attention through the night when a fireman or watchman is not employed; (2) because of its great durability. Cast iron pipe outlast wrought iron or wrought steel pipe in the humid atmosphere of greenhouses.

The greenhouse heating contractor divides the quantity of glass and glass equivalent in the section of the greenhouse by the proper factor from the Table 52 for the temperature desired, and accepts the result obtained as the required number of lines of 3½-in. cast iron pipe, this size providing about 1 sq. ft. of surface to the lineal foot of pipe (1.05 sq. ft.).

In most commercial greenhouses, 2-in. pipe is used for hot-water heating, and where the houses are not too long, or there are not too many of them, 2-in. pipe does not, of course, hold the same quantity of water as 3½ in., and therefore requires a little closer attention. Its cost, however, is considerably less; hence it is used in commercial ranges.

The coils are constructed, for hot-water heating, of parallel lines with the number of flows equal to the number of return lines. Two-inch pipe coils are constructed of pipes 4½ in. center to center, horizontally and vertically. It is desirable to place the bulk of the piping on the sides of the house, and the remainder of it about evenly distributed under the plant benches or on the sides of the solid beds, the main idea being to produce a proper transmission of heat across the full width of the house with due regard to the shape of the roof, its greatest cooling surface.

POSITION OF RADIATION

Greenhouses are piped in all sorts of ways to suit the great number of different ideas of greenhouse operators; to suit 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 short, it may be said that the greenhouse heating engineer does not always place the piping, the radiating surface, just where it belongs, but he does put it where he may or where the operator's plant 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 where air may collect and be released.

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

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. When 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 0.5 lb. pressure will do the same work. This fact is inconsistent with the application of the divisors given

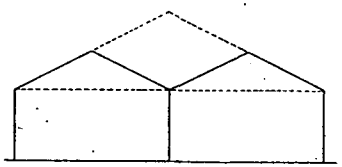

FIG. 39. SKETCH SHOWS RELATION OF CUBIC CONTENTS AND ROOF GLASS SURFACES

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 it is easily possible to increase the pressure as desired.

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