his eyes in the dark till the next observation. There were twenty-five observers. The result seems worthy of notice.

(1) Of the twenty-five all agree that the colour of the filament is at first very pale. Thirteen call it very pale yellow, three call it white, seven a faint pink, two a bluish white.

(2) All agree that, as the temperature rises, the tint grows deeper and redder, passing through orange *before* reaching crimson. The words used to designate the final tint reached in the experiment vary from deep reddish orange to copper colour, dark red, blood red, crimson.

I may add that some of the observers had had considerable practice in observation, and their eyes were known to be normal so far as the perception of the tints of the visible spectrum is concerned. There is no reason to suppose that more than one, or two at most, possessed any abnormal sense of colour.

Assuming that in the cases of iron and carbon *light of greater frequency of vibration is emitted as the temperature rises, in addition to the light emitted at lower temperatures* (the vibrations causing which are merely increased in *amplitude*), is it not possible (1) that the *selective* power of the pigments of the retina at first scarcely comes into play, the slower vibrations acting on all to a certain extent, on the red more than the green, and the green more than the violet, in the normal eye? or (2) Does not the fact that all colours are more difficult to distinguish in a faint light, *e.g.* moonlight, make it likely that very weak irritation of *any part* of the retina (I mean a part which causes the sensation of light, and that coloured, when the irritation is stronger) is perceived as "light," the indication of specific absorption not being strong enough in comparison with the total amount of irritation to produce the sensation of any special colour in the light perceived? or lastly, if we do not make the above assumption, it would seem that iron and carbon at all events emit, when first visible, light of far wider limits of frequency of vibration than, so far as I know, is generally admitted.

Some photographic experiments which I hope may throw fresh light on the subject have been begun.

Eton College Laboratory, April 4. T. C. PORTER.

Self-Registering Weather-cock.

I SHOULD be grateful if any of your readers would kindly recommend me a simple, inexpensive instrument, to automatically register the movements of a weather-cock above the roof.

Such an appliance must roughly indicate the direction of the wind at the time being.

Some years ago, a London builder put me up a very expensive instrument, which, beyond making considerable noise, was utterly useless. J. LAWRENCE-HAMILTON.

30 Sussex Square, Brighton, April 11.

THE ROLLING OF SHIPS.

ONE fact that often strikes the thoughtful traveller by sea is that, notwithstanding the great and numerous improvements of recent years which have made life on shipboard pleasant and luxurious, little or nothing has been done to steady a vessel when she meets with waves that set her rolling heavily from side to side. The tendency seems to be rather in the direction of increased than of diminished rolling; for the steadying influence of sails, which makes the motion so easy and agreeable in a sailing ship, is fast disappearing in large steamers. Masts and sails add appreciably to the resistance of large fast steamers; so they have been cut down in size year by year till such fragments of sail as still remain are so small compared with the size of the ship as to retain little power to reduce rolling.

Shipowners and seamen do not show much sympathy with the discomfort and misery that rolling causes to most passengers. They perhaps get anxious about an occasional vessel that acquires the evil reputation of being a bad roller, because passengers may be frightened away and the receipts fall off in consequence; but beyond wishing, or attempting, to deal with abnormal cases, nothing seems to be thought of. Rolling is considered incurable, or as not of sufficient importance to trouble about. Yet there is nothing which would contribute so directly to the comfort of landsmen at sea, or do so much to change what is for many misery and torture into comfort, as to check and reduce as far as possible the rolling proclivities of ships.

The laws which govern rolling are now well understood, and it is strange that this knowledge has not enabled an effective means of control to be devised. What is stranger still is that well-known means of mitigating rolling—such as the use of bilge keels—are employed in but very few cases. A ship rolls about a longitudinal axis which is approximately at her centre of gravity, and the rolling is practically isochronous at moderate angles in ordinary ships. The heaviest rolling occurs when the wave-period synchronizes with the natural period of oscillation of the ship. Many vessels are comparatively free from rolling till they meet waves of this period, and if such meeting could be avoided, excessive rolling could be prevented. Some vessels have periods as long as fifteen to eighteen seconds for the double oscillation, and as these would require to meet with waves 1300 to 1500 feet in length, in order to furnish the conditions of synchronism, it is seldom that they suffer from heavy or cumulative rolling. Such waves are, however, not rare in the Atlantic.

The limits of heavy rolling are fixed, of course, by the resistance offered by the water and air to the transverse rotation of the ship, which is very great because of the large areas that directly oppose motion in a transverse direction. But for this resistance, and the condition that rolling is only isochronous within moderate angles of inclination, a few waves of the same period as that of a ship would capsize her.

The two most obvious modes of preventing heavy rolling are, therefore, (1) to make the period of rolling of a ship as long as possible, so as to reduce the chances of meeting waves whose period will synchronize with it, and (2) to increase the resistance to rolling. The period of a ship varies directly as her radius of gyration, and inversely as the square root of her metacentric height. Hence the period may be increased by increasing the moment of inertia of the ship, or by decreasing the metacentric height. In armoured war-vessels the moment of inertia is large, on account of the heavy weights of armour on the sides, and the heavy guns that are either placed at the side or high up above the centre of gravity. Ordinary steamers have no such weights concentrated at great distances from the centre of gravity, and their moments of inertia are determined by the distribution of material in the hull that is fixed by structural conditions and by the stowage required for their voyages. Metacentric height cannot be reduced below a certain amount, which is necessary to prevent too easy inclination of the ship, or crankness, in still water. On the whole, we may regard the longest periods that the largest ships are likely to have with advantage to be about those named above, *i.e.* fifteen to eighteen seconds.

Length of period cannot give immunity against occasional heavy rolling; but increase of resistance reduces the angles of roll at all times, and especially when the angular velocity is greatest and the rolling is worst. Such resistance is furnished by the frictional resistance of the bottom of a ship and by the direct resistance of projecting parts of the bottom, such as the keel and the large flat surfaces below at the stem and stern. This resistance can be largely increased by means of bilge keels. The value of bilge keels is recognized in the Royal Navy, and the ships of the Navy have been fitted with them for many years with highly beneficial results. The advantage of bilge keels was proved beyond all doubt many years ago by careful experiments made in this country and in France; and the late Mr. Wm. Froude showed, by the trials he made of H.M.S. *Greyhound*