bodies, retain the property of producing scintillations on a blende screen, and are non-penetrating].

It seems probable that in these phenomena we are actually witnessing the bombardment of the screen by the electrons[1] hurled off by radium with a velocity of the order of that of light; each scintillation rendering visible the impact of an electron on the screen. Although, at present, I have not been able to form even a rough approximation to the number of electrons hitting the screen in a given time, it is evident that this is not of an order of magnitude inconceivably great. Each electron is rendered apparent only by the enormous extent of lateral disturbance produced by its impact on the sensitive surface, just as individual drops of rain falling on a still pool are not seen as such, but by reason of the splash they make on impact, and the ripples and waves they produce in ever-widening circles.

THE PSYCHOLOGY AND NATURAL DEVELOPMENT OF GEOMETRY.

IN connection with recent endeavours to place the teaching of geometry on the best possible basis, much interest attaches to Dr. Mach's attempt to trace the order in which geometrical facts first made themselves known in the natural order of evolution.

The earliest notions of space must have been suggested by the relations of physical bodies to the parts of the human body, the spacial behaviour of bodies towards one another subsequently acquiring a mediate and indirect interest far transcending that of the momentary sensations. While the senses of sight and touch only give rise to sensations of surface, crude physical experience soon impels us to conceive the notion of volume, and the *constancy of volume* of bodies would be one of the first attributes to manifest themselves to our senses. Geometry, although asserted to be concerned with ideal objects only, arose from the consideration of the space relations of physical bodies. The earliest units of measurement were derived from our hands and feet. But the material properties of bodies rather than their spacial properties possess the greatest interest for us, and Dr. Mach considers that the first ideas of measurement were those of volume, and arose from counting the number of equal identical immediately adjacent bodies which would fill a given space. The notion of *areas* would be derived from the number of food-bearing plants which a given field would contain or the labour required in planting them, *distance* would be estimated by hours of travel. The measurement of lines and areas by means of *solids* is a notion now completely estranged from our geometrical ideas, but in early times we should have measured lengths and areas by the number of solid bodies placed in line or distributed over a surface required to cover them, an idea which is borne out by the remarkably elegant methods of mensuration expounded in the seventeenth century by Cavalieri.

Although movable bodies present different spacial sensations to the visual sense dependent on the position and distance of the observer, the notion of spacial constancy becomes associated with them both by the sense of touch and by combined experience.

The earliest conceptions of *purely spacial* properties naturally asserted themselves in the pursuit of trades and arts. The property that a number of equal and similar triangles of any shape can be fitted together in regular order to form a pavement or mosaic naturally leads to the property that the three angles of a triangle are together equal to a straight angle. A consideration of the way in which the triangles run in rows would lead to the notion of parallels, and the property that the adjacent angles made by the parallel lines with any transversal are together equal to two right angles. The theorem of the Pythagoreans, according to which superficial space can only be partitioned into regular polygons in three ways, namely, into equilateral triangles, squares, or hexagons, naturally finds its origin in the same source.

A stretched string furnishes the simplest visualisation of a straight line, and leads to the property that a straight line is the shortest distance between two points, but Dr. Mach reminds us that this property cannot be regarded as being established by mere visualisation. It is true that we have learnt instinctively to reproduce in our imagination some method of demonstrating that, for example, two sides of a triangle are greater than the third side, but the source of our knowledge here is *physical experience* derived from our knowledge of material bodies. Another property of straight lines, namely, that a straight line is self-congruent if made to slide or rotate upon itself, is also a result of experience with straight and bent wires.

The knowledge that the measures of geometry depend on one another was reached in divers ways. The division of a parallelogrammatic field into smaller fields gave rise to the area being measured by the product of the length and breadth, and the knowledge that the area of a rectangle is greater than that of a parallelogram having the same sides gave rise to the idea that the area also depended on the angles.

In regard to *angles*, Dr. Mach points out that the definition of an angle as the difference between two directions is a *physiological* definition, the notion of direction being a purely physiological conception. In *abstract space*, obtained by metrical experiences with physical objects, differences of direction do not exist. An angle is determined when the distance is assigned between two points on its arm at given distances from the vertex, but, as Dr. Mach points out, this measure, though closely resembling those adopted in trigonometry, was not used in geometry, because angles so measured would not possess *additive* properties. The simpler measure of an angle by the arc or area which it intercepts on a circle surrounding the vertex thus became generally adopted. In connection with Dr. Mach's views on this point, it may be maintained that even with our present experience of geometry an angle instinctively suggests the idea of *space*, extending, no doubt, indefinitely from the vertex, but possessing the remarkable property of being a definite fraction of the whole space surrounding that point.

The object of geometry is to answer questions that occur repeatedly in the same form, and with this object has arisen the study of deductive geometry, which takes theorems and proves them once for all. But it will be seen that Dr. Mach strongly emphasises the *physical* and *material origin* of geometry, and his studies will naturally support the view that geometry is likely to be best understood when taught in its early stages from the experimental side.

THE EUCALYPTS.[1]

THE economic importance of the genus Eucalyptus to our Australian Colonies accounts, no doubt, for the somewhat extensive official literature which has grown up there on this subject. This includes numerous publications by the Government botanists and forest officials of the Australian colonies, and especially the classic "Eucalyptographia," now, unfortunately, no longer obtainable, of the late Baron von Mueller, whose enthusiasm for the genus is mainly responsible for the large Eucalyptus plantations now existing in Italy, France, Algeria, California and other countries.

Messrs. Baker and Smith, in their contribution to Eucalyptus literature, give an account of the results they have secured in the course of a systematic study of the Eucalypts, both from the botanical and chemical points of view, and they conclude from the data so obtained that the trees belonging to this genus may be divided into a series of natural groups, in which there is a striking correlation between the structure of the leaves, and to a certain extent, also, of the barks, and the composition of the essential oils produced by the species; thus, in *Eucalyptus tesselaris*, which the authors regard as the primitive type, the leaves have a characteristic parallel lateral venation and furnish

[1] Radiant matter, satellites, corpuscles, nuclei; whatever they are, they act like material masses.

[2] Abstract of a paper by Dr. E. Mach in the *Monist*. Translated by T. J. McCormack.

[1] "A Research on the Eucalypts especially in regard to their Essential Oils." By R. T. Baker, F.L.S., and H. G. Smith, F.C.S. Pp. 295; with 9 plates. (Technological Museum: New South Wales.)

"Eucalypts Cultivated in the United States." By A. J. McClatchie, M.A. Pp. 101; with 91 plates. (Department of Agriculture, U.S.A.)