UFOs - An International Scientific Problem

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(Presented March 12, 1968, at the Canadian Aeronautics and
Space Institute Astronautics Symposium, Montreal, Canada)

Introduction

At the outset, let me try to summarize concisely the main points of my position:

1) From my studies of the UFO problem, I conclude that, quite apart from being the "nonsense problem" it is so often labelled, it appears to be a matter of extraordinarily great scientific interest.

2) Over twenty years of evidence (admittedly largely, though not solely, anecdotal in nature) suggests that machine-like objects, products of some technology rather than atmospheric optical or electrical anomalies, have been repeatedly seen - often by observers of very high credibility. I favor an extraterrestrial hypothesis for UFOs.

3) A search for patterns in these observations discloses one major feature - the seemingly global scale on which the observations are coming in. Hence we appear to be confronting here an international scientific problem.

4) There has never been a scientific investigation of the UFOs that can be termed thorough-going. Repeated assurances that U. S. Air Force Project Bluebook has been doing a careful study utilizing the best scientific talent available to the U. S. Air Force are found, on careful checking, to be without basis in fact. No other country of the world appears to have undertaken even as much investigation as the U. S. has done via Project Bluebook. Thus the UFO problem has not received anything that can be called scientifically adequate study.

5) I do not see convincing evidence of any U.S. cover-up conspiracy operating to conceal the true nature of the UFO problem; rather I see substantial and dismaying evidence pointing to failure to do more than superficial investigation, employing only very limited scientific talent, and exhibiting (especially since 1953) strong negative bias towards "explaining away" the UFO problem on the part of the U. S. Air Force. It is my strong impression that Air Force officials and public information officers sincerely believe that the UFO problem is a nonsense problem, one involving nothing more than misidentified natural phenomena.

6) The present Condon Committee at the University of Colorado, sponsored by the U. S. Air Force, is charged with trying to clarify the nature of the UFOs. I must state that I have become quite disappointed with the lack of scientific vigor with which that group has prosecuted its study, and I am disturbed by the frequency with which its Director has publicly indicated that he had already taken a position (negative in tone) long before the working staff had assembled adequate data to justify taking any position. I must also express my inability to understand the Director's evident preoccupation with the cultist and crackpot type of UFO accounts which, in my own experience, are quite easily filtered out and ignored. I have elaborated these criticisms in communications to Dr. Condon quite recently.

7) I would urge that scientific groups in countries other than the United States immediately undertake careful reviews of UFO reports from their

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own areas and systematic appraisals of a spectrum of conceivable hypotheses to account for the UFO phenomena. It seems quite possible that a group outside the United States, entirely free of the obstacles one encounters within the U.S. as a result of twenty years' officially negative attitude towards the UFO problem, might rapidly make very real progress towards clarifying the scientific issues at stake, given adequate scientific personnel and support. The UFO study program now developing at the University of Toronto's Institute for Aerospace Studies, here in Canada, is a laudable step towards solution of the UFO problem. More such groups in other parts of the world are needed.

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Matters of Definition

It would seem logically necessary to frame, early in any discussion of the "UFO problem" a working definition of what shall be understood by "an Unidentified Flying Object." The effort quickly entangles one in semantic difficulties of a more or less obvious nature. Clearly, untrained observers can report as a UFO a wide range of things seen in the sky or moving near the earth's surface or even resting on the surface in un-flying manner. Fireballs (meteors brighter than -5 magnitude by present astronomical definition) constitute a good example; many persons are quite unfamiliar with the phenomenology of fireballs and bolides, and will turn in sincere and often rather accurate descriptions of fireballs under the claimed heading of UFOs. Aircraft running lights, aircraft landing lights, aerial reconnaissance strobe lights, re-entering satellite debris, bright planets, and a wide miscellany of other sources of night-luminous objects are reported from time to time as "UFOs". The U.S. Air Force, and various persons who scoff at the notion that there exists a scientifically significant UFO problem, are entirely correct in suggesting that many UFO reports fall into this category. Only a little experience in querying observers makes clear that, of all reports that temporarily bear the label "UFO", a substantial fraction are, indeed, misidentified natural or technological phenomena of such types. There is plenty of noise mixed in with whatever real signal may exist; that this is so need not surprise any scientist. Noise-filtering is a standard problem in many areas of research.

The "UFO problem" which I have come to regard as so extremely important, centers around that portion of all reports of initially unidentified objects which is left as a residuum after the bulk of inadequately reported or obviously misidentified phenomena is filtered out. Only a little reflection on the foregoing remarks reveals that it is scarcely a clear-cut definition. Nevertheless, it may afford an initial basis to begin discussion.

A curiously similar definitional problem arises in dealing with the class of "ball lightning" reports. In the literature one can find reports of luminous masses, tagged as "ball lightning", that span so broad a range of phenomena that one must be quite careful that he is not subsuming many diverse phenomena under that single heading. The situation with respect to "ball lightning" turns out to be similar to that for "UFOs" in the further significant sense that the basic nature of each phenomenon is not yet clearly understood, so that clear-cut working definitions are simply not yet possible. Such a situation is really not new in science; think of the semantic ambiguity, in earlier days of science, centering around such terms as atom, compound, force, species, ether, disease, meteor, etc.

In point of fact, the above definitional problems cause rather less trouble in scientific discourse on the UFO problem than a philosopher might predict. So let's proceed.

Matters of UFO History

Although I would probably be incorrect to assume that all CASI members are thoroughly familiar with the history of the past twenty years of the UFO problem, I do not choose to elaborate that history here in great detail. Much

of my own view of that history has been summarized in a form now available elsewhere[1]. It appears to me that, following an initial flurry of official USAF concern that American UFO observations of 1947 might be hostile aeronautical devices[2], an era of puzzled investigation (generally devoid of solid scientific talent) ensued in the period 1948-52, the era of USAF Project Sign and Project Grudge. I have studied many of the 243 cases finally analyzed by and reported by Project Grudge and can only say that, even in that earliest phase of official investigation, it is startling to see how little scientific insight was brought to bear on reports of a frequently very intriguing nature.

In 1952, a brief year's energetic investigation (still not characterized by strong scientific expertise, but definitely characterized by vigorous Air Force checking and data-gathering in many striking cases) was the high-water mark of the official American UFO studies. The year 1952 saw about 1500 reports turned into Project Bluebook, some 300 of which were conceded to be Unidentifieds. When I visited Bluebook in 1966 for the first time, I was quite astonished at the number of feet of files on 1952 cases - and much more astonished to scan the contents of randomly sampled file-folders within that year's shelfful. Case after case of, to me, entirely inexplicable cases, many coming from within Air Force channels (pilots, controllers, ground crewmen, etc.) told the story of the outstanding year in American UFO history.

The wave of 1952 reports drew strong press attention, above all after Washington, D. C., became the site of two successive nights (July 19 and 26) of radar-visual sightings of Unknowns. (These were explained away in a big press conference on July 29 as due to anomalous radar propagation and optical refraction anomalies. (See below.) By late 1952, intelligence organizations became concerned over the UFO problem, evidently because of overloading of reporting and investigative channels with the large numbers of reports being fed to the Air Force by all sources. In January of 1953, the Robertson Panel, assembled by the CIA, met and ruled that there was neither evidence of hostility nor evidence of scientific significance in all those reports (of which that Panel reviewed, in its few days of activity, only about two dozen, and even those not by any means the most startling or significant then in USAF files). All of this I have discussed in enough detail previously[1] that I must gloss over many further points of great historical interest.

I have studied the final report of the Robertson Panel (in briefly declassified status prior to the CIA's reclassifying it in the summer of 1966). From repeated reexamination of the details of the UFO history and from personal discussions with four of the persons present during the Robertson Panel's activities, I form the impression of a brief but futile attempt to look for something of interest, followed by CIA's request that the Air Force adopt a policy of "debunking flying saucers" to "decrease public interest". After 1953, no further vigorous Bluebook UFO investigation program ever reappeared. The UFO problem went steadily downhill, its priority status at WPAFB steadily declined, and in 1966, when I visited Bluebook three times, its staff consisted of a major, a sergeant, and a secretary, plus a lieutenant then being broken in for future investigative duty. The total amount of scientific talent visibly focussed on UFOs via the staff and its consulting pool appeared to me to be grossly out of proportion to the embarrassment being created for the Air Force by a continuing series of absurd and scientifically outrageous "explanations" of individual UFO reports.

For further insights and facts concerning the past twenty years' history of UFO matters see Hall[3], Stanton[4], Young[5]. For information on many cases in the Air Force files prior to about 1953, and for what appears to me (on the basis of many independent checks) to be generally rather reliable history of Air Force handling of the problem prior to 1953, see Ruppelt[6]. For the viewpoints of a UFO investigator operating through those years, but outside of

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official channels, see the several books of Keyhoe[7]. When the full history of the UFO problem is written, Keyhoe's efforts, from 1949 to the present, to get the UFO problem out into the light of open scientific investigation, will, I believe, be acknowledged as having been of great significance, despite the slowness with which his efforts (and similar efforts of others) have borne fruit. His role as Director of NICAP (National Investigations Committee on Aerial Phenomena) has been seriously misunderstood by USAF personnel who, failing to recognize the utter inadequacies of their own UFO investigations, mistook his criticisms and his efforts to press for Congressional investigations as ill-conceived. I believe they were all too soundly conceived; but they pressed against massive resistance based on what seem to be generally honest misconceptions on the part of misinformed officials. Or so I see it at present.

I elaborate these viewpoints here because I have devoted a good deal of study in arriving at those viewpoints and because I believe that the misinformation generated within American information channels by the illusion that Project Bluebook was a scientific operation has diffused outside our national boundaries and has misled officials, scientists, and members of the public throughout the world. International scientific progress on the UFO problem will not begin until that misinformation is clearly recognized.

The alternative historical interpretation which holds that there has existed a conspiracy to conceal the truth about the UFO problem, a conspiracy sometimes painted-in on a canvas of international scale, does not square with such facts as I have been able to glean. I am, to be sure, puzzled by the sometimes startling similarity between "explanations" for UFOs emanating from foreign official channels (often foreign air forces) and "explanations" of the type so painfully familiar in USAF press releases following widely-publicized UFO cases. But I ascribe this similarity to factors other than a highly effective international conspiracy to which the USSR, the US, the UK, France, Australia, Canada, and many other countries would have to be party! Stanton[4] has some pithy remarks on the conspiracy theory. Young[5], by contrast, does feel there exists some American coverup at high levels; I would be prepared to defend my alternative of the "grand foulup" hypothesis against every instance he cites in defense of his "grand coverup" hypothesis. But I do not wish to have that assurance equated to categorical rejection of the "grand coverup" hypothesis. New facts or new interpretations of the many old facts I have pondered could still change my views on this issue. I would reiterate a point made earlier[1]: I suspect that some of those who have so long insisted the conspiracy theory have not been in a position to recognize clearly how scientifically inadequate the Bluebook work has been since 1953; they may have confused incompetence with inscrutability.

Scientifically, what's sorely needed is a number of entirely fresh starts, free from all pressures of governmental bodies that have taken an established position. This may be better achieved in countries other than the United States because of twenty years of Air Force assurances that there's really nothing to all the talk about UFOs, nothing of any scientific or technological significance. That view is dominant in Washington, in higher scientific circles, and among most of the elder statesmen of science in the U. S. I can speak with a good deal of authority on that point! Months of effort on my own part to generate some new scientific UFO research on an adequate national scale, with adequate science-agency support, seem to have generated only very slight response. In Washington "everybody knows the UFOs are a lot of nonsense"; and if they do admit to marginal doubt, they then insist on the propriety of waiting for Condon's report from Colorado, due at the end of 1968 if plans go forward as now set. My own doubts about the propriety of "waiting for Colorado" have recently been expressed elsewhere[8], so need not be reiterated here.

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Some Illustrative UFO Reports

One of the conclusions one must draw from studying UFO reports from all parts of the world is that there is an essential similarity in the types of unexplained phenomena reported from all parts of the globe. Discs and cigar-shaped objects dominate; nighttime observations are most common; and highly unconventional performance characteristics are described by observers in widely varying geographical areas, and by observers of quite diverse cultural backgrounds (primitive groups as well as more advanced groups). To bring out certain of these points, a small number of specific cases will be briefly summarized next.

Case 1. BOAC Stratocruiser, Seven Islands, Quebec, June 29, 1954

A famous case in UFO annals that has an appropriately international flavor occurred near sunset on June 29, 1954, over eastern Canada, when crew and passengers of a British Overseas Airways Corp. Stratocruiser, outbound from New York to London, observed, for a total period of 18 minutes (about 90 miles of flight path) one large object and five or six smaller objects somewhat north of Seven Islands. The UFOs were sighted just aft of the port wing, at a very roughly estimated distance of 5-6 miles, maneuvering in unconventional manner. Capt. James Howard, the pilot, stated, after landing in London[9], "...they were obviously not aircraft as we know them. All appeared black and I will swear they were solid...There was a big central object that appeared to keep changing shape...The six smaller objects dodged about either in front or behind." When interviewed by USAF intelligence personnel at Goose Bay, Labrador, it was established that all of the crew had participated in the sighting, as did a number of passengers, a total of over 20 witnesses. A fighter plane scrambled from Goose Bay at Howard's request. Just before it reached their area, the UFOs rapidly moved out of sight towards the northwest.

The group of UFOs maintained relatively constant position, relative to the airliner, until their departure, and lay approximately five degrees to left of the just-setting sun. No meteorological-optical phenomenon(assuredly not a sundog) could reasonably account for the reported phenomena. The Stratocruiser was cruising at about 240 knots at 19,000 ft on the southwest edge of a high-pressure center over Labrador, scarcely meteorological conditions favorable to ball lightning or any other electrical disturbances; and visibility was described by Capt. Howard as "perfect." To suggest that a natural plasmoid of any sort could keep pace with an aircraft at 240 kts for 18 minutes and 90 miles seems entirely unreasonable on a number of grounds. The speed and motions categorically rule out meteors. The peculiar maneuvering of the smaller objects and the curious shape-changes of the larger object suggest no conventional explanation. It was First Officer Lee Boyd's impression that the smaller ones merged into the larger prior to departure, again defying obvious explanation.

At that time, Howard had 7500 flying hours; he is still flying with BOAC. In a recent interview, he corroborated details of the 1954 press accounts and even added interesting additional points. The distance of the objects precluded seeing any structural details, if any had been present; it is the performance characteristics and the pronounced shape-changes that mark this well-authenticated sighting as a puzzling UFO case for which no adequate explanation has ever been proposed, to my knowledge.

Case 2. Cressy, Tasmania, October 4, 1960

A half-dozen years after Case 1, and halfway around the globe from Quebec, a well-documented sighting bearing a certain resemblance to it (a number of

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small objects around a larger one), was made by two reliable witnesses. Rev. Lionel B. Browning, an Anglican clergyman, was admiring a rainbow as he and his wife looked out a window of the Cressy, Tasmania, rectory. It was 6:10 p.m., the sun was just setting in the west. A curtain of rain concealed Ben Lomond ridge off to their east and extended through the southeast and to their south. Mrs. Browning suddenly called Rev. Browning's attention to what they both first interpreted as a large aircraft emerging from a rain-curtain nearly due east. Although the Brownings never felt entirely sure of the range of this object, they estimated it at perhaps 3 miles, since the object seemed to be over an estate known to be at that distance. Their first guess that it was an aircraft was next modified to an aircraft stalling, since the speed of the object, crudely scaled from the subjective size-and-distance estimates, seemed to be not much over 50-60 mph.

I had an opportunity to interview Rev. Browning last summer and verified contemporary press accounts[10]. He and Mrs. Browning quickly noted that the cigar-shaped object seemed to lack wings, had several vertical bands or ridges on its gray-colored surface, and some odd protuberance on its "forward" end. They watched it glide northward for about a minute before it suddenly stopped in mid-air and hovered over the ground at an altitude they very roughly guessed at 400-500 feet. Then, from out of the rainclouds farther east, there came about a half-dozen much smaller objects, of perceptibly discoid form, the Brownings stated. These smaller discs moved much faster than the larger cigar-shaped object, at speeds that Rev. Browning stated to me might have approached jet-aircraft speed. He stressed that these smaller objects "skipped like stones on water", a phraseology that I learned from associates of Rev. Browning did not originate from any previous study of UFO reports, since, prior to that October, 1960 sighting, Rev. Browning not only ignored UFO reports but took a very negative view of the authenticity of most such reports.

The Brownings next saw the discs seem to take up a "formation" around the cigar-shaped object, which had been hovering motionless during the approach and formation of the smaller objects (whose diameter the Brownings guessed at perhaps some tens of feet, in contrast to the perhaps tenfold larger length of the cigar-shaped object). Then, the entire assemblage started moving towards the south, back into the rainshower out of which the large object had first been seen emerging, whence the group was lost from sight, terminating the observation after a total elapsed time estimated by the witnesses as about two minutes, perhaps as long as three minutes.

These objects were illuminated by the setting sun, and Rev. Browning emphasized to me that there was a distinct difference in tone between the dull gray of the larger object and the shiny, metallic luster of the smaller disc-like objects.

The Brownings, after a brief discussion of this event (which by then they construed as "some Russian devices"), called the nearby airdrome to report it, which ultimately brought it to the attention of the RAAF. I have recently had a letter from the RAAF officer who did the interrogation of the Brownings. Wg. Cmdr. G. L. Waller states in his communication that the Brownings "impressed me as being mature, stable, and mentally alert individuals who had no cause or desire to see objects in the sky other than objects of definite form and substance." That impression is attested to by many others who know the Brownings personally, as I established by direct queries in Hobart and Melbourne last year.

My questions as to the ultimate public explanation which the RAAF put on the sighting elicited somewhat bitter comment from Rev. Browning, comment that I later found elaborated in press clippings made available to me by the

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officers of a very creditable private UFO group in Melbourne (Victorian Flying Saucer Research Society). The Directorate of Air Force Intelligence, RAAF, made official explanation early in 1961: "The phenomena was the result of the moonrise associated with meteorological conditions at the time of the sighting. On 4th October, 1960, moonrise (full quarter) at Cressy would have been visible shortly after 1800 hours and in an ESE direction. The objects apparently seen were near the sky-line in an easterly direction. The presence of "scud" type clouds, moving in varying directions due to turbulence in and around the rain squall near which the objects were sighted, and the position of the moon or its reflections, produced the impression of flying objects."

Such an "explanation" has a curiously familiar ring to anyone who has studied large numbers of USAF "explanations" of UFO sightings. One can quickly establish that the moon was full on the date of the Cressy sighting and that it would have risen not in the ESE but a few degrees north of east. And, still worse for the official explanation, there was not only a dense rain storm obscuring all the eastern sky as seen from the Cressy rectory, but the highest mountain range of Tasmania lay behind those dense clouds to further obscure the just-rising full moon. (Ben Lomond, summit 6160 ft, lies to ENE of Cressy, and the ridges extend off to south and north from that summit point.) From my own viewpoint, as one interested in atmospheric optics and in unusual refractive and reflective anomalies, the official suggestion that "scud" subject to turbulent motions could (had the moon not been wholly obscured by rain and mountain) be optically distorted into anything remotely resembling the phenomena reported by the Brownings seems entirely out of question. (Because USAF explanations have many times asserted, as has also Dr. D. H. Menzel in his writings on UFOs[11], that the sun and the moon can be "reflected" off sides or tops of clouds, it may be well to state that nothing in decades of meteorological optical observations supports such a notion, save for the phenomenon of the "undersun", which involves specular reflection off tabular ice crystals falling in completely non-turbulent air, and visible only from an aircraft or elevated vantage point. Sun and moon do not yield anything like distinct images by reflection off the walls of clouds; all UFO explanations invoking such optical absurdities are unreasonable. It might be added that Menzel has repeatedly erred in referring to sundogs, i.e., parhelia, as resulting from "reflection", since that familiar optical effect is caused by ice-crystal refraction.) In asserting such a meteorological explanation as was issued by the RAAF intelligence office, little evidence of scientific knowledge was exhibited, unless that office felt that the essential features of the Brownings' account had to be simply disregarded as unreliable. Yet the interrogating RAAF officer, Wg. Cdr. Waller, evidently had no such inclination to disregard these witnesses' description of their observations, nor do I.

Case 3. Fukuoka, Japan, October 15, 1948

From Air Force Project Bluebook files comes the material summarized here for this officially UNIDENTIFIED case involving airborne-radar and air-visual observation of an unconventional "bullet-shaped" object. At 11:05 p.m. LST, a USAF F-61 Black Widow fighter, with crew of pilot and radar observer, flying near Fukuoka, obtained a radar pickup on an unknown target at an altitude of around 6000 ft, and an initial range of about 10 miles. The total encounter, occupying a period of about ten minutes, is too complex to describe in full detail here. The Bluebook file on it, about a quarter-inch thick, contains a number of different intelligence reports that are not mutually compatible on certain quantitative details (closure distances, etc.). Briefly, a total of six radar passes were made, and each time the F-61 closed to about 4000 yards, whereupon the unknown accelerated suddenly from about 200 mph to an estimated 1200 mph. The original report from Far East Air Forces intelligence sources

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states that the unknown "had a high rate of acceleration and could go almost straight up or down out of radar elevation limits...There was sufficient moonlight to permit a silhouette to be discerned although no details were observed." The F-61 crew thought it possible that the six passes might have been made on two separate unknowns, but this was inferential.

Another portion of the official file includes a FEAF followup report, describing some other points: "When the F-61 approached within 12,000 ft the target executed a 180° turn and dived under the F-61. The F-61 attempted to dive with the target but was unable to keep pace...It is believed that the object was not lost from the scope due to normal skip null-zones common to all radar equipment. The pilot and observer feel that it was the high rate of speed of the object which enabled it to disappear so rapidly." And still another document in the Bluebook file on this UNIDENTIFIED describes the visual sighting made at one juncture: "At time of only visual sighting target was on a level with observing aircraft. Under night visibility all that was visible was a silhouette. Type of tail stabilizers is unknown. General classification - very short body giving a stubby appearance. Canopy, if present, was formed into aircraft body to give the object cleancut lines and was not discernible." The estimated size was 20-30 feet, and an accompanying sketch shows it as having a sharply cut-off tail ("bullet-shaped"). No exhaust was seen. The moon was nearly full on that night, and the airmen saw the outline against a moonlit cloud, they stated in their report. USAF ground-radar stations at Shigamo-Shima and Fukae-Shima had the F-61 on their scopes intermittently as it moved in and out of ground clutter, but at no times obtained a radar-return from the unknown.

Ruppelt[6] states that the Fukuoka sighting was one of the first UFO cases where an UNIDENTIFIED was seen on a radarscope; but many have since attained that distinction. Indeed, when one reads the full text of the 1953 Robertson Panel, one of the arresting points is the evident concern with the large number of "radar fast-tracks" already on record by that date. Despite the existence in USAF records of a number of UNIDENTIFIEDS seen on radar (often with both airborne and ground radar and sometimes also with ground- and air-visual sightings in accord), members of a Congressional Armed Services Committee investigation, inquiring into the UFO problem after the 1966 Michigan "swamp gas" episode, were told on April 5, 1966, by the USAF Bluebook officer, "We have no radar cases which are unexplained", when Congressman Schweiker raised that pertinent question. Dr. J. A. Hynek, Air Force scientific consultant for then 18 years, present in the hearing-room, did not correct this misinformation given to concerned Congressional inquirers.

Case 4. Gulf of Mexico, December 6, 1952

Just to cite briefly another example of a radar-visual sighting in the official UNIDENTIFIED category, one might mention the December 6, 1952 airborne sighting by the crew of an Air Force B-29 flying over the Gulf of Mexico at 18000 ft in bright moonlight. (See 7 for further details.) A total of over a half-dozen separate unknowns, seen on the B-29 radarscopes and by crewmen watching out side-blisters, passed at high speed (some speeds roughly estimated at 5000 mph from blip displacements). Some of them were seen below the flight altitude, and others maneuvered in most unconventional patterns (sudden course-reversals). No meteor explanation would fit the visual sightings, and ground-return effects are essentially out of the question by virtue of the high altitude and by the features of the atmospheric lapse rate at the time and area of the unusual sighting. It remains an UNIDENTIFIED in USAF files.

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Case 5. Washington National Airport, July 19 and 26, 1952

Many more Bluebook file reports that are in the "explained" category also involve radar-tracking of intriguing nature, but have been tagged with a variety of other identifications. One of the msot famous is the 1952 episode near Washington National Airport (July 19 and 26, 1952). I shall not give an account of it here (see for example Hall or Ruppelt or Ref. 1), but only remark that my own analysis of the radiosonde data for those two nights leads me to diametrically opposite conclusions from those that have remained the official views for fifteen years. There were only very weak inversions and moisture gradients present on those nights, incapable of causing the striking radar and visual effects reliably reported. I have recently interviewed five of the CAA controllers and four pilots involved in that sighting and can only say that it is a case of extremely great interest - fully deserving the national-headline treatment it got in 1952.

Further measure of the limited knowledge of the actual history of UFO investigations held by the USAF personnel charged with UFO responsibilities can be found in the same April 5, 1966 testimony previously cited. (See H.D. 55, Hearing by Committee on Armed Services, HR, 89th Congress, 2d Session, 4/5/66, p. 6075). Congressman Stratton asked Bluebook Officer Quintanilla: "Was there not a sighting, back it seems to me in 1947, when an object was observed on radar, either at National Airport or Bolling, both coming in and going out? It seems to me there was also a visual sighting that went along with that...Is this in your records at all?" Now, almost anyone who had attempted a serious study of UFO history would immediately recognize that Mr. Stratton, albeit confused about his recollected details, was asking of the famous Washington National sightings of July, 1952. Yet the incumbent Bluebook officer replied, "I am sure that if the sighting was reported to the Air Force it is on record, but I am not aware of this particular one, sir." Dr. Hynek did not offer correction, if he was aware that correction was needed.

Some months later, after I had been at Project Bluebook, studied their file on this important case, recomputed the refractive-index gradients to assess the Air Force claims that anomalous propagation effects caused the radar returns (numerous objects moving with variable speeds, high accelerations) and weighed official claims that optical refraction anomalies caused the visual reports (mainly from pilots flying well above the weak ground-inversion and sighting some of the objects maneuvering even above their flight altitudes), I asked Air Force consultant Hynek how he could have permitted those incorrect radar "explanations" to be passed on to press, public, and Congress for all these years. His reply was in the form of a question: "How could I set myself up against all those radar experts from Washington?" This led me to comment that it should have taken him only about one or two weeks of study of standard radar-propagation references to become fully conversant with all relevant radar details, and that homework ought to have been done by him twenty years ago, in view of his UFO consulting obligations. It is, I fear, such casual failure to really close with the puzzling nature of the UFO problem that has left it in limbo for twenty years. And all of that time, Pentagon press statements gave repeated assurances that real expertise was at work proving the correctness of the Air Force position as to misidentified natural phenomena. It is a very distressing and a very unbelievable story, which is only faintly hinted by the brief remarks that can be made here. But from the point of view of deserved international scientific attention to the UFO problem, candid criticisms of the USAF handling of this problem seems necessary to make clear that there has never been any in-depth UFO study within the U. S. Hence, I now wish to put myself on record once again as characterizing most of the past 15 years of Bluebook work as

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scientifically incompetent and superficial. Yet it has done the trick: it has kept all of us unconcerned about the UFO problem.

Conspiracy? No, not as I see it. Foulup.

Case 6. Near Barcelona, Spain, September 10, 1967

Over the past twenty years, airline pilots and flight crews have been a continuing source of scientifically puzzling UFO reports. One of the earliest, still carried by Bluebook as one of its UNIDENTIFIEDS, is a July 4, 1947 UAL sighting near Boise[2]. When some months ago I interviewed Capt. E. J. Smith, pilot of the DC-3 from which the sighting was made at sunset, shortly after takeoff, his opinion that the two formations of disc-like objects that he, his co-pilot, and a stewardess had seen 20 years earlier were no conventional aircraft seemed as strong as it had been when he was interviewed by reporters in 1947. From Capt. Smith's sighting down to the present, the class of airline-pilot reports has remained a most important class because of obvious observer-credibility factors. Let me recapitulate a much more recent one.

Just before sunset on September 10, 1967, four crew members of an Air Ferry Ltd. DC-6, bound for England from Majorca, sighted an unconventional airborne object about 60 miles NW of Barcelona, at 16,000 ft. A brief report appeared in the Sept. 11 edition of the London Daily Express, independent British investigators assembled further information, and one of the crew, F/L Brian Dunlop, submitted a summary account to VFON headquarters (Volunteer Flight Officers Network, a clearing-house in Denver for meteor, vehicle-reentry, and other aerial-sighting reports).

When first sighted, according to Dunlop, the unknown was about 30° to the left of their northbound flight path, heading towards the west at an altitude slightly above theirs. Its initial estimated distance was put at a number of tens of miles as it crossed to their right, turned towards them, and then approached after an apparent deceleration and a descending motion. The shape of the metallic-appearing object resembled an inverted ice cream cone, with a rounded base and pointed top. Dunlop stated, "There was a definite solid object the like of which none of the four crew that saw it had ever seen before, and we had been quick enough we could have got a good photo of it." Capt. F. E. C. Underhill stated in another interview that the UFO "must have been under control...it definitely altered course substantially." The course alteration brought it on a head-on approach, but it passed under the DC-6's starboard wing and disappeared to their south. The crew did not alert any of the 96 passengers aboard in the total viewing time of about 2-3 minutes, not wishing to alarm them. Estimated speed of the object was 600-700 knots, whereas the ambient wind at flight level was only 10 knots from the north. A check with Barcelona flight controllers indicated there were no known aircraft in the area, but reports do not indicate if radar coverage was available.

The shape, the veering path, the passage under the aircraft's flight level all rule out meteoric phenomena. That it was not a balloon was indicated not only by the shape, but its reported motions do not match balloon behavior in any obvious way. It would seem to be one more airline-reported unidentified flying object.

Case 7. Peruvian coast, December 30, 1966

South America has been a source of extremely large numbers of UFO reports. I have never been in a good position to evaluate the credibility and credentials of witnesses in these reports and hence pass no present judgment on most of them, but stress that they warrant searching study. One rather interesting

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case that has been cross-checked sufficiently to appear well authenticated involves observations by the 6-man flight-crew of a Canadian-Pacific Airlines DC-8, who sighted an unconventionally behaving airborne object over the Peruvian coast as they headed northwest at 35,000 ft altitude on the indicated date early in the morning (0300 LST). A report to VFON, and other reports in the press and elsewhere, give salient features of the event.

Capt. Robert Millbank's report stated that the unknown was first spotted 70° to the left of their flight path, at an estimated elevation angle of about 10°. There was a clear sky, with stars visible. At first detection, the unknown seemed to consist of a pair of lights of high luminosity, hovering for perhaps a minute, and pulsating. It next moved down towards the plane, and assumed a position off their left wing, seeming to pace the DC-8 for another minute or two.

All six crewmen took turns looking at the unknown through various windows to be positive that window-reflection effects were not involved. As the unknown paced the aircraft, it appeared to be a pair of bright lights, separated by 3-4°, and with some vaguely perceptible structure joining the lights, according to some of the crew's accounts. Others felt that no interconnecting structure was discernible, in the estimated 1-2 minutes that the object lay off the port wing (at a distance that could not be reliably estimated, but was felt to be of the order of perhaps a mile). A V-shaped pair of thin light beams emanated from the object, pointing upwards initially, but downwards later, according to Millbank's account. All passengers were asleep, and no photographs were made.

Millbank stated that "in 26 years of flying I have never seen anything like this before." Second Officer J. D. Dahl said, "...in my opinion, the only answer to this sighting is a craft with speed and controllability unknown to us." Other sighting details will be omitted here. After a few minutes of pacing to the DC-8's port side, the object was seen to accelerate, pull away, and climb rapidly out over the Pacific to the west, where it was lost in the distance.

Here, as in such a disturbingly large number of commercial airline UFO reports that have been ignored or explained away during the past two decades, one is hard put to give any conventional explanation. Clearly, unless one throws out most of the sighting details provided by the six crewmen, it will be quite unreasonable to call this unknown an aircraft, a balloon, a meteor, a plasmoid, an hallucination, or any of the other frequently-invoked misidentifieds.

Case 8. Corning, California, July 4, 1967

At about 5:15 a.m., PDT, on the morning of July 4, 1967, at least five witnesses (and reportedly others not yet locatable) saw an object of unconventional nature moving over Highway 5 on the edge of Corning, California. Hearing of the event from NICAP, I began searching for the witnesses and eventually telephone-interviewed four. Press accounts from the Corning Daily Observer and Oakland Tribune afforded further corroboration.

Jay Munger, operator of an all-night bowling alley, was drinking coffee with two police officers, James Overton of the Corning force and Frank Rakes of the Orland force, when Munger suddenly spotted the object out the front windows of his bowling alley. In a moment all three were outside observing what they each described as a dark gray oval or disc-shaped object with a bright light shining upwards on its top and a dimmer light shining downward from the underside. A dark gray or black band encircled the mid-section of the object. When first sighted, it lay almost due west, at a distance that

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they estimated at a quarter of a mile (later substantiated by independent witnesses viewing it at right angles to the line of sight of the trio at the bowling alley). It was barely moving, and seemed to be only a few hundred feet above terrain. The dawn light illuminated the object, but not so brightly as to obscure the two lights on top and bottom, they stated.

Munger, thinking to get an independent observation from a different part of Corning, returned almost immediately to telephone his wife; but she never saw it for reasons of tree-obscuration. At my request, Munger re-enacted the telephoning process to form a rough estimate of elapsed time. He obtained a time of 1-1.5 minutes. This time is of interest because, when he completed the call and rejoined Overton and Rakes, the object had still moved only a short distance south on Highway 5 (about a quarter of a mile perhaps), but then quickly accelerated and passed off to the south, going out of their sight in only about 10 seconds, far to their south.

Many skeptics reasonably enough ask why there are not many good photographs of UFOs. This is a difficult question to answer; certainly it is true that when hoax photos or dubious photos are excluded, one seems to have left a dismayingly small number of good UFO photos after 20 years of UFO sightings. A factor that may often be involved is that even those witnesses who do have loaded cameras nearby may not recover from their surprise before the object is gone. Officer Overton stated to me in my telephone interview that he had binoculars and a loaded camera in his patrol car, only a few tens of feet from the parking-lot spot where he stood gazing at the object, yet he was so stunned by the unprecedented nature of what he was seeing that it never occurred to him to run for his camera. Munger's phoning-time check suggests that this failure to think of his camera lasted over an interval of about a minute and a half.

Paul Heideman, of Fremont, California, was driving south on Highway 5 at the time of the above sighting, along with a friend, Robert King. I located Heideman and obtained from him an account of his observation made from a point on the highway north of Corning. He saw the light from the object, and had it in sight for an estimated three minutes, as it headed south, and then veered east (a turn not seen from the more restricted viewing point of the bowling-alley parking lot). Heideman said that, when first seen, it lay almost straight down Highway 5, serving to check the estimate of the other observers that the object lay only a few city blocks to their west.

The weather was clear, no haze, no wind, according to the witnesses. Munger's concise comment was, "I've never seen anything like it before." He estimated its "diameter" at perhaps 50-100 ft, and its vertical thickness as perhaps 15-20 ft, with some kind of edge (band) perhaps 5-10 ft thick. No sound was ever heard. Overton stated to me that he had no idea what it was, but that "there was no doubt it was a craft of some sort."

Here one has a daylight sighting by at least five witnesses from two viewing points, lasting for many tens of seconds. The object exhibits opacity plus light-sources. Its motion varies from near-hovering to high speed. It is seen over an azimuthal range of almost 90° by the three observers who got the closest look, yet no wings or empennage is seen. What is it? Lack of sound at as close a range as a quarter-mile and in the quiet of the early morning in a small town rules out a helicopter; lack of wings rules out a conventional aircraft. Balloons, meteors, meteorological-optical effects, and the rest of the constellation of frequently-invoked explanations do not appear to fit such a sighting. It appears necessary to describe the object as an unconventional machine-like object - or reject the witness' testimony. The scientifically embarrassing point here is that <u>many</u> other such hard-to-explain observations of machine-like objects are now on record - and being ignored.

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Case 9. Kansas City, Kansas, August 12, 1961

Another such case, involving very much closer-range observation of a craft-like object, is to be found in Bluebook files as an UNIDENTIFIED. (USAF has repeatedly asserted, for 15 years, that in their unidentified cases lies nothing that defies explanation "in terms of present-day science and technology." Not so, I am obliged to say. I am making a special study of Air Force UNIDENTIFIEDS, and would stress that there is a very large body of phenomenology in those UNIDENTIFIEDS that most certainly defies explanation in terms of today's science or today's technology! Indeed, this is the principal conclusion of the studies of all serious students of the UFO problem.)

At about 9:00 p.m. on August 12, 1961, two college-age boys living in Kansas City, Kansas, became involved in a close-range sighting of considerable interest[12]. I have recently interviewed both of these witnesses, T. A. Phipps and J. B. Furkenhoff. They were driving towards Furkenhoff's home in Phipps' open-top convertible near Old Mission High School on 50th Street. Furkenhoff sighted the object first and had been watching it for some time before he called it to Phipps' attention. It seemed to be hovering, by that time, at perhaps 50-100 ft altitude over a point only a few city blocks away. It appeared to have lights all around its lower edge, and made no sound then or later.

They drove almost directly under it and looked up at its base, where it hovered over houses whose residents were evidently unaware of the presence of the object, since no other persons were seen out of doors by the two boys. No wings, tail or propellers were visible, and no exhaust or noise was perceptible. The lights around its underside were yellowish and had a neon-glow character, according to Phipps. It was the complete lack of sound that eventually made them uneasy after a total viewing-time that they estimated at several minutes. They did not get out of the convertible, from which they had a quite adequate view. Phipps could not recall whether he stopped his engine.

The size was estimated at that of "a football field" when they were interrogated by USAF personnel in 1961 (Bluebook file account), but when I interviewed them in early 1968, they put it at more like 100 ft across. It was opaque, solid, and obscured the sky above, which was cloudless according to the Bluebook data. The Bluebook file report indicated that its shape was compared to that of a "sled with running boards", yet neither witness, when I questioned them, had the slightest idea how such a description was filed by the interrogating personnel. Their recollections differed as to shape: Phipps recalled it as disc-shaped, while Furkenhoff recalled it as a rounded cylinder.

After about 3-4 minutes of observing the silently hovering object, their uneasiness was broken by the sudden departure of the object. It accelerated from a stationary position and climbed away out of sight in a time of only a few seconds, each witness agreed. The precise climb-out path was recalled somewhat differently by the two witnesses. The 1961 Air Force interview recorded the climb-out as beginning with a directly vertical ascent followed by an inclined departure path to the east.

They each told their parents, and Phipps' mother asked a friend who was on active Air Force duty, a Maj. John Yancer, to phone the Richards-Gebaur AFB near Kansas City. He was told that an unidentified had been seen on radar, and so he urged that the boys be interviewed by USAF personnel. Telephone interviews were accomplished the next day, but no further USAF interrogation in the ensuing half-dozen years was ever carried out. This, despite the fact that it was put in the UNIDENTIFIED category at Bluebook. Such lack of

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followup of even the most intriguing UNIDENTIFIED cases is almost the rule, not the exception; this systematic failure to pursue UFO reports is only one of many disturbing facets of the USAF investigations since 1953.

The August 1961 sighting is not readily explained. Economy of expression suggests calling the object an unconventional machine-like object exhibiting performance characteristics well beyond the state of the art. I must say it also seems to defy explanation in terms of present-day science and technology, to use the Air Force's threadbare phraseology.

Case 10. Moe, Australia, February 15, 1963

To maintain a certain international tone, in keeping with the title of my remarks, I close with another interesting sighting made in a distant area. With the aid of the Melbourne VFSRS group, I was able to interview Australian farmer Charles Brew and his son Trevor last summer. They operate a small dairy farm east of Melbourne, near Moe, Vic. My interview was carried out in the milking shed where Brew and his son were working at about 7:00 a.m. on Feb. 15, 1963, when an unusual object swooped down nearby.

It was already light on this summer morning, although rainclouds lay overhead. Trevor was working in a part of the milking shed where his view of the eastern sky was obscured and he did not see the object during its short-duration passage nearby. Charles Brew, however, was standing in an opening, with a full view to the eastern sky when the object descended towards his shed and cattle-pens at an angle that he put at about 45°. The object might be loosely described as a domed disc, estimated by Brew at 25 ft in diameter, gray in color except for a transparent dome on top. Around the circumference of the object he saw an array of scoop-like or bucket-like vanes or protuberances.

As the object swooped down, almost as if to land on the hillside nearby, the cattle and horses reacted in violent panic which Brew described (in his own terms) as unprecedented. It descended to an altitude that he judged to be 75-100 feet, as estimated by the height of a tree near its point of minimal altitude. Then, after seeming to hover near the tree for a few seconds, it began a climb at roughly 45°, continuing on its westward course and passing up into the cloud deck again.

The dome was not rotating, but the central section and bottom portion appeared to be rotating at about once per second, Brew judged. The spinning motion caused the protuberances (Brew thought) to generate the swishing noise, somewhat like a turbine noise, that was clearly audible not only to Brew but also to Trevor, located inside the shed and not far from a Diesel unit powering the milking machines. The sound was even audible over the latter local noise-sources, Trevor stated.

It took some time to recover the animals that had bolted, and those already inside the fenced area were strongly disturbed for some time. Brew stated to me that it was many days before any of his cattle would walk over the part of the hillside pasture over which the object had momentarily hovered. Brew himself reported an uncommon headache persisting for a number of hours after the incident, but whether this was fortuitous cannot be concluded.

Brew has been interviewed many times by Australian UFO investigators without any reasons being found to discount his unusual sighting. My reaction to Brew was similar. It is unfortunate that the son was not in position to confirm the sighting, but he confirms the unusual sound ("like a diggerydoo", as Brew put it). The object is similar in its general features and size to that seen by a witness I interviewed in New Zealand, Mrs. Eileen Moreland. Her July 13, 1959 observation, like Brew's, and like that of many other UFO

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witnesses, is extremely difficult to explain in present-day scientific or technological terms.

* * *

The foregoing constitute ten UFO cases from fairly widely ranging geographical areas, and spanning almost two decades of time. They are intended to be illustrative but not "representative", since one of the baffling features of UFO reports (easily scoffed out of court by the skeptic) is the remarkable variety of shapes, sizes, and maneuvers reported. No mere sample of ten cases can give any feeling for that puzzling range of UFO phenomenology. Nor can a mere ten cases out of the thousands that now are on record in official or unofficial files convince a properly skeptical scientist that we are dealing here with extraterrestrial surveillance (the hypothesis that my studies suggest as most likely). One must carefully examine not tens but hundreds of such reports before the weight of evidence is seen in some perspective. The difficulty has been that very few scientists have carried out such examination to date, and hence the low a priori probability of extraterrestrial surveillance leads most scientists to discount such a possibility.

Hence, the above ten illustrative cases are only intended to convey a general impression of the puzzlement that inheres in so many UFO reports, to suggest that possibly we do have here a problem of considerable scientific interest. In my own opinion, the UFO problem may be the greatest scientific problem of our times; but I do not expect ten cases to convince doubters. I was most certainly not convinced by the first ten good cases I had checked. But I was quite intrigued, and hence kept checking. Many more scientists must do the same and add the weight of their opinion pro and con the extraterrestrial hypothesis.

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Alternatives to the Extraterrestrial Hypothesis

The UFO problem is one for which prudence dictates a studied application of Chamberlain's "method of multiple hypotheses". Since I have in previous discussions[1,8] cataloged the eight alternative hypotheses under which I like to scrutinize UFO data, I shall not recapitulate them here. When I say to you that my present position, based on months of study of UFO cases and UFO investigations, is one of favoring the hypothesis that UFOs are some form of extraterrestrial surveillance devices, I am saying that I feel that all of the obviously competing alternative hypotheses seem inadequate; by a process of elimination I come to the extraterrestrial hypothesis, as have others.

Although argument by elimination is logically sound, it is not the type of argumentation that scientists like to see used in a difficult problem. They much prefer positive arguments. The reason for this preference is simple enough: Success of argument by elimination demands that you have in your initial set of considered hypotheses all possible hypotheses, and one may not be so clever or so unbiased as to start from that point. With respect to UFOs, to put it in simple terms, one would prefer "solid evidence" - in the form of a tail fin, a jettisoned "motor", a crashed UFO, a lot of good photos, etc. Such positive evidence does not seem to exist, despite stories to the contrary. That there seem to be no crashed UFOs can be whimsically explained away by asserting that "they" seem to have attained Zero Defects. Droll, but scarcely overwhelming argumentation (even if it might prove essentially correct).

Hoaxes, illusions, hallucinations, frauds and fabrications must continually be considered, with frauds and fabrications by far the most troublesome from the viewpoint of report-evaluation. Suggestions that UFOs are advanced vehicles of a secret terrestrial technology seem absurd when one scrutinizes UFO reports and then examines the nature and state of advancement

of global technologies. I omit further comment here because I feel sure that CASI members need no long arguments on that hypothesis.

The leading alternative to the extraterrestrial hypothesis seems to be that of "misidentified natural phenomena", viewed in terms broad enough to include misidentified conventional aircraft, satellites, balloons, etc. The Bluebook position has for years been that UFOs are almost entirely such "misidentifieds", and Bluebook has repeatedly asserted that their small percentage of UNIDENTIFIEDS would fall into that category if more adequate data were at hand. I do not agree, after studying hundreds of their cases. Rather, I say that adequate and open-minded scientific scrutiny of the roughly 12,000 UFO cases now on file at Air Force Bluebook Project would probably raise the percentage of UNIDENTIFIEDS from the acknowledged few per cent (figure varies from year to year) to perhaps 30-40 per cent. An extremely important point to recognize is that intelligence personnel at the airbase levels from which the bulk of Bluebook's reports originate simply do not bother to go through the quintuplicate-filing process on any UFO report that they feel involves somebody seeing Venus, or seeing a strobe-light, or an aerial reconnaissance plane, etc. They operate with a degree of airbase-level flexibility on UFO reporting that serves effectively to filter out the obvious misidentifieds (as well as a lot more, I fear). Few persons sense this important point. The system is so loosely organized and depends so much on the interest and zeal of the individual base intelligence personnel that some obvious misidentifieds do get up to Bluebook, but by no means the large numbers that one might guess. The net result is that the Bluebook files are fascinating - not boring as I suspect many USAF officials with little scientific training think to be the case.

In addition to being fascinating, I found the Bluebook files to be extremely irritating, because after looking at the reported observational material one next looks at the official "explanation", and from a scientific viewpoint there is usually an unbelievable gap between the report-content and the official categorization. When one then tries to query, on scientific grounds, the USAF personnel responsible for those categorizations, one finds he cannot engage in anything like a scientific discussion because scientifically skilled personnel are not involved in the Bluebook operation. It is entirely clear that this has been true for the past fifteen years; and still earlier cases unfortunately point in the same direction, even back in the 1952 period of temporarily energetic investigatory work.

So, when one hears that the USAF position is that the bulk of the UFO reports they get are misidentifieds, it is necessary to probe much further to get at the truth.

Reflections and Mirages - Menzel's Views

However, it is not only Bluebook that stresses misidentifieds. For about 15 years, Dr. D. H. Menzel, former Director of Harvard College Observatory, has been saying that UFO reports fall almost entirely in that category. His two books[11,13], other writings, and many television and lecture discussions have invariably emphasized that position. It has been of particular scientific interest to me that a majority of his alternative explanations fall within my own area of interest, atmospheric physics. Consequently I have examined his arguments rather carefully and must say that they do not at all convince me. Since I have cited specific examples and discussed specific objects elsewhere[1,8], I shall not give numerous examples here.

But one category of Menzel's explanations that has evidently influenced Bluebook thinking of recent years (since similar explaining shows up in

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official files) deals with "reflection" of light from atmospheric inversions and "haze layers." Menzel's explanation of the August 20, 1949, Las Cruces N.M., sighting by Dr. Clyde Tombaugh is a case in point (11, p. 266). Menzel argues that lights from windows on some house, reflected off an elevated inversion layer produced the appearance of six yellowish rectangles that Tombaugh, along with two members of his family, saw shooting across the sky in that famous sighting. Tombaugh first spotted the geometric array of six pale-yellow rectangles almost directly overhead. Menzel suggests that they were reflections of window lights on an inversion layer at which haze had collected (despite Tombaugh's strong emphasis on the unprecedented transparency of the air that night!). Since only collimated beams like searchlight beams can yield distinct spots on haze layers, one seems left only with the notion that when Menzel says "reflection" he means just that. Let us examine the possibility that atmospheric inversion layers could yield perceptible reflectivity at near-normal incidence such as would have to be involved if Menzel's suggestion is to be acceptable.

For ideally sharp refractive index discontinuities, the Young-Fresnel equation (see, for example, 14, p. 420) gives the reflectivity R across a discontinuity between two media of relative refractive index n as

$$R = [(n - 1)/(n + 1)]^2$$

for normal incidence. Even for off-normal incidence angles out to several tens of degrees, the order of magnitude of R is well-estimated by that familiar optical relation. Menzel's qualitative discussions about how UFO apparitions stem from reflection off atmospheric discontinuities frequently involve such near-normal incidence. Hence the question becomes that of asking about how large n can become. For visible light in air at NTP, the refractive index relative to a vacuum is about 1.0003, and temperature effects across an inversion boundary (even if idealized as mathematically sharp) make changes only in about the fifth or sixth decimal place of that parameter. Clearly, then, one will make a gross overestimate of R to go the extreme case of an "inversion" separating standard air from a perfect vacuum, *i.e.*, by inserting into the Young-Fresnel relation the magnitude n = 1.0003. The result is seen to be roughly

$$R = 10^{-7}$$

This negligibly small reflectivity could not conceivably yield window-reflections of the type adduced by Menzel to account for sightings such as Tombaugh's, despite its grossly overestimating the actual "inversion-layer" reflectivity that might be encountered in the real atmosphere. Such quantitative considerations are what are not found in Menzel's defense of his discussions of UFO misidentifications, even in areas where his particular professional background ought to have made him sense the orders of magnitude likely to be involved.

In the February issue of *Air Force/Space Digest*[15] will be found a Letter discussing an observation of an odd aerial apparition seen by Lt. Col. R. G. Hill, and treated by *AF/SD* as an example of UFO reports that are explainable if only one looks far enough. I have spoken with Col. Hill to get a few further details and can only wonder if Menzel's "inversion-reflection" ideas and Bluebook's misuse of the same have not misled Hill and the editors of *AF/SD*. The four luminous discs which Hill saw on a November evening a half dozen years ago are tentatively explained in Hill's communication as "Possibly the result of some atmospheric phenomenon that caused two interfacing layers of air to reflect the light from a nearby source such as the mercury vapor lamps illuminating the parking lot at the shopping center where these objects appeared." As I have stated to Col. Hill and to *AF/SD*, this is quantitatively quite out of question, Menzel's and Bluebook's arguments notwithstanding.

Indeed, everyday experience with window-glass, whose refractive index relative to air is about 1.5, ought to have served to prevent the widespread misimpression concerning UFOs caused by "inversion-reflections." Window-glass gives an unimpressive normal-incidence reflectivity of about 4 per cent; yet

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it is obvious that it must be orders of magnitude more reflective than adjoining air layers could ever be.

That type of UFO explanation is being so seriously misapplied, by Bluebook staff and consultants, that I believe it may be well to carry the counter-arguments one step closer to the real atmosphere, for deserved emphasis. One never actually deals with mathematically sharp index-discontinuities in the earth's atmosphere, only with layers across which density may vary in some smooth, even if locally steep manner. For such "transition layers" in the index distribution, one cannot apply the Young-Fresnel equation. The mathematical problem is generally quite difficult, but Rayleigh[16] has found one model that permits useful mathematical analysis of wave-propagation at the kind of inversions that can occur in our atmosphere.

To give great benefit of doubt to inversion-reflection, one might imagine an inversion layer of such meteorologically improbable intensity that the air above the layer was 20°C hotter than that below, and in which all of this absurdly large temperature jump was concentrated within a transition layer of the unreasonably small thickness of a mere 1 centimeter. I emphasize that such intense inversions are not known in the atmosphere, so I shall still be seriously overestimating reflectivities by applying the Rayleigh theory to such a case. The computed reflectivity, again treating normal incidence, is found to be

$$R = 10^{-19}$$

I repeat; even this is an overestimate by a very large margin of what to expect in the real atmosphere.

Mirage phenomena are very real; but involve angles of incidence so far from near-normal that the small, but significant, gradients across real inversions do give refractive anomalies of readily perceptible magnitude. But one's line of sight must strike the inversion layers at almost grazing angle (order of only tens of minutes departure from the horizontal in most instances), whereas Menzel has treated miraging in his UFO discussions as if it could occur with lines of sight that often depart by many degrees from the horizontal, which is quantitatively absurd.

I could discuss other aspects of atmospheric physics that seem to me to be mishandled in Menzel's treatment of UFOs, but wish to turn to another, newer effort to account for many UFO reports in terms of another alleged type of atmospheric-physical phenomena - "plasma-UFOs", as recently discussed by Klass.

Corona, Ball Lightning, and Plasma-UFOs - Klass's Views

In working from the method of multiple hypotheses, one needs to look in all directions for possible alternatives. Quite early in my own examination of the UFO problem, I was confronted by colleagues at the University of Arizona with challenges on the ground that UFOs could be some unrecognized form of plasmoid. For example, scientists at our Lunar and Planetary Laboratory proposed that, since the wake of an entering meteoroid is a plasma and since a meteoroid sets up a highly turbulent wake-flow, perhaps vortical motions on the meteor-wake boundary could spin off masses of incandescent plasma that descend into the lower atmosphere and are reported as a UFO. I pointed out seemingly insuperable difficulties centering around rapid ion-recombination and buoyancy of hot plasmoids that would have made it most improbable that any such plasmoids could penetrate from entry-levels to the near-surface levels where innumerable "UFOs" have been reported. But mainly I stressed the more basic point that the type of UFO reports that are provocative are not mere balls of luminosity but structured objects described by seemingly quite credible witnesses as resembling machines of some type.

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Klass' Plasma-UFO Theory. I reiterate that latter strong objection to the "plasma-UFO" concept when I turn next to the recent writings of Aviation Week Senior Avionics Editor, Philip J. Klass. My most basic objection to the position he is now defending concerning plasma-UFOs is that I feel he does not confront the fact that the interesting UFO reports do not involve hazy, glowing amorphous masses, but involve reportedly sharp-edged objects often exhibiting discernible structural details, carry discrete lights or port-like apertures, and maneuver for time-periods and in kinematical patterns that are extremely difficult to square with his plasma-UFO hypothesis. And to that objection I add the same one I raise against so much of Menzel's UFO argumentation - it fails to deal quantitatively with parts of the argument that are, in terms of existing scientific knowledge, amenable to quantitative analysis.

(May I interject here that my just-cited objection can and should be turned against my own position as to the extraterrestrial hypothesis on the grounds that we do now know something about prospects of interstellar travel and certain quantitative objections about propulsion difficulties can be raised against such travel. Indeed - and many have already cited these quantitative difficulties, including Purcell, von Hoerner, and Markowitz. I reiterate (see 1, 8) that my lame yet not necessarily invalid defense is that we may not yet know all there is to know about the technology of interstellar travel and hence our attempts at quantitative assessment of the extraterrestrial surveillance hypothesis may be inconclusive. Beyond that I cannot go.)

Klass has developed his position in two magazine articles[17] and a just-published book[18]. He does not assert that all UFOs are plasma-UFOs; other misidentifications contribute, he feels. But he does argue that most students of the UFO problem (and he specifically cites me as an example) seem to have missed the "plasma fingerprint" which he sees in so much of the UFO evidence. He disclaims any view that the UFO problem is a "nonsense problem"; rather he suggests that it is one of keen scientific interest because it comprises a body of phenomena from which careful study of the plasma-hypothesis will generate valuable new knowledge of atmospheric physics and atmospheric electricity.

Now one puzzling and far from understood phenomenon of atmospheric electricity that does seem to lie in the plasma category is "ball lightning", which, for brevity, will be identified here as BL. Only within about the past decade has BL been admitted as a real phenomenon rather than some kind of illusion. In this sense, the history of BL studies is amusingly parallel to that of UFOs. It can be stated unequivocally that, in 1968, students of atmospheric electricity have not yet succeeded in developing an adequate theoretical understanding of the baffling phenomena reported under this heading. The fact that BL reports, like UFO reports, come largely from untrained observers who happen suddenly to become witnesses to the phenomenon hampers data-gathering. Also, it is sufficiently uncommon that it has been discouraging to try to set up special recording systems to gather instrumental data on the phenomenon (as is true also for UFOs). And the range of BL behavior characteristics is so wide that no single mathematical model has fit very satisfactorily the reported effects as well as the known atmospheric electrical facts. As I noted earlier above, there even exist parallels to the UFO problem in the sense that a semantic difficulty arises: One is not at all sure, in looking at published summaries of BL reports, that one is dealing with a single phenomenon. One suspects that, mixed into the alleged BL sample, are some other quite different phenomena, so that one may be trying to explain more than necessary.

Summaries of BL reports have been given by Brand[19], Dewan[20], Rayle[21] and McNally[22]; and others have published accounts of smaller numbers of individual reports. BL models have been discussed by so many workers that no catalog of

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individual papers is in order here. Dewan[23] has presented a brief summary of models developed up to about 1963, and other notions are to be found in a volume edited by Coroniti[24]. None of these models, or those subsequently offered by others such as Uman and Helstrom[25] can be viewed as entirely satisfactory.

However, one major feature of reports and mathematical models is that the majority of the former and all of the latter suggest that BL is a phenomenon closely related to ordinary thunderstorm lightning.

Fair-Weather Ball Lightning. The notion that "ball lightning" can be generated in fair weather free of all thunderstorm activity has been developed by Klass, and defended on the ground that, in the literature of atmospheric electricity, one can find a half-dozen or so reports of lightning discharges in clear air. He also defends it on the ground that, in some of the above-cited summaries of BL reports, are luminous masses that were called "ball lightning" by the witness or the data-collector, yet occurred in the absence of thunderstorms. This is a confusing situation. We do not yet know precisely what we shall mean by "ball lightning", do not know how Nature produces it, and have to concede that we may lump under that one heading phenomena of diverse nature. To illustrate that, consider Klass' citing (18, p. 121) an observation made from a USAF F-100 flying over the British Isles at 11,000 ft near midday, where a luminous orange ball with a tail streaming behind it "somewhat like a flaming meteorite" was sighted by the pilot under clear-weather condition. Klass uses that observation to support his assertions that BL can not only occur under clear-air conditions, but can move through the atmosphere at relatively high speeds. But, one must emphatically object, it is by no means obvious that it is correct to call this a BL report. Far more reasonable would be to call it an observation of a bright daylight meteor, many of which are on record in the annals of meteoritics. The very fact that the original account compares the tail to that of a meteorite ought to prompt this identification in preference to the BL identification. I urge you to read Klass' book in full to see if you do not agree that just such easy slipping of a wide range of odd observations into his plasma category has led his arguments seriously astray.* At no place in his book does he defend his assumption that plasmoids can move through the atmosphere at speeds of hundreds of meters per second, except in one special and quite interesting case - when they are electrically attracted to aircraft bearing tribo-electrically induced charges. Let us examine that notion, therefore.

Attraction of Plasma-UFOs to Aircraft. Klass takes note of the fact that UFOs have been seen following aircraft in flight, and proposes a theory to explain this. Remarking that aircraft often develop strong net charges due to contact with snow, rain, or dust particles, he suggests (18, p. 124) that "an airplane having, say a strong positive charge comes within reaction distance

* The suggestion which Klass makes that BL can form under fair-weather conditions is, like many of his other suggestions, shown to be quantitatively absurd by some elementary computations. The fair-weather earth-air current is known (28, p. 150) to average about 10^{-12} amp/m^2, and the fair-weather potential gradient averages about 100 V/m. If, then, we ask for the area of the earth's surface over which we would have to collect current to have Joule-heating within a slab, say, 100 meters deep in amount equal to a modest estimate of 100 watts (*cf.* 25, where 1000 watts is taken as perhaps more representative), we obtain an area of 10,000 km^2 as our answer! Obviously the assumption of a slab 100 m deep was quite arbitrary, but it would seem to give benefit of doubt to Klass' argument, so the figures suffice to make the notion of fair-weather ball lightning seem rather far-fetched.

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of a plasma whose surface has a negative charge" with the result that "the two will be attracted to each other, like two magnets..." He remarks that, since the aircraft has far greater mass than the plasma, the latter "will be drawn towards the aircraft rather than the reverse."

Is this subjected to any quantitative assay? No.

Let's examine that idea quantitatively here, then.

For simplicity, assume a spherical plasmoid, with the greatest allowable surface charge density, namely, that which brings the surface electric field intensity to the dielectric breakdown strength of air, E, of the order of 20,000 V/cm at typical aircraft altitudes. Similarly, let the aircraft be roughly modelled as a sphere, also charged (with assumed opposite sign) to that same breakdown limit (this will actually overestimate net aircraft charge by something like an order of magnitude, giving more benefit to Klass' assumed model). Since the surface charge density σ will satisfy $E = 4\pi\sigma$, each object will then hold a charge $Q = r^2E$ (esu), where r is the object-radius and E is taken as 20,000 V/cm $\doteq$ 65 esu/cm. If d is the separation of the centers of aircraft and plasmoid, then the force F (cgs) acting between the two entities is

$$F = Q_aQ_p/d^2 = r_a^2r_p^2E^2/d^2$$

where subscripts a and p correspond, respectively, to aircraft and plasmoid. For present rough purposes, we may generously set both radii equal to ten meters, and we may let the plasmoid tag along behind the aircraft that is dragging it, on Klass' hypothesis, through the air at a lag-distance d = 100 meters. We get, then, $F \doteq 4\times10^7$ dynes.

To fulfill Klass' assumed requirements, this Coulomb attraction F must equal the effective aerodynamic drag force D, to which the fast-moving plasmoid is subjected (if it is not to be torn apart or brought to rest). Calling the drag coefficient C, the air density ρ, and the speed of aircraft and the trailing plasmoid V, we have,

$$D = \tfrac{1}{2}\,\rho\,V^2C\pi r_p^2$$

and setting D = F to determine the allowed airspeed V,

$$V^2 = (2r_a^2E^2)/(\pi\rho Cd^2).$$

Thus the radius of the UFO plasmoid disappears from the V-relation. Using $\rho \doteq 7\times10^{-4}$g/cm^3, C $\doteq$ 0.2 for the high Reynolds number regime here involved, and the previously suggested values for the other parameters, we get

$$V \doteq 4\times10^2 \text{ cm/sec} \doteq 9 \text{ mph}$$

Thus, even upon assuming a large maximally-charged aircraft and plasmoid, and limiting the trailing-distance to no more than 100 meters, we obtain so low a value for the allowed V that it is absurd.

But the conclusions are even more negative for Klass' hypothesis than is suggested by the limit V $\doteq$ 9 mph, since it is known from experience with aircraft charging [26,27] that steady leakage of autogenous charges keep surface field strengths down to values generally under 10^3V/cm (a factor of twenty lower than assumed above for the aircraft), and even that value would not be found in flying through clear air free of snow or dust. And neither Klass nor I have proposed any basis for assuming that his airborne plasmoids will be so decidedly non-neutral as to have surface charge densities anywhere near the breakdown limit, as assumed in the above calculation to give Klass full benefit of doubt on that socre. When some allowance is made for those factors, it is seen that a plasmoid could not be drawn through the atmosphere at the pace of even a very slow walk by the Coulomb interactions which Klass

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invokes to fit his hypothesis of plasma-UFOs, hence his ideas on plasma-UFOs pacing aircraft are quantitatively untenable. He states that they do not come very close to the charged aircraft because the aircraft's "windstream serves as a protective sheath", another qualitatively *ad hoc* assumption that can now be seen to be irrelevant.

In one of his articles[17], Klass explains inability of jet interceptors to close on UFOs as resulting from the circumstance that aircraft and plasma have the same charge, so that the interceptor repels the plasma-UFO and can never catch up with it. This is equally absurd.

Other objections could be raised: Klass fails to confront his hypothesis with cases where UFOs were neither attracted to nor repelled by aircraft, yet UFOs have made close passes coming from all relative directions and exhibited many unusual maneuvers not fitting his model. For example, a very famous UFO sighting, the July 24, 1948, Chiles-Whitted sighting over Montgomery, Alabama, is briefly alluded to on p. 118 of his book, so Klass must know that Chiles and Whitted saw the object (which they said had a double row of windows, a length comparable to a B-29, a cherry-red wake, and a blue glow from nose to tail along its undersurface) come almost directly at their DC-3 on a near-collision course before it passed them and then did an abrupt pullup before it disappeared. Coulomb attractions at work? Innumerable other aircraft-observed UFOs could be cited that would not fit Klass' Coulomb-attraction model, even if it did make quantitative sense for trailing UFOs. It can only be concluded that Klass has not provided an explanation for why UFOs sometimes come near aircraft.

Not only does Klass suggest that "highly charged aircraft" can attract his plasma-UFOs, but also (18, p. 125-6) suggests that charged automobiles attract "low-altitude UFOs". Then, carrying the idea to its full absurdity, he proposes that a charged pedestrian "who encounters a very low-altitude UFO may find it is drawn slowly toward him or that it backs off as he approaches it." The question of whether it shall be attracted or repelled depends, Klass adds, on the sign of the charge of the UFO and that "of the very slight charge on the person". To make such assertions without any attempt at inserting numbers into the elementary calculations that disclose their low plausibility is quite typical of Klass' book.

[It might be added, in this final version of the draft presented at the Montreal CASI meeting, that my use of the figure 20,000 V/cm in my rough check of Klass' aircraft-pacing model was challenged from the floor by Klass. He stated that this figure must obviously be incorrect, for he had information that helicopters flying over dusty terrain can be charged up to 500,000 volts (see 18, p. 171). As I pointed out by way of clarification, Klass was confusing "volts" with "volts per centimeter"; and to reconcile his figure with mine we need only be sure that the helicopter had a clearance above ground of at least 25 cm (since 25 cm multiplied by 20,000 V/cm equals 500,000 volts). Here again, one is startled to encounter confusion over such elementary electrical concepts. That the dielectric breakdown strength of air is of order of 10,000 to 30,000 V/cm, depending on electrode geometry and air pressure is certainly not open to question.]

Formation of Plasma-UFOs in Wingtip Vortices. For the most part, Klass offers his readers no hint of the origin of the plasmoids to which he wishes to equate UFOs. But one case on which he appears to offer an idea of origin is in connection with aircraft. Klass (see below) has the idea that pollution products exert a helpful influence in plasma-formation. Aircraft engines emit pollution products. Therefore Klass suggests that pollutants, along with the charges which he believes are collected in the tip vortices (18, p. 168), somehow form a plasma-UFO.

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Let's go over that in more detail. First, to repeat, impact charging of aircraft in clear, particle-free air is negligible. One must have rain, snow, or dust impacting on the aircraft surfaces to generate strong autogenous charges [26,27], so Klass is in serious initial trouble on this score alone. Furthermore, when an aircraft is undergoing such impact-charging, what actually occurs is that the surface charge densities build up to an equilibrium value such that the leakage-rate just equals the charging rate. (One great value of charge-dissipating whips on wing trailing edges is that they boost the effective discharge rate to so high a value that the steady-state values of total aircraft charge are low.) Under the steady state that is quickly attained on entering a dust or snow cloud, the air passing off the wing has zero net charge, since the leakage charge just balances the residue left over from the impact charging. Thus, Klass will not get plasmoids bearing any significant net charge by such a process, so his aircraft-chasing UFOs are not accounted for by the only model that he offers his reader to get his plasmoids airborne.

But the difficulties are much more serious than absence of significant net charge. To have a plasmoid in the usual sense of the term requires high concentrations of free electrons, whereas all that will be sweeping off the trailing edge of an aircraft wing when flown under conditions favoring charging (dust, snow, rain) will be "ions" in the sense employed in atmospheric electricity. All free electrons will attach to oxygens in microseconds; and exhaust pollutants will further demobilize the small ions that are thus formed. Between this and ordinary ion-recombination processes, nothing remotely resembling a luminous plasmoid can possibly be expected to appear within the trailing vortices of an aircraft. When Klass states (18, p. 168) that "an aircraft could accumulate electrical energy and focus it into periodic discharges which could create a plasma-UFO in its wake when conditions were right," and then adds that these plasmoids would be left behind so that "another pilot flying along the same airway a few minutes later might encounter a glowing plasma," he is using arguments that would collapse if he were to try to put numbers into them. The temporal and spatial instability of plasmoids is one of their most outstanding characteristics. Klass accounts neither for their formation nor for their survival in this context of aircraft-related plasmas.

Diurnal Variations of UFOs. Klass suggests that UFOs are a mystery of atmospheric electricity. Students of that subject will certainly find some surprising mysteries of an atmospheric-electrical nature on pp. 164-167 [18].

Klass cites Vallee's evidence for an evening maximum of low-altitude UFO sightings, between 6 p.m. and 10 p.m., roughly. Klass notes that Brand[19] finds a diurnal peak frequency of BL sightings at 5 p.m. Klass feels that this rough temporal correlation indicates a genetic relation between BLs and UFOs. Meteorologists could suggest to him that a 5 p.m. peak in BL observations would match the generally late-afternoon peak of thunderstorm activity. I believe that the early evening peak of UFO reports is the result of greater likelihood of detecting a luminous object at night than a non-luminous object by day. I gather that Klass shares some of the latter view; but he proceeds to a further idea that plasmas are formed with diurnal peak frequency in the early evening. The route by which he gets there is curious indeed.

First, he discusses the diurnal variation of the atmospheric electric field-strength near the earth's surface and calls attention to a tendency for most land-stations to have a maximum of field-strength near 7 p.m. He glosses over the point that more UFOs are seen in summer than in winter, and that during summer most land stations have a strong maximum of field strength

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in the mid-morning. But where his physics goes astray is that he mistakenly attributes the peak field-strength to a concurrent maximum of radon gas that produces much of the air-ionization in the lowest atmosphere.

The actual situation is[28] that increased ionization would, *per se*, increase the air's conductivity and thus decrease the observed atmospheric electric field strength - precisely the opposite of what Klass claims. Briefly, the earth-ionosphere potential difference may here be treated as constant (we may ignore the well-known universal diurnal variation), whence vertical current densities will remain sensibly constant so long as diurnal factors only alter the conductivity in a relatively shallow air layer near the earth's surface. But with constant current density, the atmospheric electric field intensity must adjust itself to vary inversely with air conductivity. Pollutants decrease air conductivity; ionization processes increase it. The well-known evening increase in field intensity is due to development of an evening low-level inversion that traps pollutants, the pollutants attach small ions to generate large ions of low mobility, the air conductivity consequently goes down, and the observed field intensity must, to maintain fixed current density, go up.

If radon-trapping were the dominating factor here, as Klass evidently thinks, evening would be a time of minimal, not maximal, field-intensity!

He extrapolates the above to a claimed explanation for the higher frequency of UFO sightings in rural areas vs. urban areas; but again it is based on the above misconception of the role of inversions, so that this deduction of Klass' is also invalid.

But even beyond the confusion engendered by Klass' thoroughly confusing the physics of the diurnal variations of conductivity and potential gradient, there lie further basic shortcomings that warrant emphasis. One must ask, just what does he have in mind in talking about all this? How does it relate to formation of luminous, active plasmas? Evidently the answer is to be found on p. 166 (18), where he asserts that these cyclical variations of "pollution and electrification" serve to set the stage "for the chance triggering of a plasma-UFO by a corona discharge on a high-tension line or perhaps by a brief power surge in a high-power TV or radio transmitter.

Let's examine these two categories separately.

One can only conclude that Klass believes that an increase of atmospheric ionization by the small factor (less than about 2) which he had in mind when he became confused over the foregoing diurnal-variation arguments can exert an important "triggering" action on power-line corona. That he is not clear as to the physics of corona-formation seems evident when he states earlier (18, p. 22) that "under freak conditions an electrical avalanche occurs." He must be unaware that corona discharge from power structures is not dependent upon unusual concentrations of atmospheric ions but only upon establishing sufficiently strong field strengths that the continually forming free electrons (ejected by cosmic-ray or air-radioactivity bombardment of neutral air molecules) shall be accelerated within one free path to energies sufficiently high to cause an additional impact-ionization event. Being confused on this point, he draws the erroneous inference that if he could account for some extra air-ionization, he'd account for extra "corona discharge on a high-tension line." Also, coronas don't detach from power lines.

Next consider the idea of a "brief power surge in a high-power TV or radio transmitter. A clear-channel radio broadcasting station is permitted 50,000 watt output. TV stations are typically operated at outputs in the neighborhood of 150,000 watts, though some can legally emit as much as twice this wattage. Let's take a generously large value of 300,000 watts for the

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power output from an elevated TV antenna, and, for wavelength reasons, we'll be generous to Klass in assuming an effective emitting area of only 1 m^2. From the Poynting equation, we then wish to estimate the maximum electric field strength prevailing near the antenna with a flux density of 3×10^5 watts/m^2. Since $P = 1.3 \times 10^{-3} E_o^2$ (P in watts/m^2, E_o in V/m), we find by this order-of-magnitude estimate that $E_o \doteq 150$ V/cm. Even after allowing for the reduction in dielectric strength of air at the radio frequencies involved, this generously high estimate of 150 V/cm is more than an order of magnitude too low (in fact, probably about two orders of magnitude too low) to initiate rf-breakdown and plasma-formation (see, *e.g.*, 35, p. 185 and 36, p. 156). Thus, far more than "a brief power surge" will be required to cause plasmas to appear around an antenna - and a mere two-fold variation of air-ionization would be entirely inconsequential in abetting this improbable event. So Klass appears to be in difficulty here, too, even if he had not made the prior mistakes with respect to the diurnal variations in atmospheric-electrical parameters that led him into all this.

Air Pollution as a Plasma Promoter. In the foregoing, there have now been several allusions to an underlying idea that runs through much of Klass' book: Air pollutants are alleged to aid in the formation of plasma-UFOs. This is such a curious idea, and the source of this notion is treated so casually by Klass (18, p. 153) that few readers are likely to realize how it arose. Because Klass weaves it into so much of his argument, it warrants closer examination.

Klass contacted Dr. J. R. Powell concerning some interesting laboratory work done at Brookhaven National Laboratory (APS abstract in BNL 10625, entitled "Laboratory Production of Self-sustained Atmospheric Luminosities", by Powell, Zucker, Manwaring, and Finkelstein). Using a 75 MHz rf arc discharge as the primary power source, and feeding its output into a walk-in size resonant cavity filled with selected gases at atmospheric pressure, the Brookhaven group were studying luminosities with radii in the decimeter range and lifetimes of order of a second or more after shutoff of the rf power supply. Early work indicated that such luminosities could be produced in air, N_2, O_2, or N_2O, though not in A or CO_2. It was hypothesized that the rf "pumping" stored energy in certain energetically accessible long-lived (metastable) states of N_2, or O_2, or N_2O, and that vaporized electrode atoms (e.g., Cu) produced the visible radiation after acquiring energy in collisions of the second kind with the excited chamber-gas atoms. Possible relations to the ball lightning problem were noted by the investigators.

The important points to note here are that this experiment appears to involve three crucial features: 1) a tuned cavity, 2) an rf power source feeding into it, and 3) a gas, filling the cavity at 1 atm pressure and selected to have metastable states with lifetimes of the order of seconds such as to constitute an energy reservoir upon which the light-emitting species (metal vapor atoms) can feed repetitively during the post-shutoff glow period. (Whether the interpretations put on this promising experimental work stand the test of time need not bother us here; they do appear plausible.)

Upon hearing of this laboratory work, Klass jumped via several erroneous steps to his idea that pollutants from aircraft, cars, and factories will enhance the likelihood of forming plasma-UFOs.

His first error lay in mistakenly identifying what he terms "nitrous oxides" (his plural) with the "nitrogen oxides" of air pollution literature (18, p. 153). As a matter of fact, nitrous oxide, N_2O, is a natural

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constituent of air, not considered an atmospheric pollutant (29, p. 156), and is therefore not even mentioned in most air pollution literature on the problem of the nitrogen oxides (30, p. 3-12; 31, p. 83). NO is copiously produced in all combustion processes, including those in aircraft and automobiles, and oxidizes quickly in air to NO_2, the primary photon-acceptor in photo-oxidation air pollution of the Los Angeles type. N_2O, a rather stable compound, always present in concentrations about twice that of all other nitrogen oxides characterizing polluted atmospheres, plays no part at all in any pollution problems, since it "is dangerous only in concentrations of about 90 per cent and then has mainly an anoxic effect" (32, p. 149). Indeed, chemical analysis of the "nitrogen oxides" in polluted atmospheres was not meaningful until tests, such as the phenoldisulfonic acid method (29, p.159), were developed to react to all N-oxides except N_2O! Briefly, through an error of interpretation of elementary chemical terminology, Klass misidentified the N_2O of the Brookhaven experiments with true pollutants and was off on one of the many error-chains that so weaken his treatment of the UFO problem.

Next, he failed to appreciate relevant quantitative aspects concerning the "air pollutants" he thus began to discuss. Average concentrations of N_2O at sea level are near 0.5 ppm (parts per million by volume). Average concentrations of all pollutant-N-oxides in Los Angeles run about half that (31, p. 84). To suggest that any gas present in such trace quantities could play the energy-reservoir role of the test-gases with which the Brookhaven group filled their tuned cavity is to miss completely a basic quantitative aspect of the experiments. Yet this is what Klass suggests; so here we have the next stage in his error-compounding. If the metal atoms have to make a million or more collisions, on the average, before finding one of Klass' pollutant molecules, not much light would be coming from the system.

In fact, it will have to be interjected somewhere here that, once one understands what Powell and co-workers think happens in their chamber, it becomes somewhat unreasonable to talk about adding anything to ordinary air by way of abetting the process, for they clearly assert that the N_2 and O_2 of ordinary air do quite well in providing suitable metastable energy levels to make the process work. In view of this point, all of Klass' discussion about diurnal variation in pollutant concentrations, about pollutants swept into tip vortices, and about alleged concentrations of pollutants near highways is seen to be irrelevant and based on a network of misconceptions.

But, finally, the most basic error of Klass' attempts to fit the Brookhaven experiments into his thesis lies in ignoring the very special nature of the energy source used in the laboratory work, and in casually overlooking the complete absence of anything even roughly similar to it in the outdoor environments in which he claims plasma-UFOs are being formed. The buildup of fields in the standing-wave pattern of the Brookhaven tuned cavity fed at the resonant frequency (75 MHz) provides excitation conditions that simply cannot be blandly assumed to exist aft of a wing-tip, or under an inversion in a rural area, or above an automobile speeding down a highway - or even near a high-power TV antenna, as shown above.

In the light of the preceding points, it is interesting to re-read the kinds of inferences Klass attempts to draw: He asks (18, p. 153) if it is "merely coincidence" that "both air pollution and UFOs have experienced a dramatic increase within the past two decades"; and then goes on in similar vein. "Is it also merely coincidence that many low-altitude UFOs are seen near highways, where growing numbers of autos spew out their pollution products? And is it coincidence again that many of the high-altitude UFOs are reported by pilots while flying along well-traveled airways, where aircraft also leave a trail of combustion-engine pollution products in their wake?"

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Other Misconstrued Laboratory Experiments. Although it is the Brookhaven experiments that Klass misuses most extensively in his book, three other experiments are discussed in a manner purporting to provide support for his basic plasma-UFO hypothesis. Because in each instance Klass fails to recognize quantitative factors that render the laboratory results irrelevant to the case he is trying to make, brief comments on all three seem in order.

First, he cites some demonstration experiments devised by A. F. Jenzano, director of Morehead Planetarium in North Carolina, and displays photos in support of the contention that erratically moving cigar- and disc-shaped UFOs may result from open-air counterparts of the planetarium experiments (18, p. 68 and plate 3b; also 17, p. 57 and 61). But when one reads the nature of the experiments in question, they prove to be low-pressure glow discharges carried out under pressure conditions and with externally varying capacitance quite unrelated to anything involved in UFO sightings. To make his point, Klass would have to show that something resembling the electric field strengths and near-vacuum gas pressures used in these demonstrations occurs at times of UFO sightings in the atmosphere; but such confrontation with relevant quantitative considerations is absent here, as elsewhere in Klass' treatment. Jenzano is quoted as saying he uses the device to simulate Northern Lights; this is rather more reasonable. But UFOs and the aurora are certainly two quite different matters.

Secondly, Klass cites (18, p. 132) laboratory work of W. H. Bostick on small moving plasmoids. Klass quotes Bostick as saying "...the plasma travels...not as an amorphous blob, but as a structure (called a plasmoid) whose form is determined by the magnetic field it carries along with itself." He also quotes a passage that may seem to some readers to still further support the Klass plasma hypothesis for UFOs: "...the two plasmoids seemed to seek each other out unerringly...and attach themselves to each other." The implication is that Bostick's work has some bearing on the UFO problem. However, on consulting the original papers (*e.g.*, 33), one finds that to get the observed phenomena Bostick worked at gas pressures of 10^{-5} mm HG (about a hundred-millionth of an atmosphere), except when the pressure was raised to that of "a poor vacuum (10^{-3} mm Hg) in order to slow the plasmoid down". And about equally remote from any conditions prevailing in situations where UFOs have been reported, Bostick used externally applied dc magnetic fields ranging from 500 to 2000 Gauss. The geomagnetic field has a strength of a few tenths of a Gauss. Despite Klass' intimations, the Bostick laboratory experiments bear no relation to the problem of explaining UFOs, their sometimes startlingly fast movements, and their sometimes high luminosity.

Thirdly, Klass recounts (18, p. 284) some laboratory experiments which the press featured as possibly explaining UFOs. Workers at Melpar, Inc. reportedly (34, p. 16) obtained luminous emissions from a mixture of ammonia and oxygen after spark-ignition. Neither cited account permits a reader to decide whether this was some slow combustion process or perhaps chemiluminescence. Klass states that, on triggering the process with the spark, "a glowing saucer-shaped object would form, providing the mixture had the right proportions." "Sometimes the glowing object would hover horizontally...at other times, the tiny UFO would pulsate mysteriously and flip over onto its rim or turn upside down." Interesting, from a scientific point of view; but what can this have to do with the UFO problem? Klass answers that question: "The ammonia gas that Melpar used in its experiments...could be found over newly fertilized farmlands - another possible reason why UFOs are more frequently seen in rural areas." Here is one more good illustration of omitting highly relevant quantitative considerations.

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The Melpar experiment is not described in terms one would require in order to make precise statements; but it seems clear that the partial pressure of NH_3 in their reaction vessel is a fair fraction of an atmosphere. Lacking data on maximum NH_3 concentrations over farm barnyards, I will appeal to the fact that public health officials seem never to have expressed concern over the safety of farmers exposed to hazardous concentrations of that gas, so that barnyard concentrations presumably fall well under the 100 ppm "maximum allowable concentration" set as the industrial safe limit (29, p. 24). This would be three to four orders of magnitude below the partial pressures likely to be involved in the Melpar demonstration. Not only would reaction rates be slowed down by something like 3-4 orders of magnitude by virtue of that adverse concentration ratio, but it seems entirely out of the question that it could be self-sustaining in such concentrations, even if there were a spark-source near every barnyard to provide the requisite ignition. Actually, it seems so unreasonable to suggest that farm concentrations of NH_3 could yield effects comparable to those obtained in the Melpar laboratory demonstration that the proper reaction would seem to be astonishment that any such suggestion should have been made in the first place.

Argumentation by Concatenation - Thunderstorms, Dust Devils, and Ball Lightning. Throughout his book, Klass uses a very curious type of "argumentation by concatenation". Noting that there exists some vague relation between concept A and concept B, he next passes on to observe another remote relation between B and C. Then C may have something or other in common with D, and Klass is soon asserting that A and D are related. Put in that abstract form, the only criticism that could be made is that stringing such chains may be dangerous. But seen in the form of particular instances, Klass' use of this mode of deduction appears almost ludicrous. A good illustration has already been cited - that concerning the chain of steps by which Klass went from the diurnal variation of potential gradient at land stations to a conclusion that this bears on the diurnal variation of UFO reports, via pollutants and inversions and radon gas.

Another example of this uncomfortably non-scientific mode of argument leads him to the following conclusion (18, p. 113): "The dust devil and the kugelblitz (BL), which a few weeks earlier had seemed poles apart, now were beginning to show signs of a possible family tie, at least on some occasions. Nature, I was beginning to realize, offers an even wider range of explanations for UFOs than I had first imagined."

Let's trace back through the concatenation of remarks that led to that statement.

He gets into it by attempts to explain the many daytime sightings in which UFO witnesses have asserted that the object looked "metallic". This, Klass feels, can be understood if the UFOs are glowing plasmas (18, p. 108). Briefly, the observer is fooled into thinking that the self-glow is "metallic reflection" of sunlight. Leaving aside objections to that conclusion, we next find (18, p. 109) him bothered by a UFO sighting in which "dark crescents" were seen on an otherwise white or silvery UFO; so Klass asks himself what might render a plasma-UFO dark in spots. He explains: "The most obvious answer popped into my mind: dust particles."

Next he cites a model of BL due to E. L. Hill, in which it had been suggested that BL might consist of "electrically charged dust particles and groups of molecules which somehow are electrically separated into positively and negatively charged clusters by the action of a lightning stroke," a

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model which I believe most students of the BL problem would regard as unpromising. But that model has dust and it has spin, and that's the direction in which this chain is to be strung out.

By way of seeming to confirm the notion that dust may be involved in UFO phenomena, Klass then cites (18, p. 111) a UFO sighting in which beams of light, from the UFO's eight large "windows", were described as shining so brightly that air-dust could be seen in the beams. (See 3, p. 69 for the complete account that is very abbreviated in the summary given by Klass. The sighting was made by a minister and his wife in Cleveland in the early evening of Nov. 5, 1955; the object hovered for an estimated ten minutes, at a height estimated at 500 ft and at a distance from the two witnesses of about a half mile before it began to slowly move away and pass out of sight. Out of all this, Klass takes the point that dust was visible in the beams reportedly shining out of apertures of some sort on the object, and builds that point into his chain. The fact that this plasma lasted ten minutes and had eight bright spots rather than dust-produced dark spots is ignored. The important point for the idea-chain is that dust was present.)

So next (18, p. 111), Klass ponders "swirling, charged dust particles, interacting in complex ways with charged air particles in a plasma (which could) explain the mysterious, moving, dark crescent-shaped areas" in the sighting that started the chain. This is preparation for the next jump: "This suggested still another phenomenon that I ought to investigate - 'dust devils'...". So he then spoke with several persons who gave him information about the well-known fact that dust-devils and dust storms (28, p.122) can disturb the fair-weather potential gradient by virtue of strong frictional electrification. When one of his informants remarked that dust devils are sometimes formed around the outflowing cool air that spreads out from thunderstorm downdrafts in summer storms over the arid Southwest, the last link in the chain was forged. Klass notes, with an almost audible "Ah, hah!" implicit in the italicized windup that " . . . thunderstorms are the most frequent sources of ball lightning."

That, in brief, is how Klass arrived at the passage quoted at the start of this section. That is how he established the bond between dust devils and ball lightning, with swirling, dust-laden vortical plasmoids created out of the rhetorical exercise.

The term "vortex" is one Klass likes to conjure with; it comes up repeatedly throughout the book, and is woven into his model of the plasma-UFO in several ways - almost invariably without paying any attention to scale-factors, as in the above case of dust devils and BL. One sees that same casual neglect of disparate scale factors, the same word-play in a later discussion where concatenative argumentation takes Klass from tornadoes to spinning UFOs. At one intermediate step of that particular chain (18, p. 157), he begins a paragraph speaking about tornadoes in the ordinary sense of the word, and shifts to an idea proposed by one investigator of the radar-angel problem, namely, that some angels are small airborne vortices, which that investigator dubbed "micro-tornadoes." Because Klass had, elsewhere in the book (18, p. 89) intimated that probably angels are often caused by plasma-UFOs (thus clearing up, in his contention, many cases where UFOs were tracked on radar), one comes out of the cited paragraph on p. 157 with the impression that Klass does indeed infer that "tornadoes and at least some UFOs may be distantly related members of the same family," and evidently "micro-tornadoes" and angels are also in that family. If in approaching problems of meteorology and geophysics, scientists customarily employed that kind of concatenative logic, so casually ignored important scale considerations, and rested everything on verbal arguments almost wholly devoid of quantitative considerations, they could easily show that volcanoes are related to hurricanes and earthquakes to blizzards.

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UFOs and Radar. From the chapter so labeled in Klass' book, one can draw additional instances of the author's failure to understand much of what he is talking about. He remarks, correctly, that plasmas can be seen on radar, re-entry plasma sheaths around space capsules and satellite debris being a well-known example. From that qualitatively correct beginning, without further attention to all-important quantitative matters, he proceeds to explain instances of UFOs seen on radar.

Citing (quite incompletely) a case from Hall (3, p. 85) in which an unknown object whose radar return suggested it was as big as "any of our larger transport planes" was followed for over 30 minutes from an East coast USAF radar installation, Klass proceeds to the conclusion that this was just a plasma. The important item of information concerning duration of the radar sighting was omitted by Klass; it was a clear moonlit night in the fall, and plasmoids lasting 30 minutes are rather difficult to explain. The radar target was described as moving, then stopping and remaining fixed (for the 30-minute period). An Air Force C-124 transport that came into the radar-coverage area was vectored towards the unknown. Both blips remained on the scope until the C-124 came to within a distance that the radar operator estimated at about a half-mile from the unknown, at which juncture the unknown suddenly disappeared from the scope.

Klass explains the fact that the C-124 crew could not see the plasma as due to its being "on its last legs", so that "it did not have sufficient energy to be luminous and thus was not visible..." Its sudden disappearance from the radar scope Klass sees as having resulted from the fact that "the proximity of the large metal aircraft hastened the plasma's demise, serving to drain off its residual energy in much the same way that a lightning rod attracts a lightning stroke..."

This kind of easy argumentation makes it possible to assert that casually that a plasma too weak to yield a visible glow is at so high an electrical potential relative to an ungrounded aircraft that it sends out a stroke over the half-mile gap separating it from the aircraft. And it permits Klass to ignore all considerations of recombination-times as he glosses over the 30+ minutes' duration of the reported radar sighting prior to sudden disappearance. Considering lightning returns on radar gives a much fairer comparison than plasma-sheathed re-entry vehicles. The latter draw steadily upon the kinetic energy of the entering object to maintain the plasma against recombinative losses. In lightning strokes, however, no such "steady" energy source is available. The result is that spotting lightning strokes on radar is a rather rare (though definitely well-known) occurrence. Why? Because to get a discernible radar return demands that the electron concentration in the lightning channel shall imply a "plasma frequency" greater than the radar frequency. For the frequencies employed in conventional radar practice, the requisite electron concentration runs from about 10^{10} to 10^{12} electrons/cm^3. But recombination processes go on at rates that rise very rapidly (roughly as the square) with increasing free electron concentration, so that lightning channels quickly quench out to radar-invisibility (37, p. 108). Estimated durations of radar-visibility of lightning run well under a second. The sweep-periods of typical search radar are so long compared with this time that the probability of seeing a lightning stroke on radar is rather low.

All the same, basic physics must apply to any plasmoid that one hopes to see on radar. If it lacks a sustaining steady energy source (virtually all of Klass' plasmoids suffer that deficiency), then their lifetimes relative to radar visibility must closely parallel that of lightning channels - of the order of a second or less. An unknown that gives a radar-return as intense as that of a large transport aircraft over a period exceeding 30 minutes can, therefore, be explained as a plasma only if one accounts for a continuing source of energy. Klass does not do so.

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(Sudden disappearance of unknowns from radar screens, following unconventional behavior, is encountered in many UFO radar cases. Significantly, "sudden" disappearance in the sense of getting out of sight in a few seconds, is even more common among cases of visual sightings by credible observers. As has often been remarked before, anything that could move many miles in a few seconds would seem to disappear "suddenly" from all surveillance radars with sweep periods greater than a number of seconds.)

Another example of misunderstanding of radar principles from the cited chapter concerns anomalous propagation effects (18, p. 88-9). Klass seems to be under the misimpression that spurious returns occur with anomalous propagation only if an aircraft is flying in the vicinity to provide an airborne reflecting agent. He also seems to feel that "motions and turbulence in the atmospheric layers" cause ground-returns, bounced off the aircraft, to shift and move erratically, yielding the impression that the radar observer's vicinity "is being invaded by dozens of UFOs." This particular set of misconceptions appears suspiciously like a garbled version of Menzel's misconceptions about anomalous propagation and aircraft-reflections (11, p. 153-171). The reader familiar with radar propagation physics is urged to study both of these treatments and judge for himself. A detailed recounting of Klass' version of the matter does not seem worth presenting here.

He argues (18, p. 89) that because 67 per cent of NICAP's UFO radar sightings[3] fell in the months of May, July, August, September, and November, when radar "angels" prove to be most common, it follows that the NICAP radar cases "are classic radar angels", for there would have been "only 42 per cent in these five months had the UFO radar cases been equally distributed throughout the year." Evidently Klass has very scant knowledge of statistical sampling theory, too. He intimates that the famous July, 1952 Washington National Airport UFO radar-visual sightings might have been plasma-UFOs, and closes with the comment that complete analysis is difficult fifteen years later. Not so. The data on that famous sighting, as I indicated earlier here, can be reexamined quite meaningfully even today, including the erroneous USAF claims that anomalous propagation and mirage effects accounted for its main features. Neither the latter, nor plasma-UFOs match convincingly the events of those two famous nights in UFO history.

Klass asks, finally, why all of our surveillance radar nets never see UFOs. My reply to that is to ask why he feels so sure that they do not?

Spinning Plasmas. As noted above, Klass seems to place considerable emphasis upon rotation of his plasmoids. He notes that extensive surveys of ball lightning witnesses (esp. 21, 22) find that from a fourth to a third of the BL reports involve mention of a noticeable spinning motion. His arguments about dust devils, tornadoes, and micro-tornadoes, plus other similar arguments, dispose him to the view that UFO-plasmas will often (perhaps usually) be spinning.

On p. 160, he accepts a qualitative suggestion that rotation of a doughnut-shaped plasmoid might store enough energy as rotational kinetic energy to account for its characteristics. But suppose we hope thereby to extract luminous energy at the modest rate of 100 watts for the reasonable time of 10 seconds, *i.e.*, we ask for 10^{10} ergs. The result is a spin rate of about 1000 rev/sec. Clearly, no human eye could discern angular motions at so extremely high a speed. Angular motions do not constitute a particularly attractive storage mode for energy of plasmoids.

Klass turns to an experiment by Vonnegut, Moore, and Harris[38] which, to fill his needs, he identifies as one relating to vortex motion of the outer

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shell of a plasma." On reading the original paper, one finds that it is only very distantly related to Klass' idea of plasma-UFOs, for it actually concerns the favorable effects of a vortex on maintenance of an arc discharge struck along the axis of air rotation. The inward-directed buoyancy-forces, the authors note, convectively force the hot arc gases into the center of the vortex, reducing sinuous excursions of the arc and permitting an arc to exist stably over arc-spacings about twice the spacings attainable without the vortex. Clearly, the vortical effects employed here bear on stability of the high-temperature gases in an arc discharge but have no obvious bearing on stability of BL or UFOs, since no one believes that arc discharge is involved in either of those phenomena. One more instance wherein Klass either fails to understand what he is talking about or else crowds it into his mold - probably the former.

The just-cited section of the book is followed by another curiosity. Klass suggests next that "this same vortex motion also helps to explain some of the weird movements reported both for ball lightning and UFOs, such as their right-angle turns, because it would make them behave like gyroscopes (18, p. 161). He next remarks that a spinning gyro "does not move in the direction of the push" one applies to it, "instead its gyroscopic properties cause it to move at right-angles to the direction of the push." He then suggests that "if a plasma-UFO is spinning at moderately high speed when it comes near a metal object or a source of electromagnetic fields, the electrical interaction in combination with its gyroscopic properties could cause it to move at right angles to the direction of its previous motion, as is frequently reported."

Here, as before, Klass gets demerits for ignorance of undergraduate physics. It is torques, not gross body forces, which produce the notoriously perverse reactions of gyros. A fast-spinning gyro acted upon by an external force moves in entirely direct response thereto, and not at 90° to that force, as Klass evidently assumes.

Plasmas as Nature's Rorschach Blots. To meet the objection that many witnesses have reported seeing machine-like UFOs, sometimes with ports, domes, leg-like structures, etc., Klass offers the proposal that a plasma would act like a Rorschach ink blot (18, p. 77). Without wishing to become embroiled in arguments of primarily psychological nature, I would object that projective tests of the Rorschach type do not function by virtue of the illusory mechanism Klass adduces. Normal persons arrive at their Rorschach answers by dint of requested interpretation of the unstructured blots displayed before them. To suggest, as Klass does, that light and dark areas on his alleged plasmoids are illusorily converted by observers into fanciful ports and domes is to introduce something well beyond Rorschach factors. I cite this because it is the closest Klass seems to come to confronting the very important point that, in many highly credible UFO reports, structured, craft-like objects are described in terms that fail to square with an amorphous blob of glowing plasma. I would suggest that his Rorschach idea be dropped as unreasonable. The best observations of machine-like UFOs are daylight observations where no glow is even involved, so the Rorschach-plasma idea seems to fail completely. See, for example, the Powell sighting of May 21, 1966 [8] for a single example which Klass has heard directly from the witnesses, at the same time that I did. An 18,000-hour pilot, with a second witness, saw a domed disc pass his light plane at an estimated distance of a hundred yards in midday, with excellent visibility. It was opaque, and was described as having quite distinct edges, and had a sharply contrasting white dome over red disc. Many others in that kind of category not covered by Rorschach effects could be cited.

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Mesmeric Properties of Plasma-UFOs. Not only does Klass propose that his plasma-UFOs are Rorschach blots, but also he intimates (18, p. 227) that perhaps they have " a hypnotic effect on some observers, especially if the UFO were seen at close quarters in darkness." Commenting on use of lights in concentrating a subject's attention in hypnotic experiments, he notes that "the plasma-UFO, with its intense glow, its flashing pockets of color, and its changing shape, certainly would focus the observers' attention. This could deprive his brain of its normal contact with the outside world, especially for night sightings when the object is in a remote spot..."

There is one very striking similarity between Klass' plasma-UFOs and Menzel's meteorological-optical phenomena: Both are stretched to cover a most astonishing range of UFO events. The stretching and straining of scientific principles found in their writings on UFOs is paralleled in the crackpot literature on UFOs. Indeed, if some of the unreasonable argumentation which they employ were found in something by, say George Adamski, it would be regarded as scientifically hilarious. As it is, such warping of familiar scientific principles seems only depressing.

Interference of Non-Coherent Light Sources. Another bothersome example of failure to understand rather elementary physical principles is to be found in Klass' discussion of a sighting in which a chemist, having the presence of mind to try viewing a UFO through his Polaroid glasses, discerned a series of concentric light and dark rings around the airborne UFO (18, p. 99). Klass, ignoring the basic requirement of having coherent light sources if one is to generate interference effects, offers the suggestion that interference between polarized sky light and the light being emitted by the object caused the light and dark circles reportedly seen by Webb. Not realizing that his argument was already lost, Klass continues to suggest that the reason that the light from the UFO was polarized was that motions of charges in the plasma that it really was generated magnetic fields that caused the polarization of the emitted light that then interfered with sky light when viewed through the chemist's Polaroid sunglasses. With arguments like that, one might hope to show that the moon is a plasmoid.

Cold Plasmas of Ice Crystals. Perhaps the most bothersome general feature of Klass' book is the way it repeatedly tends to carry the unwary through what may appear to be reasonable deductions, but which involve large leaps of unjustified nature when you reexamine them.

A good example concerns his discussion of "cold plasmas" (18, pp. 114-115). Let me quote his conclusion first, and then go back over the arguments that purportedly support it: "...one thing was emerging as absolutely certain. Nature has a surprisingly large bag of atmospheric electrical tricks with which it can create unusual 'flying objects.'" Working backwards, one sees some intermediate remarks about "cold plasmas" of charged ice crystals, and working still further back one arrives at a reference to a short note by Vonnegut in the October, 1955 issue of *Weather*. Reading Klass' version of it, one gets the impression that electrical discharges in thunderclouds can so alter electrical forces on charged ice crystals as to make them change attitude relative to the sun that marked reflectivity or transmissivity of the cloud could result, and that this "would cause the ice cloud to appear solid (because no sunlight passes through) and could even give a silhouette effect." Then, in a non sequitur he adds that "the raw materials for such a phenomenon, beyond those provided by nature, could come from the growing numbers of high-altitude jet aircraft", and seems to intimate that the charges are to come from jet turbine blades!

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But returning to the foundation on which the above series of steps rests, let us see just what Vonnegut actually reported in the cited note. What he reported was a pilot observation of a bright band that propagated across the top of a thunderhead, a ground observation of a bright streamer of cloud that built up slowly and then disappeared suddenly at the moment of lightning discharge within the thunderstorm, and finally some field observations by Vonnegut on brightness changes (amounting to a mere few tenths of a per cent) of thunderclouds at instant of lightning discharge within the cloud (as detected by radio-frequency noise gear). What in all of this remotely suggests UFOs to Klass? One could start talking about a very large variety of cloud-physical effects of unusual nature and remain equally far from the area of UFOs. Yet after juxtaposing the foregoing, Klass leaves his reader with the conclusion that "Nature has a surprisingly large bag of atmospheric electrical tricks with which it can create unusual 'flying objects.'" What flying objects?

In an earlier discussion of Vonnegut's note[17], Klass went even farther from such slim supporting evidence. Introducing without any atmospheric-physical basis the notion of a "vortex of ice crystals", he merges it with Vonnegut's idea of electrical orientation effects as follows: "If the angle of incidence of sunlight playing on a vortex of ice crystals aligned by electric fields were such that reflected light was directed away from an observer, it conceivably could produce a silhouette effect...(and) if the airborne vortex contains charged dust particles, similarly aligned by electric fields...a very pronounced silhouette could result. If electric discharge is taking place within the vortex between charged dust particles, as has been suggested by some ball lightning theories, it could easily create the illusion of a solid spacecraft with small lighted windows." All of this suggests the conclusion that if someone sets out to create UFOs out of almost thin air, he can do so.

Mirror Images and the Car-Stopping Problem. Klass (18, p. 96) evidently accepts, as do I, the reality of a puzzling number of instances where observers have reported engine and headlight failure coincident with close passage of a UFO. Klass suggests that "because a plasma contains a cloud of electrified particles, there is no doubt that if an auto battery were enveloped by such a plasma the battery could be short-circuited. But it is difficult to explain how a UFO-plasma could gain entry to the car battery in the engine compartment without first dissipating its energy to the metal body of the car."

However, he then comes up with an extremely curious suggestion that may be some measure of the scientific level of Klass' analyses. He needs to have his plasma ions inside the hood, to short the battery. So he remarks that "an electric charge in the vicinity of a conducting surface, such as a car's hood, creates a mirror image of itself on the opposite side of the conducting surface." Quite clearly, Klass is under the impression that "image charges" are real charges, and that the "image charge" induced on the inside of the hooded engine compartment can short-circuit the battery and cause other real effects. This is a puzzlingly erroneous misconception to be held by an electrical engineer.

Aeronautical engineers in the CASI audience can appreciate the parallel to another closely similar situation where boundary-conditions can be handled by a similar ruse: The use of "image-objects" in flow problems near solid, plane boundaries. For instance, the enhanced lift that accounts for the familiar "flare-out" as an aircraft comes down to within a few feet of an airstrip can be treated, mathematically, in terms of an identical aircraft imagined to be upside down and moving along at a distance below the real

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aircraft's true distance above the ground-plane. In fact, wind-tunnel tests of flow problems near the ground-plane are actually conducted with real model-pairs mounted in this "mirror-image" attitude. To suggest that a real automobile battery could be shorted out by "image charges" induced in the hood is comparable, then, to suggesting that "flare-out" on landing results from the fact that a real aircraft is actually flying along upside down, just underneath the airstrip.

Summary-Critique of Klass' Plasma-UFO Thesis. In the foregoing sections, I have pointed out a number of serious scientific errors and misconceptions that mark Klass' writings on UFOs[17,18]. Although he has diligently pursued the subject of UFOs for some months, his handling of the scientific questions involved reveals so many misunderstandings, often of elementary principles, that his principal thesis, namely, that a substantial portion of the previously most puzzling UFO cases can be explained as plasmas, cannot be regarded as supported.

It is important to note that Klass does not claim that all UFOs are plasmoids (18, p. 282); he feels that meteors, balloons, optical phenomena, planets, and other misidentified phenomena account for many UFO reports. He does indicate, however, that he feels he has "identified most if not all of the previously unexplained UFOs as atmospheric electrical phenomena, using NICAP's most convincing cases (18, p. 174)." By the latter, he refers to the more than 700 cases in Hall's *UFO Evidence*[3]. Such a claim is fatuous; there are in Reference 3 hundreds of cases that could not even remotely be reconciled with Klass' plasma-UFO hypothesis on any reasonable, scientific grounds. Indeed, even considering the percentually small sampling of those NICAP cases that are specifically cited in Klass' book, I would say that only perhaps two or three cases could be even tentatively viewed as some atmospheric-electrical plasmoid phenomenon. His claims to have "identified" the difficult NICAP UFO cases are gratuitous and lacking in scientific basis.

Klass asserts (18, p. 286) that "it is time that these two influential organizations (meaning NICAP and APRO) encouraged their members to open their minds to the possibility that UFOs may be only freak atmospheric electrical phenomena." He adds that NICAP and APRO should "more fully inform their members about the plasma theory", evidently thinking that this will lead them to accept his hypothesis that the most interesting UFOs are "freak atmospheric electrical phenomena." As a matter of fact, members of NICAP and APRO had weighed and rejected hypotheses similar to Klass' long before he developed an interest in the UFO problem, and three communications cited in his book (18, pp. 55, 58, and 177) from NICAP members contain more reasoned, albeit brief, reactions to that hypothesis than one finds in all of Klass' writings. The provocative UFO cases are low-altitude, close-range sightings of structured, machine-like objects of entirely unconventional nature, reported by witnesses whose credibility does not appear to be in question. The nearest Klass comes to confronting such cases is to suggest hypnotic effects or Rorschach-projective effects that make the witnesses see plasmoids as if they were structured vehicular objects with domes, panels, legs, ports, markings, etc. I have, myself, interviewed so many witnesses who have seen such objects that I can only smile weakly at the unreasonableness of Klass' intimation that he has "identified" such UFOs as plasmoids.

Furthermore, implicit in Klass' plea that NICAP, APRO, and the rest of those whom he labels as "UFOrians" should be made "fully informed" about plasma theory, is the tacit assumption that Klass, himself, is so informed. The many instances cited above wherein Klass completely misconceived pertinent aspects of the plasma physics he was attempting to talk about make such a plea quite hollow. The net effect of further study of plasma theory by

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any "UFOrians" will be to make still clearer that Klass has written a book filled with sometimes ludicrous errors concerning plasma theory and related physics. He accuses the "UFOrians" of having closed minds; looking at his handling of the UFO problem, I am left with the difficult choice of deciding whether he, himself, has an even more tightly closed mind or whether the glaring weakness of his book simply reflects his ignorance of elementary principles of physics and electrical engineering. Rather than make that choice, I split my opinion about down the middle on those two alternatives.

The principal points I would emphasize by way of critique of Klass' plasma-UFO theory are the following:

1) He fails to put numbers into his hypotheses where numbers are readily inserted. The result is that he presents what may appear to be plausible arguments because they contain some qualitatively plausible elements. In this regard, Klass resembles Menzel. Quantitative evaluations reveal serious difficulties, sometimes outright absurdity, in instance after instance in the writings of these two principal proponents of the notion that UFOs are only misidentified natural phenomena.

2) Plasmas are notoriously unstable and evanescent, except when suitably contained and provided with sustaining energy sources. Klass appears to be almost unaware of these prime characteristics of plasmas for he casually adduces plasma-explanations in UFO incidents for which he offers no suggestions as to what provides the continuing energy sources of his plasmas, often over times of the order of not only tens of seconds, but often tens of minutes.

3) In the one or two instances where Klass does actually propose something resembling an energy source (powerline corona, TV antennas, aircraft charge-leakage), it has been shown above that there are fatal difficulties with his position.

4) Through a quite astonishing series of misunderstandings, Klass builds up a thesis to the effect that air pollutants are favorable to plasma-formation, and from this, makes repeated deductions (such as greater incidence of high-altitude UFOs because of more jets polluting the airways) of exorbitant nature. That Klass would go to press with such error-riddled ideas is surprising.

5) Through failure to understand elementary principles of atmospheric electricity (the field in which he claims to be making discoveries), he builds an error-chain extending from diurnal variation of atmospheric potential gradient to diurnal variation of UFOs, and deduces therefrom an "explanation" of excess of rural over urban sightings. For someone claiming to have uncovered an intriguing new phenomenon of atmospheric electricity, Klass' ignorance of fundamentals of that subject seems startling.

6) His claim to have accounted for the high frequency with which pilots observe UFOs following aircraft falls apart completely on subjecting the idea to quantitative assessment, as shown above. His related intimations that charged automobiles and charged pedestrians also attract plasma-UFOs are absurd. It is to be stressed that the quantitative evaluation of that hypothesis involves only elementary physics and, say, electrical engineering, yet no such evaluation was made by Klass. And, to add an extremely important criticism, he overlooks dozens of well-reported cases wherein UFO maneuvers would defy explanation in terms of his Coulomb-attraction hypothesis.

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7) It seems entirely fair to suggest that part of the reason for the credence and attention given Klass' plasma-UFO hypothesis in press and non-scientific journals rests on his being an electrical engineer (the other part being, of course, his senior editorial position with a well-known aviation/aerospace magazine). In this light, his almost incredible misconceptions about "mirror-image charges", as noted above in connection with the long-puzzling UFO car-stopping problem, and the cited instance in which he was clearly confusing voltage and voltage-gradient, not to mention the many misconceptions about plasmas themselves, deserve the emphasis given to them above.

8) Finally, the most pervasively disturbing feature of Klass' book[18] is the frequency with which it relies on argument by innuendo, argument by concatenation (to re-use the phrase employed above, argument by juxtaposition - that is, his specious assembly of what to many an unwary reader will look like a clever series of related deductions, carried out in the detective-story atmosphere that he repeatedly tries to create in his writing. After giving that annoying feature of his writing a good deal of thought, and after reflecting on the high frequency of scientific errors in his writing, it is my guess that these arguments are probably not deviously contrived to fool the reader but constitute reflection on the lack of preparation of the author. The reason that they need exposure, however, is that at the present time, the UFO problem is not yet being fought-out in the usual context of serious scientific discussion. The present major difficulty still remains that of convincing a large number of persons (in the scientific community, in federal science-related agencies, in Congress, and in the general public) that the UFO problem is an extremely serious scientific problem too long laughed out of court. For this reason, the kind of of easy acceptance already given to Klass in the press cannot be viewed as unimportant. Menzel's role in helping to foster the impression, for many years now, that UFOs are all explainable in quite conventional terms has had very deleterious influence on the UFO problem; Klass will now join Menzel in extending that influence if the serious deficiencies of his thesis are not held up to careful scrutiny. It is for this reason that I have devoted so much space here to what ought perhaps to be regarded as so unscientific an exposition as to need no comment.

Summary and Conclusion

Returning now to more positive considerations, let me stress that my own studies of the UFO problem have forced me to the conclusion that it is an international scientific problem of potentially enormous importance.

In my view, the hypothesis of an extraterrestrial origin for UFOs appears (via argument by elimination of many alternative hypotheses) to be the most satisfactory hypothesis to account for the impressive body of observational evidence that has been accumulated over the past two decades of UFO sightings. Space has not permitted my confronting here the many obvious challenges that such a position properly evokes; I have confronted some of those elsewhere in cited references. Others are simply unanswerable in terms of presently available information. That's scarcely a new situation in the history of science.

If there is admitted to be even a very slim possibility that UFOs are extraterrestrial surveillance devices of some type (and I incline to that

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view at present, as do many other serious students of the UFO problem), then it should be obvious that a very energetic scientific investigation of that possibility ought to be launched. Instead, to date, world scientific opinion still leans predominantly in the direction that UFOs constitute a "nonsense problem", a bothersome host of reports of misidentified natural phenomena. However, one finds that the spokesmen who most strongly emphasize that view are (with almost no exceptions) quite uninformed as to the real nature of the UFO evidence. Ridicule and official mishandling of the problem have kept the true nature of the UFO evidence well out of sight. As one American writer recently quipped, "The American public is not telling the Air Force the truth about UFOs." This has been true on a global scale, while the mass of evidence has grown steadily greater.

New, independent, vigorous UFO investigatory programs are sorely needed. Investigators in countries other than the U.S. may have a superior opportunity to make progress towards clarification of the UFO problem because they will not be working against the long-standing prejudices so visible in official U.S. handling of the subject. Thus, I urge that programs such as the newly created Canadian UFO investigation at the University of Toronto be instituted in other countries in all parts of the world, to delve vigorously and imaginatively into the fascinating and potentially world-shaking problem of the Unidentified Flying Objects.

UFOs are, in my opinion, the greatest international scientific problem of our times.

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