west in about 3 sec. There were scattered clouds. It seems possible that this was the sighting of a meteor seen through thin clouds producing the soft, yellow-glow effect. In any event, the description does not correspond with the simultaneous radar track of the first UFO.

With visibility of 50 mi. it seems strange that the scrambled aircraft could not sight either of the UFOs. The Air Force report comments:

> It is believed that due to radar units being slightly off calibration and due to delay in communication, interceptors did chase their own tail or were sent to intercept themselves.
>
> It is also believed that the majority of the radar plots were legitimate unidentified objects.
>
> The preparing officer knows of no object which flies at 275 knots, that could remain in the Canal Zone area for nearly six hours, maneuver from 1000 through 28,000 feet altitude, make no sound, and evade interception.

In fact, it is difficult to imagine any material object that could accomplish all these feats. The strange radar tracks were probably the product of anomalous propagation conditions, an hypothesis that would account for the facts above. The atmospheric conditions were certainly favorable for AP, as can be seen from the A-profiles in Figs 24 and 25. However, there are two considerations that argue against this hypothesis.

(1) The targets tracked behaved in a more rational, continuous manner, and covered a greater altitude range, than AP echoes of the type usually observed;

(2) If they were AP echoes, should these targets have appeared at not only 1806-2349 LST but around 1000 LST when the profile was obviously more favorable for AP than the 2200 LST profile?

Despite these two contradictions to the AP hypothesis, the lack of any visual corroboration of the two UFOs makes any other

hypothesis even more difficult to accept. This case therefore seems to fall, albeit inconclusively, into the classification of probable AP radar returns.

Case 21. Colorado Springs, Colo., 13 May 1967, 1540 LST (1640 MDT). Weather: overcast, cold, scattered showers and snow showers (graupel) in area, winds northerly about 30 mph., gusts to 40 mph., visibility fair -- more than 15 mi. (Colorado Springs airport is not horizon-limited; visibilities of 100 mi. are routinely reported on clear days). This is a radar-only case, and is of particular interest because the UFO could not be seen, when there was every indication that it should have been seen.(See Section IV).

From the time the UFO was first picked up on radar to the time the Braniff flight touched down on runway 35, the UFO track behaved like a ghost echo, perhaps a ground return being reflected from the aircraft. This is indicated by the fact that the UFO blip appeared at about twice the range of the Braniff blip, and on the same azimuth, although the elevation angle appears to have been different. When Braniff touched down, however, the situation changed radically. The UFO blip pulled to the right (east) and passed over the airport at an indicated height of about 200 ft. As pointed out by the FAA, this is precisely the correct procedure for an overtaking aircraft, or one which is practicing an ILS approach but does not actually intend to touch down. Although the UFO track passed within 1.5 mi. of the control tower, and the personnel there were alerted to the situation, the UFO was not visible, even through binoculars. A Continental Airlines flight, which was monitored 3-4 mi. behind the UFO at first contact, and was flying in the same direction, never saw it either.

Both the PAR and ASR radar transmitting antennas are located to the east of runway 35, and they are about 1,000 ft. apart on a SW-NE line. A ghost echo seems to be ruled out by at least the following considerations:

(1) A ghost echo, either direct or indirect, normally will not be indicated at a height of 200 ft. while the ghost-producer is on the ground, as was the case here:

(2) A direct ghost is always at the same azimuth as the moving target, and an indirect ghost is on the same azimuth as the fixed reflector involved. (See Section VI Chapter 5). If an indirect ghost were involved here, the ghost echo would thus have always appeared well to the east of Braniff, not at the same azimutn.

The radar flight characteristics of the UFO in this case were all compatible with the hypothesis that the unknown was a century-series jet (F100, F104, etc.), yet nothing was ever seen or heard.

This must remain as one of the most puzzling radar cases on record, and no conclusion is possible at this time. It seems inconceivable that an anomalous propagation echo would behave in the manner described, particularly with respect to the reported altitude changes, even if AP had been likely at the time. In view of the meteorological situation, it would seem that AP was rather unlikely. Besides, what is the probability that an AP return would appear only once, and at that time appear to execute a perfect practice ILS approach?

Case 35. Vandenberg AFB, Lompoc, Calif., 6-7 October 1967, 1900-0130 LST. Weather: clear, good visibility, strong temperature inversions near the surface caused by advection of very warm (80°-90°F), dry air over the cool ocean surface (water temperature 58°-59°F). This sighting begins with an apparent mirage (of a ship probably 60 mi. beyond the normal horizon) and continues with a very large number of unknown targets that were found on tracking radars which were being used in a search mode (they normally are not used in this way). The project case file contains a good analysis of the probable nature of the radar targets, some of which were apparently birds and some apparently ships tracked at 80 mi. ranges as well as other AP-like returns that may have been associated with local intensification of the ducting layer. The nature of the visual objects is not as clear, although at least two of them appear to have been superior mirages of ships beyond the normal horizon. There were possibly some meteor sightings involved.

The meteorological conditions were quite interesting. The warm, dry air was apparently quite close to the water surface, at least in places. Data from Vandenberg and San Nicholas island indicate that in places the inversion was no thicker than about 90 m. (10 mb pressure difference). The contrast that may have existed can be calculated from these data:

		At or Near Sea Surface:	At 90 Meters or Less:
Pressure:		1004 mb	994 mb
Temperature:	°F:	58°F	90°F
	°C:	14°C	32°C
	°K:	287°K	305°K
Optical N (5570Å)		275 (ppm)	256 (ppm)

The optical refractive index gradient that may have existed at the time was therefore on the order of -210 ppm. km^{-1}, or a somewhat greater negative value, depending upon the thickness chosen for the layer. The value above is computed as (256-275) /0.090, based on the 90 m. maximum thickness assumed. Since the critical value of the gradient for a superior mirage is -157 ppm. km^{-1}, it is quite apparent that the conditions required for the formation of extended superior mirages were most likely present on the date in question.
The only problem with this explanation is the reported elevation angle of 10°, but as pointed out in the conclusions to this chapter such estimates by visual observers are invariably over-estimated by a large factor.

In summary, the conclusions arrived at by the investigators in this case seem to be adequately supported by the meteorological data available.

The sighting reported for 12 October 1967, 0025 LST, seems to be a classic example of the description of a scintillating, wandering star image seen through a strong inversion layer. Note particularly the estimated ratio of vertical and horizontal movements. Two very bright stars would have been close to the horizon at this time: Altair, magnitude 0.9, would have been at 277° azimuth and about 4° elevation angle; Vega, magnitude 0.1, would have been at about 313° azimuth and about 12° elevation angle. Of the two, Altair seems the more likely target because of the smaller elevation angle; the observers gave no estimate of either azimuth or elevation angle.

3. Summary of Results.

A summary of the results of this investigation is given in Table 1.

The reader should note that the assignment of cases into the probable AP cause category could have been made on the basis of the observational testimony alone. That is to say, there was no case where the meteorological data available tended to negate the anomalous propagation hypothesis, thereby causing that case to be assigned to some other category. Therefore, a review of the meteorological data available for the 19 probable-AP cases is in order.

(1) Every one of the 19 cases is associated with clear or nearly clear weather. In 15 cases weather is described as "clear and visibility unlimited" (CAVU), in many of these "exceptional visibility" is noted; in four cases the weather is "generally clear," with some scattered clouds, or a "high, thin broken" condition (usually meaning cirriform clouds). Such weather is indicative of stable atmospheric conditions that are favorable for the formation of layered, stratified

Table 1

Frequency of Occurrence of Most Probable UFO Causes

Class	Most Likely or Most Plausible Explanation				Class
	Anomalous Propagation	Man-Made Device	Unknown	No UFO	Total
I-A	6	1	2	0	9
I-B	2	1	0	0	3
I-C	1	0	1	0	2
I-D	0	4	2	0	6
All Class I	9	6	5	0	19
II-A	6	0	0	0	6
II-B	4	2	2	1	9
All Class II	10	2	2	1	15
All Classes	19	8	7	1	35

refractive index profiles, i.e., they are conducive to anomalous propagation effects. The *a priori* probability of such a result, from a truly random sample of dates-times-places is roughly on the order of one chance in 200,000 (assuming that the probability of clear weather is roughly 0.5 in any single case).

(2) Of the 19 cases, all but two occur during the night. Although AP often occurs during the daytime, the nighttime hours are generally more favorable, and tend to greatly increase the *a priori* probability of encountering AP.

(3) In the 11 cases for which pertinent meteorological data are available, in every case the refractive index profile is favorable, to a greater or lesser degree, for the presence of anomalous propagation effects. The weakest case, the data for Silver Hill, 19 July 1952, (see p. 47), where inadequacies in the data were pointed out, has a near-super-refractive surface layer (gradient -81 ppm. km^{-1}) and an elevated subrefractive layer. Of the remaining 11 profiles, seven showing decting gradients (-157 ppm, km^{-1} or greater negative value) and four show super-refractive gradients (-100 to -157 ppm. km^{-1}). Since the *a priori* probability of the occurrence of such profiles is on the order of 0.25 (Bean, 1966b), the *a priori* probability of this result, given a truly random sample, is on the order of one in 10^6.

In overall summary of these results, as they pertain to anomalous propagation of radio or optical waves, it seems that where the observational data pointed to anomalous propagation as the probable cause of an UFO incident, the meteorological data are overwhelmingly in favor of the plausibility of the AP hypothesis. That this result could have been only coincidental has been shown to be only remotely probable.

4. Conclusions and Recommendations for Further Work

The following conclusions can be stated as a result of the investigation reported in this chapter:

(1) Anomalous Propagation (AP) effects are probably responsible for a large number of UFO reports in cases involving radar and visual sightings.

(2) There are two common patterns that are evidenced in radar-visual cases involving anomalous propagation effects:

(a) Unusual AP radar targets are detected, and visual observers are instructed where to look for apparent UFOs and usually "find" them in the form of a star or other convenient object.

(b) Unusual optical effects cause visual observers to report UFOs and radar operators are directed where to look for them. As above, they usually "find" them, most often in the form of intermittent AP echoes, occasionally of the unusual moving variety.

(3) In radar-visual UFO sightings there is a pronounced tendency for observers to assume that radar and visual targets are correlated, often despite glaring discrepancies in the reported positions. There is a perhaps related tendency to accept radar information without checking it as carefully as the observer might normally do; hence errors are promulgated such as, direction of UFO movement confused with the azimuth at which it aas observed on the radar scope, and UFO speed reported that is grossly at variance with plotted positions at times (both of these effects are well illustrated in Case 93-B).

(4) There is a general tendency among even experienced visual observers to grossly over-estimate small elevation angles. Minnaert (1954) states that the average "moon illusion" involves a factor of 2.5-3.5. The results of the present investigation imply that objects at elevation angles as small as 1° are estimated to be at angles larger than the true value by at least this factor or more. Interestingly, all of the elevation angles reported of visual objects in the cases examined in this chapter, not a single one is reported to be less than 10°. The fact that radar may subsequently "see" the UFOs at angles of only 1° to 4° seems not to bother the visual observers at all; in fact when the visual observers report apparent

height-range, these values often turn out to be equivalent to elevation angles of only a degree or two. There seems to be a sort of "quantum effect" at work here, where an object must be either "on the horizon" (i.e., at 0°) or at an elevation of greater than 10°.

(5) There are apparently some very unusual propagation effects, rarely encountered or reported, that occur under atmospheric conditions so rare that they may constitute unknown phenomena; if so, they deserve study. This seems to be the only conclusion one can reasonably reach from examination of some of the strangest cases (e.g., 190-N, 5 and 21).

(6) There is a small, but significant, residue of cases from the radar-visual files (i.e., 1482-N, Case 2) that have no plausible explanation as propagation phenomena and/or misinterpreted man-made objects.

A number of recommendations for future UFO investigative procedures are indicated by the results of this chapter:

(1) In any investigation of a UFO report, extremely careful efforts should be made to determine the correct azimuth and elevation angles of any visual or radar objects, by "post mortem" re-creation of sightings if necessary. This information is probably more useful in analysis of the case than the description of the objects or targets.

(2) Reported speeds and directions of UFOs, especially of radar UFOs, should be carefully checked (again, "post mortem" if necessary) and cross-checked for validity. This information is also often critical for subsequent analysis.

(3) Every effort should be made to get the most comprehensive and applicable meteorological data available for an UFO incident as quickly as possible. Many types of weather data are not retained permanently, and it is difficult or impossible to retrieve the appropriate

data for a sighting months or years after the fact. Copies of original radiosonde recordings should be obtained for the closest sites, since these may be analyzed in more detail than that routinely practiced by weather bureaus for synoptic purposes. It should be emphasized that, for example, a nighttime profile is usually more germane to a nighttime sighting than is a daytime profile. For example, if an UFO incident occurs at 2100 or 2200 LST, an 0600 LST (next day) raob will generally be more pertinent to the propagation conditions involved than will an 1800 LST raob. The converse is also true.

(4) Any field team investigating UFO reports and seeking to explore all radio/optical propagation aspects of the sighting (a highly desirable goal), should be equipped with the following personnel as a minimum:

(1) An expert on the unusual aspects of electromagnetic wave propagation, at both radio and optical wave lengths;

(2) An expert in the interpretation and theory of radar targets, who is acquainted with all types of anomalous propagation and other spurious radar returns;

(3) An expert with wide experience in the physiology and psychology of human eyesight, and familiarity with optical illusory effects, etc.;

(4) A meteorologist, with specialized experience in micrometeorology-climatology, mesoscale meteorology, and atmospheric physics.

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Chapter 6

Visual Observations Made by U. S. Astronauts

Franklin E. Roach

Astronauts in orbit view the earth, its atmosphere and the astronomical sky from altitudes ranging from 100 to 800 + nautical miles (160 to 1300 km.) above mean sea level, well above many of the restrictions of the ground-based observer. They are skilled in accurate observations, their eyesight is excellent, they have an intimate familiarity with navigational astronomy and a broad understanding of the basic physical sciences. Their reports from orbit of visual sightings therefore deserve careful consideration.

Between 12 April 1961 and 15 November 1966, 30 astronauts spent a total of 2503 hours in orbit. (see Tables 1 and 2) During the flights the astronauts carried out assigned tasks of several general categories, viz: defense, engineering, medical, and scientific. A list of the assigned tasks that were part of the Mercury program is provided in Table 3 to give an idea of the kinds of visual observations the astronauts were asked to make.

As a part of the program, debriefings were held following each U.S. mission. At these sessions, the astronauts were questioned by scientists involved in the design of the experiments about their observations, unplanned as well as specifically assigned. The debriefings complemented on-the-spot reports made by the astronauts during the mission in radio contacts with the ground-control center. In this way, a comprehensive summary was obtained of what the astronauts had seen while in orbit.

This chapter discusses the conditions under which the astronauts observed, with particular reference to the Mercury and Gemini series, and the observations, both planned and unplanned, made by them. The

Table 1

Astronauts' Time in Orbit

Name	Total Time In Orbit HOURS	MINUTES	Flight Designation*
Aldrin	94	34	GT-12
Armstrong	10	42	GT-8
Borman	330	55	GT-7
Belayeyev	27	2	Voshkod II
Bykovsky	119	6	Vostok V
Carpenter	4	56	MA-7
Cernan	72	21	GT-9
Collins	70	47	GT-10
Conrad	262	13	GT-5, GT-11
Cooper	225	16	MA-9, GT-5
Feoktisov	24	17	Voshkod I
Gagarin	1	48	Vostok I
Glenn	4	56	MA-6
Gordon	71	17	GT-11
Grissom	5	10	MR-4, GT-3
Komarov	24	17	Voshkod I
Leonov	27	2	Voshkod II
Lovell	425	29	GT-7, GT-12
McDivitt	97	50	GT-4
Nikoyaiev	94	35	Vostok III
Popovich	70	57	Vostok IV
Schirra	35	4	MA-8, GT-6
Scott	10	42	GT-8
Shepherd	0	15	MR-3
Stafford	98	12	GT-6, GT-9
Tereshkova	70	50	Vostok VI
Titov	25	18	Vostok II
White	97	50	GT-4
Yegorov	24	17	Voshkod I
Young	75	41	GT-3, GT-10
Total (for 30 astronauts)	2503	39	Total Man-flights 37

* GT = Gemini series; MA and MR = Mercury series; flights designated by words beginning with "V" refer to Soviet flights.

Table 2

Log of Manned Flights

Flight	Astronauts	Launch Date		Number of Revolutions	Duration Hr.	Duration Min.	Altitudes (Statute Miles) Perigee	Altitudes (Statute Miles) Apogee
Vostok I	Gagarin	12 April	61	1	1	48	110	187
MR-3	Shepherd	5 May	61	Suborbital		15	116	-
MR-4	Grissom	21 July	61	Suborbital		16	118	-
Vostok II	Titov	6 Aug	61	17	25	18	100	159
MA-6	Glenn	20 Feb	62	3	4	56	100	162
MA-7	Carpenter	24 May	62	3	4	56	99	167
Vostok III	Nikoyalev	11 Aug	62	64	94	35	114	156
Vostok IV	Popovich	12 Aug	62	48	70	57	112	158
MA-8	Schirra	3 Oct	62	6	9	13	100	176
MA-9	Cooper	15 May	63	22	34	20	100	166
Vostok V	Bykovsky	14 June	63	81	119	6	107	146
Vostok VI	Tereshkova	16 June	63	48	70	50	113	144
Voshkod I	Komarov, Yegorov, Feoktisov	16 Oct	64	16	24	17	110	255
Voshkod II	Belayayev, Leonov	18 Mar	65	17	27	2	107	307
GT-3	Grissom, Young	23 Mar	65	3	4	54	100	139
GT-4	McDivitt, White	3 June	65	63	97	50	100	175
GT-5	Cooper, Conrad	21 Aug	65	120	190	56	100	189
GT-6	Schirra, Stafford	15 Dec	65	16	25	51	100	140
GT-7	Borman, Lovell	4 Dec	65	205	330	55	100	177
GT-8	Armstrong, Scott	16 Mar	66	7	10	42	99	147
GT-9	Stafford, Cernan	3 June	66	46	72	21	99	144
*GT-10	Young, Collins	18 July	66	44	70	47	99	145
*GT-11	Conrad, Gordon	12 Sept	66	45	71	17	100	151
GT-12	Lovell, Aldrin	11 Nov	66	59	94	34	100	185
Total (of 24 flights)				934	1457	56		

*Extreme altitudes of 475 and 850, respectively, were achieved in GT-10 and GT-11 by powered departures from the "stable" orbits indicated by the perigee and apogee given in the table.

Table 3

Assigned Scientific Observations Mercury Program

Assigned Observations	Mission Numbers	Equipment	Results
Observe dimlight phenomena to increase our knowledge of auroras, faint comets near the sun, faint magnitude limit of stars, gegenschein, libration, clouds, meteorite flashes, zodiacal light.	6,9	Unaided eye Camera Voasmeter photometer	MA-6 not dark adapted. MA-9 saw zodiacal light and airglow. Photographs of airglow obtained.
Measure atmospheric attenuation of sunlight and starlight intensity.	6	Voasmeter photometer	No result
Determine intensity, distribution structure, variation and color of visual airglow.	6,7,8,9	Unaided eye with 5577 A filter Camera	Airglow was seen on all flights; was photographed on MA-9. Filter was used on MA-7.
Determine danger of micrometeorite impact and relate to spacecraft protection.	6,7,8,9	Visual and microscopic inspection	One impact found on MA-9 window.
Determine intensity, distribution structure, variation and color of red airglow	8,9	Unaided eye	Detected visually on MA-8; Confirmed visually on MA-9.
Test and refine theory of optics vis à vis refraction of images near horizon.	6,7,9	Unaided eye Camera	Photographs MA-6, MA-7 Visual MA-7, MA-9

Table 3 (cont'd)

Assigned Observations	Mission Numbers	Equipment	Results
Determine nature and source of the so-called "Glenn effect" or particles.	6,7,8,9	Unaided eye Camera	Discovered on MA-6; all others saw visually; MA-7 photographs.
Compare observations of albedo intensities, day and night times with theory and refine theory.	6	Unaided eye Voasmeter photometer	Not obtained due to instrument malfunction.
Photograph cloud structure for comparison with Liros photos. Improve map forecasts.	6,7,8,9	Camera with filters of various wavelengths	MA-8 and MA-9 obtained scheduled photographs.
Take general weather photographs and make general meteorological observation for comparison with those made by Liros satellite.	6,7,8,9	Unaided eye Camera	All obtained photographs.
Determine best wavelength for definition of horizon for navigation	7,9	Camera with red and blue filters.	Successful. The red photographs were sharper; the blue more stable.
Obtain ultraviolet spectra of Orion stars for extension of knowledge below 3000 A	6	Ultraviolet spectrograph.	Spectra were obtained but window did not transmit to expected wavelength.

Table 3 (cont'd)

Assigned Observations	Mission Numbers	Equipment	Results
Identify geological and topographical features from high altitude photographs for comparison with surface features as mapped.	6,7,8,9	Unaided eye Camera	Photographs obtained on all. Quality best on MA-9.
Identification of photographs of surface targets by comparison with known geological features.	8	Unaided eye Camera	Few selected ones obtained. Quality fair.

sources of information are: (1) the official National Aeronautics and Space Administration reports (see references), (2) transcripts of press discussions during and following the missions, (3) mission commentaries released systematically to the press during the missions, (4) transcripts of astronaut reports based on tapes made shortly after return from the mission, (5) personal notes made by me during scientific briefings and debriefing of the astronauts, and (6) conversations with many of the astronauts.

2. The Spacecraft as an Observatory

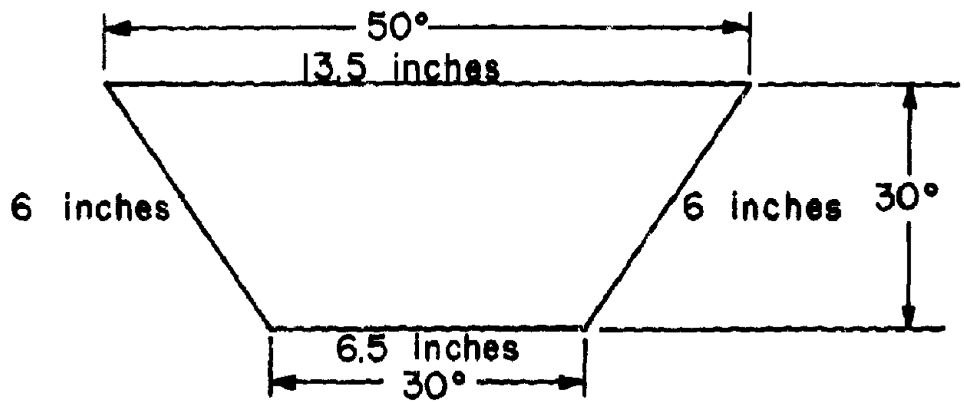
The conditions under which astronauts made their observations are similar to those which would be encountered by one or two persons in the front seat of a small car having no side or rear windows and a partially covered, smudged windshield.

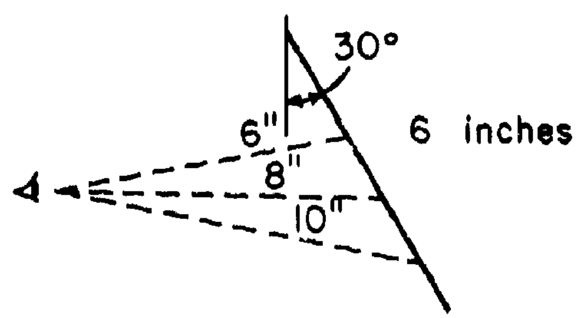
The dimensions and configuration of the spacecraft windows, which are inclined 30° towards the astronauts, are given in Figure 1. The windows are small and permit only a limited forward (with respect to the astronauts) view of the sky. The sphere of view around a capsule in space contains 41,253 square degrees, but the astronauts are able to see only 1200 square degrees or about 3% of that sphere; and only 6% of a hemisphere. The spacecraft can be turned to enable the astronauts to see a different area than the one they face, but fuel must be conserved and maneuvers were not usually made simply to provide a better or different view. In effect, therefore, 94% of the solid angle of space around the capsule was, at any given moment, out of view of the spacecraft occupants.

In addition to this restricted field of vision, the windows themselves were never entirely clean, and the difficulties imposed by the scattering of light from deposits on the window were severe. The deposits apparently occurred during the firing of third-stage rockets, when gases were swept past the windows. Attempts were made to eliminate the smudging by use of temporary covers jettisoned once

Figure 1

THE GEMINI WINDOW





orbit was achieved, but even then deposits were present on the inside of the outer pane of glass. Another source of contamination was apparently the material used to seal the glass to the frames. The net result was that the windows were never entirely clean, and scattered light hampered the astronauts' observations.

There were differences from one flight to another in viewing quality of the windows and from one window to the other on the same flight. For example on Gemini 7, the command pilot in the left seat was able to identify stars to magnitude 6 during satellite night, while the pilot in the right seat was limited to magnitude 4.4. The difference of 1.6 magnitudes (a factor of 4.4) was undoubtedly due to a difference in window transmission. It should be noted that stars as faint as magnitude 6 can be identified from the ground only under superb conditions (absence of artificial lights and moonlight plus a very clear sky).

The astronauts who had relatively clean windows often referred to the appearance of the night sky as seen in orbit, as similar to that seen by the pilot of a jet aircraft at 40,000 feet.

The smudged windows affected the visibility of objects during satellite night due to the decrease in the window transmission, but the effect was even more serious during satellite daytime when the glare from the light scattered by the smudge often was so bright as to destroy the contrast by which objects could be easily distinguished.

3. Orbital Dynamics

Satellites in orbit are subjected to atmospheric drag, which ultimately causes them to reenter the earth's atmosphere, often producing a brilliant display as they do so. Reentries are sometimes reported as UFOs. One recent case in particular stands as an example of a reentry reported as an UFO and later identified tentatively as the reentries of Agena of Gemini 11 (Case 11) and Zond IV (see Section VI, Chapter 2).

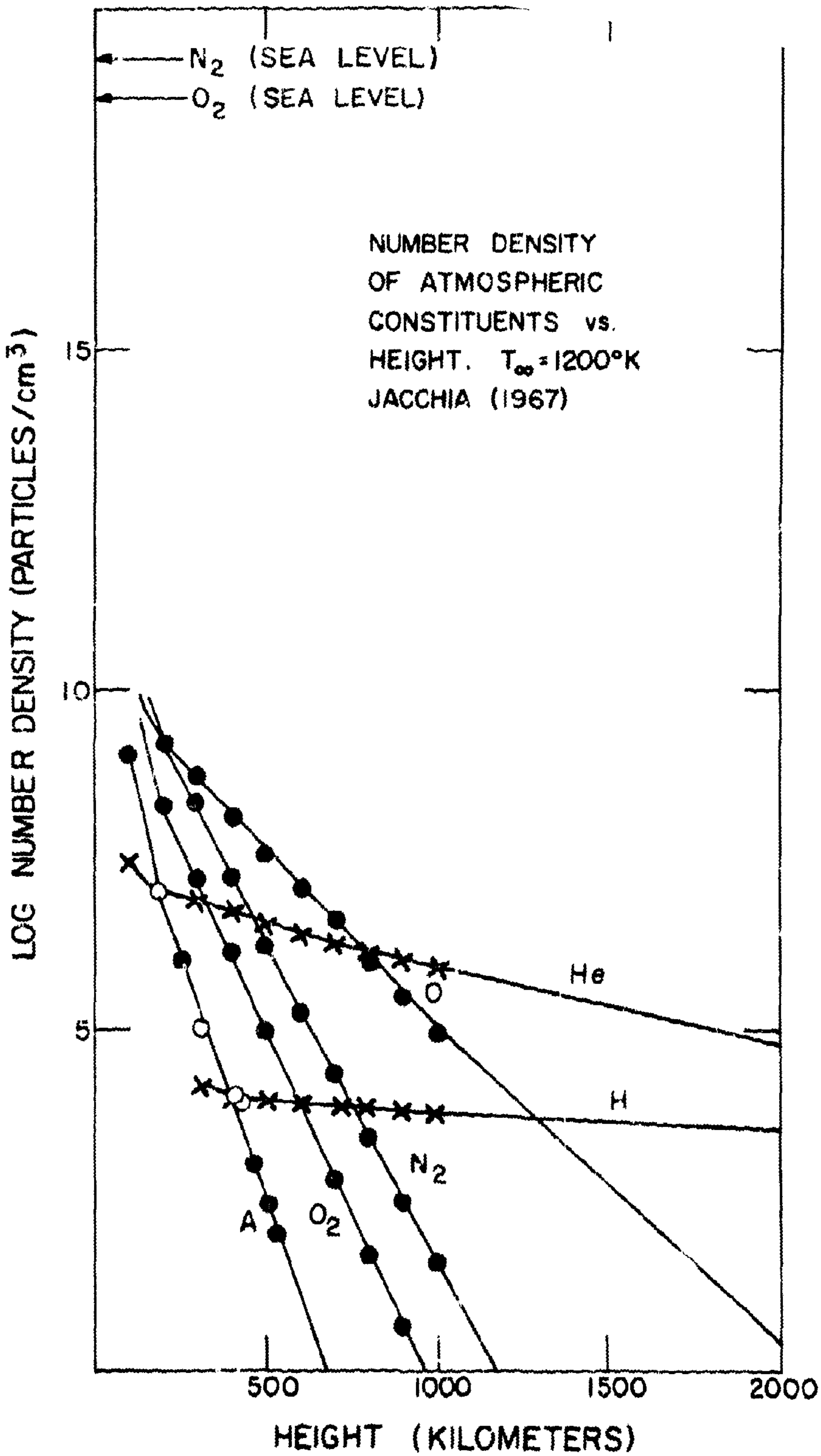

N2 (SEA LEVEL)
O2 (SEA LEVEL)
NUMBER DENSITY OF ATMOSPHERIC CONSTITUENTS vs. HEIGHT. T∞ = 1200°K JACCHIA (1967)
LOG NUMBER DENSITY (PARTICLES/cm3)
15
10
5
He
O
H
N2
O2
A
500
1000
1500
2000
HEIGHT (KILOMETERS)

Figure 2

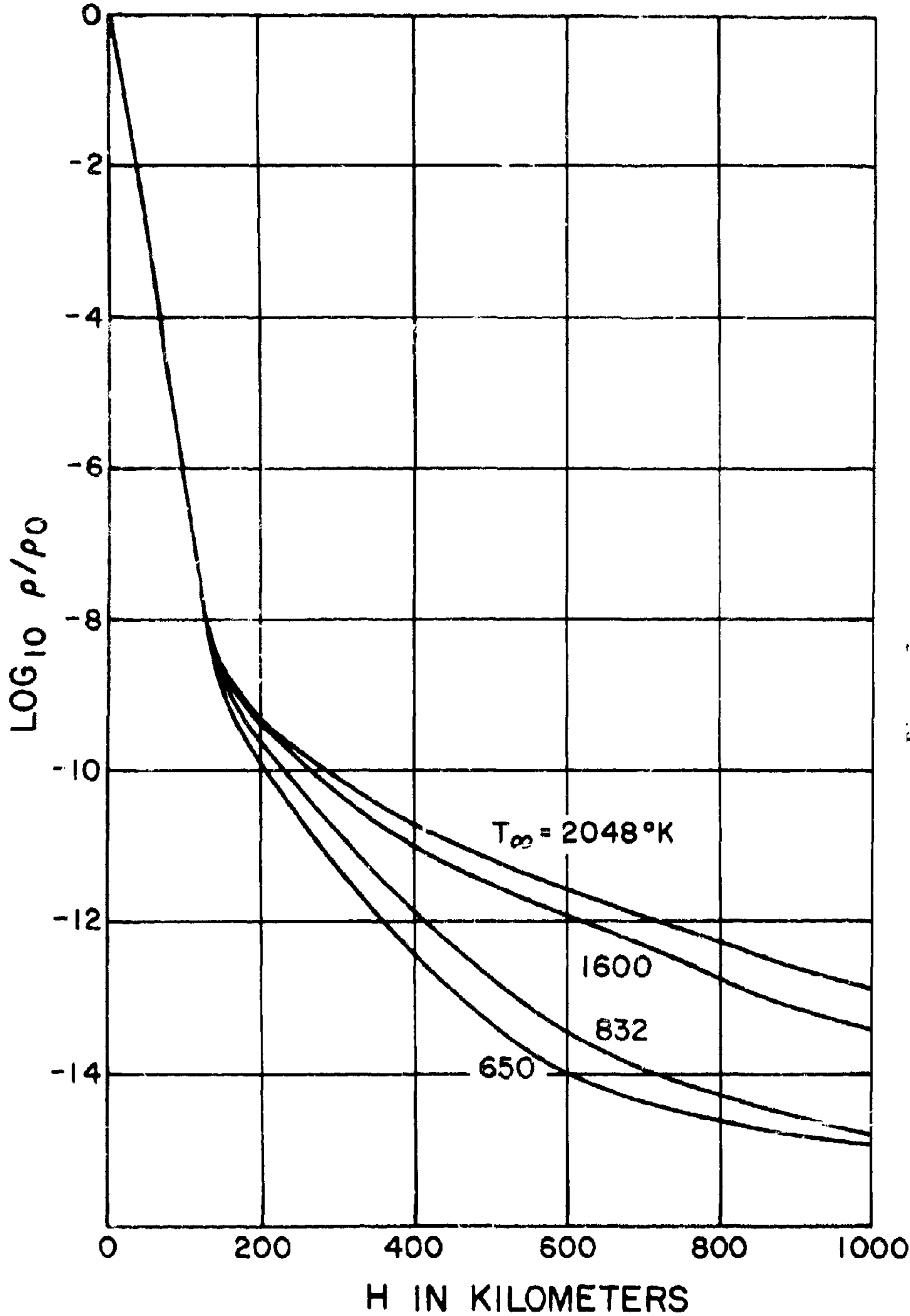

0
-2
-4
-6
-8
-10
-12
-14
LOG10 ρ/ρ0
T∞ = 2048°K
1600
832
650
0
200
400
600
800
1000
H IN KILOMETERS

Figure 3

Space from 100 to 1000 km. is not a perfect vacuum, nor is it isothermal. At about 100 km. the mean molecular weight of the atmosphere undergoes a marked change, where O_2 becomes dissociated by sunlight into atomic oxygen (see Fig. 2). Up to about 100 km. the temperature profile varies between about 200°K. and 300°K. Above 100 km. the temperature undergoes a steady increase to 1000°K. or more. Fig. 3 shows how the relative density of the atmosphere varies with height up to a height of 1000 km. Above 200 km. the density is sensitive to the asymptotic high-level temperature, too, which varies with the solar cycle and geomagnetic activity.

If the earth were a perfect sphere and if there were no atmospheric drag, satellites in orbit around our planet would behave according to Kepler's Laws of planetary orbits around the sun. Table 4 is derived from Kepler's third law. The relationship between the period in seconds (p) and the mean distance in centimeters (r) is expressed by:

$$p^2 = \frac{4 \pi^2 r^3}{G M_\oplus} = 0.9906 \times 10^{-19} r^3$$

where G, the gravitational constant, is 6.668×10^{-8} cgs and $M_\oplus$, the mass of the earth, is 5.977×10^{27} grams. The mean speed in orbit (the last column) is obtained from the relationship:

$$S = \frac{2\pi r}{p} = \frac{1.996 \times 10^{10}}{\sqrt{r}}$$

By applying Kepler's third law we have implied the validity of Kepler's first two laws with respect to satellite orbits; i.e.: that satellites move about the earth in elliptical orbits with the center of the earth at one focus of the ellipse; and that the radius vector swept out by the satellite with respect to the center of the earth sweeps out equal areas in equal times.

The angular velocity of a satellite, (proportional to the reciprocal of the period), decreases as the radius of the orbit

Table 4

Radius of Orbit	Period of Orbit Around Earth				Speed
r(km.)	P(secs.)	P(mins.)	P(hrs.)	P(days)	S(km/sec)
6378 + 200	5310	88.5			7.78
6378 + 500	5677	94.6			7.61
6378 + 1000	6307	105.1			7.35
6378 + 35,862	86,400		24		3.07 (geostationary)
6378 + 378,025	2372×10^6			27.4	1.02 (moon)

*mean radius of earth = 6378 km.

increases. Thus the process of docking, or flying in formation, with a satellite already in a preceding orbit becomes a complicated and difficult maneuver involving descent to a lower, and therefore smaller, orbit with the resultant increase in angular velocity causing the following orbiting body to approach the preceding.

Atmospheric drag slows the satellite speed, especially near perigee, and this causes the satellite to swing out to a smaller subsequent apogee. The orbit contracts and becomes more circular. Eventually the satellite descends to an altitude where the drag causes the satellite to reenter the earth's atmosphere.

Table 5 shows some calculated decelerations for a massive object such as a satellite, and a small meteoritic particle of 0.1 cm. diameter and density of 0.4 gm/cm^{-3} (mass = 2.09×10^{-4} grams). At 160 km. (the perigee of many of the manned spacecraft orbits) the deceleration on the spacecraft is not trivial (0.017 cm/sec^{-2}) and the orbit will slowly, but surely degrade to a reentry. Of interest in connection with the observation of small particles by the astronauts is the differential acceleration between the spacecraft and the particles. In a period of ten seconds small particles will "drift" away from the spacecraft a distance of some meters. Typical relative speeds of small particles with respect to the spacecraft have been estimated by the astronauts as 1 or 2 m/sec.

During reentry, the spacecraft and fragments flaked off of its surface become luminous, producing the displays sometimes reported as UFOs. A satellite reentry normally occurs along a grazing path, but the trajectories of meteorites are more radial, and therefore the duration of luminosity is usually no more than two to three seconds.

Table 6 shows the masses of objects for given apparent stellar magnitudes and varying periods of luminosity, calculated on the assumption that all the orbital kinetic energy of the object is

Table 5

Deceleration Calculations

Satellite

mass	diameter	Ratio area/mass	Altitude	Air density	Deceleration
3.63×10^{6} gm.	400 cm.	0.00865	160 km.	8.271×10^{-13}	1.741×10^{-2} cm. sec^{-2}
			200 km.	1.098×10^{-13}	2.311×10^{-3} cm. sec^{-2}

Small Particle

mass	diameter	Ratio area/mass	Altitude	Air density	Deceleration	Separation from craft after:		
2.09×10^{-4} gm.	0.1 cm.	37.5	160 km.	8.271×10^{-13}	18.86 cm. sec^{-2}	1 sec.	10 sec.	100 sec.
			200 km.	1.098×10^{-13}	2.50 cm. sec^{-2}	1.25 cm.	125 cm.	12500 cm.

converted into light as a consequence of its deceleration on reentry.

4. Brightness of Objects Illuminated by the Sun

Astronauts have reported observations they have made, while in orbit, of artifacts (defined here as man-made objects) as well as observations made of natural geophysical and astronomical phenomena during flight. It is among the observations of artifacts that unidentified sightings are most likely to occur, if at all.

A man-made satellite moving slowly against the star background has become a familiar sight. Even though the sun may be below the observer's horizon, the satellite, some hundreds of kilometers above the earth's surface catches the sun's rays and reflects them back to the ground-based observer. Since artifact sightings made from a spacecraft are frequently also the result of reflection of sunlight from a solid object, the question of the brightness of objects illuminated by the sun is pertinent to the consideration of observations from the space vehicles. One observation was reported of a dark object against the bright day sky (window?) background (see Section 9)of this chapter).

Satellite brightness, as observed from the ground, is usually given in apparent stellar magnitudes because of the convenience of comparing a satellite with the star background. The unaided eye on a clear moonless night can perceive magnitudes as faint as between +5 and +6. Telescopic satellite searches are able to detect fainter magnitudes; for example, the United Kingdom optical tracking stations can acquire satellites as faint as +9 (Pilkington, 1967). The brightness of artificial satellites and their visual acquisition has been discussed by several writers (Pilkington, 1967; Roach, J.R., 1967; Summers, et al, 1966; and Zink, 1963).

Plots of the apparent visual magnitude of sun-illuminated objects as a function of slant distance (in kilometers) and of diameter (in centimeters) of the object are shown in Figs. 4 and 5 respectively.

Table 6

Masses of objects (grams) for given duration of visibility and apparent magnitudes.

DURATION OF VISIBILITY / APPARENT MAGNITUDE	1 Second	10 Seconds	100 Seconds
5	.000078 gm	.00078 gm.	.0078 gm.
0	.0078	.078	.78
-5	.79	7.8	78.
-10	79.	780	7800.

initial speed = 30 km/sec.

DURATION OF VISIBILITY / APPARENT MAGNITUDE	100 Seconds
-5	1000 gm.
-10	100,000 (100 kilograms)

initial speed 7.5 km/sec.

In curve A of Fig. 4 and in Fig. 5 the illuminated object is assumed to be a sphere. In curve B of Fig. 4 the object is the Orbiting Solar Observatory (OSO) with its sails broadside to the observer (Roach, J.R., 1967). The plots for the sphere are based on the assumption that a sun-illuminated sphere of diameter 1 meter at a distance of 1000 kilometers has an apparent magnitude of 7.84 (Pilkington, 1967). From this, a general relationship between apparent magnitude, m, diameter, d in meters, and slant distance, r in kilometers, is obtained:

$$m = -7.16 - 5.0 \log d + 5.0 \log r \ . \ . \ . \qquad (1)$$

Fig. 5 indicates that artifacts 1 m. in diameter are brighter than m = +5 and therefore visible to the normal unaided eye to distances of 100 km. The same spacecraft becomes brighter than Venus at her brightest (m = -3) if closer to the observer than 10 km. In the case of a non-spherical object with an albedo that is less than unity, equation (1) is only a guide and the references in the bibliography should be consulted for details.

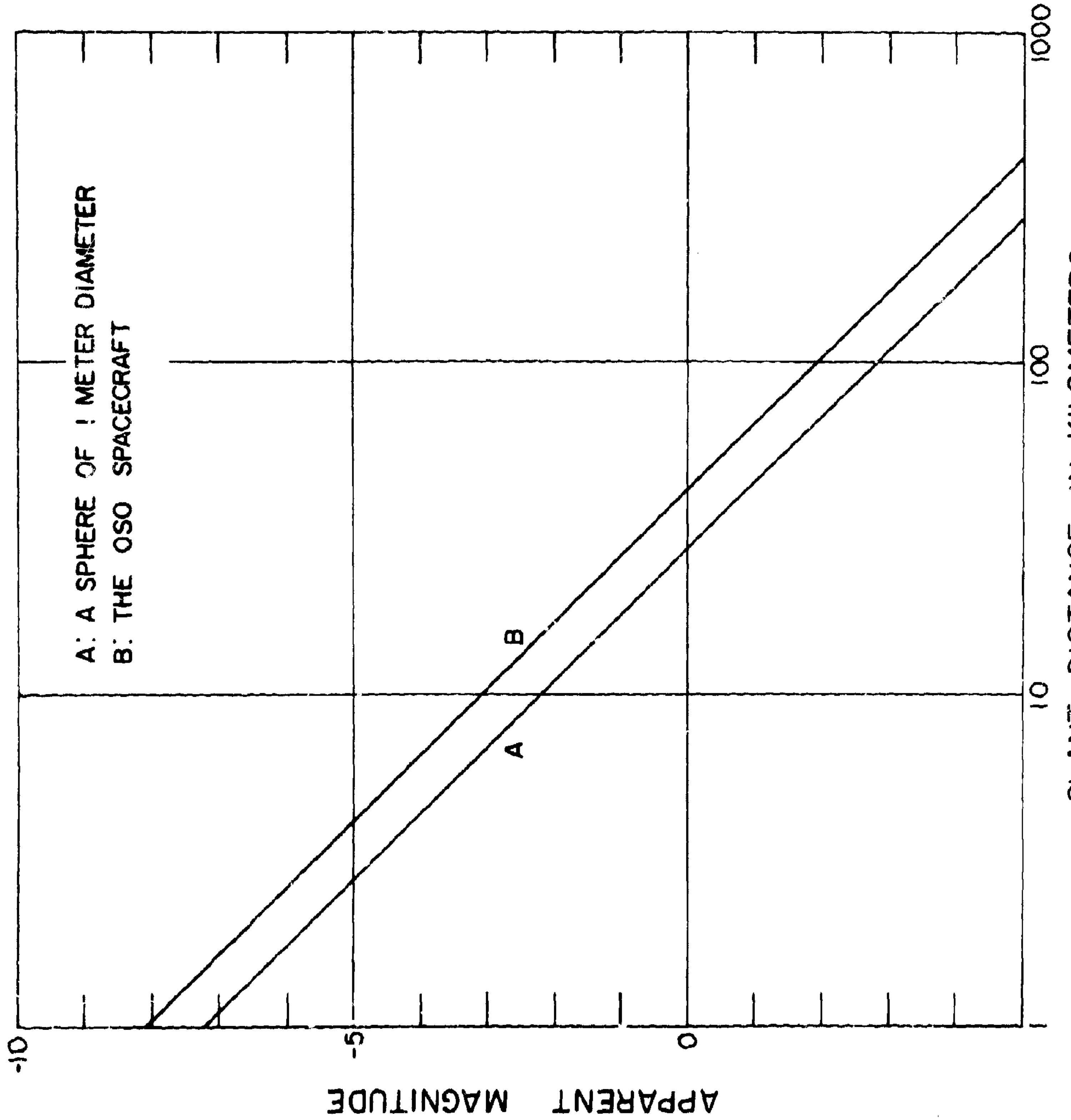
Fig. 5 is pertinent to the observation of the Glenn "fireflies" and the "uriglow" (see pp. 303-304) and shows that seen close up, i.e.; at 1 to 10 m., even very small sun-illuminated particles are dazzlingly bright.

Legend

Fig. 5 . Apparent magnitude of spheres illuminated by the sun as a function of the diameter of the spheres. It is assumed that the distance from the observer to the spheres is 1 meter (Curve A) and 10 meters (Curve B). See equation (1) p. 286.

Fig. 4. The apparent visual magnitude of objects illuminated by the sun as a function of distance between observer and object. Curve A is for a sphere of 1 meter diameter (see equation 1 in text). Curve B is for the OSO spacecraft assuming as albedo of 0.4, a window transmission of 0.5, a solar cosine of 0.5, and the OSO sails broadside to the observer (Roach, J.R., 1967.)

Figure 4


A: A SPHERE OF 1 METER DIAMETER
B: THE OSO SPACECRAFT
A
B
-10
-5
0
APPARENT MAGNITUDE
10
100
1000
SLANT DISTANCE IN KILOMETERS

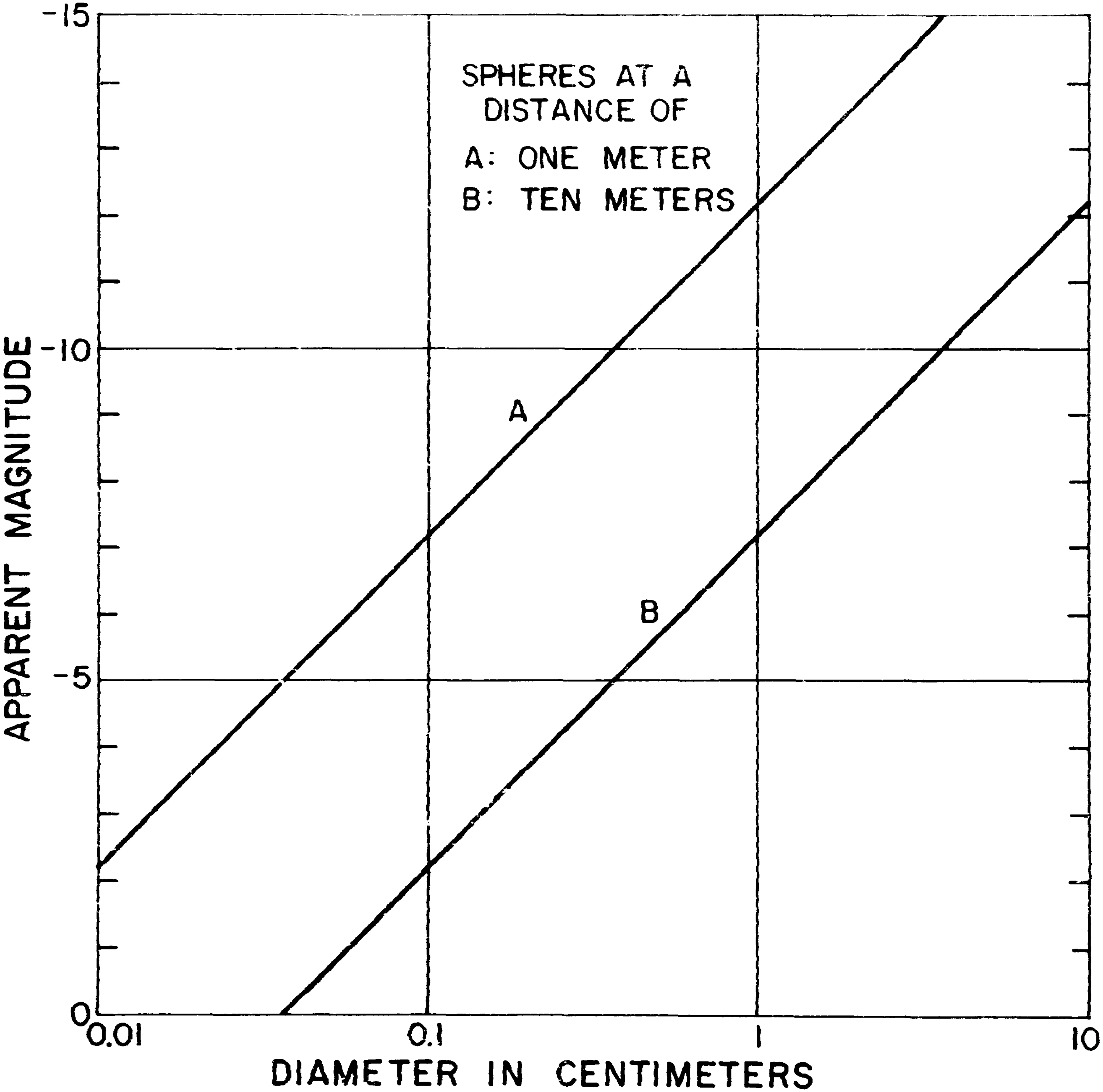

SPHERES AT A DISTANCE OF
A: ONE METER
B: TEN METERS
A
B
APPARENT MAGNITUDE
-15
-10
-5
0
0.01
0.1
1
10
DIAMETER IN CENTIMETERS

Figure 5

5. Visual Acuity of the Astronauts

Reports by the Mercury astronauts that they were able to observe very small objects on the ground aroused considerable interest in the general matter of the visual acuity of the astronauts. One of the criteria in the selection of the astronauts to begin with was that they have excellent eyesight, but it was not known whether their high level of visual acuity would be sustained during flight. Therefore, experiments were designed to test whether any significant change in visual acuity could be detected during extended flights. These experiments were carried out during Gemini 5 (8 days) and Gemini 7 (14 days).

An in-flight vision tester was used one or more times per day, and the results were compared with preflight tests made with the same equipment. In addition, a test pattern was laid out on the ground near Laredo, Tex. for observation during flight. The reader is referred to the original report for the details of the carefully controlled experiments, which led to the following conclusions:

> Data from the inflight vision tester show that no change was detected in the visual performance of any of the four astronauts who composed the crews of Gemini 5 and Gemini 7. Results from observations of the ground site near Laredo, Tex., confirm that the visual performance of the astronauts during space flight was within the statistical range of their preflight visual performance and demonstrate that laboratory visual data can be combined with environmental optical data to predict correctly the limiting visual capability of astronauts to discriminate small objects on the surface of the earth in the daylight.

In addition, the astronauts' vision was tested both before and after the flights and the test results were compared with preflight measurements. There were no significant differences in the level of their acuity, as shown in the following tabulation of test results:

Astronaut		Preflight		+ Postflight	
		O.S.	O.D.	O.S.	O.D.
Cooper	Far	20/15	20/15	20/15	20/15
	Near	20/15	20/15	20/20	20/20
Conrad	Far	20/15	20/15	20/12.5	20/12.5
	Near	20/15	20/15	20/15	20/15
Borman	Far	20/15	20/15	20/15	20/15
	Near	20/15	20/15	20/15	20/15
Lovell	Far	20/15	20/15	20/15	20/15
	Near	20/15	20/15	20/15	20/15

It is clear that the men selected to participate in the space program of the U.S. have excellent eyesight and that th level of performance is sustained over long and tiring flights.

At the same time, a hindrance to top observing performance was that the astronauts were never thoroughly dark-adapted for any length of time. Good dark-adaptation is achieved some 30 minutes after the eyes are initially subjected to darkness. A [illegible] cal orbit period was 90 minutes during which the astronauts were in full sunlight for 45 minutes and in darkness for 45 minutes. The astronauts therefore were fully dark-adapted for only 15 minutes out of every 90 minute orbit (assuming no cabin lights).

6. Sample Observations of Natural Phenomena

The Night Airglow

The first American to go into orbit, astronaut John Glenn, (MA-6) reported observing an annular ring around the horizon during satellite night. It appeared to him to be several degrees above the solid earth surface and he noted that stars seemed to dim as they "set" behind the layer. Astronaut Carpenter (MA-7) made careful measurements of the angular height of the layer above the earth's surface and estimated its brightness. All the astronauts have since become familiar with the phenomenon. Soon after Glenn's report (Plate 13) the ring was identified as an airglow layer seen tangentially. It is especially noticeable when there is no moon in the sky and the solid earth surface is barely discernible (Plate 14); as a matter of fact it is easier to use the airglow layer than the earth edge as a reference in making sextant measurements of angular elevations of stars.

Ground-based studies of the night airglow show that it is composed of a number of separate and distinct layers. The layer visibl to the astronauts is a narrow one at a height of about 100 km. which, seen tangentially by the astronauts, is easily visible. (It can be seen from the earth's surface only marginally but is easily measured with photometers.)

At a height of about 250 km. there is another airglow layer which is especially prominent in the tropics. It is probable that airglow from this higher level was seen on two occasions. Astronaut Schirra (MA-8) reported a faint luminosity of a patchy nature while south of Madagascar, looking in the general direction of India (NASA SP-12, page 53, 3 October 1962) as follows:

> A smog-appearing layer was evident during the fourth pass while I was in drifting flight on the night side, almost at 32° south latitude. I would say that this layer represented about a quarter of the field of view out of the window and this surprised me. I thought I was looking at clouds all the time until I saw stars down at the bottom or underneath the glowing layer.

> Seeing the stars below the glowing layer was probably the biggest surprise I had during the flight. I expect that future flights may help to clarify the nature of this band of light, which appeared to be thicker than that reported by Scott Carpenter.

All the astronauts of later flights knew of astronaut Schirra's sighting, but on only one other occasion was an observation made of a similar phenomenon. At 05h 11m 34s into the Mercury flight, astronaut Cooper reported "Right now I can make out a lot of luminous activities in an easterly direction at 180° yaw . . . . I wouldn't say it was much like a layer. It wasn't distinct and it didn't last long; but it was higher than I was. It wasn't even in the vicinity of the horizon and was not well defined. A good size." I had occasion to query him a bit more about his report during a debriefing following the flight:

> Roach: More like a patch?
>
> Cooper: Smoother. It was a good sized area.
>
> Roach: You didn't feel this had a discrete shape?
>
> Cooper: It was very indistinct in shape. It was a faint glow with a reddish brown cast."

The phenomenon was estimated to be at about 50° west longitude and about 0° latitude.

The hypothesis has been advanced that the two observations are of the tropical airglow. We know from ground observations of this phenomenon that it is often observed to be patchy. The spectroscopic composition of the phenomenon is about 80% 6300Å and 20% 5577Å. If a bright patchy region of 1000 km. extension (horizontal) came into the view of an astronaut it could appear to be "smog appearing" (Schirra) or "reddish brown" (Cooper). The tropical airglow was relatively bright during 1962 and 1963, and became quite faint during 1964 to 1966, the sunspot minimum. During 1967, as the new sunspot maximum approached, the tropical airglow underwent a significant enhancement. This solar cycle dependence could account for the fact that the Gemini astronauts (1965-1966), although alerted to look for this "high airglow," did not see it.

The Aurora

The Mercury and Gemini orbits were confined within geographic latitudes of 32°N and 32°S. Since the auroral zones are at geomagnetic latitudes of 67°N and 67°S it would seem unlikely that auroras could be seen by the astronauts. However two circumstances were favorable for such sightings. First, the "dip" of the horizon at orbital heights puts the viewed horizon at a considerable distance from the sub-satellite point. For example at a satellite height of 166km. (perigee for GT-4) the dip of the horizon is about 13° and at a height of 297 km. (apogee for GT-4) it is about 17°. Second, the auroral zone, being controlled by the geomagnetic field, is inclined to parallels of geographic latitude as illustrated in Plate 15. Nighttime passes over the eastern United States or over southern Australia bring the spacecraft closest to the auroral zone. On several occasions auroras were seen in the Australia-New Zealand region. Plate 16 (Fig. 32-7 of NASA SP-121) shows a reproduction of a sketch made by the Gemini 7 crew. An auroral arch is seen below the airglow layer.

The Visibility of Stars

Satellite orbits are at a minimum height of about 160 km. where the "sky" above is not the familiar blue as it is from the earth's surface. Since the small fraction of the atmosphere above the spacecraft produces a very low amount of scattering, even in full sunlight, it was anticipated that the day sky from a spacecraft would therefore display the full astronomical panoply. This was decidedly *not* the case. All the American astronauts have expressed themselves most forcefully that during satellite daytime, i.e., when the sun is above the horizon, they could not see the stars, even the brighter ones. Only on a few occasions, if the low sun was completely occulted by the spacecraft were some bright stars noted. The inability to observe the stars as anticipated is ascribed to two reasons; (1) the satellite window surfaces scattered light from the oblique sun or even from the earth sufficiently to destroy the visibility of stars, just as does the scattered light of our daytime sky at the earth's surface; and (2) the astronauts are generally not well dark-adapted, as mentioned in section 5 of this Chapter.

Mention has already been made of the dispersion in star visibility during satellite night because of the smudging of the windows. Under the best window conditions the astronomical sky is reported to be similar to that from an aircraft at 40,000 ft. Under the particularly poor conditions of Mercury 8, astronaut Schirra, who is very familiar with the constellations, could not distinguish the Milky Way.

Meteors

In general, meteors become luminous below 100 km., well below any stable orbit. Although organized searches for meteor trails were not part of the scientific planning of the NASA programs, sporadic observations were made by the astronauts who reported that the meteor trails could be readily distinguished from lightning flashes. Because of their sporadic nature, these observations cannot be systematically compared with the ground-observed statistics of the known variation of meteors during the year as the earth crosses the paths of interplanetary debris. However Gemini 5 was put into orbit shortly after the peak of the August Leonid shower and ground observations of the shower were confirmed in a rough way when astronauts Cooper and Conrad observed a significant number of meteor flashes.

The Zodiacal Light Band

Two factors tend to offset each other in the observation of the zodiacal light band from a spacecraft. A favorable factor is that the zodiacal band gets very rapidly brighter as it is observed as close as some 5° or 6° to the sun, as is possible from spacecraft in contrast with the twilight restriction on the earth's surface of about 25°. The ratio of brightness at an elongation of 5°, B(5), to that at 25°, B(25), is

$$\frac{B\ (5)}{B\ (25)} = 50$$

At the same time, it is difficult to detect the zodiacal band through the spacecraft window with its restricted angular view since one cannot sweep his eyes over a wide enough arc to see the bright band standing out with respect to the darker adjacent sky. By contrast, to locate the zodiacal band observing from the earth's surface, one can sweep over an arc of some 90°, in the center of which the bright band can be readily distinguished.

The most convincing description of a visual sighting of the zodiacal band was by astronaut Cooper (Mercury 9). From his description, I concluded that he distinguished the zodiacal band some 6° from the sun.

Twilight Bands

The satellite "day" for orbits relatively near the earth is about 45 min. long. The sunrise and sunset sequence occurs during each satellite day. The bright twilight band extending along the earth's surface and centered above the sun is referred to by the astronauts as of spectacular beauty.

8. Observations of Artifacts in Space

In the decade since the launching of Sputnik I (4 October 1957) a large number of objects have been put in orbit. With each launch, an average of five objects go into orbit. As of 1 January 1967, a total of 2,606 objects had been identified from 512 launchings, of which 1,139 were still in orbit and 1,467 had reentered. The objects in quasi-stable orbits are catalogued by the North American Air Defense Command (NORAD), and up-to-date lists of orbital characteristics are given annually in Planetary and Space Science (Quinn and King-Hele, 1967) from which tabular and graphic statistics have been prepared for this report. (Tables 7 and 8 and Fig. 6).

Table 7

Number of Satellite (piece) decays or Reentries

Calendar year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Total to date	Reentries during preceding year
Pieces put in orbit during calendar year	5	12	15	50	297	190	204	329	950	554	2606	
Decays as of: 1 Jan. 1963	5	8	10	22	64	92					201	
1 Jan. 1964	5	8	10	22	66	139	83				333	132
1 Jan. 1965	5	8	10	22	66	141	87	210			549	216
1 Jan. 1966	5	8	10	23	68	141	93	233	380		961	412
1 Jan. 1967	5	8	10	23	71	142	98	241	455	414	1467	506
Still in orbit as of 1 Jan. 1967	0	4	5	27	226	48	106	88	495	140	1139	

Table 8

Summary of artificial satellites for the decade 1957-1966

Total Launchings 512

	Pieces put in Orbit	Decayed	Still in Orbit (1 Jan. 1967)
Instrumented satellites	643	379	264
Separate rockets	298	179	119
Other fragments	1665	909	756
Total	2606	1467	1139
Percent	100.0	56.3	43.7

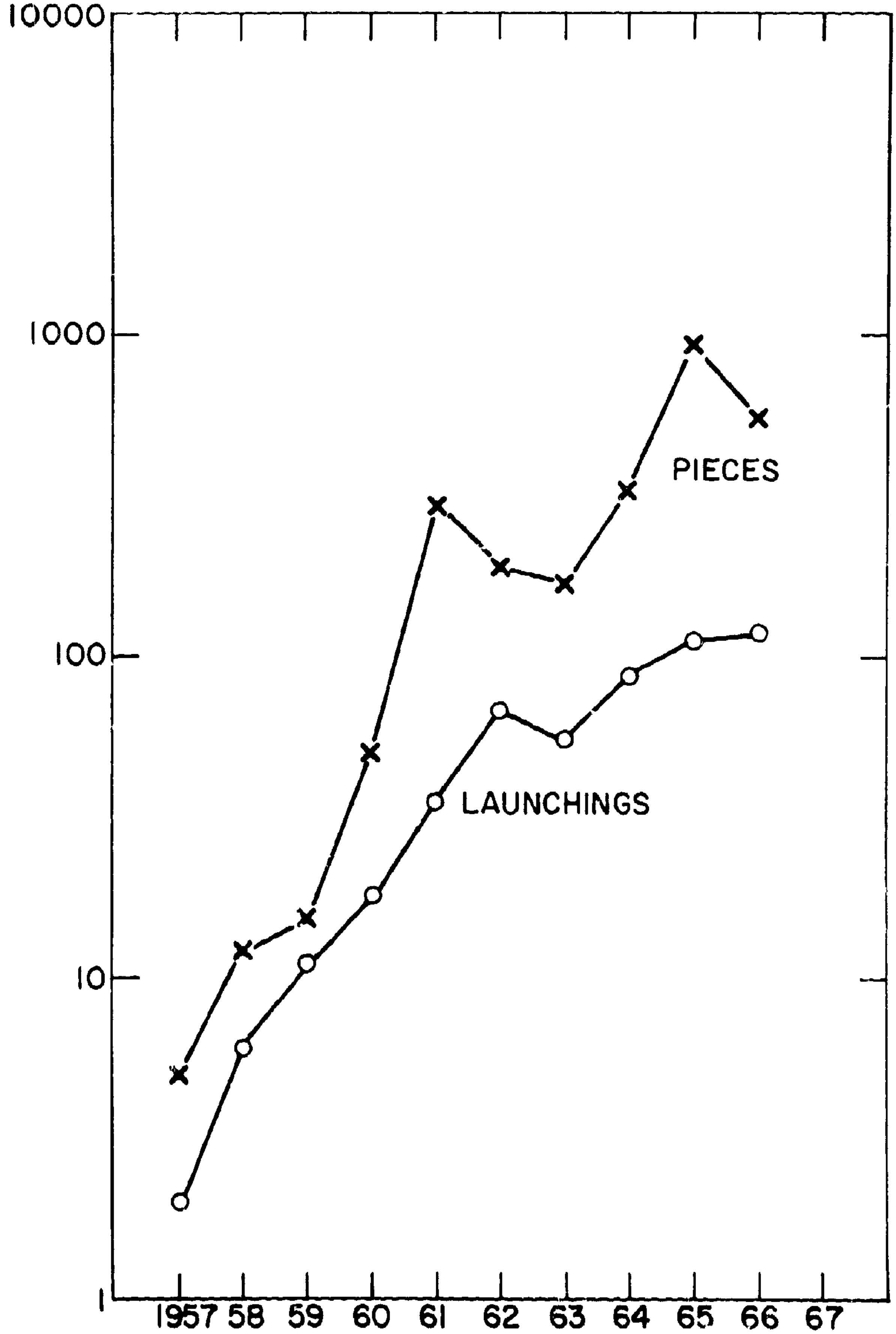

10000
1000
100
10
1
PIECES
LAUNCHINGS
1957 58 59 60 61 62 63 64 65 66 67

Figure 6

At any given moment during the two-year period of the Gemini program (1965 and 1966) approximately 1000 known objects were in orbit. During the same biennium, there was a total of 918 known reentries. Even though the probability of a collision with an orbiting artifact is statistically trivial, NASA and NORAD coordinated closely to keep track of the relative positions in space of the objects orbiting there.

Proton III

An interesting example of an unexpected sighting of another spacecraft was made by the Gemini 11 astronauts. Quoting from the transcript (GT-11, tape 133, page 1)

> We had a wingman flying wing on us going into sunset here, off to my left. A large object that was tumbling at about 1 rps and we flew -- we had him in sight, I say fairly close to us, I don't know, it could depend on how big he is and I guess he could have been anything from our ELSS* to something else. We took pictures of it.

The identification of the sighting (tape 209, page 2) was given as follows:

> We have a report on the object sighted by Pete Conrad over Tananarive yesterday on the 18th revolution. It has been identified by NORAD as the Proton III satellite. Since Proton III was more than 450 kilometers from Gemini 11, it is unlikely that any photographs would show more than a point of light.

The pictures referred to are shown in enlargement in Plates 17 and 18.

The Proton III satellite and its rocket are included in the P.A.S.S. listings under the numbers 1966-60A and 1966-60B with the following characteristics:

* ELSS = extravehicular life support system

	Satellite	Booster
	1966-60A	1966-60B
Launch Date	1966 July 6	1966 July 6
Lifetime	72.20 days	46.33 days
Predicted Reentry Date	16 Sept 1966	21 August 1966
Shape	Cylinder	Cylinder
Weight	12,200 kg.	4,000 kg. (?)
Size	3 meters long (?) 4 meters diameter (?)	10 meters long (?) 4 meters diameter (?)
Orbital Characteristics	See P.A.S.S. Vol.15, p. 1,192 (1967)	

Inspection of the photos taken at the time of this sighting (Plates 17 and 18) reveals considerably more detail than just a point of light. If the distance from the spacecraft to Proton III is given by the NORAD calculations, then we may infer the physical separation of the several objects in the photographs Plates 17 and 18 are 100 x enlargements of the photographs of Proton III made with the Hasselblad camera of 38 mm. focal length. The scale on the original negatives was 1 mm. = 1/38 radian = 1°.508. The scale on the enlargements is therefore 1 mm. = 0°.01508. Four distinct objects can be distinguished with extreme separation of 30 mm. corresponding to 0°.452 or 3.55 km. at a distance of 450 km. The minimum separation of any two components is about one third of the above or more than 1 km. Referring to the table of the Proton III dimensions it is obvious that the photographs are recording multiple pieces of Proton III including possibly its booster plus two other components.

Radar Evaluation Pod

The sighting of objects associated with a Gemini mission itself is an interesting part of the record. In Gemini 5 a rendezvous exercise was performed with a Radar Evaluation Pod (REP), a package equipped with flashing lights and ejected from the spacecraft early in the mission. Although the primary aim of the rendezvous exercise was to test radar techniques, the Gemini astronauts, in their conversations with NASA control, commented (Table 9) on the visibility or non-visibility of the REP. Plate 19 shows a photograph of the REP made by the astronauts.

Referring to Fig. 4, Section 4 of this chapter, the REP illuminated by sunlight should be of apparent magnitude -2 at a distance of 10 km. (assuming a 1 meter effective diameter) and magnitude +3 at a distance of 100 km.

The Agena Rendezvous

The rendezvous with the REP was a rehearsal for the rendezvous and docking exercises with the Agena. In turn the Agena exercises were rehearsals for the coming Apollo program in which space dockings will be a part of both the terrestrial and lunar flights.

The Agena vehicle is a cylindrical object 8 m. long with a diameter of 1.5 m. Its size makes it a conspicuous object at considerable distances when illuminated by the sun. Plate 20 illustrates its appearance at distances varying between 25 and 250 ft. At 250 ft. its apparent magnitude when sun-illuminated is -9.74 (about 1/13 the brightness of the full moon).

The original plan was to rendezvous with an Agena on the Gemini missions 6-12 inclusive. The planned procedure was to send up the Agena prior to the launching of the manned spacecraft. In the case of the GT-6, the associated Agena did not achieve orbit, so a rendezvous with GT-7 was substituted.

Table 9

Tabulations of REP sightings

Tape	Page	Comment
40	1	REP about 1 mile away
60	1, 3	REP near spacecraft (~1000 ft.) and is visible (flashing light)
62	1, 23	
67	3, 4	Looked for REP -- Could not see
68	1	Looked for REP -- Could not see
76	1	Looked for REP -- Could not see
80	2	Looked for REP at distance of 75 mi. Did not see.
234	2, 3	Discussion of photography of REP

The sun-illuminated Agena, when close to the astronauts, was of blinding brightness. Details could be made out at a distance of 26 km. (GT-11, tape 216, page 2). It was picked up visually at distances up to 122 km. (GT-11, tape 50, page 7). Assuming an effective diameter of 4.0 meters, we note from equation (1) that its apparent magnitude was about +0.3 at a distance of 122 km.

The Rendezvous of GT-6 and GT-7

The rendezvous of these two spacecraft involved close coordinations of radar and visual acquisitions and of ground and on-board calculations. Some of the most spectacular photographs of the entire Mercury-G ini program were obtained during the rendezvous and one is l in this report (Plate 21).

.e of the drama of the rendezvous which also suggests the nature of the visual sightings is brought out in the words of astronaut Lovell during the post-flight press conference (tape 5, page 1). The question was asked of both astronauts - "What was your first reaction when you realized you had successfully carried off rendezvous?"

Answer (Lovell):

> I can only talk for myself, looking at it from a passive point of view. I think Frank (Borman) and I expressed the same feeling -- it was night time just become light, we were face down and, coming out of the murky blackness of the dark clouds this little point of light. The sun was just coming up and it was not illuminating the ground yet, but on the adapter of 6 (Gemini 6) we could see this illumination. As it got closer and closer, it became a half moon and, it was just like it was on rails. At about half a mile, we could see the thrusters firing like light hazes, something like a water hose coming out -- just in front of us without moving it stopped, fantastic.

The Glenn "Fireflies", Local Debris

During the first Mercury manned orbital space flight, astronaut Glenn reported as follows:

> The biggest surprise of the flight occurred at dawn. Coming out of the night on the first orbit, at the first glint of sunlight on the spacecraft, I was looking inside the spacecraft checking instruments for perhaps 15 to 20 seconds. When I glanced back through the window my initial reaction was that the spacecraft had tumbled and that I could see nothing but stars through the window. I realized, however, that I was still in the normal attitude. The spacecraft was surrounded by luminous particles.
>
> These particles were a light yellowish green color. It was as if the spacecraft were moving through a field of fireflies. They were about the brightness of a first magnitude star and appeared to vary in size from a pinhead up to possibly 3/8 inch. They were about 8 to 10 feet apart and evenly distributed through the space around the spacecraft. Occasionally, one or two of them would move slowly up around the spacecraft and across the window, drifting very, very slowly, and would then gradually move off, back in the direction I was looking. I observed these luminous objects for approximately 4 minutes each time the sun came up.
>
> During the third sunrise I turned the spacecraft around and faced forward to see if I could determine where the particles were coming from. Facing forwards I could see only about 10 percent as many particles as I had when my back was to the sun. Still, they seemed to be coming towards me from some distance so that they appeared not to be coming from the spacecraft.

Dr. John A. O'Keefe has concluded that "the most probable explanation of the Glenn effect is millimeter-size flakes of material liberated at or near sunrise by the spacecraft" (NASA, 1965, pp. 199-203).

Reference is here made to Fig. 5. We note that the apparent magnitude of the sun-illuminated sphere of diameter 1 mm. at 1 m. is -7. This is in general agreement with the description of brightness given by Glenn who referred to them as looking like steady fireflies.

Observations by astronauts in subsequent flights showed that O'Keefe's interpretation is almost certainly correct. Astronaut Carpenter in Mercury 7 found for example that (NASA SP-6, p. 72).

> At dawn on the third orbit as I reached for the densitometer, I inadvertently hit the spacecraft hatch and a cloud of particles flew by the window . . . I continued to knock on the hatch and on other portions of the spacecraft walls, and each time a cloud of particles came past the window. The particles varied in size, brightness, and color. Some were grey and others were white. The largest were 4 to 5 times the size of the smaller ones. One that I saw was a half inch long. It was shaped like a curlicue and looked like a lathe turning.

A modification of the "knocking" technique used by astronaut Carpenter to get the "firefly" effect was used by some of the Gemini astronauts who discovered that a brilliant display resulted from a urine dump at sunrise. The crystals which formed near the spacecraft, when illuminated by the sun, looked like brilliant stars. Plate 22 illustrates the effect (GT-6, Magazine B, Frame 29).

Similar spectacular effects were obtained by venting one of the on-board storage tanks when the sun was low. One such event is described by astronaut Conrad (GT-5, tape 269, page 2) speaking to the ground crew:

> We just had one of our more spectacular sights of our flight coming into sunset just before you acquired us. Either our cryo-hydrogen or our cryo-oxygen tank vented, and it just all froze when it came out and it looked like we had 7 billion stars passing by the windows which was really quite a sight.

The Glenn particles were observed to move with respect to the spacecraft at velocities of 1 to 2 m/sec. Thus the particles and the spacecraft have velocities identical within about 1 part in 4000 in all three coordinates. According to O'Keefe this implies that the orbital inclinations were the same within $\pm$ 0.01°.

The Rocket Boosters

The rocket booster often achieves orbit along with the primary spacecraft, and can often be seen by the astronauts until the relative orbits have diverged to put the booster out of sight.

Extra-Vehicular Activity Discards

Because of the crowded conditions in the Gemini spacecraft, the usual procedure after completion of extra-vehicular activity (EVA) was to discard all the equipment and material that had been essential to the EVA but was now useless. This material stayed in essentially the same orbit as the spacecraft and was visible to the astronauts after the disposal. An interesting example occurred in Gemini 12 mission when four discarded objects were seen some time later as four "stars" (GT 12, Astronaut debriefing, page K/3, 4).

Lovell:

> I did not see any objects in space other than the ones we had put there except for several meteors that whistled in below us during the night passes. I might mention we -- during the last standup EVA we discarded. *In addition to the ELSS, three bags*, one of which was the umbilical bag and the other had some food in it and the third one had several hoses that we

were discarding. And I pushed these forward with a velocity, I would guess, might be 3 or 4 feet per second. And we watched these for quite some time period until they finally disappeared about 2 maybe 3 or possibly 4 orbits later at sunrise condition, we looked out again and saw 4 objects lined up in a row and they weren't stars I know. They must have been these same things we tossed overboard.

Much has been made of this event by John A. Keel, who apparently thought there was discrepancy between the number of objects thrown out by the astronauts (three) and the number of objects later seen as illuminated objects (four). The pertinent part of Keel's article follows (Keel, 1967):

> You never read about it in your local newspaper but during the last successful manned space shot -- the flight of *Gemini 12* in November 1966 -- astronauts James Lovell and Edwin Aldrin reported seeing four unidentifiable objects near their orbit.
>
> "We saw four objects lined up in a row" Captain Lovell told a press conference on November 23rd, "and they weren't stars I know". Several orbits earlier, he explained, they had thrown three small plastic bags of garbage out of the spacecraft. He hinted that these four starlike objects standing in a neat row were, somehow, that trio of non-luminous garbage bags.

A careful reading of the original transcript however shows that four objects were discarded, i.e. *the ELSS, plus three bags.*

9. Unidentified Flying Objects

There are three visual sightings made by the astronauts while in orbit which, in the judgment of the writer, have not been adequately explained. These are:

1. Gemini 4, astronaut McDivitt. Observation of a cylindrical object with a protuberance.
2. Gemini 4, astronaut McDivitt. Observation of a moving bright light at a higher level than the Gemini spacecraft.
3. Gemini 7, astronaut Borman saw what he referred to as a "bogey" flying in formation with the spacecraft.

1. Gemini 4. cylindrical object with protuberance.

Astronaut McDivitt described seeing at 3:00 CST, on 4 June 1965, a cylindrical object that appeared to have arms sticking out, a description suggesting a spacecraft with an antenna.

I had a conversation with astronaut McDivitt on 3 October 1967, about this sighting and reproduce here my summary of the conversation.

McDivitt saw a cylindrical-shaped object with an antenna-like extension. The appearance was something like the second phase of a Titan (not necessarily implying that that is actually what he saw). It was not possible to estimate its distance but it did have angular extension, that is it did not appear as a "point." It gave a white or silvery appearance as seen against the day sky. The spacecraft was in free drifting flight somewhere over the Pacific Ocean. One still picture was taken plus some movie exposures on black and white film. The impression was not that the object was moving parallel with the spacecraft but rather that it was closing in and that it was nearby. The reaction of the astronaut was that it might be necessary to take action to avoid a collision. The object was lost to view when the sun shone on the window (which was rather dirty). He tried to get the object back into view by maneuvering so the sun was not on the window but was not able to pick it up again.

When they landed, the film was sent from the carrier to land and was not seen again by McDivitt for four days. The NASA photo interpreter had released three or four pictures but McDivitt says that the pictures released were definitely not of the object he had seen. His personal inspection of the film later revealed what he had seen although the quality of the image and of the blown-up point was such that the object was seen only "hazily" against the sky. But he feels that a positive identification had been made.

It is McDivitt's opinion that the object was *probably* some unmanned satellite. NORAD made an investigation of possible satellites and came up with the suggestion that the object might have been Pegasus which was 1200 miles away at the time. McDivitt questions this identification.

The NORAD computer facility's determination of the distances from GT-4 to other known objects in space at the time of the astronaut McDivitt's sighting yielded the following tabulation.

Object	Number: Spadats (NORAD)	Number: International (PASS)	Time (C.S.T.)	Distance in km from GT-4
Fragment	975		2:56	439
Tank	932		3:01	740
Fragment	514		3:04	427
Omicron	646		3:06	905
Omicron	477		3:07	979
Fragment	726		3:09	625
Fragment	874		3:13	905
Omicron	124		3:13	722
Pegasus Debris	1385		3:16	757
Yo-Yo Despin Weight	167		3:18	684
Pegasus B		1965-39A	3:06	2000

Table 10
(Source: Gemini News Center, Release Number 17, 4 June 1965)

A preliminary identification of the object as Pegasus B is suspect. When fully extended Pegasus B has a maximum dimension of 29.3 meters, which corresponds to 1/20 minute of arc at a distance of 2000 km. This is much too small an angular extension for the structure of the craft to be resolved and thus does not agree with the description of "arms sticking out." Later in the mission Pegasus B was at a much more favorable distance (497 km.) from the Gemini 4 spacecraft or four times as close as during the reported sighting. Astronauts McDivitt and White reported that they were *not* successful in a serious attempt to visually identify the Pegasus B satellite during this encounter.

The ten objects in addition to Pegasus B in the NORAD list were all at considerably greater distances away from GT-4 than an admittedly crude estimate of 10 miles (16 km.) made by McDivitt, and were of the same or smaller size than Pegasus B. They would not appear to be likely candidates for the object sighted by the astronaut.

2. Gemini 4, moving bright light, higher than spacecraft.

At 50h 58m 03s of elapsed time of GT-4, astronaut McDivitt made the following report.

> Just saw a satellite, very high . . . spotted away just like a star on the ground when you see one go by, a long, long ways away. When I saw this satellite go by we were pointed just about directly overhead. It looked like it was going from left to right . . . back toward the west, so it must have been going from south to north.

Although McDivitt referred to this sighting as a satellite, I have included it among the puzzlers because it was higher than the GT-4 and moving in a polar orbit. It was reported as looking like a "star" so we have no indication of an angular extension.

The suggestion at the time of sighting that this was a satellite has not been confirmed, so far as I know, by a definite identification of a known satellite.

Conversations with McDivitt indicate that on one other occasion, off the coast of China, he saw a "light" that was moving with respect to the star background. No details could be made out by him.

3. Gemini 7, "bogey."

Portions of the transcript (GT 7/6, tape 51, pages 4,5,6) from Gemini 7 are reproduced here. The following conversation took place between the spacecraft and the ground control at Houston and referred to a sighting at the start of the second revolution of the flight:

Spacecraft:	Gemini 7 here, Houston how do you read?
Capcom:	Loud and clear. 7, go ahead.
Spacecraft:	Bogey at 10 o'clock high.
Capcom:	This is Houston. Say again 7.
Spacecraft:	Said we have a bogey at 10 o'clock high.
Capcom:	Roger. Gemini 7, is that the booster or is that an actual sighting?
Spacecraft:	We have several, looks like debris up here. Actual sighting.
Capcom:	You have any more information? Estimate distance or size?
Spacecraft:	We also have the booster in sight.
Capcom:	Understand you also have the booster in sight, Roger.
Spacecraft:	Yea, we have a very, very many -- look like hundreds of little particles banked on the left out about 3 to 7 miles.
Capcom:	Understand you have many small particles going by on the left. At what distance?
Spacecraft:	Oh about -- it looks like a path of the vehicle at 90 degrees.
Capcom:	Roger, understand that they are about 3 to 4 miles away.
Spacecraft:	They are passed now they are in polar orbit.
Capcom:	Roger, understand they were about 3 or 4 miles away.
Spacecraft:	That's what it appeared like. That's roger.
Capcom:	Were these particles in addition to the booster and the bogey at 10 o'clock high?
Spacecraft:	Roger -- Spacecraft (Lovell) I have the booster on *my* side, it's a brilliant body

	in the sun, against a black background with trillions of particles on it.	
Capcom:	Roger. What direction is it from you?	
Spacecraft:	It's about at my 2 o'clock position.	(Lovell)
Capcom:	Does that mean that it's ahead of you?	
Spacecraft:	It's ahead of us at 2 o'clock, slowly tumbling.	

The general reconstruction of the sighting based on the above conversation is that in addition to the booster travelling in an orbit similar to that of the spacecraft there was another bright object (bogey) together with many illuminated particles. It might be conjectured that the bogey and particles were fragments from the launching of Gemini 7, but this is impossible if they were travelling in a polar orbit as they appeared to the astronauts to be doing.

10. Summary and Evaluation

Many of the engineering problems involved in putting men into orbit would have been alleviated if it had been decided to omit the windows in the spacecraft, although it is questionable whether the astronauts would have accepted assignments in such a vehicle. The windows did make possible many planned experiments but the observations discussed in this chapter are largely sporadic and unplanned. The program of engineering, medical and scientific experiments was sufficiently heavy to keep the astronauts moderately busy on a regular working schedule but left reasonable opportunity for the inspection of natural phenomena.

The training and perspicacity of the astronauts put their reports of sightings in the highest category of credibility. They are always meticulous in describing the "facts," avoiding any tendentious "interpretations." The negative factors inherent in spacecraft observations which have been mentioned in this chapter would seem to be more or less balanced by the positive advantages of good observers in a favorable region.

The three unexplained sightings which have been gleaned from a great mass of reports are a challenge to the analyst. Especially puzzling is the first one on the list, the daytime sighting of an object showing details such as arms (antennas?) protruding from a body having a noticeable angular extension. If the NORAD listing of objects near the GT-4 spacecraft at the time of the sighting is complete as it presumably is, we shall have to find a rational explanation or, alternatively, keep it on our list of unidentifieds.

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Chapter 7

Public Attitudes Toward UFO Phenomena

Aldora Lee

1. Introduction

Reported in this chapter are the findings of four opinion surveys conducted during the spring of 1968. The major surveys were of 2050 adults and 451 teen-agers, representing a cross-section of the U. S. population. The other two surveys concerned college students and UFO sighters. These latter two however, are not representative samples of college students and UFO sighters. In this report, findings regarding the proportion of sighters in the United States, opinions regarding the reporting of UFOs, and attitudes toward UFOs and related phenomena are considered.

It has been suggested that UFO phenomena should be studied by both physical and social scientists. Although some events are easily categorized as physical and others as social, some do not belong exclusively in one or the other domain of investigation. A focus of the study of tornadoes or other natural disasters, for example, may be upon the physical origin, evolution and demise of the phenomenon, a problem for the physical scientist; another focus may be upon the behavior and attitides of individuals regarding the phenomenon, a problem for the social or behavioral scientist. In such cases not only does the phenomenon have potential implications regarding the physical world, but it also has implications for the behavior of individuals as a function of that kind of situation.

Still, another condition may obtain. If a reported phenomenon is as yet ill-defined, it is particularly appropriate to investigate both its physical and social aspects in order to maximize the amount of information to be gained and to delimit the parameters of that phenomenon.

Two other considerations also support the study of opinions and attitudes regarding UFO phenomena. First, the great majority of UFO reports consist entirely of verbal reports; material or physical evidence is infrequently available. Even when evidence of some kind is provided, there is still necessarily a heavy reliance on the description provided by the observer. Second, most UFO reports are dependent on the perceptual and cognitive processes (Considerations regarding the nature of perception and misinterpretation are examined in Section VI Chapters 1, 2, & 3). But perception influences and is influenced by the attitudes and beliefs of the perceiver. Equally important is the fact that the attitudes and beliefs of any individual exist in a social context and are either congruent or incongruent with the attitudes and beliefs of others. In the case of attitudes regarding UFOs and related topics, it is not known whether the beliefs of for example, sighters and non-sighters differ, much less what degrees of opinion characterize the public at large.

Finally, a study of opinions and attitudes toward UFO phenomena gains support from the fact that public opinion, concerning an apparently ill-defined phenomenon, was one reason for the establishment of the Scientific Study of Unidentified Flying Objects of the University of Colorado.

In the past three public opinion polls regarding "flying saucers" have been conducted by the American Institute of Public Opinion, more familiarly known as the Gallup Poll. The report of the first poll appeared in August of 1947, shortly after Kenneth Arnold's widely publicized report of flying saucers. The Gallup news release indicate that 90% of the American public had heard of flying saucers (Gallup, 1947). About three years later, a second poll was conducted; at that time 94% of those polled had heard or read about flying saucers (Gallup, 1950). Sixteen years had passed when in 1966, the report of the third poll announced that "more than five million Americans claim to have seen something they believed to be a 'flying saucer'" (Gallup, 1966).

Because of the substantial public interest in UFO phenomena and the absence of information in the area of attitudes and opinions on the subject, opinion surveys were undertaken for the Colorado project in February 1968. The primary surveys were of adults and teen-agers, representing a cross-section of the population of the United States and were conducted for the project by the ORC Caravan Surveys Division of

Opinion Research Corporation, Princeton, N.J. Two ancillary surveys, one of UFO sighters and another of college students, were also conducted. Before these surveys are described previous research in the area of attitudes and opinions toward UFOs and related phenomena will be considered.

2. Prior Research

In the 1966 Gallup Poll, 1,575 persons were interviewed according to a stratified area sampling procedure. The interview included the following four questions:

(1) "Have you ever heard or read about 'flying saucers'?"

(2) "Have you, yourself, ever seen anything you thought was a 'flying saucer'?"

(3) "In your opinion, are they something real, or just people's imagination?"

(4) "Do you think there are people somewhat like ourselves living on other planets in the universe?"

No further explanations or elaborations of the questions were provided, so that replies necessarily were contingent on the respondent's interpretation of such words and expressions as "real" and "people somewhat like ourselves." For example, that 48% of the respondents felt that flying saucers are real does not imply that the respondents necessarily view them as space-vehicles; "real" in this context suggests a multitude of alternatives (such as weather balloons, or secret weaponry, or airplanes), all of which would afford explanations other than "people's imagination."

The major findings of this poll appear in Table 1 . As also indicated by the 1947 and 1950 polls, all but a very small proportion of the respondents had heard or read about flying saucers. From the replies to the second question in Table 1 , the Gallup organization estimated that over 5,000,000 persons had seen a flying saucer. Responses to the third and fourth questions reveal that opinion is clearly divided among those who voice an opinion, and that over 20% say that they have no opinion.

In general, the results of opinion polls may be used in two ways: first simply to represent or typify public opinion; and second, to delineate characteristics which are related to differences in opinion. Taking the

Table 1

Major Findings of the 1966 Gallup Poll

Question	Yes	No	No Opinion	Total	N
1. Have you heard or read about "flying saucers?"	96%	4	--	100%	(1575)
2. Have you ever seen anything you thought was a "flying saucer?"	5%	94	1	100%*	(1518)
3. In your opinion, are they something real, or just people's imagination?	48%**	31***	22	100%*	(1518)
4. Do you think there are people somewhat like ourselves living on other planets in the universe?	34%	45	21	100%	(1575)

*Percents are based on the number of respondents who indicated that they had heard or read about flying saucers.

**Real

***Imaginary

latter approach, the raw data from the 1966 poll were obtained from the Gallup Organization in order to examine the relationships between demographic characteristics of the respondents and their replies to the Gallup Poll questions. The finding presented here (including those of Table 1) are based on the Colorado project's statistical analyses of these data.

To determine whether those holding different opinions differ or whether sighters and nonsighters differ with respect to other characteristics, the replies to the four poll questions were examined with regard to the region of the country in which the respondents lived, age, sex, education, and where appropriate, whether the respondents were sighters.

The four regions of the country, East, Midwest, South, and West, did not differ from each other in the proportion of respondents who had heard of flying saucers. The differences among the proportions having seen a flying saucer, by region, also were not statistically significant. (To say that a difference *is* statistically significant is to indicate that the difference is not likely to be due to chance alone. For example, a difference which is significant at the .05 level is said to be so large that that or one greater would occur only 5 times out of 100 if only chance were operating). The proportion of respondents within each region indicating that flying saucers are "real" varied somewhat, with the largest percentage to say "real," 52% from the West, and the smallest, 45% from the South, with 48% and 47% for Easterners and Midwesterners, respectively. However these differences are not large enough to be statistically significant. When it came to consideration of "people on other planets," the percentage of Southerners, 27% to say "yes," was smaller than those from the other areas of the country. The percent of those from the East, Midwest, and West were 36%, 37%, and 35% respectively. The difference between southerners and others is statistically significant at the .05 level. No sufficient explanation can be offered for this regional difference on the basis of the present analyses.

In addition, the data were analysed according to age. Respondents were categorized as being in their 20's, 30's, 40's, 50's, 60's, or 70 and above. The percentage having heard of flying saucers is constant across age groups, as is the percentage who identify themselves as sighters. On the other hand, the age of the respondents does appear to be related to the replies to the other questions, as to whether flying saucers are real and whether there are people on other planets. The results of the analysis appear in Table 2. They show that the younger the respondents, the greater the proportion willing to indicate that they feel that flying saucers are "real." About twice as many persons in the youngest group answer "real" as answer "imagination," while in the oldest group the proportion answering "imagination" outweighs those replying "real." It can also be seen that the percent reporting "no opinion" varies, with a larger proportion of the older people than of the younger reporting "no opinion."

The analysis by age of the question concerning "people on other planets" appears in Table 3. Again, response is related to age, with more of the younger respondents indicating an opinion. Of those who voice an opinion, the youngest persons are fairly evenly divided between "yes" and "no," while "no's" outweigh "yeses" two to one among the eldest. The above analyses of these two opinion questions strongly suggest that age is, in some way, an important factor in beliefs regarding UFOs and related topics. The implications of these findings are considered later in conjunction with the analyses of the opinion surveys of the Colorado study.

When the questions are analysed according to sex, it is found that men and women *do not* differ in their replies, except to the question which asks whether flying saucers are real or imaginary. 43% of the men and 52% of the women indicate they think flying saucers are real; 35% and 26%, respectively, hold them to be imaginary and 22% of each group have no opinion.

Although the relationships are not strong, the results of the 1966 Gallup poll suggest that education is related to opinions. The greater the education, the higher the proportion who indicated they have heard of flying saucers, who think they are real rather than the product of imagination and who believe that there are people somewhat like ourselves living on other planets.

Table 2

Responses to the Question:

"In your opinion, are they something real, or just people's imagination?"

Age	Real	Imagination	No Opinion	Total
21-29	55%	26	19	100%
30-39	51%	27	22	100%
40-49	51%	30	20	100%
50-59	53%	31	16	100%
60-69	38%	33	29	100%
70 and above	32%	42	26	100%

Table 3

Responses to the Question:

"Do you think there are people somewhat like ourselves living on other planets in the universe?"

Age	Yes	No	No Opinion	Total
21-29	42%	41	17	100%
30-39	41%	39	21	100%
40-49	35%	48	18	100%
50-59	29%	51	20	100%
60-69	29%	44	27	100%
70 and above	23%	47	30	100%

A comparison of sighters and nonsighters shows that sighters are more inclined to say that flying saucers are real, 76% of the sighters as compared with 46% of the nonsighters, and that there are people on other planets, 51% as compared with 34%.

In summary, the analysis of the 1966 Gallup data indicate the following:

(1) Most Americans, 96%, have heard of flying saucers.

(2) About 5% of the population claim to have seen a flying saucer.

(3) About one-half of the population feel that they are real.

(4) About one-third feel that there are people on other planets.

(5) People who are better educated are more likely to have heard of flying saucers.

(6) Sighters do not differ from nonsighters with respect to education, region of the country, age, or sex.

(7) Age, sex, and education all appear to be related to whether flying saucers are considered to be real or imaginary. That is, younger persons, women, and those who are better educated tend to be more inclined than older persons, men, and the less educated, respectively, to consider flying saucers to be real.

(8) Age, education, and respondent's region of the country appear to be related to whether it seems possible that there are people on other planets in the universe. That is, younger persons, those who are better educated, and individuals from the East, Midwest, and West are more inclined than older persons, the less well educated, and those who reside in the South to think that there are "people somewhat like ourselves on other planets in the universe."

The findings of Scott (1966) provide a different kind of information about the investigation of attitudes regarding UFOs. His study was concerned with the problem of an individual's public association with UFO phenomena. Because it is commonly said that people will not report a flying saucer because they are reluctant to be associated with such a controversial topic, he undertook a small study to determine whether individuals would be less inclined to indicate acquaintance with the phenomena under public than under private conditions.

As the instructor of a class of 210 students in introductory psychology, he explained that he was collecting some data for a colleague and asked the students to indicate, by raising their hands, if they had seen each of the objects he was about to name. Each of the 11 objects that were named referred to one of three sets: neutral items, taboo (socially unacceptable or negatively sanctioned) items, and unidentified flying objects. Seven of the items were neutral, two taboo, and two UFO. The two items in the UFO set were "UFO" and "flying saucer." The number of responses to each item was recorded. A short time later, an assistant arrived with questionnaire forms listing all 11 items. The instructor indicated that he had already completed the survey; the assistant said that there must have been some misunderstanding because the students were to have indicated their answers on the forms he had brought. Subsequently the students filled in the forms. Later the written responses were tallied and compared with the results of the previous inquiry. The study thus involved the comparison of public response when the response of the individual was visible to others, versus a private response, when the responses could not be observed and would remain anonymous.

A comparison of the number of students indicating that they had seen a given object under the public conditon and the number under the private condition revealed a general increase for all items. The mean percent increase for the seven neutral items, which may serve as a baseline for comparison, was 24%. The mean increase for the two taboo items was 85% and for the two UFO items 61%. Comparisons among the three classes of items suggest that the public-private discrepancy for "UFO" and "flying saucer" is more like that for taboo words than that for neutral objects. That is, the subjects appeared to be nearly as reluctant to be associated publicly with these words as with the taboo words.

5. <u>The Colorado Study of Public Attitudes</u>

Turning now to the 1968 Colorado Study, the objectives of the research to be reported in the remainder of this chapter are: 1) To estimate the proportion of the adult American population which represents sighters; 2) to compare sighters and nonsighters with respect to age, sex, education, and region of the country in which they live; 3) to determine the attitudes of both sighters and nonsighters regarding the reporting of sightings; 4) to assess attitudes regarding various aspects of UFO phenomena and related topics.

Method

Survey Sample

In the 1968 Colorado study, four surveys were carried out: a survey of adults, a survey of teen-agers, a survey of sighters, and a survey of college students.

A. Adult sample, national opinion survey.

The data in this survey were obtained by means of a personal interview research survey, conducted by the Opinion Research Corporation, of 2,050 adults 18 years of age and over residing in private households in the continental United States. Interviewing took place between 21 February and 15 March 1968. Sample selection was made by an equal-probability sample technique. A detailed description of the sampling procedure provided by Opinion Research Corporation appears in Appendix O. Comparisons of population and survey sample characteristic appear in Tables 4 and 5, provided by the Opinion Research Corporation. The size of the sample and the method of sampling make it possible to make inferences regarding the American public at large and to make comparisons among subgroups.

B. Teen-age sample, national opinion survey.

This survey of 451 teen-agers was conducted in conjunction with the adult survey; each teen-ager who participated was a member of a household in which an adult was also interviewed. Comparisons of population and sample characteristics for teen-agers appear in Table 5, also provided by Opinion Research Corporation.

C. Sighter survey

Data were obtained from 94 sighters of UFOs whose names were drawn from the project sighting files. In addition to reports made directly to the project, there were report files, duplicating in part cases on file with the Air Force's Project Blue Book and with NICAP.

Table 4

Sample Characteristics, February 1968, ORC Caravan Surveys: Adult Sample

The data in the table below compare the characteristics of the weighted [1] Caravan sample with those of the total population, 18 years of age or over. The table shows that the distribution of the total sample parallels very closely that of the population under study.

	Total		Men		Women	
	Population [2]	Caravan Sample	Population [2]	Caravan Sample	Population [2]	Caravan Sample
Age						
18 - 29	26%	26%	25%	25%	26%	27%
30 - 39	18	18	19	17	17	19
40 - 49	19	20	20	20	19	19
50 - 59	16	16	16	18	16	15
60 or over	21	20	20	20	22	20
Race						
White	89%	89%	90%	89%	89%	89%
Nonwhite	11	11	10	11	11	11
City Size						
Rural, under 2,500 population	29%	31%	30%	35%	27%	27%
2,500 - 99,999	19	21	)			
100,000 - 999,999	23	23	) 70	65	73	73
1,000,000 or over	29	25	)			
Geographic Region						
Northeast	25%	25%	25%	25%	25%	25%
North Central	28	26	28	26	28	26
South	30	33	30	33	30	32
West	17	16	17	16	17	17

[1] Weights were introduced into the tabulations to compensate for differences in size of household and variations in completion rates between rural and urban areas.

[2] Source: Latest data from U. S. Bureau of the Census, regular and interim reports.