

## LETTERS TO THE EDITORS

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## Barometer Effect of Penetrating Cosmic-Ray Showers

DURING the past sixteen months we have recorded penetrating cosmic ray showers and barometric pressure. As it was not the main object of the experiment to correlate pressure and penetrating shower intensity, the disposition of the counter arrangement was changed frequently. Altogether two different counter arrangements with fourteen different dispositions of absorbers were used for various lengths of time. One of the arrangements has been described previously<sup>1</sup>.

Correlation between barometer and counting-rate was determined in the usual way for each of the separate arrangements. The barometer coefficients obtained for the individual sets of readings were rather uncertain, because of the large statistical fluctuations which were to be expected in consequence of the small counting-rates usual for penetrating showers.

The weighted mean of the fourteen single barometer coefficients appears, however, significant. It was found to be

$$B = -11.7 \pm 2.7 \text{ per cent per cm. mercury.}$$

The stated error is the *standard error* of  $B$ .

The value of  $B$  was computed from 270 single readings covering 8,220 hours during which 4,363 coincidences were recorded. The root mean square variation of the barometer during this period was found to be  $\pm 0.87$  cm. mercury.

The fluctuations around the average values of the individual values corrected for the barometer were found to be statistical. Thus there is no indication of large variations of the intensity due to causes other than changing pressure.

The barometer coefficient  $B$  is very large and is of the same order as that found by Cosyns<sup>2</sup> and Auger and Daudin<sup>3</sup> for extensive air showers. This confirms the connexion between air showers and penetrating showers.

The large value of the barometer coefficient is, however, surprising in view of the small absorption of penetrating showers in lead. According to our previous measurements, 30 cm. of lead absorbs only about 20 per cent of the observed shower intensity. This difficulty might be removed by assuming that the absorption of penetrating showers is much greater in air than in lead. Such an assumption appears unlikely, as the penetrating showers seem to consist mainly of mesons, and the absorption of mesons is proportional to mass. The decay of mesons which gives rise to absorption anomalies would give rise to a temperature effect rather than a barometer effect.

An alternative explanation of the large barometer coefficient is that the change of intensity of the penetrating showers with barometric pressure is due not to the absorption of the penetrating showers themselves in air but to the absorption of the primaries which give rise to penetrating showers.

Consider those primaries which at a certain air pressure can just reach the top of a lead absorber placed above the counter arrangement. If 1 cm. more of lead is placed above the apparatus, these

primaries will be absorbed in the additional lead. But while absorbed, these primaries will give rise to penetrating showers which will be recorded. On the other hand, if instead of the additional lead absorber the air pressure increases by a corresponding amount, the primaries which would have just reached the top of the absorber will now be absorbed about 100 m. above the arrangement. The penetrating showers which are produced will reach the apparatus too diffused to give rise to coincidences. Thus the barometer effect is a measure of the rate of absorption of the primaries.

This point will be dealt with in detail in another paper.

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<sup>1</sup> Jánossy and Rochester, *NATURE*, 150, 633 (1942); *Proc. Roy. Soc.*, in the press.

<sup>2</sup> Cosyns, *NATURE*, 145, 668 (1940).

<sup>3</sup> Auger and Daudin, *Phys. Rev.*, 61, 91 (1942).

## Boiling Point and Viscosity of Gases

RECENT experimental studies<sup>1</sup> on the compressibility of liquids and liquid-mixtures indicated the existence of a connexion between the compressibility and viscosity. The usual equations representing viscosity - temperature relation of liquids do not, in any form, contain the compressibility function. After trial, it was observed that the viscosity of liquids could be well represented by an equation of the form:

$$\eta = AT^{1/2}e^{B/\beta}, \quad (1)$$

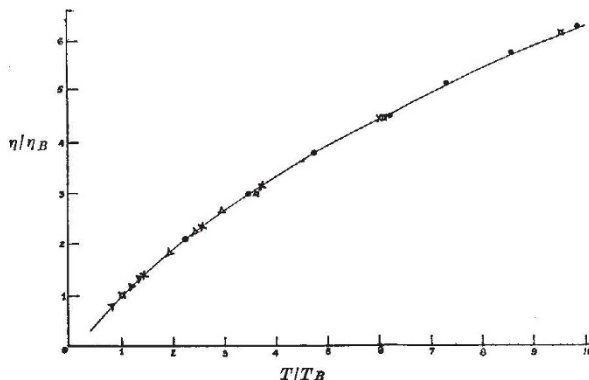
where  $A$  and  $B$  are constants, and  $\beta$  is the adiabatic compressibility.  $\beta$ , at any temperature, was calculated from the supersonic velocity and the density of the liquid for that temperature.

I was led, further, to consider the question of the viscosity of gases, and from considerations of interaction energy at collision, the following simple formula was obtained, giving the viscosity  $\eta$  at the temperature  $T$ :

$$\eta = AT^{1/2} \exp. - (T_B/T)^{1/2}, \quad (2)$$

$$\text{or } \eta/\eta_B = xe^{(1-x)}, \quad x = (T/T_B)^{1/2}, \quad (3)$$

where  $T_B$  is the boiling-point temperature and  $\eta_B$  the viscosity of the gas at that temperature. The relationship was tried and found to hold good for air, argon, hydrogen, nitrogen, oxygen, carbon monoxide



GRAPH SHOWING THE RELATION BETWEEN  $\eta/\eta_B$  AND  $T/T_B$  FOR GAS AND VAPOURS. THE EXPERIMENTAL POINTS REFER TO: AIR ●, ARGON ×, HYDROGEN □, CARBON DIOXIDE Δ AND BENZENE ▼.