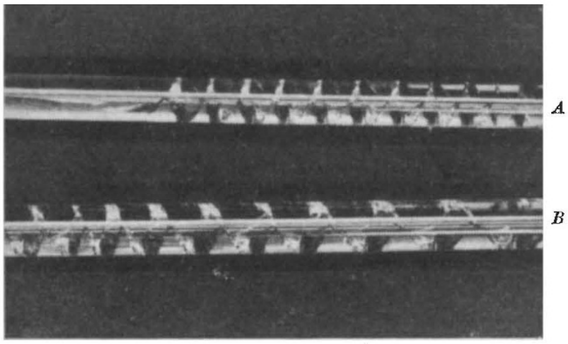

to a close spiral (Fig. *A*). and from a lower temperature a coarser spiral. A temperature gradient along the tube, made by touching one end of the tube to the hot plate and raising the other end slightly, results in a tapered spiral (Fig. *B*). Too low temperature of heating before quenching gives a straight line or a wavy line fracture, while a too high temperature may cause short segments of the tube to be broken off. Left- and right-handed spirals are equally prevalent, even in sections of the same tube.

As a result of this heating and quenching, one may qualitatively describe the cracking of the glass as follows. Well-annealed glass is strain-free when uniformly heated. When such hot glass is suddenly plunged for a moment into water, the outside of the glass in contact with the water is chilled and undergoes tensional stress while the hot interior is compressed. Under the tensional stress, any minute fissure in the surface of the glass (usually at the end) may open and start a crack which travels over the surface of the glass and relieves the tensional strain. Prolonged cooling deepens the crack and causes a secondary crack to form which is continuous with the first and completes the spiral rupture. The spiral pattern is apparently the one that gives most strain release in the circumstances.

The simplicity of this form of fracture would indicate that the related mathematical problem in heat transfer and stress-strain relations might have a relatively simple solution.

JOHN J. HOPFIELD

Applied Physics Laboratory,
Johns Hopkins University,
Silver Spring, Maryland.
Sept. 22.

* Contribution No. 4 from the Applied Physics Laboratory of The Johns Hopkins University; the work described here was done in connexion with Contract NOrd 7386 with the U.S. Naval Bureau of Ordnance.

Electron Accelerator of Synchrotron Type

WHILE accelerators of the cyclotron type have facilitated the production of energetic particles, they are, as yet, beyond the financial means of a great many laboratories. Moreover, the attainment of energies nearing the range of a thousand million electron-volts is associated with considerable difficulty and expense if attempted by current methods. It is suggested that, by using the synchrotron principle[1] together with a magnet of unusual design, these objections might be overcome.

It can be shown that the energy and radius of an equilibrium orbit in the synchrotron are determined by

$$E = \sqrt{(Bcer)^2 + E_0^2}\ , \quad . \quad . \quad (1)$$

$$r = \sqrt{(c/\omega)^2 - (E_0/Bce)^2}\ , \quad . \quad . \quad (2)$$

where E is equilibrium energy (total); E_0 is rest mass energy; r is radius of equilibrium orbit; B is magnetic flux density at orbit; ω is angular velocity of 'dee' voltage; e is charge on particle; c is velocity of light.

Equation (1) shows that the equilibrium energy may be increased by increasing B—as observed by McMillan. Equation (2) indicates that the equilibrium radius may be maintained constant by causing a suitable increase in ω as the value of B is raised.

Rendering the equilibrium radius constant in this way allows the use of a magnet of simplified design. The most convenient form of magnet is a laminated steel bobbin, the depth and width of which are small compared with its diameter. The vacuum chamber and energizing coil lie between the cheeks of the bobbin, the coil having the smaller diameter. Ring-shaped pole pieces are fastened to the cheeks in the region of the vacuum chamber so that the distribution of the field may be controlled. The usual magnet yoke is eliminated in this way and, since it is unnecessary to increase the depth and width of the bobbin in direct proportion to the diameter, the saving in material and the efficiency are greater for larger accelerators. The magnet of the small (13 Mev.) electron accelerator which is being built at this University weighs less than 200 lb.

While some difficulty is associated with the required change in ω, no insuperable difficulty is anticipated. It is certainly possible to produce a change large enough to accelerate electrons to high energy from a reasonable injection energy. It is thought that, where the final velocity of an accelerated particle is several times the initial value, the difficulty of producing a correspondingly large frequency change might be circumvented by the use of 'harmonic orbits'. The fact that a particle can be accelerated when its period is an integral multiple of the period of the 'dee' voltage suggests that a large change in velocity may be accommodated by repeatedly changing ω over a 2 : 1 range. The frequency is increased slowly and decreased very rapidly, several such cycles occurring as the magnetic field increases to its maximum. We hope to verify this when our accelerator is placed in operation.

A. I. ARCHER

University of the Witwatersrand,
Johannesburg.
Sept. 10.

[1] McMillan, E. M., *Phys. Rev.*, **68**, 143 (1945).

Reaction Velocity at Phase Limits and its Dependence on the Frequency of the Vibration of the Lattice

IN studying reactions between two solid phases, it is found that the reaction velocity in systems such as MgO/Ag_2SO_4[1], MgO/Ag_3PO_4[1], $MgO/Mg_2P_2O_7$[2] and $MgO/MgSiO_3$[3] is not determined by the diffusion process through the reaction products, but by reactions at one of the phase limits. The reaction velocity is independent of the thickness of the layer of reaction product and changes with temperature according to the exponential equation

$$dm/dt = C.\exp(-q/RT).$$

The reaction velocity of the systems magnesium oxide/silver salt is at a certain temperature about a million times as great as in the system $MgO/Mg_2P_2O_7$, and in the latter is considerably greater than in the system $MgO/MgSiO_3$; but this difference is dependent only on the great differences in energy of activation. On the other hand, the constant C for all the four systems is practically the same.

System	q kcal.	C gm.-mol. MgO cm.$^{-2}$ sec.$^{-1}$
MgO/Ag_2SO_4	61	$2{\cdot}0 \times 10^5$
MgO/Ag_3PO_4	61	$2{\cdot}0 \times 10^5$
$MgO/Mg_2P_2O_7$	82	$2{\cdot}1 \times 10^5$
$MgO/MgSiO_3$	112	$1{\cdot}0 \times 10^5$

Since the specific gravity of magnesium oxide is about 3·2, the constant C corresponds to a yield of 5×10^{13}–$1{\cdot}0 \times 10^{14}$ molecule layers per second: the linear reaction velocity in cm. sec.$^{-1}$ is in the systems investigated proportional to the product of atom frequency and lattice spacing of the oxide[4].

When investigating the thermal decomposition of zinc oxide we have arrived at an analogous result[5]:

$$dx/dt = 1{\cdot}2 \times 10^{12} \exp(-94{,}000/RT).$$

ROBERT JAGITSCH

Department of Chemical Technology,
Chalmers College of Technology,
Gothenburg.
Sept. 2.

[1] Jagitsch, R., and Hedvall, J. A., *Ark. kemi., min. o. geol.* (Stockholm), **19** A, No. 14 (1944).
[2] Jagitsch, R., and Perlström, G., *Ark. kemi., min. o. geol.* (Stockholm), **22** A, No. 4 (1946).
[3] Unpublished results.
[4] cf. Polanyi, M., and Wigner, E., *Z. phys. Chem.*, A, **139**, 439 (1928).
[5] Bengtson, B., and Jagitsch, R., *Ark. kemi., min. o. geol.* (Stockholm), in the press.

An Extension of the Lens-Mirror System of Maksutov

THE lens-mirror system described by D. D. Maksutov[1], in which the aberrations of a spherical mirror are corrected by a single spherical-surfaced meniscus lens, while eminently suitable for telescope objectives of moderate relative aperture, combining the coma correction of the refractor with a virtual absence of secondary spectrum, suffers from two sets of limitations which restrict its possible application in other fields. In the first place, the higher order spherical aberration is too great to yield the highest resolving power at very great relative apertures (except at very small focal lengths). Secondly, since the system has only three variables apart from meniscus thickness, the oblique aberrations other than coma cannot be corrected simultaneously with spherical aberration and axial achromatism, thus restricting its use over large angular fields. The former limitation may be reduced by increased thickness of the meniscus, but this necessarily involves larger uncorrected oblique aberrations.

D. G. Hawkins and E. H. Linfoot[2] recently described in *Nature* a combination of a concentric Maksutov meniscus and a doublet Schmidt aspheric plate which overcomes these limitations. Similar results may be obtained without the use of non-spherical curves by the use of two spherical-surfaced meniscus lenses, one concave and one convex to the mirror. In such a system, conserving the secondary-spectrum correction of the Maksutov system, the higher order spherical aberration is very considerably reduced, the first order oblique aberrations may be completely corrected, and the meniscus thicknesses may be increased with further considerable gain in axial correction, without detriment to the oblique imagery. Moreover, the variables of the system being more than are required to fulfil the Seidel conditions, a form of lens may be chosen reducing the higher order oblique aberrations to negligible size; this is possible in these two-meniscus systems by adopting a form in which the effective stop lies between the centres of curvature of the two surfaces of each meniscus (which are close together), thus reducing the angles of incidence of a principal ray to very small values. This is not possible in the Maksutov systems, since in these coma correction requires that the stop should be relatively far removed from the meniscus centres of curvature.