and the results should be self-consistent. At high signal to noise ratio azimuths are quite consistent from different tripartites.

3. Of course we are not sure of the exact distance to the source but the intensity probably is of the same order of magnitude as that from tornadic storms.

Sonett, C. P.: Unless an auroral sound wave has a scale comparable to the earth, is there not an attenuation in ducted propagation?

Young: We do not think attenuation is very important, however the propagation constants and structure of the thin spherical shell of atmosphere surrounding the earth should be taken into account.

Ness: Is the instrument sensitive to earthquake generated sound disturbances? Does this affect the correlation of activity with magnetic field activity?

Young: Radiation from surface waves of very large earthquakes are occasionally recorded but this represents only a very very small proportion of the time.

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II-1A-P1. Hydromagnetic Picture of Earth Storms

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A description of the principal features of magnetic storms has been given in other papers in this proceedings. Therefore, rather than duplicating these other presentations, I will restrict my remarks to subsidiary topics not previously covered.

§1. Stability of the Interface between the Geomagnetic Field and the Solar Wind.

The sudden commencement and initial phase of a magnetic storm are usually attributed to the impact and pressure of solar plasma on the geomagnetic field. It is this period of time during which we can be relatively certain that an enhanced solar plasma is flowing past the earth. It is found, from an inspection of standard magnetometer records and ELF records, that the geomagnetic field at the earth's surface often is not particularly disturbed during the initial phase. On the basis of these observations it may be argued that the boundary between the geomagnetic field and solar wind is inherently stable since any large scale turbulence at the boundary would lead to the generation of hydromagnetic waves that could be detected at the earth's surface. If one wishes to contend that the surface is actually unstable but that the h.m. waves are attenuated before they reach the earth's surface, then a time dependent attenuation mechanism must be envoked, for sometimes the h.m. waves are seen at the earth's surface and sometimes they are not. In light of our present knowledge of the exosphere, such a time dependent attenuation seems quite improbable. Hydromagnetic waves may be generated by energy density fluctuations in the solar wind; the surface magnetometer records may be interpreted as indicating that the initial flow of solar plasma past the earth is smooth and several hours later becomes irregular and turbulent.

(The subject of the stability of the interface is discussed in more detail in a recent letter to the Editor: Dessler, 1961[1]) and in a rebuttal to this analysis by Coleman and

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Sonett, 1961[2].)

§ 2. Transient Fluctuations in the Geomagnetic Field.

It is my opinion that the most promising field of future geomagnetic research will be in the study of magnetic fluctuations with periods less than 10 min and greater than 0.1 sec. The aim of this research should be to determine how the magnetosphere oscillates and how charged particle and auroral effects contribute to short period geomagnetic activity. There are important geophysical effects that may be associated with these h.m. waves such as scattering of Van Allen belt protons (Dragt, 1961[3]) and h.m. heating of the ionosphere (Francis and Karplus, 1960[4]).

In order to unravel the various phenomena connected with the short period fluctuations, it will be necessary to handle enormous quantities of data. The most reasonable way to accomplish this data handling is to utilize computors: therefore, I would urge the experimentors to record their data in digital form. The analog form of data recording that is now widely used is almost impossible to analyse quantitatively. When data is in digital form, computors can be used to perform such tasks as making Fourier analysis, search for correlations between stations, correct for instrumental distortions, etc.

References

1) A. J. Dessler: *The stability of the interface between the solar wind and the geomagnetic field*, J. Geophys. Res. October (1961).
2) P. J. Coleman, Jr. and C. P. Sonett: *Note on hydromagnetic propagation and geomagnetic field stability*, J. Geophys. Res. October (1961).
3) A. J. Dragt: J. Geophys. Res. **66** (1961) 1641.
4) W. E. Francis and R. Karplus: J. Geophys. Res. **65** (1960) 3593.

Discussion

Singer, S. F.: Do you feel it is justified to use Alfvén velocity where you are dealing with a large amplitude wave or shock wave? Also how do you take account of the various wave modes which can exist in a magnetosphere which is anisotropic and birefringent?

Dessler, A. J.: If shock waves form, they will only be maintained far out where $\Delta B/B$ is large. As the wave approaches the earth $\Delta B/B$ falls off about as $1/r^4$, therefore the shock velocity can not modify our transit time results significantly.

We use only the isotropic mode which is the fastest h.m. mode.

Ratcliffe, J. A.: How far can it be accepted that h.m. waves can heat the atmosphere enough to produce the observed satellite drag?

Dessler: The evidence for h.m. heating is rather well founded in my opinion. Particularly in view of the fact that no acceptable alternative has been offered (see discussion by Nicolet elsewhere in these proceedings).

The theory of h.m. has been worked out in three independent papers that are in agreement (Dessler, Fejer, Francis and Karplus). A judgement of a fourth paper that disagrees with the previous three (Akasofu) is left to the critical reader.

However, until direct measurements are made of the h.m. wave amplitude above the ionospheric absorbing layer, the theory must remain in some doubt.

Vestine, E.H.: I should like to make the obvious comment that the way to settle the matter of the magnitude of hydromagnetic waves in the ionosphere. It is my impression that we have here the case of two theoretical workers arguing bitterly about the conclusions that can be drawn from non-existent data.

Dessler: As stated in my answer to Ratcliffe's question, I believe that the critical reader can easily conclude whose work is correct. Therefore, I have not felt the need to debate the soundness of my work on h.m. heating.

However, I agree with Dr. Vestine that it is very important to measure the magnetic fluctuation spectrum near 1 cps, above the F2 peak. In particular, the spectrum should be measured during a storm.

Carmichael, H.: May I have permission to make a sketch on the blackboard?

(Dungey "Granted") I wish to illustrate the well known phenomena in a cylindrical shock tube.

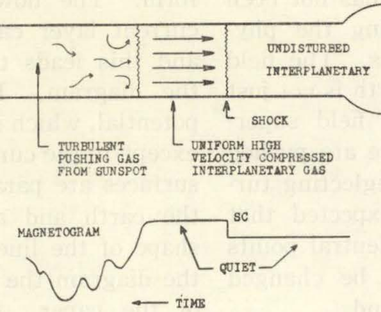

Fig. 1.

1. Is the parallel between the known shock tube phenomena and the magnetogram correct?
2. Is it also true that the pushing gas actually travels from the close vicinity of the sunspot to distances past the earth?

Dessler: 1. I believe so far the magnetograms I have shown. For other magnetic storms the situation may be more complicated.

2. Again, I believe so-your model may be taken as a simple extension of Parker's "Blast Wave" model (published in Astrophys. J., May, 1961).

Hessler, V.P.: Your presentation suggests that the pattern of the magnetic storm is determined by the structure of the solar corpuscular stream as it impinges upon the geomagnetic field. How then would one account for the similarity in form of the fine structure (10 to 20 minutes periods) of the storm which often repeats on a near 24 hour basis for two or three days?

Dessler: The phenomenon you describe may be due to a particular mode of oscillation of the magnetosphere becoming dominant for a few days. The structure in the solar wind would then be filtered by the magnetosphere; the dominant factor in determining what is seen at the earth's surface is the magnetospheric transfer function.

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II-1A-P2. The Interplanetary Field and Auroral Theory

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Most of the theoretical work on auroral problems omits any interplanetary magnetic field, though some time ago both Hoyle and Alfvén suggested that it plays a vital part. An attempt will be made here to predict what would happen, if there were an approximately southward interplanetary field, and it will be seen that the model appears to fit some of the observed phenomena.

In the model there is an interplanetary plasma wind, whose velocity relative to the earth is assumed to lie nearly in the ecliptic plane, and for the sake of drawing a diagram it is assumed to be coplanar with interplane-