Theories of Magnetic Storms and Auroræ

RECENT theories of magnetic storms and auroræ due to Alfvén[1] and Martyn[2] have had considerable success in explaining various observations, though Alfvén and Chapman have both pointed out[3] that the most satisfactory test of these theories would be an experimental one. Further insight into these theories may also be expected using a different theoretical approach: instead of calculating typical orbits for the particles, the continuous gas model may be used. This facilitates the use of Maxwell's equations in considering the effect of the charged particles on the electromagnetic field; the knowledge gained about the field can then be used in discussing the orbits.

This approach leads to a criticism of that aspect of the theories mentioned which concerns the acceleration of the auroral particles; the acceleration of these particles gives rise to a 'back effect' which has not been taken into account by Alfvén or Martyn. In both theories the auroral particles are supposed to be accelerated by a steady electric field occurring within a few earth radii of the earth, although the mechanism by which this field is supposed to be set up is different in the two theories. If there were a region containing such an electric field, it is obvious that all charged particles in that region would be accelerated, and, if they were to acquire the necessary energy of 10 keV., all the electrons in this region would be moving in nearly the same direction with velocities of 6×10^9 cm./sec. Then if there are 100 electrons per c.c., as inferred from one theory, the current density is 300 e.s.u., which is relatively large, and Maxwell's equation:

$$c \operatorname{curl} \mathbf{H} - \partial \mathbf{E}/\partial t = 4\pi \mathbf{j},$$

must be considered. The displacement current becomes important only for phenomena at radio frequencies, so that $|\operatorname{curl} \mathbf{H}|$ must be of the order of 10^{-7} gauss/cm., which again is relatively large. Just how curl **H** attains this magnitude must be discussed using another of Maxwell's equations:

$$\partial \mathbf{H}/\partial t = - c \operatorname{curl} \mathbf{E}.$$

I have investigated this question[4], using the approximation $\mathbf{E} = - \mathbf{u} \wedge \mathbf{H}/c$, where **u** is the bulk velocity of the gas; this approximation is valid before the current density becomes large and is therefore good enough to decide whether the current density becomes large. The point of the discussion is that the magnetic field reacts on the gas through the force density $\mathbf{j} \wedge \mathbf{H}/c$, and, since the temporal rate of change of the magnetic field depends on the velocity of the gas, the important question is whether this force density favours or opposes the type of motion which will increase $|\operatorname{curl} \mathbf{H}|$ and therefore also increase the current density. It is found to oppose this type of motion except in the neighbourhood of a neutral point of the magnetic field, and hence, if $|\operatorname{curl} \mathbf{H}|$ is to be increased elsewhere, some force is needed 'to drive the dynamo'. Alfvén and Martyn have not allowed for this reaction of the field on the gas, and it is therefore doubtful whether the accelerating processes they have proposed can occur.

The suggestion that an electric discharge would occur at a neutral point was first made by Giovanelli[5] in connexion with solar flares, and Hoyle[6] has proposed a theory of the aurora in which the auroral particles are accelerated at neutral points. The neutral points are due to the combination of the magnetic field of the earth and a magnetic field carried out from the sun. Alfvén's model does, in fact, incorporate a magnetic field of solar origin, and further discussion of all aspects of such models seems likely to be fruitful.

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[5] Giovanelli, R. G., *Mon. Not. Roy. Astro. Soc.*, **107**, 338 (1947); **108**, 163 (1948).
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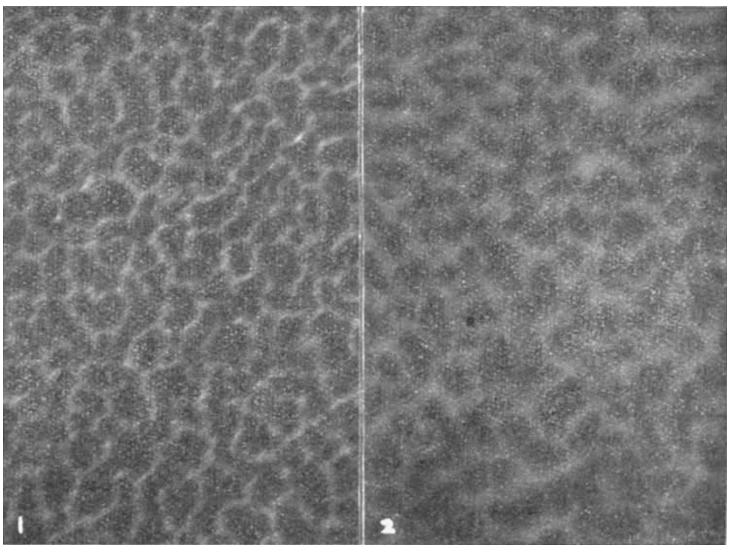
Thin Glass Layers as Supports for Electron Microscopy

IN the usual technique of electron microscopy, 'Formvar' or collodion layers are used as supports. We have been studying the electrical properties of thin metallic layers and determined their structure by means of the electron microscope. The electrical resistances were made on glass strips, while 'Formvar' layers were used as support for the electron microscope examination. We have always hesitated to consider the picture obtained on 'Formvar' as identical with the structure obtained on the glass surface; therefore we tried to use very thin glass layers as supports, and eventually succeeded.

The technique is as follows. A closed glass tube is heated in a coal gas – oxygen flame and blown out suddenly into the air. Thus the room is filled with very small pieces of glass flakes floating down to the floor. The thickest ones come down first, while the



Silver deposit (1) on 'Formvar', (2) on glass

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