tions (cf. G. Gamow and C. Longmire); but it is apparent that at this point of evolution the static model must go over into some kind of periodic motion. When the stability conditions are just exceeded, we would expect short-period motion with small amplitudes. As the core grows, both period and amplitude would be expected to become larger and larger. Thus, we have here a picture which may be useful for the explanation of the Kukarkin–Parenago relation, provided we consider different *U*-Geminorum stars as successive evolutionary stages of a single stellar mass. It may, indeed, easily happen that the 'oscillations' described above will result in periodic convectional instabilities. In this case a rapid mixing of cool hydrogen from the envelope with hot helium from the core will result in periodic nuclear explosions of the star. There is also the possibility that similar instabilities may develop in 'swollen-up' solutions of the shell-model. If the resulting central explosions are comparatively weak, they will not show through the thick body of the star and may act as a 'buzzer' mechanism for maintaining regular stellar pulsations.

It is too early to say whether or not the above views will lead to a correct explanation of the dynamical states of ageing stars. The study of the hydrodynamical equations involved in the problem is extremely difficult, and can be done only by means of modern electronic computers. Work in this direction is now being done by the author and his colleagues, A. Carson, G. Keller, C. Longmire, N. Metropolis, L. Peck and R. Richtmeyer, with the hope of having solutions run on a new electronic computer ('Maniac') under construction at the Los Alamos Scientific Laboratory.

G. Gamow

George Washington University,
Washington, D.C.
March 15.

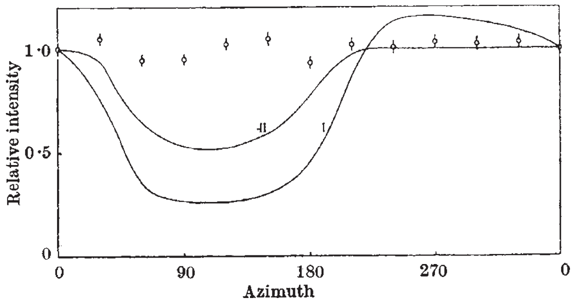
BIBLIOGRAPHY

Gamow, G., *Astrophys. J.*, **87**, 206 (1938). Critchfield, C., and Gamow, G., *Astrophys. J.*, **89**, 244 (1939). Henrich, R., and Chandrasekhar, S., *Astrophys. J.*, **94**, 525 (1941). Schoenberg, M., and Chandrasekhar, S., *Astrophys. J.*, **96**, 161 (1942). Gamow, G., *Phys. Rev.*, **67**, 120 (1945). Gamow, G., and Keller, G., *Rev. Mod. Phys.*, **17**, 125 (1945). Harrison, Marjorie H., *Astrophys. J.*, **103**, 193 (1946); **105**, 322 (1947). Reiz, A., *Kgl. Danske Vid. Sels.*, **25** (1948); *Arkiv f. Astr.*, **1** (1949). Hayashi, Chushrio (private communication). Gamow, G., and Longmire, C., *Phys. Rev.*, **79**, 743 (1950).

Evidence of Multiple Meson Production

Direct evidence of the production of several mesons by a single primary proton in cosmic rays has been obtained by cloud chambers and photographic plates[1], and indirect evidence by observations of a relatively low average energy of mesons at sea-level[2,3]. Further indirect evidence is furnished by the absence of azimuthal intensity variation obtained as a result of the experiment described here.

Four triple-coincidence counter telescopes, each differing in azimuth by 90°, were used at sea-level, geomagnetic latitude 43·5° S., the middle counter in each telescope having 5 cm. of lead on either side of it. The angle subtended by each telescope was 13° × 3·5°, the larger angle being in the vertical plane, and the zenith angle was 60°. Intensity measurements were made at azimuth intervals of 30°, the average counting-rate being 16·00 per day. From the measured counting-rates, 3·75 counts per day were subtracted, this figure being taken as the shower counting-rate, obtained using a telescope identical with the others except that the middle counter was moved out of line.



Cosmic ray intensity at sea-level
Theoretical curves I (single meson production) and II (including meson decay). ○, observed intensities, showing ± standard error

From the shadow cone theory[4] the primary cut-off momentum interval explored was calculated to be from 3,600 MeV./c at azimuth 270° to 16,000 MeV./c at 120°.

The measured intensities, after shower correction, are plotted in the accompanying graph, each point being based on approximately 1,700 counts. Curve I is calculated using a primary momentum spectrum $dN = KP^{-2}dP$, the exact form of which is not important, assuming each primary gives rise to a single meson capable of penetrating to sea-level, and is normalized to unit intensity at 0°, corresponding to an observed corrected value of 12·19 ± 0·38 counts per day. Curve II is drawn taking into account the effect of meson decay. It is clear that an asymmetry is to be expected, which is at variance with the observations, for only one point differs from the mean of 12·25 by more than twice the standard error.

The observed uniform intensity at all azimuths may be explained by assuming that several secondaries are produced by each primary, and that the maximum momentum of a secondary produced by a primary with momentum between 3,600 and 16,000 MeV./c is less than the momentum loss in traversing the inclined atmospheric path, that is, less than 4,000 MeV./c. If the effect of meson decay is considered, this maximum may be increased slightly, as the probability of a meson of initial momentum 5,000 MeV./c penetrating to sea-level is less than 0·1. This conclusion appears to be in agreement with previous results[1–3].

J. B. Swan

Physics Department,
University of Western Australia,
Nedlands.
March 9.

[1] Freier and Ney, *Phys. Rev.*, **77**, 337 (1950).
[2] Blackett, *Proc. Roy. Soc.*, A, **159**, 1 (1937).
[3] Caro, Parry and Rathgeber, *Nature*, **165**, 688 (1950).
[4] Schremp, *Phys. Rev.*, **54**, 158 (1938).

A Convenient Synthesis of Carbon-labelled Benzene

Several syntheses of benzene and its simple derivatives labelled in the nucleus with isotopic carbon have been described[1–5]. The aluminium-halide catalysed rearrangement of alkyl *cyclo*pentanes to *cyclo*hexanes[6,7] affords an attractive route to benzene and its homologues, and we now present a