

The University of Arizona, Tucson, Arizona

Meteorological Factors in Unidentified Radar Returns

14th Radar Meteorology Conference, American Meteorological Society, November 17-20, 1970

James E. McDonald

1. Introduction:

Radar meteorology might be said to have its earliest roots in attempts to account for unexplained echoes detected with Navy shipboard CXAM radar on the U.S.S. Yorktown 450 miles off the southern California coast in the summer of 1940 (Page, 1962). The echoes were demonstrated to be multiple-sweep returns from the distant San Diego coastal area, seen via the now notorious anomalous propagation (AP) conditions prevalent in that area. Similarly, productive research on what ultimately proved to be a wide variety of types of "radar angels" stemmed from efforts to account for peculiar echoes not identifiable as aircraft or precipitation or ground returns. Lightning echoes went through a similar period of existence as unidentified returns, as did those caused by intense tornado vortices, sea breeze fronts, etc. Clearly, unidentified radar returns, and the meteorological factors contributing to them, have provided a fruitful source of stimulating new problems in radar meteorology over the past three decades. Perhaps the most recent example thereof is found in current studies of the meteorological implications of the astonishing breaking-wave echoes seen on certain ultrasensitive, ultra-high-resolution radars, such as the new CW/FM vertically-pointing set developed at the Naval Electronics Laboratory. The curious scalloped and braided echo-patterns went unidentified for a time after being first noted some years back, but are now reliably attributed to index discontinuities whose shear-generated undulations and refractivity variance must come as a distinct surprise to every meteorologist on first seeing graphic records of these phenomena. In these and other cases of initially unidentified radar returns, experience has shown that close attention to recurrent features of the patterns of puzzling returns has paid off in new and important understanding of the atmosphere and its electromagnetic propagation characteristics.

The present paper will comment upon and cite some examples of a category of unidentified radar returns that do not seem to be well-known to investigators in radar meteorology, despite the fact that the phenomena have frequently been attributed to anomalous propagation and other weather effects. These are a type of returns observed on operational radars, chiefly military and air traffic radars, intermittently over a period of about twenty years, yet never subjected to any very careful, systematic, and extended scientific scrutiny, as near as I have been able to ascertain.

2. Past Studies:

It is to be understood that I exclude from this discussion (a) all really extensive layer-type returns of the sort now fairly familiar to radar meteorologists from many studies, (b) dot-angels of both wind-independent (insects, birds) and wind-dependent (atmospheric refractive anomalies) types, (c) ring angels, and (d) intense but generally really extensive and only slowly changing ground returns due to AP. After that elimination, there still remains a class of wind-independent returns, often highly localized and often exhibiting apparent speeds of propagation well above ambient wind speeds and sometimes even well above known aircraft speeds. In Plank's (1956) review of angel phenomena, he appears to have been cognizant of such a residual class, which he labeled Type III Angels ("Echoes, frequently erratic-moving, from localized, non-wind carried sources"). That he had in mind returns of the category

here under consideration seems further confirmed by his subsequent treatment (Plank, 1959, p. 23) of what he termed "a type of non-aircraft echo that suddenly appears, moves for a matter of minutes in a semi-straight line path at velocities of some 600-2000 mph, and then disappears." Echoes of this nature were discussed earlier by Borden and Vickers (1953) following two widely publicized episodes at Washington National Airport on July 19 and 26, 1952. (See also Air Weather Service, 1954.) Plank (1958) has also briefly discussed those two episodes and described the prevailing conditions as "exceedingly super-refractive." However, my own computations of the relevant N-gradients in the weak surface-inversion layer present showed a value of only about half the ducting value, and subsequent checks by Plank (personal communication) revealed that a factor of two had been inadvertently omitted from his earlier computations when his estimated gradients were in error by a factor of two, on the high side. Thayer's gradient computations confirm this (he does show a thin duct on 7/26/52, but its elevation of 1 km essentially rules out trapping), yet he too attributes the episode to AP, which is difficult to understand.

To my present knowledge, the only discussion of any substantial number of cases in the category of unusual radar returns to be considered here is that of Thayer (1969), presented as part of the University of Colorado's study of unidentified flying objects (UFOs). Since Thayer attributes many of his cases to AP, his analyses are of present interest. Blackmer et al. (1965) ostensibly addressed themselves to the present category, but in fact do not discuss a single specific instance that falls in the class of interest here; they merely review known propagation anomalies. Hardy (1969) has also described unusual radar echoes in a symposium whose context was that of the long-puzzling UFO problem; but all of his examples, like those touched on by Blackmer et al., were drawn from categories of known types of angels and gravity-wave effects and none from the category here under discussion. In the same symposium, I discussed in considerable detail (McDonald, 1969) four specific cases in the category of present interest, two of which cases Thayer (1969) had attributed to AP effects. I gave reasons for rejecting such an interpretation (McDonald 1969). For brevity, the category of present interest will be referred to as "radar UFOs" in the remainder of these remarks.

3. Some Illustrative Examples of Radar UFOs Attributed to Atmospheric Effects:

We do face a semantic problem here as to what shall be understood by the term "radar UFO." I would emphasize, first, as did Plank in describing his "Type III angels", that they must be discrete echoes (often as intense as or more intense than, conventional aircraft at corresponding ranges); and, second, they must exhibit motions whose kinematic characteristics are quite distinct from those of conventional aircraft or of familiar ground-return effects. I would also add a third stipulation that they must be unlike any of the familiar interference and ECM effects (spoking, running-rabbits, blanking, etc.). Those three stipulations may at least be suggestive of relevant elimination criteria, even if each calls for much more careful specification than is possible within present space-limitations.

Plank stressed "erratic" motion; but in many instances of radar UFOs, strong targets have moved in straight-line paths from one side of an operational scope to the other at speeds far in excess of aircraft speeds (i.e., several thousands of miles per hour) without any change of apparent course. In other instances, high-speed tracks have exhibited sharp direction-changes, stops, closed one-sweep course-reversals, or closed orbits at extreme g-levels, in fashion quite inexplicable in terms of known aeronautical devices. Plank's term "erratic" is thus somewhat misleading, although there certainly are cases on record where that description would fit rather well. His speed range, 600-2000 mph, is not acceptable here, at either its lower or upper limit. Cases that I have looked into include targets whose speeds have, within a single tracking episode, varied from zero to several times his suggested upper limit. However, I believe that, for initial purposes of discussion, there is probably rough correspondence between what Plank referred to as "Type III angels" and what I shall here term "radar UFOs", though his omission of specific details of cases he had in mind renders that conclusion a bit uncertain. Thayer was definitely concerned with the same general category that I wish to discuss, as will be seen in examples below; Hardy (1969) and Blackmer et al. (1969), to repeat, simply were not, in my opinion, treating the present problem.

3.1 Case 1: Kincheloe AFB, Sept. 11-12, 1967:

Between 2242E, Sept. 11 and 0001E, Sept. 11-12, 1967, targets were observed with an MPN-14 radar (S-band, 60-mile range, 20 rpm scan, beam tilt-range 0-10 degrees) at the Rapcon Site, Kincheloe AFB, Michigan. The phenomena to be described below were officially explained as "probable anomalous propagation" by Air Force Project Blue Book; and Thayer (1969), p. 164 concludes that this is a "case of observations of moving AP- echoes produced by unusually well-stratified atmospheric conditions." Thus we confront here a case of some unusual echoes that have been attributed to atmospheric effects by two investigations.

My examination of the episode is based on study of file material in Air Force archives and on direct interviews with Sgt M. Y. Burns, the senior radar operator on duty during the episode. It is relevant to remark that Burns, at that time, had 7 years' experience in radar, 3 of them at Kincheloe AFB working with the equipment involved in this case. Useful information on the case has also been provided by Dr. Norman E. Levine, who was one of two investigators representing the University of Colorado UFO Project in an on-site check carried out approximately three weeks after the incident. Thayer was not at the site, nor did he interview personnel involved. Like most other cases of interest in the category of radar UFOs, this one is too involved to describe in full detail here; but salient features will be noted, in order to suggest the kind of problems that I regard as still unsolved.

A total of 17 targets were followed during the roughly 80 minutes' duration of this episode. On only two occasions were two targets painting on the scope at the same time; the other 13 were singles. At the time of the appearance of the first target, a B-52 which was outbound about 30 mi west was being followed routinely (recounted to me by Levine, confirmed to me by Burns in direct interview, and confirmed in Blue Book case-file in archives), when a second blip was noted heading N to S on a potential collision course with the B-52. The pilot was alerted but never saw any other aircraft or object. He was asked if he was "playing with radar" but no ECM was involved. Burns estimates that the target's initial speed was somewhat faster than that of the bomber; but then it suddenly slowed to roughly half its initial apparent speed and the B-52 cleared it, the target seeming to pass southward behind the aircraft. The blip then abruptly turned eastward and accelerated to a speed that Burns and other duty personnel estimated at approximately 2000 mph (1.5 mi/sweep, roughly). Burns could not recall if this first target crossed the scope; all of his original notes were given to Levine and hence are presumably in the University of Colorado archives. Burns told me that this target, like most of the subsequent targets, was stronger than the B-52 return, and that he had MTI on and it was taking out all ground clutter. In response to my query, he stated that he had looked for AP all that night but saw none at any time. He contacted Minneapolis ARTC and the ADC SAGE center, but they had nothing on such a target.

Eight minutes later a second target appeared. (Following data from official case-file, and only rather sketchy information is given on most of the targets; but, on directly querying TSgt Burns, I learned that all were hard targets, not diffuse echoes of the sort typical of small elements of ground-return from AP.) This second target was seen at 250 degrees azimuth, heading towards 50ø azimuth, speed not specified in case file.

Then between 2250E and 2330E "nine other UFOs" were observed on the MPN-14: (1) at 270 degrees tracking towards 90 degrees; (2) at 230 degrees, tracking 30 degrees; (3) at 380 degrees, tracking 100 degrees; (4) at 270 degrees, tracking 90 degrees; (5) at 230 degrees, tracking 30 degrees for 20 miles, then changed course, heading 360 degrees; (6) at 280 degrees tracking 100 degrees for 20 miles, then turned to 180 degrees. Then these last two targets (5 and 6) "joined at 30 miles due west of Kincheloe AFB and both went eastbound at 2000 mph," passing overhead but not visually observed. (Quote from original TWX from Kincheloe to Project Blue Book, in case-file.) The remaining three UFOs were: (7) at 160 degrees, tracking 360 degrees; (8) at 30 degrees, tracking 200 degrees; and (9) at 30 degrees, tracking 270 degrees.

Then, at 2338E another target was picked up at 200 degrees, tracking 360 degrees. At 2358E, another at 280 degrees, tracking 120 degrees from 60 miles out until 20 miles out then turned and headed towards 270 degrees.

At 0000E (on the 12th), Burns logged the second of two instances in which two unidentified targets were on-scope concurrently. One was at azimuth 200 degrees, tracking 90 degrees but then turned to a heading of 360 degrees, slowed down over an interval of 8 miles, turned to a 270 degrees heading, and "disappeared from scope" (sic). The second of the two was at 250 degrees initially, and tracking 90 degrees, but then turned towards a heading of 360 degrees and left the scope.

Finally, the seventeenth observed anomalous target, detected at 0001E, was first picked up at 270 degrees, tracking 30 degrees, but turned to a 360 degrees heading, slowed down, turned to 270 degrees, then turned again to a 360 degrees heading, and speeded up again.

The case-file includes further comments and clarifications Lt. T. E. Leaman at Kincheloe and Lt. W. B. Stoecker, ADC (SAGE) Duluth, as well as by Blue Book officers. These include the statement noting that the sergeant who reported the sighting "is very experienced and would probably know what it was if it was anomalous propagation," and statements that no interceptor scramble from Kincheloe was called because no scramble capability existed there, while none was called from SAGE Duluth because their remoted scopes did not show the unknowns (with single exception of a strobe seen from the 753rd AC&Wron near Sault Ste. Marie). Stoecker suggested that the objects may have been too low over Kincheloe to be seen from the SAGE sites; on the other hand, as the file states (and as Burns stressed to me), tower personnel at Kincheloe saw nothing visually despite good visibility and only scattered high clouds, which is puzzling, though by no means unprecedented. Burns tried beam-tilting and tended to get stronger returns at high than at low tilt. No RHI equipment was locally available, unfortunately. The case-file states that Sgt. Burns tried switching channels, as a cross-check against possible ECM, but got no change in target intensity, tending to discount that possibility. I asked Burns if he tried IFF, and he said he did but got no IFF, just skin-return. He pointed out that the 752d AC&Wron at Empire, Mich., queried him at one point during this episode, asking if he was getting a return at about 100 mi SE, heading his way. But his MPN-14 had only 60-mi range and could not then detect it; nor did a target subsequently enter his scope from that sector. The only target that he carried which he knew to be concurrently carried by another radar was one at a bearing of about 250 degrees from Kincheloe that was also seen at least briefly by radar at the 753d at Sault Ste. Marie. Burns recalled that the 753d had a height on that target, but they did not release it to him. There is no indication in the casefile that this important point was checked by anyone.

Because targets in the radar UFO category have often been reported to stop for variable periods of time, I asked Burns what he felt the slowest speed had been. He replied that in several instances some of these targets hovered motionless for a time of the order of 10-15 seconds (3-5 scans). The MTI was set to function out to approximately 15 miles; whether the hovering targets lay within or beyond the MTI limit is not now clear.

What interpretation is to be put on a radar episode such as the above? At Project Blue Book, the considerable experience of the senior man on duty and his specific yet unsuccessful search for AP symptoms were rather casually ignored in the following evaluative comment by V. D. Bryant, dated 15 January 1968 and included in the official case-file: "The obvious 'excuse' or 'explanation' for the sightings appears to be temperature inversion. The erratic courses taken by the 'objects', their wide variations in speed (150 to 2000 mph), and the fact that no noise was heard, even at the low altitudes assumed, all point toward anomalous propagation due to temperature inversions." And, on that basis, the Kincheloe sighting is so carried in the official files. This is a representative Blue Book radar evaluation, I have found.

Thayer (1969), reviewing this case in the Condon Report, states: "This is a good example of moving radar targets that cannot be seen visually, where there is a 'forbidden cone' over the radar site. Some of the returns were even seen to approach within 5-15 mi of the radar and disappear, apparently subsequently reappearing on the other side of the radar scope at about the same range that they disappeared. This sort of behavior is symptomatic of AP-echoes." [That gross misinterpretation of the blind spot over-head in all search-type radars is made by Thayer in other cases

he analyzes in the Condon Report, including the extremely significant Lakenheath case of 1956 in England (Thayer, 1969, p. 163).]

Thayer displays refractivity profiles for the time and general vicinity of the Kincheloe episode and, on the basis of an elevated duct in the 300-500m layer, suggests that "strong partial reflection should be expected," and that "moving AP-echoes, produced in the manner described by Borden and Vickers (1953), could be expected to appear at apparent heights of between 2000-3000 ft and 7000-9000 ft." Confusingly, those heights do not match either of the diagrams he displays, one of which is, in fact, labeled 9 Nov. 1967, a month and a half after this episode. Also, Thayer systematically plots his index profiles on A-Z coordinates, yet always labels the super-refractive layers in terms of the vertical N-gradient, not the A-gradient. This is more than merely confusing; it promotes the misinterpretation that ducting is present in cases (numerical value between about -115 km^{-1} and -157 km^{-1}), where it really is not.

A basic difficulty in examining the validity of Thayer's assertion concerning "strong partial reflection" is that he does not define his usage of that term. In usual practice, it has acquired two distinct meanings: (1) Partial direct reflection, i.e., back-scatter, to put it more precisely, or (2) partial forward-scatter. Neither of those interpretations offers any hope of accounting for the kinematics of the reported Kincheloe targets, and certainly the former could not conceivably yield apparent radar cross-sections rather greater than that of a B-52, as Sgt. Burns characterized the intensities of these unidentified returns.

Nor does Thayer clarify his position by seeming to equate "strong partial reflections" with the ideas proposed by Borden and Vickers (1953). Their discussion postulates essentially specular reflection from moving waves on an inversion surface, the propagation speeds being of the order of the wind speed and the apparent targets thus being assigned roughly twice the speed at inversion level, for reasons of simple reflection-geometry. First, it must be remarked that, although the Borden and Vickers report has often been cited as if it settled the July, 1952 Washington radar UFO episodes, I find that view unsupported by the very sketchy and entirely qualitative mode they propose. Secondly, the upper-level winds at Kincheloe that night were less than 10 kts up to the 850 mb level (below which lay the only index gradients of any significance), which would scarcely account for the reported target speeds on anything remotely like the Borden-Vickers hypothesis. And third, the Borden-Vickers hypothesis of "glint" reflections from favorably disposed undulations on an inversion surface could scarcely be invoked to account for apparent target movements, whose directional variability matched that seen on the Kincheloe MPN-14 during this episode; nor could it possibly account for sudden turns, hovering, and accelerations described in the official case-file. Other slightly subtler objections could easily be raised, but those simple ones seem sufficient to reject Thayer's loose explanation (let alone the still less meaningful one contained in the official case file).

One might ask how Thayer would suggest that any form of propagation anomaly or "partial reflection" could explain the complex kinematics reported by the Kincheloe Rapcon Site for this night. One partial answer may be that he offers that suggestion in a mere 4-paragraph account of this intriguing case, an account that gives the reader no hint that 17 distinct targets were seen, that says nothing about turns, hovering periods, or accelerations, that omits any mention of speeds of the order of 2000 mph, and that gives no suggestion that in one instance two such targets converged from opposite directions, turned eastward together, and then moved across the scope side-by-side at about Mach 3, passing over and beyond Kincheloe AFB. Unfortunately, I must add that my detailed checking of the discussions of the 35 "optical and radar analyses" in the Condon Report has established that such omissions of crucial sighting details are typical, not exceptional in that Report.

Plank (1958, 1959) has suggested that perhaps some of the "erratically moving angels" (his Type III) might be caused by "shock waves, echo being the product of direct back scatter or diversion of energy to the ground." He then notes that shock waves are thin, on the order of microns, yet can have refractive index differences across them of "several hundred N-units." The high speeds exhibited by some of the targets in this Kincheloe episode (and in many others of interest) might vaguely suggest shock phenomena, so perhaps a few remarks negating that hypothesis are

in order. First, Plank really does not offer any geometric model to support the kind of kinematics found in interesting radar UFO cases. (Quite possibly he is unaware of the content of most such cases.) Only extremely simple paths would be possible; certainly his emphasis upon erratic movement goes wholly unexplained on any such model. But the greater objections are the quantitative objections. He mentions N-changes of several hundred units; but this is quite unreasonable. First, only temperature jumps and not humidity jumps could accompany shockwave passage. Secondly, in the lower atmosphere, one N-unit change is associated with approximately 1 degree C of temperature change. Third, the Rankine-Hugoniot equations permit one to relate shock-front temperature changes to concomitant peak overpressures; and an over-pressure of, say, 5 psi, is found to lead to a transient shock-heating of only about 30 degrees C (hence about 30 N-units jump across shock-front), yet this is an overpressure not only great enough to take out all nearby windows but to level weak structures and collapse roofs. In brief, the only shock waves capable of giving significant radar-reflecting characteristics would be of rather severely damaging nature, would leave unmistakable after-effects, and yet could influence a radar beam for only fractions of a second. The shock-wave suggestion seems unpromising for explaining radar UFOs, in general, and the Kincheloe targets in particular. Indeed, one of the characteristic puzzles of high-speed radar UFOs (and the Kincheloe UFOs in particular) is that no discernible sonic boom is associated with cases where the radar-deduced speeds are markedly supersonic.

In summary, it is by no means clear that one can accept any known kind of anomalous propagation for targets in the class exemplified by the Kincheloe targets. However, we are doubtless still unaware of certain types of propagation anomalies in our atmosphere, and the breaking-wave echoes may attest to interesting surprises yet to come. But there seems to exist so large a margin of separation between any of the now-suspected atmospheric effects and the characteristics of what I am terming radar UFOs that I do find it difficult to understand how AP and "weather effects" have so long been casually employed to explain radar unidentified targets within Project Blue Book, and how they have more recently been invoked in the Condon Report by Thayer in essentially similar manner.

Perhaps a clue to the latter is found in a curious introductory definition of what Thayer (1969, p.117) terms "blip-like" radar returns: "Cases where the radar target (or targets shared characteristics similar to the return from a solid object (such as an aircraft, etc.) and where the target did not display erratic or discontinuous behavior. Acceleration or velocity in excess of known aircraft capabilities, or periods of immobility were not considered to be contrary to normal target behavior." I fear that this definition be paraphrased fairly by saying that Thayer adopted at the outset explicatory rules by which completely abnormal radar returns were agreed to be quite normal. Many examples in support of such a paraphrase have come to my attention in follow-up investigations of the Condon Report, whose handling of the radar UFO cases I find almost wholly uncritical, generally tendentious, and often absurd -- and, more than that, disturbingly incomplete with respect to the scientifically most puzzling features of many of the cases (cf. McDonald, 1969). If we are to learn anything meteorologically interesting from radar UFOs, it will come only from much more discriminating and more thorough analyses than any now at hand.

3.2 Case 2: U. S. Naval Air Station, North Island, San Diego, Calif., Oct. 14 1957:

As another illustration of past radar UFO cases that have been officially explained in terms of meteorological effects, we might consider one that, unlike the preceding case, involves visual as well as radar observations, and for which the radar observations were made from the air rather than from the ground. Cases of both the latter types are scattered through the Air Force archives, and some, like this one, emanated from another service. I have not interviewed any of the observers in this particular case, so, in order to fulfill written agreements with the Air Force, I cannot cite witness-names. Instead, I shall be forced to use merely initials of the Navy personnel involved. (I am currently challenging Air Force structures against citation of names of military and government-agency witnesses in past UFO cases, contending that they are blocking full and credible scientific discussion of case details and arguing that these strictures stand in violation of P.L. 552. It is the present Air Force position (SAFOI letter, 7 Aug 1970) that scientific citation of witness names would constitute an "invasion of privacy", despite the fact that these were personnel of the military, FAA, USWB, etc., whose observations and official reports were made in regular line of duty. At this writing, my efforts to get the Air Force to rescind these strictures have not yet proved successful, so unfortunately I am obliged to omit all names from this account of my checks on this scientifically significant case.

No strictures against citation of names of investigative and evaluative personnel have ever been imposed in the course of my investigations, so I do cite certain names in those categories, since they, too, are of obvious documental relevance.)

Slightly before 1900 PST, on October 14, 1957, at NAS North Island, AC/3 VEE (initials of enlisted Navy tower controller) noted "a bright, round, white light, about the size of a dime, bearing 210 degrees T from the tower and approximately 300 ft above the Point Loma land mass," according to a 17 October 1957 report to the Air Force Office of Special Investigations from the District Intelligence Officer, Eleventh Naval District. VEE observed the object remain stationary for about 2 minutes and then fade out. One or two minutes later a similar light, presumably the same, suddenly reappeared slightly farther north and a bit lower than before, and now somewhat brighter. After remaining stationary about two minutes, it again faded away, the report notes. Somewhere in this sequence, VEE alerted two other enlisted personnel, DC and MD, also on duty in the tower; and all used binoculars in the later portions of the visual observations, according to the intelligence summary. It soon reappeared once more, again farther north and again lower; it seemed now to wobble slightly and exhibited a half-halo on its upper portion, with a bluish tint on one side. No angular estimate is given.

Concurrently, a Navy S2F tracker (anti-sub-marine search aircraft), attached to VS-21 at NAS North Island, moved into position for takeoff, and AC/3 VEE had to divide his attentions between the unexplained light over Pt. Loma and the S2F ready for takeoff. In the process of controlling the takeoff and vectoring the aircraft to attempt a search, VEE lost the object, the reasons becoming clearer below.

According to Air Intelligence Information Report 01-03-57, dated 23 October 1957, prepared by Maj. L. W. Bruner, 27th Air Division, Norton AFB, Calif., based on a signed summary statement by the S2F pilot, Lt. ALR (initials), the aircrew, during engine warmup, had heard the tower operator take three radio calls to an "unidentified aircraft", requesting identity and intentions, but getting no reply. On requesting and getting takeoff clearance, Lt. ALR was asked by the tower operator to maintain 200 ft altitude after liftoff and proceed to Pt. Loma to identify a stationary light source apparently hovering at that estimated altitude. Lt. ALR notes that both the copilot, Lt.(jg) GTC, and he observed the light, while still on the runway before starting their run.

"After take-off, I turned outbound over the channel," Lt. ALR wrote in VS-21 msg 152348Z of Oct 1957, "and climbed to 200 feet, all the while keeping the light in view. My intentions were to proceed seaward of the light so as to silhouette its airframe against the lights of San Diego. However, when we drew abreast of it off our right wingtip, we observed it undergoing a rapid acceleration away from us and to the west. I noted relative motion between it and the lights of San Diego. As our range opened the light began to alternately vary in color and intensity. The extremes were bright red and a blue white, with no regular period of change from one to the other."

"I turned West and assumed a heading of 230 mag. with the light then dead ahead. In about four or five minutes (warm-up time) our radar operator reported a target dead ahead at seventeen miles and above us. The weather was clear ahead and above, with a discernable horizon and low clouds 30 miles west. The stars were bright and clear but small and dim compared with the light we were following. During the chase there was always evident a relative motion between this object and the background of stars."

"From Pt. Loma on out the object climbed steadily and I followed in a gradual ascent at 240 knots IAS, closing irregularly. At 4500 ft the object leveled off 12 miles ahead, and then drifted right 10 degrees in about five seconds. I turned right to 240 mag., leveled off and increased speed to 160 knots. The range closed to 10 miles and stabilized. After following for about three minutes at 10 miles I decreased speed to 120 knots but observed no range-rate on radar. I then advanced speed to 180 knots IAS and still observed no range-rate."

"The object in the meantime drifted 20 degrees to the left (220 mag.) in no more than 10 seconds, and then closed range to 8 miles in one rotation of the radar antenna (7.5 seconds). The range stabilized again at 8 miles and we began another gradual climb. At 8000 ft and about 40 miles from Pt. Loma the object leveled

off and shortly after disappeared visually and on radar. Fifteen seconds later it reappeared visually but not on radar although the operator switched to sector-scan and searched continuously."

Lt. ALR concluded his summary with the comment that they maintained visual contact until the S2F was 50 miles from Pt. Loma, at which time they lost visual contact, too (fadeout), terminating the incident. His statement notes that all four aircrewmembers saw it and can substantiate his descriptions. (The two enlisted men aboard were WES and WPC.)

This is only one more of many radar UFO cases I have recently been studying as a result of extensive searches through the Air Force archives and only one of many hundreds of UFO cases I have checked during the past four years. Each case has certain unique features, but many have the common feature that it is exceedingly difficult to propose for them conventional explanations. Yet, here as in almost all the rest that have received the Project Blue Book evaluations, a conventional explanation has been assigned by Blue Book.

I quote from that explanation, extracted from Air Force archives, since it invokes atmospheric phenomena of potential interest to radar meteorologists and atmospheric physicists:

"Distortion of light and changing colors attributed to probable inversion off coast. That Arcturus was the object is ... indicated by the fact that the pilots could not close on the object. Its jumping around and the spurious radar returns caused by inversion or other weather conditions conclusive to distortion of atmospheric optics. Sighting was of short duration and Arcturus set at about the time of object's disappearance."

(Actually, I must note that there is a slight confusion on the official evaluation of this case, Although the above case-summary explains the sighting in terms of Arcturus and some form of anomalous propagation, the casecard in the archives shows it as "Possible Balloon." There is no evidence of any real analysis of either hypothesis, no weather data, no computations of positions, or other quantitative assessment; but the original teletype message from AIRASRON-21 to Wright-Patterson AFB, which notes how the object "drifted across chase plane's course at speeds estimated by pilot to be in excess of 1000 mph," has a pencil-sketch of a top-view of an aircraft flying past a sphere, with arrows and lines evidently intended to depict the viewpoint contained in evaluating annotations that nearly obliterate parts of the TWX: "Tests have shown that when a/c slipstream from wing tip hits balloons it sends it rapidly sideways." The sketch and pencilled evaluative comments, typical of many documents in the UFO archives, are signed by Capt. George T. Gregory, who was Project Blue Book officer in the 1957-59 period. Many of such UFO reports were processed in about this way over the years.

But this one has the alternative (and evidently officially preferred) explanation of suggested inversion effects on Arcturus and the S2F's radar. Consider certain difficulties with that explanation: (1) The tower observers reported to Navy intelligence interrogators that the light shifted three times, from its azimuth of first appearance at 210 degrees T. At about 1900 PST on this date, Arcturus was nearing the horizon at about 290 degrees T. This light over Pt. Loma was seen by the cockpit crew from the runway and held in sight until they drew nearly abreast of it, viewing it off the right wingtip, whereupon it suddenly accelerated westward and started climbing. (2) The subsequent air chase involved a sequence of pursuit headings stated to be 230 degrees mag, then 240 degrees mag, then 220 degrees mag, the source finally pulling away and fading out at 230 degrees mag, after an approximately 20-minute visual-radar chase, at about 230 degrees mag. The magnetic variation off the San Diego coast is about 15 degrees E, whence the bearing to Arcturus would have been about 275 degrees mag, some 35 to 50 degrees from the luminous object's reported azimuth, far in excess of uncertainties that would affect observations under these conditions. (3) Viewed from the S2F, the object appeared to climb, then level out, on two occasions. And it executed fast lateral shifts to both left and right, through arcs stated by the Navy pilot to approximate 10 degrees and 20 degrees of relative azimuth. (4) The aircraft was flying, after the first few minutes, at altitudes well above the coastal subsidence inversion whose refractive effects are adduced in the official explanation to account for angular image-excursions whose amplitudes dwarf the 10's of seconds of arc displacement associated with stellar scintillation

effects, even under unfavorable viewing conditions at the surface, let alone at 4-8000 ft level. (5) Nor does the official explanation that the "inversion and weather conditions" were responsible make better sense of the reported radar behavior. Ranges opened and closed, angular altitude varied, and azimuths shifted, all this during a 40-mile pursuit, at altitudes ultimately near 8000 ft. (6) The estimated lateral speeds (order of 1000 mph) came from rough calculations based on radar ranges, plus compass-based angular estimates. A target at 10-mile radar range that moves 20 degrees in 10 seconds has exhibited an apparent velocity near 1200 mph.

To suggest that optical refraction effects plus anomalous propagation could cause such extreme behavior, and to suggest it without the slightest supporting argument, is simply not reasonable.

Could there be some truly phenomenal optical and radar-propagational anomalies of the atmosphere that might be capable of yielding visual and radar indications of this sort? The archives have many more such anomalies that will require at least equal extensions of present scientific knowledge if we are to account for them along the lines of application of atmospheric physics that I have found typical of Project Blue Book UFO explanations over the past two decades.

3.3 Case 3: Gulf of Mexico, B-29, Dec. 6, 1952:

With so large a number of previously unknown cases that I could discuss and so little space available here, it is difficult to select a final example. But because of my strong concern over the serious inadequacies of the radar-optical UFO case-analyses in the Condon Report, I choose a last one that exhibits some of those deficiencies, that is explained in terms of alleged atmospheric effects, and that happens to be a rather famous case in UFO annals. I believe that the ad hoc panel that reviewed and endorsed the Condon Report (NAS, 1969) could not possibly have scrutinized carefully the level of analysis of cases such as this in that Report, a point that I have elaborated elsewhere (McDonald, 1969b).

In the early morning hours of December 6, 1952, a B-29, on the return leg of a training flight out of Randolph AFB had turned around over Tampa and taken up a generally westbound course across the Gulf. When about 100 miles south of the Louisiana coast at an altitude of 20,000 ft, visual sighting of oilwell flares on the coast led the Instructor Navigator, 1/Lt WN, to request a student radar operator to turn on his set and try to pick up the coastline on 100 mile range. After the student operator's failure to detect the coast, WN confirmed that no coastline echo was discernible, so called for a set calibration. Some time later he was alerted to presence of some four blips ahead and in rapid closure with the B-29. [Air Intelligence Information Report No. IR-86-52, filed from Randolph AFB by Maj. J. R. Sheffield, Wing Operations Officer, 3510th Flying Training Wing, includes a summary of the events, the sightings, a map, and signed statements by three officers and two enlisted men who figure in the incident. These items, plus the original TWX and other materials in the archived case-file indicate that the B-29 had turned to a heading of 320 degrees at some earlier time, after the unsuccessful search for the coastline on the navigational radar, and had reached coordinates of 28 degrees 10'N, 92 degrees 04'W when the sightings began. I cite these points because they are quite relevant to a point that Thayer (1969) regards as crucial, yet seem to me to be a misinterpretation of the intelligence report. I infer from coordinates and times that inability to pick up the coastline occurred while the B-29 was still just over 100 miles offshore, beyond the set's 100-mile range. Furthermore, the set was then uncalibrated, as the Instructor Navigator makes clear in his signed statement.]

The first 4 targets were sighted at 0525 CST, "with no specific grouping such as a radar beacon transmits apparent on the scope at 330 degrees," Lt. WN stated. The radar had azimuth stabilization; its scan rate was 25 rpm. The navigator, 2/Lt RKE, verified WN's assertion that these first blips advanced southeastward about 5 mi/scan, and MSgt BRP, the aircraft performance technician, using 1/Lt NK's stopwatch data and the indicated displacements per scan, informed the crew that the computed target speed was about 5000 mph. These targets, viewed on three repeater scopes, passed to the right of the B-29 and moved offscope at a bearing of about 70 degrees.

Then, immediately after a calibration-check, a second group of blips was seen coming in along a similar path. This time the pilot called off relative bearings from his repeater scope, with instructions for the crew to watch on the starboard. SSgt WJD states: "I immediately looked in that position (3 o' clock bearing called out from cockpit) and saw two flashes of approximately 3 seconds, which did not alter course whatsoever. The flash was of a blue-white nature and did not change brilliance... when it disappeared." Two objects were also seen by MSgt BRP, and he was evidently forward for he saw them move rearward and disappear under the wing. In 1/Lt WN's account, he confirms that these flashes were seen to "go from front to rear under our wing "

The interrogating officer, Maj. J. R. Sheffield, in his intelligence report from Randolph AFB, gives 18,000 ft as the approximate altitude of the objects and 20,000 ft as the B-29's altitude, accepting the crew's statements that the objects came in below the B-29. Despite this, Sheffield states in his report that: "Visual sightings are indecisive and of little confirmatory value," but no explanation of why he discounts the two crewmen's observations is given.

Like many other Blue Book reports, this case-file leaves unanswered a number of pertinent questions. The total number of objects followed on radar is not clearly specified. 1/Lt NK says he observed: "about twenty objects in all, sometimes as many as two and three on the scope at one time." Crewmen refer to one radar-observed event involving a merger of targets (a feature that I have now found in a number of reports of radar UFOs). As WN described it: "Contact was broken off at 0535 after a group of blips merged into a half-inch curved arc about 30 miles from our a/c at 320 degrees and proceeded across the scope and off it at a computed speed of over 9000 mph." WN also stresses one other significant target-movement: "One group of blips, after the scope was calibrated, were noted, after moving from 330 degrees to 150 degrees across the scope, to arc about and swing in behind us at approximately 30 miles and maintain speed and distance for approximately 10 seconds and then disappear."

Given that summary, consider Thayer's (1969) explanation of this case (which Blue Book has carried as "unidentified" since 1953): "The visual sightings were probably Geminid meteors," he writes. No supporting discussion; just that assertion. In fact, one finds that the radiant of this December shower lay at about 280 degrees azimuth and about 55 degrees elevation angle at 0535C on this date. Hence, any Geminids seen to the starboard of an aircraft on 315-320 degrees heading at 0530C would have been descending almost perpendicular to the NE horizon, a 90 degrees direct mismatch with Thayer's explanation.

The above-described multiple radar target events Thayer explains in terms of a ducting layer that showed on the 0900C Burwood radar. "The strange moving targets seen on the radar were probably caused by imperfections in the atmospheric layer forming the radio duct allowing radio energy to enter the ducting layer at various points. This would create sporadic returns." The failure to pick up the coastline just prior to the UFO episode he explains as follows: "A transmitter located above a radio duct and emitting a high enough frequency to be affected, as the radar undoubtedly was, does not excite propagation within the duct. This implies that the coastline below the duct would not be visible to the radar located above the duct." Thayer's argument is, of course, quite erroneous; he has his argument upside down. And casual suggestion that the complex target behavior reported in this case was the result of "a series of gravity waves running along the duct" is mere verbalism.

Thus were radar UFOs discounted in the Condon Report. Perhaps the above examples will give at least some indication that there remains an unsolved scientific problem here, that there exist unidentified radar returns of a category for which atmospheric effects have been proposed as explanations, but on ground that are to date less than satisfactory.

REFERENCES:

- Air Weather Service, 1954: Radar objects over Washington. AWS Bulletin, Sept., 42-57.
- Blackmer, R. H., et al., 1969: Radar and the observation of UFOs. In Scientific Study of UFOs, E. U. Condon, princ. inv., Bantam Books, 965 pp.
- Borden, R. C., and T. K. Vickers, 1953: A preliminary study of unidentified targets observed on Air Traffic Control Radars, CAA Tech. Div. Rpt. 180, Indianapolis, 16 pp.
- Hardy, K. R., 1969: Unusual radar echoes. Presented at UFO Symposium, 136th meeting AAAS, Boston, Mass., 26-27 Dec.
- McDonald, J. E., 1969a: Science in default: 22 years of inadequate UFO investigations. Presented at UFO Symposium, 136th meeting AAAS, Boston, Mass., 26-27 Dec.
- McDonald, J. E., 1969b: Review of the Condon Report. Icarus, 11, 443-447.
- National Academy of Sciences 1969: Review of the University of Colorado Report on Unidentified Flying Objects. Icarus, 11, 440-443.
- Page, R. M., 1962: Origin of Radar. Doubleday, N.Y., 196 pp.
- Plank, V. G., 1956: A meteorological study of radar angels. Geophys. Res. Paper No. 52, AFCRL, 117 pp.
- Plank, V. G., 1958: Atmospheric angels mimic radar echoes. Electronics, 31, March 14, 1958.
- Plank, V. G., 1959: Spurious echoes on radar, a survey. Geophys. Res. Paper No. 62, AFCRL, 51 pp.
- Thayer, G. D., 1969: Optical and radar analyses of field cases. In Scientific Study of UFOs, E. U. Condon, princ. inv., Bantam books, 965 pp.