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SHOCK WAVE FROM A RELEASE OF GAS AT 230 KM ALTITUDE

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An ESRO experiment consisting of the payload S 18 launched with a Skylark rocket from the Salto di Quira launching site in Sardinia at evening twilight on 13 July 1966 was observed, from a ground station based at Nuraxi de Mesu, with spectrographic and photographic equipment. The nose cone and a tank containing ammonia prepared by the Institut d'Astrophysique de l'Université de Liège were exploded at 230 ± 4 km altitude when the solar depression angle was 10°. A shock wave was formed which was expanding rapidly and remained visible for 75 sec. This wave is shown in fig. 1 at two successive stages of expansion. These pictures are reproduced from a 16 mm Kodak 2475 film taken at 9.78 frames per second, with an objective opening of f/1.4 and a focal length of 2.520 cm. The phenomenon was observed in the North East direction at an elevation of $58^{\circ}54'$. The line of sight was making an angle of 71° with the sun rays. The diameter of the wave is plotted versus time in fig. 2. Three typical phases of a shock wave generated in the atmosphere can be distinguished and are probably related to the phases described by Groves [1]. The ambient gas is first swept at a very high speed by the explosion. The high pressure region formed is then pushed towards the low pressure region. During that period the expansion has no spherical symmetry as shown in fig. 2 where the smallest and the largest dimensions have been plotted. Finally, between the 7th and 8th second the wave moves freely in the atmosphere at the velocity of sound. The increase of speed which seems to appear after the 12th second might be due to a diffusion process or simply to the difficulty of the measurements when the image density becomes small.

The spectrum of the emitted light was obtained on Kodak I-N plates by imaging the glow on the entrance slit of a Huet C1 type spectrograph. During the first ten seconds and also later it displays the characteristic features of the twilight spectrum. This indicates that most of the luminosity has to be attributed to scattered sunlight.

The speed of the shock wave can be related with the atmospheric temperature as has already been mentioned by Sheppard [2]. Using 22 a.m.u. for the mean molecular mass, 1.4 for the ratio between specific heat at constant pressure and at constant volume and a radial speed of the shock wave of 6.27×10^{4} cm sec^{-1} represented by the full line in fig. 2, one obtains a temperature of 743°K at 230 km altitude. A difference of 3% in temperature represents a difference in speed shown by the dotted lines. Taking into account the uncertainties in the measurements, in the evaluation of the altitude and of the mean molecular mass, the most probable error in this temperature determination appears to be ±5%.

On 13 July, the 10.7 cm solar flux reached a value of 99×10^{-22} W m^{-2} (cycle/sec)$^{-1}$ and the 27 days mean value was of the order of 102×10^{-22} W m^{-2} (cycle/sec)$^{-1}$. According to Nicolet's [3] analysis, such a flux corresponds to an isothermal nighttime temperature of (788 ± 26) $^{\circ}$K which leads to a temperature of about (760 ±25)$^{\circ}$K at 230 km.

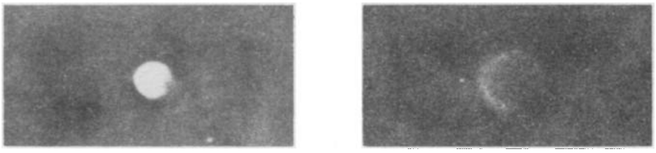

Fig. 1. The wave 5.33 and 10.71 sec after the explosion.

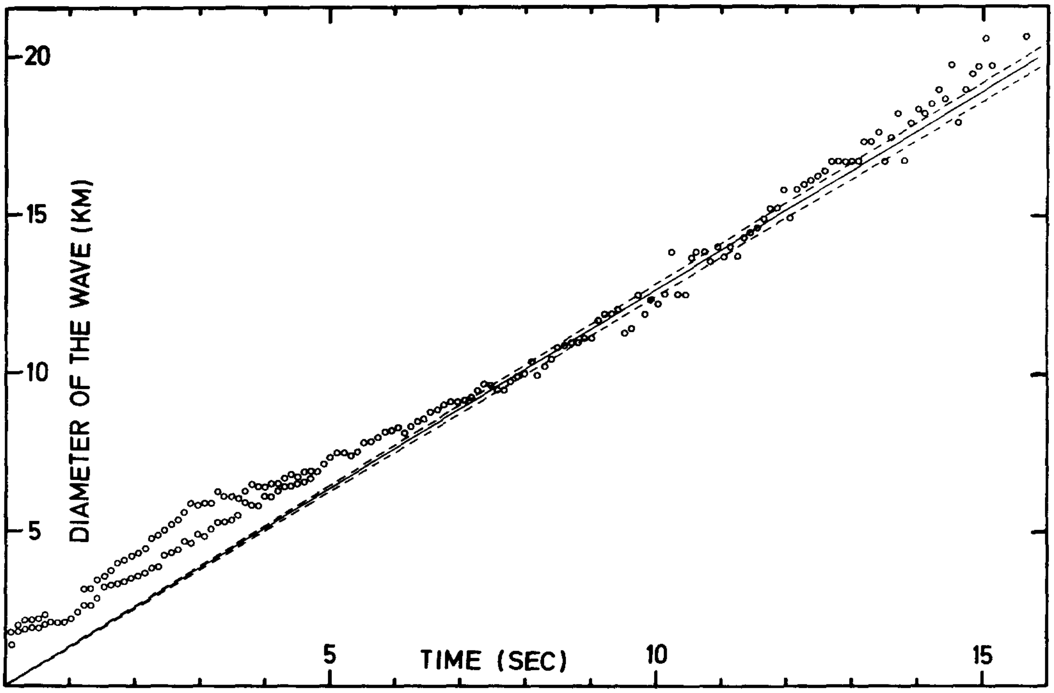

Fig. 2. Diameter of the wave versus time.

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