ballast bear some particular and constant ratio to the motion of this short-period pendulum to keep the balance true. The inertia of a heavy mass will cause some loss of time, as we can only use a limited force for its control; but it is possible to accelerate the phase of motion and overcome this difficulty so far as to get good results.

"If, now, we imagine the ship to roll in still water, the effect of the combination just described will be to balance the ship's stability for a limited angle; but this defect is removed by the introduction of a second pendulum of long period, which tends to move the ballast in the opposite direction to the first one, and enables the apparatus to discriminate between the angular motion of the water and that of the vessel.

"I find, however, that the long-period pendulum is rather a delicate instrument, and that its function can be served by a cataract arranged so as to always slowly return the ballast to the centre, and this device has the effect of accelerating the phase of motion, which, in some cases, we also require.

"We are therefore able, by very simple parts, to construct an apparatus which will indicate the direction and amount of motion necessary to be given to the ballast at a particular time so as to resist the wave effort; this power of indicating may be converted into one of controlling by suitable mechanism. The loss of time due to inertia of the necessary ballast is not always unfavorable when the apparatus has to extinguish rolling motion, the greatest effect being obtained when the ballast crosses the centre line of the ship at a time when it is most inclined to the water surface, and this corresponds to a quarter of the phase behind the motion of the short pendulum."

The apparatus has been working for some time in the steam yacht "Cecile" with very good results. What the objections may be to applying it to the largest passenger steamers remains to be seen. A moving weight of something like 100 or 150 tons would probably be required in such vessels. The power necessary to control the movement of the weight appears to be small, and Mr. Thornycroft's invention seems at any rate to show the way towards obtaining the long-desired boon of substantially reducing, if not checking altogether, the rolling of ships. If it succeed in doing upon a large scale only a portion of what is claimed for it in the way of anticipating and counteracting the heeling effect of waves, without the possibility of acting in an erratic or undesirable way, we may hope to see it adopted some day in passenger steamers.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

A Fire-Ball.

A TELEPHONE wire was supported on cedar posts 20 feet high and 20 rods apart. During last August [1889] we had a thunderstorm, during which there was a sharp and heavy crash. Several of the poles were found to have been struck, and portions to have been taken out through their entire length. One of these portions, of the size of a medium rail, was thrown into an adjoining field some rods from the pole. Portions from the others were smaller and more or less shattered. Near the southernmost pole struck, a family were in a house with doors and windows open, and a luminous ball seemed to leap from the wire, pass through the open door and a window, and pursue its course some rods through the open space behind the house. A boy in the room grasped his thumb and cried out, "I'm struck," and Mr. Hewett felt a sensation of numbness in his left arm for some time. A girl seized her shawl and rushed out of the house to chase the ball. She reported that she pursued it some distance, while it bounded lightly along, until it seemed to be dissipated in the air without an explosion. The size of the ball was about that of the two fists, and its velocity about that of a ball thrown by the hand.

C. C. BAYLEY.

Lightning.

THE account of a stroke of lightning in *Science* for Jan. 29 last and the article in the issue of April 8 on "The New Method of Protecting Buildings from Lightning" call attention to a subject which has been greatly neglected, viz., the nature, characteristics, and effects of lightning strokes. Besides the passage of the electricity from the cloud to the earth, or the reverse, heavy discharges are always accompanied by other phenomena, which vary on different occasions, and which, for want of record and tabulation, have not yet been explained and their laws determined. In the loose accounts given of them in our daily journals they are spoken of as "freaks of lightning," and no further notice is taken of them. In the hope of doing something towards making a careful record, I offer the following, which has never been published.

The village of Amherst, Mass., is supplied with water from a reservoir among the Pelham hills, about five miles distant. The aqueduct runs nearly in a straight line from east to west. The pipes are made of thick sheet-iron bent into tubes, and the overlapping edges are riveted together with copper rivets about two inches apart. They are covered both without and within with a thick coat of cement. The joints are filled with cement so that the irons do not come in contact, an iron ring five or six inches broad is slipped over the joint, and the whole covered with cement. At a place about half a mile west of the reservoir the aqueduct runs near the foot of a steep hill that is seventy or eighty feet high and covered with a recent growth of white pine, shrub oaks, and yellow birch from ten to thirty feet in height, the intervals of the trees being filled with bushes. During a very heavy shower in July, 1884, a thunder-bolt was seen to fall on the hill. It struck a pine tree half-way down the side of the hill, whose top, on a horizontal line, was not more than two rods from the bottom of the trees on the summit. The tree struck was about twenty-five feet high and eight inches in diameter at the butt. The lightning did not apparently strike it on the top, but about one-fourth of its height from the top, at three equidistant points on the circumference the bark began to be ruptured, and the ruptures continued in straight lines to the ground. There the three currents united, ran over the ground, scattering the dirt and leaves in all directions for two rods, until it came over the aqueduct. There it bored a hole an inch in diameter down to the pipes. It struck about the middle of one of the lengths, broke the cement, and indented the iron as with a heavy blow of a sledge-hammer. The surface of the indentation appeared to have been melted. The current then turned to the west, ran along the top of the pipes, which were full of water under heavy pressure, stripped off the cement and slit the iron tubes through the whole, or a part, of their length. When a line of rivets came in its path, it cut them off between the overlapping edges of the iron as smoothly as with a knife, leaving the parts in each edge undisturbed. At the joints it rent off rings and cement, and indented the edge facing the current, melting the surface as in the place where it first struck the pipe. Rarely was the edge from which the current flowed indented. These effects continued for more than a mile, growing less and less, and finally disappeared.

Several questions in this connection require solution.

1. If the discharge is simply the equalizing of the potential between the cloud and the earth, why was that not accomplished as