fell to 10 dollars. At present the cost of moving merchandise by canal from Buffalo to New York, a distance of 500 miles, does not, on the average, exceed one dollar, or four shillings per ton.

European States are devoting millions of money annually to the construction of canals and canalised rivers, with the result that it costs less to-day to bring sugar from Hungary, thousands of miles across Europe, to London than to carry the same sugar on our own railways from London to Manchester. Goods which can be carried from Hamburg to Berlin, a distance of 174 miles, at four shillings per ton cost eight shillings and fourpence per ton from Manchester to Liverpool, a distance of 30 miles. Cattle can be sent at less cost from Chicago to Liverpool (about 4000 miles) than from Northumberland to Liverpool. It costs more to send one ton of goods from London to the west of Ireland than from London to Japan. Denmark can send her dairy and farm produce to London at less cost for transport than can the English farmer living only 30 miles away in the home counties.

Mr. Levinstein calls for a reform of the patent laws. He attributes, as do many of the witnesses examined by the committee of the Technical Education Board, much of the success of the German manufacturer to the excellent and protective patent laws, which have been in operation since 1876. Yet though our patent laws leave very much to be desired, they do not directly, as Prof. Meldola points out, prevent discovery or originality. Indirectly they may do so, because if a man feels that his invention is not properly protected, he may give up working in disgust. In order that a patent may be valid in Germany, it is necessary that the article patented should be manufactured in Germany. We have no similar provision. It pays an inventor to manufacture in Germany and export to England better than to build extra works here, where British labour would be employed.

Admitting, however, that our patent laws are bad, our manufacturers narrow-minded and unscientific and our business methods lacking in enterprise, and that therefore we are, if not absolutely falling behind, barely holding our own in the markets of the world, we always come back to the fact, if we will but admit it, that all these causes may directly or indirectly be traced to our educational system or want of system.

The report of the Technical Education Board is so valuable that I should like to suggest that the County Council publish a digest of it in pamphlet form and circulate it among manufacturers in London. This may seem a rather large order, but how otherwise are these men, upon whom so much depends, to be reached?

F. MOLLWO PERKIN.

BIRD-PHOTOGRAPHY IN THE GARDEN.[1]

ALTHOUGH he disclaims the title of naturalist and states that he knows nothing of photography, the author has contrived to produce a very entertaining little work, illustrated by reproductions from photographs which we have seldom seen equalled and rarely surpassed. They are, in fact—especially the full-page plates—ideal representations of the birds they portray, and ought to tempt the amateur photographer to try to do likewise—if he can. The object of the volume, like so many others at the present day, is to show the outdoor naturalist and bird-lover how full an insight he can obtain of the life-history and habits of his feathered favourites by portraying them in their natural haunts and surroundings. And with this end in view, he describes in some detail the type of camera and plates best suited for the purpose, and the mode of using them. His main difficulty appears to be to find a "shutter" which shall be sufficiently rapid in action, and at the same time not frighten the bird as it falls.

As the title implies, the author, in place of wandering far afield, has been content with the birds commonly met with in any English country garden, and he shows how much may be learnt that is more or less new even with regard to familiar species. Perhaps he would have been better advised had he refrained from saying that our knowledge of bird-anatomy is such that work is no longer needed in that branch of ornithology. Indeed, it is a great pity that field-naturalists and museum-workers are constantly in the habit of belittling one another's efforts; each has his appointed place, and the work of the one cannot be completed without that of the other.

The author restricts himself to ten species, five of which are tits, and he has something interesting to say about each. If we were asked to select the two best illustrations in a work in which all the pictures are charming, we should choose the page-plates of the pied flycatcher and redbreast. We reproduce one of the text-figures.

FIG. 1.—Robin Pausing at Food. (From "Birds in the Garden.")

R. L.

[1] "Birds in the Garden." By G. Sharp. Pp. xi + 190; illustrated. (London: J. M. Dent and Co., 1902.)

A NEW THEORY OF THE TIDES OF TERRESTRIAL OCEANS.

MR. ROLLIN HARRIS has done so much good work in preparing his "Manual of Tides" for the United States Coast Survey that it is an ungrateful task to find oneself constrained to criticise adversely his recently published part iv. A. of that treatise.[1]

I shall pass over many points of interest which occur in the earlier portions of the book, because the discussion of them is apparently designed to lead up to a new theory of oceanic tides. That theory, to which I shall confine my attention, depends on a proposition that it is possible to dissect our oceans into a number of basins in which the oscillations are virtually independent of one another and are almost unaffected by the diurnal rotation of the earth.

We may, then, pass at once to chapter vi., where Mr. Harris considers forced oscillations in tanks, as impeded by friction. The waves are treated as long waves in which the water in any vertical slice always remains vertical, and the friction is assumed to be proportional to the velocity of the slice. These assumptions are open to criticism, but I will follow Mr. Harris in supposing that

[1] Reports of the U.S. Coast Survey. Parts i., ii., Appendices 8, 9, Report for 1897. Part iii., Appendix 7, Report for 1894. Part iv. A., Appendix 7, Report for 1900.

the physical conditions are adequately represented in this way.

He desires to find a solution when the period of the external disturbing force is the same as that of a free standing oscillation of the type of a seiche in a lake. For a seiche with a single central node the length of the tank must be equal to half the distance traversed by a long wave in the period of the external force. Thus the size of the tank is determined by the period of the external force and by the depth of the water. In the detailed treatment of the problem the depth is supposed to be uniform. Mr. Harris writes his equation of motion in the form of an equation of virtual work; he reverses the forces of inertia, adds them to the impressed forces and equates the virtual work to zero. Lagrange made the displacements arbitrary, and thus his equation of virtual work was exactly equivalent to as many differential equations of motion as there were variables; but Mr. Harris takes the displacements as proportional to the actual displacements per unit time and obtains a single equation. This is permissible, but the result cannot be anything but an equation of energy. I am unable to see any advantage in this procedure. He then assumes that the type of oscillation will be the same as in free oscillations, but this is surely a quite unwarrantable assumption. If the periodic forces have the same period as the free oscillation the oscillations will be large, but the type will in general be different. Does not this error vitiate his whole treatment of the problem? However, let us proceed. The type and period being the same as those of a free oscillation in the absence of friction, the periodic sustaining forces must exactly balance the frictions, and the frictional forces are proportional to the velocities. Now the motion being of the same type as in a free oscillation, the displacements are all simple harmonic functions of the time, and at any instant are all in the same phase. Hence the frictional forces, and therefore also the sustaining forces, are all in a phase differing from that of the displacements by a quarter period. Thus all the sustaining forces vanish at the instant when the displacement is a maximum, and we get nothing out of the equation of virtual work but what was put into it by dubious assumptions.[1]

As a result of this discussion the following rule (p. 621) is given:—

"Project the force arrow" (of a number of tidal-force diagrams giving the direction and magnitude of the forces at various parts of the basin at successive hours) "belonging to the assumed time in each diagram upon the line of motion passing through it; the aggregate of the elementary masses, each multiplied by the intensity of the tidal force in the direction of the displacement, and again by a quantity proportional to the value of the maximum displacement (since the oscillation is harmonic), must be zero at the time of high and low water. The algebraic sum of these products for any given hour should be plotted as an ordinate at that hour. Where the curve thus constructed crosses the time axis denotes the time of high and low water."

Besides the objection to the proposition raised above in the case of the canal of uniform depth with synchronous disturbing force, I fail to see any adequate consideration of the variability of depth, of the absence of synchronism in the component disturbing force in the direction of the canal, or of the effects of the component transverse to the canal.

But even if it were possible to assent to this rule, it appears to me that there are other still more doubtful assumptions. On p. 624 we read:—

"Considering the actual distribution of land and water, a few computations upon hypothetical cases will suffice to convince one that as a rule the ocean tides, as we know them, are so great that they can be produced only by successive actions of the tidal forces upon oscillatory systems, each having, as free period, approximately the period of the forces, and each perfect enough to preserve the general character of its motion during several such periods were the forces to cease their action. This greatly simplifies matters. . . ." Undoubtedly the simplification is great, but is it true?

Then later:—"The paths of the particles being practically fixed and determined by the boundary conditions, it becomes possible to disregard the forces arising from the earth's rotation."

Now Lord Kelvin has concluded that "the oscillations of water in a rotating rectangular trough are not of the simple harmonic type in respect to form, and the problem of finding them remains unsolved" (*Phil. Mag.*, vol. x., 1880, p. 113). He has, however, solved the case of a rotating endless canal with straight sides, and adduces his results as probably dominating some remarkable characteristics of the tides of the English Channel. It seems to follow that either Lord Kelvin or Mr. Harris is wrong.

I gather that the free period of oscillation in the several basins into which the ocean is partitioned is the same as that of the tidal force. Now it is surely profoundly improbable that any large portion of our curiously shaped oceans should possess even approximately the critical free period, yet unless this is so the theory seems to be inapplicable. Finally, I think that the process of partition should receive an elaborate and critical discussion as to each basin; but I do not find that this is given in the book.

I can, in conclusion, only express a hope that I am not doing an injustice to Mr. Harris in dissenting so absolutely from his views. No one would have welcomed more warmly than I a new clue to our treatment of this difficult problem. I venture to express my admiration at the courage of the attempt, and although, as I think, it is a failure, yet it may inspire others to more successful attacks.

G. H. DARWIN.

[1] A considerable portion of this criticism is due to Prof. Love, with whom I have had the advantage of discussing the matter. He points out, further, that Mr. Harris's equation (308), p. 619, which forms the key-note of the whole, is really identically satisfied by the assumptions.

NOTES.

THE hundredth anniversary of the birth of Abel, the great Norwegian geometrician, is on the point of being celebrated at Christiania. Representative men of science from many countries are expected to be present. The interest which His Majesty King Oscar II. has manifested in this centenary celebration is another proof of his continued sympathy with mathematical work and scientific research generally. It is announced that the Paris Academy of Sciences will be represented by M. Darboux and the Paris University by M. Émile Picard.

IT is announced in *Science* that at a recent meeting of the corporation of the Marine Biological Laboratory at Woods Holl it was voted to transfer the Laboratory and its equipment to the Carnegie Institution. This action was taken after it had been stated to the members of the corporation that the executive committee of the Carnegie Institution would recommend to the trustees that the Laboratory should be accepted, that its debts should be paid, that new buildings should be erected, that 20,000 dollars a year should be allowed for maintenance and that the scientific management should rest as heretofore with the naturalists of the United States.

THE Cape Town correspondent of the *Times* states that great interest is being manifested there in the suggested visit of the British Association in 1905. As a preliminary measure, free passes on all the South African railways are promised for the