in this circuit, and leading the wire in a north and south direction directly over an ordinary pocket compass. If the lightning-rod enters moist ground, or makes a connection with the earth, the compass should indicate an electrical current by its deflection. Generally it will be found that no such earth-connection exists, and the lightning-rod is therefore worse than useless. It should be immediately connected with the water-pipe, or with a spring, or some body of water. To illustrate the fact that the mere entrance of a metallic rod into the ground is not enough to insure the passage of an electrical discharge to the ground, drive two metallic rods into your lawn, at any suitable distance apart; connect them by a wire, which includes a Leclanché or other voltaic cell; and, having led the wire over a pocket-compass in a north and south direction, see if you obtain a deflection of the needle. If, moreover, you labor under the delusion that a surface-sprinkling of the earth near the rods will give an electrical connection, it is best to perform the experiment. It is probable that several acres of lawn would have to be thoroughly sprinkled before a suitable earth-connection could be obtained. A few experiments with a modern electrical machine—a Toepler-Holtz machine, for instance—will readily convince one of the effect of points in dissipating an electrical charge, and of the fact that an electrical discharge always takes the path of least electrical resistance between two points. Having ascertained these facts, one has acquired all the intellectual capital that is possessed by most lightning-rod men. If one apparently discovers that gilded lightning-conductors, or twisted ones, have peculiar attractions for the electrical discharges, one leaves the sure ground of fact for the region of the unproven. The difficulty in our study of thunder-storms is, that we cannot experiment on a sufficiently large scale, and our means are too tardy to allow us to follow the exceedingly rapid changes of electrified bodies. What we call freaks of lightning are merely the expressions of electrical laws, combined with the laws of elasticity of matter. The forked lightning discharge is an expression of the fact that a positive charge is combining with a negative charge along a path of least resistance; and the air is fractured, so to speak, by the compression, just as a plate of glass yields in zigzag cracks when it is supported on one edge, and a force of compression is applied to the other edge. The influence of the medium through which the electrical discharge takes place can be readily seen by obtaining the electrical discharge in different gases, such as carbonic-acid gas or nitrogen, and comparing these photographs with those taken in free air. Although we can study certain phenomena of atmospheric electricity successfully in our laboratories, yet we cannot charge a cloud with positive electricity, and fill the sky with different strata of hot and cold air. It is generally believed to-day among scientific men, that the electricity of thunder-storms cannot be attributed to sudden evaporation or condensation of moisture; for direct experiment has failed to reveal any electricity which is due to these causes. Mr. Freeman made many delicate experiments in the physical laboratory of Johns Hopkins university to decide the question whether evaporation produces electricity, and he could find no evidence of any that was due to this cause. Herr Kayser has also lately experimented at the physical laboratory of Berlin upon the electrical effects of condensation, with negative results. Personally I feel that all the experiments hitherto conducted on the electricity due to evaporation and to condensation have been conducted on too small a scale to test the question; and I do not see how they can be conducted on a larger scale. When we think of the immense plan upon which these operations are conducted in nature, of the evaporation from every square foot of the ocean, and of the rapid condensation through miles of space, we can realize that an infinitesimal amount of electrical charge, too small to be detected in a laboratory, might be integrated into a large amount, and, becoming localized, might produce the tremendous electrical disturbances which we witness in thunder-storms.

How, then, can we conduct future investigations upon thunder-storms? The most promising direction for scientific work seems to be in the establishment of systematic observations on thunder-storms, and on atmospheric electricity in general, over a large tract of country. In certain regions, thunder-storms follow certain definite paths, and other tracts are never visited by them. There is a general impression that electrical storms are, in common language, attracted by rivers, and are more severe about large bodies of water in general. However this may be, nothing but systematic daily simultaneous observation, long continued, can increase our knowledge. If the government, in connection with the signal-service, should establish a number of electrical stations throughout the west and south, where thunder-storms and tornadoes are so frequent, daily thunder-storm maps might be issued, showing the probable path of the electric disturbances. Perhaps we should then see, in districts peculiarly infested by thunder-storms, certain "insurance-against-danger-by-lightning retreats," in which Benjamin Franklin's lightning-rod should rise from a small hut, completely covered with a net-work of metallic rods which are connected with running water or a large extent of moist earth. The safe retreats would certainly be a great desideratum for many who now suffer greatly from nervous terrors during thunder-storms.—*Science.*

THE SEA HORIZON.

It is amusing to note how ignorant many ordinary seamen and nearly all sea travellers are of such matters as the distance of the sea horizon, the way in which a ship's place at sea is determined, and other such matters—which all seamen might be expected to understand, and most persons of decent education might be expected to have learned something about at school. Ask a sailor how far off a ship may be, which is hull down, and he will give you an opinion based entirely on his knowledge of the ship's probable size, and on the distinctness with which he sees her. This opinion is often pretty near the truth; but it may be preposterously wrong if his idea of the ship's real size is very incorrect, and is sometimes quite wrong even when he knows her size somewhat accurately. Any notion that the distance may be very precisely inferred from the relative postion of the hull and the horizon line seems not to enter the average sailors's head. During my last journey across the Atlantic we had several curious illustrations of this. For instance, on one occasion a steamer was passing at such a distance as to be nearly hull down. From her character it was known that the portion of her hull concealed was about 12 feet in height, while it was equally well known that the eye of an observer standing on the saloon-passengers' deck on the *City of Rome* was about 30 feet above the water-level. A sailor, asked (by way of experiment) how far off the steamer was, answered, "Six or seven miles." "But she is nearly hull down," some one said to him. "I didn't say she warn't, as I knows on," was the quaint but stupid reply. Now, it might be supposed to be a generally known fact that even as seen from the deck of one of the ordinary Atlantic steamers, the horizon is fully six miles away, the height of the eye being about 18 or 20 feet, and that for the concealed portion of the other ship's hull a distance of four or five miles more must be allowed: so that the man's mistake was a gross one. And several other cases of a similar kind occurred during my seven days' journey from Queenstown to New York.

The rules for determining the distances of objects at sea, when the height of the observer's eye and the height of the concealed part of the remote object above the sea-level are both known, are exceeding simple, and should be well known to all. Geometrically, the dip of the sea surface is eight inches for a mile, four times this for two miles, nine times for three miles, and so forth; the amount being obtained by squaring the number of miles and taking so many times eight inches. But, in reality, we are concerned only with the optical depression, which is somewhat less, because the line of sight to the horizon is slightly curved (the concavity of the curve being turned downward). Instead of eight inches for a mile, the optical depression is about six inches at sea, where the real horizon can be observed. But, substituting six inches for eight, the rule is as above given. Six inches being half a foot, we obtain the number of six-inch lengths in the height of an observer's eye by doubling the number of feet in that height; the square root of this number of six-inch lengths gives the number of miles in the distance of the sea horizon. Thus, suppose the eye of the observer to be eighteen feet above the sea level; then we double eighteen, getting thirty-six, the square root of which is 6; hence the horizon lies at a distance of six miles as seen from an elevation of 18 feet. For a height of 30 feet, which is about that of the eye of an observer on the best deck of the *City of Rome*, we double 30, getting 60, the square root of which is 7·7; hence, as seen from that deck the horizon lies at a distance of 7 $\frac{7}{10}$ miles. If the depth of a part of a distant ship's hull below the horizon is known, the distance of that ship *beyond the horizon* is obtained in the same way. Thus, suppose the depth of the part concealed to be 12 feet then we take the square root of twice 12, or 24, giving 4·9, showing that