$(C_p + C'_p x)(T' - 273)$, which, since the process is adiabatic, is equal to the heat in the initial stage,

$$C_p(T-273)+x(T'-273).$$

That is:

1. The heat content of any air equals the heat content of the same air saturated at its wet-bulb temperature minus the heat content of the liquid water required so as saturate it.

2. The wet-bulb temperature of air adiabatically cooled, whether much or little, by evaporation into it from spray or other source, is constant.

3. If the wet-bulb temperatures of several portions of air are equal that of their mixture will be the same, however different their actual temperatures.

Furthermore, since the quantity of heat added to an object divided by the current absolute temperature of that object is the change in its entropy, the entropy per gram of dry air at the absolute temperature T, counting from 0° C. is

$$C_p \int_{273}^{T} \frac{dT}{T} = C_p \log \frac{T}{273}.$$

Similarly the entropy of $1+x$ grams of saturated air at the absolute temperature T', also from 0° C. is, since the specific heat of water is one,

$$C_p \log \frac{T'}{273} + x \log \frac{T'}{273} + \frac{Lx}{T'},$$

in which L is the heat of vaporization of a gram of water at the absolute temperature T'.

But

$$C_p \log \frac{T}{273} = C_p \log \frac{T'}{273} + \frac{Lx}{T'} \text{ nearly,}$$

since, on putting $Lx = C_p(T - T')$, the expression reduces to

$$\log \frac{T}{T'} = \frac{T}{T'} - 1 - \tfrac{1}{2}\left(\frac{T}{T'}-1\right)^2 + \tfrac{1}{3}\left(\frac{T}{T'}-1\right)^3 \ldots\ldots = \frac{T}{T'} - 1,$$

nearly, which is true for all ordinary values of T/T'.

Hence, in Normand's words:

The entropy of any air approximately equals the entropy of the same air saturated at its wet-bulb temperature *minus* the entropy of the liquid water required so to saturate it.

ATMOSPHERIC TEMPERATURE AND THE CODLING MOTH.

By CHARLES C. GARRETT, Meteorologist.

[Weather Bureau, Walla Walla, Wash., Sept. 8, 1922.]

Among the numerous insect pests that infest the orchards of the United States and cause great losses to fruit growers, undoubtedly one of the most destructive of those that attack apples and pears is the codling moth. In a letter to the writer the District Horticulturist for the southeast Washington fruit district stated that in the season of 1918 the Yakima Valley apple growers suffered a loss of over $2,000,000 due to the ravages of the codling moth alone. The Walla Walla district fared somewhat better, but the shipping data kept by the Horticultural Department showed that 28 per cent of all the apples were culls, and in accordance with the State horticultural laws were necessarily shipped to by-product plants, fed to hogs, or left to rot upon the ground. Conservatively speaking, at least 26 per cent of this total was accounted for by the codling moth.

The codling moth passes the winter in a cocoon, mostly under the loose bark of the trees. In early spring the larvae begin to transform into pupae, and soon after the apple blossoms have fallen the moths begin to emerge and continue to do so until the middle of summer. They lay their eggs chiefly on the leaves of the trees. On hatching, the young larvae seeks the easiest place to enter the apple, which is furnished by the calyx, or blossom end of the fruit, although a certain proportion enter through the stem end or through the skin. Between three and four weeks are spent by the larvae, or worms, in the fruit. Most of the wormy fruit falls before the larvae emerge.

In ordinary seasons, in northwestern apple districts, the codling moth has three generations and a partial fourth. Also, under ordinary weather conditions, the broods hatch at distinct periods. Dates of the main portion of each brood's hatching are determined, from which proper dates for spraying can be ascertained.

The means of control of the codling moth consist in covering the fruit and foliage with a poison mixture by spraying with a force pump. The first, or calyx spray, is begun when most of the petals have dropped, with calyx cups still open to receive the poison, and finished before the calyxes are closed. Succeeding sprays, known as cover sprays, are applied at varying intervals during the late spring and summer seasons for combating the later brood larvae.

As the cost of spraying adds materially to the expenses of an orchard, it is very essential that the work be done when it is most effective, and that, in order to avoid waste, no more be done than necessary to combat the pests. Most progressive fruit growers have come to depend upon the advice of the State horticulturists for proper dates for spraying.

Codling moth cages, in which dormant larvae are placed early in the season, are distributed throughout a district, care being taken to have each cage correspond in every way to natural conditions. The length of time from the appearance of the moth, or adult butterfly, to the appearance of its offspring, the young larvae, is a known quantity, provided the atmospheric temperature is observed and recorded. While it has long been recognized that climatic factors influence the severity of the ravages of the codling moth, it was not until recent years that the close relationship that exists between the temperature of the air and the development and activity of the moths has been studied and charted. Here is where the services of the meteorologist are needed in cooperation with those of the entomologist and horticulturist.

In a letter to the writer, dated August 21, 1922, Mr. E. J. Newcomer, entomologist, United States Bureau of Entomology, who has been engaged for several seasons in deciduous-fruit insect investigations in the Yakima Valley, Washington, stated: "Codling moths do not deposit eggs when the temperature is below 60° F. Three fourths of the eggs are laid between 3 p. m. and 9 p. m." Mr. Newcomer kindly furnished a diagram which is repro-

(To face p. 128.)

FIG. 2.—Moth cage.

(To face p 129)

FIG. 1.—Snowfall at La Crosse, Wis., March 4, 1923.

duced with this paper (fig. 1). This diagram shows graphically the relationship that exists between the late afternoon and evening temperature and the number of codling moth eggs laid daily. The average daily temperature for the 6-hour period, 3 p. m. to 9 p. m., is

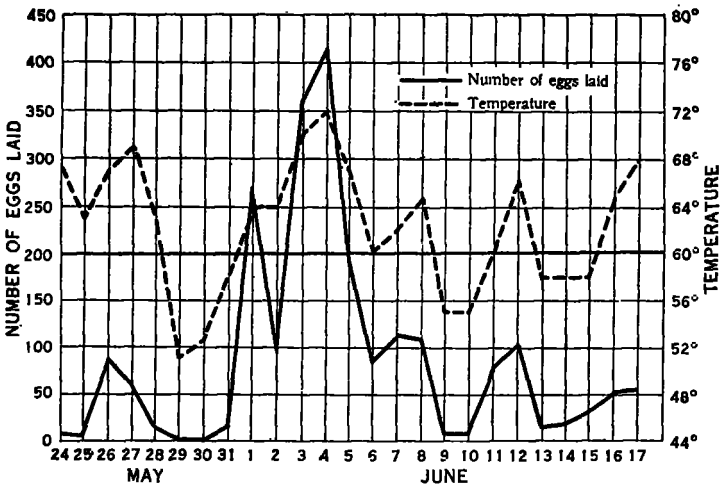

FIG. 1.—Relationship between late afternoon and evening temperature and the number of eggs laid daily by the codling moth.

shown on the chart by the broken line. The number of eggs laid is indicated by the solid line. Mr. Newcomer states that this is merely a sample taken from their records for four years. It will be seen that when the temperature drops below the 60° line, the number of eggs laid drops to zero or nearly to zero. According to Mr. Newcomer, a temperature of 60° or higher at 8 p. m. for two or three nights in succession will produce enough eggs to make a spray necessary, and that as these eggs will hatch in from one to three weeks, depending on the temperature, the spray must be applied accordingly. He further states that if the weather turns cold, that is, with maximum temperatures of 70° or lower, after these eggs are laid, the spray would not have to be on the trees for ten days or two weeks, while if it remains warm (maximum 75° or higher) the spray should be on in a week.

With the desire of cooperating as fully as practicable with the office of the district horticulturist in the work of determining the proper spraying dates for codling moth, the Walla Walla station of the Weather Bureau has installed thermometer shelters in three different parts of the Walla Walla fruit district. Each shelter is equipped with maximum and minimum thermometers and a short-range thermograph. As the temperature varies considerably in different parts of the district owing to differences in topography, more than one station is needed for best results. Two of the shelters are located in commercial apple orchards, and one in the yard of the writer's home in the city of Walla Walla. These special stations have been in operation for the last five seasons, and the records, in the words of one of the horticulturists, "have played a large part in codling-moth control in this district." Those that are located in the orchards are in close proximity to the codling-moth cages, and the records are kept by the orchardists who also keep the records of moth emergence. A view of one of the moth cages is shown in Figure 2. These are located in the Pomona orchard, northeast of Walla Walla.

THREE WISCONSIN SNOWSTORMS.

By W. P. STEWART, Meteorologist.

[Weather Bureau, Milwaukee, Wis., April 21, 1923.]

The average snowfall in Wisconsin during March, 1923, was 19.8 inches. This is the greatest of record and is more than double the usual March snowfall. The greatest previous average for the State was 18.3 inches in 1891, and the least, 0.8 inch in 1910. Because of snowdrifts, highways throughout Wisconsin were impassable except for horse-drawn vehicles during the greater part of the month.

In most sections it was a month of frequent and heavy snows. Snow fell in some part of the State every day in the month but one. The first general and considerable snowfall occurred on March 4. This was heaviest in the vicinity of La Crosse where much damage was done to trees and overhead-wire systems. This was followed by intermittent snows from the 6th to the 9th. Then followed a series of 3 storms during which most of the month's snowfall occurred; crossing the State in rapid succession they made almost one continuous snowstorm throughout the second decade. These storms delayed rail traffic, damaged overhead-wire systems, blocked highways, and caused an economic and property loss in Wisconsin estimated at over $1,000,000.

The first of these three storms occurred on March 11, 12, and 13, in connection with the movement eastward across the State of a barometric depression of unusual intensity. During its passage the barometer at Milwaukee fell to 28.82 inches, sea-level reading. This is the lowest of record with one exception. The snow from this storm was unusually moist, so there was little drifting, notwithstanding a gale of 30 to 60 miles. The snowfall in southern and eastern Wisconsin ranged from 6 to 20 inches, the heaviest being in southern counties near Lake Michigan. The moist snow, at first mixed with some rain and sleet, stuck to wires, poles, and trees, and froze there. This made a coating of porous ice, or mixed ice and snow, which on wires and the small branches of trees and shrubbery was about 1½ inches in diameter. Over a wide area in southern and southeastern Wisconsin branches of trees, and in many cases whole trees, broke down. These in turn, aided by the gale, bore down thousands of telegraph and telephone poles and many miles of wire. One company alone estimated its loss from this cause at $250,000. Telegraph and telephone services were more or less seriously delayed for approximately 5 days.