low frequency, an anomaly was observed. On three occasions the low-frequency anomaly coincided with a reported increase in atmospherics observed on a frequency of 27 kc./s. On the remaining eight days no fade-out or increase of atmospherics was reported, but the low-frequency phase anomaly was associated with a magnetic anomaly, occurring within one hour of the observation.

We conclude that a catastrophic ionospheric disturbance has a marked effect at the level of reflection of the low-frequency waves (70 km.), this effect being most evident as a decrease in reflection height of the waves.

Our experiments have not shown any clear indication of a change in reflected wave amplitude at the time of the phase anomalies. The change in received amplitude of atmospherics noticed by Bureau may be the result of a change in reflection height altering the phase relation between the interfering downcoming and ground waves, or it may be due to a real change in the amplitude of the downcoming wave, which occurs in his case but not in ours, either because the reflection is much more oblique, or because the frequency of his observations is different from that of ours.

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[1] Dellinger, *Bur. Stand. J. Research*, **19**, 111 (1937).
[2] Bureau, *Comptes rendus*, **203**, 1257 (1936).
[3] Best, Ratcliffe and Wilkes, *Proc. Roy. Soc.*, A, **156**, 614 (1937).

Effect of a Magnetic Field on the Electrodeless High-Frequency Discharge

THE following experiment, which originated from an investigation of the magnetron, seems to be of more general interest as it happens to confirm some recent theories (especially those of Prof. V. A. Bailey) on what happens to wireless waves in the upper atmosphere.

It is well known that the electrodeless high-frequency luminous discharge can be started by comparatively low voltages in a gas at very low pressures. It is only necessary to place the bulb of low-pressure gas between two plates connected across a tuned circuit coupled to a medium-power wireless generator. If the pressure is so low that the mean free path is long, any electrons present will vary in speed in unison with the voltage alternations, and if the maximum speed attained (which depends on the amplitude of this voltage) is sufficient to produce ionization by collision, a discharge may be started. It seemed likely that if instead of allowing the speed of the electrons to rise and fall they were continually accelerated a discharge would start with a much lower voltage. This can be done by applying a fixed magnetic field perpendicular to the electric force which causes the electrons to move round in orbits; the time of turning through 360° depending only on the magnetic field strength. If this strength is so adjusted that this time is equal to the periodic time of the high-frequency voltage, a sort of resonance occurs (if the free path is long enough) and the electrons move round faster and faster in orbits which get bigger and bigger. The condition for resonance is that the product of the wave-length in metres and the field in gauss should be approximately 110.

It is necessary, however, if the orbit in which ionizing speed is attained is not to be too large, so that the experiment can be conducted in a bulb of reasonable size, that a short wave be used. The following experiment was done with a 6 metre wave-length and a field of about 18 gauss. As the pressure of air in the bulb was reduced, it was found that down to pressures of about $\frac{1}{10}$ mm. of mercury, the potential required to start the discharge was unaffected by the magnetic field, but a further reduction in pressure and consequent increase in the mean free path had a most striking effect. At $\frac{1}{30}$ mm. the field reduced the starting potential by a factor of 5, at $\frac{1}{100}$ mm. by a factor of about 40, and at the lowest pressure which could be read on the gauge—something less than $\frac{1}{300}$ mm.—the discharge still started quite easily with the magnetic field on but it could not be started at all without it.

In the upper atmosphere, the magnetic field is less than 1 gauss and the wave-length for resonance is therefore much longer than the above, but there is no bulb to limit the orbit size. The electric force in a wireless wave is of course far too small to work the electrons up to ionizing speed before a collision, but the resonance results in the transfer of considerable energy from the wave to the medium, with the consequences explained by Prof. Bailey.

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Interpretation of Atomic Constitution

A WARY man hesitates to cross swords with a skilful fencer, but it is cowardly to decline to face difficulties. Colonel Moore-Brabazon might well have asked for other explanations—Why two electricities? What is the difference between the so-called positive and negative electricities? What is negative energy? Why does not the electron explode? However, he is probably prepared, like the rest of us, to accept Nature as we find it, and the paths that we follow are forced upon us rather than chosen.

It is permissible at least to emphasize the *protean* forms of energy which exist, for the transmutations of energy are quite remarkable. For example, work generates a proportionate quantity of heat (kinetic energy). The energy $w = Jh$, where h is in heat-units and J is Joule's constant; alter the units and state $W = H$, or energy equals heat generated.

Again, energy is proportional to mass ($w = mc^2$, where c is the velocity of light). Change the unit of mass, and energy equals mass, or $W = M$.

So, too, energy may leave an atom as a photon and $w = hf$, where f is the frequency of the wave and h is Planck's constant. With another change of units, it follows that $W = F$, or energy is frequency. Altogether it follows that energy = mass = heat = frequency!

The conservation of energy is the conservation of mass and is the conservation of frequency, and frequency may be as important as energy. But no one supposes that mass is merely a number—the first blow dispels that illusion.

Most remarkable is the fact that in certain circumstances a photon, in the shape of a high-frequency gamma ray, will *materialize* and give rise to an electron and a positron, so that 'light' becomes two masses, if you like, two charges, if you will, two waves, if you prefer it, but certainly two entities,