

tration of a pipe was used with the endeavour to aid the conceptions in some respects, rather than for rigid accuracy of comparison. The idea of the exterior fluid being *at rest* was subsequently guarded against by stating that it had "important functions" to perform. In regard to the fact of only mentioning "friction" as an element of resistance in a totally immersed body, I wished rather to convey the general idea that if no energy were given to the molecules of the surrounding liquid at the passage of the immersed body, there would be no "resistance." The object of the article was, however, not so much to lay stress on these points as to notice certain, perhaps less appreciated (*à priori*), aspects of the problem.

S. TOLVER PRESTON

Songs of Birds

YOUR correspondent "A. N." (*ante*, p. 97) does not seem to be aware that the best observers are nowadays agreed in believing that the hen cuckoo does not sing. Hence his suggestion in regard to the difference of note observed by Mr. Birmingham (*ante*, p. 76) hardly applies to the case in question.

ALFRED NEWTON

Magdalene College, Cambridge, June 6

I HAVE been in the habit of observing the notes of cuckoos, and have noticed that the musical interval is very variable. It is not always, or even often, amenable to our tempered scale, but may lie anywhere between a major 2nd and a 4th. The major 3rd seems to be about as frequent as the minor. The interval may vary in the same bird, as it is well known that the cuckoo's song alters greatly with the approach of summer.

FRANK J. ALLEN

St. John's College, Cambridge, June 6

Cup-marked Stones

ON a large block of fine-grained hard whitish sandstone near Burghead, Elgin, are forty-four cup-marks of various sizes, but all very finely formed. Four of the cups have channels or grooves of various lengths and running in different directions, but none to the edge of the stone. Five have one ring, and channels of various lengths, and in different directions. Four have got two rings and channels, and one has three rings and a channel. In some cases the rings are not complete, that is, they stop short on either side of the channel, but close to it. One cup has a simple ring.

From this example, and if I recollect the figures in Sir J. Y. Simpson's work, there seems to be but few cases in which the channels run to the edge of the stone.

Out of a considerable number of cup-marked stones partly on finely ice-polished rock surfaces and partly on detached blocks large and small, in Elginshire, this is the only one that has rings and grooves. A full description of these, with plans, I have nearly ready to lay before the Society of Antiquaries at one of their early meetings of next session.

JAMES LINN

Keith, June 2

THE DUMAS NUMBER.—In reply to numerous inquiries we may state that the portrait of M. Dumas should form the frontispiece to vol. xxi., and the article by Dr. Hofmann be placed after the index in the beginning of the volume.

ENERGY AND FORCE¹

[ON March 28, 1873, Clifford delivered a Friday evening discourse on this subject at the Royal Institution. By some accident no trace of it, not even the date or title, appears in the printed *Proceedings*. Thus the lecture escaped notice when Clifford's literary and scientific remains were collected in the summer of last year. A few weeks ago I lighted on my own rough notes of it taken down at the time, probably the only record now in existence. These I have written out, with only so much alteration and addition (indicated by square brackets) as necessary to make them intelligible. The

¹ An unpublished discourse by the late Prof. Clifford. With an introductory note by J. F. Moulton.

paper thus produced has been seen by Clifford's friend and mine, Mr. J. F. Moulton, who (besides his general competence in mathematical physics) was thoroughly acquainted with Clifford's mathematical work and ideas. Mr. Moulton has added, by way of introduction, some remarks founded on this intimate knowledge, which will explain the aims of the discourse and supplement the too meagre report which is all that I am able to reconstruct from my notes.—F. POLLOCK.]

This lecture was, I think, written as a protest against certain loose ideas that had become prevalent relating to energy, motion, and force. The discoveries as to the equivalence of the many forms of energy and the invariability of the total of energy in any system not operated on by external forces (one case of which is the whole material universe), had led philosophical writers and others to treat force as an entity with a separate existence like matter, and also, like it, indestructible. The error of thus treating force as an entity with a separate existence was not an unnatural one in those who had not much acquaintance with the theories of physics. No idea is more consonant with the ordinary modes of thought than that force is a something operating from without on a body, and producing effects thereupon in the shape of an alteration of its motion, so that the quasi-personification of force contained in the above does not appear to be in any way an unwarranted conception. The further step, which ascribes to force an indestructibility as absolute as that of matter, is due to a confusion in the terms used by mathematicians themselves in speaking of these subjects, for which they are to blame. Before the conservation of energy was fully formulated, mathematicians were acquainted with a particular case of the general principle, and it had received the name of conservation of force. This unfortunate appellation, with all its misleading tendencies, was often applied to the general principle when the latter first became known, and hence unscientific writers naturally assumed that force and energy were convertible terms and that they were alike indestructible. These erroneous conceptions had attracted Prof. Clifford's attention, and with his usual zeal for preserving scientific ideas from all taint, he set about correcting them. His mode of doing so is highly characteristic. He strikes straight at the root of the matter, and would have us at once cease to think of force as an entity at all. Indeed he goes so far as almost to warn us against tolerating the conception of a cause as distinguished from its effects.

All we know as to force and motion, he says, is that a certain arrangement of surrounding bodies produces a certain alteration in the motion of a body. It has been usual to say that this arrangement of surrounding bodies produces a certain force, and that it is the action of this force that produces the alteration of the motion. Why have this intermediate term at all? Why should we not go at once from the surrounding circumstances to the alteration of motion which follows? The intermediate term is only a mental inference either from the existence of the surrounding circumstances or from the occurrence of the alteration in the motion; and if we only accustom ourselves to pass from one to the other without its assistance, it will cease to be necessary, and like other useless mental conceptions, be gradually forgotten. And with it will pass all tendency to give to this useless mental phantom any such real and material qualities as indestructibility.

I was not present when the lecture was given, nor do I know otherwise than from these notes how Prof. Clifford carried out these ideas. But in conversation he had often discussed the matter with me, and made me fully acquainted with his views on the subject, so that I am able thus far to confirm the accuracy and completeness of these notes. It will be seen that he defines force as