a rainfall of an inch in depth would equal 6,272,640 cubic inches of water, and we may convert the latter into gallons, barrels, or tons, as we please.

We recently computed for publication in the Year Book of an Agricultural Journal, a table giving the quantity of water corresponding to different depths of rainfall. A correspondent offers the criticism that the wine gallon of 231 cubic inches should have been used instead of the imperial (British) gallon of 277.463 cubic inches, as the former is the legal standard in the United States and the one commonly in use. We have, therefore, recomputed the table, giving the number of gallons per acre corresponding to given depths of rainfall in both measures for the convenience of all concerned. One inch of rainfall = 22,607 imperial gallons per acre, or 27,154 United States gallons.

Quantity of rainfall corresponding to given depths.

Depth of rainfall.	Cubic inches per acre.	Gallons per acre.		Ton per acre (2,000 pounds).
		United States or Queen Anne.	Imperial (British).	
Inches.				
0.25	1,568,160	6,789	5,652	28
0.50	3,136,320	13,577	11,303	56
0.75	4,704,480	20,366	16,955	85
1.00	6,272,640	27,154	22,607	113
1.25	7,840,800	33,943	28,259	141
1.50	9,408,960	40,371	33,911	170
1.75	10,977,120	47,520	39,563	198
2.00	12,545,280	54,309	45,214	226
2.25	14,113,440	61,097	50,866	255
2.50	15,681,600	67,886	56,517	283
2.75	17,249,760	74,674	62,169	311
3.00	18,817,920	81,463	67,821	339
4.00	25,090,560	108,617	90,428	452
5.00	31,363,200	135,772	113,035	565
6.00	37,635,840	162,926	135,642	678

The United States gallon adopted by Congress in 1830 is identical with the wine gallon of Queen Anne. The latter as well as the Winchester corn-gallon of 274¼ cubic inches, and the standard ale gallon of Queen Elizabeth of 282 cubic inches, were abolished as standard measures of capacity in Great Britain in 1824, when the new imperial standard gallon containing 10 pounds weight of water at temperature 62° F., barometer 30 inches, was made the standard of capacity for liquid measures. At the same time a cubic inch of distilled water, weighed in air by brass weights at the temperature of 62° F., the barometer being at 30 inches, was declared to contain 252.458 grains, thus making the contents of the imperial gallon 277.274 cubic inches.

A redetermination of the weight of a cubic inch of distilled water at the Board of Trade, Standards Department, London, 1889, by Mr. H. J. Chaney (Philosophical Transactions of the Royal Society of London, Vol. 183 A., pp. 331–354), gave 252.286 grains as the true weight, instead of the hitherto accepted value of 252.458, whence it follows that the capacity of the imperial gallon is 277.463 cubic inches, and the number of gallons per acre $= \frac{6,272,640}{277.463} = 22,607$, as above.

The figures in the last column, tons per acre, were obtained by reckoning 200 imperial gallons to the ton of 2,000 pounds.

COLONEL CHILDS' RECORD OF RAINFALL IN NICARAGUA.

Through the kindness of Rear-Admiral John G. Walker, United States Navy, president of the Nicaragua Canal Commission, the Weather Bureau has obtained a copy of the record of rainfall in Nicaragua, September 9, 1850, to September 25, 1851, made in connection with the survey of the Nicaragua route for a ship canal, by Col. O. W. Childs, civil engineer. This record has often been referred to, but we are not aware that it has ever before been made available to meteorologists, and we therefore publish it in full.

The original manuscript states:

The observations were taken at Rivas de Nicaragua from September 9, 1850, to March 11, 1851, and from the latter period to September 25 of the same year, they were taken on the San Juan River.

The rainfall was carefully ascertained by means of a rain gauge. The observations were in all cases taken by a member of the party, except during a term of thirty-four days in September and October, 1850, when they were taken by Don Fruita Chomorro, then prefect of that department of the state.

It is not likely that the missing days in September, 1850 and 1851, will materially affect the monthly totals; but, in order that a summary for exactly one year may be obtained, the following data were given in Colonel Childs' manuscript:

Summary for one year, from September 9, 1850, *to September* 8, 1851.

Whole number of days on which rain fell	139	
Whole number of days on which no rain fell	226	
From May to October, the wet season, there fell	90.88	inches
From November to April, the dry season, there fell	6.55	"
Greatest fall in any one month (July, 1851)	22.54	"
Least fall in any one month (February, 1851)	0.00	"

The rainfall is almost invariably by showers of short duration, which occur in the latter part of the day and in the night.

In the following table a bracket indicates that the rainfall of two days is given in one measurement. The blank spaces at the beginning and end show those dates for which there is no record. The time of day at which the record was made daily is not mentioned, but was presumably at some early hour, in accordance with universal custom.

Precipitation at Rivas and San Juan River, Nicaragua.

	1850.				1851.								
	Sept.	Oct.	Nov	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1	.....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.03	0.00
2	.....	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.09	2.71
3	.....	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	4.71
4	.....	0.03	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.46	0.60		0.00
5	.....	0.29	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.92		1.32	0.64
6	.....	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.77	0.00
7	.....	0.00	0.31	0.60	0.00	0.00	0.00	0.00	0.00	0.35	0.49	0.00	0.16
8	.....	0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.73	0.72	1.26	0.00
9	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.25	0.00		0.70		0.30
10		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.66	1.23	1.51	0.00
11	0.00	0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.66	0.06		0.54	0.00
12	0.44	1.30	0.02	0.00	0.00	0.00	0.00	0.00	0.66	0.24	2.65	0.63	1.11
13	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.04	0.00
14	0.75	1.90	0.00	0.49	0.00	0.00	0.00	0.00	0.13	1.38	0.07	0.00	0.00
15	0.00	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.82	0.22	0.49	0.00
16	0.26	2.79	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.16	0.58	0.64	0.00
17	0.26	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.00	0.78	0.00	0.00
18	0.31	1.15	0.00	0.35	0.00	0.00	0.00	0.00	0.14	0.00	0.19	0.05	0.47
19	1.03	0.04	0.18	0.00	0.00	0.00	0.00	0.00	0.92	0.35		0.00	1.72
20	0.09	0.14	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.52	0.53	0.00
21	0.93	0.01	0.00	0.00	0.19	0.00	0.12	0.00	0.27	0.99	0.00	0.00	0.00
22	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.03	0.00	1.34	0.24	0.27
23	0.19	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.12	0.71	0.00	0.00	0.08
24	0.00	1.74	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.45	1.01	0.00
25	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.09		0.00	0.07
26	0.00	2.04	0.00	0.14	0.00	0.00	0.00	0.00	0.76	0.10	5.92	0.50	.....
27	0.23	0.00	0.04	0.00	0.00	0.00	0.47	0.00	0.42	0.83	0.41	0.61	.....
28	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	2.77	0.52	0.09	.....
29	1.60	0.07	0.60	0.00	0.00	.....	0.00	0.00	0.13	0.30		0.50	.....
30	0.38	0.69	0.00	0.00	0.00	.....	0.00	0.18	0.27	1.39	2.29	0.00	.....
31	.....	0.00	.....	0.00	0.00	.....	0.00	.....	0.25	.....	0.51	0.00	.....
Sums	7.00	17.86	1.39	3.21	0.38	0.00	1.14	0.43	9.14	14.31	22.54	11.81	12.24

SEVERE HAILSTORM IN MISSOURI.

Communicated by A. E. HACKETT, Section Director, Columbia, Mo.

Mr. J. R. Brink, voluntary observer at Maryville, Mo., sends an account of a hailstorm of unusual violence that occurred on September 5, in Nodaway County, on the northern border of that State. The path of the hailstorm was about three miles wide; it extended far to the westward and moved due eastward for 18 miles across Nodaway County to One Hundred and Two River where it suddenly stopped. From the newspaper accounts it appears that the hail was heavy enough

to do much damage throughout this entire region, but that the greatest destruction occurred about 4 miles east of Clearmont, over a region of about 4 square miles, as indicated on the accompanying map. Mr. Brink states that at one point in this region the fall of hail was so heavy that a drift unprotected by any artificial means remained lying on the ground for four weeks after the storm, and this too at a season of the year when the soil had a comparatively high temperature. Mr. Brink, leaving Marysville, visited the region where the storm occurred, just four weeks after September 5, and secured several excellent photographs of the scene. Even at that time he found the people of the neighborhood gathering the hail for the purpose of making ice cream. Pieces of ice had been picked up at the time of the storm of a cylindrical form of about four inches long by about two and a half in diameter. We reproduce on Chart XVI, Fig. *a*, a photograph showing how complete had been the destruction of growing corn. The stalk seen in the photograph was quite mature, and is the only one left standing in a field of 80 acres. Had it not been for the hailstorm, this field would have yielded 60 bushels to the acre when harvested in the middle of September. The half tone, Chart XVI, Fig. *b*, shows the complete destruction of the foliage in a grove of young trees. Of course, the falling cakes of ice destroyed the roofs and even the sides of the houses, sometimes the north and sometimes the north and west sides at Clearmont; when its force was not sufficient to make a fresh hole through the boarding, the hail would generally, at least knock out the knot holes. The northern edge of the storm seems to have passed about ten miles north of Maryville; but 2 or 3 miles farther north a narrow strip of country also suffered severely; see Chart XVI. The statement that in some places the earth was covered to the depth of a foot, while everywhere it was white with ice, seems to justify the conclusion that there must have been an average depth of from 4 to 6 inches over the central region of, at least, 4 square miles in area.

THE TELEGRAPH SERVICE WITH THE WEST INDIES.

By J. H. ROBINSON, Chief of Division.

Daily telegraphic weather reports from the West Indies, Central and South America, and the Mexican Gulf Coast are now received at the Central Office of the Weather Bureau, i. e., from Nassau, Habana, Santiago de Cuba, Kingston, Santo Domingo, San Juan, St. Thomas, St. Kitts, Dominica, Martinique, Barbados, Trinidad, Curaçoa, Colon, Coatzacoalcos Vera Cruz, Tampico, and from Merida when the conditions are threatening. Daily reports are also received from Bermuda. For details as to routes of submarine cables over which reports are transmitted, see Chart XIII, showing points at which the cables connect with the land lines.

During the entire duration of the recent war with Spain daily weather reports were regularly received at the Central Office of the Weather Bureau from Habana. The observations were taken by the observers of the Spanish Meteorological Service for the Antilles, and were telegraphed by their operators to Key West, where they were retelegraphed to Washington. The submarine cable from Key West to Habana remained intact during the entire war, as did also the cable from Santiago de Cuba to Kingston, Jamaica. As the Key West–Habana cable had its outlet through the United States, it was not deemed wise to disturb it; the Santiago de Cuba–Jamaica cable, however, was grappled for, but not caught.

In connection with this article, perhaps it would be of interest to know that the Weather Bureau observers on the seacoast in many instances rendered efficient service to their country by reporting passing vessels, one of the most important being the arrival of the *Oregon* off Jupiter, Fla.

WEATHER TYPES AT HAVRE, MONT.

By C. W. LING, Observer, Weather Bureau (dated October 10, 1898).

I forward herewith a few generalizations relative to the marked pressure conditions that produce certain weather in this vicinity as deduced from a study of the daily weather maps for the past two years. The cause of the warm southwest chinook winds that prevail here is easily explained to visitors as due to mechanical or dynamic heating, and the old Japan current theory, still held by many, is easily obliterated. The conditions preceding cold waves, or colder weather, are very well marked and invariably produce the expected cold weather, with high northwest winds.

Chinook conditions.—A high over Wyoming and southern Idaho, with a low pressure over northern Montana, invariably brings to Havre a dynamic rise in temperature, i. e., a chinook wind in winter and a warmer spell of weather in summer, and accompanied by high southwest winds.

Cold wave conditions.—A low barometer over Wyoming, Utah, and southern Idaho, with high over northern Montana, Alberta, and Assiniboia, indicates intensely cold weather for Havre in winter and much cooler in summer. A high pressure area, with the low in Wyoming, by its vortical action, draws down intensely cold air from above (see journal of December 1 and 2, 1897, and of March 25, 26, 27, 1898). These conditions produce cold, high, northwest winds.

The summer type of weather conditions in Oregon, i. e., a high over Washington and Oregon with a low over the northern part of Montana and southern Alberta, indicates a warm spell for Havre and vicinity (see data July 13 to 17, 1898).

A falling barometer after a dry and warm spell of weather, barometer falling below the normal, with falling temperature, with the forecast for warm, indicates a heavy June or July rain in a day or two; also a cool atmospheric wave, followed by a warm wave (see thermograph sheet July 18 to 19, 1898, and the precipitation on those dates).

A low pressure area of 29.7, or lower, extending west to the coast and far south, indicates for Havre two or three days of rain or snow.

ANEROID BAROMETERS.

By C. F. MARVIN, Professor of Meteorology (dated November 8, 1898).

The unreliability of aneroid barometers when anything like accurate measures of pressure are required is almost proverbial. It is evident that much work remains to be done in order to ascertain the laws governing the irregular action of this most convenient and, in some cases, indispensable type of barometer. It will be still better if we can ascertain and eliminate the real causes of the anomalous behavior. The face reading of an aneroid even when not compensated for temperature is often thoughtlessly accepted with every confidence as to its infallibility, but it is pretty generally understood among the more critical observers that aneroids require to be frequently checked and verified by comparison with standards, and that a slow change goes on within them after they have been subjected to a considerable change in air pressure.

It may be stated that, broadly classified, the inherent errors of all aneroids are of two kinds. When the instrument is exposed over long periods to only such pressure changes as occur at any station at the earth's surface from day to day, its error will remain sensibly constant for a considerable period of time, but from time to time relatively large changes may and generally do take place in this error without any apparent cause and can not, therefore, be duly allowed for. The other inherent error is an effect connected with any considerable change in pressure. Suppose, for example, the pressure is changed in a short space of time from 30 to 25 inches; at the instant the pressure becomes stationary the index of the aneroid will show a certain read-

Chart XVI. Hailstorm in Nodaway County, Mo.

Fig. *a*.

Fig. *b*.
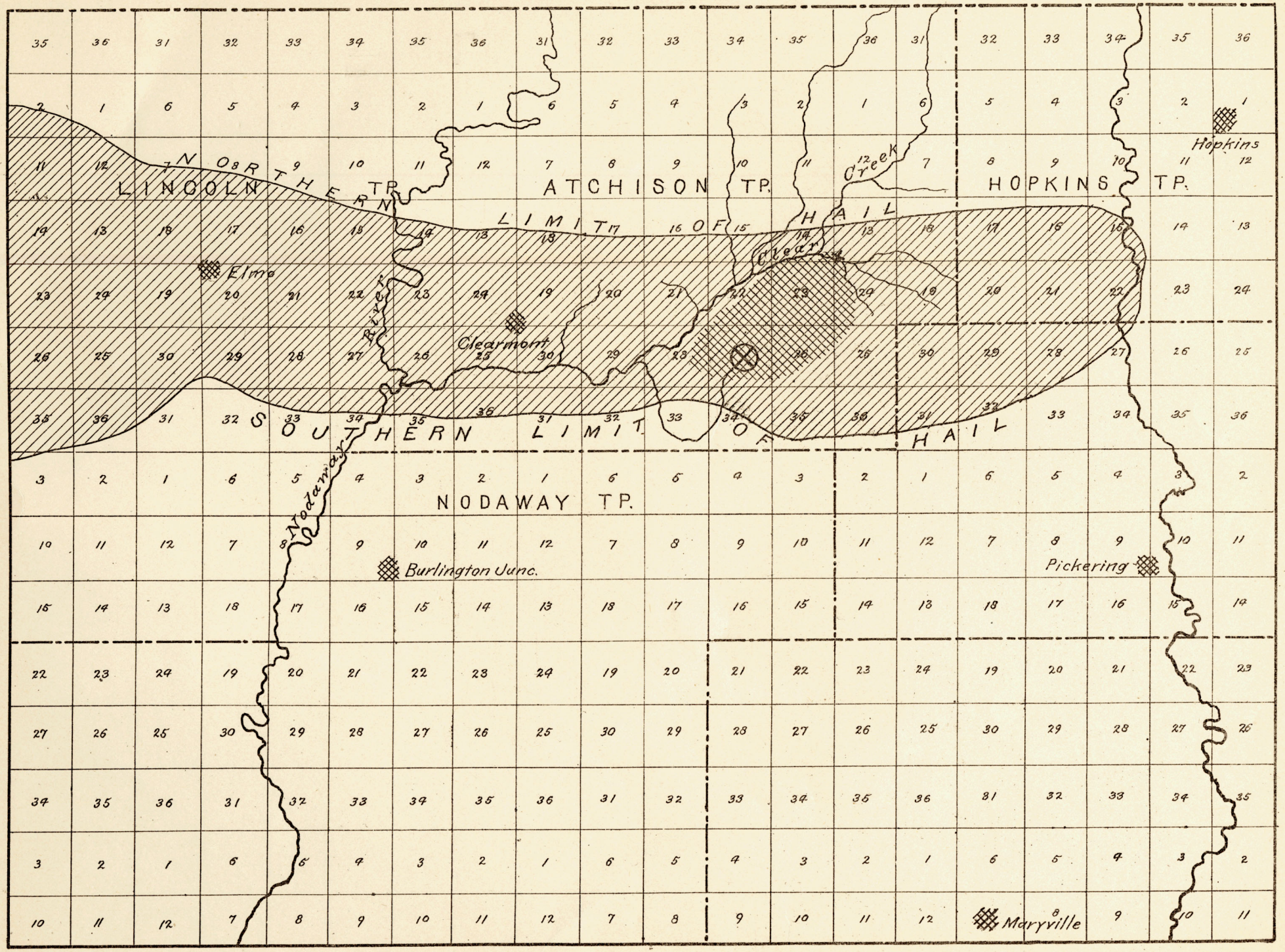
Chart XVII. Hailstorm in Nodaway County, Mo.