COLLISIONLESS SHOCK WAVES

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PART I
A GENERAL REVIEW

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RELEVANCE OF SHOCK STUDIES

1.1. Occurrence of shocks

The first upsurge of interest in plasma shock waves was stimulated by the possibility of heating ions rapidly to thermonuclear temperatures. Under these conditions the plasma and the shock would necessarily be free from classical binary collisions, that is collisionless. More recently, however, interest has centred on geophysical and astrophysical phenomena, in which the same collisionless conditions prevail.

A shock is produced by the rapid compression of a plasma and it necessarily results in energy dissipation, that is in irreversible plasma heating. The non-classical heating mechanism involved in collisionless shocks has attracted much theoretical interest.

In the laboratory collisionless shocks have been observed in various experiments. The pinch effect is frequently used to compress an initial plasma, and consequently to generate a cylindrically imploding shock. Non-cylindrical pinches, such as occur in very short pinch tubes, toroidal pinches, plasma guns and plasma focus devices also produce shocks. These various pinch devices are used in fusion research and as sources of electromagnetic and neutron radiation. Simulation of geophysical shocks has been performed in a plasma wind tunnel driven by a special arc source. Some early plasma shock studies were performed using electromagnetic shock tubes of both "T" and annular geometry.

In the field of geophysics, satellite observations have shown that the earth's magnetosphere is embedded in a supersonic flow of plasma from the sun, but protected from it by a collisionless bow shock, as shown in Fig. 1. Such observations have also demonstrated the correlation between terrestrial magnetic storms and interplanetary shock waves travelling through the
Fig. 1. Schematic of magnetospheric bow shock.

Fig. 2. Interplanetary shock observed by VELA 3A satellite and at Guam on the earth, January 19-20th 1966.