Hotbeds and Coldframes
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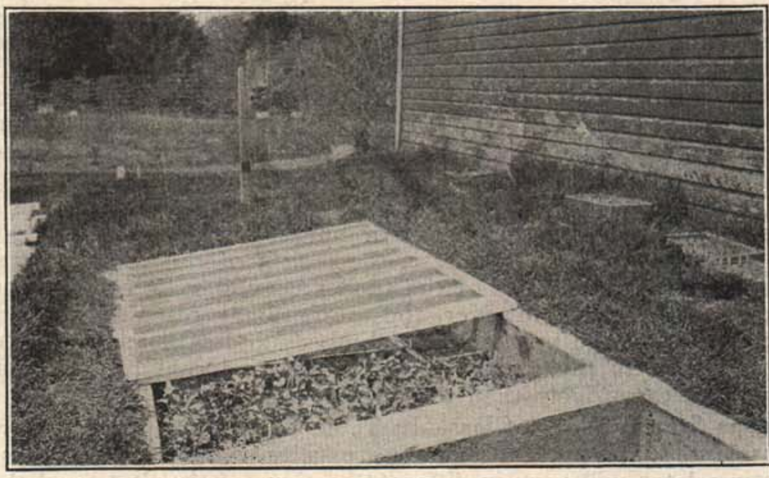

MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

EXTENSION DIVISION

R. J. Baldwin, Director

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HOTBEDS AND COLD FRAMES

C. H. MAHONEY AND O. E. ROBEY

There are certain vegetable crops which are grown most successfully when the seeds are sown under glass and the transplants set out in the garden. This method is also used with other vegetables to get earlier crops than could be obtained by sowing seed directly in the field. There are, in addition, some cool season crops, such as head lettuce and cauliflower, which are seriously injured by hot weather. These crops, when grown as a late spring or early summer crop, are usually started under glass and the transplants set out comparatively early. There are long season hot weather crops, such as tomatoes, eggplants, and peppers which should be started and transplanted once under glass before setting out in the field in warm weather.

The use of sash and cloth covered frames will lengthen the season in southern Michigan for many of our vegetable crops. In some of the northern parts of the State, the length of the growing season is often too short for many of the tender vegetables if ordinary cultural practices are used. However, these crops may often be grown fairly successfully by the proper use of hotbeds and sash and cloth covered frames. It is in this section that hotbeds and cold frames should be used more extensively than they are at the present.

Crops Started Under Glass—In Table 1, data are given for growing transplants of a number of crops usually started under glass. The planting dates will vary in different sections of the State and the suggested planting dates given in the table are averages for the southern part of lower Michigan having an average date of last killing frost in the spring between May 2 and May 10.

Seed and Seed Treatment—Cheap seed is very poor economy, and only the best possible seed that will produce uniform plants true to type should be used. Only small quantities of seed are required for starting plants under glass and, in most cases, the cost of seed is only a minor item in the cost of production. However, it is usually more economical to buy larger quantities of seed and use it for several years.

Seed of the vegetable plants which are usually started under glass may be divided into four arbitrary groups based upon the length of time that the seed remain commercially viable if properly stored. Group one, onion and pepper seed viable for two years; group two, celery and tomato seed viable for three years; group three, cabbage, cauliflower, broccoli, and radish seed viable for four years; group four, cucumber, eggplant, muskmelon, and watermelon seed are viable for five or more years.

There are many diseases of vegetables which are seed borne. Some are carried on the outside of the seed coat whereas others are carried

Table 1.—General data on growing vegetable transplants.

Crop	Field spacing	Time to grow. Once transplanted, weeks	No. plants required per acre	Transplanting distance in frames	Actual No. of plants per sash[1] (3 x 6′)	No. of sash to grow transplants for 1 acre[2]	No. of transplants per standard flat[3] (3 x 12 x 18″)	Approximate dates to start seedlings in Southern Michigan
Early Celery	3′ x 4″	10–14	43,560	1½″ x 1½″	1120	26.7	96	Jan. 25 to Feb. 10
Cabbage and Broccoli	3′ x 12″ 3′ x 15″ 3′ x 18″ 3′ x 24″	6–7	17,424 11,616 9,680 7,260	1½″ x 1½″	1120	26.7 10.4 8.6 6.4	96	Jan. 25 to Feb. 15
Eggplant	3′ x 3′	8–10	4,840	3″ x 3″	288	16.8	24	Mar. 15 to Apr. 1
Lettuce	18″ x 12″	5–7	29,040	1½″ x 1½″	1120	10.4	96	Mar. 20 to Apr. 1
Melons	6′ x 6′	Bands Not transpl. 4–5	1,210 (2 pls.)	4″ x 4″	162	7.5	Bands	Apr. 21 to May 1
and Cucumbers	6′ x 4′		1,815	3″ x 3″	288	11.2	Bands	
Peppers	3′ x 18″ 3′ x 24″	8–10	9,680 7,260	2″ x 2″	648	15 11.2	54	Mar. 15 to Apr. 1
Tomatoes	3′ x 4′ 3′ x 5′ 4′ x 4′ 4′ x 5′	8–10	3,630 2,904 2,722 2,178	4″ x 4″	162	22.4 17.9 16.8 13.4	3′ x 3′=24	Mar. 15 to Apr. 1
Watermelons	7′ x 7′ 8′ x 8′ 9′ x 9′	Bands Not transpl. 4–6	889 hills 680 hills 537 hills	3″ x 3″	288	3.1 2.3 1.9	Bands	Apr. 15 to May 1

[1]Based upon plants growing in soil or wood bands. If flats are used the number will be somewhat less.
[2]No allowance made for rejection of poor plants or for losses due to various causes.
[3]A standard flat will produce 800 to 1,000 seedlings when seed is sown in rows 2 inches apart and 10 to 12 seeds per inch, of cabbage, cauliflower, tomatoes, peppers and eggplant.

Table 2.—Seed treatments recommended for vegetable crops.

Family and Crop	Seed Borne Disease	Seed Treatment for Disease	Length of Time for Treatment, Minutes	Length of Time to Wash in Fresh Water Important	Time of Year to Treat Seed	Dust Treatment to Increase Stand and Prevent Damping-off
Crucifereae						
Cabbage Cauliflower Brussels Sprouts	Black Leg Black Rot	Hot water 122°F. Use thermometer (not boiling) Test seed after	20 18 20	Rinse in cold water and dry thoroughly	1-3 weeks before planting. Put in sun to dry.	Semesan
Radish		Mercuric chloride 1 oz. in 7½ gallons water	30	15 minutes	1-3 weeks before planting. Put in sun to dry.	Semesan
Solanaceae						
Tomato	Bacterial Spot Grand Rapids Disease Streak	Corrosive Sublimate (1–3000) 1 oz. in 22½ gal.	5	15 minutes	1-3 weeks before planting. Put in sun to dry.	Monohydrate Copper sulphate Dust. 1 tablespoon per lb. of seed.
Pepper	Bacterial Spot	Corrosive Sublimate (1–1000) 1 oz. in 7½ gal. water	2	15 minutes	1-3 weeks before planting. Put in sun to dry.	Formaldehyde Dust
Eggplant	Phomopsis Blight	Corrosive Sublimate (1–1000) 1 oz. in 7½ gal. water	10	15 minutes	At planting time. Do not dry.	Formaldehyde Dust
Cucurbitaceae						
Cucumber	Anthracnose Angular Leaf Spot	Corrosive Sublimate (1–1000) 1 oz. in 7½ gal. water	5	15 minutes	1 week before planting. Dry seed and then use dust.	Semesan Jr.
Muskmelon	Anthracnose Angular Leaf Spot	Corrosive Sublimate (1–1000) 1 oz. in 7½ gal. water	5	15 minutes	1 week before planting. Dry seed and then use dust.	Semesan Jr.
Pumpkins and Squash	Anthracnose Angular Leaf Spot	Corrosive Sublimate (1–1000) 1 oz. in 7½ gal. water	5	15 minutes	1 week before planting. Dry seed and then use dust.	Semesan Jr.

on the inside as well. These diseases can largely be eliminated by various seed treatments. These treatments are given in Table 2. It is important that the seed be washed thoroughly in fresh running water after seed treatment or the seed will not germinate. The dust treatments listed in the last column should be given in addition to the liquid treatments. They have been found to be very efficient in increasing the stand by prevention of losses due to "damping-off" fungi.

Soils and Soil Sterilization—Those growers investing money in glass for plant growing should have an abundant supply of compost. One of the most satisfactory types of compost for the smaller grower is the soil compost. Soil compost can be prepared by piling alternate layers of manure and garden loam in piles about four feet high and about eight feet wide and any length. This pile can be made during the late winter or early spring and enough water should be added to prevent "fire-fanging". Three or four weeks after starting the compost the pile should be turned and if water is necessary it should be added. The pile should be turned five or six times during the rest of the year and usually good compost will be available for the following springs work. Good compost is essential for producing tomato or pepper plants by the "blocking" method, and also for use in plant bands. A one to two proportion of this compost and sandy loam soil will make ideal mixture for seed flats.

The benefits of seed treatment will be lost if seed is planted in diseased soil. "Damping-off" fungi, blackleg, black-rot of cabbage and related crops, tomato blights, and nematodes which cause root-knot, live over in the soil from year to year. With movable frames, it is advisable to change the location each year. The frame walls should be thoroughly disinfected with a solution of corrosive sublimate, one ounce in seven and one-half gallons of water. Changing soils is also used extensively in the smaller permanent frames but this is an expensive and laborious task and does not always accomplish its purpose. Too often some of the contaminated soil is left in the frame and soon the new soil is filled with the disease.

Steam-sterilization—This is one of the most satisfactory methods of handling disease infested soils. Steam sterilization, either by means of tile laid under the frames or by sterilization of flats of soil or soil itself in an especially constructed box is by far the most satisfactory method. This method is usually limited to the larger growers who have steam heat, but could be used by the smaller grower if a source of steam is available. For full details on steam sterilization of hotbeds see section on "Hotbeds".

Formaldehyde—For the grower who does not have steam and has fairly large frames to sterilize, the formaldehyde treatment is probably the most practical. Four pounds or pints, one-half gallon, of 40 per cent formaldehyde are added to 50 gallons of water and the solution is applied to the soil at the rate of one gallon to each square foot of soil. This amount is necessary to penetrate six to eight inches. The soil should be loosened before this application. The soil should be covered with paper or burlap for 48 hours in order to confine the gas in the soil. The cover is then removed and the soil aerated for two weeks, after which the seed may be planted.

For a limited number of seed flats the 6 or 8 per cent formaldehyde dust is the simplest method of sterilization. The dust is used at the rate of one and one-half ounces per square foot, two ounces per standard 3″ x 12″ x 18″ flat worked into the soil to a depth of three inches. Seed, except celery, may be planted immediately but transplants and celery seed should not be planted until the flat has been aerated for 72 hours. This dust method is also applicable to small frames when the necessary two weeks of aeration required in the liquid treatment are for some reason not available. **Never plant seed or transplants in flats or frames in which the soil was diseased the previous year without using one of the above methods of sterilization.**

HOTBEDS

Surface Hotbed—The surface hotbed is temporary, is heated by manure and can be used later in the season as a cold frame. This type of hotbed is similar to the knock-down cold frame in construction. Details of construction of this five sash cold frame are shown in Fig. 6. In preparing the surface hotbed, manure is hauled, piled, watered, and allowed to ferment for about 10 days, turning it several times to start fermentation. After fermentation has begun, the pile is leveled off to about 16 to 18 inches deep, the frame set on top of it, the manure banked up against the side boards, and the sash put on. As soon as the manure has begun to heat again, the previously prepared soil compost is put into the frame on top of the manure to a depth of six inches. The composted soil will usually heat up for several days to rather high temperatures, but seed may be planted when the soil temperature has dropped to 90 degrees. This type of hotbed is quite satisfactory for starting a limited number of plants. Bottom heat hotbeds are not as satisfactory as surface heated beds for the decidedly cool season crops such as lettuce, cauliflower, early cabbage and other related crops.

ELECTRIC HOTBEDS

Hotbeds, heated with electricity, are very convenient and when properly constructed are fairly economical to operate. The construction of the frame of the hotbed can be very similar to the one shown in Fig. 6. There are, however, some additional details which should be observed. These are pointed out in Fig. 1. Considerable electricity can be saved by paying particular attention to insulation and the elimination of cracks between the sash and the hotbed frame and at the corners.

A layer of insulating board that has first been treated with asphalt paint can be used on the inside of the frame. Pieces of insulating board, mats or canvas can be used to lay over the sash on cold nights and dark cold days. A layer of sand or cinders placed under the hotbed soil tends to prevent the heat from being lost downward. The frame should also be banked around the outside with cinders or strawy manure.

A number of methods of heating have been developed. The electric current is usually controlled by a thermostat. The thermostat gives a more uniform temperature and is more economical in the use of cur-

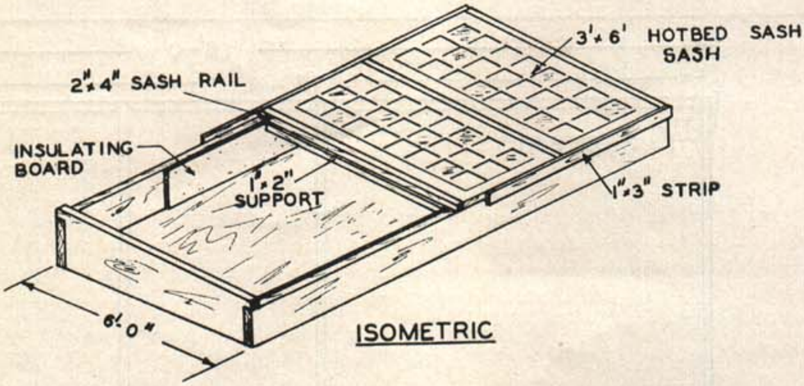


Fig. 1.—The electric hotbed should be protected against heat losses.

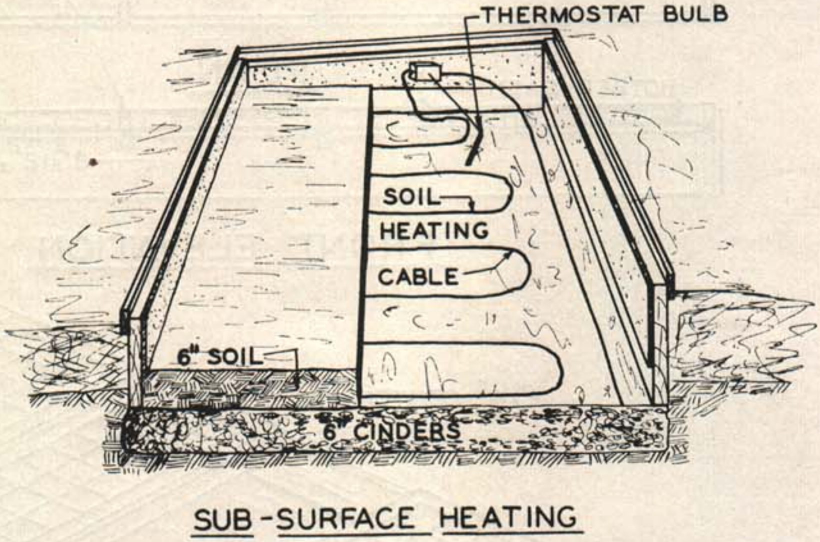


Fig. 2.—Electrically heated hotbed with heating cable below the surface.

rent. When a thermostat is used, it should be one that is thoroughly reliable.

Methods of Heating:

1. Lead sheathed heating cable can be placed about six inches below the surface. Of the cable now on the market, it requires 60 feet to heat a two-sash bed six feet by six feet, when 110 volt current is used. The cable can be arranged as illustrated in Fig. 2. One end of the cable is connected directly to the source of power, the other end to the thermostat. The wiring diagram is shown in Fig. 3.

2. Recent experiments[1] indicate that surface heating of hotbeds

[1]Kable, G. W., and A. V. Krewatch—1932, Electric Soil Heating, Nat. Rural Electric Project Mimeo. Report No. 10, College Park, Md.

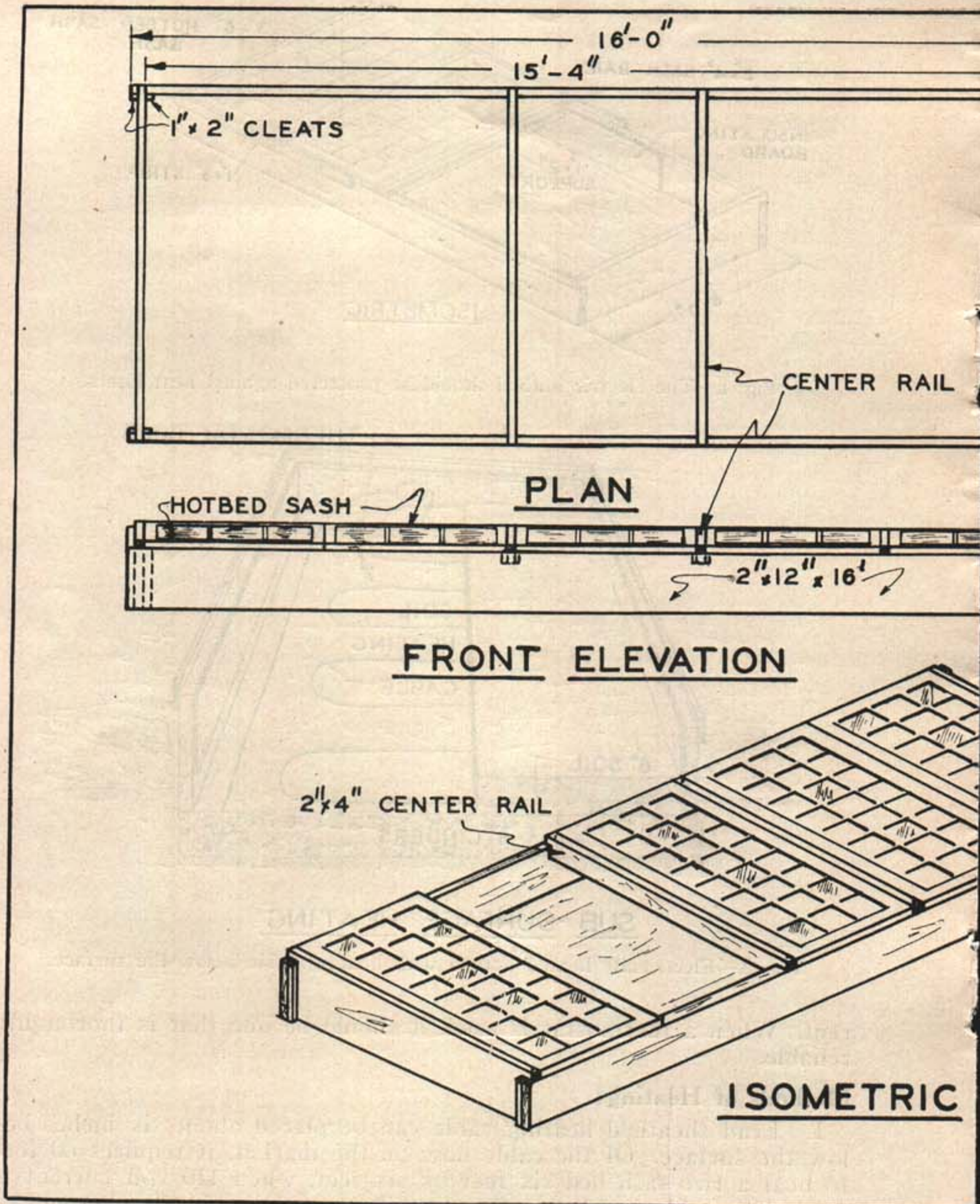
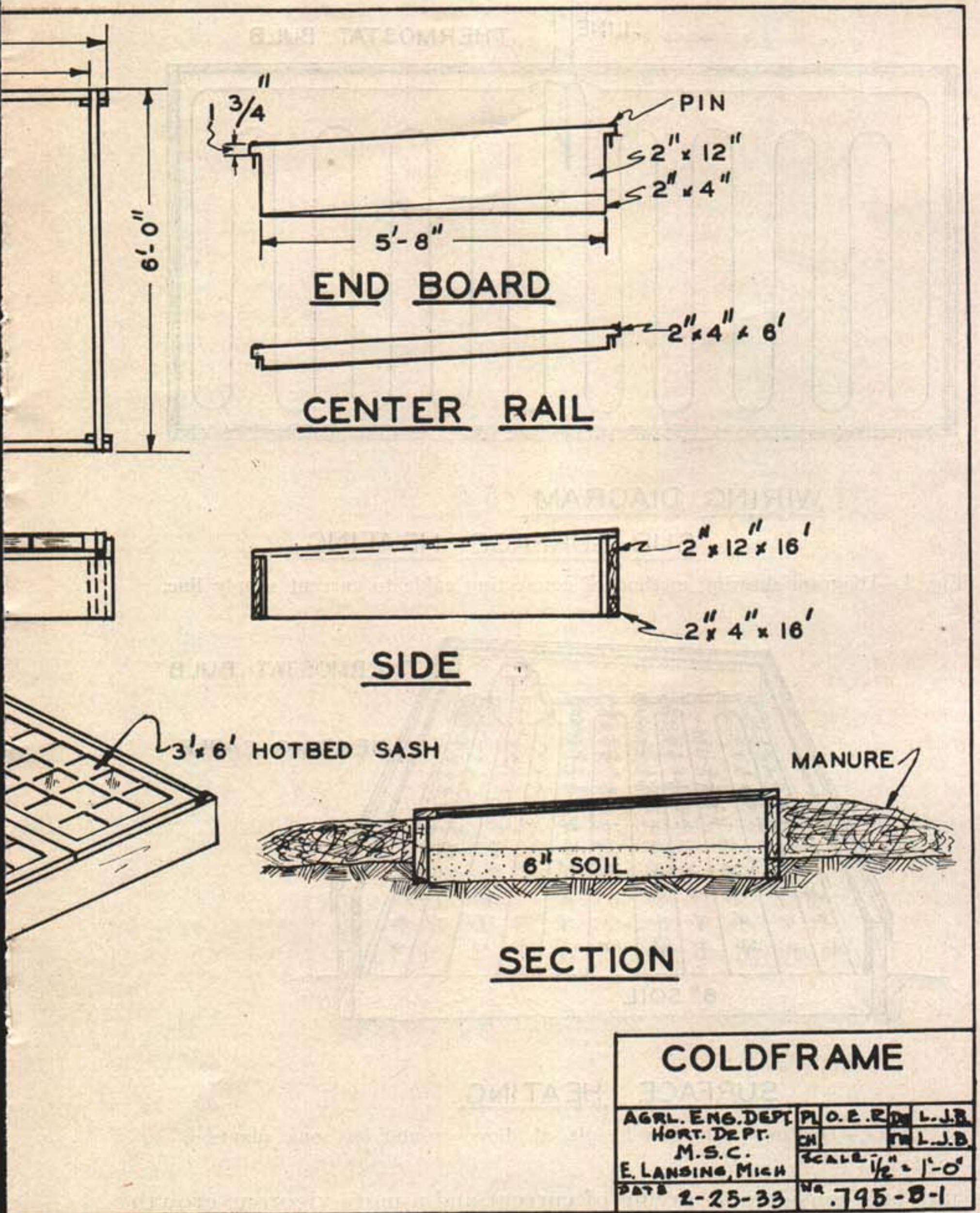


Fig. 6.—Construction details



for a five-sash cold frame.

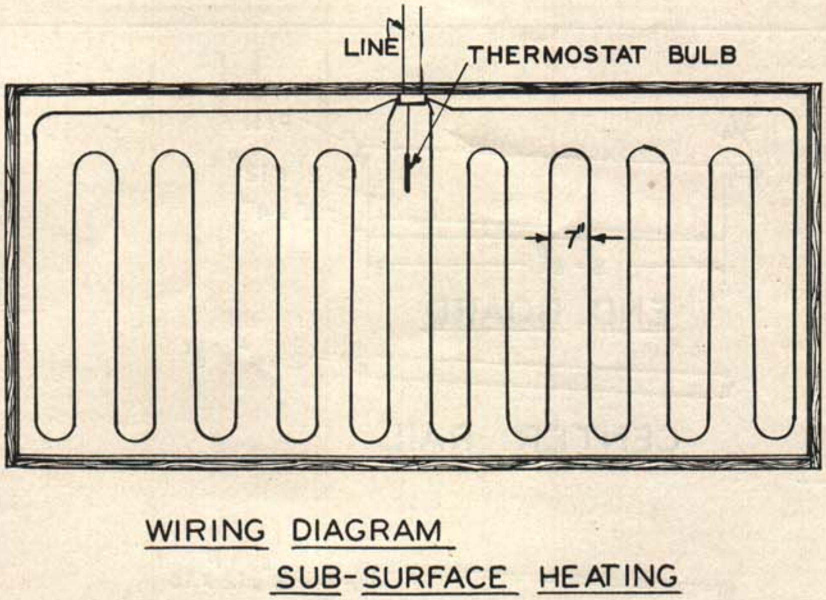


Fig. 3.—Diagram showing method of connecting cable to current supply line.

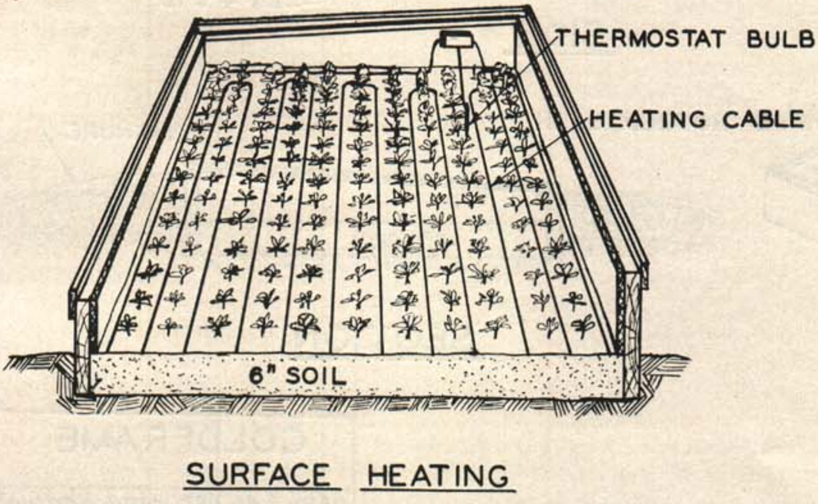


Fig. 4.—Heating cable may be placed above ground for some plants.

results in a considerable saving of current and a more vigorous growth of the plants. In this method of heating, the lead sheathed cable referred to above, is laid on the surface of the soil and spaced as shown in Fig. 4. The experiments at Maryland show that a saving of over 50 per cent of the current may be effected by the use of surface heat instead of under-surface heat. This method of heating is suitable for peppers, tomatoes, eggplant, but not for spinach or lettuce.

3. For cool season crops, the heating cable may be attached to the inside of the hotbed frame, as shown in Fig. 5. The cable is usually attached by means of wiring knobs or cleats spaced about three feet apart. Since 60 feet of cable is required to heat a bed six feet by six feet, it is necessary to arrange the cable so that the heat will be as evenly distributed as possible. Suggested arrangements for both large and small beds are given in Figs. 7 and 8. This method of heating is suitable for cauliflower, cabbage, lettuce, beets, and broccoli.

Electrical Details—Several beds may be operated by one thermostat with the addition of a relay. When a relay is used, the thermostat handles only sufficient current to operate the coil of the relay. When the thermostat closes the circuit, it energizes the coil of the relay which closes the switch and turns on the heaters in several beds at once.

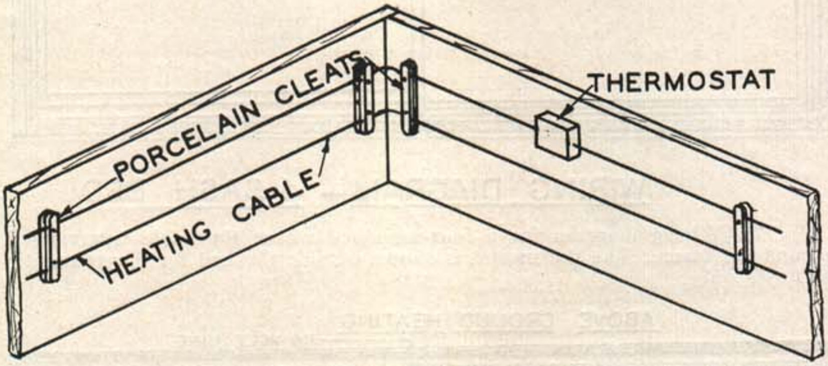


Fig. 5.—The heating cable is sometimes placed around the walls of the hotbed.

When heating with lead sheathed cable, the amount of cable recommended by the manufacturers[1] should be used. It requires 400 watts to heat a six foot by six foot hotbed. Increasing the length of cable decreases the amount of heat. The length of the cable should not be decreased materially as this will increase the temperature of the cable beyond the point which it will stand.

The cost of operating an electric hotbed will depend upon its construction, the outside temperature and the cost of current. Maryland[2] experiments show that a saving of about 35 per cent of the current was made by putting eight inches of cinders under the bed and 10 inches of cinders around the outside and stripping around the sash to prevent air leakage. Experiments conducted at the Minnesota[3] Station indicate that a six foot by six foot hotbed requires about one kilowatt of current per week for each degree difference of temperature between inside and outside. Thus, if the inside temperature averaged 55 degrees and the outside 20 degrees, the difference would be 35 degrees and would require 35 kilowatts per week.

[1]Cable is manufactured by the General Electric Company, Schenectady, New York and the General Cable Corporation, New York City.
[2]Kable, G. W., and A. V. Krewatch—1932, Electric Soil Heating, Nat. Rural Electric Project Mimeo. Report No. 10, College Park, Md.
[3]Currence, T. M.—1932, Methods of Supplying Electric Heat to Hotbeds. Minn. Exp. Sta. Bul. 289.

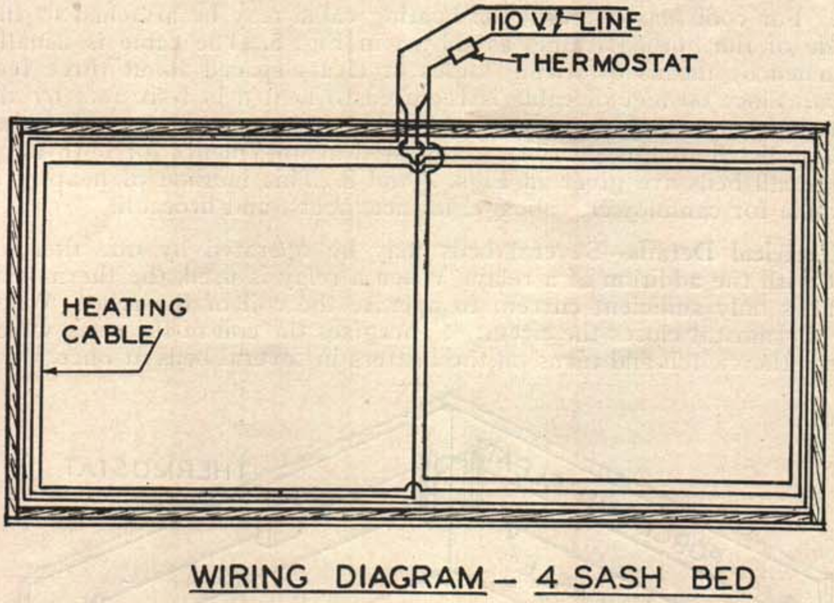


Fig. 7.—Wiring diagram for a four-sash bed where the cable is arranged around the frame. The thermostat is shown outside the bed for diagrammatic purposes only.

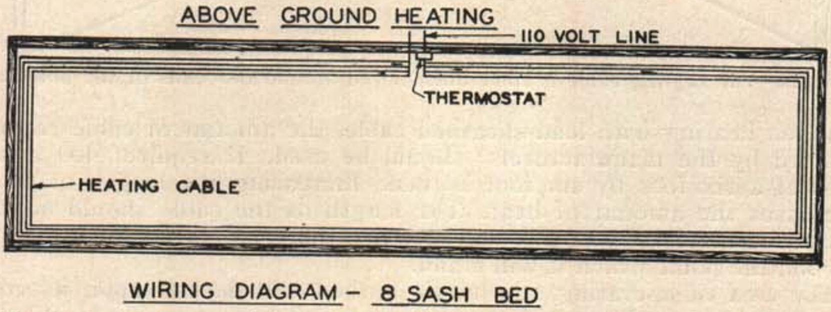


Fig. 8.—In wiring an eight-sash bed a thermostat and relay should be used for controlling the current.

The average cost of operating six foot by six foot hotbeds with current at three cents per kilowatt in some experimental work has been:
Minnesota—Five week period. Avg. outside temp. 19.7 degrees—cost $1.50 per week.
Maryland—Twenty-four day period. Outside temp. 28-79 degrees—cost $.43 per week.

STEAM AND HOT WATER HEATED HOTBEDS

Steam or hot water may be used for heating hotbeds. Where the beds are located adjacent to a sash house heated by steam or hot water, this method of heating is convenient and economical.

The heating pipes are usually run along both sides of the bed frame as near the top as possible. The feed pipe is placed on the north or high side of the bed and the return on the low side. This arrangement permits of a small amount of fall in the lines.

In order to maintain 50 to 55 degrees in sub-zero weather, about three and one-half feet of steam radiation is required for each sash; for hot water about six feet of radiation per sash is required. For steam, a two-inch feed line should be used and a one and one-fourth inch return is necessary.

Fig. 9 shows a more substantial type of construction for a hotbed. The walls are made of concrete. When concrete construction is used, footings should be provided as shown. Since concrete is a rather poor insulator, either cinders or strawy manure should be banked around the outside.

This type of hotbed is the most practical for the commercial grower having a steam boiler. The bed is wide enough to accommodate two standard sash or 12 feet in width. Since this is a permanent bed tile has been laid for steam sterilization, details of which are given in Figs. 9 and 10. This type of bed can also be used for growing to maturity certain crops such as winter parsley, early radishes, green onions, and spinach. Some growers have used this type of bed for growing early head lettuce.

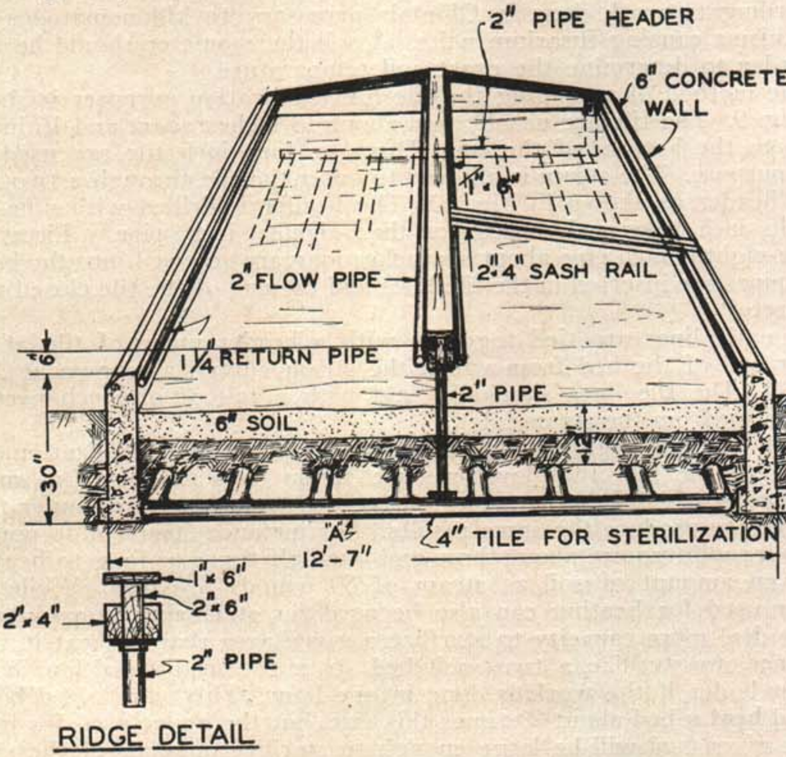


Fig. 9.—A permanent type of hotbed built of concrete with steam or hot water heat and with tile for sterilization.

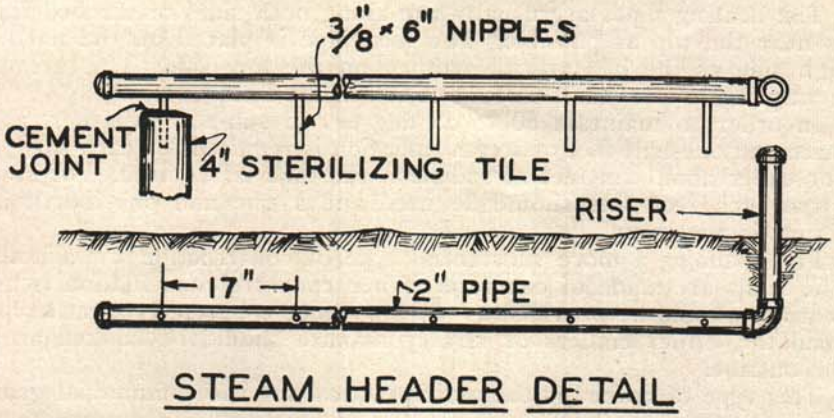


Fig. 10.—Header pipe used for conducting steam into tile lines.

When this type of bed is sterilized a temperature of approximately 182 degrees F. should be maintained for at least one hour, but it will usually require four to 10 hours to heat all the soil in the bed to this temperature, depending upon the steam pressure. This temperature according to work done in Ohio[1] is necessary to kill nematodes and organisms causing fusarium wilts. A soil thermometer should be used in order to determine the exact soil temperature.

The method of arranging the tile for sterilization purposes is shown in Fig. 9. The tile are usually laid about 18 inches apart and 16 inches deep to the bottom of the tile. Three or four inch tile are used for this purpose. The steam is allowed to enter the tile through a two-inch pipe header as shown in Fig. 10. The header is drilled with nine-sixteenths inch holes and tapped for three-eighths inch pipe. Pieces of three-eighths inch pipe about six inches long are screwed into the holes. The pipes are inserted in the tile lines and the end of the tile closed with concrete.

The tile lines are tied together with a header made of tile at the other end of the bed from which the steam enters, as shown at A in Fig. 9. The tile lines should be laid with a fall of one-inch per 100 feet away from the steam inlet.

Both low and high pressure steam can be used for sterilization, but owing to the fact that low pressure steam does not carry as many heat units, it will be necessary to leave the steam on for a longer time in order to produce the same results. For instance steam of 10 pounds pressure will require about three and one-half times as long to heat up a given amount of soil as steam of 80 pounds pressure. While the boiler used for heating can also be used for sterilizing, it requires a great deal more capacity to sterilize a given area than to heat it. For instance, to sterilize a two sash bed (6′ x 6′) requires a four-horse power boiler if the work is done in one hour. This same sized boiler would **heat** a bed about 20 times this size, but the boiler used for heating a given bed will be large enough to sterilize one-half of the same

[1]Newhall, A. G.—1930, Control of Root-knot Nematode in Greenhouses. Ohio Exp. Sta. Bul. 451.

bed if the steam is applied for 10 to 12 hours. Tile lines may be as long as 150 feet, but if only a small capacity boiler is available headers must be put in so that an area within the capacity of the boiler can be sterilized at one time. This can be accomplished by putting a header and a temporary partition across the bed and sterilizing these sections one at a time. For example, if a ten-horse power boiler is used, it will be necessary to sterilize the hotbed in 5-sash sections (15′ x 6′). The bed should be covered over with matting or canvas to prevent the loss of heat.

In working with high pressure steam, long tile lines are desirable to prevent blowouts. Also considerable saving in heat can be made if the ground is sterilized when comparatively dry. It requires a great deal of steam to heat up the water in the soil.

The most difficult portion of the bed to sterilize is directly above the header where the steam enters. This portion of the bed can usually be effectively treated by continuing the sterilization for a longer period of time or by providing some means of injecting steam into the soil at this point.

Table 3.—Showing capacity of boilers for heating and sterilization of hotbeds.

Size of boiler in terms of "horse power"	Heating capacity feet radiation	Number sash which can be heated	Area which can be sterilized in 10 hours
1	100	28	1 sash
3	300	50	3 sash
5	500	140	5 sash
10	1000	280	10 sash
15	1500	420	15 sash
25	2500	700	25 sash
50	5000	1400	50 sash

COLD FRAMES

Cold frames are used, and should be used, as a supplement to the hotbed or sash house. Their greatest use is to furnish space for plants moved from the hotbed to make way for starting other plants. This is very important for the gardener growing several different crops and allows him to get the maximum use of space under heated glass frames. Cold frames are also used to accustom early plants, which have been grown in a heated frame, to outdoor conditions preparatory to field setting. They are also used to start plants in containers, such as melons and early cucumbers, in order to get an earlier crop.

Standard hotbed sash are used on cold frames, and, early in the season, mats or additional covering may be required at night. It is not necessary to have sash for all the cold frames. Many of the earlier cool season crops can be carried under muslin covers towards the end of their stay in the frames, and this allows the use of the sash on frames to carry the crops planted later. By careful planning a few sash may be made to cover a large number of plants.

Details for the construction of a five-sash knock-down cold frame are given. The sides and ends may be banked with strawy manure for additional insulation. Efficient inexpensive mats may be made from fertilizer sacks which have been ripped open, washed, sewed together, and dipped in raw linseed oil. Burlap or canvas when dipped in a waterproofing mixture and doubled also make good mats.

Large cloth covered cold frames 12 to 18 feet in width and any length could be used on especially prepared rich soil for the production of early crops of peppers, eggplants and head lettuce. Irrigation is required for this special type of production. Heavy waterproofed canvas is tacked on the north side and a two by four is used for a roller on the south side. Narrow strips are placed across the frames to support the canvas, which is used on cold days and at night in the early part of the season.

Transplanting—A standard flat (3″ x 12″ x 18″) will usually grow 800 to 1,000 seedlings when seed is sown in rows two inches apart and 10 to 12 seed per inch. These seedlings must be transplanted as soon as the first true leaves appear. Otherwise the seedlings will be stunted and much of the advantage of starting the plants early will be lost. It is also just as important to give the plants proper spacing in the hotbed or cold frame. It is very poor economy to crowd plants too closely at transplanting time as they must be transplanted again or be stunted due to crowding. More than one transplanting is not necessary if proper spacing is allowed. Plants that have never been transplanted make more rapid growth than ones that have been, but proper hotbed management almost requires one transplanting. The proper "spotting" distances are given in Table 1. There are some vegetables which are never transplanted, such as muskmelons, squash, and watermelons. The seed of these crops is planted in the container in which the plant grows until field setting time. One of the most popular containers is wood veneer bands. These bands are four inches deep, are square in shape, and are made in different sizes. They have neither top nor bottom and the band is taken off when the plants are set in the field.

Hardening-off—The purpose of hardening-off of plants is to produce sturdy and stocky plants that can withstand the hot sun, drying winds, droughts, and cold weather. Hardening-off will not make tender plants, such as peppers, eggplants, and muskmelons, resistant to frost nor even to cold weather but plants so treated will usually survive field conditions when untreated plants are seriously damaged. Cool season crops, such as cabbage and cauliflower, may be hardened so that they will withstand frosts.

The most efficient method of hardening plants is by withholding moisture or watering only sparingly for a week or 10 days before the plants are transferred to the field. This method is just as efficient as subjecting the plants to lower and lower temperatures, and for crops such as celery and beets, will not cause "bolting" to seed. Increased ventilation along with a decreased water supply is also beneficial, but it is not necessary to subject plants to cold night temperatures and it is often dangerous.

Bulletins on growing the special crops such as tomatoes and melons will be sent upon request. These bulletins give full particulars on plant production for these crops.