SCIENCE

Physics of the Atmosphere

THE earth's atmosphere has been examined closely only during the past several centuries. In 1714 Halley stated, "The theory of the air seems now to be perfectly well understood, and its different densities at all altitudes, both by reason and experiment, are sufficiently defined." At that time it had been concluded that the atmosphere was about 70 km in extent and that it became rarer and colder with increasing altitude. Dalton's treatise (1793) *On the Atmosphere; its Constitution, Figure, Height, etc.* criticized the twilight technique for determining the thickness of the atmosphere and determined a relationship (that is approximately correct up to the tropopause) for the temperature decrease with altitude. In 1749 kites were utilized to study the atmosphere above the surface; however, the use of free balloons languished until 1892. Subsequent balloon flights revealed the isothermal region which de Bort termed the "stratosphere." In 1880 Hartley correctly ascribed the absorption bands, which limit atmospheric transparency near 2950 A, to ozone. A study of geomagnetism permitted some of the earliest inferences regarding the electrical state of the high atmosphere. Gauss, in 1839, wrote that the "mysterious phenomena of the aurora . . . forbid us to deny outright the possibility of [electric] currents" in the high atmosphere. Stewart's work (1878), seeking to clarify geomagnetic variations by atmospheric events, was quantitatively extended by Schuster (1889). Marconi's transatlantic radio transmission led to Kennelly's and Heaviside's independent suggestion (1902) of the existence of the ionospheric layers, but experimental proof was lacking until 1925.

Below 100 km the temperature varies between 200° and 300° K, rising to a maximum of about 3900° K (summer) near 400 km. Molecular oxygen dissociates in the vicinity of 100 km or perhaps slightly higher, but the state of nitrogen is controversial; both oxygen and nitrogen, however, probably extend to the exosphere. Auroral observations suggest the presence of ionized molecular nitrogen to 1000 km. The diffusive separation of the atmospheric gases has been recognized to be a complex, three-dimensional problem of diffusion in a heterogeneous mixture having sources and sinks, and being further complicated by the presence of ions in a magnetic field. Large-scale wind circulation, turbulence, and tidal oscillations are found in the high atmosphere. The profound distortions of long-enduring meteor trains, indicative of violent motions in the altitude range 70–140 km, have long been known. Cloudlike patches, either of high electron density or of concentrated turbulence, exist near 100 km; these patches of sporadic E move rapidly at speeds of about 200 km/hr. Radio probings of each of the ionospheric layers indicate comparable speeds, with diurnal and seasonal variations.

The fascinating luminosities of the aurora are being coaxed not only to provide information with respect to atmospheric temperature and constituents, but also to yield data on the nature and energy of the particles (presumably of solar origin) bombarding the earth's atmosphere. Meinel's remarkable observations, already confirmed, demonstrated that protons entering the atmosphere at speeds of 10^8 cm/sec accompany some types of auroral displays.

Notwithstanding the progress already made, research on the high atmosphere is still in its infancy. Much work remains to be done on cross sections for collision and energy absorption, on the origin of magnetic variations, on the formation of the aurora, on the constituents present, on innumerable photochemical reactions possible, etc. Knowledge of these factors will enable us better to predict the changes to be expected in the high atmospheric regions.

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