multiplets. Taking the structure diagram of neon, namely,

$$\begin{array}{ccccc} K & & & & \\ 2 & & & & \\ & L_1 & L_2 & & \\ & 2 & 5 & & \\ & & M_1 & M_2 & M_3 \\ & & & N_1 & N_2, \end{array}$$

it is found that the expected terms and combinations are as follows :

$$\begin{array}{lllll} {}^5L_2 & \longrightarrow {}^4L_2\,M_1 & \longrightarrow {}^4L_2\,M_2 & \nearrow {}^4L_2\,M_3 & \\ & & & {}^4F\ {}^4D\ {}^4P & \\ & & & {}^2F\ {}^2D\ {}^2P & \\ {}^2P & {}^4P\ {}^2D & {}^4D\ {}^4P\ {}^4S & & \\ & {}^2P\ {}^2S & {}^2D\ {}^2P\ {}^2S & \searrow {}^4L_2\,N_1 & \\ & & & {}^4P\ {}^2D & \\ & & & {}^2P\ {}^2S & \end{array}$$

I have obtained combinations which are combinations between ${}^4L_2M_2$ and $({}^4L_2M_3,\ {}^4L_2N_1)$-terms. Two multiplets are shown below :

	${}^4P_1$	${}^4P_2$	${}^4P_3$
${}^4P_1$	36082·3 (1)	36264·8 (3)	
${}^4P_2$	35777·6 (3)	35960·0 (2)	36182·3 (2)
${}^4P_3$		35582·9 (4)	35805·5 (4)
${}^4D_1$	32825·2 (3)	33006·0 (4)	
${}^4D_2$	32726·9 (5)	32909·5 (3)	33131·9 (3)
${}^4D_3$		32803·6 (6)	33025·7 (4)
${}^4D_4$			32944·9 (5)

A complete analysis will shortly be published.

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Herbert Spencer's Electrical Apparatus.

IT may be of interest to record the fact that the electrical apparatus formerly owned by Herbert Spencer, consisting of a cylinder machine, three Leyden jars, an insulated stand and plates, with other accessories, which include an electrical pistol, is still in existence. One of the smaller pieces of apparatus bears the name G. Adams, London, who was presumably the maker, and the whole is contained in a wooden box.

The apparatus belonged originally to Herbert Spencer's father, William George Spencer, usually known as George Spencer, who kept a school in Derby and was for many years secretary of the Derby Philosophical Society founded by Erasmus Darwin. It was his practice to show electrical experiments to his pupils and at the meetings of the Society. Herbert Spencer in his autobiography says: "My father had an electrical machine and an air-pump, and from time to time classes of his pupils came to see pneumatic and electrical phenomena. I had frequently to make preparation for the experiments and aid in the performance of them. The result was that being on many occasions witness to the facts, and hearing the explanations given, I early gained some knowledge of physics. Incidentally I was led into Chemistry. One of my duties in preparing for these lectures was that of making hydrogen to fill the electrical pistol."

The history of the apparatus is well authenticated. Herbert Spencer's mother died in 1867, and shortly afterwards he gave up the Derby house and distributed most of the contents. In the autobiography he says: "Soon after my mother's death I therefore arranged to give up the house. Reserving valued relics and such few pieces of furniture as promised to be useful in London, and distributing the rest among my relations, I surrendered the key to the landlord."

It was at this time, or shortly afterwards, that Herbert Spencer gave the electrical apparatus to George Holme, who as a youth of sixteen or seventeen had saved him from drowning and had been his friend ever since. George Holme afterwards became a well-to-do manufacturer and was Mayor of Derby in 1875. An edition of Spencer's works was inscribed: "From Herbert Spencer to his old friend George Holme, without whose courageous aid rendered in boyhood neither this work nor any of the accompanying works would ever have existed." On the death of George Holme the apparatus was left to his grandson, George Hyde. At his death his widow gave it to their nephew, Mr. Colin Hyde Bennett, the present owner, whose parents still live in Derby. It is to their courtesy that the present writer owes the opportunity of inspecting the apparatus, as well as the supreme satisfaction of firing the electrical pistol, which shot its cork vigorously across the room.

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April 14.

Convection of Heat in Fluid Flow through Pipes.

IN his letter in NATURE of April 9, p. 527, Mr. H. F. P. Purday proposes to add yet another purely empirical formula to the many already proposed for representing the transfer of heat from a tube to a fluid passing through it. I cannot believe that much progress is possible along this line. Any further advance must, I think, be based on physical considerations, which will indicate the form of the functions involved, as to which the theory of dimensions can give us no information whatever.

It is now, I think, generally agreed, that in the turbulent flow of a fluid through a pipe there is always a layer which creeps in viscous or laminar flow along the surface of the tube, whilst the remainder of the cross-section of the tube is filled with turbulent fluid. Osborne Reynolds, many years ago, gave a rational expression for the transfer of heat from the interior surface of the viscous layer to the turbulent core. Across the viscous layer, heat transfer can only take place by conduction. If we knew its thickness we could find a complete expression for the transfer of heat from the hot wall to the fluid. Such an expression must necessarily involve at least two terms, since the transfer is effected in part by conduction and in part by convection.

Whilst it does not seem possible to calculate directly the thickness of the laminar film, it is possible from physical considerations to fix an upper limit to its maximum possible thickness. The actual thickness must be less than this, so that if the limiting thickness be found, as above indicated, the actual thickness will be ϕt, where t is the limiting thickness and ϕ a coefficient to be determined by