

## SECTION II.—GENERAL METEOROLOGY.

## CURRENT EVAPORATION OBSERVATIONS BY THE WEATHER BUREAU.

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[Dated Weather Bureau, Washington, Jan. 18, 1917.]

## INTRODUCTORY.

The Weather Bureau has been engaged for the past two years in gradually installing at various points in the United States a chain of uniformly equipped stations for the measurement of evaporation losses from water confined in metal pans. Friendly cooperation on the part of State agricultural colleges, private irrigation interests, Weather Bureau officials, and others has permitted the work to progress to a degree that warrants the belief that the results being secured will be of considerable value to engineers, climatologists, botanists, plant physiologists, foresters, and others; and as arrangements have been made to publish the observational material monthly, it seems proper to record here the stations at which evaporation observations are now being made as well as to give some account of their equipment, their operation, and the places of publication. A list of these stations, known as

TABLE 1.—Class "A" evaporation stations of the Weather Bureau in operation Jan. 1, 1917. (See also figure 1.)

Stations by States.	Latitude (north).	Longitude (west).	Approximate altitude of pan above sealevel.	Date of first observation.
<i>Arizona:</i>				
Roosevelt.....	33 40	111 09	<i>Fcft.</i> 2,275	Nov. 25, 1915
<i>California:</i>				
Tahoe.....	39 10	120 09	6,230	July 1, 1916
<i>District of Columbia:</i>				
American University.....	38 56	77 05	392	Apr. 18, 1915
<i>Iaaho:</i>				
Arrowrock Reservation.....	43 36	115 55	3,230	June 17, 1916
Deer Flat Reservation.....	43 35	116 42	2,510	Mar. 13, 1916
<i>Kansas:</i>				
Lawrence.....	38 58	95 15	1,018	Aug. 7, 1916
Tribune.....	38 28	101 46	926	Aug. 16, 1916
<i>Maine:</i>				
Gardiner a.....	44 14	69 46	130±	June 4, 1915
<i>Missouri:</i>				
Columbia (University of Missouri campus).....	38 57	92 20	738	Apr. 1, 1916
Columbia (University of Missouri golf links).....	38 57	92 20		Apr. 15, 1916
<i>Montana:</i>				
Bozeman.....	45 40	111 03	4,754	July 1, 1916
Valier.....	48 25	112 20		July 1, 1916
<i>New Mexico:</i>				
Elephant Butte.....	33 10	107 10	4,475	Apr. 14, 1916
Santa Fe.....	35 41	105 57	6,975	May 18, 1916
Tucumcari.....	35 10	103 48	4,200	July 1, 1916
<i>Nevada:</i>				
Indian Springs.....	36 31	115 43	3,136	June 25, 1916
Lamoille.....	40 27	115 25	6,100	July 1, 1916
Mariette Lake.....	39 10	119 55	7,900	Sept. 15, 1916
<i>Ohio:</i>				
Wooster.....	40 47	81 56	1,030	June 11, 1916
<i>Porto Rico:</i>				
San Juan.....	18 29	66 07	48	May 29, 1916
<i>South Dakota:</i>				
Rapid City.....	44 04	103 12	3,240	May 1, 1916
<i>Texas:</i>				
Austin (Hill's ranch, land pan).....	30 14	97 41	475	Mar. 9, 1916
Austin (Hill's ranch, floating pan).....				
<i>Washington:</i>				
Walla Walla.....	46 02	118 20	1,000	May 16, 1916

a Observes at 7 a. m. and at 6 p. m., all other stations observe but once a day at about 7 a. m. local time.

"class A evaporation stations," now in operation is given in Table 1 and their locations indicated on figure 6. Their equipment and operation are briefly described in the following paragraphs.<sup>1</sup> The observations at each of these 24 stations are limited to one daily measurement of the loss due to evaporation from a pan of water, the daily wind movement across the pan, and such other meteorological observations as will serve to identify the general climate of the region.

## EQUIPMENT.

In order to insure comparable observational results from many different portions of our country the entire equipment has been worked out with a view to securing the greatest practicable uniformity of exposure conditions and of equipment. Each station presents essentially the appearance of the one illustrated in the accompanying figure 1; a plan is shown in figure 2.

Each station is equipped as follows:

- 1 evaporation pan, 4 feet by 10 inches, with its support. (See fig. 5.)
- 1 still-well, with a 4-inch carpenter's bench level. (See fig. 3.)
- 1 hook-gage. (See fig. 4.)
- 1 fence.
- 1 supply tank (covered), where required.
- 1 raingage, Weather Bureau 8-inch, with wooden support and measuring stick.
- 1 shelter, Weather Bureau cotton-region pattern. (See fig. 1.)
- 1 pair maximum and minimum thermometers, with their support.
- 1 anemometer, Weather Bureau Robinson, with a special support.

*The pan.*—The standard evaporation pan is cylindrical in form, 10 inches deep, 48 inches in diameter, inside dimensions. It is made of 22 B. W. G. iron, galvanized before the pan is made up. The bottom is turned up and riveted to the sides. The top, or rim, is fitted with a  $\frac{1}{2}$  by 1 inch galvanized iron hoop securely riveted to the pan.

*The still-well.*—The standard still-well, designed by B. C. Kadel and adopted by the Weather Bureau, consists of a triangular galvanized cast-iron base, 12 inches on each side by  $\frac{1}{2}$  inch thick with a levelling screw 3 inches long at each corner, and the well proper 8 inches high and 3 $\frac{1}{2}$  inches outside diameter, made of seamless brass tubing rigidly mounted on this triangular base. The water is admitted to the well by means of a short length of standard  $\frac{1}{4}$ -inch brass pipe extending through the cast-iron base. (See fig. 3.)

A 4-inch carpenter's bench level is provided for testing the horizontality of the top of the still-well.

*The hook-gage.*—The micrometer evaporation hook-gage shown in accompanying figure 4 was specially designed by Prof. Charles F. Marvin for evaporation work.

<sup>1</sup> More complete details are given in: *Weather Bureau. Instructions for the installation and operation of class "A" evaporation station.* By Benj. C. Kadel. Washington, 1915. 28 p. illus. 8". (Instrument Division, Circular 1.)

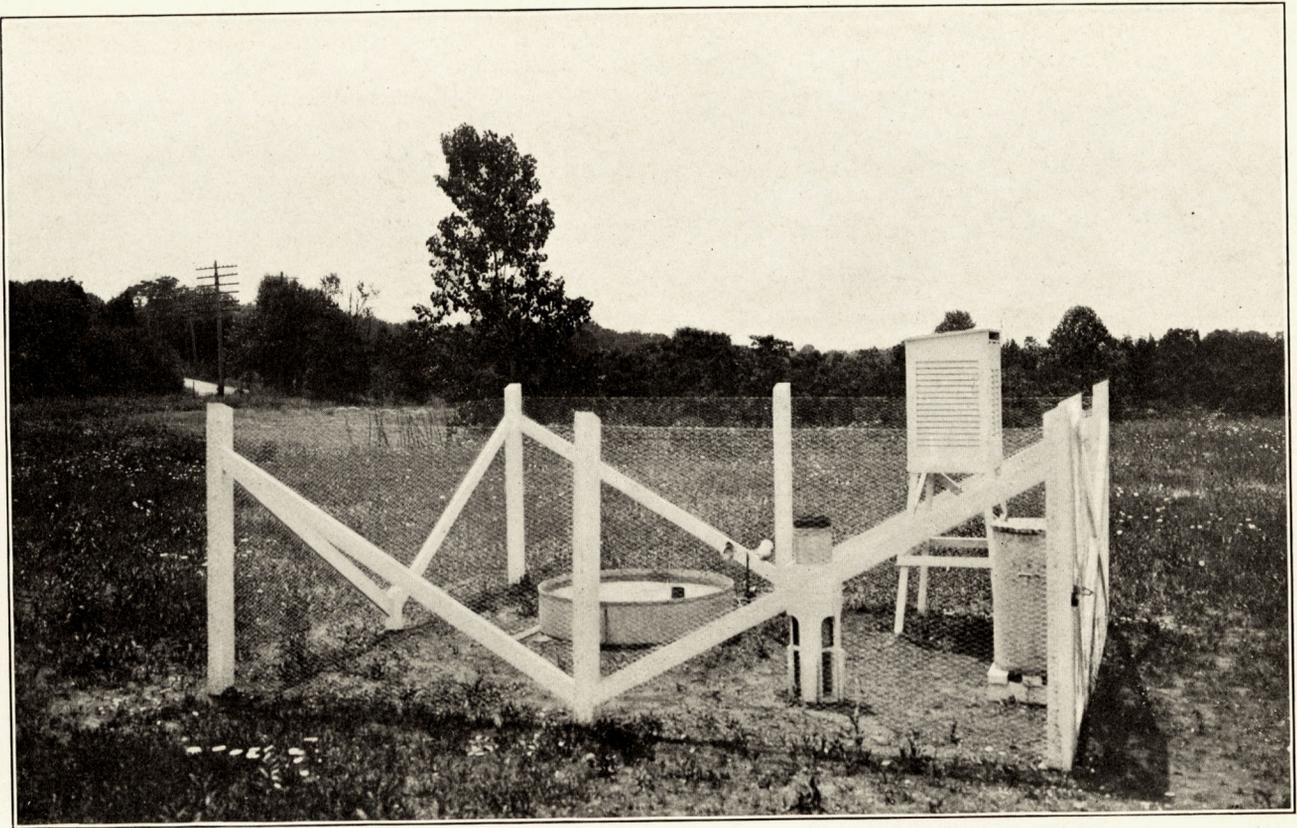


FIG. 1.—General view of a Weather Bureau standard Class A evaporation station. (American University, District of Columbia.) (See also fig. 2.)

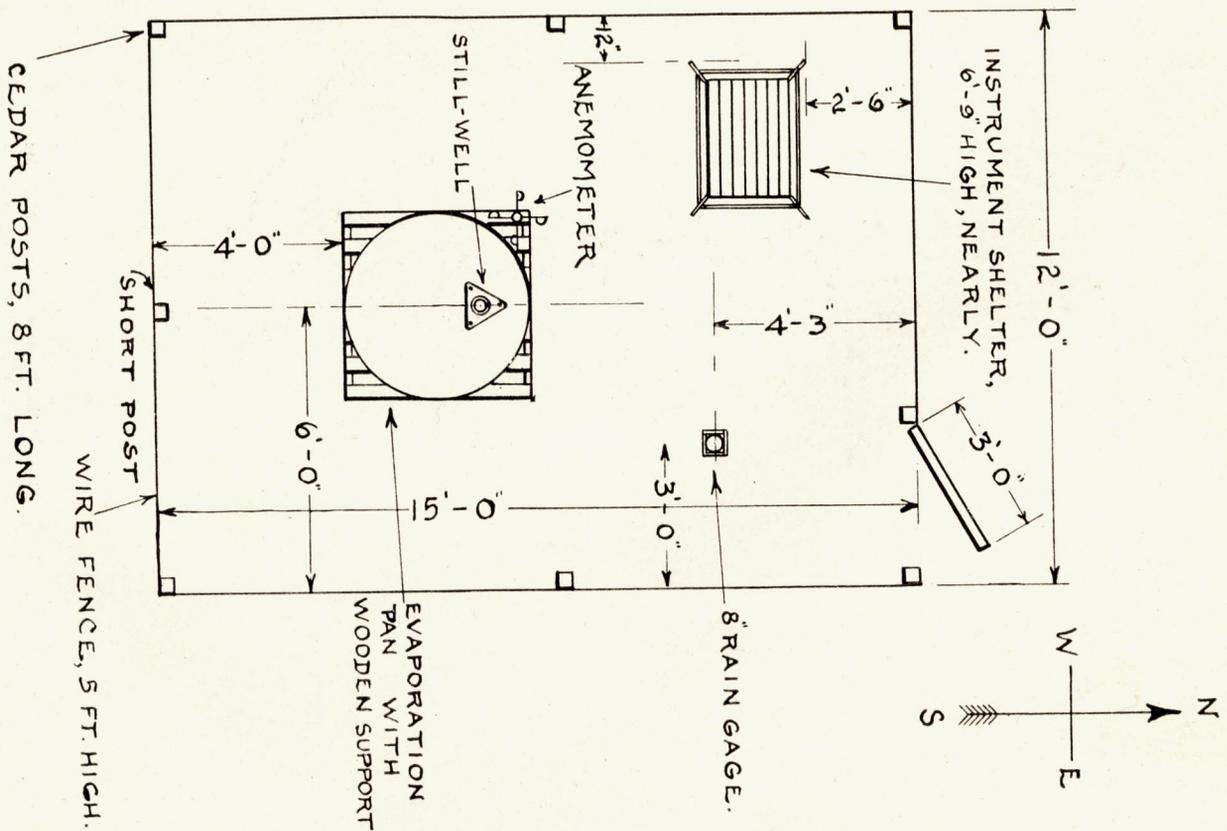


FIG. 2.—Plan of a Weather Bureau standard Class A evaporation station. (See also fig. 1.)

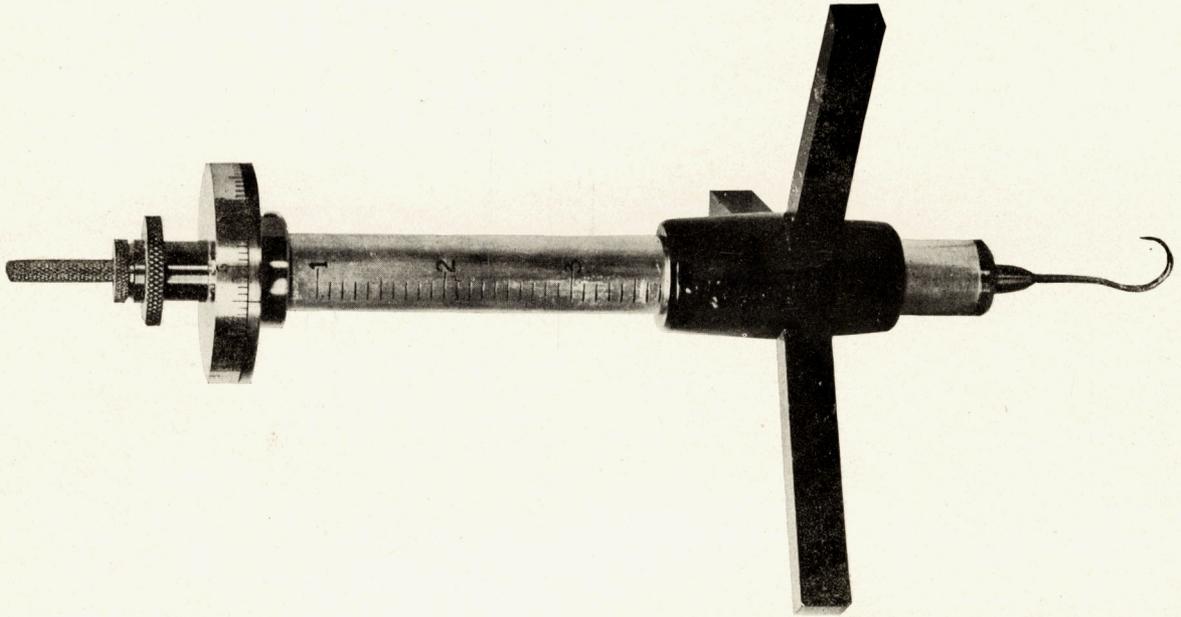


FIG. 4.—Micrometer evaporation hook-gage.

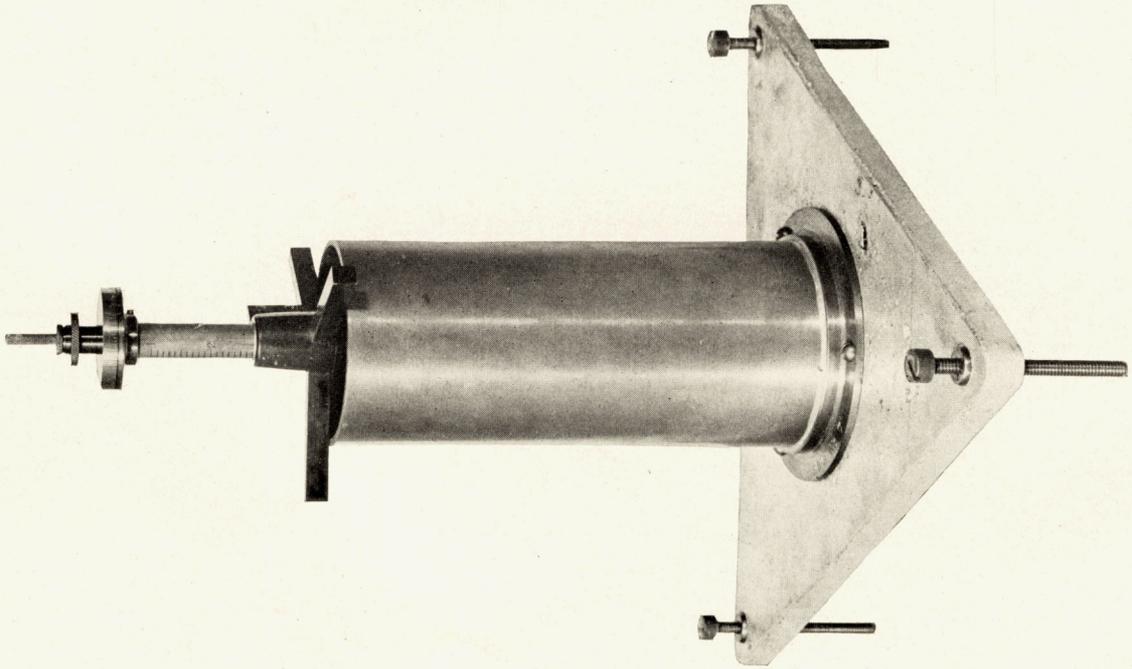


FIG. 3.—Still-well with hook-gage in position.

It is so constructed that one complete revolution of its micrometer screw head moves the hook vertically through exactly  $\frac{1}{10}$  inch. The inches and tenths are graduated on the casing or tube, and the hundredths and thousandths are on the micrometer screw head.

*Supply water tank.*—This is needed only where the water supply is so far distant that an appreciable error would result from the long time required to bring water to fill the pan. The tank, when present, is kept covered to prevent its contents influencing the vapor over the evaporation pan.

*Instrument shelter.*—This is the standard louvered Weather Bureau shelter issued to cooperative stations.

#### INSTALLATION OF EQUIPMENT.

*Exposure.*—The instructions for selecting the site of the evaporation station read as follows:

Select a comparatively level location, representative of the region and open to the sunshine all day, if possible. If hills, trees, buildings, etc., can not be avoided, the length of time the pan is shaded morning and evening should be indicated in the description of the station. In order to be free from possible reflected heat the pan should be no nearer to any tree, building, cliff, or other object than the height of the object. Nearness to ponds and swamps, particularly when such ponds or swamps are temporary in character, should be avoided, as a rule, but it may at times be desirable to expose pans near a body of water or even on a raft floating in the water. Such exposures should be carefully described so that the results may be correctly interpreted when comparison of the records of one station are made with those of another.

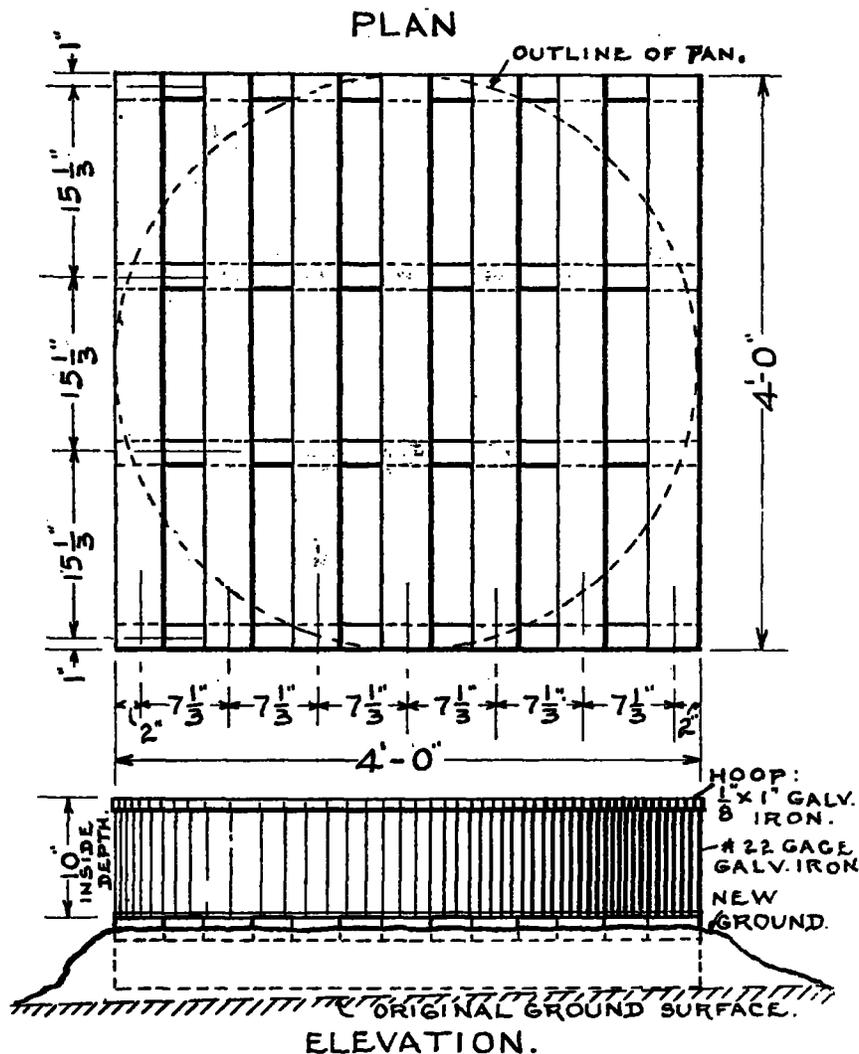


FIG. 5.—Plan and elevation of a Weather Bureau standard evaporation pan on its support.

It screens the maximum and minimum thermometers supplied to the station. Both the shelter and its support are painted white in all cases.

*Raingage.*—The standard Weather Bureau 8-inch gage consists of a funnel 8 inches in diameter, a brass measuring tube whose cross section is  $\frac{1}{10}$  the area of the funnel receiver, and an overflow can of galvanized iron. (See Instrument Division Circular B and C, for accounts of thermometers and raingage.)

*The anemometer support.*—In the present outfit this support is a simple brass casting which combines a brass pin with a flange adapted to being fastened to the wooden support of the evaporation pan.

Grass and weeds in the immediate neighborhood of the station should be cut occasionally.

The arrangement of the equipment for these standard stations is shown in figures 1 and 2. The rectangular plot of open ground, 12 by 15 feet in size, is inclosed by a 5-foot fence of 1-inch mesh woven wire stretched taut between eight braced posts.

The wooden support for the evaporation pan is laid on the ground with the low side blocked up to make it level, then it is filled up within an inch of the top with ground brought from a distance, and this is well tamped in. Thus drainage is assured, and a desirable slight circulation of air underneath the pan is permitted. (See fig. 5.)

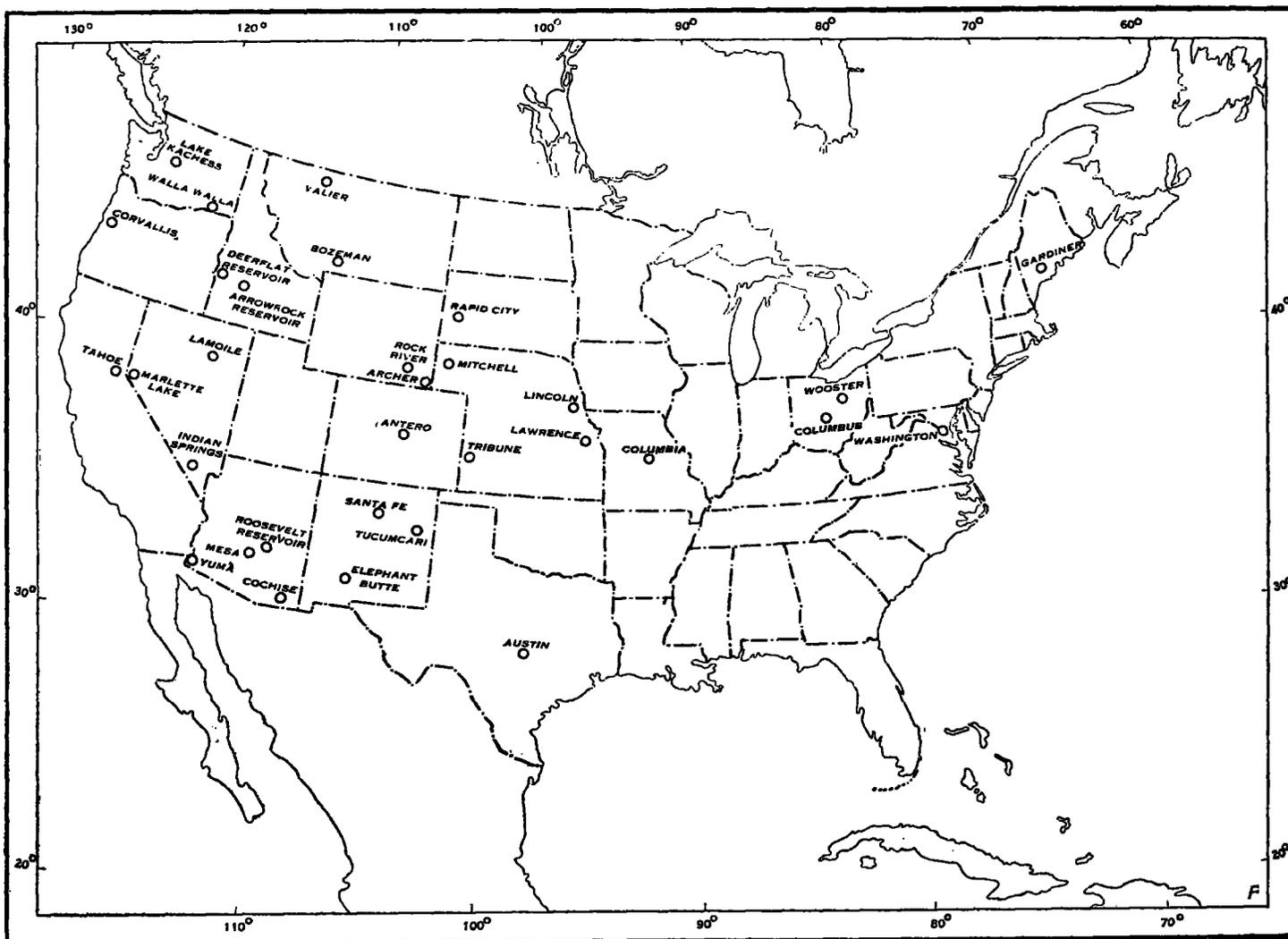


Fig. 6.—Map showing locations of Weather Bureau standard Class A evaporation stations that were reporting on January 1, 1917. (See also Table 1, p. 674.)

The pan is placed on the wooden support with care that the pan bottom does not buckle when pressed downward, particularly in the region to be occupied by the still-well. When thus set in place the bottom of the 10-inch-deep pan stands not less than 6 inches, and its rim not less than 16 inches above the general surface of the inclosure.

The still-well is placed within and about a foot from the north side of the pan; it is so adjusted that the top of its brass cylinder is level in two mutually perpendicular directions. It is found best to have the triangular still-well base rather high on the leveling screws; and it is kept standing in place in the pan continuously to avoid errors incident to careless placing before each reading.

The anemometer support is fastened to the northwest projecting corner of the pan's wooden support. This position brings the anemometer cups with their centers 6 inches above the rim of the pan at a point that permits the shadows of the cups to fall on the pan only during late afternoon.

The thermometer shelter is mounted on its standard support in such a manner that the shelter door opens to the north, and is located just far enough within the northern fence to permit the door to swing clear. Its standard support is designed to bring the shelter floor 4 feet above the ground at each station; and to bring the thermometer bulbs 5½ feet above the general level of the inclosure.

#### MANNER OF OBSERVING.

The time of observation is uniformly within half an hour of 7 a. m., local standard time; and whatever hour is fixed upon within this limit, is adhered to at the station in the future.

Evaporation measurement is made by placing the hook-gage (fig. 4) into the still-well with the hook near the center of the well as shown in figure 3; then, with the hook standing slightly below the level of the water, the final setting is invariably made by causing the point of the hook to rise slowly until it just pierces the water surface, making the smallest possible pricking. The observer is encouraged to test his readings by making several successive settings, removing the hook-gage and changing the position of the hook between each pair of settings.

After a setting has been made, the gage is removed from the still-well to read and the reading is at once recorded on the blank form provided.

The evaporation pan is kept filled with clean fresh water to within 2 inches (50.8 mm.) of the rim, and it is refilled at a regular observation when the water level has receded 1 inch (25.4 mm.). The depth of water in the pan is thus maintained at between 7 and 8 inches at all stations, while space for a reasonably heavy rainfall is also available.

Overflow and resultant loss of record due to heavy rain, is to be foreseen and guarded against by the timely re-

Form No. 1024.

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU.

Record of evaporation and meteorological conditions during the month of July, 1915;  
 Station, Amer. Univ'y., D. C.; Latitude, 38° 54'; Longitude, 77° 03'; Meridian time used, 75<sup>h</sup>;  
 Evaporation tank: \_\_\_\_\_ inches deep, \_\_\_\_\_ inches diameter, filled to approximate depth of 8 inches; description  
 of station filed, at Office of the Weather Bureau, Washington, D. C.

DATE.	EXACT TIME OF OBSERVATION.	NUMBER OF HOURS SINCE LAST OBSERVATION.	METEOROLOGICAL CONDITIONS.							WIND.			EVAPORATION.		
			AIR TEMPERATURE.				PRECIPITATION.*			ANEMOMETER DIAL READING.	SINCE LAST OBSERVATION		GAGE READING.	GAGE READING WHEN TANK FILLED.	ACTUAL AMOUNT. (†)
			Max.	Min.	Set Max.	Mean.	Character.	Began.	Ended.		Amount.	Total Movement.			
F°.	F°.	F°.	F°.				In.	MI.	MI.		In.	In.	In.		
1.	7:00 a.	24	82.1	65.6	70.6	72.6	R	DN	DN	0.550	362	48	2.920	*	0.286
2.	7:00 a.	24	85.1	66.2	74.4	75.2	R	DN	DN	0.135	403	41	2.726		0.229
3.	7:00 a.	24	84.3	64.9	70.8	73.3	R	DN	DN	0.475	475	72	2.420		0.306
4.	7:00 a.	24	84.5	62.6	68.2	71.8				0.050	501	26	2.301		0.169
5.	7:00 a.	24	82.3	68.2	68.8	73.1	R	DN	9:00 a.	0.200	562	61	2.327		0.174
30.															
31.															
SUMS.	(a)	(a)					(a)	(a)	(a)		(a)		(a)	(a)	
MEANS.	(a)	(a)					(a)	(a)	(a)		(a)		(a)	(a)	

8-3288

(a) No data required.

\* Including rain, hail, sleet, and melted snow.

† Last gage reading plus precipitation minus present

(IN TRIPLICATE.)

Observer, George F. Hand Address, \_\_\_\_\_

FIG. 7.—Illustration of entries on form used by Class A evaporation stations.

removal of a sufficient amount of water, making hook-gage readings before and after such removal. The pan is emptied and stored during the season of freezing temperatures.

The anemometer is read once daily at the observation hour, and the total wind movement of the past 24 hours is recorded.

The prevailing direction of the wind is determined by means of frequent eye observations on the movement of smoke, bending of tree twigs, etc., and the entry made at the time of the evaporation observation refers to the prevailing direction since the last entry. When the wind has blown from various directions the entry "variable" (var.) is made.

The temperature observations are made in the usual Weather Bureau manner, by means of the maximum and minimum thermometers exposed in the shelter shown in figure 1. Readings are made and entered at the regular observation hour (about 7 a. m.) and obviously give the air temperature only.

The recording form supplied and used is best understood by the sample extract shown in figure 7.

PUBLICATION OF OBSERVATIONS.

As remarked in the introduction, the Weather Bureau has been engaged in these installations during the past two years; indeed, the first observations according to this system were made at the Weather Bureau station on the American University campus, District of Columbia, beginning April 18, 1915. On December 12, 1916, the Chief of Bureau issued a circular announcing that the evaporation data now being collected will, thereafter, be published in the monthly State Section Reports, i. e.,

"Climatological data by [State] sections" (not the same as another publication of data by sections bearing the same title but also known as Weather Bureau Bulletin "W"). All evaporation observations of this current series made under the direct supervision of the Weather Bureau during 1915 and 1916 will be published in the Annual Summary for 1916 of the "Climatological Data by [State] Sections" for the appropriate State.

A detailed description of each station will be published in the respective issues which contain the first data for the station. These descriptions will not be repeated in subsequent issues unless changes in a station occur. The temperature, cloudiness, and wind direction will appear in the regular tables of climatological data as now published in these section reports, but the daily evaporation measurements and wind movements, together with any other special data will be placed in a separate table of a form similar to that now used for the daily temperature extremes.

SLOPE AND VALLEY AIR TEMPERATURES.

By WILLIAM R. BLAIR, Professor of Meteorology.

[A short time ago the Weather Bureau received a communication asking for information that will help orchardists to avoid the known cold valley floors, to seek out the warmer zones along the valley slopes, to find the spots that are warmest just before sunrise, etc. The following reply was prepared and is here reprinted for the readers of the REVIEW.—C. A., jr.]

The more important factors entering into the temperature conditions experienced in a given locality are:

1 See U. S. Reclamation service. Reclamation Record, January, 1917, 8:40-41.