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GREENBELT, MARYLAND

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INTERACTIONS BETWEEN A HYPERSONIC NEUTRAL GAS BEAM AND AN ORIFICED PRESSURE GAUGE MOUNTED IN A SPINNING SATELLITE

The data from the atmospheric density experiment flown on the Explorer 32 aeronomy satellite allowed comparison of kinetic theory predictions of orificed chamber pressures with pressures measured by orificed, cold-cathode, magnetron gauges. The two gauges were of different geometries and constructed from different materials [1]. The satellite was spin stabilized with a nominal two second spin period, and the spin equator was maintained nearly co-planar with the satellite orbit plane. The gauges were mounted on the spin equator and maximum pressures were observed when the atmospheric gas particles beamed directly into the gauges. Minimum pressures were observed each time the chamber orifices looked into the rarefaction region behind the satellite. Two typical gauge pressure variations are shown in Figures 1 and 2.

The maximum and minimum gauge pressures at the satellite perigee (280 km altitude) were near 10^{-6} and 10^{-8} Torr respectively. Near apogee (2700 km altitude) no spin modulations of the gauge pressures were observed, instead constant pressures near 10^{-9} Torr for the GCA gauge and 10^{-10} Torr for the NRC gauge were measured. The apogee gauge pressures resulted from desorption of gas from the gauge internal surfaces.

Theoretical predictions of gauge pressures as a function of angle of attack were compared to the measured pressures after the local rarefaction pressures (assumed to be due to desorption) were subtracted from the data. One theory [2] is for an ideal orificed chamber. The second theory [3] takes into consideration the internal geometry of the chamber and gas-surface interactions of the entering particles with the internal gauge surfaces. The comparisons were made by taking the ratios of measured pressure to theoretical pressures calculated for a speed ratio of 8 (ratio of satellite speed to most probable thermal speed). The results are plotted versus angle of attack in Figure 3. The curves shown in Figure 3 are representative of results obtained throughout the satellite operational lifetime of 9 months. These curves appear to be valid for maximum pressures in the range 10^{-6} to 5×10^{-8} Torr. The error in the ratios in Figure 3, to be used when comparing values on the same curve or between one pair of curves, is believed to be

less than or equal to ±6%, including theoretical calculational accuracy and experimental precision. The ordinates in Figure 3 contain an undetermined scaling factor which is the same on all graphs. If the theory and parameter values used to calculate a ratio curve correctly described the measurements, then that curve in Figure 3 would be a horizontal line.

Assuming the theoretical model is correct, it is suggested by Figure 3C that the incoming particles do not all make one specular collision, a result in agreement with Monte-Carlo calculations [4] for these and similar instruments [5] Figure 3D shows that the inclusion of an adsorption probability of 0.01 causes large changes in the ratios, in such a way as to diminish the agreement between the measured and theoretical values. It can be preliminarily concluded that the theoretical results of Pearl and Vogel which assume no specular collisions and no adsorption most nearly describe the measurements. This, however, implies that the values of atmospheric density determined by these instruments should be decreased by between 20% and 35%. Further studies of the combined effects of specular reflection and adsorption are in progress.

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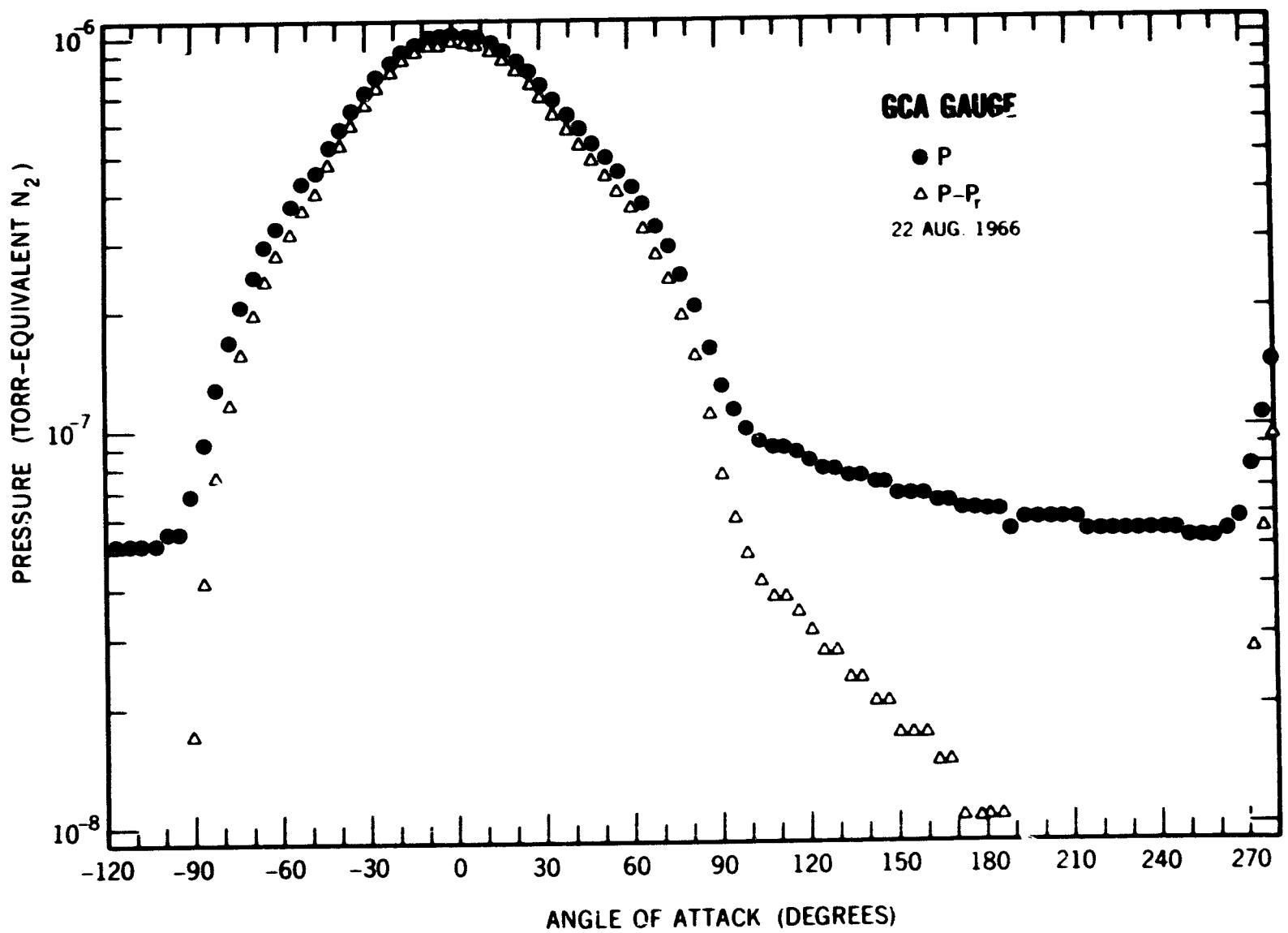

Figure 1.–Measured gauge pressure (P) and gauge pressure minus local rarefraction pressure ($P - P_r$) versus angle of attack for GCA gauge.

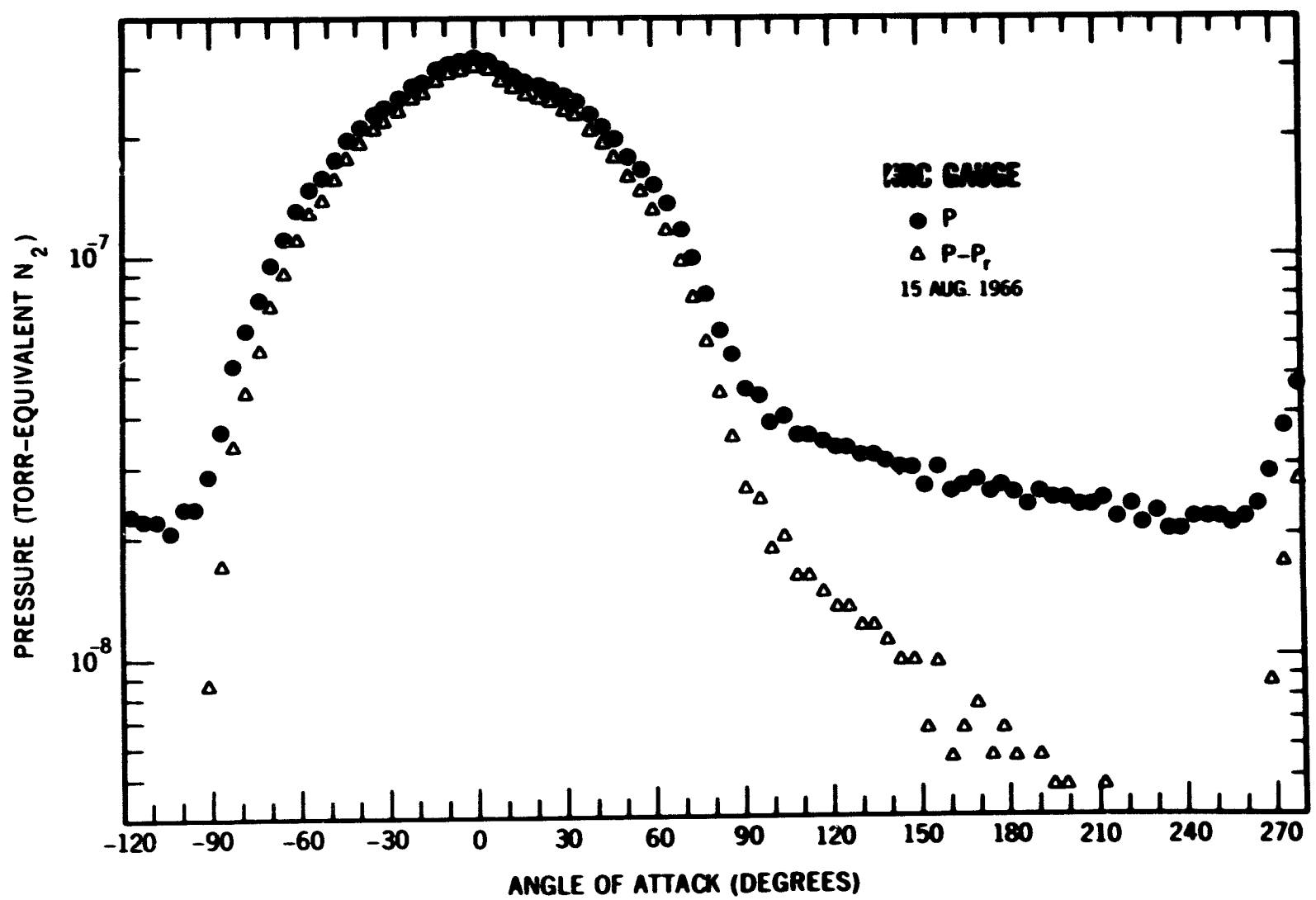

Figure 2–Measured gauge pressure (P) and gauge pressure minus local rarefaction pressure ($P - P_r$) versus angle of attack for NRC gauge. The structure near -20° angle of attack results from an instability in the magnetron gauge discharge.

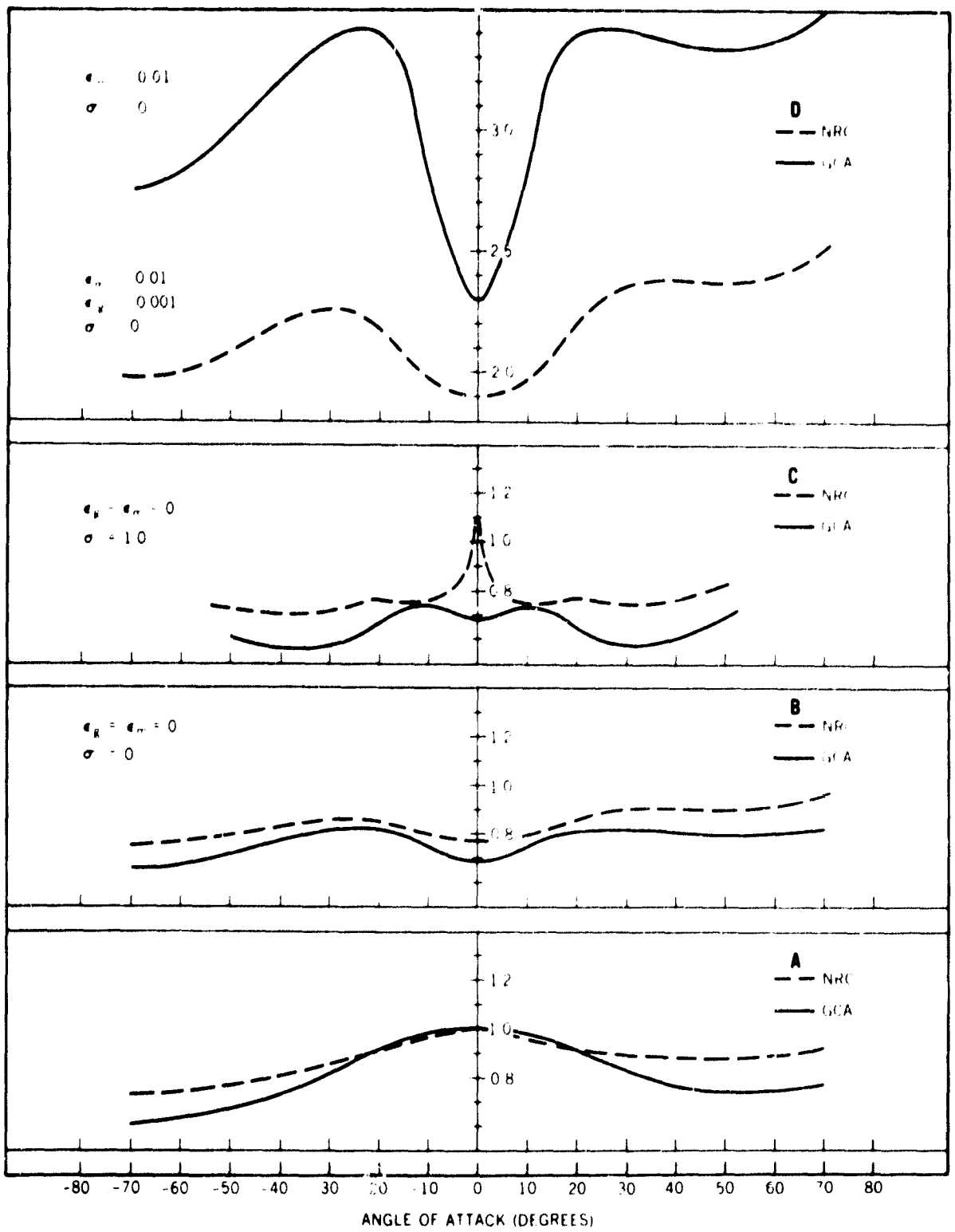

Figure 3–Ratios of measured pressure minus local rarefaction pressure ($P - P_r$) to theoretical gauge pressure versus angle of attack. 3A, theoretical values after Spencer, et. al. 3B, 3C and 3D theoretical values after Pearl and Vogel. ϵg and ϵm are the fractions of particles adsorbed on each surface collision for glass and metal respectively. σ is the fraction of particles specularly reflected on the first surface collision. All ordinates have the same scale factor and are in the same arbitrary units.