The range in standard air, for the long group, is $3 \cdot 90 \pm 0 \cdot 08$ cm. As this range is nearly identical with that of polonium α-particles, we are now making careful tests in order to decide if the second group must be attributed to contamination by this element. It is improbable that the contamination was contained in the sample of rare earth sulphates, for we used material more than ten years old, a period in which the concentration of polonium would have decayed to 1 in 10^8 of its original value. Further, we did not find tracks due to contamination by other radioactive elements, which, in view of their chemical properties, might have been expected in larger amount than polonium.

Because of the integrating characteristic of the photographic plate and the absence of background due to cosmic radiation, or β- and γ-rays, the method gives us a very powerful instrument for determining the decay constant of long-lived radioactive nuclei and of making determinations of very low concentrations of radioactive substances. Thus we have estimated the total number of short-range particles liberated in a given time from a known mass of samarium by counting the number of tracks in specimen areas of the plate and estimating the total area of the emulsion impregnated. As a result, we obtain a value of the decay period of samarium of $(1 \cdot 3 \pm 0 \cdot 1) \times 10^{11}$ years. Corresponding to this value of the half-life the concentration of polonium required to give the observed number of long tracks is only 10^{-13} of that of samarium. In the present determination the main error arises from the uncertainty in the precise area impregnated with samarium, and in future experiments this can be substantially reduced by suitable technical improvements.

If the long-range group is not due to contamination by polonium, its presence could be explained by attributing it to the element 61 present in amounts too small to be detected by the usual methods of analysis, and support for such a view can be found in the work of M. Curie and Takvorian[2], who tested the radiation emitted by fractions of samarium and neodymium by electrical methods. They found that the intermediate fractions, which ought to be rich in 61, emitted a more penetrating radiation than pure samarium. The long-range group would then correspond to the disintegration of a nucleus with a much shorter decay period than that of samarium but still long enough to allow us to account for its existence in Nature in small quantities. A serious objection, however, to such an interpretation is that an application of the Gamow theory of the α-decay to this case gives a value for the half-life of the order of only 10^{-7} sec.

In conclusion, we want to thank Dr. C. F. Powell for providing us with the possibility of carrying out this work and also for much helpful advice and criticism. We are indebted to Dr. L. C. Jackson for the pure samarium sulphate and neodymium employed in this experiment, and for pure specimens of six other of the rare earths which we are examining for radioactivity by similar methods.

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A Zonally Corrected Electron Lens

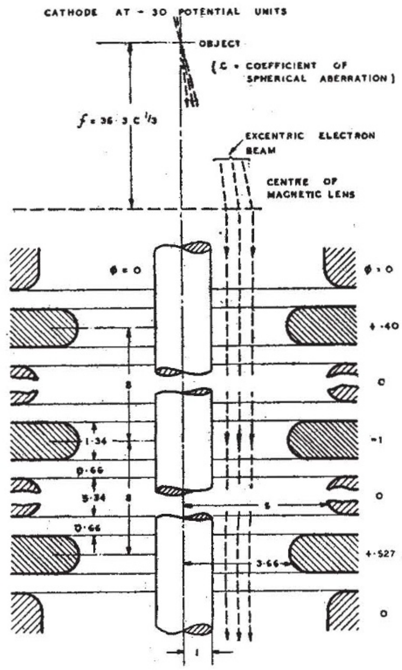
SCHERZER[1] has proved that the first-order spherical aberration of electron lenses can never be corrected by any combination of electric or magnetic fields, in the absence of space charges. Suggestions regarding space charge corrected lenses have been made[2], but have not yet been submitted to experimental tests.

As the present performance of electron microscopes is mainly limited by spherical aberration, it is of considerable interest to explore possible avenues of improvement which are not barred by Scherzer's theorem. Zonal correction, in combination with an annular or excentric stop, is one of these, but it cannot be achieved in electron lenses of the conventional or 'coreless' type, in which the axis is free from electrodes or conductors. Dropping this condition does not, however, lead to as great a variety of new lenses as one might expect, as in the objectives of electron microscopes space is so restricted, and the requirements of accuracy are so high, that only the simplest arrangements can be seriously considered.

In the simplest type, which may be called a 'coaxial lens', there is only one central electrode, consisting of a straight cylindrical wire in the axis, surrounded by one or several annular electrodes. Evidently it is not possible to utilize a complete annular aperture, as the wire must be firmly supported at one or both ends. But it can be easily seen that very little resolving power is lost if the electron beam is restricted tangentially to about the same width as in radial direction. Such beams can be produced by ordinary electron guns, merely by tilting the axis of the gun and of the condenser lens with relation to the axis of the objective, in such a direction as to miss the supports of the central wire. These supports must be arranged in field-free zones, so that the field in the coaxial lens itself is free from perturbations of rotational symmetry.

Preliminary calculations have shown that coaxial lenses cannot be made with sufficiently high power to replace microscope objectives without incurring the danger of auto-electronic discharges. Their use must be rather restricted to the correction of conventional objectives, preferably of the magnetic type. In order to be effective, and to improve the resolving power beyond the present limit, the correcting lens has to fulfil three mathematical conditions simultaneously. In the combination the first, second and third differential quotient of the zonal power with respect to the initial angle of the electron trajectories must be zero, and the fourth as small as possible. In ordinary, coreless lenses the first condition is automatically fulfilled, as the deflexion is in first approximation proportional to the off-axis distance, and thus to the initial angle. But in coaxial lenses the deflexion is in first approximation inversely proportional to the radius; hence even the first condition by itself can be satisfied only by a combination of coaxial lenses, containing one central wire but several annular electrodes.

Lengthy calculations, which could be carried out with the required high accuracy only by means of numerical methods, have shown that these conditions can be satisfied by certain three-element coaxial lenses. An example is illustrated in the accompanying drawing. It may be assumed that the magnetic objective by itself is about as good as possible, with 3 mm. focal length and $0 \cdot 2$ spherical aberration coefficient at 60 keV. In this case the diameter of the central wire must be about $0 \cdot 27$ mm. The other dimensions of the lens are indicated in the figure, with the radius of the wire as unit.



Linear dimensions in units of the radius of the central wire. Potential in units of potential of central electrode

With the potentials as indicated, the aberrations are corrected in a zone of $2 \pm 0 \cdot 135$ wire radii, corresponding to an angular range of $0 \cdot 090 \pm 0 \cdot 006$ radian, with an error of not more than 10^{-7} radian. With the above data this gives a geometrical error of about 3 A. and a diffraction error of less than 3 A. This is appreciably less than the optimum values obtainable with uncorrected lenses. It is impossible to say at the moment how this gain will be affected by the unavoidable errors of manufacture. But it may be mentioned that even with a resolving power not superior to that of conventional microscopes, objectives with zonal correction might have a certain advantage, as their focal depth is about thirty times less, which might make it possible to explore objects *in depth*.

The extensive step-by-step numerical calculations which led to the above lens have been carried out by Mr. J. W. Dungey and Miss C. R. Hull, and will be published elsewhere.

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Theory of Binary Azeotropes

WE have recently had occasion to survey critically the sparse literature concerned with the theory of azeotropes and have been led to the conclusion that the most general, albeit formally exact, thermodynamic treatment is of little practical use[1,2]. Logical extension of the statistical thermodynamic treatment of strictly regular solutions[3] indicates that azeotropes formed by such solutions would obey the empirical rules of behaviour of real azeotropes which have been advanced by Timmermans, Merriman and Wrewsky. Moreover, we find that closely approximate relations between N_2, P and T (N_2 being the mol fraction of component 2), derivable from the treatment, do in fact describe the behaviour of many of the azeotropic systems which have been experimentally studied.

These relationships are of the following remarkably simple forms.