A grade, or pitch, of ⅜th of an inch in 10 ft. is ample in either case.

There is a dearth of dependable data and rules for the sizing of mains with which to connect the coils with the boiler or boilers, owing to the fact that greenhouse heating uses more pipe for radiating surface with less head or elevation than is required or used with any other type of gravity heating. Resistance through the heating unit is less, it is believed, in greenhouse heating than with any other unit; the frictional resistance through coils made up of two or more lines of steam piping 300 ft. long must be less than through a smiliar quantity of radiating surface in any other form.

Mains generally are planned for shortest distance between two points; there is a minimum of bends in greenhouse heating mains. For gravity hot water heating and for gravity steam heating in greenhouses it is believed that greater quantities of radiation are carried on mains than for any other purpose for the reason above given.

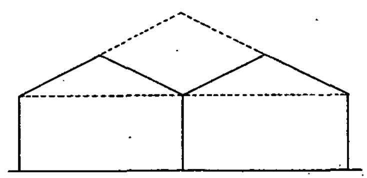

Fig. 1. Sketch Shows Relation of Cubic Contents and Roof Glass Surfaces

When it is found that the size of the system is so large as to call for large mains, say 7 in. pipe, or larger, it may generally be stated as a fact that the system is a little too large for gravity hot-water heating. Greenhouses should then be heated with steam, or at any rate the circulation should be accelerated by means of a centrifugal pump or hot-water circulator or accelerator, because large mains in gravity hot-water heating systems almost always present difficulties in the way of distinct self-contained circulations and counter currents.

For steam heating, 1¼-in. pipe is used almost exclusively, and the greenhouse man has found that where one line of 3½-in. pipe is required to produce a certain specified temperature with hot water as the heating medium, one line of 1¼-in. steam pipe at low pressure will do the same work. This fact is inconsistent with the application of the divisors given for quantities of radiation, but the difference is probably accounted for by the fact that 1¼-in. pipe, being of so much higher temperature, is better distributed. Much of it is distributed in single lines; most of it in flat coils, and seldom in two rows, one over the other, and even then the coils are constructed so as to provide drainage, with a pitch from the supply end to the return bends at the opposite end, and back from the return bends to the return header, so that the coils converge and are not close

together. The pipe lines do not, therefore, interfere with each other in radiating their heat. Furthermore, with the proper boiler power it is easily possible to increase the pressure and consequently the temperature so that a greater range is possible than with hot water systems.

LARGE RANGES HAVE STEAM SYSTEMS

Hot-water heating was used almost exclusively 20 to 25 years ago. Now the use of hot-water heating is confined to private ranges and to small and medium-sized commercial ranges. It is practically never used in large commercial greenhouse ranges. Its cost would be prohibitive. Hot water is, of course, much more economical in small houses, but in large ranges a properly designed hot-water plant and a properly designed steam system would be equally economical, but the first cost of hot water is very much above the first cost of steam. In very large ranges vacuum steam heating is frequently used. This permits the use of smaller mains, smaller return connections and has the advantage of quick circulation, and immediately responds to sudden demands.

Overhead mains, generally speaking, are very desirable in a steam heating plant and not at all desirable in a hot water system; it should be understood that overhead mains are a little too near to the glass roof, that convection currents are almost entirely above the mains and not below, that most of the heat given off by these overhead pipes is lost through the glass.

A steam system, especially in long greenhouses, and commercial greenhouses are generally long, must be so fitted up as to provide for expansion, it must be flexible, and furthermore the clear space underneath plant benches, or the heights of solid beds, are such that there is insufficient room for running in converging coils; this makes overhead mains absolutely necessary in some cases and very desirable in others, but with hot water heating the runs of pipe are not so long and the temperature range is not so great, consequently there is not so much expansion to be provided for. There is not, therefore, the same necessity for overhead mains and furthermore, greenhouses that are heated with hot water, in which overhead mains are run to the far end and there deliver to floor coils, on walls under benches or in walks, which are in a sense return lines, are very unevenly heated as must be perfectly apparent.

In such systems the hottest water is of necessity in the overhead mains, the coldest water is in the returns. The floor coils are naturally hottest at the far end of the greenhouse and they lose their heat in their progress towards the boiler. Furthermore, the far end of the house, the end at which the coils are fed by the overhead main, is the warmer end.

The coldest days, the zero days, especially in this part of the country, are few, indeed, probably in all six such days in the whole firing season. Most of the days of the firing season are mild and even in midwinter, during coldest weather, when the sun shines, there is very little need for heat and at such times, with overhead hot water mains, the small amount