

principle as applied in acoustics, we find four cases: (1) approach of observer, source and medium being at rest; (2) recession of observer, source and medium at rest; (3) approach of source, observer and medium at rest; (4) recession of source, observer and medium at rest.

I have consulted all the standard authorities which have occurred to me, and find they all agree in the 1st and 2nd cases. In (3), Doppler, Lord Rayleigh, Prof. Everett (1st method in "Deschanel"), Jamin, and Ganot have the same result as in (1). Lord Rayleigh in his "Theory of Sound," vol. ii. p. 142, says, "In the case of a periodic disturbance a velocity of approach v is equivalent to an increase of frequency in the ratio $a : a + v$," a being the velocity of sound. In another place the same author says that it is the *relative* velocity of source and observer alone that is important. The above-mentioned authorities appear to hold the same views.

But Prof. Everett has a more rigorous demonstration than the above, which leads to the result—old pitch : new pitch :: $a - v : a$. This result is the same as that given by Mach, "Ton u. Färberänderung durch Bewegung" (1874), and as that used by Balfour Stewart, "Treatise on Heat."

In the 4th case the first-mentioned authors again agree, giving as a result—new pitch : old pitch :: $a : a - v$. Prof. Everett's and E. Mach's results agree in giving $a + v : a$ as the ratio.

It will be readily admitted that the first two cases are simpler problems to attack than the last two. The results of the minority for the cases (3) and (4) seem to me to come from looking at the change in wave-length first, those of the majority from taking into account the number of waves met by the observer. In any case the disagreement among such authorities is naturally beyond me to explain. The motion of the medium does not appear to offer any special difficulty.

G. H. WYATT.

The Relative Prevalence of North-east and South-west Winds.

THE direction of the wind has been noted twice daily at this Observatory (9 a.m. and 9 p.m.) during the past 6 years, with the following mean results:—

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
56	48	30	25	23	65	45	60	13

The period under consideration is not sufficiently long to make the series of observations of any great value, but as Mr. Ellis asks for comparisons, I am happy to give them for what they are worth.

C. E. PEEK.

Rousdon Observatory, Lyme Regis, April 26.

The London Mathematical Society's List of Papers.

IN NATURE (vol. xli. p. 594) it is stated that "a complete index of the papers printed in the Proceedings of the London Mathematical Society has been issued." It will be in the recollection of some that a previous issue of the Index to the papers contained in the first 17 volumes was announced in NATURE (vol. xxxvi. p. 42): it is a re-issue of this list completed for the first 20 volumes that is now noted. The former edition of 3000 copies was soon dispersed, and resulted in warm expressions of thanks from mathematicians, and also in an increased sale of the Proceedings. If other Societies would, in like manner, issue lists of the titles of papers printed in their Proceedings, they would no doubt meet with a like reward. All mathematicians, and others who are interested in mathematical research, can have a copy on application to the Secretaries (22 Albemarle Street, W.), or to the publisher (Francis Hodgson, 89 Farringdon Street, E.C.).

April 26.

R. TUCKER, Hon. Sec.

THE UNITED STATES SCIENTIFIC EXPEDITION TO WEST AFRICA, 1839.

AS the work of the Expedition approaches conclusion, I venture to hope that a brief partial recital of results may be worth notice in NATURE, particularly as, in many of the ports we have visited, English courtesy

and English hospitality have contributed in large measure to the facilities for prosecuting our work, not to say also very greatly to the delight of doing it.

I find it a trifle difficult to say just where to begin, but Dr. David Gill, H.M. Astronomer at the Cape, comes first to mind, and surely no one could have devoted himself more unsparingly to the interests of the Expedition than he did during our stay of a fortnight and more at Cape Town: and through his liberal provision for every requirement of the observers, it became possible to swing the pendulums in the Royal Observatory buildings, the same spot occupied in previous gravity-research at the Cape. Had it been expedient to delay the *Pensacola* longer, Dr. Gill's suggestion would gladly have been acted upon, and an additional gravity-determination made at the Kimberley diamond fields, 650 miles in the interior, at an elevation of about 4000 feet; but there was time only for members of the Expedition not engaged in exact measures to proceed as far inland as that; and the movements and operations of the naturalists and others who desired to visit the Cape Colony country as far as Kimberley became feasible through the kind offers of Mr. Difford, the Secretary of the Colonial Government Railways.

Nor only at Cape Town had we much occasion to thank His Excellency Sir H. B. Lock, the Governor of the Colony, but two months later, at Ascension Island, through his courteous intervention, and the obliging civilities of Admiral Wells, R.N., all possible preparation had been made; while, on our arrival, Captain Napier, R.N., in charge of Ascension, most thoughtfully smoothed the way by arranging to our entire satisfaction all matters which could in any way facilitate the work we had planned for that interesting island.

Nor am I forgetting the multitude of courtesies at the hands of Governor Antrobus of St. Helena, where all desired assistance was afforded, and where work similar to that at Ascension was undertaken and completed.

In this connection, I must not omit mention of the American Navy, for neither the Expedition in its present form nor its work could have become an accomplished fact but for the enlightened policy of Secretary Tracy, who assigned a man-of-war for its transport to Africa and home again; of Admiral Walker, and later, Commodore Dewey, Chiefs of Naval Bureaux, who devoted their energies ungrudgingly to the regulation of all matters official affecting the welfare of the Expedition; and of Captain Yates, the commander of the U.S.S. *Pensacola*, who has done everything in his power to forward the prosecution of the scientific work.

The *Pensacola* left New York on October 16 last; called at the ports of Horta, Fayal, Azores, November 2-3; San Vicente, Cape Verdes, November 10-12; St. George's Parish, Sierra Leone, November 18-20; Elmina, Gold Coast, November 26-28; São Paulo di Loanda, December 6-7; Eclipse Bay, Cape Ledo, December 8-27; again at Loanda, December 28-January 6; Cape Town, January 17-February 6; St. Helena, February 20-March 10; and arrived at Ascension six days later, which port she will probably leave about April 10.

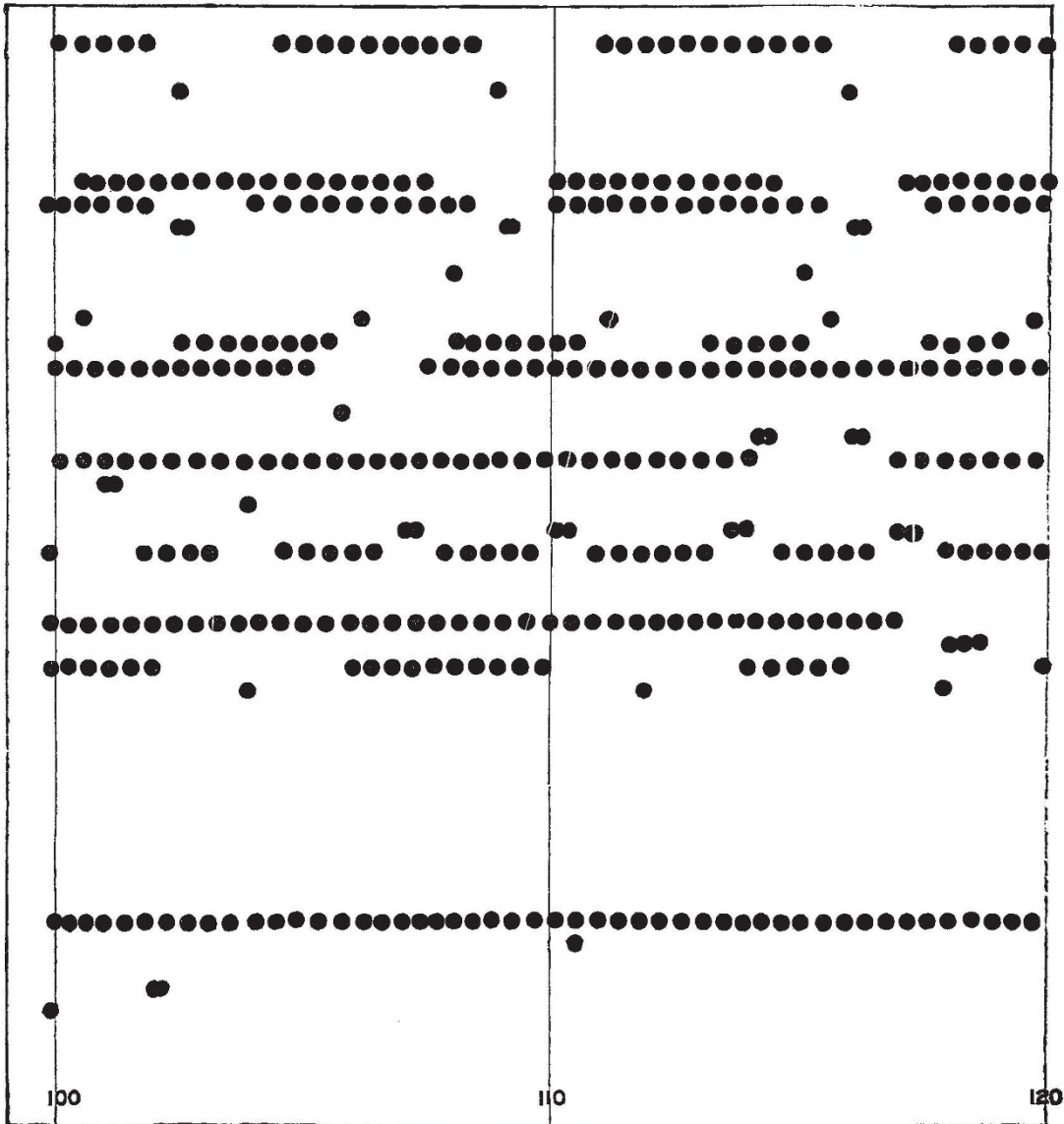
Now to some of the results.

At all these stations except Cape Ledo, the magnetic elements have been carefully investigated by Mr. Preston, of the U.S. Coast and Geodetic Survey. Also he had an additional magnetic station at Cabiri, about 45 miles interior from Loanda, whither he went for the immediate eclipse period.

The short time available before the eclipse made it impracticable to begin the gravity-determinations until Loanda; there Mr. Preston swung the Peirce pendulums, and again at the Royal Observatory, Cape Town. At St. Helena two complete swings were obtained, the one at a sea-level station near the Castle, Jamestown, and the other at Longwood, elevation 1750 feet. It was not

thought practicable to re-occupy Foster's station at Lemon Valley. Here at Ascension the sea-level station at Garrison is already complete; and, as I write, Mr. Preston and Prof. Bigelow are taking quarters near the summit of Green Mountain for the second station, near the spot occupied by Foster sixty years ago, elevation between two and three thousand feet. Auxiliary magnetic work is undertaken at both these upper-level island stations. Between Ascension and New York but one

prolonged stop is at present contemplated—at Bridgetown, Barbados—where magnetics will be done, and gravity-work, if practicable. Also, Bermudas may be included, but that is perhaps unlikely. In addition to the bearing of this work on terrestrial physics and geologic theories, it is worthy of note, in passing, that all these stations, including Washington, where swings are made both before the departure of the Expedition and after its return, lie within a narrow great-circle belt, which can at



Control-sheet of the Pneumatic Commutator Between the 100th and 120th seconds of Totality.

any time be continued on through the United States and Canadas and Alaska, forming an extraordinary stretch of gravimetric survey.

Regarding the eclipse and the stay of the astronomers at Cape Ledo, it has to be said, to our great regret, that the direct photo-heliograph of 40 feet focal length was the only instrument with which eclipse-records could be secured. These were photographs of the partial phases, over 100 in number, obtained between clouds. The instrument was built under the immediate supervision of

Prof. Bigelow, and has, among other peculiarities, a skeleton tripod-mounting which will be fully figured in the definitive report of the Expedition. It has been proven practicable to dispense with the heliostat mirror, always the weak point in the horizontal photo-heliograph; and to manipulate readily a camera long enough to produce a 4½-inch solar image direct: and this, too, by means of a mounting easy to transport and to set in position. The photographs were taken in groups of ten, on circular plates of 22 inches diameter. The apparatus auxiliary

to these rotating plates made the whole automatic, the driving power being compressed air under electric control. A form of sand-clock was found most efficient for counteracting the diurnal motion.

For the total phase our preparations were even more elaborate. What I attempted was nothing short of the complete automatic operation of all the photographic instruments, whether photometers, spectroscopes, cameras, or polariscopes. Over a score of these instruments were securely adjusted upon an immense polar axis, split, and mounted on the English plan. Powerful clock-work with a Repsold governor carried the whole with great accuracy. All such mechanical movements were specially invented and constructed as were necessary to work the exposing-shutters, to change exposed plates for fresh ones, and to perform all other operations, as rotating Nicols, varying apertures of objectives, trailing plates, and the like. Each movement, of whatever sort, took place as a result of the thrust of a small, collapsible, pneumatic bellows. The precise instants of collapse of these bellows were controlled through the intervention of the Gally pneumatic valve, a most ingenious device whereby any required number of very small air-currents (exhaust) are made to control the motion of an equal number of large air-currents (also exhaust). This principle has been very successfully employed in the automatic playing of musical instruments; and anyone familiar with the modern forms of these, in which a perforated paper sheet takes the place of the music, will readily comprehend how the whole thing was done. In the pneumatic commutator actually used at the African station forty-eight half-inch currents were under absolute control of a small paper sheet, about nine inches wide, suitably perforated, and unwinding at an invariable rate from a chronograph barrel. Thence it passed over the series of minute apertures through which flowed the lesser exhaust-currents, each of which controlled the action of its own valve, and consequently of its appropriate large exhaust-current, through suitable pipes leading to the individual pneumatic bellows. A portion of the commutator-sheet is represented in the illustration.

I do not need to specify here the detail of astronomical apparatus which this pneumatic commutator operated; but in the collection of totality-instruments were two 8-inch silver-on-glass mirrors, four spectroscopes, and a variety of objectives for a variety of purposes, ranging all the way from a $\frac{3}{4}$ -inch aperture in one of the polariscopes to the Harvard 8-inch doublet of 13 feet focal length. The whole number of plates, or separate exposures, was in excess of 300, totality being 190 seconds in duration; and when once started, the whole affair looked out for itself absolutely, so long as the necessary power was supplied at the main exhaust-bellows.

But totality was completely clouded under; and instead of a fine accumulation of photographic data, I have only the gratification of having shown it to be practicable in the future for one eclipse observer to operate an indefinite amount of photographic apparatus quite as readily as, and with greater certainty than, he would have attended to only two or three cameras by hand heretofore. In converging all this apparatus toward readiness for eclipse-day, I had of course much valued assistance, which will be fully acknowledged elsewhere; and I need only mention here Prof. Bigelow, Mr. Davis, and Mr. Van Guysling, who were specially helpful in devising required movements and practically constructing them.

The totality-area in West Africa appears to have been unusually overcast. Auxiliary observers at Cabiri had clouds; at Cunga, clouds; at Dondo, clouds; while at Cazengo, Oeiras, Muxima, Kakulu, and Bom-Jesus it was cloudy too. Also, about 15 miles out at sea, in the path of central eclipse, whither the *Pensacola* had gone in the hope of additional results, the sky-conditions were perhaps slightly better, but still so bad that it is doubtful whether the true corona was seen at all.

Let I weary anyone who may be reading this with too long a statement of our work, I omit here all account of the natural history of the Expedition, only saying for the present that Messrs. Brown, sent out by the U.S. National Museum, have been actively engaged in collecting at all the ports made by the *Pensacola*, and their materials will, I dare say, be competently discussed on the return of the Expedition. More about this later. At Ascension, opportunity for trawling is now for the first time available, and so far with fair success. While the main eclipse party was established at Cape Ledo, naturalists and anthropologists were in the interior about three weeks, at Cunga and at Dondo, His Excellency the Governor of Loanda, and the Directors of the Caminho de Ferro Trans-Africano, having courteously afforded them every facility for the prosecution of their work there. Physical measurements were taken among the Umbundus, Cabindas, Bailundas, Quissamas, and others; collections of folk-lore, fetishes, and mind-products made; and general information gathered concerning a variety of subjects indicated in the manual of the Anthropological Society of Great Britain. On reaching the Cape, both naturalist and anthropologist found the outlook so promising that they applied for discharge from the Expedition there, in order to continue their work in the Cape peninsula. The opportunities were indeed rare: a great exploring Expedition was about organizing, under the auspices of the English Syndicate, to which the King of the Matabele has granted unusual privileges and concessions, in a region for the most part untravelled by white men, and represented as very rich in material for natural history and other research. The Expedition is particularly indebted to the Rev. G. H. R. Fisk, of Cape Town, for a very valuable collection of tortoises, embracing *Testudo pardalis*, *T. angulata*, *T. trimeni*, and *T. tentoria*; *Homopus areolatus*, *H. femoralis*, and *H. signatus*, the representatives of these latter forming a perfect series of the South African *Homopus*.

The progress of M. Heli Chatelain's researches in the West African tongues is gratifying, and bids fair to constitute a valuable section of the work of the Expedition. He remains in Angola for some months yet, to gather linguistic material for various works he has in hand—among them his "Grundzüge des Ki-mbundu," in which the elements of this language are compared with those of Kixi-kongo, Luba, Lunda, N-mbundu, Oshi-ndonga, and Otyi-herero. The results will enable one to form an idea of the mutual relations of the languages of Central West Africa.

I may say here that Prof. Bigelow, in addition to assisting in the pendulum-work at St. Helena and Ascension, has been diligently engaged upon theoretic researches on the corona and terrestrial magnetism, the beginnings of which are outlined in his paper already published by the Smithsonian Institution. As yet he inclines to speak of this work with much reserve; but if the key to the solution of these complex phenomena has not actually been found, it surely looks strongly that way. By Dr. Gill's kindness, the resources of the excellent library of the Cape Observatory were freely and gladly drawn upon in this work.

Of the Bulletins, or preliminary publications of the Expedition, thirteen are already issued—one each relating to general matters, to terrestrial physics, to philology, and to localities of scientific interest in St. Helena; two to meteorology and to natural history; and five to the total eclipse.

I reserve for another occasion all account of the important researches which Prof. Cleveland Abbe, Meteorologist of the Expedition, has been sedulously prosecuting for the past five months and over, with improved means, and under rare conditions at sea and on land.

DAVID P. TODD.

U.S.S. *Pensacola*, Ascension, March 27.