weighs about 11 lb. per line ft.. and holds 2 qt. of water per lineal foot; its superficial surface is about 1.05 sq. ft. to the lineal foot.

The two principal virtues of the 3½ in. cast iron pipe are that it is practically indestructible—it resists corrosion in the humid atmospheres of greenhouses much longer than any wrought pipe, and its large water content provides stability of temperatures, which is very desirable in private greenhouses, where the gardeners give no attention at all through the night to fires, or at most look after them only on especially cold nights.

Pipe of 2 in. diameter, both wrought iron and wrought steel, is used in small commercial houses where hot-water heating is suitable. The genuine wrought iron pipe costs considerably more than the steel pipe and hence is not used as frequently. Steel pipe as now manufactured is much more durable than formerly.

Pipe that is 1¼ in. in diameter is used almost exclusively for steam heating in whatever form. With hot-water heating, in order to provide even temperatures throughout the length of the greenhouse, it is desirable that the number of flow lines be equal to the number of return lines, consequently as much as possible the designer of the system always plans for coils of even numbers of lines which are usually placed under benches in two rows, the upper rows the flows and the lower the returns.

With steam heating, when overhead mains are used, coils may be considered as returns and it does not matter much whether there are an equal number or not. Mains and connections are designed so that the pressure drop will be low and with little loss of pressure there is very little difference in temperature end to end.

Gravity hot water coils constructed of 2 in. pipe are not practical in lengths of over 200 ft., indeed they are not really practical in lengths of over 150 ft., whereas steam coils or steam return lines are frequently installed 300 ft. in length.

Cast iron pipe of 3½ in. size is jointed by means of what are commonly called "rust joints;" the pipes are laid 6⅛ in. center to center; fittings are manufactured with hubs or bells and spigots; all are caulked together with rust joints.

Rust joints are not as well known or understood as they should be though they have been made for a century or more; the average fitter does not seem to take to the making of greenhouse rust joints and these mechanics seem bound to use salamoniac, salt or some such substance to set up rapid oxidation. These joints are properly made as follows:

Tarred rope cordage, or hemp is caulked into the hub or bell and then clean, moist iron borings are caulked on top of the rope foundation; the borings should be moist, just so that they will cake in the hand and should not be wet and they should be added a little at a time and caulked, not tamped; the more they are hammered, the better they are. They should be caulked sufficiently so that the finished joint will present a hard metallic surface.

Such joints properly made will permit turning on the water and operation of system immediately after the last joint is caulked and they

improve with age. Some old time steam heating systems are constructed with mains of cast iron pipe and caulked joints and the joints held against low pressure steam.

Besides the advantages of durability and of large water content, resulting in stability of temperatures, cast iron pipe is really desirable because it reduces labor costs, necessity for skilled labor and for cutting and threading tools—no tools are necessary, other than vise, pipe cutter, hammer, cold chisel and caulking tools. The use of vise and pipe cutter has only developed within recent years; formerly greenhouse pipefitters cut all pipe with cold chisels.

The making of a new connection or the repairing of a leak in a 3½ in. pipe line is much less serious an affair than the placing of tees in 3½ in. wrought pipe lines, pieces may be cut in and cut out and ends sleeved together easily and economically.

The 2 in. pipe is placed 4½ in. center to center and 1¼ in. pipe 3 in. *center to center.*

POSITION OF RADIATION

Greenhouses are piped in all sorts of ways to suit the great number of different ideas of greenhouse owners and operators; their different ideas on the subject of plant bench or plant bed arrangement which arrangements govern largely the location and arrangement of the piping; and to suit the special requirements of the plants or flowers to be grown in the houses. In houses for vegetable growing, where planting is directly on the floor of the greenhouse, piping should be, mainly and if possible, entirely on the sides so as to provide the maximum growing surface. For rose growing the piping is required to be more scattered or distributed than for any other purpose—if there are raised benches, some heating surface must be under every bench; if there are solid beds, some radiating surface must be in every walk.

The bulk of the piping for all purposes, however, should be on the side walls, or just inside the outer walls of the greenhouse. For sweet pea growing, most of the pipe surface should be on the side walls and some on the pipe columns, generally high enough to permit walking under; however there is much latitude in the placing of pipe coils and it may be said that the greenhouse heating engineer does not always place piping, the radiating surface, just where it belongs, or just where he should place it, but rather he places it where he may, or the operator's planting arrangement permits.

As intimated, there are many problems of distribution of coils. When they must be large or long, and small or short coils served by the same mains, care must be taken to avoid short circuits through the short coils. Long pipe coils always present the problem of taking care of expansion.

The coils need not be graded very considerably in order to produce circulation; pitch, or grade, is required to produce high points in hot water heating where air may collect and be released and in steam systems for the purpose of drainage. Condensation should always flow with the steam current.