

free path of their molecules. When pressure is lowered these gases appear to conduct less well than the diatomic gases; and it may be that their molecular constitution is less affected, if affected at all, by diminution of pressure.

The behaviour of mixtures of argon and helium at low pressures is somewhat inscrutable. Why should argon convey current almost to the exclusion of helium, if, indeed, visibility of its spectrum be taken as an indication of conductivity? In this respect argon rather resembles the diatomic gases.

It may be objected that, in making such observations, one consideration has been neglected. It is the nature of the electrodes. This may indeed play a not unimportant part in the phenomena. It is unquestionable that hydrogen and helium are both absorbed by platinum, and it would appear that nitrogen, too, can be made to combine, for it is removed from a vacuum tube containing it, if the platinum is "splashed" on to the walls. But the experiments on mixtures of gases were performed in vacuum tubes without electrodes, and the influence of the electrodes comes in only with experiments on gases at atmospheric pressure, and in those in which pressure was reduced. Their pressure may, however, conduce to some kind of polarising influence, and the conclusions, such as they are, may be vitiated by neglecting this factor.

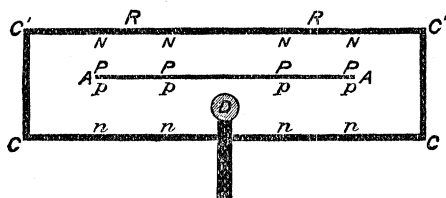
We trust that these somewhat rash speculations will be forgiven; the subject is a difficult one, and we have carried out the experiments more with the view of obtaining practical help in recognising the purity of argon and helium than of carrying out a research on the relative conductivities of gases. There is evidently a wide field for research, and we shall be glad if this description of our methods of manipulation and of the somewhat meagre results which we have obtained may induce others, better qualified than we, to make similar investigations.

## II. "On the Generation of Longitudinal Waves in Ether."

By LORD KELVIN, F.R.S. Received February 10, 1896.

In a short note published in last week's 'Nature,' of which a copy is appended, I suggested an arrangement of four insulated and electrified spherical conductors with their centres in one line, giving rise to ethereal waves in the surrounding atmosphere, of which the disturbance in the line of centres is essentially longitudinal. But at any finite distance from this line there must also be laminar or distortional waves of the kind expressed in Maxwell's equations. The object of my present communication is to show an arrangement by which a large space of air is traversed by pressural disturbance, or by waves essentially longitudinal, or by condensational-rarefactional

vibrations; with but a very small proportion, practically evanescent, of laminar waves.



Let *AA* be a plane circular metal plate insulated within a metal case *CCC'C'*, as indicated in the drawing. Let *D* be a discharger which can be pushed in so as to make contact with *A*.

Let *A* be charged to begin with, positively for instance as indicated by the letters *PPpp*; *NNnn* showing negative electricity induced by it. Let now the discharger be pushed in till a spark passes. The result, as regards the space between *AA* and the roof *RR* over it, will be either an instantaneous transmission of commencement of diminution of electrostatic force, or a set of electric waves of almost purely longitudinal displacement, according as ether is incompressible or compressible.

Hence, if the theory of longitudinal waves, suggested by Röntgen as the explanation of his discovery (for the consideration of which he has given strong reasons), be true, it would seem probable that a sensitive photographic plate in the space between *AA* and *RR* should be acted on, as sensitive plates are, by Röntgen rays. Either a Wimshurst electrical machine or an induction-coil, adapted to keep incessantly charging *AA* with great rapidity so as to cause an exceedingly rapid succession of sparks between *D* and *A*, might give a practical result. In trying for it, the light of the sparks at *D* must be carefully screened to prevent general illumination of the interior of the case and ordinary photographic action on the sensitive plate.

The arrangement may be varied by making the roof of sheet aluminium, perhaps about a millimetre thick, and placing the sensitive photographic plate, or phosphorescent substance, on the outside of this roof, or in any convenient position above it. When a photographic plate is used there must of course, be an outer cover of metal or of wood, to shut out all ordinary light from above. This arrangement will allow the spark gap at *D* to be made wider and wider, until in preference the sparks pass between *AA* and the aluminium roof above it. The transparency of the aluminium for Röntgen light will allow the photographic plate to be marked, if enough of this kind of light is produced in the space between the roof and *AA*, whether with or without sparks.

The new photography has hitherto, so far as generally known, been performed only by light obtained from electric action in vacuum; but

that vacuum is not essential for the generation of the Röntgen light might seem to be demonstrated by an experiment by Lord Blythswood, which he described at a meeting of the Glasgow Philosophical Society last Wednesday (February 5). As a result he exhibited a glass photographic dry plate with splendidly clear marking which had been produced on it when placed inside its dark slide, wrapped round many times in black velvet cloth, and held in front of the space between the main electrodes of his powerful Wimshurst electrical machine, but not in the direct line of the discharge. He also exhibited photographic results obtained from the same arrangement with only the difference that the dark slide, wrapped in black velvet, was held in the direct line of the discharge. In this case the photographic result was due, perhaps wholly, and certainly in part, to electric sparks or brushes inside the enclosing box, which was, as usual, made of mahogany with metal hinges and interior metal mountings. It is not improbable that the results of the first experiments described by Lord Blythswood may also be wholly due to sparking within the wooden case. I have suggested to him to repeat his experiments with a thoroughly well closed aluminium box, instead of the ordinary photographic dark slide which he used, and without any black cloth wrapped round outside. The complete metallic enclosure will be a perfect guarantee against any sparks or brushes inside.

If the arrangement which I now suggest, with no sparks or brushes between AA and the roof, gives a satisfactory photographic result, or if it shows a visible glow on phosphorescent material placed anywhere in the space between AA and the roof above it, or above the aluminium roof, it would prove the truth of Röntgen's hypothesis. But failure to obtain any such results would not disprove this hypothesis. The electric action, even with the place of the spark so close to the field of the action sought for as it is at D, in the suggested arrangement, may not be sudden enough or violent enough to produce enough of longitudinal waves, or of condensational-rarefactional vibrations, to act sensibly on a photographic plate, or to produce a visible glow on a phosphorescent substance.

(Extract from 'Nature,' referred to above.)

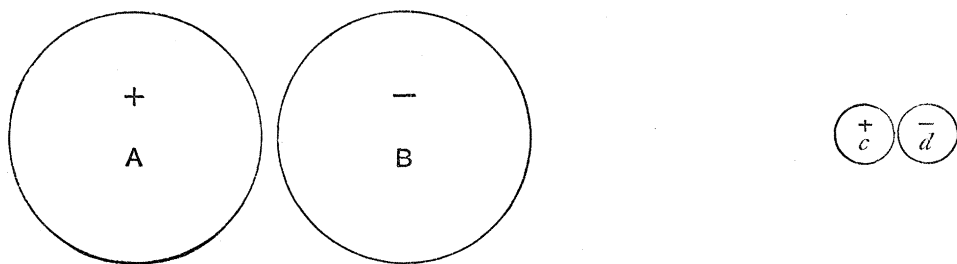
*"Velocity of Propagation of Electrostatic Force.*

"Dr. Bottomley's note published in 'Nature,' of January 23, quotes an extract from my Baltimore Lectures of October, 1884, in which this subject is spoken of, with an illustration consisting of two metal spheres at a great distance asunder, having periodically varying opposite electrifications maintained in them by a wire connecting them through an alternate current dynamo.

"For an illustration absolutely freed from connecting wire and all

complications, consider four metal spheres, A, B, *c*, *d*, with their centres all in one straight line;—their relative magnitudes and positions being such as shown in the accompanying diagram. Let each of the four be initially electrified, A and *c* positively, B and *d* negatively. Let the charges on *c* and *d* be so strong that a spark is only just prevented from passing between them by the influence of B and A. Let A be gradually brought nearer to B till a spark passes between them. Will the consequent spark between *c* and *d* take place at the same instant or a little later? It is not easy to see how this question could be answered experimentally; but remembering the wonderful ingenuity shown by Hertz in finding how to answer questions related to it, we need not, perhaps, despair to see *it* also answered by experiment.

“The elastic solid theory restricted to the supposition of incompressibility (which is expressed by Maxwell’s formulas) makes the difference of times between the two sparks infinitely small. The



unrestricted elastic solid theory gives for the difference of times the amount calculated according to the velocity of the condensational-rarefactional wave.

“But I feel that it is an abuse of words to speak of the ‘elastic solid theory of electricity and magnetism’ when no one hitherto has shown how to find in an elastic solid anything analogous to the attraction between rubbed sealing-wax and a little fragment of paper; or between a loadstone or steel magnet and a piece of iron; or between two wires conveying electric currents. Elastic solid, however, we must have, or a definite mechanical analogue of it, for the undulatory theory of light and of magnetic waves and of electric waves. And consideration of the definite knowledge we have of the properties of a real elastic solid, which we have learned from observation and experiment, aided by mathematics, is exceedingly valuable in suggesting and guiding ideas towards a general theory which shall include light (Old and New), old and new knowledge of electricity, and the whole of electro-magnetism.

“KELVIN.”

