curred no losses ensued, in fact no movable property was lost in this city or in the country on account of the flood. The only damage, so far as learned, was to crops where farmers had planted them in the spring on bottom land, taking chances of their being inundated. Losses of this character, however, were smaller than usual, as most of the farmers were expecting a big rise and were prepared for it. The river at Portland was above the flood stage from June 4 to July 17, inclusive, or 44 days in all. Part of this time it was as much as six feet above the flood stage and the utility of the service can not be questioned when it is considered that vast quantities of goods were moved to places of safety without any losses whatever except the extra cost of moving.

TABLE 2.—*Flood crests, Columbia River drainage*, 1909.

Stations.	Height.	Date.
	Feet.	
Weiser, Idaho	12.6	June 7
Lewiston, Idaho	19.0	June 5
Riparia, Wash.	17.8	June 6
Bonners Ferry, Idaho	27.9	June 6
Newport, Wash.	18.6	June 25
Northport, Wash.	32.9	June 23
Wenatchee, Wash.	39.7	June 24
Kennewick, Wash.	19.4	June 20
Umatilla, Oreg.	22.6	June 18
Celilo, Oreg.	19.3	June 20
The Dalles, Oreg.	38.1	June 19
Cascade Locks, Oreg.	30.1	June 20
Vancouver, Wash.	22.0	June 22
Portland, Oreg.	21.4	June 21

TABLE 3.—*Flood crests at Portland, Oreg., during the annual rise of the Columbia River.*

Year.	Stage.	Year.	Stage.
	Feet.		*Feet.*
1879	19.3	1895	16.3
1880	27.3	1896	23.8
1881	19.7	1897	23.7
1882	26.1	1898	20.7
1883	17.8	1899	24.2
1884	20.2	1900	17.8
1885	14.5	1901	20.8
1886	20.0	1902	20.7
1887	25.7	1903	24.0
1888	18.2	1904	20.8
1889	10.0	1905	13.6
1890	20.1	1906	13.4
1891	14.1	1907	19.2
1892	19.3	1908	21.2
1893	22.0	1909	21.4
1894	33.0		

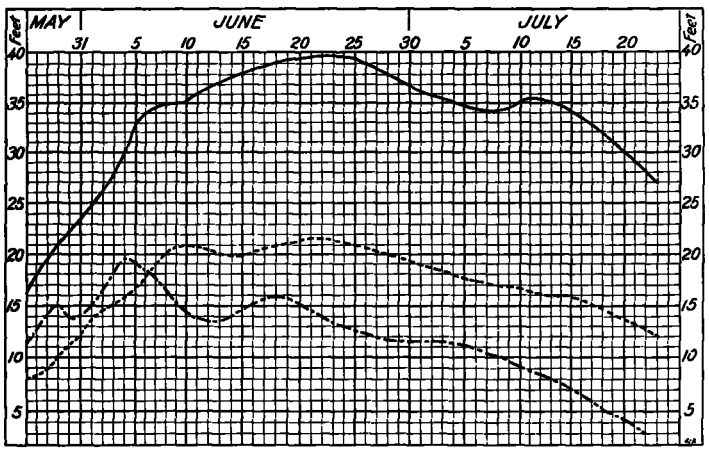

FIG. 1.—Hydrographs of daily stages on the Columbia River system, June and July, 1909.

——— Columbia River at Wenatchee, Wash.
– – – Snake River at Lewiston, Idaho.
– · – · Willamette River at Portland, Oreg.

FROST DAMAGE PREVENTED BY COVERS.

Prof. A. G. McADIE. Dated San Francisco, Cal., June 23, 1909.

A recent letter from Eastern Agricultural College, Wye, Kent, England, brings up the question whether it is the heat or the smoke developed by the fires and smudges of frost-fighting apparatus, which prevents the damage by frost in orchards, vineyards, etc.

The great mass of experiments made in California orchards show that direct heating of the air by open fires has not been sufficient to prevent injury at times of very low temperatures. A large amount of the heat thus produced is wasted; the efficiency of the method is low. This is illustrated by the following experience of a gentleman who is a close observer, an earnest student of the problem of frost-protection, and one in whom I have the greatest confidence. During the night of December 20–21, 1908, on a certain California ranch, the temperature for fourteen hours ranged between 19° and 24° F. For thirty-six hours the temperature did not rise above 28°. During this night the gentleman referred to burned 15 cords of wood and about 40 tons of wet hay in his efforts to protect his orchard. The relative humidity was low, there was little movement of the air, and he reports that "the smoke rose as straight as a pine tree." At the intersection of two roads in the orchard a large fire was maintained, and 30 feet distant the temperature in an olive tree was observed. Another fire was burning within 20 feet of this tree on a second side, and on yet a third side was a third fire maintained within 25 feet of the same tree. The temperature at the tree, however, remained at about 20° F. from 3 to 8 a.m. of December 21. This was the coldest weather in this locality since 1888. It is evident that in this case a large amount of heat escaped without producing the desired warming effect, i. e., was lost, wasted. It is, of course, well known that the rate of conduction of heat through air is low.

Other evidence has led me to the conclusion that open fires of coal, oil, etc., in wire baskets, in pots, on the ground, or indeed any source of heat will not, unaided, serve to protect plants under *severe* conditions. The oil pot is objectionable both because of its low efficiency and because the soot from it may settle on the fruit. The briquette has similar drawbacks and also is troublesome to ignite. The small sheet-iron stove is more satisfactory and the heat radiated by it is not lost to the same degree that it is from other devices. It has the additional advantage that it warms the air near the ground whence by a step-to-step process the heat is conducted to the higher strata, i. e., those 10 to 16 feet above the ground, thus affording protection to the branches of the deciduous fruit trees also.

The ideal method of frost protection is a combination of a cover device and a heating device. The cover, properly placed, prevents the excessive loss of heat from the soil, plants, and objects beneath it, and it may be stated that the heat energy involved is much greater than that given for the same area by a number of brisk fires burning for hours. By conserving the earth's heat we employ the very cheapest heat energy that can be obtained, notwithstanding the initial expense of the cover. A proper cover is, in my opinion, the most effective means of protection against injury to plants from low temperatures. Furthermore, the locations most subject to frost are the low points, vales, hollows, and depressions. Elevated valleys shut in by hills are especially bad. We now clearly recognize that the conditions of *air drainage* must be studied for any given locality. Many investigations could be quoted proving the correlation of low temperatures with the low levels. Consequently a cover spread some feet above the surface where there is a particularly frosty spot would by its mechanical interference with the flow of the air, as well as by obstructing the radiation of heat, prevent injury by frost.

It is my opinion that those who claim that "heat and not

smoke" is what prevents damage from frost, are not altogether correct in their statements. The pots for open coal fires are effective only in part and over quite limited areas. For low temperatures the proper method is to use a cover, and supplement this, if necessary, by small stoves and shallow pans of hot water.

THE FIREBALL OF SEPTEMBER 20, 1909.

By Prof. FRANK W. VERY. Dated Westwood, Mass., September 21, 1909.

At about twelve minutes before 8 p. m., ± three minutes, my wife saw a fireball low in the NNW. When first noticed it was near β Ursæ Majoris, and descended in a vertical direction to the horizon in about two seconds. There was a bright nucleus, apparently several minutes in sensible diameter, which was surrounded by a pale green coma of circular shape and about as large as the full moon when seen near the horizon. The appearance was that of a white light seen through a green gauze. The brightness of the entire object was perhaps half that of the crescent moon then visible low in the western sky, but instead of the yellow tint which the moon would have had if near the horizon, the fireball exhibited a decided green color, although it would be called a pale green, i. e., a mixture of green and white. The motion was a halting one, an alternate slowing and quickening, repeated twice or thrice. This may have represented a real revolution in a vertical plane about a more massive, but less luminous companion bolide.

If we assume that the meteor, when first seen, had an altitude above the horizon of 11.5° (sin=0.2) and a height above the earth's surface of 60 miles, its distance was roughly about 5 × 60=300 miles, and the real diameter of the coma would have been about 3 miles. The greenish color may have been due to the prominence of the green carbon band in its spectrum, and if so, the coma may have been a flame of carbon or hydrocarbon particles continuously produced from the nucleus and as rapidly consumed. If the bolide were moving 15 miles per second it would pass through the diameter of the coma in 1/5 second, and this time interval must represent approximately the duration of the flame, since there was no appreciable elongation of the coma. This gives for the velocity with which the particles (of carbon?) were expelled from the nucleus 1.5/0.2=7.5 miles per second, or one-half the assumed speed of the bolide, which is not an improbable figure. Bearing in mind the extreme rarification of the oxygen atmosphere at a height of 60 miles, carbonaceous particles, even in an extremely fine state of division, may plausibly be assumed to travel through a distance of 1½ miles, the radius of the coma, before being entirely consumed.

The light was such as may have come from white hot incandescent particles of carbon or other solid material, mixed with a green gaseous flame. The intensity of light from the full moon being about 1/6 candle-meter or 1/50 candle-foot, that of the crescent moon may have been 1/500 candle-foot, and that of the fireball 1/1000 candle-foot. At a distance of 300 miles=1,584,000 feet this gives a total original brightness equal to that of a million powerful arc lights of 2,500 candles each. This distributed over a section of 21 million square feet gives 119 candle power per square foot. But since the actual composition of the coma was probably not that of a continuous flame, but rather that of a swarm of minute flaming particles separated by wide spaces, the intrinsic brightness of the flame can not be found.

TORNADOES IN KANSAS.

On the afternoon of June 24 there was a series of about seven tornadoes within a radius of 20 miles in Norton County in the northwest part of the State, and great damage was done to live stock and buildings, but, fortunately, no person was killed though there were a number of very narrow escapes. The one farthest north formed near Devizes and moved northeastward through Hendley, Nebr. Four or five other tornadoes formed from 4 to 10 miles northwest of Norton, each moving toward the northeast. In their paths houses, outbuildings, fences and windmills were destroyed and in some instances entirely blown away. About 83 head of live stock were either killed or badly injured. These disturbances were accompanied by heavy hail over narrow bands of country and a violent thunderstorm. The cloud of the last of this group of tornadoes resembled the letter "S" lying on its back thus ∽. The seventh tornado formed about 6 miles north of Lenora. It was a vertical column and moved slowly, traveling only about 4 miles in forty-five minutes, and people had time to get out of its way. The paths of the tornadoes were from 120 to 400 feet wide. The value of the property destroyed is estimated at $22,500. Further details are given in the Monthly Climatological Report, Kansas Section, for June, 1909.—*T. B. Jennings.*

TORNADOES IN MISSOURI.

(Extract from Monthly Climatological Report, Missouri Section, June, 1909.)

The weather map of June 22, 1909, showed a barometric depression over most of the territory lying between the Mississippi and the Rocky Mountains, and extending from Sonora, Mexico, to Manitoba, Canada, with rather well-developed lows at both extremes. On either side of the depression were fairly well-formed highs, one resting over the South Atlantic States and the other over the north Pacific slope. On the east side of the low area the temperature gradient was decidedly flat, the isotherm of 70° passing through the middle and following the general trend of the depression; on the west side there was a temperature gradient of about 30 degrees in 500 miles.

While this distribution of pressure would indicate thunderstorms, or more accurately thundershowers, one would hardly expect tornadoes. Yet, several severe local storms having tornado characteristics occurred in Missouri on the date mentioned. The most noteworthy of these occurred near Monett, Barry County, in the southwestern part of the State. The tornado, which, from reliable reports, had a well-defined pendant funnel-shaped cloud, was first seen between 8 and 9 p. m., central time, about 3 miles southwest of Monett, whence it moved eastward leaving the ground when about 3 miles southeast of that village; thence it travelled northeastward, again touching the ground about 12 miles northeast of Monett near Aurora, Lawrence County, where, however, it did no damage, and then disappeared.

The section of country over which the storm passed is comparatively thinly settled. The storm's path averaged about 350 feet. From the evidence furnished by fallen trees and other wreckage, there must have been a decided rotary motion to the storm. The estimated damage and loss to property and live stock was about $8,000, of which at least $1,000 is covered by tornado insurance. Only one person was killed, so far as could be ascertained, and seven injured. Some fish were found a quarter of a mile from a pond which lay on the path of the tornado.—*George Reeder.*

WEATHER CYCLES IN THE GROWTH OF BIG TREES.

By Prof. A. E. DOUGLASS, D. Sc. Dated Tucson, Ariz., October, 1908.

NOTE BY THE EDITOR.—Inasmuch as it was impossible to reproduce in the Monthly Weather Review the diagrams furnished by Professor Douglass, the Editor asked him kindly to furnish the table of original measurements so that students of this interesting subject may have at hand the valuable material for further investigations, which indeed now gives this memoir a specially high value.—*C. A.*

Climatically Arizona is divided into two parts, the northern, a great plateau at an average elevation of 6,000 feet, and the southern, a broken country consisting of scattered mountain ranges separated by broad level valleys averaging some 2,000 thousand feet above the sea. The higher elevations,