periods of December, 1924, two of these machines were given a careful test in a lemon grove near Pasadena, Calif. One broke down immediately because of the settling of the motor. The other was kept running only with difficulty, because of overheating of the motor, but it was operated throughout all the cold nights. It showed practically no effect whatever on the temperature in the orchard, even within a few feet of the base of the machine.

Following the earlier tests, which showed that the temperature in the orchard was not raised appreciably, the officials of the company had claimed that protection against freezing of the fruit was afforded regardless of temperature simply by creating a breeze over the trees. In the latest test, however, this contention was entirely disproved. The fruit crop was a total loss, and the trees were defoliated and severely damaged.

This corporation has spent probably several hundred thousand dollars in experimental work, without much encouragement. At present it appears that the method will be abandoned. The machines cost several thousand dollars each, and it is believed that by discouraging their purchase the Weather Bureau has been instrumental in saving the growers large sums of money.

Overhead sprinklers.—During the past two years several citrus growers have installed overhead sprinklers, for irrigation and frost fighting combined. Vertical pipes carrying the sprinklers at their tops are set at intervals which allow the entire grove to be sprayed.

From the beginning, we have done everything possible to prevent growers from counting on the efficiency of overhead sprinklers in protecting fruit from frost. Despite this, several large citrus groves were equipped with them, mainly for frost protection.

During the winter of 1924–25 a careful check on the effect of this artificial rain was made under actual frost conditions. The temperature was raised about 3°, but it was necessary to shut off the water after about two hours, because the heavy coating of ice threatened to strip the branches from the trees. We have thus been able to convince the growers that overhead irrigation for this purpose is not practical.

To describe all the new heaters tested would exceed the limits set for this paper. They may be briefly mentioned. First is the central heating plant. The fuel was burned in a large furnace, and the heated gases driven through large pipes through the orchard. Second is the covering of the trees with canvas tents. Third is the running of irrigation water in furrows in the orchard; this practice appears to have some value, but is effective only when the temperature does not fall much below the danger point. In a carefully conducted experiment, it was found that running water at a temperature of 72° in an orange grove held the temperature about 1.5° on the average above the outside temperature. Fourth is the use of coal briquets for orchard heater fuel. These were found to be satisfactory for protecting small acreages, but high labor charges and other drawbacks make their use inadvisable for large acreages.

To sum up the matter, the orchard heater is today the only practical means of obtaining complete protection from low temperatures in orchards, but constant effort is being directed toward finding some more satisfactory method.

VALUE OF SMUDGE-POTS IN PREVENTING FROST IN CRANBERRY BOGS

(Summary of a report by R. A. Wells and Perry Parker)

By FLOYD D. YOUNG

The Fruit-Frost Service of the Weather Bureau receives numerous inquiries regarding the practicability of using heaters to protect low-growing crops, such as strawberries, potatoes and tomatoes, from frost damage. Tests conducted recently by Mr. Roy A. Wells, in charge of the Weather Bureau office at North Head, Wash., and Mr. Perry Parker, his assistant, to determine the amount of the temperature rise that can be obtained by burning fuel oil in lard-pail heaters on the cranberry bogs near the mouth of the Columbia River, are of considerable interest in this connection. The flooding of the bogs for frost protection, as is done in Wisconsin and the Atlantic coast cranberry sections, is not practicable in Washington.

A one-half acre plot, equipped with forty 10-quart lard-pail oil heaters, was selected for the heating tests. The heaters are similar in shape to an ordinary lard pail, from which they take their name. They are 9 inches in height, with a top 9½ inches in diameter, and a bottom 8½ inches in diameter. The "spider" is a removable disk, which is placed over the top of the heater, reducing the rate of fuel consumption.

An instrument shelter was placed in the center of the plot, and another in a bog not equipped with heaters, about 300 feet distant, for a check on the outside temperature. Both shelters were set directly on the vines. The instrument shelter in the protected area was placed 15 feet from the nearest heater. Exposed thermometers were placed on the surface of the vines near both instrument shelters, for a check on the radiation temperature.

The heaters were lighted on two frosty nights, September 25–26, and October 10–11, 1924. On both nights a ground fog hung over the check plot at intervals, but no fog formed over the heated plot. During the first experiment the heaters were set on iron tripods, of the type shown in Figure 1, with the tops of the heaters 2½ feet above the surface of the vines. The heaters were burned with the so-called "soot arresters" or "spiders" in place, reducing the rate of burning about two-thirds. The maximum rise in temperature inside the instrument shelter, due to the heaters, was 2.9° F. The ground fog at the check station affected the temperature indicated by the thermometer exposed on the surface of the vines, so that a direct comparison between the exposed thermometer readings at the two plots can not be made. However, by comparing the difference between the readings of the sheltered and exposed thermometers in the area equipped with heaters before the heaters were lighted, with the difference while the heaters were burning, some conception of the effect of the direct radiation from the heaters on the temperature of the vines, may be obtained.

Before the heaters were lighted the average difference between the readings of the sheltered and exposed thermometers was 5.1° F. When the heaters were lighted the difference was reduced to 1.4° F., making a rise of 3.7° F. due to the heating. Adding the rise of 2.9° F. shown by the sheltered thermometer, to the 3.7° F. rise shown by the unsheltered thermometer, due to direct radiation from the heaters, a maximum effective rise in temperature at the surface of the vines of 6.6° F. is indicated. The average effective rise in temperature on this night was 5.1° F. at the surface of the vines.

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FIG. 1.—Lard-pail oil-burning heaters set on metal stands in cranberry bog near Seaview, Wash. The heaters are used in the spring to protect the blossoms and buds from damage by frost, and in the fall to protect the berries

FIG. 2.—Close-up view of heater on metal stand in cranberry bog. The three legs of the stand are forced into the ground several inches, so that the strong winds which sometimes blow in the district can not overturn tne heaters

When the heaters burned out in the morning there was a dry area about 4 feet in diameter and a frost-free area about 8 feet in diameter, around each heater.

On the second night the heaters were set directly on the surface of the cranberry vines. The "soot arresters" were removed after the heaters had been burning one hour, increasing the rate at which fuel was consumed about three times. After an hour of burning at this rate, the dry area around the heaters was about 6 feet in diameter, and the frost-free area about 10 feet in diameter. An inverted cone, 2 feet in diameter, placed directly over one of the heaters, increased, the diameter of the dry area to 8 feet, and the frost-free area to 12 feet.

The vines in a very small area around the heaters were scorched when the heaters were set directly on the surface of the vines. There was no scorching when the heaters were burned on the tripods. The effective rise in temperature at the surface of the vines, as shown by exposed thermometers laid directly on the vines, averaged 3.6° F. on the second night. The smaller rise was probably due largely to the flame from the heaters being closer to the ground.

The average gain in temperature on the two nights, due to the use of the heaters, was 1.7° F. inside the instrument shelter, and 4° F. on the surface of the vines.

The frost on the two nights of the test caused about 15 per cent damage in the check plot. There was no damage in the plot equipped with heaters.

The fuel oil burned in the heaters cost 6 cents per gallon in barrel lots. The cost of the oil burned was 96 cents per acre per hour with the soot arresters in place, and $3 per acre per hour without them.

The experiments conducted by Messrs. Wells and Parker indicate that it is practicable to protect cranberries from frost damage by the use of orchard heaters, at a reasonable cost. It is believed that as good or better results can be secured in protecting other low-growing crops, using the same methods.

SAMPLING THE HIGHER ATMOSPHERE

By W. J. HUMPHREYS

It seems practically certain that the percentages of the several gases of the atmosphere, except water vapor, are very nearly constant from the surface of the earth up to the base of the stratosphere, that is, throughout the layer of considerable convectional mixing. In the stratosphere, however, where convection exists only feebly if at all, and each gas therefore is distributed substantially as it would be if it alone were present, these percentages presumably vary with height, those of the heavier constituents decreasing and those of the lighter increasing.

If this be the actual condition of the stratosphere, as seems highly probable, then the composition and density of the atmosphere at any level in this region readily could be computed if we knew the temperature distribution below that point. Now, the average temperature of the air at every level, from the surface of the earth up to the height of at least 30 kilometers, is well known, season by season, for many places. In the middle latitudes, for instance, the temperature of the air from the height of about 11 kilometers up as far as explored, 30 to 35 kilometers, is around −55° C., varying slightly with the seasons and with the weather in the lower atmosphere. What the temperature, hence also the density, and even the composition, of the air is beyond the levels explored by the registering instruments carried by sounding balloons no one really knows. This temperature may remain substantially constant to the limit of the atmosphere of measurable density. Many have assumed it to do so as the result of a flux of outgoing radiation, practically invariable with height. On the other hand Vegard [1], at least, has argued from his studies of the aurora, that the temperature of the very high atmosphere, 100 kilometers, and up, above the surface, must be more or less below that of melting nitrogen, or, say −225° C.; and, furthermore, that the higher portions of the atmosphere contain neither helium nor hydrogen, but consist of nitrogen only, chiefly in the form of crystals held up by their state of electrification. Finally, Lindemann and Dobson [2] conclude from their study of meteor data that the temperature of the outer air, 40 to 50 kilometers and beyond, is in the neighborhood of 30° C.—tropical heat.

Here then was confusion which, though theory might greatly reduce, only direct observations, perhaps, could fully remove. This confusion remained as bad as ever until near the middle of 1924, since when it has so greatly yielded as now to be much less pronounced and provoking.

Free hydrogen might, of course, be present in the lower portions of the atmosphere and not in its outermost layers, owing partly, at least, to the presence of ozone, which might oxidize the hydrogen to water vapor, somewhere in the upper air. However, no similar argument applies to helium.

McLennan [3] has shown that the green fluorescent lines of solid nitrogen, produced by electron bombardment, do not coincide with auroral lines, and in particular that, "the" auroral line, λ 5577.35, is not so produced, contrary to Vegard's original belief that it was. Furthermore, McLennan and Shrum [4] have shown that this line is produced by an electric discharge through a mixture of air and helium, or oxygen and helium, at low temperature, also at room temperature, and low pressure. Hence the assumptions that there is helium in the upper levels of the atmosphere, and that the temperature of this region is above that of frozen nitrogen, are not only restored to reasonableness, but raised well nigh to certainties.

The logic of Lindemann and Dobson for a high temperature of the atmosphere at the 40 to 50 kilometer level and beyond, also has been questioned. A different line of attack from theirs by Sparrow [5] of the problem of meteor luminescence seems to remove the apparent necessity for any higher temperature in the outer reaches of the atmosphere than that measured hundreds of times and known to obtain at every level from, say, 12 to 30 kilometers.

Perhaps, then, the other horn of our upper air dilemma also is removed. If so it again would seem reasonable to assume that the outer air contains helium, and possibly hydrogen, and that its temperature in middle latitudes is around −55° C.

But however reasonable these assumptions may be they are not known facts. We do not know certainly either the average temperature or the composition of the air beyond levels reached by sounding balloons. This ignorance about the state and condition of our atmosphere is reason enough why we should try to ascertain

[1] Phil. Mag., 46, p. 577, 1923.
[2] Proc. Roy. Soc., A, 102, 411, 1923; 103, 339, 1923.
[3] Toronto meeting of the British Association for the Advancement of Science; and elsewhere.
[4] Proc. Roy. Soc., A, 108, 501, 1925.
[5] To be printed in an early issue of the Astrophysical Journal.