such as might be anticipated. As an illustration of this I will take the Californian earthquake of April 18. This originated along lines of great length on the western side of that country. The reflecting surface I take to be the Sierras, 200 miles distant. A wave group would travel to the Sierras and back in about four minutes, and this is approximately the time interval between the two first large wave groups in the few seismograms I have of that disturbance.

In offering these suggestions I concur with Dr. Farr that very frequently terminal vibrations of an earthquake present characteristics suggestive of interference effects, but it is premature to suppose that all the peculiarities of a seismogram are to be explained in the same manner. Rhythmical beats at an origin may result in rhythmical beats at a distance.

JOHN MILNE.

Shide, Isle of Wight, September 5.

Remarkable Rainbow Phenomena.

On Monday, September 3, a very heavy thunder-shower passed from west to east over the parish of Deerness, Orkney, from 5.30 p.m. to 6.25 p.m. When the dark nimbus cloud to the west had lifted its pall, the sun came out in great brilliancy. A rainbow now began to form to the north-east, but instead of the ordinary bow there was one of a bifurcated nature. Two stumps which coalesced on the horizon gradually developed into two magnificent bows, which met on both horizons, viz. north-east and south-west, but were about five or six degrees apart at the apex. All the colours of a radiant bow were present in both, and both had the colours arranged in the order of the primary bow. The secondary bow also appeared with the colours reversed and the same bifurcation, but in this case it extended only to about thirty or thirty-five degrees above the horizon, as secondaries generally do. As I had never seen or heard of anything like this, my first impulse was to find a cause. When the double rainbows were at their best, there was a bar of stratus cloud extending across the middle of the sun, and in breadth about one-sixth of its diameter. The two primary bows remained complete from 6.30 p.m. to 6.35 p.m., and without the arc of the apex for about another five minutes.

At first the bow to the south was the more complete, and finally the one to the north. However, after the sun had crept from behind the bar of cloud there were still double stumps clearly visible. If the cause here attributed be correct, then the only explanation of the bifurcated rainbow being visible after the cloud passed is, that from the points of the heavens where the rainbows were the bar might still be dividing the sun's rays. Nothing in my meteorological books indicated that this phenomenon had been previously seen. On inquiring as to what others had seen after the thunder-shower, two friends, one five miles and the other three miles almost directly west of me, saw only a perfect bow and its secondary. Others nearer the position I occupied saw what they called four rainbows, but had observed neither the coloration nor bifurcation clearly enough for descriptive purposes.

M. SPENCE.

Deerness, Orkney.

The Mixed Transformation of Lagrange's Equations.

MR. A. B. BASSET, in a letter to NATURE of August 2, states that the theory of the mixed transformation was first given by himself in 1887, and refers to his treatise on "Hydrodynamics," vol. i., p. 171. If he will kindly look at my essay for the Adam's prize, pp. 61-4, he will find an elimination similar to that which he speaks of. The resulting modified functions appear to agree term for term. There is also the introduction of a "modified function" by which we can use Lagrange's equations for some of the coordinates and Hamilton's equations for the others. That essay dates from December, 1876, and was published in August, 1877. The method was afterwards explained without much change in all the editions of my "Rigid Dynamics" which follow that date, beginning with the fourth edition, 1882.

E. J. ROUTH.

September 14.

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THE RECENT CONTROVERSY ON RADIUM.

THE recent correspondence on the subject of radium, started in the *Times* by Lord Kelvin, has, after lasting nearly a month and causing widespread interest, apparently closed without any very definite conclusion being reached. Whatever opinion may be formed of the merits of the controversy, all must unite in admiration for the boldness with which Lord Kelvin initiated his campaign, and the intellectual keenness with which he conducted, almost single-handed, what appeared to many from the first almost a forlorn hope against the transmutational and evolutionary doctrines framed to account for the properties of radium. The weight of years and the almost unanimous opinion of his younger colleagues against him have not deterred him from leading a lost cause, if not to a victorious termination, at least to one from which no one will grudge him the honours of war. If peace and tranquillity now result, and a measure of agreement is arrived at between conflicting views, it will be a result which all concerned will heartily welcome. The most ardent believer in the truth of the new doctrines cannot be other than satisfied that every feature and assumption that is admittedly speculative should be clearly recognised as such and separated from that which is not, if thereby the experimental foundations of the science of radio-activity are freed from further wordy and unprofitable controversy. There seems now to be a reasonable prospect that this has been secured.

Lord Kelvin's opening challenge (August 9) was broad and sweeping. He took exception to the statement, made by the writer in opening the discussion on the evolution of the elements at the British Association at York, that the production of helium from radium has established the fact of the gradual evolution of one element into others, and denied that this discovery affected the atomic doctrine any more than the original discovery of helium in cleveite. The obvious conclusion was that both cleveite and radium contained helium. He also stated that there was no experimental foundation for the hypothesis that the heat of the sun was due to radium, and ascribed it to gravitation.

The challenge was taken up on the other side successively by Sir Oliver Lodge, the Hon. Mr. Strutt, and other well-known authorities, and it soon became apparent that for argument at least Lord Kelvin on his side had to rely practically on himself alone. Prof. Armstrong, it is true, immediately enrolled under Lord Kelvin's banner, and entered the lists with an embracing criticism of physicists in general, whom, he declared, are strangely innocent workers under the all-potent influence of formula and fashion. He made the statement that no one had handled radium in such quantity or in such manner that we can say precisely what it is, and throughout put the word *radium* in inverted commas.

Whether or no his opponents are all as innocent and ignorant as Prof. Armstrong imagines, the fact remains that, except for this *ex cathedra* utterance and a leading article, argument against the accepted view there was little or none except that contributed by Lord Kelvin himself. Prof. Armstrong's letter merely served to provide Sir Oliver Lodge with justification for his favourite theme, which appears to be that whereas chemists have an instinct of their own for arriving at their results, reason is the monopoly of the physicist, whose results the chemist usually manages to absorb in the end. No better argument against the unfairness of this could be provided than by the history of radio-activity itself, which