"It's a bird, it's a plane, it's …"

Economic Round Table ("ROUNDERS") Talk on Anomalistic Observational Phenomena or "UFOs"

The California Club, 538 S. Flower St., Los Angeles, California

January 14, 2016

By Bob Baker

SUMMARY

The beginning of the UFO phenomenon caused by Kenneth Arnold's report of "… nine shiny Unidentified Flying Objects (UFOs) around Mount Rainer in formation going at about 1,200 mph …" in 1947, initiated a discussion of such Anomalistic Observational Phenomena (AOP). Two film clips, purported to be UFOs, were analyzed for the US Air Force by Bob Baker in the 1950s and were discussed. Excerpts from his testimony before the US Congress in 1968 and chapters of his textbook related to anomalous phenomena were distributed in a pamphlet to the Rounders. The general concept of alien visitors from another planet or exoplanet was considered. Bob concluded that there was not much likelihood of advanced alien beings visiting us and the paucity of video AOP observations since the advent of the iPhone and their ubiquitous distribution as video cameras over the globe supported this conclusion – unless, of course, alien visitors are "… just plain camera shy!" The recent observations of planetary systems around many stars in our Universe by NASA's Kepler satellite observatory indicated that such "exoplanets" were as numerous as the stars themselves. In fact, there may be as many as 100,000,000,000,000,000,000,000 of them in our Universe! Bob suggested in 1961 that the first encounter with extraterrestrial intelligent beings would be by the interception of their interstellar communications. Since light, radio waves or, in general, electromagnetic radiation is so easily absorbed; Bob stated that the messages would be via high-frequency gravitational waves that, like gravity itself, pass thru all matter unattenuated. Next follows the excerpts from Bob's pertinent publications:

SYMPOSIUM ON UNIDENTIFIED FLYING OBJECTS

HEARINGS

BEFORE THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS U.S. HOUSE OF REPRESENTATIVES

NINETIETH CONGRESS

SECOND SESSION

JULY 29, 1968

[No. 7]

Printed for the use of the Committee on Science and Astronautics

STATEMENT BY DR. ROBERT M. L. BAKER, JR.

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(The biography of Dr. Baker, Jr., is as follows:)

DR. ROBERT M. L. BAKER, JR.

Dr. Baker is a 36 year old scientist who received his BA with Highest Honors in Physics and Mathematics at UCLA in 1954, and was elected to Phi Beta Kappa. In 1956 he was granted a MA in Physics, and was the recipient of the UCLA Physics Prize. In 1958 Dr. Baker received a PhD in Engineering, which was the first of its kind to be granted in the nation with a specialty in Astronautics.

With respect to his academic background. Dr. Baker was on the Faculty of the Department of Astronomy at UCLA from 1959 to 1963. Since that time he has been on the Faculty of the Department of Engineering at UCLA where he currently offers courses in astronautics, fluid mechanics, and structural mechanics.

Dr. Baker is an internationally recognized expert in various fields of science and engineering. He was a research contributor to .the development of preliminary orbit determination procedures utilizing radar data, astrodynamic constants, near free-molecular flow drag—all utilized in the nation's space programs. He has also developed unique theories in the area of hydrofoil marine craft design.

In private industry Dr. Baker has initiated, supervised, and conducted research programs in astronautics, physics, fluid mechanics, mathematics, and computer program design. He has contributed to problem definition and analysis of scientific and engineering problems in both industrial and military projects.

Dr. Baker's industrial career began in 1954 as a consultant to Douglas Aircraft Company. Between 1957 and 1960 he was a Senior Scientist at Aeronutronic-Philco-Ford. While in the Air Force during 1960 and 1961, he was a project officer on a number of classified Air Force projects. Between 1961 and 1964 he was the head of Lockheed's Astrodynamics Research Center, where he directed the efforts of approximately 25 scientists in various scientific areas. In 1964 Dr. Baker joined the Computer Sciences Corporation (CSC), first as Associate Manager for Research and Analysis, and later as the Senior Scientist of CSC's System Sciences subdivision. In this latter capacity he is currently involved in several Air Force, Navy, and NASA projects.

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Dr. Baker represented the United States Air Force at the International Astronautical Federation meeting in Stockholm, Sweden in 1961, represented the United States at the International Union of Theoretical and Applied Mechanics European Conferences in 1962 and in 1965 and was an invitee to the Astronomical Councile [sic] of the Academy of Sciences of USSR in Moscow in 1967. He was voted an Outstanding Young Man of the Year by the Junior Chamber of Commerce in 1965. From 1963 to 1964 he was the National Chairman of the Astrodynamics Technical Committee of the American Institute of Aeronautics and Astronautics and is currently a member of Computer Sciences Technical Committee.

Dr. Baker has been the Editor of the Journal of the Astronautical Sciences since 1968. He was the joint editor of the Proceedings of the 1961 International Astronautical Federation Congress and the senior author of the first textbook on astrodynamics: An Introduction to Astrodynamics published in 1960. Dr. Baker is the author of four books and over 70 technical papers (see Appendix 2).

Dr. Baker's professional society memberships include the American Association for the Advancement of Science, Phi Beta Kappa, Sigma Xi, Sigma Pi Sigma, American Astronautical Society (Fellow), British Interplanetary Society (Fellow), American Institute of Aeronautics and Astronautics (Associate Fellow and member of the Computer Sciences Technical Committee), British Astronomical Society (Fellow), American Astronomical Society, American Physical Society, and Meteoritical Society.

His active security clearance is top secret.

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STATEMENT OF DR. ROBERT M. L. BAKER, JR., SENIOR SCIENTIST, COMPUTER SCIENCES CORP., El SEGUNDO, CALIF., AND FACULTY, DEPARTMENT OF ENGINEERING, UCLA

Dr. Baker. Fine, thank you, Mr. Roush.

I should like to preface my remarks by stating my preference for the term "anomalistic observational phenomena," as opposed to the term "unidentified flying objects."

Mr. Roush. I observed you were going to say that and I wonder about some of my Hoosiers back home using those terms.

Dr. Baker. It comes trippingly off the tongue.

Mr. Roush. It might not only cause some Hoosiers but some laymen some problems. It might be easier to say UFO's. You may go ahead.

Dr. Baker. I call it AOP.

From the data that I have reviewed and analyzed since 1954, it is my belief that there does exist substantial evidence to support the claim that an unexplained phenomenon -- or phenomena -- is present in the environs of the earth, but that it may not be "flying," may not always be "unidentified," and, perhaps, may not even be substantive "objects." In the following statement I will --

(1) Present a summary of the analyses that I have accomplished to date -- those that have led me to believe that anomalistic phenomena exist;

(2) Explain the probable inadequacy of our current terrestrial sensors in observing and/or defining the characteristics of the anomalistic phenomena;

(3) Suggest a number of tentative hypothetical sources for the phenomena, and the justification for their scientific study;

(4) And, finally, I will make specific recommendations concerning the necessity for new types of closely related observational and study programs which might be implemented in a fashion that would permit the detection and quantitative analysis of the anomalistic phenomena.

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Several appendices accompany this report. The first two are in response to Congressman Roush's invitational letter of July 10, 1968, and consist of my biographical sketch and a listing of my bibliography, respectively. The third appendix relates directly to my specific recommendations, and was included with the kind permission of Dr. Sydney Walker III. The fourth appendix presents three reprints of articles (Baker (1968a) and (1968b) and Walker (1968)) that are pertinent to the subject matter of this report.

PART 1. ANALYSES OF ANOMALISTIC OBSERVATIONAL PHENOMENA

UTAH AND MONTANA FILMS

My initial contact with anomalistic observational phenomena -- AOP -- came in 1954 when I was a consultant to Douglas Aircraft Co. in Santa Monica, Calif., serving as special assistant to Dr. W. B. Klemperer, director of Douglas' research staff. The data consisted of two short film clips: one taken in Montana -- termed by us as the Montana film -- and one taken in Utah -- called by us the Utah film. These films were provided to us by the Air Technical Intelligence Center -- ATIC, now the Foreign Technology Division -- FTD -- at Wright-Patterson Air Force Base; 35-millimeter prints were furnished by Green-Rouse Productions of Samuel Goldwyn Studios.

Both films had been taken by apparently reliable and unbiased men using amateur movie cameras and, in each case, there was a credible, substantiating witness present. The films exhibited the motion of rather fuzzy white dots, but the Montana film was remarkable in that foreground was visible on most of the frames.

Preliminary analysis excluded most natural phenomena. More detailed study indicated that the only remaining natural phenomenon candidate for the Utah film was birds in flight, and for the Montana film it was airplane fuselage reflections of the sun. After about 18 months of rather detailed, albeit not continuous, study using various film-measuring equipments [sic] at Douglas and at UCLA, as well as analysis of a photogrammetric experiment, it appeared that neither of these hypothesized natural phenomena explanations had merit, and a report was published by me (Baker (1956)) and forwarded to Brig. Gen. Harold E. Watson, commander, ATIC. Since the description of the circumstances of the filmings and the analyses of the data provided on the films is rather lengthy, and have since been published in the open literature,[1] it does not seem unreasonable to repeat the analyses here. [*NCAS Editor's note*: This last sentence appears to be a mis-transcription; the two analyses were not presented in Dr. Baker's statement.]

FLORIDA FILM

During the course of this study we also had the opportunity to view some gun-camera photographs taken over Florida. Unfortunately, we could not retain this film, and did not have time available to accomplish a comprehensive analysis. Like the Montana and Utah films, this film also exhibited only white-dot images; however, since a foreground was present, a competent study could have been carried out. Dr. Klemperer and I agreed on the preliminary conclusion -- not supported by detailed analyses -- that, again, no natural phenomenon was a likely source for the images.

[1]For the Utah film, see Baker and Makemson (1967): for the Montana film, see Baker (1968a). This latter reference is included in app. 4 to this paper.

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VENEZUELA FILM

In June of 1963 I received a movie film clip from a Mr. Richard Hall that had purportedly been taken from an aircraft (DC-3) near Angel Falls, Venezuela, at about 12:15 p.m. This film clip was 8-millimeter color film, exposed at 16 frames per second and showed a very bright yellow, slightly pear-shaped object that disappeared in a cloud bank after about 60 or 70 frames. At the time I was the head of the Lockheed Aircraft Co.'s Astrodynamics Research Center. We had developed a small group of photogrammetrists consisting of Dr. P. M. Merifeld and Mr. James Rammelkamp, and were able to undertake a study of the film. Initially, Merifeld and Rammelkamp found little of interest on the film. After their preliminary examination, I expended considerable effort in further analysis. Again, I was only able to draw the conclusion that the yellow object was no known natural phenomenon; but [before] we could make a quantitative determination of angular rates and accelerations, and the bounds of distance, linear velocity, and acceleration, the film was lost (except for a microphotograph exhibiting the object on one frame). There was, however, no question in my mind as to the anomalistic character of the images.

CALIFORNIA FILM

In January 1964, Mr. Zan Overall showed me three cinetheodolite films which had been taken simultaneously by three different cameras of a Thor-Able Star launching at Vandenberg AFB (project A4/01019). These films depicted a white object moving vertically (relative to the film frame) against a clear, blue-sky background. The object was about as bright as the booster's second-stage exhaust, and passed the booster at about one-third degree per second. Rough estimates of the direction of the Sun -- based on shadows on early frames -- and the winds aloft -- indicated by the motion of the rocket's exhaust plume) -- were made. These, together with the brightness of the object and its rate of ascent, seemed to rule out balloons, airplanes, lens flare, mirages, et cetera. Since one of the cinetheodolites was at a site some distance from the other two, a parallax determination of the actual distance and speed of the object could be determined rather easily. Because the films were on loan from the Navy, I was unable to carry out the necessary study and a determination of the precise character of the phenomenon (natural or anomalistic) could not be made. In 1967, I discussed the matter with Prof. William K. Hartmann of the University of Arizona, and Prof. Roy Craig of the University of Colorado. At that time, they were involved in the Colorado UFO Study Group, and indicated that they would attempt to obtain the film for further analysis. Although I am confident that they made a conscientious effort to obtain the films, apparently they were unsuccessful (as of 6 months ago, at least).

PROBABLY NONANOMALISTIC FILMS

In addition to the foregoing film clips -- which seemed to involve data that were the result of anomalistic phenomena -- the Montana film in my opinion, certainly was anomalistic and all of the other

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films except for the California film, most probably were anomalistic -- I have also had the opportunity to view approximately a half dozen other films, purportedly of "UFO's." The images on these films appeared possibly to be the result of natural phenomena, such as reflections on airplanes, atmospheric mirages, optical flares, birds, balloons, insects, satellites, et cetera. For example, a recent (February 1968) set of two films were taken, using professional motion picture equipment, by a Universal Studio crew on location. Although rather peculiar in appearance, the objects thus photographed could have conceivably been the result of airplane reflections.

To this date my analyses of anomalistic motion picture data have been rather ungratifying. Although I am convinced that many of the films indeed demonstrated the presence of anomalistic phenomena, they all have the characteristic or rather ill-defined blobs of light, and one can actually gain little insight into the real character of the phenomena. For example, linear distance, speed, and acceleration cannot be determined precisely, nor can size and mass. As I will discuss in a moment, this situation is not particularly surprising, since, without a special-purpose sensor system expressly designed to obtain information pertinent to anomalistic observational phenomena, or a general-purpose sensor system operated so as not to disregard such data, the chance for obtaining high-quality hard data is quite small.

PART 2. INADEQUACIES OF EXISTING SENSOR EQUIPMENT AND SYSTEMS

The capabilities of astronomical optical sensors have been dealt with in a thorough fashion by Page in 1968. The Prairie Network for Meteor Observations (McCrosky and Posen (1968)) is a good example of a wide-coverage optical system, but as is so often the case, and as Page (1968) pointed out. "*** K E. McCrosky of the Smithsonian Astrophysical Observatory informed me that no thorough search (for anomalistic data) has been carried out." Even so, some astronomical photographs are bound to exhibit anomalistic data. Again quoting from Page (1968), "*** W. T. Powers of Northwestern University Astronomy Department informed me that 'several' of the Smithsonian-net photographs show anomalous trails." As I have already pointed out (Baker (1968b) to be found in appendix 4), the majority of our astronomical equipment (e.g., conventional photographic telescopes, Baker-Nunn cameras, meteor cameras, Markowitz Dual-Rate Moon Cameras, et cetera) are special purpose in nature, and would probably not detect the anomalous luminous phenomena reported by the casual observer if they were indeed present. Their photographic speed, field of view, et cetera, impose severe restrictions on their ability to collect data on objects other than those they have been specifically designed to detect As already noted in the quotes from Page (1968), even if such data were collected, the recognition of their uniqueness or anomalous character by an experimenter is improbable. Examples abound, in the history of celestial mechanics, of minor planets being detected on old astronomical plates that had been measured for other purposes, and then abandoned.

Our radar and optical space surveillance and tracking systems are even more restrictive and thus, even less likely to provide information on anomalistic phenomena than are astronomical sensors. The Signal Test Processing Facility (STPF) radar at Floyd, N.Y. is a high-performance

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performance experimental radar having a one-third degree beam width. For lockon and track, an object would have to be pinpointed to one-sixth degree, and even if the radar did achieve lockon, an erratically moving object could not be followed even in the STPF radar's monopulse mode of operation. For this reason only satellites having rather well-defined paths (i.e., ephemerides), which have been precomputed, can be acquired and tracked.

Our three BMEWS radars propagate fans of electromagnetic energy into space. If a ballistic missile or satellite penetrates two of these fans successively, then it can be identified. Since astrodynamical laws govern the time interval between detection fan penetrations for "normal" space objects, all other anomalistic "hits" by the radar are usually neglected, and even if they are not neglected, they are usually classified as spurious images or misassociated targets, and are stored away on magnetic tape, and forgotten.

One space surveillance site operates a detection radar (FPS-17) and a tracking radar (FPS-79). If a new space object is sensed by the detection radar's fans, then the tracking radar can be oriented to achieve lockon. The orientation is governed by a knowledge of the appropriate "normal" object's astrodynamic laws of motion, or by an assumption as to launch point. Thus, if an unknown is detected, and if it follows an unusual path, it is unlikely that it could, or would, be tracked. Furthermore, the director of the radar may make a decision that the unknown object detected is not of interest (because of the location of the FPS-17 fan penetration or because of the lack of prior information on a possible new launch). In the absence of detection fan penetration (the fan has a rather limited coverage), the FPS-79 tracking radar is tasked to follow other space objects on a schedule provided by the Space Defense Center, and again there is almost no likelihood that an anomalistic object could, or would, be tracked.

The NASA radars, such as those at Millstone and Goldstone, are not intended to be surveillance radars, and only track known space objects on command. Again the chances of their tracking anomalistic objects are nearly nil. The new phased-array radar at Eglin AFB (FPS-85) has considerable capability for deploying detection fans and tracking space objects in a simultaneous fashion. Such versatility raises certain energy-management problems -- that is, determining how much energy to allocate to detection and how much to tracking -- but this sensor might have a capability (albeit, perhaps, limited) to detect and track anomalistic objects. The problem is that the logic included in the software associated with the FPS-85's control computers is not organized in a fashion to detect and track anomalistic objects (I will indicate in a moment how the logic could be modified). Furthermore, the FPS-85, like the other surveillance radars is usually tasked to track a list of catalogued space objects in the Space Defense Center's data base and the opportunity to "look around" for anomalistic objects is quite limited.

There are a number of other radar surveillance systems such as a detection fence across the United States. In the case of this fence, we have a situation similar to BMEWS, in which the time interval between successive penetrations (in this case separated by an orbital period for satellites) must follow prescribed astrodynamical laws. If they do not, then the fence penetrations are either deleted from

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the data base or classified as "unknowns" or "uncorrelated targets," filed, and forgotten.

There is only one surveillance system, known to me, that exhibits sufficient and continuous coverage to have even a slight opportunity of betraying the presence of anomalistic phenomena operating above the Earth's atmosphere. The system is partially classified and, hence, I cannot go into great detail at an unclassified meeting. I can, however, state that yesterday (July 28, 1968) I traveled to Colorado Springs (location of the Air Defense Command) and confirmed that since this particular sensor system has been in operation, there have been a number of anomalistic alarms. Alarms that, as of this date, have not been explained on the basis of natural phenomena interference, equipment malfunction or inadequacy, or manmade space objects.

PART 3. HYPOTHETICAL SOURCES FOR ANOMALISTIC OBSERVATIONS AND JUSTIFICATION FOR THEIR STUDY

In Baker and Makemson (1967), I discussed the usual candidates for the natural sources of anomalistic observations. For example, some scanning radars -- such as airport radars -- pick up anomalistic returns termed "angels." A variety of explanations have been proposed, variously involving ionized air inversion layers, etc. (see Tacker (1960) and even insects (see Glover, et al. (1966)). With respect to human observation of anomalistic luminous phenomena, some rather strong positions have been taken by such authorities as Menzel (1953), who feels that the predominant natural phenomenon is atmospheric mirages; by Klass (1958a), who feels that the predominant natural phenomenon is related to ball lightning triggered by high-tension line coronal discharge, jet aircraft, electrical storms, etc.; by Robey (1960), who feels that the observations are of "cometoids" entering the earth's atmosphere, etc. The list of hypothetical sources for anomalistic observational phenomena is long indeed, but from the photographic data that I have personally analyzed, I am convinced that none of these explanations is valid.

The analyses that I have carried out to date have dealt with observational evidence that I term "hard data" -- that is, permanent photographic data. Although I will not discuss in detail the analyses of eyewitness reports (which I term "soft data"),[1] Powers (1967), McDonald (1967), Hynek (1966), and others have concluded that overwhelming evidence exists that a truly anomalistic phenomenon is present.

Of course, there are numerous others who have come to a completely opposite conclusion; in fact, it becomes almost a matter of personal preference: it is possible for one to identify all of the anomalistic data as very unusual manifestations of natural phenomena. No matter how unlikely it is, anything is possible -- even a jet plane reflecting the sun in direct opposition to the laws of optics. I'm sometimes reminded of the flat earth debates that I organized 10 years ago in my elementary astronomy courses at UCLA. Some students became so involved in justifying their positions-- either flat or spherical -- that they would grasp at even the most improbable argument in order to rationalize their stand.

[1]Except in app. 3 to this report -- a paper supplied by Dr. Sydney Walker III, concerning a hypothetical case.

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Mr. Roush. Dr. Baker, I'm sorry to interrupt, but I'm going to have a brief recess here.

Dr. Baker. Certainly.

Mr. Roush. There is a motion to recommit the military construction bill, and I would like to vote on it. None of my colleagues are here right now, so we will declare a very brief recess, and I shall return as quickly as I can.

(Whereupon a short recess was taken for a floor vote.)

Mr. Roush. The committee will be in order.

Dr Baker, you may proceed.

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ASTRODYNAMICS

SECOND EDITION

by

ROBERT M. L. BAKER, Jr.

Computer Sciences Corporation and
University of California
Los Angeles

MAUD W. MAKEMSON

University of California
Los Angeles

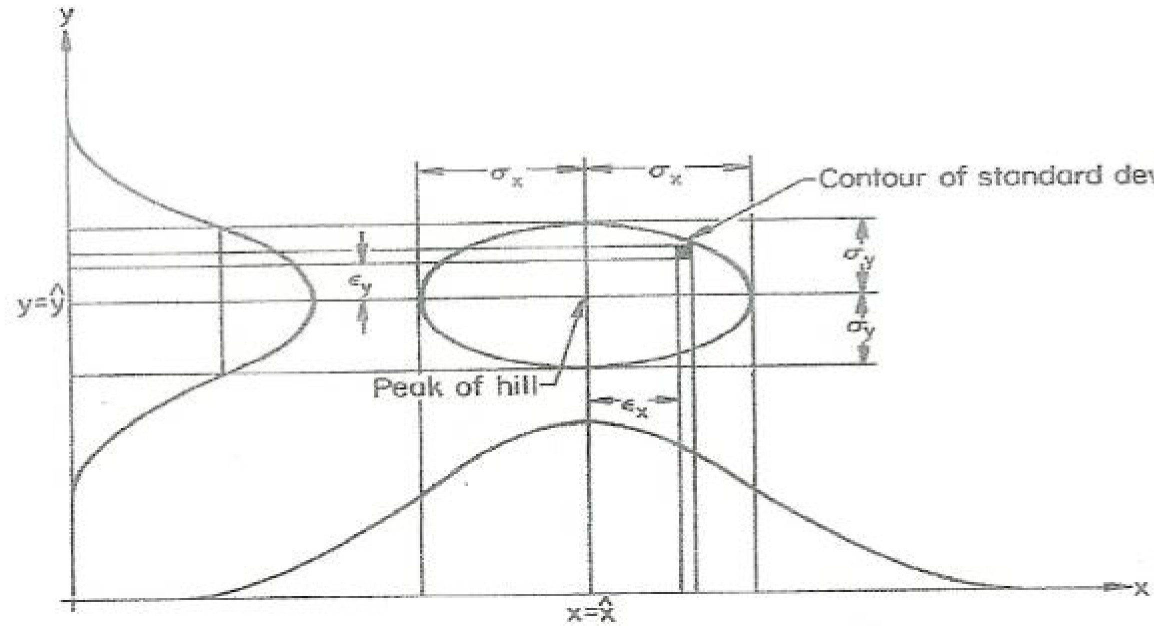

Fig. 6-19. Error hill for two uncorrelated variables.

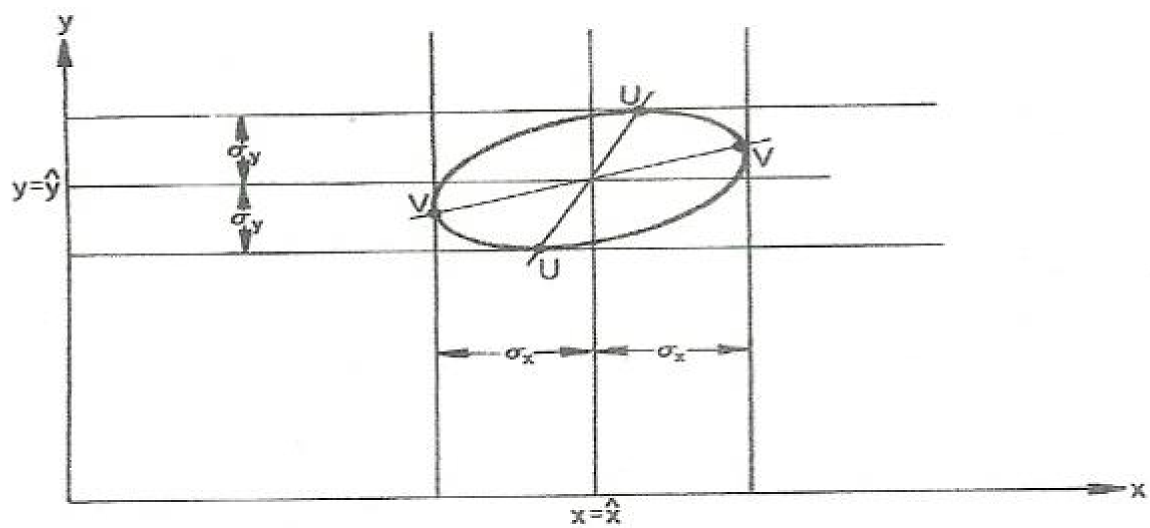

Fig. 6-20. Error hill for two correlated observables.

6.6 Anomalistic Observational Phenomena

Anomalistic observational phenomena fall into a number of categories, the most remarkable of which are those observed by either the unaided eye or commercial cameras in the hands of amateur photographers (variously called Unidentified Flying Objects (UFO) or "flying saucers"). Although such observational data take on a diverse and often bizarre form (even more often are spurious or entirely fictitious), they must be reckoned with. It is always possible that a small percentage of these data may contain valuable information. The analyses of these data may also yield procedures or techniques that may be equally useful in the reduction of anomalistic data having a greater precision and (or) a greater reliability or credibility. (See Hynek (1966).)

6.6.1 Anomalous Luminous Phenomena, Solar Reflections

As one example let us consider briefly anomalous luminous phenomena associated with light reflections from shiny surfaces. The image of any brilliant light source as seen by either the eye or a camera can appear much larger than the luminous object. An extreme example of this effect is shown in Fig. 6-21, which is a blown-up 16 mm frame showing the image of a $1\frac{1}{4}$-inch

Fig. 6-21. Bright image distortion.

Dr. Baker's Father, Robert M L Baker Sr., pictured holding array.

plane mirror at 180 ft reflecting the Sun directly into the 1-inch lens of a camera. The mirror's true size is exaggerated some 15 times. This fact has obvious bearing on the analysis of photographic films. It therefore motivated a photogrammetric experiment conducted by the author on 10 and 11 December, 1955. The experiment was devised in order to obtain empirical information about the effect of distance, lens focal length, iris stop, frame speed, and so on

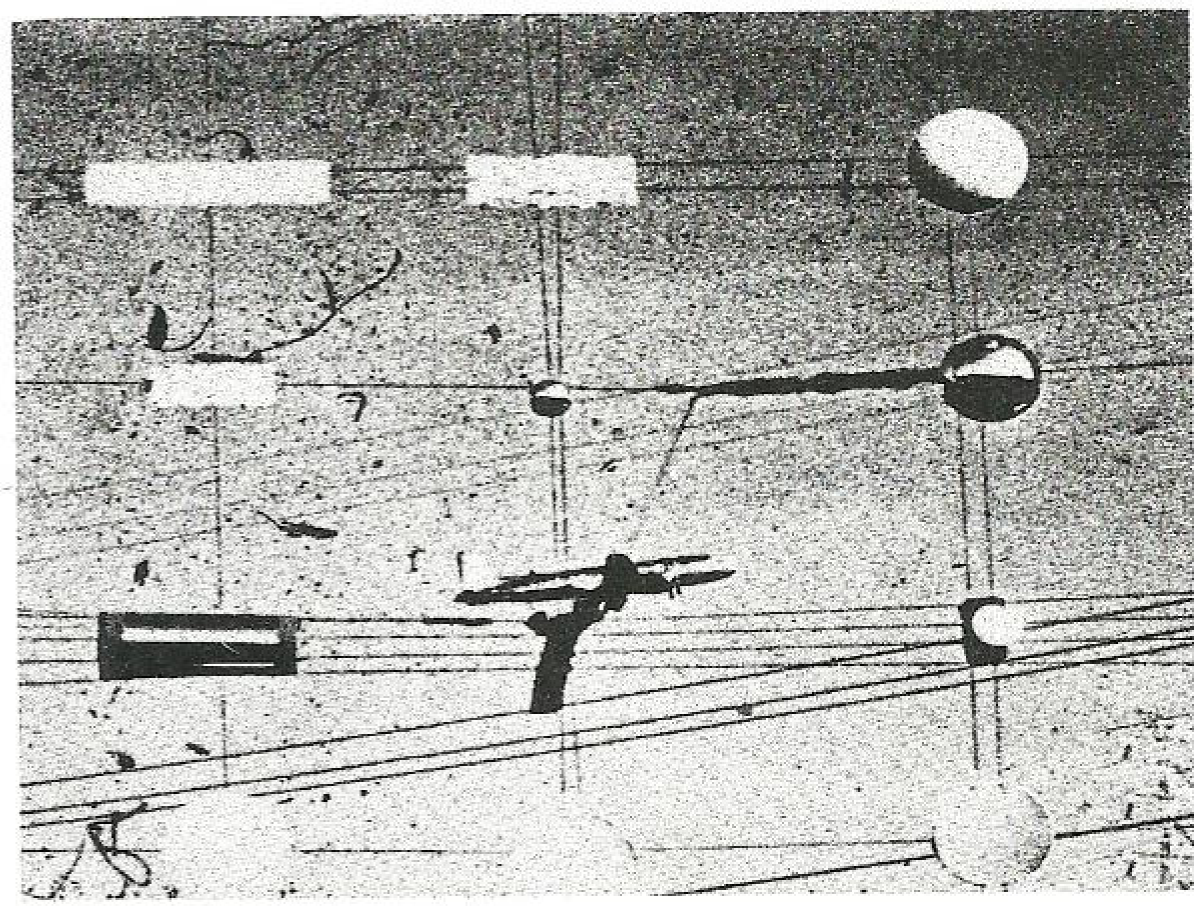

Fig. 6-22. Photographic experiment array.

on the photographic images of various small bright sources of reflected sunlight (see Fig. 6-22). One hundred and nineteen combinations of these parameters were examined. The tests included still, as well as 16- and 8-mm motion pictures, and shots of actual airplane reflections were also taken.

The most pertinent facts gleaned from this experiment involved the analysis of optimal specular Sun reflections* from a chrome plated model

* Optimal reflection is achieved when the angle of incidence of the Sun's rays on the object is equal to the angle of the reflection to the observer, the angles being taken with respect to the axis of the aircraft involved.

DC-6 and a bright cylindrical reflector. Both these objects show a magnification in the size of the image photographed over that of the actual object. In the case of a DC-6 model photographed from a distance that would give the same size picture as the full-scale airplane from about 2 miles; the bright images are of dimensions corresponding to 0.004 ± 0.002 rad. One of the photographs* shows reflection (at optimal angle) from a cylinder roughly corresponding in geometry to a 50-ft airplane at a distance of about 2 miles, the bright image's angular diameter was 0.001,5 rad. Figure (6-23)† is a

Fig. 6-23. "Montana" objects.†

* These photographs were taken with a 3-inch telephoto lens, at 16 fps, *f*/22, and with Kodachrome daylight color film. Thus they should correlate with the actual Montana and Utah films to be mentioned subsequently.

† These frames show up rather poorly when reproduced. All measurements were made on the actual movie negatives. Extracted from Baker (1956).

blown-up frame taken from the "Montana" film, which is an example of a yet to be explained luminous phenomenon.* The image's angular diameter was 0.001,4 rad. The image intensity on the "Montana" film clip appears to be slightly less than that of the experimental picture, but variation in development techniques would not allow quantitative analysis in this regard. Figure 6-24 shows optimal Sun-reflections from four jet planes; estimated distance was $2\frac{1}{2}$ miles; the angular shape of the bright image was 0.001,4 by 0.006 rad. (The reflection from these jets lasted about 5° and the jets themselves were rather easily discernible on the film.) Another photograph showed optimal

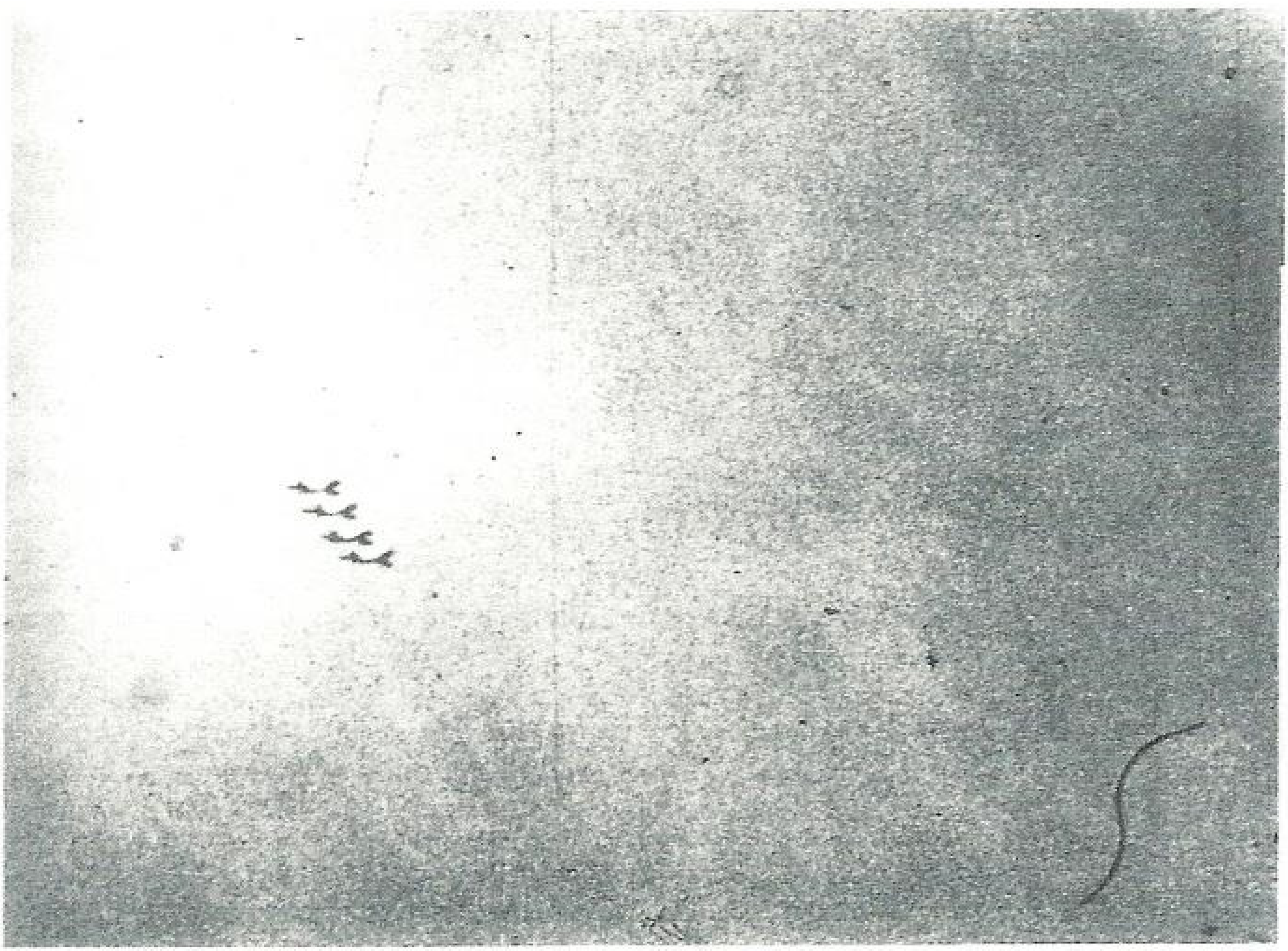

Fig. 6-24. Jet plane solar reflections.

* The so-called "Montana" film is a short sequence of 8-mm film taken at 11:30 A.M. MST, 15 August, 1950 by Nicholas Mariana, at Great Falls Base Ball Park ($\phi = 47°3'N$, $\lambda_w = 111°17'$], Great Falls, Montana, of two luminous objects, apparently drifting across the sky. Extracted from Baker (1956).

reflection from a commercial plane (100 ft in length) in a landing pattern over the Los Angeles International Airport. Its estimated distance was 12 miles and the angular image diameter was 0.000,3 rad. (The reflection in this case lasted about 10°.)

The experimental results appear to indicate that if the first few frames of the anomalous film show Sun reflections from airplanes, which are optimally oriented with respect to the Sun, then the planes would have been on the order of 1 to 3 miles distant from the observer. If, however, these first few frames represent images of the reflection from airplanes not quite optimally oriented, then the planes could have been at closer distance, but their fuselages would be identifiable on the film. Even in the light of the many sources of image distortion the experimental shots indicate that the image size of the UFO's could not be reconciled with airplane fuselage reflections at even 4 miles.

Airplane reflections have been observed both photographically and visually to persist (total angular distance from fade-in and fade-out) over angular travel ranges less than 20° (40 Moon diameters). This conclusion was borne out by manipulation of model airplanes (DC-6 and F-94) in strong sunlight.

The effects which accounted for the distortion in image size may be listed as follows: scattering in the atmosphere (between the light source and the camera),* optical aberrations (coma, astigmatism, distortion), flaring at the lens surfaces, diffraction,† turbidity in the film (sometimes called "photographic craspedomorphology"), reflections off the film backing (halation), and finally adjacency effects (chemical reactions between overexposed and underexposed areas usually produce fringes called Makie line or Eberhard effect). There are also distortions produced during development and reprinting. An excellent description and an analysis of all of the above effects have been presented by Mees (1954).

All of these effects will cause, to a greater or lesser degree, the image on the film to appear larger than the source.‡ The stronger the light source, the more prominent these effects become. Curved reflecting surfaces become a much less intense source and also have the property of not needing to be precisely oriented with respect to the Sun in order to yield a bright image. Thus fuselage skin reflections are not as bright as direct specular reflections, but last over a greater angle. There is also quite a difference between specular

* This broadening is often called "aureole"; see Kuiper (1951, p. 69).

† Light sources brilliant enough to produce this form of large-scale broadening are sufficiently intense to produce noticeable diffraction effects; see Fig. 6-21. The crosses of light appearing on the image are due to diffraction through the polygonal iris of the camera.

‡ Attenuation of the light (such as is associated with scattering) will tend to decrease many of the sources of broadening, however.

Sun reflections from fins, wings, planar windows, and so forth, and those from the fuselage. Fins, wings, and windows have more nearly planar surfaces and therefore produce more intense reflections; however, a very slight change in orientation with respect to the Sun (1° to 5°) will completely destroy the reflections. Fuselage surfaces have greater curvature and thus produce less intense reflections but the angle of orientation is not quite as critical, 5° to 10° in the horizontal plane and sometimes up to 45° in the vertical plane, for example.

Because of the above described effects, the proportions of bright objects seen from a distance may also be distorted. (In one photograph taken during the experiment a cylinder of length-to-width ratio of 1 : 3 appears almost like a circular dot.) In spite of this, fuselage reflections from planes appear to be slightly elongated; see Fig. (6-24). Of course, the amount of elongation depends upon the perspective of the observer and the distance of the object. In the case of the "Montana" films (the object's line of motion making an angle of 55° with the line of sight) the fact that the images appear as uniform white dots cannot serve as a valid deterrent to an airplane reflection hypothesis. However, this rather large angle does mean that the image would be smaller and the hypothetical planes would have to be even closer than 3 miles.* In Fig. (6-24) the jet plane motion made an angle of only about 30° to 40° with the observer's line of sight and the image definitely appears oval.

6.6.2 Sources of Anomalous Phenomena

As can be seen from the foregoing section, it is not a simple matter to analyze a potential cause of anomalous data even if the causative phenomenon is well understood. In general, little or no credence should be given to eye-witness descriptions and little attention should be given to still photography, or a single electronic datum or reading. Multiple photos (motion pictures or successive Baker–Nunn camera frames, for example) and continuous recorded electronic data are, however, usually subject to more careful scrutiny. (Those interested in eye-witness accounts should read Fuller (1966).)

There exist a number of rather common illusions that, by and large, result from the misinterpretation of well-understood phenomena. As examples we cite balloons, planets (particularly Venus and Mercury), stars, meteors, bits of paper, chaff, soaring insects, ballooning spiders, bubbles or foam, birds, peculiar clouds, spurious images introduced in optical or electronic systems [for example, "ghosts," "angels," and so on as discussed by Tacker

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* Examination of Fig. (6-24) indicates that airplanes as close as this would certainly appear on the film as identifiable shapes and not simply as white "dots."

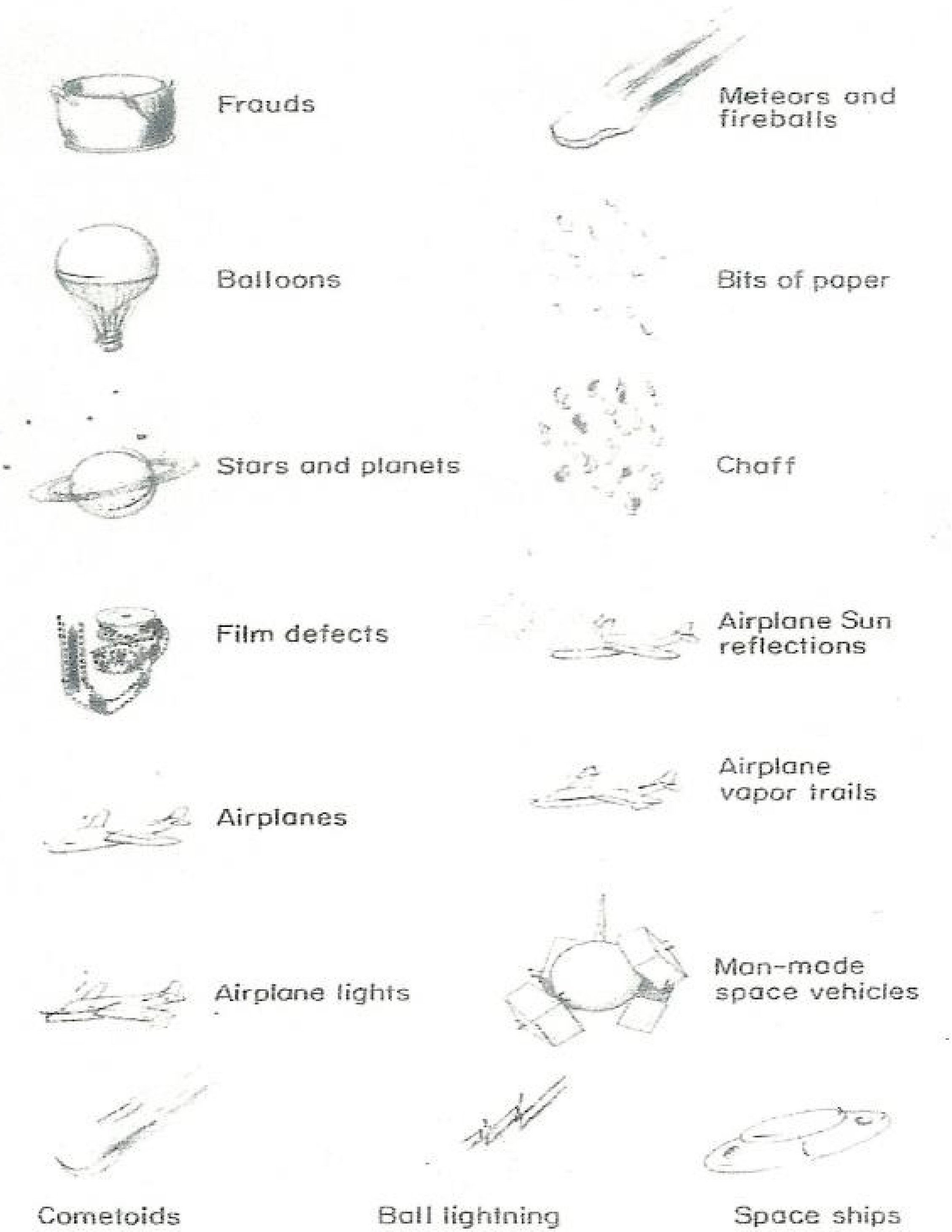

Fig. 6-25. Anomalous luminous phenomena well-understood and not well-understood.

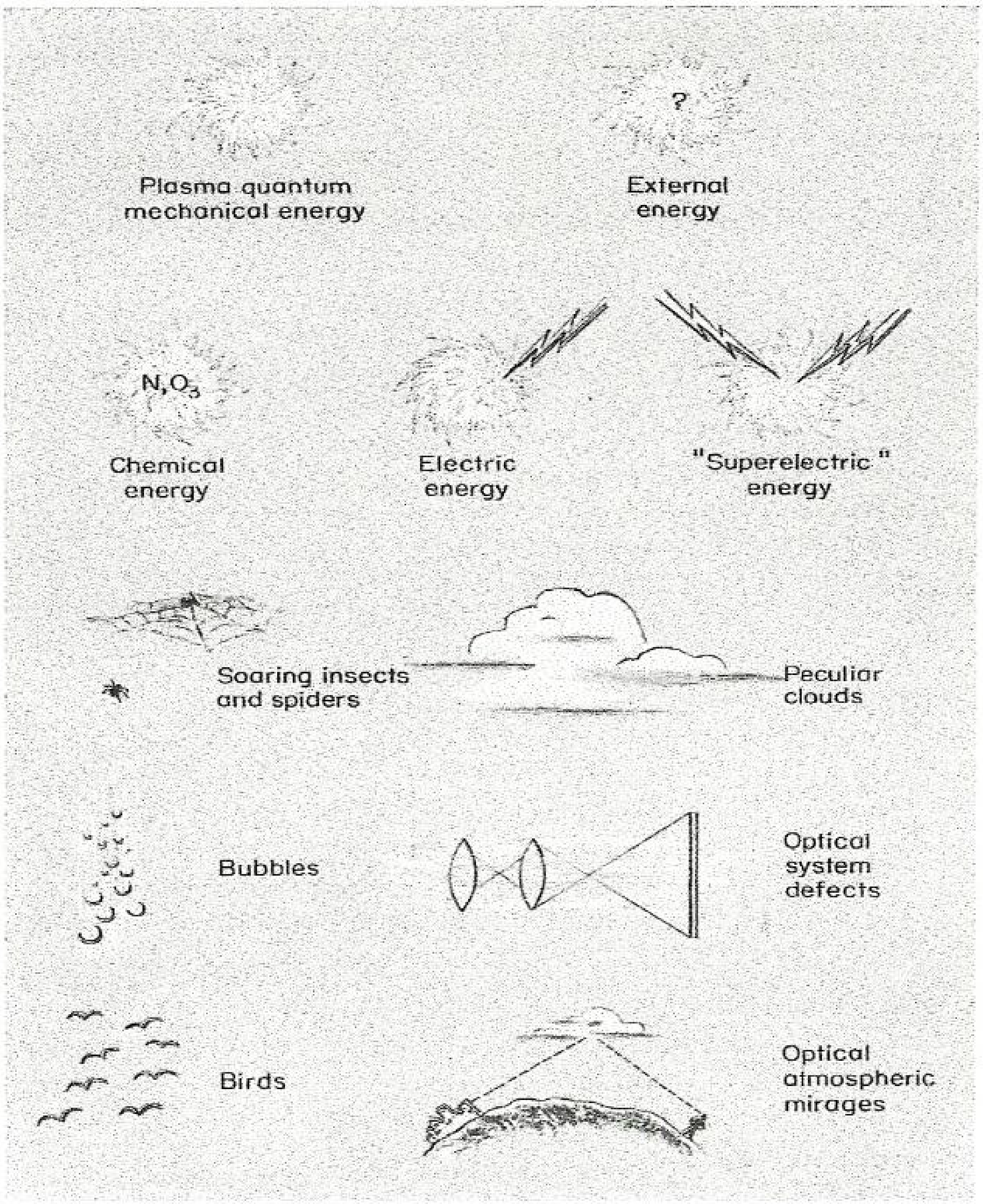

Fig. 6-26. *Ball lightning and well-understood phenomena.*

(1960)],* optical atmospheric mirages [see Menzel (1953) for a complete treatment], electronic ionosphere mirages, film or electronic recorder defects, airplanes, airplane lights, airplane Sun reflections, airplane vapor trails, man-made space vehicles (including those equipped with flashing lights), frost or frozen material (as, perhaps, viewed on occasion by astronauts), and so on. See Figs. 6-25 and 6-26 for graphic examples. The list is an almost infinite one and it often takes considerable imagination and acumen to associate these well-understood effects with anomalous data. Figure 6-27 shows a blown-up slide similar to Fig. 6-23 but showing the several white unknown objects in the "Utah"†

Fig. 6-27. "Utah" objects.

* See Fig. 2-13, page 172 of the advanced volume.

† The "Utah" film is like the "Montana" in that little detail is apparent and an amateur movie camera was used. The film was taken by Chief Warrant Officer, Delbert C. Newhouse at 11:00 A.M. MST, 2 July, 1952, on State Highway 30 seven miles north of Tremonton, Utah ($\phi = 41°51'N$, $\lambda_w = 112°10'$). Extracted from Baker (1956).

film clip. Here a possible answer might be birds in flight. This explanation is not wholly satisfactory, particularly in view of the objects' relative motion as measured in Figs. 6-28 and 6-29.

Film clips are usually the most reliable sources of anomalous observations and, like the "Utah" and "Montana" films, considerable

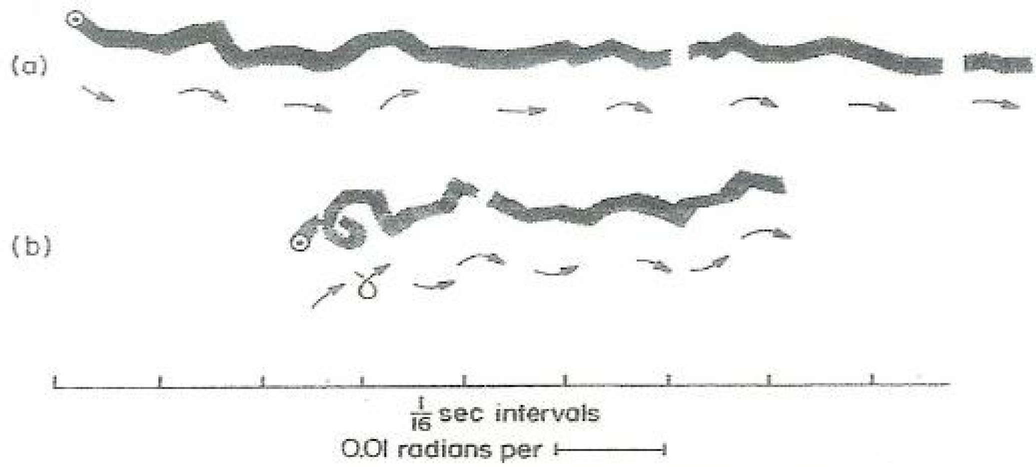

Fig. 6-28. Motion of UFO across the field of view.

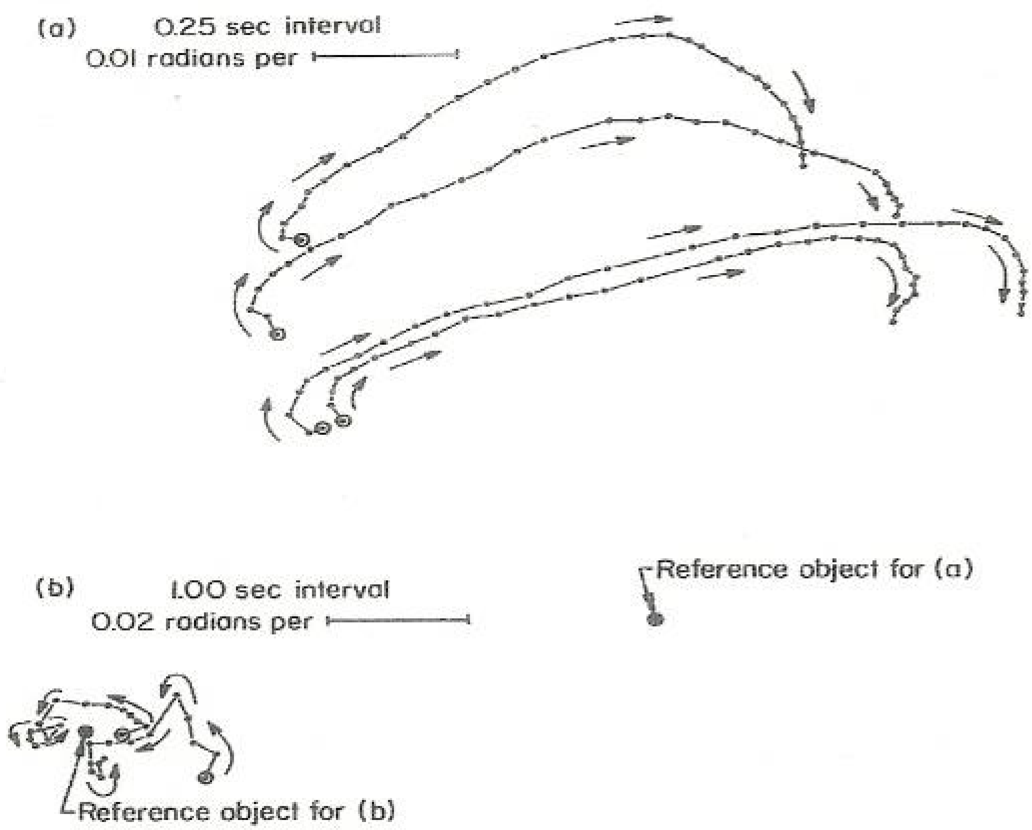

Fig. 6-29. Relative motion of UFO system.

information can be extracted from photogrammetric analysis of such film clips. Ordinarily an analysis of the film confirms without doubt that the source of the anomaly was in actuality a well-understood phenomena. Since the "Utah" and "Montana" films there have, however, been a number of other motion-picture clips showing phenomena that nearly defy explanation. One such film was taken at Edwards Air Force Base and was finally discovered to have been optical flare in the cine-theodolite (see Section 6.3) caused by spurious Sun reflections in the instrument. Along this same line, on 5 December, 1963 three Navy cameras and two Air Force cameras were viewing the launch of a Thor-Able Star (015, project A4101019). Just after the second stage was ignited three of the cameras (two of the three were at the same site, site TS-7 at Vandenburg Air Force Base) show an object as bright as the second-stage flame, moving "straight up" the film frame at about 1/3° per second. Since different cameras (from two different sites) viewed the object, it probably was not an optical illusion (such as a flare). Since the launching was near neither dawn nor dusk and the object was so bright, it probably was not an artificial satellite. It could have been a high-flying supersonic aircraft, but it is not likely that such a plane would have been allowed in the vicinity of the launching. Birds, insects, balloons, and so on are not especially reasonable answers. Certainly a triangulation study could be completed using the films since there were simultaneous views from two sites and the second stage of the Thor-Able Star could be used as a reference for both position and brightness. At this writing the author does not know of any such analysis, the outcome of which could possibly establish the natural source of the peculiar image.

To the list of well-understood phenomena must be added a number of effects which are not particularly well known. Cometoids (nuclei of comets that enter the Earth's atmosphere; see Section 3.3.3) were proposed by Donald Robey (1960) to account for certain luminous data. One possible example of impacting cometoid is the Tunguska event discussed in Section 3.3.3 and analyzed by Lamar and Baker (1965). Ball lightning* (Fig. 6-26), involving magnetohydrodynamic forces, and utilizing chemical, electrical, and exotic energy sources has been proposed and studied with considerable care over the years. An especially interesting observation of ball lightning was reported by Mohr (1966). He related an occurrence at Dunnellon, Florida, in August 1965 in which a ball, described as being "... of a color and brightness comparable to the flash seen in arc welding, with a fuzzy appearance around the edges. The movement of the ball to the floor was accompanied by a

* Those interested in the subject of ball lightning should consult Donald J. Ritchie's 1961 collection of translated Russian articles on the subject (the translations can be obtained from Consultants Bureau, 227 West 17th Street, New York, New York 10011) and Silberg *et al.* (1965).

report 'like a shotgun blast.' The entire incident was over in seconds." No one felt any heat and the explosion was heard by a neighbor about 150 ft away and it was subsequently learned that another neighbor's electric range had been shorted out at the same time. A related phenomenon is that of burning marsh gas. The so-called "Lubbock lights" reported, for example, by Ruppelt (1956, p. 133) and by Vallee (1965, pp. 136–139) have been explained by the ignition of large balls of marsh gas and their subsequent rise. The reports of "weird flying objects" on 21 March, 1966 at Ann Arbor, Michigan and on 22 March, 1966 at Hillsdale, Michigan, in which football-shaped objects were observed in nearby marshes, may be a result of such a natural phenomenon. J. Allen Hynek, Chairman of the Dearborn Observatory of Northwestern University, Evanston, Illinois, investigated these "sightings" for the Air Force's "UFO Office" at Wright-Patterson Air Force Base. It is this type of analysis by seasoned professionals, like Hynek, E. U. Condon, F. E. Roach, and S. W. Cook (the latter three from the University of Colorado's UFO Study Project), that best serves the Nation's curiosity about such phenomena and might, in fact, reveal information of considerable scientific value.

There are also a number (albeit a small number) of scientists who are not completely reluctant to agree that some anomalous phenomena have their source in extraterrestrial phenomena not yet even comprehended by man. And, finally, there are those laymen who are convinced that the source of most of these phenomena is indeed extraterrestrial and is the manifestation of beings from another world. Ordinarily, the analyses of the very difficult-to-explain anomalous data present the scientist with a dilemma: is he to stretch a point and allow that, although very improbable, the data in question must have their sources in a particular well-understood effect, or is he instead to allow that some not understood phenomena perhaps of extraterrestrial origin may be at play? Each observer must decide the question for himself.

6.6.3 Tracking Procedures for Anomalous Luminous Phenomena

The techniques for analyzing the motion of anomalous objects are as complex as the motion of the objects themselves. If motion-picture frames which exhibit background features are analyzed (such as the Montana film clip), then an angular motion study can be made and simple numerical derivative techniques (discussed in Chapter 1 of the advanced volume) can be employed to obtain angular velocities and accelerations. If no background features are apparent (as in the Utah film), then only relative angular measurements are possible (see Fig. 6-29) and only relative angular velocities can be determined (see Fig. 6-30). When either cine-theodolite or radar data are available the analysis problem is, of course, simplified.

Since most of the anomalistic objects in question do not move along paths uniquely determined by a central gravitational field (as airplanes, birds, insects, atmospheric mirages, optical flares, and so on) one is clearly not justified in fitting them to a two-body orbit. The observational data should, instead, be reduced to yield actual speeds and accelerations (as a function of range from the observer if the range is not observed by parallax or radar). For the purposes of guiding an observational instrument the modification of the Leuschner differential correction (pages 114–115 of the advanced volume) is, nevertheless, still quite applicable. Because the f and g series used in this development is truncated after the τ^3 term, the gravitational effects are not strongly coupled to the differential correction formula. It would be more accurate, however, to introduce the non-two-body form of the f and g

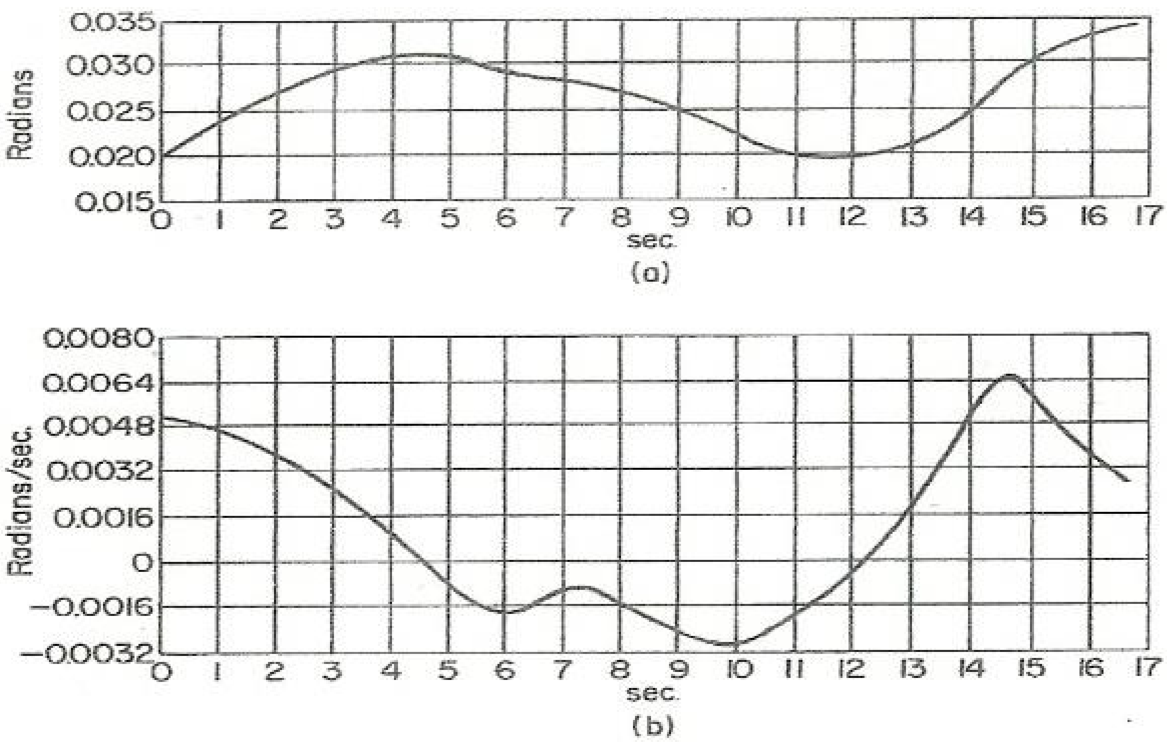

Fig. 6-30. Relative angular position and velocity.

series (see the advanced volume, Section 2.10) into the correction equation [Eqs. (1.141) to (1.144) of the advanced volume]. If this is done then the $\bar{g}_3$ term will involve a τ portion (independent of perturbations—bird flapping or otherwise), a τ^2 (dependent upon a, perhaps, unknown perturbative thrust), and a τ^3 term dependent upon the central gravitational field. One can then analyze the motion, after observation, by solving for these and similar terms in the modified non-two-body f and g series, thereby assessing the magnitude and direction of the perturbing influence. Such an analysis, based upon the modified f and g series, is not difficult, but should be reserved for the observation of objects that cannot be otherwise explained. An exercise illustrating the use of the differential correction procedure (not involving the modified f and g series) is given in the advanced volume (Chapter 1, Exercise 1.22).

As an example of where such tracking techniques might be utilized, we cite the "fireball precession" of 2 August, 1965. In this instance a number of bright objects were viewed from Kansas, Texas, Oklahoma, New Mexico, Colorado, South Dakota, Nebraska, and Wyoming. At Wichita Falls the Weather Bureau radar reported the acquisition of a number of objects on their weather radar and hundreds of people observed bright objects moving northward in the skies, changing color and directions. The reports are reminiscent of the Canadian fireball precession of 9 February, 1913 (Mebane, 1956; O'Keefe, 1961).* The cause of the luminous phenomena in both cases appears to be mesometeoritic material entering the Earth's atmosphere on nearly horizontal paths so that they appear to be "flying in formation" across the sky (see Baker, 1958). In order to track such erratically moving objects a technique similar to that outlined in the foregoing would be valuable and might lead to confirmation of the natural origin of this anomalous luminous phenomena.

* Some reports of the phenomenon seem to be at variance with this hypothesis; for instance, some radar observers reported 45 miles per hour speeds, hovering, spherical shapes, and so on.

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Observational Evidence of Anomalistic Phenomena[1]

Robert M. L. Baker, Jr.[2]

Abstract

A summary of the data obtained from a series of analyses and experiments, which were initially carried out by the author under the auspices of Douglas Aircraft Company and based upon movie film containing anomalistic data, originally provided by the United States Air Force, is presented. It is concluded that, on the basis of the photographic evidence, the images cannot be explained by any presently known natural phenomena. On the other hand, the quality of the images is insufficient to determine the nature of the anomalistic phenomena recorded on the movie film.

Introduction

Two anomalistic unidentified flying objects (UFO's) were sighted and later photographed at about 11:30 a.m. Mountain Standard Time on August 15, 1950, by Nicholas Mariana at Great Falls, Montana. Mr. Mariana owned and operated a radio station in Missoula, Montana, and was the owner of the Great Falls baseball team.

All of the soft-data (eye witness reports of Mr. Mariana and his secretary) indicated that the objects were silvery in appearance with a notch or band at one point on their periphery and could be seen to rotate in unison, hover, and then ". . . with a swishing sound, floated away to the left (SW) . . . ." The hard data from the film showed inarticulate bright white dots. Figure 1 shows the manner in which the diameter of the bright dots decreased with time. The objects passed behind a water tower and are exhibited in Fig. 2, along with the associated frame number (the frames below 65 exhibited no foreground). According to Mariana, 35 of the earlier frames, allegedly lost by the Air Force, showed a larger image, complete with a "rotating notch." Figure 2 was constructed from iconolog measurements (a film viewer with moveable cross hairs and a digitalized coordinate output) using the foreground reference points marked ③, ⑤, and ⑥. This figure is drawn like a panorama on the assumption that the photographer kept his stance without moving appreciably (which was reported by him and was well borne out by the consistence of his perspective). These initial measurements were made by the author at Douglas Aircraft Company in 1955–1956.

Analysis

The "Montana" film contains six independent data (as functions of time) on about 225 frames (frames 65 to 290), which describe the UFO images, i.e., the two degrees of freedom of each dot (as depicted on two-dimensional film after the foreground appears on frame 65) and the apparent diameter of the developed image of each on all 290 frames (no ellipticity could be seen in the images except for occasional image smear due to uneven panning). In the analysis it was convenient to treat the UFO's as a system. The four degrees of freedom chosen for this system were the azimuth and altitude of the midpoint on the line of centers between the images, their angular separation and their inclination to the horizon. The inclination to the horizon was found to be very small, the objects appearing to move almost in a plane parallel to the ground. There is a slight decrease in the angle of inclination as the objects regress, but its small value is almost masked by random errors inherent in the measurements. Figure 3a presents a plot of the angular altitude, h, and the azimuth, A, of the midpoint of the line of centers after frame 65 (i.e., after a measureable foreground appears), and Fig. 3b presents the separation distance ratio θ_0/θ as a function of time, where θ_0 is the initial angular separation (frame 1) and θ is the angular separation at any given time. In both of these plots some frames were not measured, e.g., due to obscuration of the images during water-tower passage, or were missing (there were frames missing between frame numbers 177 to 180 on the 35 mm print that was measured for separation distance, but these were accounted for in the time scale using the 16 mm original as a basis). About 225 frames after the foreground (ventilator duct) appears on the film (i.e., after the 290th frame), the objects can no longer be clearly identified and measurements become very uncertain.

[1] Manuscript submitted November, 1967. Paper was presented at an AAS Seminar at the Jet Propulsion Laboratory, Pasadena. A manuscript on the same subject matter was originally submitted in 1962. The complete revision of this earlier manuscript, after receiving three favorable reviews, was accepted.

[2] The Senior Scientist of System Sciences Corporation, a subdivision of Computer Sciences Corporation, 650 N. Sepulveda Blvd., El Segundo, Calif. 90245, and the Department of Engineering, UCLA.

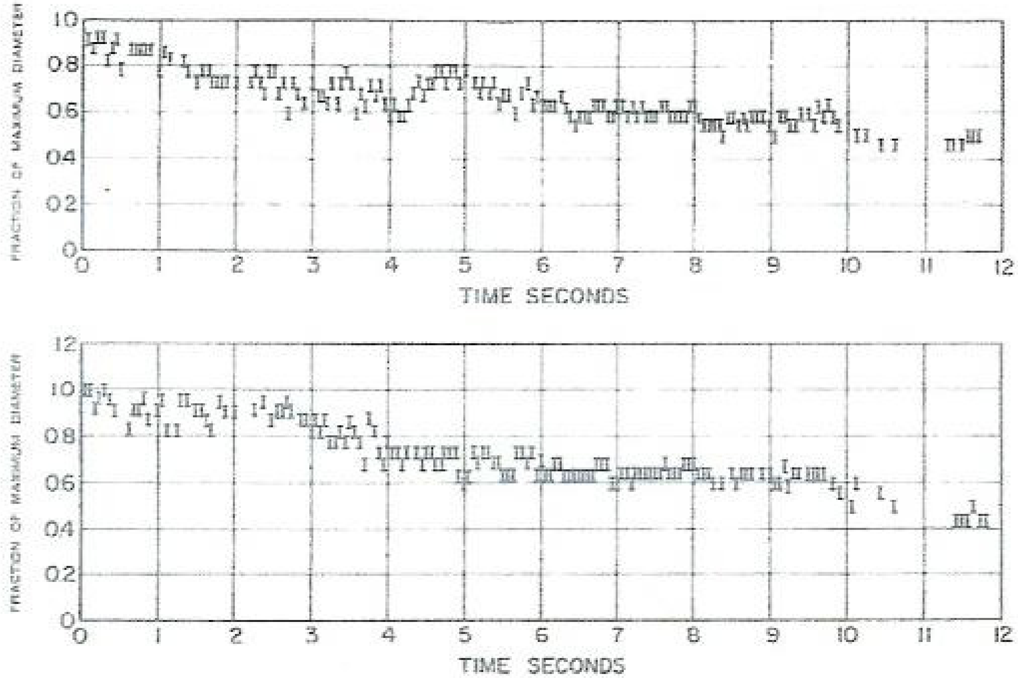

FIG. 1. Ratio of time varying value to maximum value of the angular diameters of the images of UFO #1 and UFO #2.

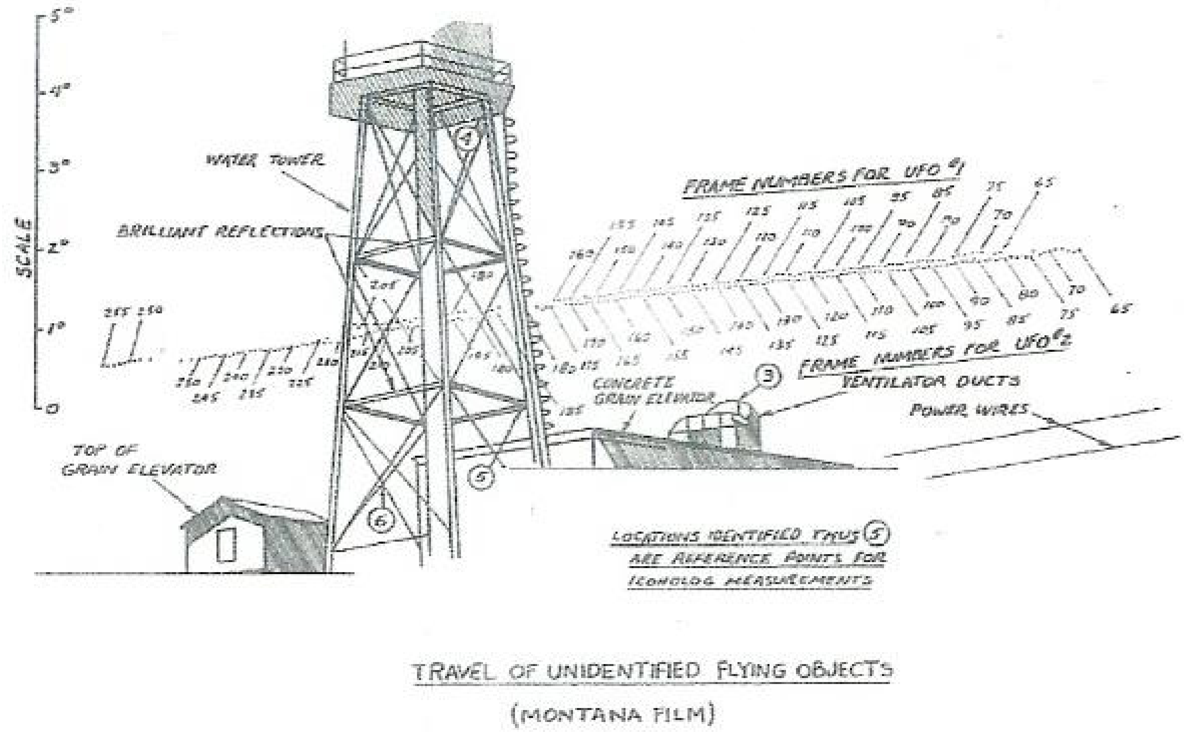

FIG. 2. Motion of unidentified flying objects relative to foreground.

In Figs. 3a and 3b the dotted lines represent what would be the locus of the data points if the objects remained the same linear distance apart and moved linearly in a horizontal plane. The headings, Δ, of 169° to 177° are exhibited. All of the data seems to be consistent with the foregoing assumptions and with a heading of 171°. Of course, one cannot absolutely rule out some other curvilinear motion of the objects. However, any such motion would necessitate the coincidence of azimuth, altitude, and separation, all varying proportionally in some very peculiar fashion to a tolerance of 1%. Figure 4 is a map of Great Falls, Montana, and includes overlays of the UFO system's motion at various hypothetical distances. (No absolute determination of

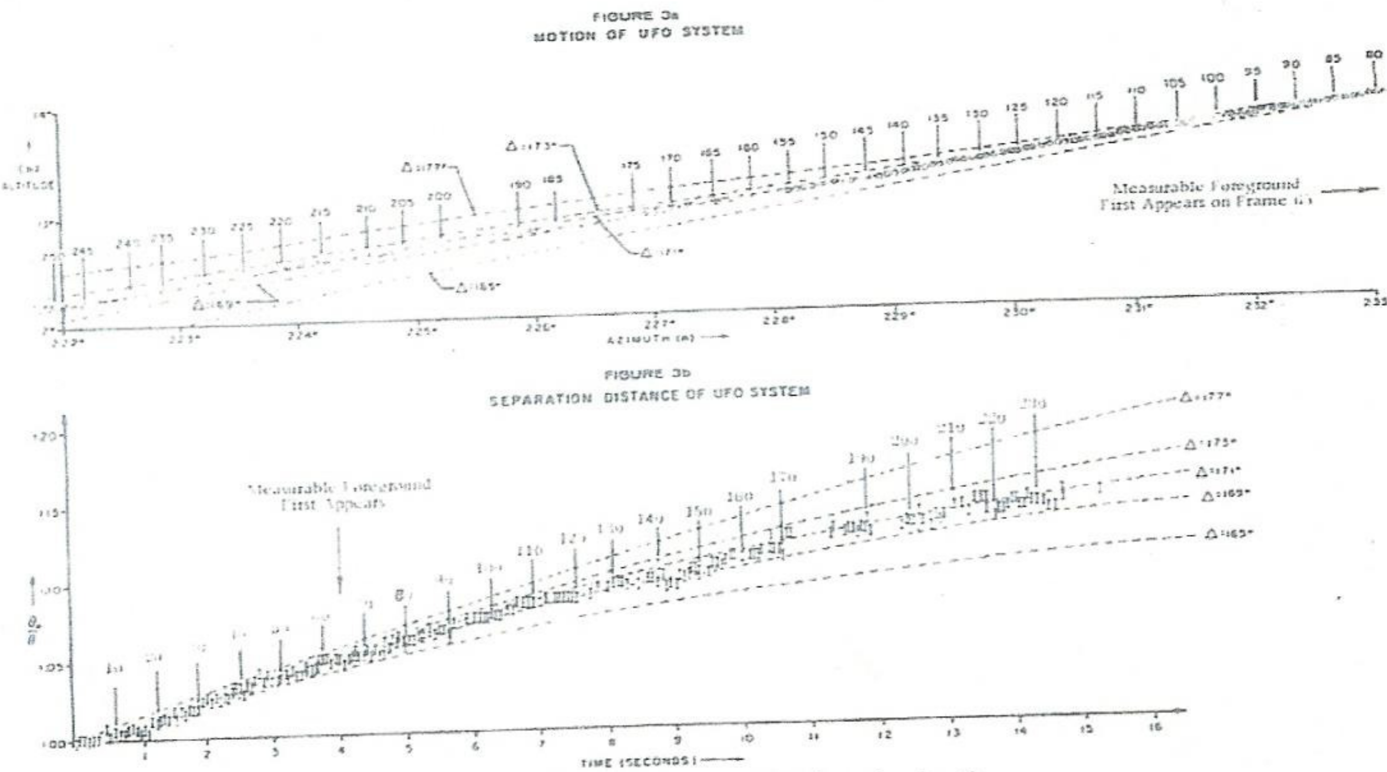

Fig. 3a. Motion of UFO system in altitude and azimuth.
Fig. 3b. Separation distance of UFO system as function of time.

distance can be made on the basis of the angular data presented by the film.) Figure 4 also shows where Mariana and his secretary first viewed the "hovering and rotating" UFO's near an Anaconda smoke stack.

After over a decade of speculation and hypothesis checks, all natural phenomena (e.g., birds, balloons, insects, meteors, mirages, etc.) have been ruled out, except airplane reflections, on the basis of winds (which the weather bureau reported as blowing in the opposite direction); the lack of an observable trail (which would have betrayed a bifurcated meteor); and brightness, angular speed, and steady motion, which could not be reconciled with the supposition that they were birds or insects. These same facts, together with the weather bureau report [1] and the Sun angle, also seemed to rule out various forms of optical lens flare, atmospheric mirages, or cloud reflections. From analyses of speed and geometry, which included a knowledge of the Sun's azimuth at the time of the photography (as confirmed by the shadows on the film) the images could have been (although not without some stretch of the imagination) specular Sun reflection from airplane fuselages. This explanation seemed attractive since it was rumored (although not verified [2]) that two jet airplanes (F-94's) were landing at Malstrom Air Force Base at the approximate time of the sighting. This rumor was reinforced by a presentation by E. J. Ruppelt to a panel of experts in January, 1953 (the panel's membership was not revealed, but may have been called the "Robertson panel" [4]). Ruppelt [5] indicates "the intelligence officer at Great Falls had dug through huge stacks of files and found that only two airplanes, two F-94's, were near the city (Great Falls) during the sighting and that they had landed about two minutes afterwards. . . . First we studied the flight paths of the two F-94's. We knew the landing pattern that was being used on the day of the sighting and we knew when the two F-94's landed. The two jets just weren't anywhere close to where the two UFO's had been." Figure 4 bears this conclusion out since the objects were in the opposite direction from Malstrom Air Force Base and headed away from the air field. The panel, however, did not consider this as positive proof for eliminating the jet-plane hypothesis.

Experiment

Using a camera similar to Mariana's (Revere turret type with a 3″ focal length telephoto lens), a series of photographic experiments were carried out by the author on an array of objects (see Figure 6–22 on page 321 of reference [3]) at various distances and Sun angles and on jet plane reflections. The results of these experiments, however, made the hypotheses of airplane reflections quite strained.

The long persistence of the images would have required the airplanes to have moved on a unique parabolic path with Mariana at the focus. Unfortunately, these hypothetical parabolic paths would be incompatible with the 171° heading defined by the data. In addition, the apparent size of the images (admittedly

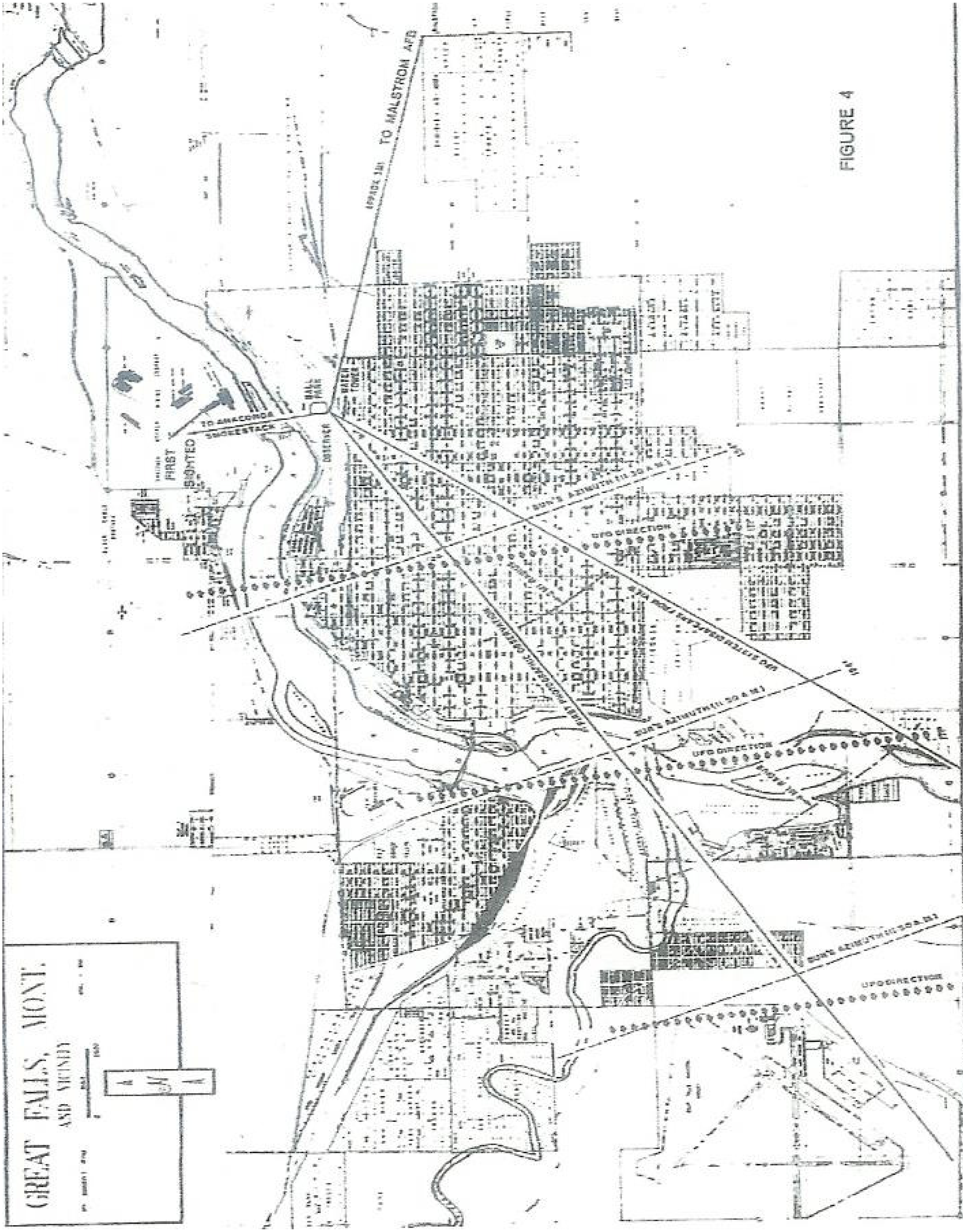
GREAT FALLS, MONT.
AND VICINITY
FIRST SIGHTED
TO ANACONDA SMOKESTACK
BALL PARK
OBSERVER
WATER TOWER
APPROX 181 TO MALSTROM AFB
FIRST PHOTOGRAPHIC OBSERVATION
UFO DIRECTION
SUN'S AZIMUTH (11:30 A.M.)
UFO SIGHTED DISAPPEARING FROM VIEW

FIGURE 4