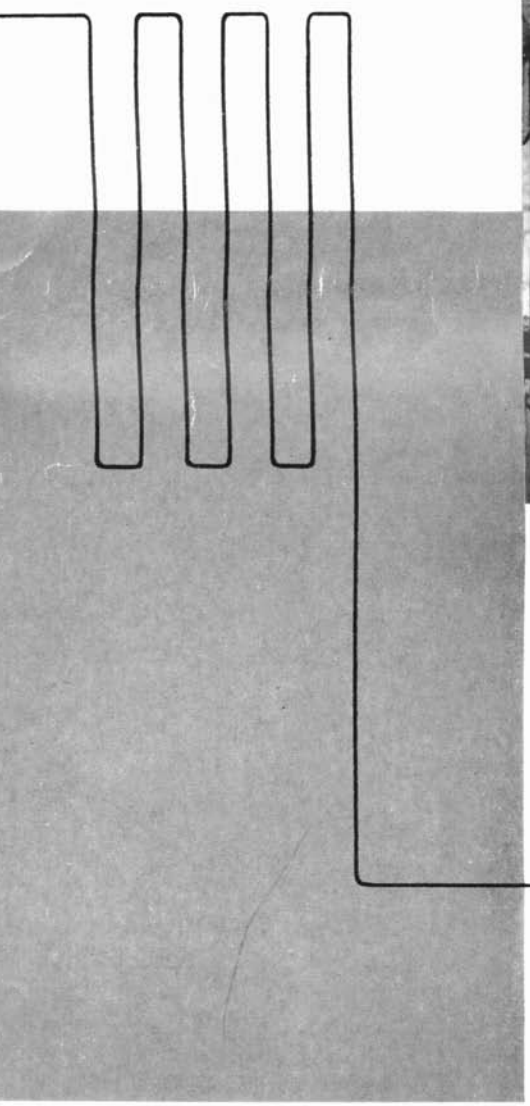
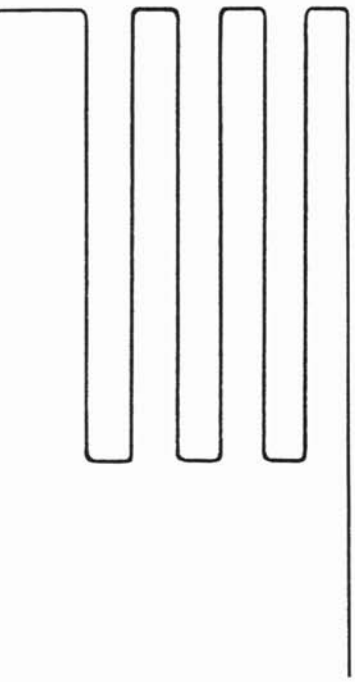
ELECTRIC HEATING CABLE FOR SWINE

By A. J. Muehling and D. R. Daum



CIRCULAR 830

UNIVERSITY OF ILLINOIS · COLLEGE OF AGRICULTURE
EXTENSION SERVICE IN AGRICULTURE AND HOME ECONOMICS



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AN INCREASING NUMBER OF ILLINOIS FARMERS are using electric heat in the floors of their farrowing houses. Electric heat is installed by embedding electrical-resistance wire directly in concrete floors or slabs. This wire is usually referred to as "cable," although it often consists of a single conductor.

This circular discusses the installation of electric heating cable for farrowing systems. Other applications of electric heating cable include melting snow and removing ice from walks and driveways, and heating work areas.

Electric underfloor heat has many advantages. Some of these are —

1. Safe operation. Because of low operating temperatures, there is no fire hazard.

2. Uniform heat at proper location. The heat is evenly distributed over the heated area. It is produced where it is needed.

3. Easy temperature control. The heating units are easily controlled with thermostats.

4. Easy installation. Cable is embedded in the floor while the concrete is being placed.

5. Requires no extra space. The cable in the floor is out of the way, and no overhead fixture is necessary.

6. Little maintenance. The permanent nature of the installation eliminates nearly all maintenance.

7. Air composition is unchanged. No oxygen is taken from the air, and there is no smoke, soot, fumes, or products of combustion.

8. Cold-room brooding. The temperature of the air in the building is considerably lower than the temperature of the heated area. This condition provides comfort for both sow and litter.

9. Protection against temporary power failure. The floor will maintain a comfortable temperature for several hours in case of a power outage.

10. Economical operation. Thermostatic control applies the heat only when required.

Electric heat in concrete floors also has some disadvantages. These are —

1. Permanent installation. Once the units are installed, they cannot be moved from one location to another.

2. Prolonged power outage. This may not be serious because the power suppliers today are equipped to make fast repairs and restore service quickly.

3. High initial cost. The initial cost of installing electric heat may be higher than that for other types of heat.

Types of Heating Cable

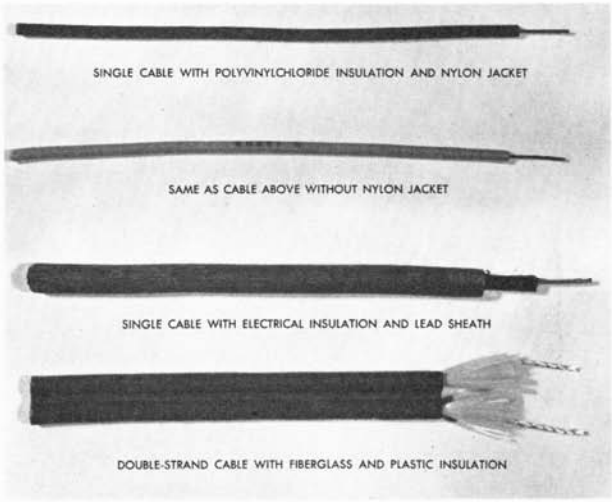
There are many types of electric heating cable. Single-strand cable is simply a small resistance wire covered with electrical insulation. Multiple-strand heating cable, also called "heating tape" or "ribbon," is made up of two or more strands of resistance wire bonded in the same strand of electrical insulation. The wires are spaced parallel to each other in the tape, but are electrically insulated from each other. This multiple-strand arrangement usually results in higher wattage per lineal foot of cable.

The cover on the cable may be lead, rubber, asbestos, nylon, or polyvinylchloride. Some typical examples are shown in Fig. 1. Experience has shown that coverings of nylon or polyvinylchloride give the best results with cable embedded in concrete. Lead sheath cable should not be used in concrete unless special care is taken to prevent direct contact between the lead sheath and the concrete.

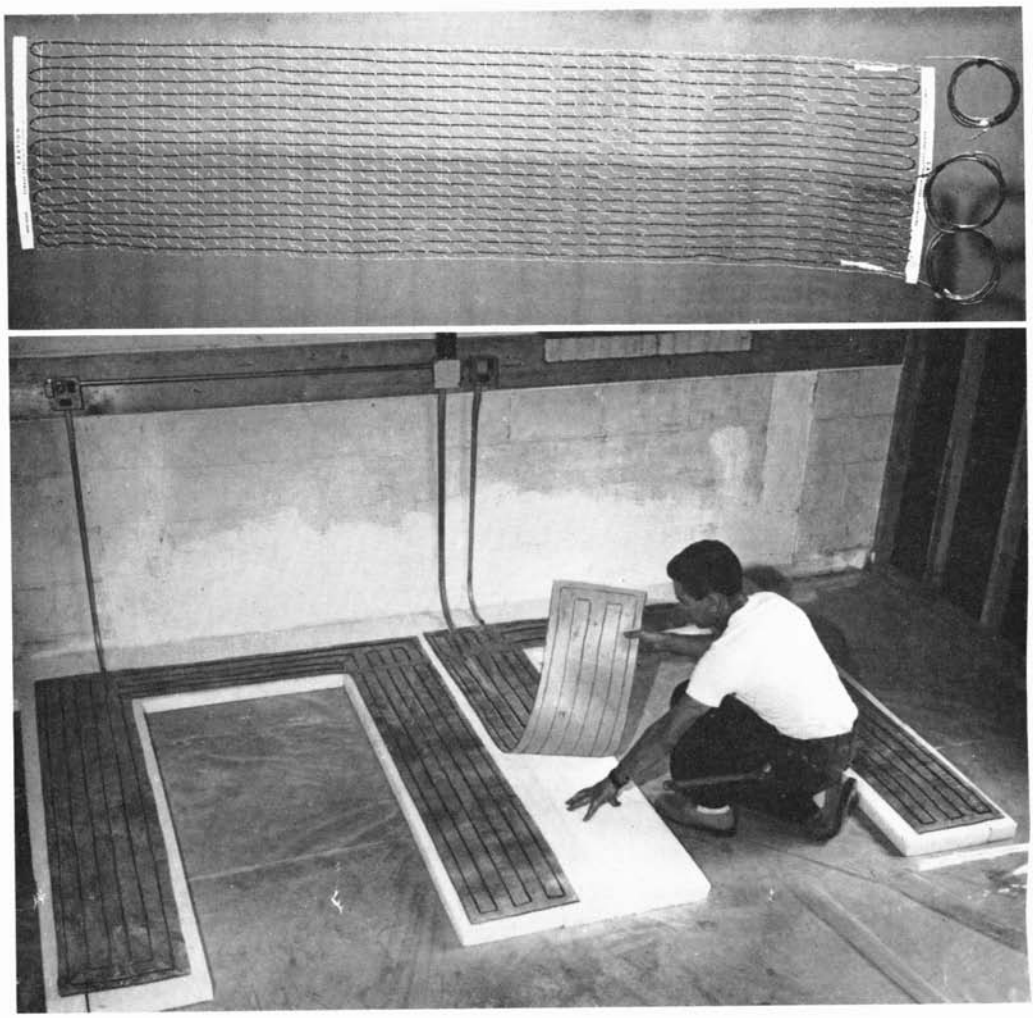
Heating-cable units are rated for either 115 to 120 volts or 230 to 240 volts. A cable must be operated at rated voltage to obtain rated wattage.

The wattage rating of heating cable varies from one manufacturer to another. Typical cable lengths, wattages, and voltages are shown below. The higher wattage units usually operate at the higher voltages.

Length of cable (feet)	Wattage	Voltage
40	200	120
53	275	120
80	400	120
105	525	120
160	800	120
80	400	230
160	800	230
320	1600	240
400	2000	240



Typical heating cable. **(Fig. 1)**



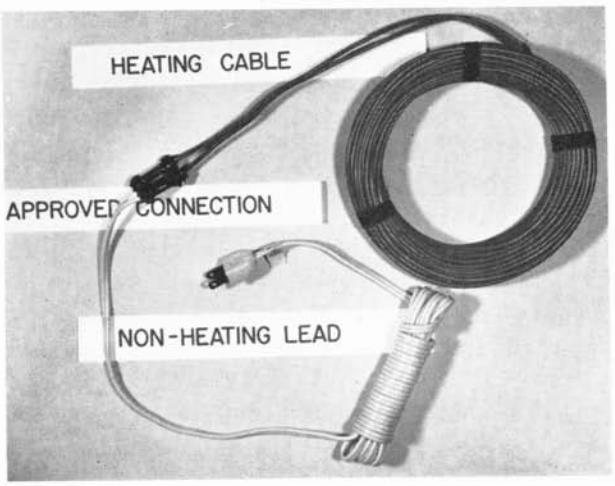
Commercial prefabricated heating units. Above, heating cable attached to poultry netting. Below, heating cable sandwiched between sheets of plastic (photo courtesy of Raehco, Springfield, Illinois). (Fig. 2)

In addition to the cables, prefabricated heating units are available. These units are mats assembled by the manufacturer for direct burial in concrete. One type of prefabricated unit consists of single-strand cable attached to 18-inch-wide poultry wire netting. It is available in various lengths for various applications. A typical example is a cable rated at 3.5 watts per foot spaced at one-inch intervals, giving a watt density of 42 watts per square foot of heated area. Another prefabricated unit has single-strand cable sandwiched between two sheets of plastic. This unit is made especially for use with farrowing crates, and is available with watt densities of 30 and 40 watts per square foot. It is possible to purchase this unit as a complete package, including thermostats, switches, and necessary conduits. Examples of these two types of units are shown in Fig. 2.

A non-heating lead at least 7 feet long should be factory attached to all heating cable (Fig. 3). The cable should not be spliced except when absolutely necessary, as, for example, in the case of a broken cable. *Never* change the length of the heating cable.

Planning the Heating System

In Illinois, the cable should be spaced to provide a watt density of 30 to 40 watts of electrical heat per square foot of heated-floor area. In the colder areas of the state, a watt density of 40 watts per square



Typical 115-volt coil of heating cable. (Fig. 3)

foot is recommended. The spacing between adjacent runs of the electrical cable for a given watt density depends on the wattage rating per lineal foot of the cable. To determine the cable spacing for the desired watt density, refer to the table below.

Watt density (watts per square foot)	Watts per lineal foot of heating cable				
	2½	2¾	3½	5	7½
	(Spacing between adjacent runs of cable, inches)				
25	$1\frac{3}{16}$	$1\frac{5}{16}$	$1\frac{11}{16}$	$2\frac{3}{8}$	$3\frac{5}{8}$
30	1	$1\frac{1}{8}$	$1\frac{3}{8}$	2	3
35	....	....	$1\frac{3}{16}$	$1\frac{3}{4}$	$2\frac{9}{16}$
40	....	....	$1\frac{1}{16}$	$1\frac{1}{2}$	$2\frac{1}{4}$
45	....	....	....	$1\frac{5}{16}$	2
50	....	....	....	$1\frac{3}{16}$	$1\frac{13}{16}$
55	....	....	....	$1\frac{1}{8}$	$1\frac{5}{8}$
60	....	....	....	1	$1\frac{1}{2}$

Let's assume that you have purchased cable rated at 5 watts per lineal foot, and that you want a watt density of 30 watts per square foot. From the table, you will see that the proper spacing for this cable is 2 inches. The spacing between adjacent runs of cable should *never be less than 1 inch.*

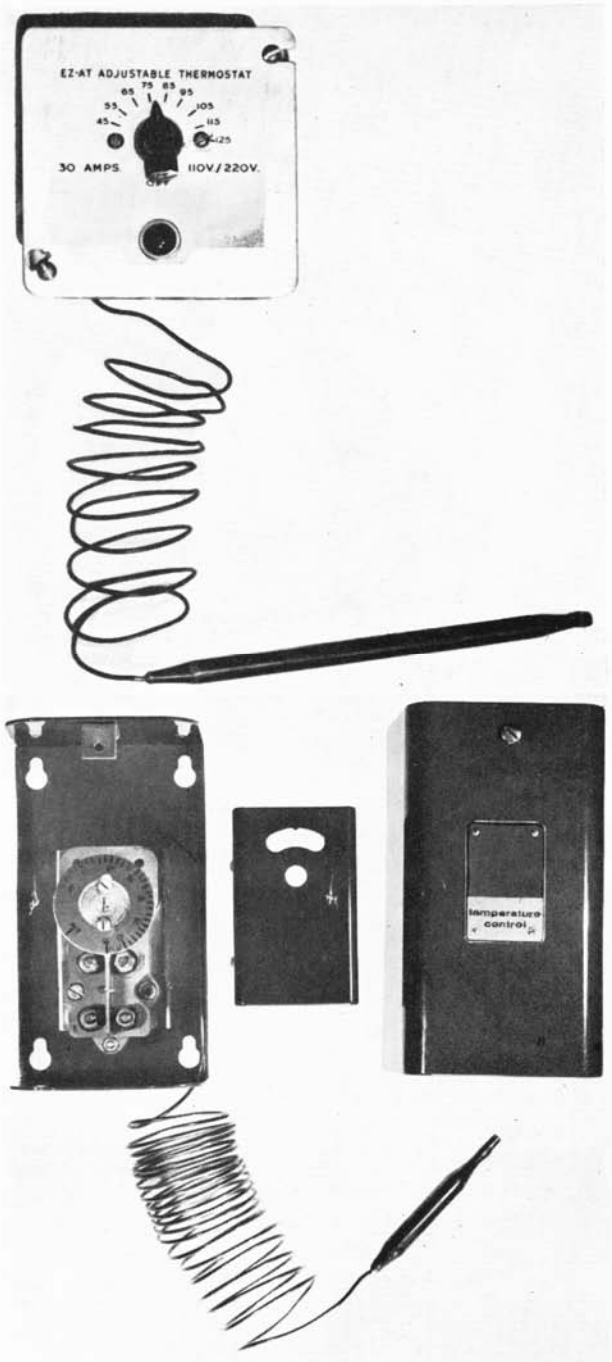
The cable is already spaced in prefabricated mats. These mats have various watt densities. If you use mats, be sure that you get the recommended watt density for your area.

A remote-bulb thermostat covering the range of 50° to 100° F. is recommended. Typical thermostats are shown in Fig. 4. (Notice the difference in the length of the sensing bulbs.) The number of stalls that can be operated by one thermostat depends on the connected load and the current rating of the thermostat. The total current drawn must not exceed the ampere rating of the thermostat.

To find the current drawn by the heating units on one thermostat, divide the total watts connected by the applied voltage. For example, a farmer connects five 400-watt units to one thermostat operating at 115 volts.

The current drawn equals $\frac{2{,}000 \text{ watts}}{115 \text{ volts}} = 17.4$ amperes.

Thermostats rated at 30 amperes (Fig. 4) would be satisfactory for this installation. The practical maximum limit is usually 5 or 6 units per thermostat. If more than one thermostat is used in a farrowing house, it is possible to maintain groups of heating units or pens at different temperature levels for pigs of different ages. When a thermostat controls more than one heating unit, the units should be individually switched so that the unused ones may be turned off. The unit containing the thermostat sensing bulb serves as the control for all of the heating units connected to the thermostat. The other units are controlled only when this unit is operating.



Thermostats for controlling heating units. (Fig. 4)

Construction of Heating Units

One of the best methods of installing heating cable when you do not use prefabricated mats is to make your own heating unit from a coil of cable. Attempting to install the cable in concrete without first fabricating a heating unit to insure proper arrangement can lead to serious problems.

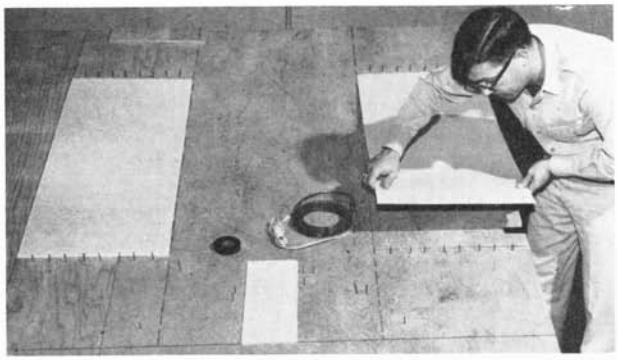
The materials required to make your own heating units are a simple plywood jig, a sheet of ⅛-inch cement asbestos board, tape, and a coil of heating cable. First, you must decide how to arrange your heating cable so that it will heat the desired area and provide the necessary watt density. Outline the area to be heated on a piece of plywood or any other suitable surface. Drive finishing nails into the plywood so that when the cable is wrapped around the nails the wire will take the desired arrangement. Cut asbestos panels to the size of the area to be heated and place the panels between the rows of nails (Fig. 5). Cement asbestos board is used because it is durable and will not absorb moisture and deteriorate. Wrap the heating cable around the nails in the desired pattern. Keep the wire snug and make definite bends in the wire at the ends (Fig. 6).

Wrap the entire length of cable on the jig, making certain that the cable does not cross. For farrowing stalls, heat is necessary only in the pig-creep area. Any excess cable can be used to add a small amount of heat behind the sow (Fig. 7).

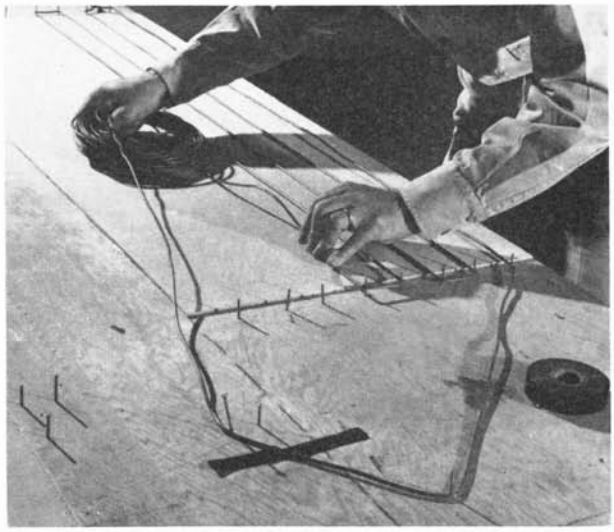
After the cable has been placed on the jig, tape the cable to the cement asbestos panels. Use plastic electrical tape, freezer tape, or any similar tape that will adhere to the panels. Press the tape tightly around each wire to insure a good bond to the panel (Fig. 8).

Tape each panel at the ends and at an adequate number of intervals between the ends to firmly secure the cable. After the panel has been taped, lift the unit from the jig, forcing the wires from the nails. If the panels are properly taped, the units can be folded, stacked, and easily transported without danger of changing the arrangement of the cable.

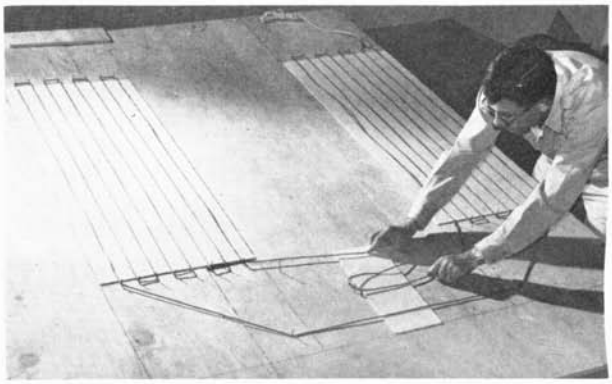
After the jig has been prepared and the panels cut, it requires one person about 10 minutes to make up each heating unit.



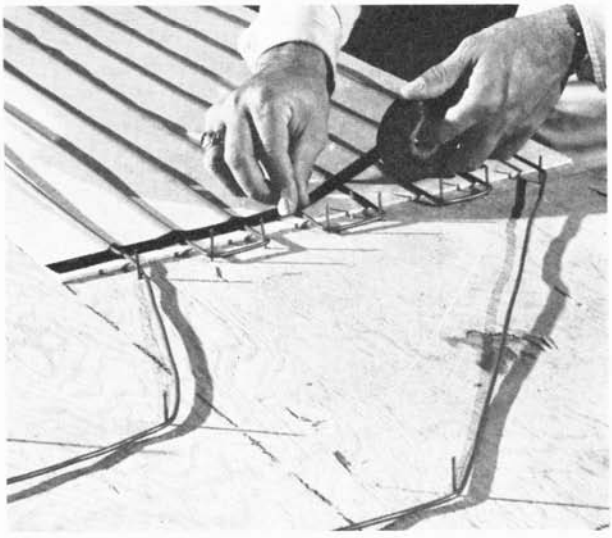
Placing cement asbestos panels on plywood jig. **(Fig. 5)**



Wrapping heating cable in the desired pattern. **(Fig. 6)**



Locating excess cable behind the sow. **(Fig. 7)**



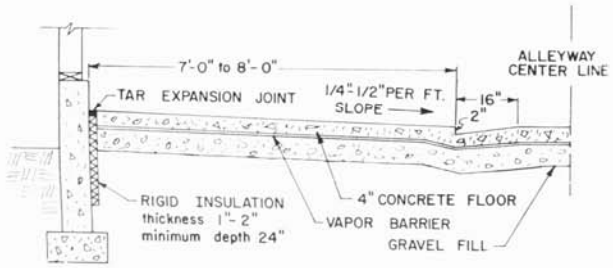
Taping the heating cable to a cement asbestos panel. **(Fig. 8)**

Recommended Construction Details

Floors

It is important that you use good-quality concrete and construction methods that will insure warm, dry floors (Fig. 9).

Place a 4- to 6-inch gravel fill under the floor. Smooth out the gravel fill, leaving room for a 4-inch concrete floor. Do not use cinders or other corrosive fill. Provide a good vapor barrier between the gravel fill and the concrete floor to prevent moisture from entering the house through the floor. A polyethylene film of at least 4 mil thickness or the equivalent serves as a suitable vapor barrier. When applying the barrier and placing the concrete, be careful not to puncture the film (Fig. 10). Once the film is punctured, its effectiveness is destroyed.



Detail of floor construction. **(Fig. 9)**

Carefully placing concrete over the vapor barrier. **(Fig. 10)**

To give adequate drainage, all floors should be sloped ¼ to ½ inch per foot. Provide adequate drainage within the house with gutters and drains.

It is important to insulate the outside edge of the floor. This perimeter insulation helps keep the floor warm and minimizes the amount of condensation that normally forms around the edges of the floor during cold weather. One to 2 inches of rigid insulation should be placed between the edge of the floor and the foundation to a depth of at least 24 inches. You can use expanded polystyrene, foamglass, or any other rigid insulation that is not subject to deterioration.

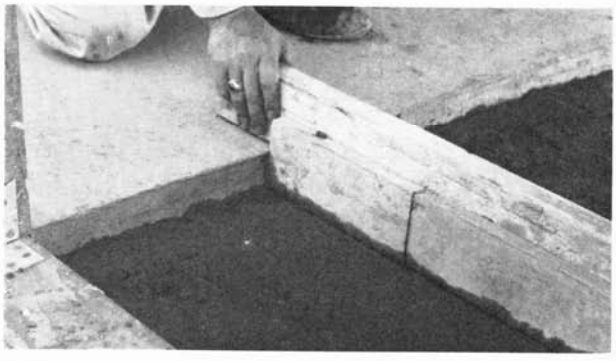
Although some heat can be saved by insulating under the heating units, the largest amount of heat is lost through the foundation. For this reason, perimeter insulation is the most important.

Good-quality concrete is necessary for satisfactory results. The recommended mix for a new 4-inch floor is a 6-bag mix (6 sacks of cement per cubic yard of concrete) with a water content of 6 gallons (maximum number of gallons per sack of cement). If you mix by hand, use one part portland cement, 2¼ parts sand, and 3 parts gravel. Add enough clean water to produce a workable, mushy mixture, but do not add over 6 gallons of water per sack of cement.

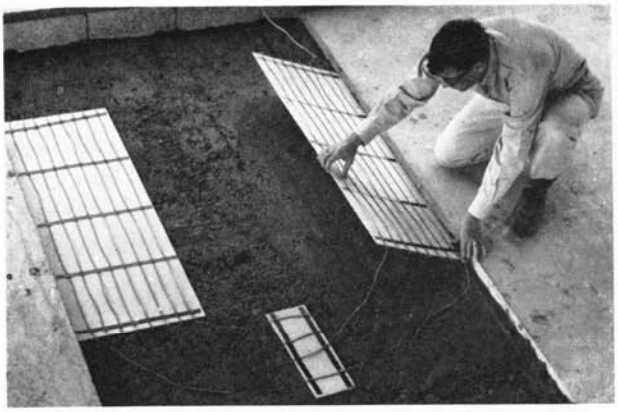
The heating unit should be placed approximately 1½ inches deep in the 4-inch floor. For easy placement of the heating unit at the correct depth, construct a special strikeboard by nailing a 1×4 cleat to a regular 2×4 strikeboard so that the cleat extends 1½ inches below the 2×4 (Fig. 11). Place enough concrete to fill the 2½ inches of depth, and strike it off 1½ inches below the finished floor level.

Now place the heating panels where you want them on the freshly placed concrete. The panels will bond to the concrete and permanently locate the cable (Fig. 12). In this farrowing-stall arrangement, notice how the heating units are located only in the pig-creep area with a small amount of cable located behind the sow.

Rigid-wall metal conduit should be used to protect the wiring between the pens and the non-heating lead wires of the heating cable from the floor to the thermostat. The conduit will prevent any mechanical damage to the wires and prevent them from being sheared off at the floor line (Fig. 13). Coat the conduit two or three inches above and below the floor line with non-lead paint or other rust preventive.



Striking off concrete at correct depth. **(Fig. 11)**



Placing heating unit in the desired location. (Fig. 12)

Installing conduit to protect wires and capillary tubes. (Fig. 13)

The capillary tube between the sensing bulb and the thermostat should also be protected with conduit. If you use a thermostat with a remote-bulb sensing element short enough to go around a standard conduit bend (Fig. 4, bottom), you may place the entire sensing bulb and capillary tube within the conduit. Plug the end of the conduit and extend the conduit over the center of either panel between the strands of heating cable (Fig. 13). Be sure that the radius of the conduit bend is large enough to pass the bulb. Insert the sensing bulb and capillary tube, and fasten the conduit and thermostat to a panel board. For most effective and accurate control, fill the conduit with ethylene glycol or a similar liquid.

If you use a thermostat with a long sensing bulb (Fig. 4, top), insert a beveled 1 × 2 wooden block on edge at the proposed location of the bulb, extending back to the edge of the pen. Oil this wooden block to make removal easier. After the concrete floor has been poured and hardened, remove the block and mortar the bulb, capillary tube, and conduit into place. If the thermostat ever needs to be replaced, the mortar can easily be removed and a new thermostat installed.

After the heating unit has been properly placed, fill the remaining 1½ inches of floor with concrete. *Do not* spout the concrete from a truck, dump a wheelbarrow, or throw shovelfuls of concrete directly on the heating units. Carefully place the concrete on the heating unit with a shovel (Fig. 14) so that the cable will not be torn loose and moved. Standing on the heating cable during the placing or finishing of the concrete may move the cable or cause direct mechanical damage to it.

Completely fill the forms with concrete and strike off with a strikeboard immediately after placing. A straight 2 × 4 makes a convenient strikeboard. It is usually best to strike off upgrade to the slope of the floor because concrete will normally settle to the lower end of the slope when it is first poured.

Some tamping is necessary to insure a uniformly dense floor. A good method of tamping is to use a "jitterbug" (Fig. 15). This tool forces the large stones from the surface and makes the job of finishing easier. Floating with a bull float immediately after striking off will also provide a surface that can be finished easily. The concrete should be spaded around the edges so that it will fill the forms evenly. To avoid damaging the cable, spade with a 1 × 4 or other blunt tool.

Expansion joints should be provided between the floor and the foundation around the entire perimeter of the floor. A ¾-inch tar joint will allow the floor and foundation to act independently and will seal out the moisture. Standard construction joints will usually permit sufficient expansion and contraction within the floor. In long floors, provide at least one construction joint every 20 feet.

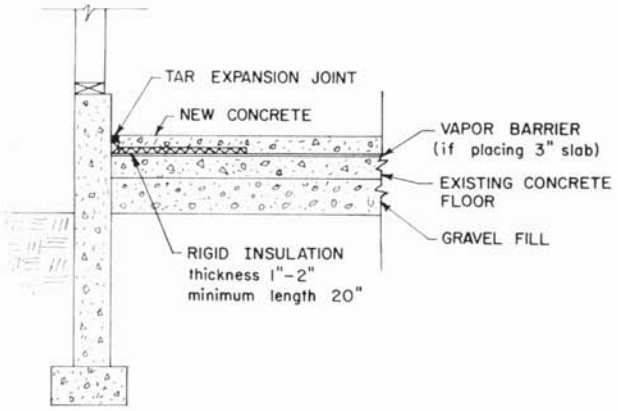
Covering heating unit with concrete. (Fig. 14)

Tamping the concrete with a "jitterbug." (Fig. 15)

Before the new concrete is finished with a wood float, it should be allowed to harden until it is stiff but still workable. A steel trowel can be used when the water sheen begins to disappear from the surface. After the concrete has been steel troweled and is reasonably firm, draw a soft, fine-bristled brush over the surface (Fig. 16). This will result in a surface that is smooth enough for easy cleaning but rough enough for the sows to stand on without difficulty.

Since new concrete needs moisture to harden properly, it should be protected from drying out for at least 5 days. After the concrete has hardened sufficiently, cover it with polyethylene film, canvas, burlap, straw, etc., and keep the floor dampened for the required time. If you place the concrete at temperatures below 35° F., take the usual precautions for placing and curing concrete during freezing weather.

Finishing the concrete floor. (Fig. 16)



Detail for placing slab over existing concrete floor. (Fig. 17)

The heating cable should not be operated for approximately two weeks after placing the concrete. *Do not* operate the cable to hasten curing or to keep the newly placed floor warm during freezing weather.

Test the heating cable for continuity *before* and *after* placing the concrete.

New Floor Over Existing Floor

During remodeling, you may want to install heating cable in an area where a concrete floor already exists. This means putting a slab over the old floor and embedding the cable in the new slab.

If rigid insulation was not installed with the old floor, install insulation around the perimeter. When placing concrete over an existing floor, it is as effective to apply the perimeter insulation horizontally as to apply it vertically along the foundation (Fig. 17).

If the existing floor has cracks, put down a vapor barrier and pour a 3-inch slab. Place the heating units in the usual way.

If the existing floor is structurally sound with no cracks, a thinner layer of concrete may be used. This layer of concrete must be bonded to the old floor. If the old concrete surface is smooth, roughen it with a pick, hammer, or rough-grinding machine. Remove loose particles and clean the floor thoroughly. Moisten the slab overnight, but do not leave any free water on the slab. For proper bond, brush on a slush coat of portland cement mixed with water to the consistency of thick paint. Brush out well so that the coat will not

be too heavy. The slush coat must not dry or harden before the concrete is placed.

Place the heating units on the old surface and cover with a 1⅝-inch floor (thickness of 2 × 4). Use a concrete mix of 1 part portland cement, 1 part sand, and from 1½ to 2 parts of coarse material by volume. The size of the coarse material should not be over ¾ inch. Use as little water as possible — *never* more than 5 gallons per sack of cement. Adjust the amount of aggregate to give the desired workability. Finish and cure as discussed earlier.

Wiring

The service entrance must have adequate capacity for the combined electrical load of the heating cables, stock-waterer heaters, lights, feed-handling equipment, etc. If you have a choice between heating cable with 110 to 120 volts or cable with 220 to 240 volts, the higher voltage is recommended. For the same number of watts, the higher voltage permits the use of smaller wire because it requires less current. If 120-volt cables are used, they should be wired so that the electrical load is balanced between the legs of the system. Use type UF or NMC cable for all wiring.

The non-heating leads of the heating cable must be protected from mechanical and chemical damage where they emerge from the concrete floor. Electrical conduit may be used for this purpose. It should extend at least 6 inches into the concrete and high enough above the floor to protect the wires from the hogs.

Each pen should be provided with an on-off switch so that unused pens may be turned off. This will conserve electricity and reduce the cost of operation. Several pens can be controlled with one thermostat, provided that the electrical capacity of the thermostat is adequate.

Proper grounding of the system is important. For safe operation, all metal boxes, fittings, drinking cups, metal farrowing crates, wire-netting mats, etc. in the building should be connected to an electrical-system ground. This can be accomplished by running a third wire through the service entrance to the driven ground. You can obtain further details and assistance on wiring from your power supplier.

Other Important Points

There are other construction details that directly affect the performance of a building. The walls and ceiling must be adequately insulated. A suitable vapor barrier should be used on the inside surface of the insulation in all walls and in the ceiling. Proper ventilation must be provided.

Arrangement of Heating Cable for Swine

Heating cable can be arranged in many ways. The most desirable cable arrangement in swine buildings depends on the type of pen. Regardless of the arrangement of the cable, it is always desirable to use a prefabricated unit. This unit can be obtained commercially or fabricated as described earlier in this circular.

Farrowing Stall

The use of heating cable in farrowing stalls has already been discussed. It is only necessary to provide heat in the pig-creep area of a farrowing stall. Normally, less than half of the pig-creep area will provide adequate heated area for all of the pigs of one litter. Heating only one of the pig-creep areas is usually not satisfactory because some of the small pigs may get trapped on the cold side of the sow. About half of each pig-creep area should be heated. A satisfactory arrangement of heating cable for a farrowing stall is shown in Fig. 18. Each of the heating units in Fig. 18 are 4 feet long and 18 inches wide.

If possible, the electrical leads and thermostat should be placed on the alleyway side of a pen so that all controls can be reached without entering the pens. In clear-span buildings, permanent posts are not located at every pen division, and the controls must be located on the outside wall.

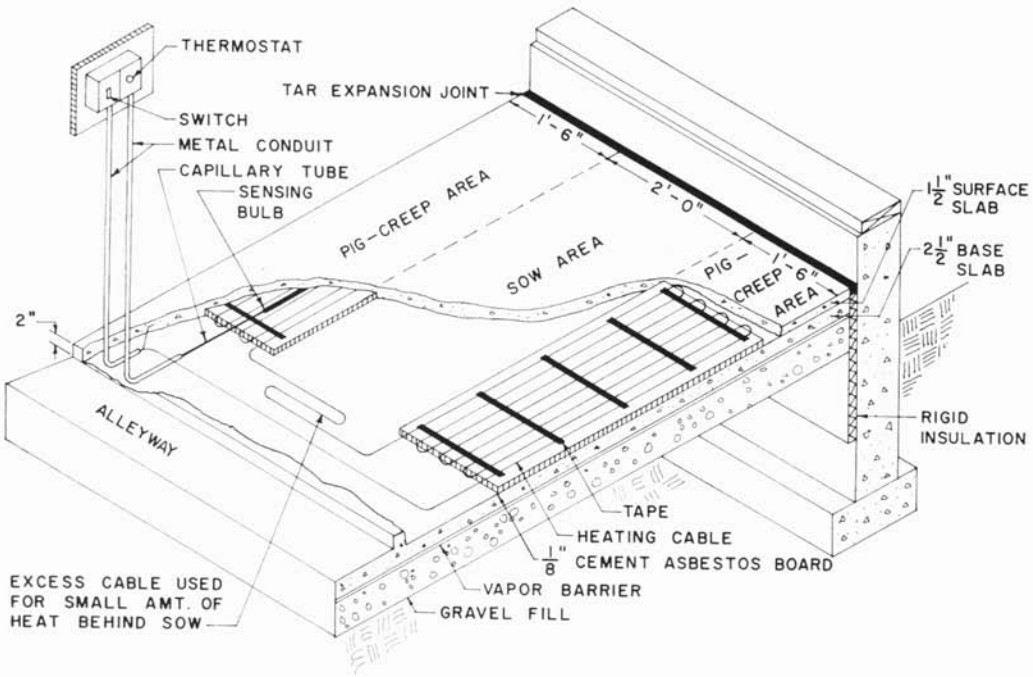
Arrange the cable to provide the watt density desired (30 to 40 watts per square foot of heated area). Any small amount of excess cable can be placed behind the sow. This will provide a warmed place for the pigs immediately after farrowing and reduce the sudden shock from a cold floor. If a large area behind the sow is heated, the pigs may stay on this warm surface where they can be stepped on rather than moving to the protected areas of the pig creeps.

Standard Farrowing Pen

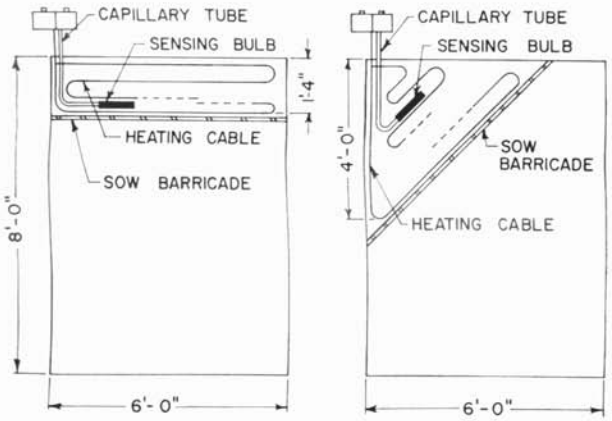
Heating cable can be used satisfactorily in standard 6- by 8-feet farrowing pens with guard rails as long as the cable is properly installed and the heated area is protected from the sow. Usually an area across the back of the pen is heated, but heat can also be provided in a corner, if desired. Fig. 19 shows two possible arrangements of heating cable in a farrowing pen. Provide a minimum of 7 square feet of heated floor for each litter.

Two-Sloped-Floor Farrowing Pen

Some Illinois farmers have used a two-sloped-floor farrowing pen with satisfactory results. The two rows



Floor construction for a farrowing stall, showing location of heating unit, thermostat and switch, and perimeter insulation. (Fig. 18)



Two arrangements of heating cable for farrowing pens. (Fig. 19)

of pens are usually 7 feet by 11 feet, with a central alleyway 4 to 5 feet wide. The back 7 feet of the pen are sloped 3 inches to the outside wall, and the front 4 feet are sloped 3 inches to the alleyway, leaving a ridge in the pen. Only the front portion of the pen is bedded, and the pigs are fed and watered on the back unbedded portion. A small pig creep (12 to 18 inches wide and 12 inches high) is provided across the front of the pen in the alleyway. A suggested arrangement of heating cable for a two-sloped-floor farrowing pen is shown in Fig. 20.

The sow will lie across the pen with her back uphill and her udder next to the heated area. The small pigs will find the heated brooder soon after they are born and remain there, protected from the sow.

Pig Nursery

Pig nurseries are used to house the pigs from the time they leave the farrowing house until they enter the growing and finishing house. Heating cable will furnish the necessary heat required by these small pigs during cold weather. Usually the floor is heated across the back of the pen.

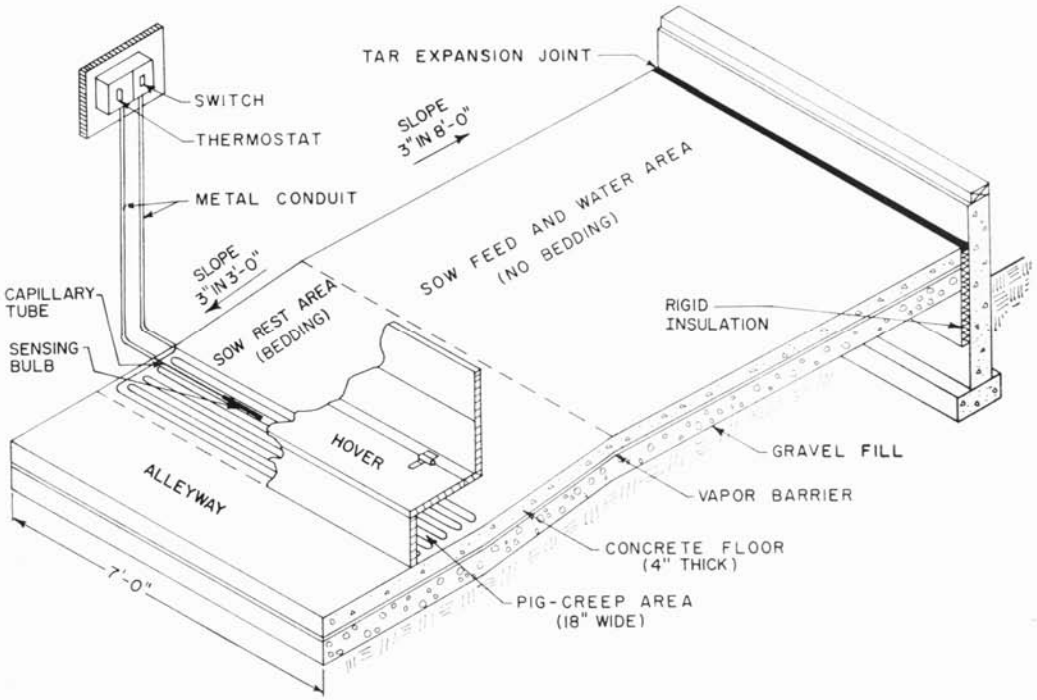
Fig. 21 shows a typical arrangement of heating cable in a pig nursery. Provide a minimum of 1 square foot of heated area per pig. Protect the heated area from the sow with a barricade placed at the edge of the heated area when the sows and pigs are first turned in together. When the pigs are less than 6 weeks old, an added benefit can be gained from the heat if the heated area is covered with a lid or hover to minimize drafts and conserve heat.

Other Applications of Heating Cable

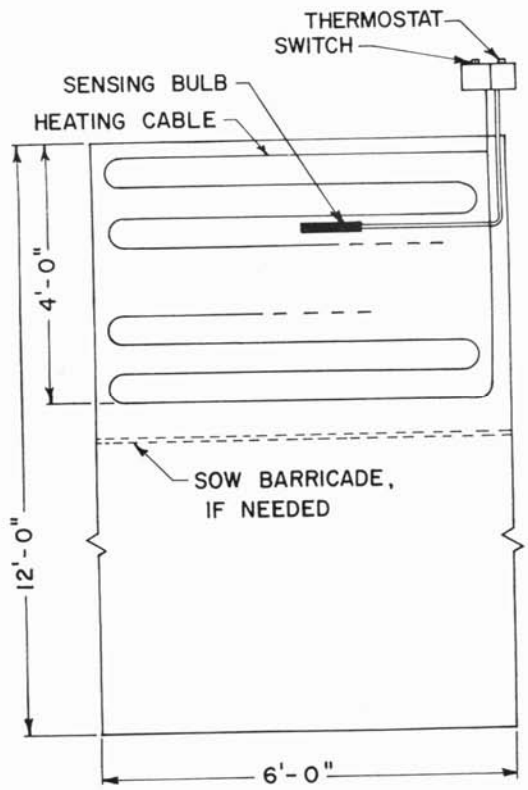
Electric heating cable can also be used satisfactorily in other applications. Regardless of the arrangement or watt density, the cable can be made into a heating unit and installed as described in this circular.

Snow and Ice Removal

Heating cable can be used effectively for melting snow and ice on walks and driveways. The cable should be installed 1 inch below the surface of the concrete, and be spaced to give a watt density of about 40 watts per square foot. A manual control should



Construction for a two-sloped-floor farrowing pen, showing location of heating cable. (Fig. 20)



Typical arrangement of cable in a pig nursery. (Fig. 21)

be used. For more effective removal of snow or ice, turn on the unit shortly before a snow so that the concrete can warm up and begin melting the snow as soon as it starts falling. For driveways, it is more economical to install the cable in a 12-inch to 18-inch width for each wheel track rather than over the entire driveway.

Work Areas

It is often convenient to have a section of floor heated in work areas. Examples of areas where electric heat in the floor can be used to advantage are in the milking parlor, milk house, egg-grading room, shop, and pump house. The recommendations for installing the cable are the same as those given for installing the cable for farrowing houses. A heating pad in a work area should have a watt density of from 30 to 40 watts per square foot.