On the morning of October 8 the final plenary meeting of the union was held for the consideration of questions of interest to the whole union as distinguished from those that pertained to the work of the individual sections only.

Before adjournment it was voted to accept the invitation of the delegates from Czechoslovakia to hold the next assembly of the union in Prague in 1927.

Probably the outstanding accomplishment of the section, the results of which will be awaited with great interest, is the provision in resolution 26 for testing the service that might be rendered by an International Meteorological Bureau. The work of compiling an atlas of weather maps of the Northern Hemisphere, with all possible completeness, for the third quarter of 1923, is a project worthy of international cooperation. However, the discussion as recorded in the minutes shows that grave doubts were entertained by some as to the propriety of "placing money at the disposal of an existing State service for carrying on work of an international character in conjunction with a commission."

Acknowledgment is made of the kindness of Secretary Eredia and Assistant Secretary Lempfert, in placing at the disposal of the author copies of the minutes of the meetings, including the text of the resolutions that were adopted.

AN APPROACH TO RUNOFF EXPECTANCY

S. L. MOYER, C. E.

[Montevideo, Minn., August, 1924]

The economics of the design of waterways for such purposes as drainage, spillways, bridge and culvert openings, etc., must fundamentally depend upon the frequency with which various run-off magnitudes may be expected.

Comparison of run-off data from different watersheds for any purpose, has very little meaning unless in some way account is taken of this factor of expectancy.

If a series of observations is arranged in the order of magnitude, and the frequency is defined as the interval of time between events of a given or exceeding magnitude, each observation being representative of a given unit of the total period covered equal to the unit in which frequency is measured, then the center of the series has a frequency value of 2 and the maximum observation has a frequency value equal to the total number of observations in the series.

Series frequencies.—From the above facts is deduced the method for determination of the various frequencies outlined as follows.

To determine the frequency for a given observation in a series, arrange and number the observations in the order of their magnitude, then the frequency

$$F=\frac{a}{b-N} \text{ in which}$$

N=the numerical designation of the observation,

$a=T+2\,\frac{T-1}{T-2}-1$ and $b=T+\frac{T-1}{T-2}$ in which again

T=the total number of observations in the series, each observation representing an interval of time equal to the unit in which the frequency is expressed and

F=frequency or interval of time, in the given unit, between events of a given or exceeding magnitude.

Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)	Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)
5	6.667	6.333	19	20.118	20.059
6	7.500	7.250	20	21.112	21.056
7	8.400	8.200	21	22.106	22.053
8	9.333	9.167	22	23.100	23.050
9	10.286	10.143	23	24.095	24.048
10	11.250	11.125	24	25.090	25.045
11	12.222	12.111	25	26.086	26.043
12	13.200	13.100	26	27.083	27.042
13	14.182	14.091	27	28.080	28.040
14	15.167	15.083	28	29.077	29.038
15	16.153	16.077	29	30.074	30.037
16	17.142	17.071	30	31.071	31.036
17	18.133	18.067	31	32.069	32.034
18	19.125	19.063	32	33.067	33.033

Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)	Total number observations in series (T)	$\left(T+2\frac{T-1}{T-2}-1\right)$ (a)	$\left(T+\frac{T-1}{T-2}\right)$ (b)
33	34.065	34.032	52	53.040	53.020
34	35.063	35.031	53	54.039	54.020
35	36.061	36.030	54	55.039	55.019
36	37.059	37.029	55	56.038	56.019
37	38.057	38.029	56	57.037	57.019
38	39.055	39.028	57	58.036	58.018
39	40.054	40.027	58	59.036	59.018
40	41.053	41.026	59	60.035	60.018
41	42.051	42.026	60	61.035	61.017
42	43.050	43.025	61	62.034	62.017
43	44.049	44.024	62	63.033	63.017
44	45.048	44.024	63	64.033	64.016
45	46.047	46.023	64	65.032	65.016
46	47.045	47.023	65	66.032	66.016
47	48.044	48.022	66	67.031	67.016
48	49.044	49.022	67	68.031	68.015
49	50.043	50.021	68	69.030	69.015
50	51.042	51.021	69	70.030	70.015
51	52.041	52.020	70	71.029	71.015

After finding the frequency for each observation, the series may be plotted against various functions of the frequency until some function is discovered which causes the observations so plotted to approximate a straight line, and the function so determined is determinate of the relation of magnitude to frequency for the series under consideration.

Annual peak flows so plotted for a number of streams suggest that, for the more frequent events at least, peak flows on any stream tend to approximate a straight line when plotted against

$$\left(\frac{1}{2F}+\frac{4{\cdot}5}{F+8}\right) \text{ in which } F=\text{frequency.}$$

A chart for ready determination of the various values produced by this expression is given in Figure 1.

Designating this expression as d, these same plottings seem to indicate that peak flows for any stream follow a law expressed by a formula of the form of

$$Q=(c-d)e$$

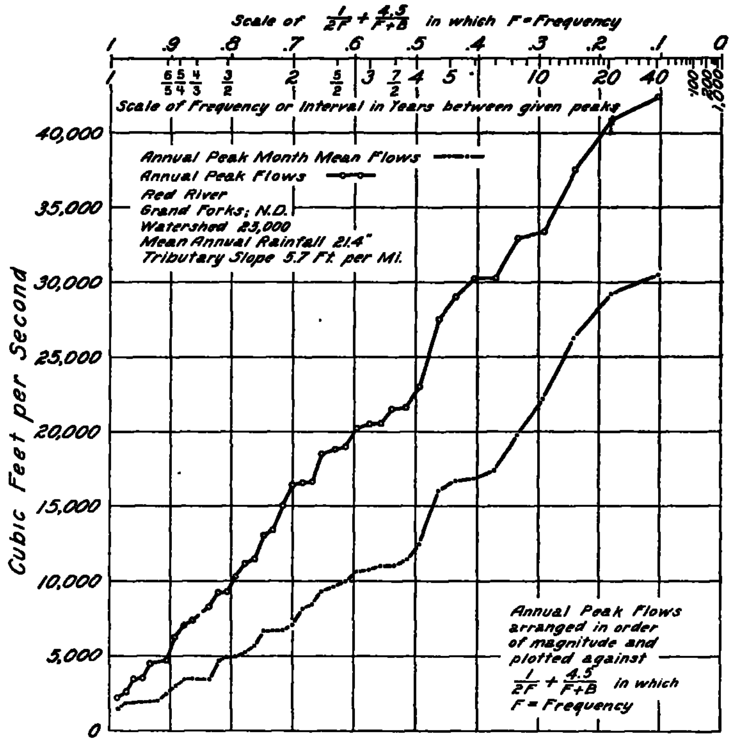
$$\text{in which } d=\left(\frac{1}{2F}+\frac{4{\cdot}5}{F+8}\right),$$

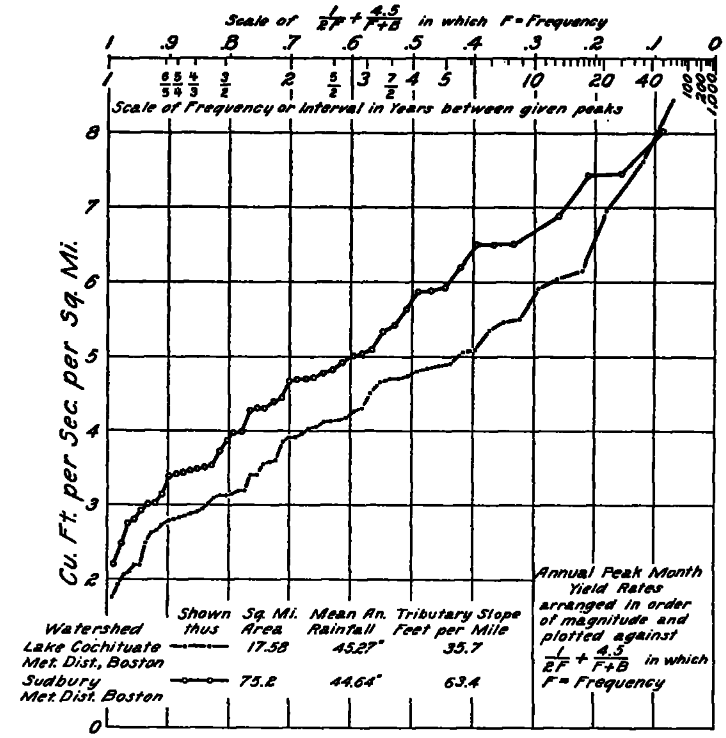
Q=magnitude of flow,

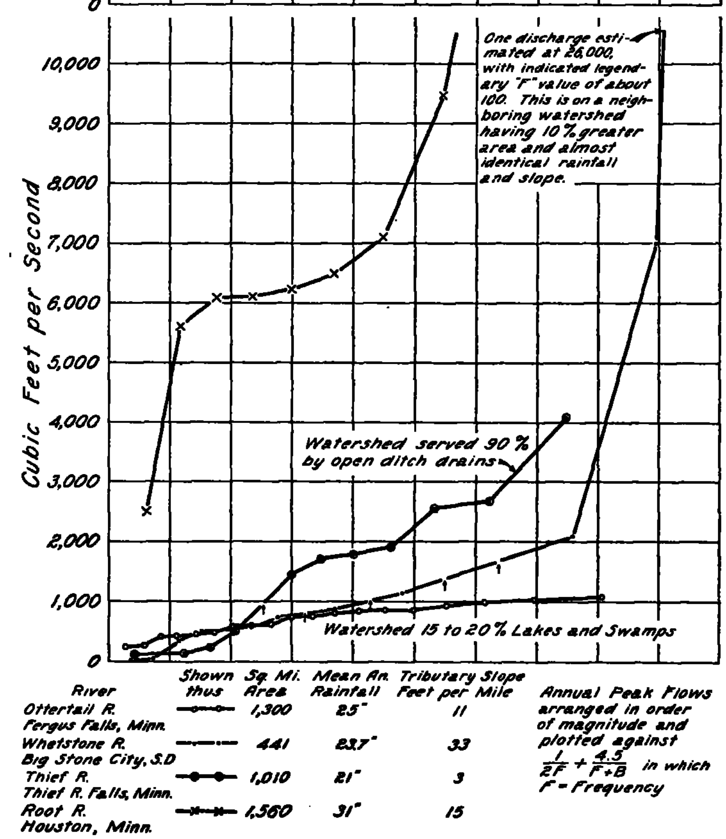
F=frequency or interval in years between peak flows of a given or exceeding magnitude,

ce=limit which magnitude approaches.

By plotting the discharges from various watersheds against d, it is possible to compare any number of records on a basis which gives rational weight to the length of the record and by computing and charting d for various values of F it is possible to construct a frequency scale conforming to this straight line relation, thus affording







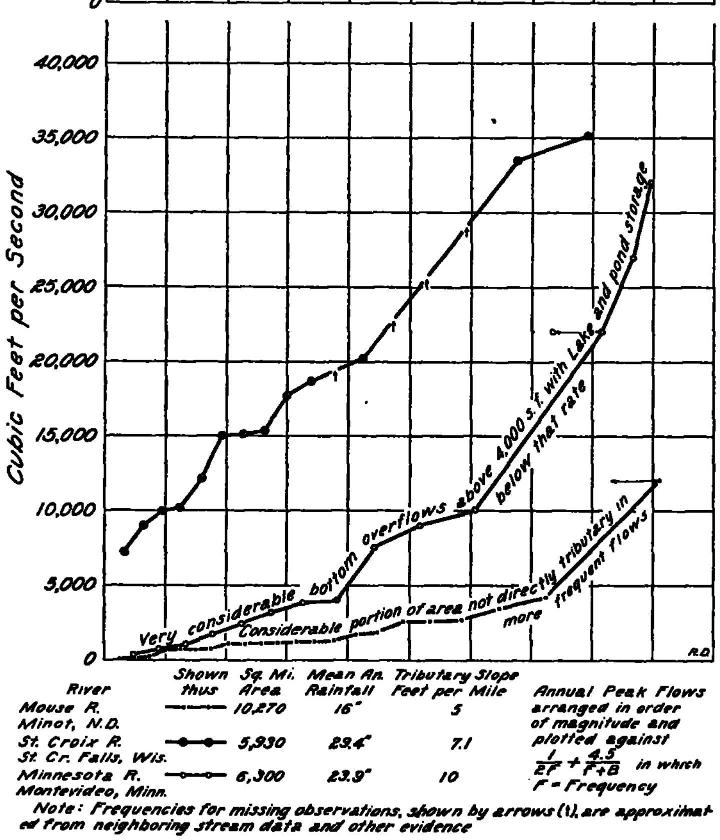


FIGURE 2 (upper left) FIGURE 4 (lower left) FIGURE 3 (upper right) FIGURE 5 (lower right) a ready graphic solution of the mysteries of frequency. Figures 2–5 illustrate such plotting.

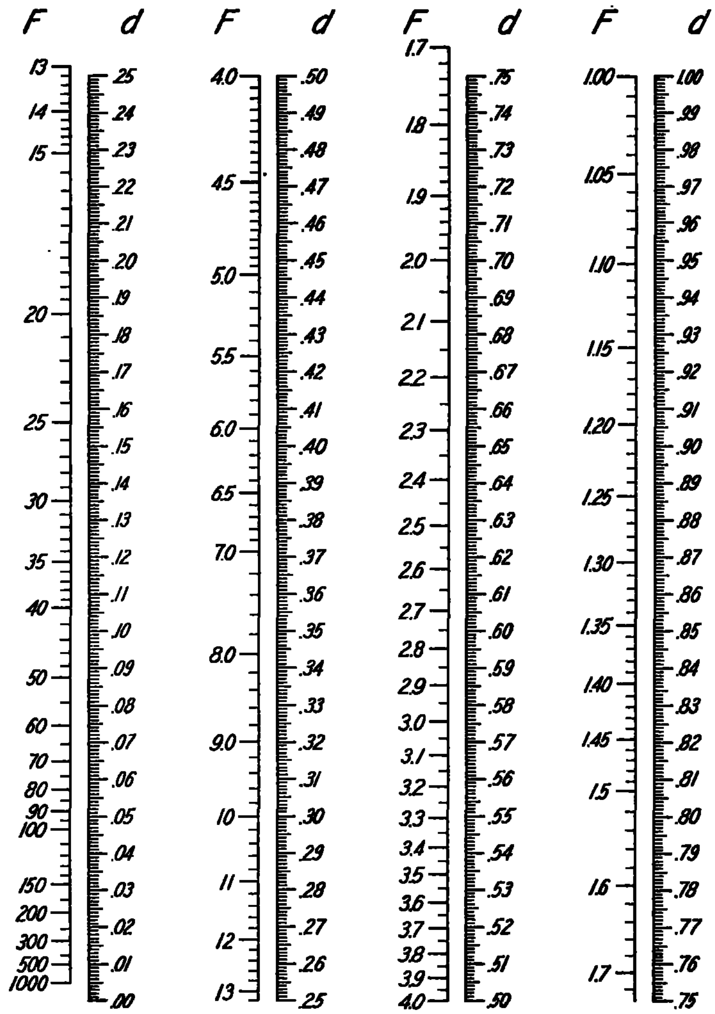
Historical and legendary information as to flows that have equalled or exceeded the maximum of record may be also utilized to extend the charted record or to correct the frequency value for the maximum discharge for short records, and the probabilities may be thereby visualized in a way that enables the mind to grasp some relations that otherwise remain obscure.

Records and historical evidence examined indicate:

1. That for large watersheds, over 20,000 to 30,000 square miles, the factor *ce* is practically constant for all frequencies.
2. That for watersheds 5,000 to 15,000 square miles, *ce* is constant for flows between limits of about 5 years out of 6 up to occurrances once in 5 to 10 years, and for more infrequent events *ce* increases with *F*.
3. That for watersheds 1,000 square miles or less, *ce* is constant from 5 years out of 6 to 1 year in 14 to 16, and for more infrequent flows *ce* increases with *F*.
4. That the variable affecting *ce* probably affects *e* only and has an inverse relation to mean annual precipitation and area, a direct relation to the tributary slope, and a relation to frequency of a similar form to that given for *Q* above.
5. That *c* has a direct relation to mean annual precipitation, and area.
6. That *e* has a direct relation to precipitation, area, and slope, and an inverse relation to storage.

Indications are that with broad enough data, the relations affecting *c* can be determined within 5 per cent of accuracy, *e* within 10 per cent, and the variable within somewhat wider limits, and this is written to assist the author in his quest for such data, long-time records being most desired.

Note added November 17, 1924.—Later investigations suggest considerable alterations in the ratios entering into the expression for *d*, and it is believed that with proper modifications those events of a frequency of once in 15 years, or of more remote occurrence, may be closely approximated as well as the more frequent events. Such a modified expression will be proposed by the author at some future date.



Values in Formula for Deduction Factor

$$d=\left(\frac{1}{2F}+\frac{4.5}{F+8}\right)$$

Fig. 1

COMPARISON OF RAIN-GAGE CAN AND THE HORTON SNOW-BOARD MEASUREMENTS OF SNOWFALL AT GRAND FORKS, N. DAK.

551.578.4 : 551.508.7

By Albert W. Cook

[Weather Bureau Office, Grand Forks, N. Dak.]

There are many difficulties in the way of securing accurate measurements of snowfall. In addition to those inherent in the conditions attending precipitation in general, additional difficulties are introduced when the temperature is near or below the freezing point of water. When the wind is high or occurs in gusts, the snow is blown about and drifted so that the amount caught in the gage can is usually deficient. Under these conditions other means of measurement must be used. An open exposed spot is chosen and a number of measurements of the actual depth of the snow is taken and the average of these is assumed to be the true depth of the snow. This method of measuring gives a fairly close measurement of the depth if the ground was clear when the snow fell. When new snow has fallen on old snow, it is difficult to determine the depth of the new snow. This is especially true when snow is falling at the time of observation. Measurement must be made of the amount up to the time of observation and then the balance is to be measured at the next following observation. The line of division is one of time and not of snowfall and there is no definite mark between the amounts recorded at each observation.

To secure a means of eliminating this difficulty a snow board patterned after the one used by R. E. Horton [1] was used.

A piece of "compo" board about 2 feet square was covered with white cotton flannel with the rough or nap side uppermost. This was done to simulate a snow surface. After each snow the board was cleaned and placed on the newly fallen snow.

The actual depth of the snow could be secured by measuring the depth of the snow on the board. There would be no possibility of including the old snow.

[1] Mo. Weather Rev., 1920; 48: 88–89.