

cessive rates are often more or less destructive to vegetation and are sometimes accompanied by hail and high winds.

Figure 3 shows a marked difference in the diurnal distribution of the rainfall frequency during the growing season, April to September, for the three districts represented by Lincoln, Thomasville, and Columbus; and

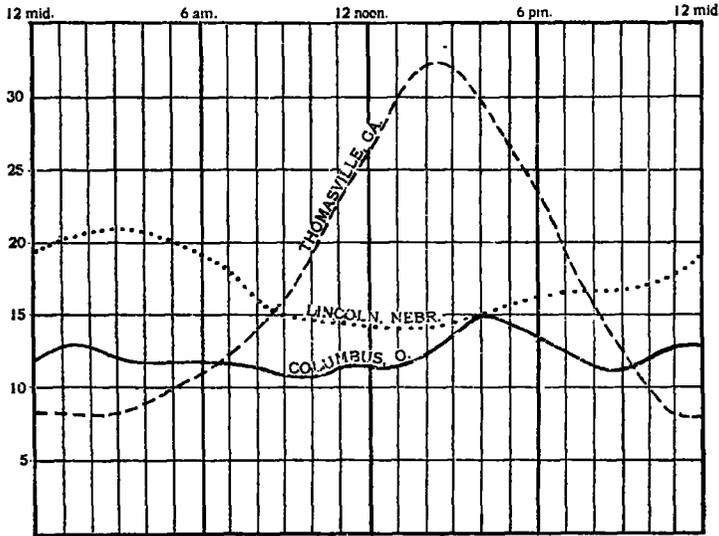


FIG. 3.—Average number of times precipitation occurred by hours, during season, April-September.

figure 4 shows similar differences in the distribution of the hourly amounts of precipitation. At Lincoln the greatest amount of rainfall occurs between 10 p. m. and 2 a. m., while figure 3 shows a corresponding preponderance of frequency of precipitation during the early morning hours, culminating at about 3 a. m., decreasing rapidly throughout the daylight morning hours, and again in-

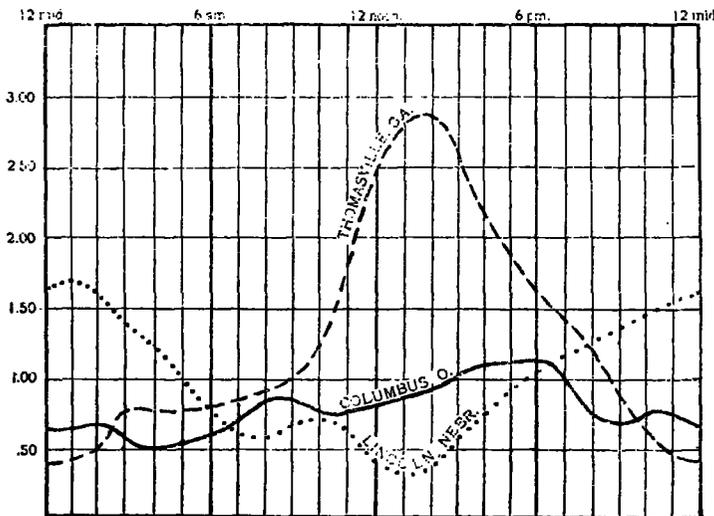


FIG. 4.—Average hourly amounts of precipitation for season, April-September.

creasing late in the afternoon to midnight. At Thomasville the greatest amount falls between 10 a. m. and 6 p. m. During the early morning hours the precipitation is least frequent, increasing rapidly with the advance of the sun, attaining a maximum at approximately 2:30 p. m., and decreasing rapidly until midnight. At Columbus the greatest amount falls between about noon and 7 p. m., with the actual maximum between 4 and 6 p. m. The

frequency shows a slight maximum at about 2 a. m., decreasing slightly, then maintaining an equable distribution until about 2 p. m., after which it increases, attaining a primary maximum at about 4 p. m., then decreasing until about 9 p. m., and increasing thereafter.

Rarely during the summer months does a cloudy day follow a nighttime shower. May it not be that precipitation falling two hours before sunset, or thereabouts, will suffer only slight evaporation for a period of 15 hours or more? Consequently the rainfall permeates the soil to a greater extent, and a maximum of benefit results. On the contrary, with the maximum frequency in the morning scarcely three hours before sunrise, the rainfall has much less opportunity to enter the ground to any considerable depth before evaporation takes place under the influence of the sun's rays. There is, of course, probably less crusting of the soil than where showers occur during the early hours of daylight. The total amount of rain falling during the period, April to September, inclusive, is slightly greater at Lincoln than at Columbus; but as previously shown, the distribution at the latter point is more favorable, and this no doubt, together with the greater opportunity for penetration of the soil, contributes to the greater yields per acre in central Ohio to which reference has already been made.

ALLEGED MANUFACTURE OF RAIN IN SOUTHERN CALIFORNIA.

By FORD ASHMAN CARPENTER, Meteorologist.

[Dated: Weather Bureau, Los Angeles, Cal., May 8, 1918.]

During the first fortnight in February, 1918, a professional "rainmaker" began his preliminary advertising activities in southern California. As a result of this publicity campaign one of the commercial bodies of the smaller cities entered into a contract to pay him \$300 as a retaining fee and to give him thereafter \$1,000 per inch of rain falling during the month of April. This contract stipulated that this rate would hold good up to a total of 5 inches. In order to gain the support of neighboring towns, committees from this organization visited nearby communities and endeavored to enlist their support in the enterprise. Nearly all of those approached referred the proposal to the Weather Bureau at Los Angeles for advice. In discussing the matter with the applicants it was expedient not only to go into the cause of rain in general, but to bring to their minds the history of alleged rainmaking in southern California during the past 20 or 25 years. Fortunately, the writer is personally familiar with the circumstances attending four or five such attempts made in this district during the past score or more of years while he was in charge of the San Diego station of the Weather Bureau and later of the Los Angeles station.

History of local rain making.—The literature of attempts to manufacture rain is so extensive that it is not possible to enumerate even general titles in a brief article. However, all methods as yet proposed are either wholly inefficient, as, for instance, cooling with liquid air, or scientifically absurd, like the exploding of bombs.

The arid and semiarid portions of the United States have been the scene of several attempts at rain making and some of these experiments have been conducted with Federal, State, and municipal aid. Confining our attention to occurrences in recent years, and to activities in the southern part of California, it is found that the rainmaker flourishes in January or February of a season

which up to that date has been characterized by deficient rainfall. During the past 22 years there have been six attempts at rainmaking in this region and nearly all of the operations took place during these months. The first notable example occurred in 1897, being followed later by similar operations in 1900, 1905, 1912, 1916, and 1918. The initial pseudo-scientific venture was personally investigated by the writer. As one of the most notable of local rainmakers became interested in the work and adopted it as a profession about that time it may be well to give some of the details of the operations. A committee from the chamber of commerce of San Diego collected scraps of zinc from many citizens, some householders even sacrificing the sheets of zinc from under their stoves for that purpose. In addition to the salvage committee there were others who collected funds wherewith to purchase sulphuric acid. Several public-spirited citizens ascended the hills about the town and liberated hydrogen gas by pouring the diluted acid on the scraps of zinc. Although much time and labor, to say nothing of several hundred dollars, were spent, the efforts of the rain-making committee were not crowned with success. Three years later another attempt was made, this time by an individual who instigated a "contract" system, whereby he was to receive so much per inch if it rained and nothing except his expenses if it did not. By utilizing the newspapers in a publicity campaign and playing upon the credulity of some of the people he was enabled to make a precarious existence, carrying on his operations in the succeeding dry seasons of 1905, 1912, 1916, and 1918.

The rainmaker's methods of operation.—At the very beginning of his operations the rainmaker's mental attitude was one of honest inquiry. My recollection of meeting one of them in the early years of rainmaking is that he possessed a limited education; he lacked, by nature, the ability to differentiate cause from effect. From his early failures he evolved a system of "no rain, no pay," which became very attractive even if the assertion was not strictly true, for he always insisted upon receiving his expenses in advance, which usually amounted to several hundred dollars. The attempts at rainmaking in 1905 were noted as follows in the MONTHLY WEATHER REVIEW:¹

FAKE RAINMAKING.

During the past winter the associated conditions referred to (pressure distribution) have prevailed, and they resulted in frequent and generally excessive rains not alone in southern California but in all of the immense territory that extends thence eastward to Texas. It is, therefore, apparent that the rainfall which was supposed to have been caused by the liberation of a few chemicals of infinitesimal power was simply the result of general atmospheric conditions that prevailed over a large area. It is hoped that the people of southern California will not be misled in this matter and give undue importance to experiments that doubtless have no value. The processes which operate to produce rain over large areas are of such magnitude that the effects upon them of the puny efforts of man are inappreciable.

In 1912 a rainmaker appeared in southern California claiming to induce rain by using a secret gas. On October 1, 1912, the writer made the following report to the Chief of Bureau:

His success in obtaining promises of money has been from people who are willing to take a chance. They figure that if it does not rain they will not be out anything, and if it *does* rain they will be so jubilant that they can afford to spare the sums subscribed. It has frequently happened, however, that when the rains did come the people in their joy and satisfaction over the good yield that they anticipated forgot the rainmaker.

He is not willing to back his promises with any money. A farmer once told me: "A rainmaker was out here one day when those hills were white with drifting clouds. Says I: 'Professor, I've a thousand acres that must have rain within three days. If you will make it rain 2 inches in 72 hours I'll give you a written promise and my check for \$2,000. I only require that you put up \$200 in escrow to be forfeited if it don't rain.'" "And," said the farmer, "the rainmaker would not take me up. And, furthermore, it rained 4 inches within 48 hours, and that with a northwest wind."

The dry autumn of 1915 gave another opportunity for a rainmaker, and this time he was successful in getting the city council of San Diego to enter into a contract for as much as \$10,000 to produce rain in January. Concerning the heavy rain during the latter part of January, the following appeared in the MONTHLY WEATHER REVIEW:²

It seems reasonable to suppose that the storm which swept over Hawaii on the 18th-19th passed over California on the 27th. It is charted as Low No. XIV, Chart III. About a week previous Low No. X, Chart III, passed inland over the middle California coast on the 17th, crossed the south-central part of the State on the 18th, and then moved northeastward into Wyoming by the morning of the 19th. During its movement over the south-central portion of California the storm slackened its progressive movement, meanwhile giving very heavy rains over the counties of southern California. Light rains had fallen during the previous three or four days, and conditions were unusually favorable for a high run-off in connection with the heavy rains of the 17th and 18th. * * * The resulting floods were severe, and much damage was done to railroads, bridges, highways, land under cultivation, and to the harbor of Los Angeles, by reason of the mass of silt deposited thereon.

A second deluge of rain descended upon the counties of southern California in connection with Low No. XIV, mentioned in a preceding paragraph. The second storm was of much shorter duration. At San Diego, Cal., the rain began at 7:18 p. m. of the 26th and ended at 7:45 p. m. on the 27th. The total fall amounted to 2.41 inches. This rainstorm was attended by unusually high winds for southern California, the average velocity at San Diego being about 30 miles per hour, with a maximum of 54 miles from the south at 4:29 a. m. of the 27th. The reservoirs in the county whence the water supply of the city of San Diego is drawn were already nearly full as a result of the rains of the previous week, and all of them, evidently, were not in a condition to withstand the added strain put upon them by the rains of the 26th-27th.

As to the effect of this storm, a bulletin³ of the United States Geological Survey issued in May, 1918, gives the extent of the storms and their serious effect on life and property.

The rains that swept southern California in mid-January, 1916, converted the streams into torrents that overran their banks and devastated wide areas of the most fertile land of the State. The rains were heaviest and the floods most disastrous in San Diego County, but they were also very heavy in parts of Riverside, San Bernardino, Los Angeles, and Ventura Counties, and they wrought widespread ruin throughout the region that extends southward from Santa Clara River to the Mexican boundary and westward from the north-south ranges of San Bernardino and San Diego Counties to the ocean. * * *

Conclusions.—It is the uncertainty of rainfall in southern California that doubtless makes this region attractive to the rainmaker. Rain is here the least dependable meteorological element; for example, during the present season in Los Angeles, 51 weeks elapsed between the last rain of one-half an inch in February, 1917, and the next rain of like amount in 1918.

An examination into the methods of the rainmaker shows a disregard of physical laws, and a review of the history of rainmaking affords no proof of his success.

By far the most important feature of his work consists in playing upon the credulity of mankind. It is therefore a psychological rather than a meteorological problem, for the fundamental factors are those of the mind and not of matter.

¹ Fake rainmaking, A Letter from the Chief of Bureau. MONTHLY WEATHER REVIEW, April, 1905, 33: 153.

² Floods of January-February, 1916, in Southern California, MONTHLY WEATHER REVIEW, January, 1916, 44: 28-29.

³ Southern California Floods of January, 1916, Water Supply Paper 426, p. 7.