required for the heating cable under the insulated blanket was 4.05 kilowatt-hours per day, as compared with 4.17 kilowatt -hours per day for the heating cable covered only with loose silage. No statistical analysis was made between the two tests, but the differences in the power required were probably not significant.

The fabrics were relatively resistant to deterioration from acids at temperatures of 165° F. However, temperature at the surface of the heating element rose to as high as 208° F. where it was in contact with the insulated blanket or dry silage. There was also a tendency for the heating cables to embed themselves into the blanket to the point where they were fully encased in fabric.

These high temperatures, combined with the acid condition of the silage, caused deterioration of the blanket covering to appear shortly after the units were placed in use. At the end of three months the blankets had deteriorated beyond use. Figure 4 shows the type of deterioration that occurred. This blanket was used in a silo where the frost had penetrated 14 to 18 inches in from the wall. The average kilowatt-hour consumption on one test extending from Jan. 5, 1953, to Mar. 5, 1953, was 5.23 kilowatt-hours per day.

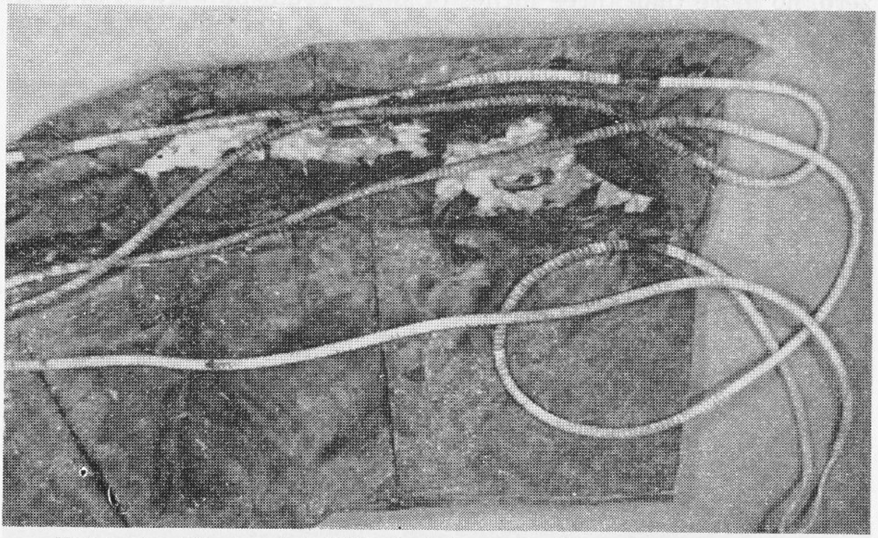


FIGURE 4.—*The insulated blanket shown in fig. 3 after deterioration had taken place.*

Rigid Heating Cable Panel

A commercial silage heating panel was tested, consisting of a 400 watt, 115 volt, 60 foot length of soil heating cable attached to the underside of a "Masonite" presdwood board 14 inches wide. The units were 10 feet long and were cut to fit the outside edge of a silo, as shown in Figs. 5 and 6. Loose silage or an insulated blanket could be placed over the panel to contain the heat. This panel provided a convenient method of moving the soil heating cable around the silo.

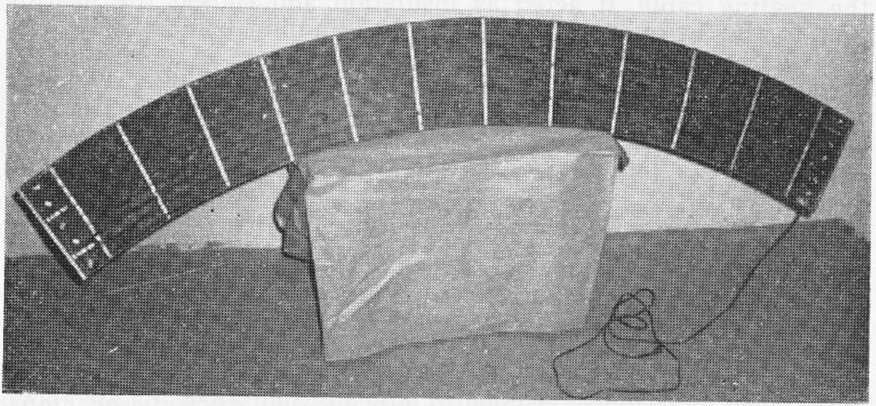


FIGURE 5.—*The commercially made silage heating panel. Neoprene covered heating wires are attached to a "Masonite" board.*

This panel thawed the silage satisfactorily to a depth of about three to five inches when the outside temperature was zero. Below zero, no more than three inches of silage could be thawed in a 12-hour period. Noticeable drying of the silage immediately adjacent to the soil heating cable was observed.

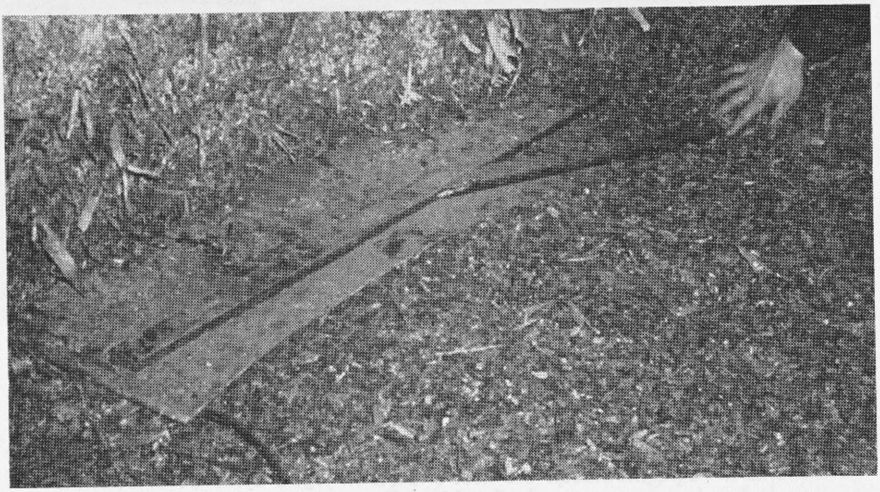


FIGURE 6.—*The same heating panel as fig.* 5 *installed in the silo. The unit is covered with loose silage for insulation.*

The rigidity of the board caused some difficulty in getting the board to fit smoothly against the outside wall of the silo. This resulted in the formation of a ledge of frozen silage along the silo wall. The frozen silage needed to be picked out occasionally.

Early in its operation, a test panel ignited and burned completely. Several other reports were received of similar failures of these commercial rigid panels when the heating elements were left on continuously. It was theorized that, as the silage dried below the heating cable, it acted as insulation and caused the heating unit to rise in temperature above the kindling point of silage or the rigid panel. This difficulty was overcome by reducing the period of operation of the heating element to not over 12 hours at one time. Satisfactory thawing was also obtained in this shorter operating time, but drying below the panel still seemed to prevent penetration of the heat.

Insulated Movable False Ceiling

Since the heating cables caused drying when in contact with the silage, and since satisfactory materials for blanket fabrication were difficult to obtain, it was felt that less drying would take place, and insulating materials could be kept away from silage acids, if an air space were left between the heat source and the silage. Past experiences seemed to indicate that when the air above the silage was warmed to temperatures as low as +40° F. satisfactory thawing would occur in the silage. This was noted when the sun's radiant heat warmed the silos. Warm air escaping from barns through the silo chute and into the silo gave similar results.

A movable false ceiling, shown in Fig. 7, was installed in a silo and heat was applied under this ceiling. Two inches of fiberglass insulation were installed on top of the canopy. Two 400 watt lengths of soil heating cable controlled by a thermostat set at 45° F., plus two 150 watt incandescent bulbs to provide both heat and light were installed on the underside of the canopy to maintain a uniform temperature between the canopy and the silage. The entire assembly was supported from an overhead girder by means of a rope and pulleys. A windlass was installed to raise and lower the canopy. The plan of operation was to lower the false ceiling to within a few inches of the silage during the day and to raise it enough to permit removal of the silage whenever necessary. The silo doors were kept closed at all times, except when silage was being removed.

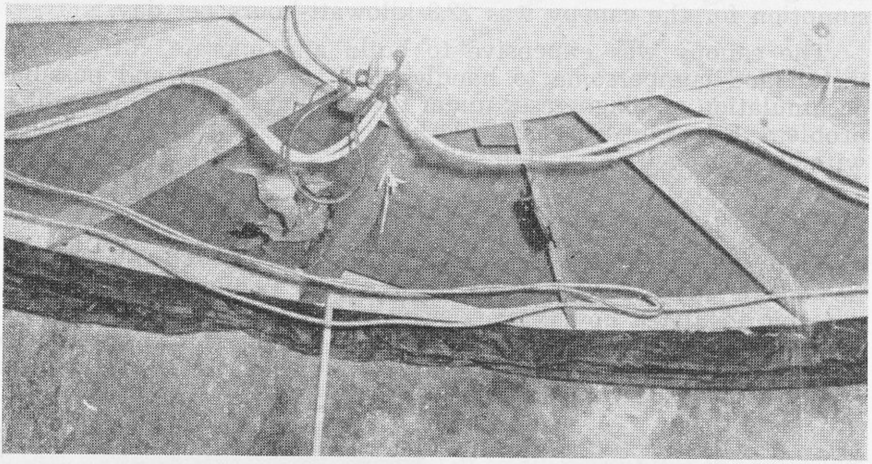


FIGURE 7.—*The insulated canopy installed in the silo above the silage.*

Many difficulties were encountered in the assembly of this unit in the silo. Its weight made it cumbersome to raise and lower. Slight irregularities in the diameter of the silo, in addition to the flexibility of the canopy, made a tight seal between the rim of the canopy and the silo wall difficult to maintain. One-half inch sill sealer was installed between the rim and silo wall to help overcome this difficulty.

At this stage of the test, silage removal had reached the level where insulation had been added to the outside of the silo. Since the canopy was difficult to raise and lower and the outside of the silo was insulated, the canopy was left in a raised position approximately six feet above the silage and the entire air space under the canopy was heated. The test was started after frost had penetrated the silage about 14 inches in from the silo walls.

The silage was removed from this silo at the rate of about three inches per day, without using a pick. Since the entire surface of the silo was thawed, the three-inch section was adequate for a day's feed. The depth of thawing varied according to outside temperature, but at no time or at no place along the outside edge of the silo was the silage thawed less than three inches, or more than five inches. Even when temperature under the canopy dropped below freezing at some time during the day, enough silage was thawed to permit feeding the usual feed without having to pick the silage loose.

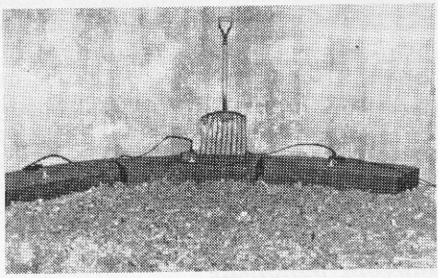
The farmers' reactions to this installation were very favorable. The farmers appreciated that no picking was necessary. They also felt that the canopy made working in the silo much more comfortable than when working in an open silo, as all drafts were eliminated and a favorable air temperature was maintained.

The period of this test, from Feb. 21 to Mar. 4, 1952, represents typical North Dakota winter conditions. During this period the average temperature was +5.2° F. The average daily energy consumption for the canopy was 22.8 kilowatt-hours per day.

The canopy was expensive to build and operate, difficult to install and cumbersome to handle. Lack of oxygen and possible accumulation of silage gases under the canopy could also present a problem. For these reasons, this heating device was discontinued without testing it in an uninsulated silo.

Portable Insulated Heated Hovers

Since the insulated false ceiling seemed to indicate that a heated air space provided reasonably good results, several small portable insulated hovers were designed and tested in an attempt to get the results of the false ceiling in a unit that was easy to handle. The most satisfactory design developed to date is illustrated by Figs. 8 and 9.



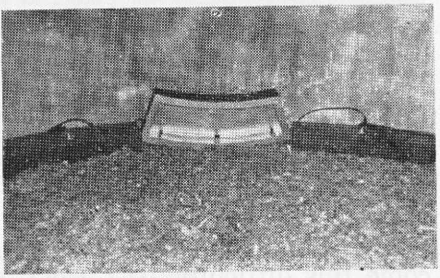


FIGURE 8.—*The portable insulated heated hovers installed in a 16 foot silo. The unit on the right is the master unit with thermostat. The other units are plugged into it.*

FIGURE 9.—*The same units shown in fig. 8 with the one unit turned up to show the two 60-watt lumiline bulbs.*

Figures 10, 11 and 12 show the details of constructing the units. These units were 4 feet 2 inches long, by 15 inches wide, by 6 inches high, and curved to fit the silo wall. The units were designed on a

15 foot diameter, which makes units that fit silos with diameters from 14 feet to 16 feet. A wood framework was constructed of 1 inch x 2-inch wood strips. The arcs for this framework were cut on a table saw with an 8-inch blade. The units were lined on the inside and outside with ⅛-inch tempered "Masonite" presdwood.

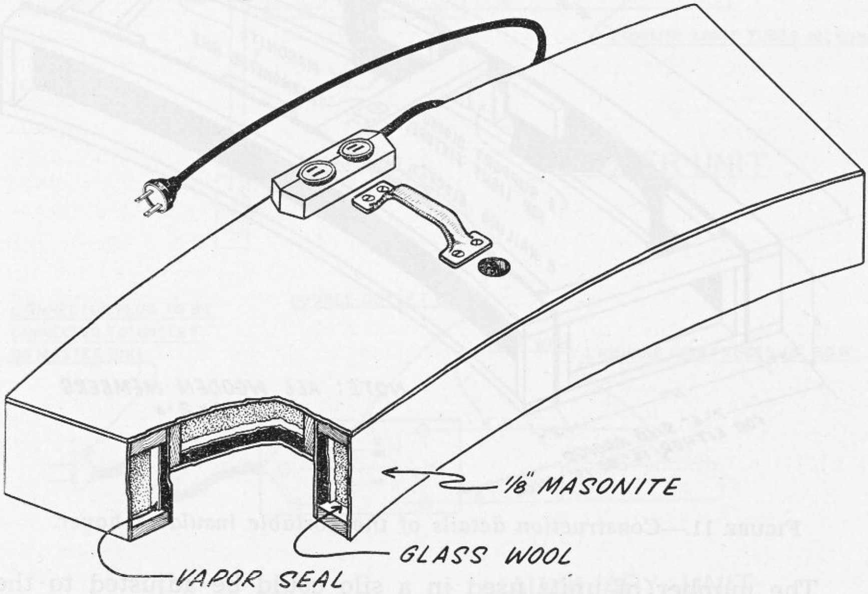


FIGURE 10.—*A line drawing of the portable insulated hover.*

Glass wool insulation filled the cavity formed between the Masonite walls. A vapor seal was installed on the inside surface as shown in Fig. 10 to prevent the insulation from becoming wet. The size of the unit was such that it could be moved into and out of the silo through the silo chute. Two 60-watt lumiline light bulbs were used as a heat source in each unit. These bulbs are similar in shape to fluorescent tubes, but are of an incandescent type. They were selected for their compactness in size, ease of replacement and because they are less likely to short circuit than is a soil heating cable.

The size of the hovers was kept to a minimum to expose less hover surface and to reduce the heat losses. The small sized unit was also easy to handle.

It was possible to operate up to six units on a regular sized thermostat. Hence, a master unit was provided with a thermostat and five other units were plugged into this master unit. Some thermostats corroded rapidly under the conditions found under the hovers, so a special enclosed-type thermostat, such as a Fenwal, Model 8A, No. 17,200, eliminated this problem.

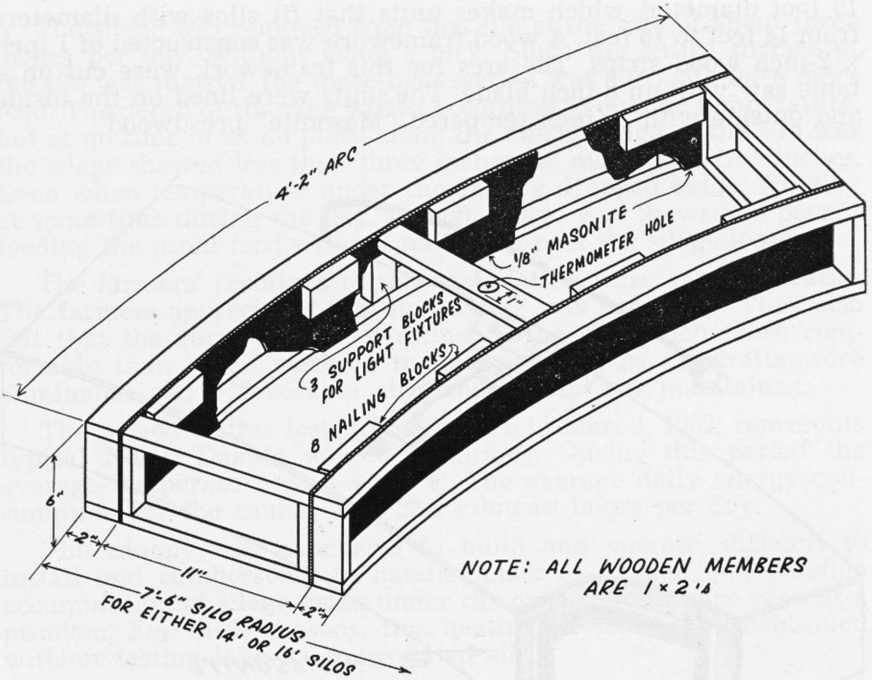


FIGURE 11.—*Construction details of the portable insulated hover.*

The number of units used in a silo could be adjusted to the quantity of feed needed each day. The units were installed around the outside edge of the silo and operated for one day with the temperature controlled by the automatic thermostat. When feed was removed the units were moved around the silo so they could be placed in position for thawing the succeeding day's silage. In this way, one set of units was moved around the silo from day to day to provide a continuous supply of feed.

The amount of thawing obtained ranged from none at the outside wall to three to five inches at a distance of four inches from the wall. The maximum depth that could be expected was five inches. In many cases it was still necessary to loosen some silage with a pick, but the thawing was sufficient to make it an easy job when compared to the work required in unthawed silage.

It was observed that good results were obtained with air temperatures under the hover of up to 100° F.; but at temperatures over 100° F. the drying effect on the surface of the silage retarded the thawing.

In a test from Dec. 22, 1954, to Mar. 31, 1955, the electrical consumption for an assembly of six units was 539 kilowatt-hours or \$13.48 at the 2½ cent rate. The average daily energy consumption was 5.5 kilowatt-hours at a cost of about 14 cents per day.

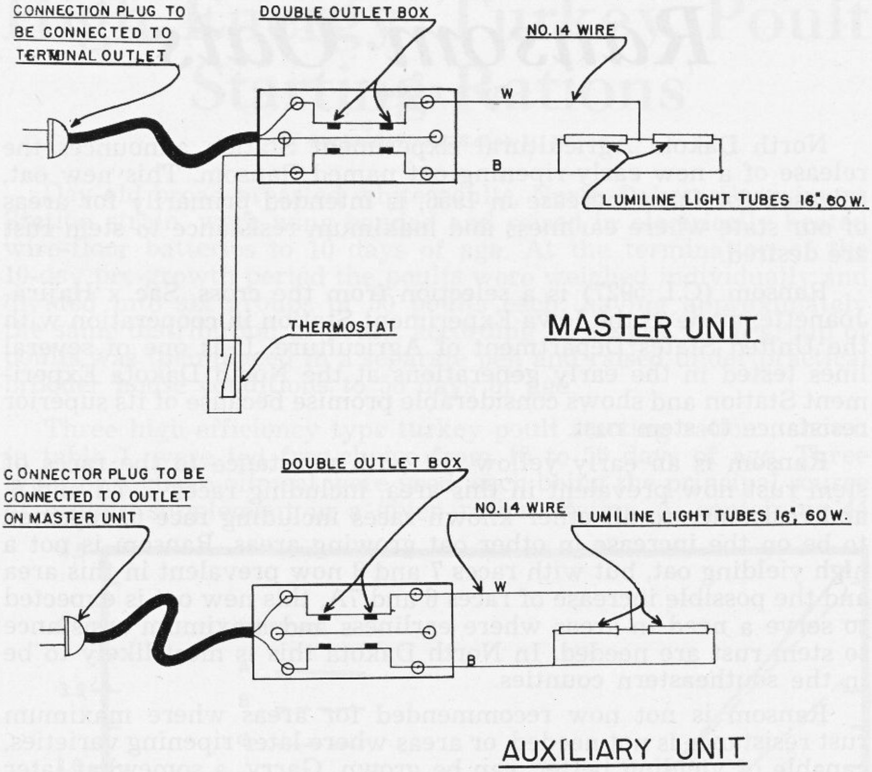


FIGURE 12.—*Schematic diagram of the wiring for the master unit and the auxiliary units of the portable insulated hovers.*

SOYBEANS LEAD IN VALUE OF PRODUCTION PER ACRE

Soybeans brought the greatest dollar return per acre of the grain and oilseed crops in North Dakota on the average during the past five years, according to the USDA Agricultural Marketing Service. Corn for grain ranked second, followed by flax, hard wheat, durum, barley, rye and oats.

The five year (1951-55) average value of production of **soybeans** was $33.79 per harvested acre. Values ranged from a low of $31.75 per acre in 1952 to $36.12 in 1954.

Grain corn averaged $31.99 per acre in the past five years and ranged from $30.60 to $34.06. The five year average return per acre of **flax** was $26.20, with a range from $21.14 in 1954 to a high of $31.11 in 1951. **Hard wheat** brought a five year average of $25.49 per acre while **durum** averaged $24.19. **Barley** returned $22.73 per acre while **rye** and **oats** brought $19.94 and $16.02, respectively.

Soybeans also brought the highest dollar return per acre harvested in three out of five years. The exceptions were in 1952 when corn exceeded soybeans and in 1955 when dollar returns from both hard wheat and durum ranked higher. Since soybeans and grain corn are grown chiefly in about the same general area (the southeastern corner of the state), returns from these crops are not strictly comparable with those grown statewide.

The value of production per acre was obtained for each crop by multiplying the state average yield per acre harvested by the season average price per bushel.