Missiles and Spaceflight

Space Congress Ends

AMONG the most important obvious results of the tenth congress of the International Astronautical Federation, which ended in London on September 5, were the proposals for an academy of astronautics under Dr. Theodore von Karman (reported last week); for an international institute of space law; and for a permanent headquarters for the Federation itself. Less apparent except to the 650 delegates, but equally important, was the international interchange of experience and ideas which such a meeting makes possible.

Among the delegates from overseas there was strong U.S. participation—from government agencies, research establishments and private companies, all of whom have space and its applications as their daily business. By contrast, British representation was for the most part confined to the enthusiasts of the British Interplanetary Society, and members of a few companies wishing to get into the space act: officials of the Ministry of Supply, for example, seemed conspicuous by their absence and, by implication, indifferent to the arguments for space research which had been put forward by their own Minister on the opening day of the congress.

After a day spent away from the lecture hall, on an excursion to Windsor and a river trip on the Thames, delegates returned on Friday, September 4, to further technical sessions at Church House and also to a simultaneous colloquium on space law held at Lincoln's Inn (this colloquium is reported on the opposite page). Final papers were read on the Saturday, and it was at a morning business session of the Federation on this day that Prof. K. Zarankiewicz collapsed and died while acting as chairman. Prof. Zarankiewicz was a member of the Committee for Astronautical Studies of the Polish Academy of Sciences, and was a well-known author of technical papers.

The new president elected by the Federation is Prof. L. Sedov of the Soviet Union. Vice-presidents comprise Ake Hjertstrand (Sweden), Col. John Stapp (U.S.A.), Dr. Eugen Sänger (Austria), Gen. J. P. Bergeron (France) and Dr. L. R. Shepherd (Britain). The proposal that the Federation should study plans for the establishment of a permanent headquarters was made by Mr. Hjertstrand and was adopted unanimously; Paris is believed to be the probable location. Next year's I.A.F. congress will be held in Stockholm.

At a congress dinner at the Dorchester Hotel on Saturday evening, September 5, a tribute to "the growing stature" of the Federation was paid in a speech by Dr. Hugh Dryden, the deputy administrator of the U.S. National Aeronautics and Space Administration. Mr. Andrew Haley, the I.A.F. president, recalled the formation of the Federation ten years ago and, emphasizing the essential internationalism of the movement, said that the freedom of cosmic space must be the main objective. The deep regret of all delegates at the untimely death of Prof. Zarankiewicz was voiced by Mr. Haley.

Other speeches at the dinner were made by Dr. Shepherd, B.I.S. chairman, who also stressed that the development of spaceflight must be an international affair; and by Mr. Hjertstrand, past chairman of the Swedish Interplanetary Society, who assured everyone of a hearty welcome at Stockholm in 1960.

Ten of the papers presented at the congress were summarized in last week's issue, and further abstracts are given on this page, preceding the report of the space law colloquium.

Determination of Air Density and the Earth's Gravitational Field from the Orbits of Artificial Satellites, *by D. G. King-Hele of the Royal Aircraft Establishment, Farnborough:* This paper presents methods for evaluating air density, scale height and average wind speed in the upper atmosphere from changes in the orbits of artificial satellites. The oblateness of the Earth and atmosphere, tumbling of the satellites and the rotation of the atmosphere are all taken into account.

The methods are applied to the ten satellites launched in 1957 and 1958 whose orbits are known in order to determine average air density at heights between 200 and 400 km. The results indicate that density decreases from 4.3×10^{-13} gm/c.c. at 200 km to 7.1×10^{-15} gm/c.c. at 400 km. Variations in air density are also determined, and these reveal maximum values at remarkably regular intervals of 28 days, implying an association with solar effects.

Scale height and air temperature cannot be determined with as great an accuracy as density, but the average scale height between 200 and 400 km is probably about 50 km and the average temperature about 1,000 deg K. Observed changes in the orbital inclination of Sputniks 2 and 3 suggest that the average wind at heights of 200-400 km is from west to east.

Determination of Atmospheric Density at an Altitude of 430 km by the Sodium Vapour Diffusion Method, *by I. S. Shklovsky and V. G. Kurt (U.S.S.R.):* In order to confirm the recent air density observations derived from the braking of Soviet and American satellites in the altitude range of 270-750 km, the analysis of the diffusion of sodium vapour emitted from rockets is proposed. This method was originally suggested by Bates and several American experiments were made at comparatively low altitudes (75-140 km).

The first experiment of this type in the upper atmosphere was made on September 19, 1958. When the Soviet rocket reached 430 km at the height of its trajectory the programmed ignition of thermite caused the ejection of sodium vapour from two vaporizers containing 2 kg of metallic sodium each. The sodium vapour cloud, lit by the rays of the sun above the earth shadow, was photographed and the photographs were analysed by the standard astrophysical method. The atmospheric temperature was estimated as more than 1,600 deg K from the accepted basic constituent—atomic oxygen.

The density figures obtained by this method, which can be used up to 500-600 km, were compared with the data from satellite braking and are shown to be between 10^{-14} and 10^{-15} gm/c.c. at 430 km altitude.

Multi-Directional g-Protection during Experimental Sled Runs, *by Harald J. von Beckh (Aeromedical Field Laboratory, Air Force Missile Development Center, Holloman Air Force Base):* The author described at the eighth I.A.F. Congress a device termed "Anti-g Capsule" which would protect a human operator or a test animal against high g-loads during space and atmospheric flight. This capsule is pivoted about the lateral axis of the craft and automatically assumes a position such that the resultant of all acting accelerations is perpendicular to the heart-head line of the subject. The ejection and stabilization mechanism of this capsule would also afford an analogous g-protection during and after escape from a disabled space vehicle within the lower layers of the atmosphere.

For testing this g-protection principle an "Anti-g-platform" was designed and mounted on catapult-driven and rocket-driven sleds. This platform consists of an aluminium sheet in the form of an isoceles triangle. Its basis is adapted to tie down a rat measuring up to 7.5in. This triangular platform was pivoted on its apex by a vertical axis which was fixed on the structure of the sled, and allowed free rotation.

Before the firing, an albino rat was tied down parallel to the base of the platform and brought in a head-forward position. The control animal was tied down in a non-movable wire netting cage in an identical head-forward position. The g-loads of the acceleration act, therefore, on the unprotected control animal in head-tail direction and those of the decelerative phase in tail-head direction. The anti-g platform, however, swings back with the onset of the acceleration. In this way the animal avoids the longitudinal g-load and receives the rest of the load in a direction transverse to spine.

On the other hand, it could be shown that during re-entry the decelerations in the longitudinal direction of the operator would be minimized. The position of the capsule at the beginning of deceleration has little influence on the protective effect.

Recent Developments and Designs of the Ion Rocket Engine, *by R. H. Boden (Rocketdyne Division of North American Aviation):* Recent developments of ion rocket engines have proceeded rapidly in the last two years under research programmes sponsored by the Air Force Office of Scientific Research. In order to understand the trend of this progress a brief summary of the basic relationships governing the operation of electrical propulsion systems are summarized.

The cross-sectional area of the engine is estimated by considering a flat-plate electrode configuration and the modifications imposed on this idealized situation by the presence of an aperture through which ions are emitted.

The relationship of engine design, vehicle design, and the mission results from the characteristic velocity required to accomplish the objective. Methods of mission analysis are referenced, but not discussed in detail. These methods result in characteristic velocity requirements which in turn establish the specific impulse or exhaust velocity the engine must develop.

The specific impulse cannot be arbitrarily chosen if the maximum payload is to be transported in the vehicle. The variation of the payload with specific impulse is demonstrated with some typical examples. The overall variation depends upon the weight of the vehicle per unit power developed and the efficiency of conversion of primary energy into directed kinetic energy in the exhaust jet. The analytical relationship among the characteristic velocity, weight per unit power of the vehicle, efficiency and the specific impulse to obtain maximum payload is graphically presented. The maximum payload for a mission accomplished with an electrically powered vehicle is estimated from these data.

The characteristic velocity of the mission also determines the operating time of the electrical rocket engine. In general it is desirable to use as low a specific impulse powerplant as possible in order to reduce the operating time; however, the operating time is also dependent upon the thrust-to-weight ratio of the vehicle. This ratio depends on the capability of the vehicle to generate adequate amounts of power. The limiting thrust-to-weight ratio has been summarized graphically for several types of vehicles including ion, plasma, and chemical rockets and modern aircraft. Comparative maximum payloads of chemical and ion rockets are presented in terms of the mission characteristic velocity.

The experimental programme and techniques for verifying these analyses on a specific type of ion rocket engine conceived at Rocketdyne are presented. The experiments are conducted in high-vacuum environments. The ion thrust chamber discussed in this paper uses electrostatic acceleration of ions generated from surface contact ion sources. Preliminary evaluation of the results of the programme indicate that a flyable prototype engine can be produced within a few years under the impetus of a progressive development programme.