It would have been of interest to compare the wind velocity of this storm with that of the historic storms at Galveston and Houston. Mr. Daly states that at both of these places the anemometer blew off at 125 miles per hour. The anemometer of the power company is located at the top of the 60-foot flagstaff at the north end of the building and is 162 feet above the elevation of the lake or at elevation 687 feet M. D.

The effect of the wind on the various plant gages is not easy to understand. All of the plant gages are dampened down so that some have an opening from the gage well to the pond no larger than a lead pencil. This partly but not wholly explains the lag in effect on the gages after the wind began to blow. Note how closely the east and west dam gages follow the indicator on the falling side. It seems reasonable to believe that such a short sharp blow as occurred would not have been very uniformly distributed as to intensity over the area which it covered. Furthermore there would be a tendency toward higher water elevations in contracted places like the location of the ice fender indicator. Note also that all the gages, with the exception of the indicator, record only at 15-minute intervals and hence do not register changes in pond level as completely as the indicator. The change in pond elevation (rise) was 0.95 foot by the indicator and 0.72 foot by the east dam gage. If the high wind had continued longer both the east and west dam gages would probably have registered as high elevations as the indicator.

A series of surges occurred in the pond following the storm as shown by the indicator curve. These surges from crest to trough were of about one and one-fourth hours' interval. This would indicate that the surges went no farther upstream than Montrose, where the storm originated, for the time interval of wave movement between Fort Madison and the dam is two and one-half hours. The wave crest shown on the chart at 2 a. m. is the last one before the pond settled down to a constant elevation.

CORRELATION OF MAXIMUM RAIN INTENSITIES FOR LONG AND SHORT TIME-INTERVALS.

551.578.1

By ROBERT E. HORTON, Cons. Hydraulic Engineer.

[Voorheesville, N. Y., Oct. 20, 1920.]

Most studies of maximum rain intensities have covered intervals of two hours or less rain duration. Some attention has been given, as by the Miami Conservancy Commission, to maximum rain intensities having durations of one or more days. It is of interest, especially in attempting to discover the laws and physical processes governing high rain intensities, to compare the relation between intensity and duration for short intervals, as one hour or less, with similar relations for longer time-intervals, from one hour to one day, and for periods of one to five or six days covered by great storms.

Data showing maximum rain intensities from six recording rain gages at New Orleans, La., based on 25 years' records, afford a single example where a comparison of rain intensities for given time intervals from one minute up to one year may be made. The data are plotted on figure 1, the time being expressed in minutes by the horizontal scale, and the maximum amount of precipitation in the given time interval in inches is expressed by the ordinates. The observational data are indicated by small circles. These points apparently represent rain intensities having an average exceedance interval of about 25 years.

The term "exceedance interval" is used to define the average interval in years in which a given value of the magnitude of an event will be equaled or exceeded.

The equation

$$P_e = \frac{44tE - t^{0.322}}{60} \quad \dots\dots\dots \quad (1)$$

was worked out, using coefficients determined from the observational data for short durations. The values given by this equation are indicated on the diagram by triangles.

It will be seen that this simple expression represents with remarkable fidelity the observational data for time-intervals of 480 minutes, or eight hours, or less. This expression has, however, a maximum for $t=996$ minutes, which is readily obtained by differentiating equation (1). For time-intervals longer than this, it gives a smaller total precipitation than for time-intervals of less than 996 minutes. The maximum precipitation observed for longer time-intervals of course increases with the duration of the interval. This suggests that the curve representing the plotted points on figure 1 is really the combination of the graphs of two equations, one of which, namely that given, represents maximum rain intensities for relatively short intervals which are effected largely by local conditions, and second, normal precipitation unaffected by these special conditions. The latter is so small relative to the total amount for very short time-intervals that its omission from the left-hand portion of the curve on figure 1 is of little importance.

It is evident that if the time-interval was sufficiently long, say 50 to 100 years, then the maximum precipitation would approach closely as a limiting value, a quantity equal to kt, where k is the normal precipitation per unit of time (one minute in this case) as determined from the long-term mean rainfall at the given station. The long-term mean annual rainfall at New Orleans is 53.82 inches, which gives a value of $k=0.00010255$. The resulting limit line is designated B. It will be observed that the plotted points apparently approach this line as the duration increases.

The line C shows a continuation of the exponential function (1) beyond its maximum point. The value of this function becomes negligible for time-intervals exceeding 500,000 minutes. The portion of the curve DE represents the sum of the values of the curve C plus the values of some function which approaches the limit line B as the time-interval increases. Actually, the nature of this function is unknown, but it is probably some form of exhaustion equation, or exponential function, as is also the expression already given for the rainfall amount for time-intervals of one day or less.

Relative maximum rain intensities for various time-intervals from records of six recording rain gages at New Orleans, La., 1894 to 1918, inclusive.

[Geo. G. Earl, Mun. and County Eng. April, 1919, p. 122.]

Time-interval.	Maximum.			Minutes.
	Amount intensities.	Intensities per hour.	Intensities per 24 hours.	
(1)	(2)	(3)	(4)	(5)
3 consecutive minutes	0.63	12.60	302.4	3
5 consecutive minutes	.84	10.08	241.9	5
15 consecutive minutes	1.73	6.92	166.1	15
30 consecutive minutes	2.64	5.28	126.7	30
45 consecutive minutes	2.99	3.99	95.8	45
1 hour	3.53	3.53	84.7	60
2 consecutive hours	4.66	2.33	55.9	120
3 consecutive hours	5.80	1.93	46.3	180
4 consecutive hours	6.60	1.65	39.6	240
5 consecutive hours	7.02	1.40	33.6	300
6 consecutive hours	7.10	1.18	28.3	360
7 consecutive hours	7.30	1.04	25.0	420
8 consecutive hours	7.40	.93	22.3	480
9 consecutive hours	7.50	.83	19.9	540
10 consecutive hours	7.60	.76	18.2	600
11 consecutive hours	8.37	.76	18.2	660
12 consecutive hours	8.75	.73	17.5	720
13 consecutive hours	8.81	.68	16.3	780
14 consecutive hours	8.81	.63	15.1	840
15 consecutive hours	9.06	.60	14.4	900
15½ consecutive hours	9.21	.59	14.2	930
16 consecutive hours	9.21	.58	13.9	960
17 consecutive hours	9.30	.55	13.2	1,022
18 consecutive hours	9.35	.52	12.5	1,080
19 consecutive hours	9.40	.49	11.8	1,140
20 consecutive hours	9.50	.47	11.3	1,200
21 consecutive hours	9.60	.46	11.0	1,260
22 consecutive hours	9.70	.44	10.6	1,320
23 consecutive hours	9.75	.42	10.1	1,380
1 day	9.80	....	9.80	1,440
2 consecutive days	9.90	....	4.95	2,880
3 consecutive days	9.90	....	3.30	4,320
4 consecutive days	11.51	....	2.88	5,760
5 consecutive days	12.73	....	2.55	7,200
6 consecutive days	12.82	....	2.13	8,640
7 consecutive days	14.01	....	2.00	10,080
8 consecutive days	14.12	....	1.76	11,520
15 consecutive days	22.24	....	1.48	21,600
30 consecutive days	23.00	....	.767	43,200
1 calendar month [1]	16.01	....	.533	43,920
2 calendar months	26.62	....	.436	87,840
3 calendar months	30.81	....	.335	131,760
4 calendar months	36.48	....	.297	175,600
5 calendar months	41.75	....	.273	219,500
6 calendar months	47.69	....	.255	263,400
7 calendar months	51.58	....	.243	307,300
8 calendar months	55.19	....	.227	351,200
9 calendar months	59.87	....	.219	395,100
10 calendar months	67.73	....	.223	439,200
11 calendar months	71.74	....	.214	482,900
12 calendar months	74.68	....	.204	526,800

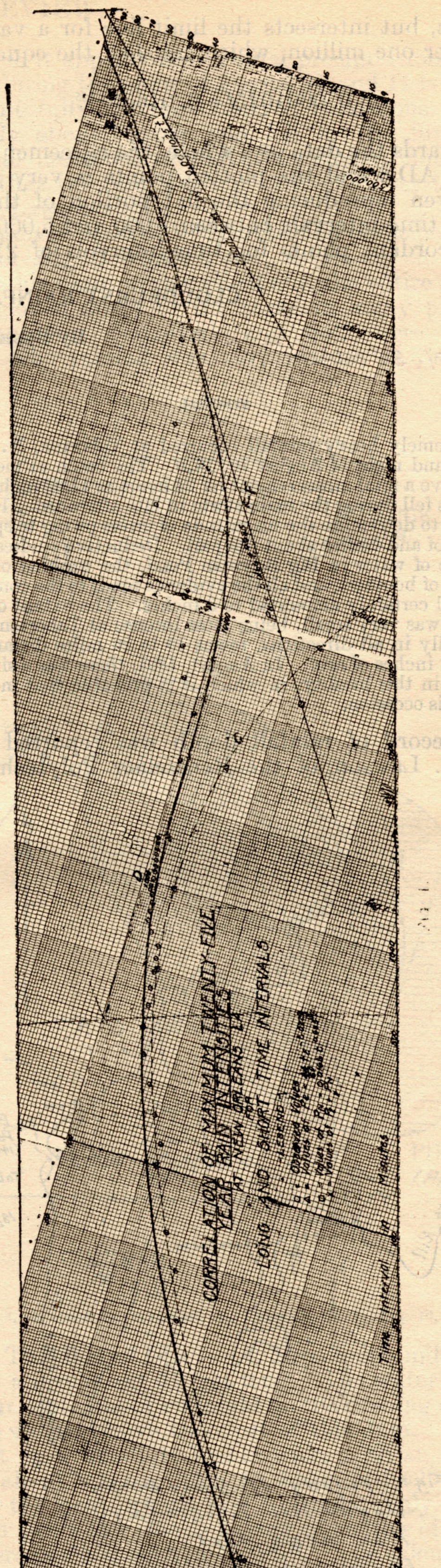
[1] Taken as 30.5 days.

An empirical expression has been worked out, the values of which are indicated by the line F, as a correction factor, showing the amount of normal precipitation to be added to the excessive precipitation given by equation (1) in order to obtain the total maximum precipitation for various time-intervals. The equation of this line is:

$$P_n = 0.0166t^{80.635} \text{ and } P = P_e + P_n. \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad (2)$$

Combining the results of equations (1) and (2), and plotting the corresponding values of P, results indicated by the line ADE are obtained. It will be noted that this line gives slightly higher values of the precipitation amounts for short time intervals than does equation (1) alone, however the data for a given number of consecutive hours, days, or months, probably does not represent quite the true maximum amount of precipitation for an equivalent number of consecutive minutes, the difference being larger for short than for longer time-intervals, so that the left-hand portion of the curve ADE possibly represents more nearly the true values which would be determined from homogeneous time intervals than do the data themselves.

The equation for P_n here used is of course not rational, since its curve does not approach the limit line B as t



increases, but intersects the limit line for a value of t a little over one million, which satisfied the equation

$$0.0001025t = 0.0166t^{80.635}$$

As regards the data as a whole, the agreement between the line ADE and the plotted points is very good, the curve even reproducing the flat portion of the plotted data for time-intervals between 1,000 and 5,000 minutes. The discordant points for time-intervals of 21,000 and 43,000 minutes, respectively, are probably due to rain intensities for these time-intervals having occurred "out of their order," or with greater frequency during the 25 years of observations than would be the case on the average. It appears that the equation for the line ADE given on the diagram represents with considerable accuracy the maximum amounts of precipitation having average exceedance intervals of about 25 years at New Orleans for time-intervals ranging all the way from 1 minute to 1 year.

CLOUDBURST RAINFALL AT TABORTON, N. Y., AUGUST 10, 1920.

By ROBERT E. HORTON and GEORGE T. TODD.

[Albany, N. Y., Oct. 15, 1920.]

SYNOPSIS.

An extremely heavy rainfall occurred at Taborton, N. Y., on the afternoon and night of August 10, 1920. The catch as measured in a bucket, gave a total measurement for 24 hours as 11.62 inches, of which 8.95 inches fell during the main storm in late afternoon. Experiments were tried to determine the magnitude of errors owing to splash from a near-by roof and eddies about the pail. Deductive studies were made on the rise of water in Big Bowman Pond, the washing of roads, and dislodging of boulders, and all the evidence tends to the conclusion that the rainfall certainly amounted to 8 inches. The extent of the heavy downpour was very small, being most intense at Taborton and falling off markedly in all directions, towns 15 to 20 miles distant receiving only 1 or 2 inches of rain. In August, 1891, there was a similar heavy downpour in this locality, in which it is probable that more rain fell than on this occasion.

The record of rainfall depth was reported by Prof. Thos. R. Lawson, of the Rensselaer Polytechnic Institute, who was at his summer cottage, located at the point marked "A" on figure 1, at the time the storm occurred.

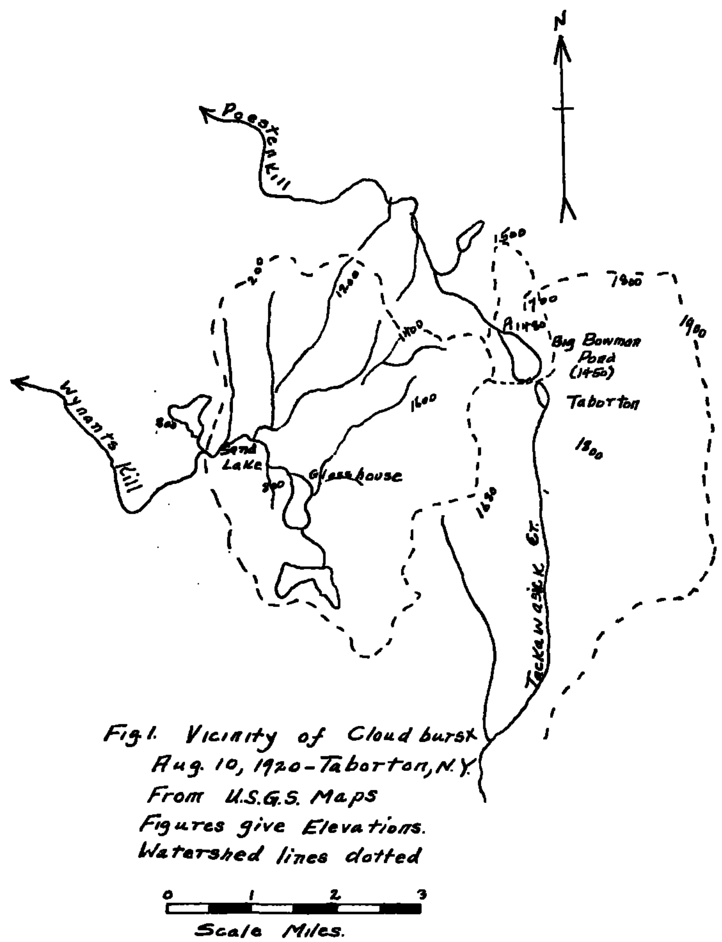


Fig. 1. Vicinity of Cloudburst Aug. 10, 1920 - Taborton, N.Y. From U.S.G.S. Maps Figures give Elevations. Watershed lines dotted

There was an ordinary tin pail with flaring sides standing on the ground 8 feet from the south corner of the house, as shown in figure 2. Where the pail stood the grass was short and the ground hard, and the pail stood level.

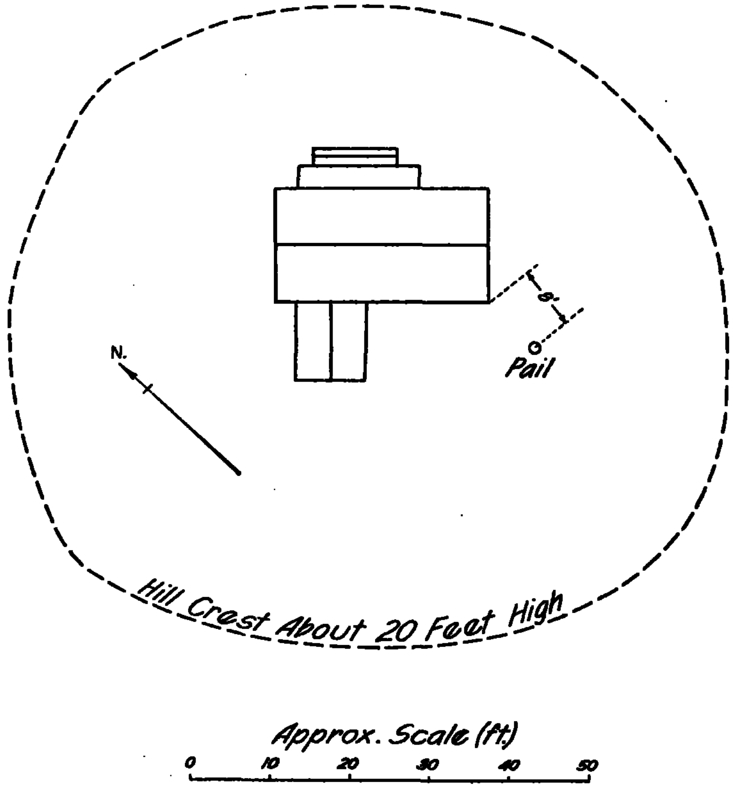


FIG. 2.—Details of location of pail near house.

The mean top diameter inside was 10 inches—mean bottom diameter $7\frac{1}{4}$ inches—and depth $8\frac{3}{4}$ inches. Prof. Lawson reports that the pail was empty before the rain. The rain began about 4 p. m., fast ["summer"] time, and the heaviest storm ended about 6 p. m. There was a lull between 5 and 6 p. m., at which time he found the pail full. He then emptied and replaced it, and at the end of the rain it was again half full or nearly so.

The surface area, or catchment of the pail, is 78.54 square inches. The pail being a truncated cone, the true depth of rainfall caught has been obtained by determining the height of a cylinder of equal volume and having a diameter of 10 inches. This amounts to 6.28 inches. The volume in the bottom half of the pail caught after the lull, reduced to the same basis is equivalent to a cylinder 10 inches in diameter and 2.67 inches high, making the total rainfall caught in the main storm equivalent to 8.95 inches.