Gaylord, Mich.: "All maple shade trees are badly broken and the poplars almost wholly stripped."—C. J. Franks.

Whittemore, Mich.: "Fruit trees were broken down and practically ruined, especially cherry trees, many of which were broken off within 2 feet of the ground. The top branches of all shade trees were broken off."—C. H Berdeslee.

Arcadia, Mich.: "Older fruit trees, including plum, cherry, and apple trees, 30 years old and older, were 90 per cent loss in this section. Ash, maple, and elm trees are practically ruined as far as appearance is concerned."—L. K. Putney & Son.

The storm a little further north of the region of greatest damage is described very well by the cooperative observer at Traverse City, Mich., Mr. E. J. Liddy. He states: "This storm began in this section about 8 p. m., February 21, with coarse, granular sleet. The granules averaged about one-fourth the size of a pea. This continued nearly all day of the 22d and at 10 p. m., that night, it turned to rain. About 8 to 10 inches of this granular snow fell. After about four hours of heavy rain during the night of the 22d and 23d it turned cold, freezing a crust 3 to 4 inches think on the snow. Then, on the 23d, beginning about 7 a. m., it snowed 2 to 3 inches of fine snow on the top of the crust."

Heavy snow was general in the extreme northern counties of the lower peninsula and throughout the upper peninsula. The greatest depth reported was 33 inches, at Ispheming, Mich. The snowstorm was attended by strong northeast winds, reaching a velocity of 46 miles an hour at Houghton, Mich., and 48 miles per hour at Escanaba, Mich., which drifted the snow to great depths in places. The railroads were completely blocked for several days, as the weather continued cold throughout the rest of the month.

ON THE DESIGN OF RAIN-GAGES.

By S. P. FERGUSSON.

[Weather Bureau, Washington, D. C., February 20, 1922.]

The following statement of the requisites of rain-gages approved by the British Meteorological Office is abridged from an editorial having the above title published in the *Meteorological Magazine* of July, 1921, omission having been made of paragraphs relating wholly to British usage. This information is of great value everywhere, and particularly so in America because of the rapidly increasing interest in the measurement of precipitation, and the fact that many of the objectionable forms of gages referred to are in use and are offered for sale in the United States and other American countries:

The existence of a large body of voluntary and self-equipped observers of rainfall in the British Isles carries with it, among a multitude of advantages, the disadvantage that it is extremely difficult to eliminate the use in many cases of rain gauges of undesirable patterns. Such gauges are not infrequently obtained by persons interested in rainfall observing, but unaware of the errors to which they are likely to give rise. The collective experience of those who have made rainfall observing a special study is unequivocally in favor of the universal adoption of the now-recognized standard patterns of rain gauge and the rejection of certain obsolete patterns.

There are unfortunately price-lists, even amongst those issued by the well-known makers of rain gauges, which include particulars of gauges which have been definitely proved to be unsuitable for accurate measurement of rainfall. It is understood, however, that there is a certain market for obsolete types of rain gauges such as the "Howard" and the "British Association," which are unsatisfactory for measuring heavy rain and snow because of the absence of the deep cylindrical rim above the collecting funnel, and are also open to other objections. In the same way the well-known "Glaisher" gauge is still frequently listed and sold, although it has been clearly proved to be liable to develop serious errors.

It therefore seems desirable that the essential characteristics of a reliable rain gauge should be briefly explained for the guidance of purchasers who may not be aware of the defects inherent in some of the listed instruments. The prototype of the approved gauge [of the Meteorological Office] is the "Snowdon" rain gauge. The "Meteorological Office" pattern gauge, the "Bradford" gauge, and the "Seathwaite" gauge are variants of this type which embody the essential features of the "Snowdon" gauge, and are therefore also satisfactory. Most other gauges are unsatisfactory in that they do not contain the essential features, which may be stated as follows:

(1) The stout brass turned ring terminating upwards in a knife-edge, exactly 5 or 8 inches in diameter, which forms the rim of the gauge.

(2) The vertical cylinder 4 to 6 inches deep, extending from the rim to the upper edge of the funnel, which is intended to retain snow and hail, to prevent the outsplashing of rain which has fallen upon the funnel and to reduce to a minimum the risk of loss due to wind eddies.

(3) An inner collecting vessel, which can be removed for measuring the fall without disturbing the body of the gauge. Taps for drawing off water are extremely objectionable.

(4) Provision for a depth of at least 6 inches of the body to be firmly fixed in the ground.

(5) Simplicity of construction and avoidance of the use of rivets.

(6) Strength and durability.

(7) A capacity of not less than 10 inches of rain for a daily gauge. Gauges for monthly readings should be larger according to the district in which they are to be used.

Drawings of some of the gauges referred to will be found in "Rules for Rainfall Observers," a copy of which will be forwarded to any address * * *, on application to the superintendent of the British Rainfall Organization [London, England]. "The Observer's Handbook" of the [British] Meteorological Office may also be consulted.

The above conditions, with the exception of that numbered (3), apply generally also to self-recording rain gauges, it being noted, however, that the diameter of the rim of modern British recording gauges is usually either 6, 8, or 11 inches. Condition (5) is most important, and the following further desiderata apply:

(8) The scale values of the chart must conform accurately with the indications of the instrument.

(9) It is desirable that the hour lines on the chart should be straight and not curved.

(10) It is desirable that the scale value for rainfall should be not less than six times the natural scale, and that the drum should make a complete revolution in 24 hours.

(11) Dial gauges, tipping-bucket, and electrical-recording rain gauges are not in general suited to modern requirements.

(12) Should the mechanism of the gauge include an automatic syphon, the design and construction of the syphon require special care; the liability to failure of syphons is a serious drawback.

(13) Space should be available inside the case of the instrument for the insertion of a small oil lamp or a night light to warm the gauge in frosty weather.

Makers of rain gauges could materially assist in the extermination of undesirable types of rain gauge by refraining, in the interests of science as well as in their own ultimate interests, from making and listing any instrument which is known to be unsuitable for measuring or recording rainfall.

Intending rainfall observers, or existing observers who have the intention of re-equipping themselves with new gauges, are advised to insist that goods should be accompanied by certificates of accuracy. These certificates not only ensure the accuracy of the construction, but also give a guarantee that the gauge is of the approved pattern.

The writer's long experience in the use of recording gages in New England and in the mountains of the West indicates that condition (10) may be modified to advantage when a recording-gage for general use is designed. Since (1), 0.01 inch is the smallest quantity that may be measured with reasonable accuracy and (2), errors of exposure, etc., often cause errors much larger than 0.01 inch, it will be sufficient that the instrument be capable of recording definitely this minimum quantity, a refinement easily accomplished by the use of a scale of two to one or even smaller. (See paper on Improved Gages for Precipitation in this REVIEW, July, 1921, 49:379–386.) The devices referred to in (11) and (12) should be definitely excluded from consideration except under circumstances where no others are available. Their complexity and large cost also are considerations. The tipping-bucket is useful when, for convenience, a record is desired at a distance from the collector, but requires care. Condition (13) is unnecessary in weighing rain- and snow-gages.