A more troublesome source of error, however, is found in the rate of the "regulator" clock. Reference to the accompanying diagram [not printed] will show that on different days the clock has gained as much as twenty seconds, or lost as much as thirty-seven seconds. For the seven days previous to September 1 the clock gained from eleven to seventeen seconds each day, the gain from noon of the 30th of August to noon of the 31st, being twelve seconds. From August 31 to September 3 no time observations were made, but during this period the clock lost twenty-eight seconds, or an average of nine seconds per day. From 9 a. m. to 12, noon, of the 3d, it gained three seconds, and from noon of the 3d to noon of the 4th, one second.

The noontime signals from the Naval Observatory are not received at this office by telegraph on Sundays nor holidays, and it so happened that September 1 fell on a Sunday, and was followed by a national holiday (Labor Day), September 2. It was not possible, therefore, to get a more accurate reduction to the actual Naval Observatory standard time than is here explained.

There seems to be no way of deciding accurately whether the regulator clock kept on gaining at the rate of twelve to fifteen seconds per day until after 6 a. m. of the 1st, or whether, between noon of the 31st and noon of the 1st it lost from twenty to forty seconds. There is, therefore, an uncertainty of at least thirty seconds in the error of the clock at 6 a. m. of September 1, and of five seconds in the interval of time that elapsed between the clock record and the seismograph record.

Adopting a mean rate for the clock from noon of the 31st to noon of the 3d, we obtain for the error of our "regulator" clock at 6 a. m. of September 1, + 1 min. 50 sec. Subtracting this error from 6 hr. 10 min. 29 sec., the time by the "regulator" clock at which the seismoscope needle was disturbed, we get 6 hr. 8 min. 39 sec. as the Naval Observatory standard seventy-fifth meridian time for the occurrence of this earthquake shock, which time is probably correct within twenty seconds.

The record of the Weather Bureau seismograph indicates that the *duration* of the shock was only a few seconds.

HOW TO OBSERVE AN EARTHQUAKE.

Prof. Charles Davison, of Birmingham, England, has been engaged for several years in studying and cataloguing the earthquakes of Great Britain, and has lately issued some instructions to observers, which are also applicable to other countries. The essential points are the following:

1. Always be prepared by keeping a written record of the correction to your watch or clock. If the record is made daily, by comparing your watch with the standard-time signal, or standard clock, and if you do not often adjust the watch, but keep its record continuously day after day, you will have the means of converting an observed time into standard time by making allowance for the error of the watch.

Immediately after the earthquake is over compare the watch or clock with other watches and clocks, especially the best standard-time clock accessible. The standard clocks of the ordinary jewelers are often allowed to be in error half a minute and are rarely adjusted to absolute correct time more than once a week or month, but by cultivating a friendship with the jeweler you can generally obtain the exact error of the clock, provided the information is to be used only for strictly scientific purposes. The standard noonday-time signal, which is flashed all over the country daily by telegraph, should always be used when possible. It can be observed at any telegraph office, and is often distributed by telephone. It is very desirable to observe the time of the shock and determine the error of the watch to the nearest second. All records should be kept in seconds, even although there may be a possible error of many seconds. Ordinary watches are liable to an irregularity in their daily rate so large that they may gain or lose ten seconds in twenty-four hours without any special apparent cause. Therefore the observer must compare his watch with the standard clock as soon as possible after the earthquake has happened. Clocks having wooden pendulums, beating seconds or half seconds, are more reliable than ordinary watches. Clocks having metallic pendulums, without compensation for changes of temperature, are less reliable than the best of the high-grade watches.

2. The most important item is the time of the instant when the strongest shock occurred. If no shock was especially strong, then record the time of the beginning and also that of the ending of the vibrations; if no shock at all is felt, record the time when the loudest rumbling noise was heard.

3. Record the nature of the shock: (*a*) Was any tremulous motion felt before the principal vibrations, and for how many seconds? (*b*) How many principal vibrations were felt, and for how many seconds did they last? (*c*) Was any tremulous motion felt after the principal vibrations, and for how many seconds? (*d*) Did the shock gradually increase in intensity and then gradually die away, or were there two or more maxima or a series of vibrations; and if so, how many were there, what were the intervals between them, and what was the order of their intensity? (*e*) Were the principal vibrations strongest near the beginning, middle, or end? (*f*) Was any vertical motion perceptible, and if so, was the movement first upward and then downward, or vice versa?

4. *Duration of the shock in seconds.*—This may be estimated after the observer has recorded the minutes and seconds of the strongest shock. To do this he should repeat at his leisure the various movements and operations that he himself went through when he observed the earthquake, and should time himself while so doing.

5. *Intensity of the shock.*—(*a*) Making windows and loose things rattle. (*b*) Perceptibly moving a chair, or bed, or the observer. (*c*) Stopping clocks, or making pendulums, pictures and chandeliers swing. (*d*) Overthrowing small ornaments or breaking the plaster from the ceiling. (*e*) Throwing down well built chimneys or cracking well built walls.

6. *The sounds.*—(*a*) Was there any unusual rumbling? (*b*) By how many seconds did the first sound precede or follow the first quaking of the earth? (*c*) By how many seconds did the last sound precede or follow the last shock? (*d*) Did the sound entirely precede, or entirely succeed the shock, and by how many seconds? (*g*) Was the sound loudest before, or at, or after the instant when the shock was strongest?

Special interest attaches to these last questions about the relation between the movement of the earth and the sound in the air. While the earthquake lasts the whole attention should be given to observing the nature of the shock and sound and their relations to one another, and their variations in intensity and character. During this time one may look at his watch and make some mark that will assist the memory, but need not write down anything except what relates to the sounds and shocks until the latter are entirely recorded, after which he may write down the record of times of beginning, maximum, and ending.

If more than one shock is felt the descriptions of the different shocks should be kept separate; slight shocks are just as important as strong ones. If you know that you are in the neighborhood of an earthquake disturbance, which you did not yourself experience, although you were in a favorable condition to do so, it is important to record that fact.

[NOTE.—The Editor has several times found by experience that when it is difficult to count the rather rapid vibrations of a building, it is still perfectly practicable to let a lead pencil held loosely in the hand trace a zigzag line that shall be a correct, graphic presentation of the number and intensities of each individual vibration, and this zigzag can be repeated an hour afterwards quite perfectly, both as to character and time. By counting the zigzags we thus determine the total number of vibrations, and by timing the process repeatedly we get a clear idea of the duration. Thus in the autumn of 1886 a building in Washington vibrated seven or eight times in the space of two seconds, and repeated this performance five times over within two minutes. In each case the first vibration was the largest, and the others steadily diminished to the end. Moreover, the last group was feebler than the first group.

After all that may be said in favor of personal observations (and they certainly are of the highest importance when we try to consider all the features of time and duration, intensity, and direction and the attending noises) still, owing to the fact that observers are generally taken unawares, the Editor must urge those persons, and especially those institutions that can afford to maintain a Weather Bureau seismograph, to contribute thus greatly to our knowledge of this subject. In the annual report of the Chief Signal Officer for 1875, pages 374–377, the Editor submitted a few suggestions as to the observation of earthquakes. Among the apparatus for recording direction the following suggestion may be worth considering: The linear extent of the horizontal movement of the earth may be computed from the movements of several heavy balls of different diameters and moments of inertia rolling or sliding on a perfectly horizontal plane. The plane should be strewn with a fine powder that will serve to mark the path of each ball. The balls should be covered with a very thin layer of some lubricant, such as tallow, to which the powder will stick if the ball should roll. The plane should have a rim and a glass cover to exclude dust and wind. Every detail of the motion of the balls will thus be recorded on their own surfaces and that of the plane. The horizontality of the plane must be determined after the earthquake shock as well as before. The balls must be as truly spherical and homogenous as possible, and, in order to secure different sizes and densities one might, for economy's sake, use the steel balls of the bicycle axles, the best of agate marbles, billiard balls of ivory and the Japanese spheres of quartz crystal. From the recorded movements of these balls one may deduce the direction and force with which they were projected from their original position of rest by the earthquake shock, but the computation, of course, involves a knowledge of dynamics.]

FROSTS IN SOUTHERN CALIFORNIA—THEIR PREDICTION AND PREVENTION.

The following article from the Los Angeles Express of January 4, 1896, presents the valuable results of much experience in that region, and may apply, with slight modifications, to some other portions of the country:

One of the most reliable horticulturists of this section, James Boyd, of Riverside, has laid down some rules bearing on this subject, in the Press, that are interesting, and their correctness is vouched for by years of experience and observation. He states that, as a matter of fact, the thermometer has seldom been known to fall between sunset and sunrise more than 10° in a cold wave, or, say, to make sure, from 7 to 8 o'clock at night to the same hour next morning. For instance, if the thermometer is above 40° at 8 o'clock at night, it need not be expected to fall below 30° before the next sunrise, although sunrise sometimes witnesses a fall of a degree or two for a few minutes, which usually does but little harm.

Again, if the wind blows all night, no matter how cold it feels, it will not freeze to hurt anything in the orchard; but if the north wind blows cold all day and dies down about sundown, with snow on the San Bernardino Mountains, it is well to prepare for the worst. But, again, if the barometer is low there will not come a destructive freeze. All of our injurious frosts have come with an exceedingly high barometer, and, no matter how much it may threaten, the cold is not likely to be excessive. The thermometer may stand for hours below the freezing point without freezing the fruit. If, on cutting the fruit, the juice flows freely it is not damaged. It must not be forgotten that it takes a much greater degree of frost to freeze a mixture of salt and water or sugar and water than of pure water, which fact is what saves the fruit; and green fruit is much more easily damaged than that which is ripe; a fact that is demonstrated every season in our vineyards, where immature grapes will be frozen while ripe fruit will be untouched.

There is one other point that may be laid down as a certainty, and that is, that the thinnest film of haze overcasting the sky will immediately raise the temperature several degrees. It is better not to run water, except when all signs point to a general freeze, for undoubtedly much harm results to the orchard, and also to the fruit, from having the ground saturated for days, or even weeks, at a time, for rain usually follows any cold spell in a few days, and the constant wetting of the soil is very apt to produce puffy fruit later on.

RATE OF ADVANCE OF RIVER FLOODS.

The rate at which river floods advance down the stream must, of course, depend upon the nature of the bed of the stream and the extent to which its banks overflowed. The cross section of the flood of water becomes so large in the lowlands and flats that the forward advance is correspondingly small, and, in fact, every broad piece of overflowed bottom land becomes a pond, temporarily, in which waters may accumulate, and thus diminish the severity of the flood in the lower parts of the stream. Each stream has, therefore, peculiarities of its own and demands a special study. The rates of advance derived from the study of one river can not be applied to another without material multiplication. As, however, detailed studies upon river floods have as yet been made in only a few river valleys, we submit the accompanying report, extracted from the proceedings of the Rochester Academy of Science, as illustrating the class of work that might profitably be repeated by engineers, for the smaller rivers at least, throughout the country. When we know at what rate the small rivers feed the larger ones we shall be better able to study the floods in the latter.

Mr. J. Y. McClintock, surveyor for the city of Rochester, having returned from an examination of the Genesee River in May, 1894, gave an address, of which the following is a summary:

We have lately seen in the Genesee Valley the third greatest flood that has occurred for thirty or forty years. Studies have been made to determine at what rate of speed the height of the flood traveled from Mount Morris to Rochester, and as this flood ran great enough to cover the broad flats it gave a good example. I found that the flood was at its height as follows: Mount Morris, May 21, 3 a. m.; Geneseo, May 21, 12 m.; York, May 22, 9 a. m.; Avon, May 23, 6 a. m.; Rochester, May 23, 2 p. m.

The distances down the general course of the valley are as follows: Mount Morris to Geneseo, 5½ miles; Geneseo to York, 3 miles; York to Avon, 5¼ miles; Avon to Rochester, 18 miles.

This shows that the flood starting from Mount Morris moved at the following speeds: To Geneseo, 0.6 mile per hour; from there to York, 0.14 mile per hour; from there to Avon, 0.21 mile per hour; and from there to Rochester, Court Street dam, 2.25 miles per hour. The total time from Mount Morris to Rochester, 59 hours.

Apparently the velocity increases gradually, although not regularly, depending upon the width of the valley, which is very much narrower below Avon than above, and affords less storage capacity.

From our observations at Rochester we had come to the conclusion that the flow of water during this flood was nearly one-third less than the flow of 1865, when so much damage was done. I was able to verify this conclusion by interviews with old residents at various points along the river. At York the high water of 1865 was about three feet above that of 1894. At Avon it was somewhat over two feet above.

One other important point was as to whether the great flats would furnish storage room for the flood below the surface of its ground to any such extent as is usually assumed. This I was able to learn by ocular demonstration.

The river banks proper are generally quite steep, of clayey soil, from 8 to 12 feet high, and as the level of the river had fallen from 12 to 15 feet within a few days, the ground has not had time to dry out, but was exuding water from its whole surface. This showed that the flats act as a great storage. The importance of this will be shown by Mr. Rafter in his forthcoming report on the proposed storage dam. He will call attention to the fact that the 60 to 80 square miles of flats when soaked with water will hold far more than the great reservoir to be made.

STORM WAVES ON THE GREAT LAKES AND THE OCEAN.

The waves that occur on a body of water are of several kinds and origins. We speak of short waves and long waves when we have in mind those that can be seen in their whole extent from any ordinary point of view. The lengths of such waves, from crest to crest, vary from a few yards to a mile. We speak of a ground swell, or a long swell, when the rise and fall of the water is but a few feet, and takes place so gently that we scarcely see it as a wave on the surface of the water, but either feel it by the motion of the vessel or recognize it by the character of the surf. The small waves due to light winds, or to the interference of two opposing currents of water, are generally known as ripples or rips; there is, however, a still smaller wave known as the capillary ripple, which does not concern us here. Some forms of ocean swell are due to distant storms whose violent waves have, in the