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Analysis and Discussion of the Images of a Cluster of Periodically Flashing Lights Filmed Off the Coast of New Zealand

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Abstract—The New Zealand UFO sightings of December 31, 1978 are unique among civilian UFO reports because there is a large amount of the documentary evidence which includes the recollections of seven witnesses, two tape recordings made during the sightings, the detection of some unusual ground and airplane radar targets and a 16 mm color movie made with a professional camera. Of the several unidentified light sources that were filmed, one of the more interesting is the cluster of lights that oscillated periodically in intensity at a rate of about once per second. An analysis of the 279 frames of film which show about 30 cycles of the oscillation indicates that there were three lights which formed an isosceles triangle. The color of the light source at the apex was pale yellow or very pale orange (the exact shade is difficult to determine). The base of the triangle was formed by two red lights, side by side. The light at the apex oscillated over an intensity range which went from zero (no image) to such a large value that it greatly overexposed the film. The red lights also oscillated, but they were generally out of phase with the light at the apex and they did not get bright enough to overexpose the film.

This paper presents some of the physical characteristics of the film images and a discussion of the visual and radar sighting, which, it is argued, took place at essentially the same time (i.e., within a minute or so) as the filming.

A number of explanations have been suggested for the film of the flashing light. The explanations are analyzed and reasons for rejecting them are presented. As yet no explanation in terms of known phenomena has been proposed that satisfactorily explains the film.

I. Introduction

A number of unusual lights were seen and filmed during a series of UFO sightings that took place off the coast of the South Island of New Zealand during the early morning hours of December 31, 1978 (Fogarty, 1982; Ireland, 1979; Maccabee, 1981; Startup & Illingworth, 1980). The witnesses were aboard an Argosy freighter aircraft and were flying east of the coast of the South Island. The first sightings occurred between 0010 hours (12:10 a.m.) local (Daylight Savings) time and 0100 hours (1:00 a.m.) while the plane flew southward from Wellington to Christchurch. More sightings occurred between 0218 and 0315 hours while the plane flew northward to Blenheim. The sighting that is the subject of this paper occurred roughly between 0245 and 0255 (exact times will be given later in the paper). The witnesses on the airplane were the pilot (William Startup), the copilot (Robert Guard), two TV news reporters (Quentin Fogarty from Melbourne, Australia, and Dennis Grant from Christchurch, N.Z.), and a professional TV cameraman (David Crockett). An unusual radar target was detected by the Wellington Air Traffic Control (WATCC) search radar in the apparent vicinity of the visually sighted cluster of lights. The witness to the radar sighting was the air traffic controller (Geoffrey Causer).

These sightings are unique in the annals of civilian UFO sightings for two basic reasons. The first reason is that there is a large amount of available information, including tape recordings and film made during the sightings. The second reason is that the sightings were immediately publicized worldwide by major news media. They were publicized because several of the witnesses were a news crew of a major Australian TV station. This section of the paper first presents a very brief history of the circumstances which led to the unusually large amount of information and publicity and then summarizes the results of the technical analysis.

Quentin Fogarty, a reporter for a TV station (formerly Channel 0, now Channel 10) in Melbourne, Australia, was responsible for the presence of a news crew on board the plane. He intended to obtain background film footage for a news story about previous visual and radar UFO sightings that had occurred off the East Coast of New Zealand about two weeks earlier. (The witnesses had been pilots who were flying Argosy freighter aircraft and air traffic controllers at Wellington.) Not expecting to see anything unusual himself, Fogarty planned to have most of the background filming done in the cargo bay of the aircraft. This background film would show him talking about the previous sightings. However, during the early part of the flight the air crew observed a number of unusual lights that they could not identify. Coincidentally, the WATCC reported a number of unexpected radar returns that were correlated in time and direction (from the plane) with the unusual lights. Because of these sightings the captain suggested that the news crew leave the cargo bay and come into the cockpit. The crew then pointed out the unusual lights and Fogarty recorded his impressions of the sightings and radar reports as they occurred. Because the air crew could not identify the unusual lights (although they did identify for the news crew numerous town and city lights, stars, coastal beacons, and ship lights) Fogarty subsequently made the public claim that the news crew had seen and filmed UFOs.

The Melbourne TV station publicized the sightings, claiming that Fogarty had the world's first film of UFOs. The film was the highlight of a short, hastily produced documentary that was shown completely or in part around the world. Even Walter Cronkite was impressed. He devoted five minutes of the CBS Evening News to the sightings (January 2, 1979).

In spite of the fact that no investigation had yet been carried out and that the only information generally available was contained in newspaper stories, scientists throughout the world were quick to offer explanations. Within a week of the sightings newspapers had published explanations proposed by "experts" from many countries. These explanations included the planet Venus, the planet Jupiter, drug runners, secret military activities, "unburned meteorites," mirages or reflections of squid fleet lights, ball lightning, earthquake lights, swarms of glowing bugs and light reflected from flocks of birds. It was also suggested that the film was a hoax by Fogarty and the cameraman or that the whole event was an attempt by the TV station to improve its ratings in the Melbourne area.

There were hundreds of small, bright, well-focused images for the producer of the documentary to choose from. However, in order to create the greatest visual impact, the producer decided to emphasize the largest images, which are round and have horizontal lines going through them. Much later it was shown that these are defocused images. However, at the time they were thought to accurately represent the structure of the unknown light source. Newspapers all over the world published several of these peculiar images. One astronomer publically identified the lines as the rings of Jupiter, in spite of the fact that the film was taken on board a vibrating airplane with lens of only 240 mm focal length. (The actual images are about 2 mm in diameter. It would require a lens with about 10 times the focal length and a stable platform to get images as large as these which show the rings of Jupiter.) In one newspaper story these images were also compared with images of Venus photographed (by a spacecraft) from a distance of only several hundred thousand miles, images which showed for the first time banding structure of the Venusian clouds. This comparison was completely ludicrous since no earth telescope had showed such structure. (It was subsequently shown that the horizontal lines across the defocused images were caused by refractive effects due to non-uniformities in the airplane window glass.)

To add to the public confusion surrounding the December 31 sightings, a second film was obtained from the coast of New Zealand on January 2, 1979. The film was obtained by a N.Z. TV news crew that resented the "scoop" by the Australian TV station. The N.Z. crew rented the largest lens available (600 mm focal length), set up its camera on the coast and waited for the UFOs to appear. Subsequently a bright light was observed on the horizon in the east and the crew filmed it. The film showed a large round image with a black dot in the center, similar to a donut shape, but with no horizontal lines. Needless to say the TV crew claimed it had filmed a UFO, and this second film was also discussed throughout the world. However, an analysis of the sighting showed that the light was Venus rising and that the unusually large round images were a result of the failure of the cameraman to correctly focus the large lens.

The proliferation of explanations for the December 31 sightings embarrassed the Melbourne TV station managers because they had publicized their UFO claim without carrying out an investigation. They had based their claim only upon the reporter's opinion that he had seen UFOs. Therefore the management publicly promised to investigate the sightings. The station subsequently contacted a UFO investigating group in the USA which then contacted this author.

I investigated the sightings by traveling to New Zealand and Australia to interview all the witnesses, by analyzing the film, and by discussing the sightings with numerous other scientists.

The main reason for the uniqueness of these sightings is the amount of information that is available for analysis. The information that is available for most other sightings is only that which is extracted from the memories of the witness(es). A relatively small fraction of all other sightings involve photographs or "landing traces" and a few have associated radar contacts ("radar-visual" sightings). However, there is no sighting (by civilians, at least), other than the N.Z. sightings, which has (a) two independent tape recordings made at the time of the events, (b) reports of unusual ground-based (search) and airborne (weather) radar targets that were coincident with visual sightings, (c) a color movie (16 mm professional camera and film), as well as (d) the memories of a sizeable number of credible witnesses (five).

The unusual amount of publicity that attended these sightings and the large amount of information which was recorded on tape and film during the sightings justifies a careful analysis of the events to determine just what did happen. This paper reports on the results of the analysis of one portion of the sightings. The information contained in this paper is based on a study, carried out over the last eight years, of the film and the testimony of the witnesses.

The flight of the aircraft, and the corresponding sightings and film, can be roughly divided into three parts: the flight from Wellington to Christchurch, the flight northeast from Christchurch, and, finally, the flight north from Kaikoura East toward Cape Campbell, which is illustrated in Figure 1. The film shot during the second part, the flight northeast from Christchurch, includes the large defocused images which were shown worldwide. However, it is the third part which is the subject of this paper. It shows a cluster of lights which oscillated regularly in intensity during the 27.9 second section of the film. Although it is known that the film was shot between 0230 and 0315, the exact time of the filming cannot be determined independently of other events since the camera was not synchronized with Fogarty's tape recorder. However, a reconstruction of the sighting events using the two tape recordings (one made by Quentin Fogarty on the plane, and one made by the WATCC) strongly suggests that the plane was at the location marked "radar-visual (0251)" on the map (Fig. 1) when the film was shot. When it was at that location the copilot, Robert Guard, reported to WATCC that he saw a "collection of lights" suddenly appear ahead of the plane. Quentin Fogarty, recorded a description of several lights which suddenly appeared and flashed a number of times. Because the tape recordings prove that other occupants of the plane saw flashing lights ahead of the plane, because Crockett was also watching the skies ahead of the plane for unusual lights, and because Fogarty's real time description contains features (the colors and the number of lights) which match features of the film images, it is herein argued that Crockett filmed lights that were described by Fogarty and Guard. Thus it is argued that the oscillating lights were filmed within a minute or so of 0251.

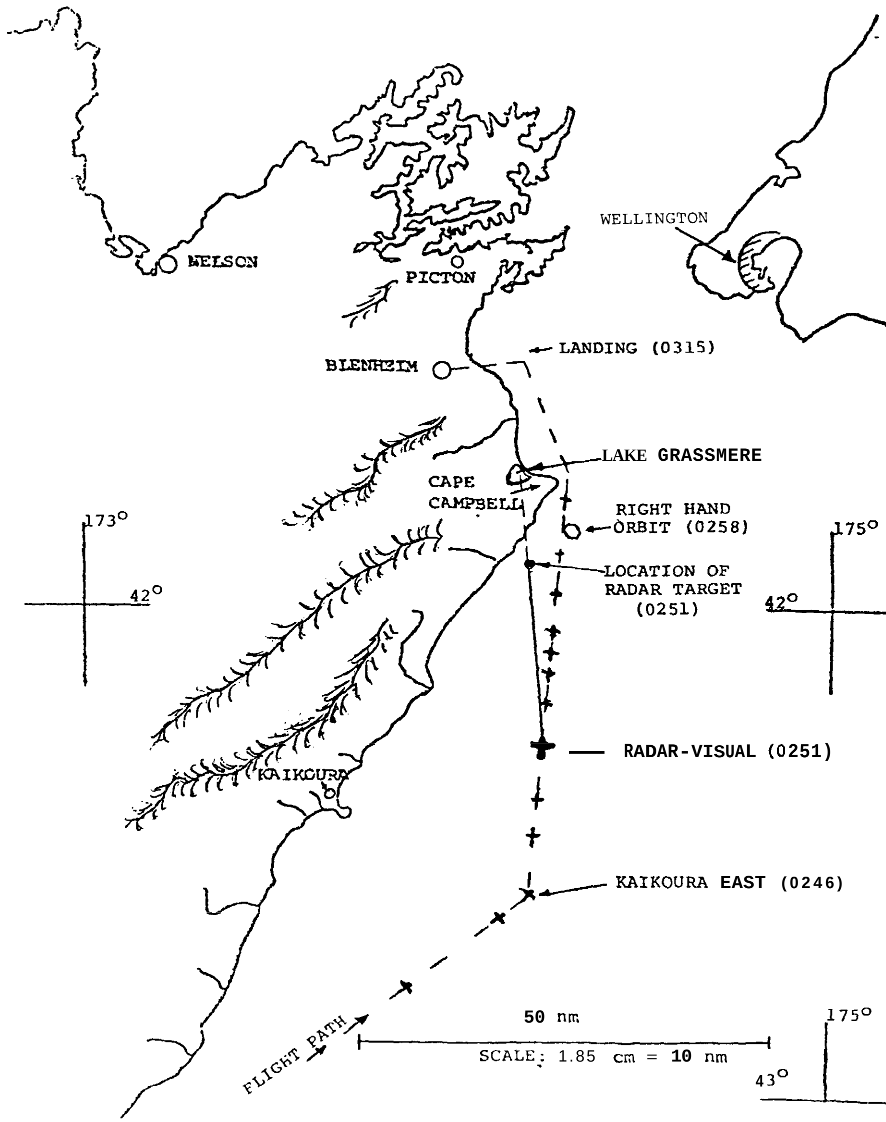


Fig. 1. Flight path from Kaikoura East to Cape Campbell.

A frame-by-frame analysis of the film shows that the images of the lights oscillate in size and color. The oscillation rate is about 1.16 cycles/sec for the full 32 cycles that were recorded. The images vary from overexposed "white" (transparent film base) with a yellowish tinge to dimmer combinations of pale yellow/orange (PY/O) and red (R), or just to red. Although all of the R images were made by a source which definitely was red, the PY/O images and the overexposed images could have been made by a single oscillating source that was pale yellow or very pale orange.

The camera was held on the cameraman's shoulder because there was no room for a tripod in the cockpit. Therefore it vibrated randomly in horizontal and vertical directions about an average position. This vibration caused most of the images to become elongated making them elliptical or "hot dog" shaped. However, a considerable number of frames with images (about 10%) were obtained when the camera was not moving, for example, at or near the time when the vibratory motion reversed direction. In several of these frames the individual images of the lights are arranged in a triangle, with the PY/O image at the apex and two R images at the corners of the base. The triangle baseline is horizontal or nearly so in all but one of the frames with triangular images. The PY/O and R images are close together (within one milliradian) suggesting a close association of the lights which made the images.

The image oscillation referred to above actually is a periodic change in size and brightness of the PY/O and R images. Although the changes in image size could, in principle, be attributed to actual changes in size of the PY/O and R light sources, it is argued in this paper that the actual sizes remained constant while the intensities oscillated. This argument is based on the fact that the photographic image of a light source increases in size with increasing intensity whether or not the light is large enough in angular size to be resolved. (The size of the image of an unresolved light source—a "point" source—is determined by its intensity, a fact that is well known to astrophotographers.)

A careful study has been made of the "transition images" which occur during each cycle between the largest (overexposed) images and the smallest (R and PY/O) images. The study indicates that there were no changes in the relative positions of the light which made the PY/O images and the lights which made the R images, indicating that they maintained a triangular arrangement. The study also indicates that the overexposed images were made by the same light source which made the much dimmer PY/O image at the apex of the triangle. Evidently the intensity of that light changed by many orders of magnitude (factors of ten, not astronomical magnitudes) during an oscillation cycle.

Red images do not occur in the frames with overexposed PY/O images. In fact, there are no red colored areas at all in the frames which contain overexposed images. This could be because either or both of the following occurred: (a) the R lights dimmed and went out as the PY/O light increased in intensity (there is some evidence for this), or (b) as the PY/O light intensity increased its image grew so big and overexposed that it "covered up" the much weaker red images, or (c) a combination of (a) and (b).

The red lights also oscillated in intensity, and occasionally they "went out" at the same time that the PY/O light was "out", thus creating film frames with no images. About nine percent of the frames have no image.

This portion of the film, showing the oscillating lights, was not publicized by the Melbourne TV station because Fogarty decided, without talking to the cameraman, that the cameraman had photographed a beacon. (The cameraman subsequently told me that he had not photographed a beacon.[1]) Consequently none of the publicized explanations were intended to apply to this section of the film. However, I and others whom I have contacted have proposed, in private communications with me and in books, eight different hypotheses to explain the film. The hypotheses and their originators are: (I) a chance alignment of ground navigation beacons (Maccabee; referee of this paper); (2) a reflection of light from within the aircraft cockpit (Maccabee); (3) lights on another aircraft (Maccabee); (4) a specific marine beacon in the entrance to Wellington Harbor (Ireland, 1979); (5) a bright non-astronomical source on the horizon affected by atmospheric propagation (Rackham, personal communication, 1980); (6) earthquake lights (Brady; see Pye, 1981); (7) an emergency vehicle on the ground (Maccabee; Sheaffer, 1981); and (8) the reflection off a propellor of the red flashing beacon on the top of the aircraft (Klass, 1983). These hypotheses are discussed in detail in a later section of this paper. Each of these hypotheses has logical consequences which have been analyzed and found to contradict the photographic evidence. Therefore it is argued here that the nature of the filmed lights has not been explained. It is also argued that the visual and radar sightings have anomalous characteristics that have not been explained. Furthermore it seems unlikely that conventional explanations that are consistent with the photographic data and testimony can be found. If this turns out to be true, then the lights filmed here can be logically called a TRue UFO (TRUFO): a phenomenon for which no conventional explanation exists. The film images and witness testimony can then be used to ascertain some of the physical properties of the TRUFO.

The following sections of the paper present technical characteristics of the lights based on the analysis of the film, supplementary information provided by the witnesses, discussions of the suggested explanations, and a discussion of the implications of this UFO sighting.

II. The Nature of the Oscillation

The periodicity of the overall image brightness is illustrated in Figures 2 and 3. Figure 2 shows that there is a linear relation between the cycle number and the number of the frame in which the image size is maximum. It will be shown later in this paper that the maximum image size corresponds to the maximum light source intensity in each cycle, assuming that the light source itself did not change its physical size. Thus the straight line means that the number of frames between the maximum intensity point in each cycle is constant. The slope of the straight line corresponds to an average of 8.62

[1] Information about the sightings and the camera operation was obtained during several interviews with David Crockett. This author personally inspected the camera and lenses during a visit to New Zealand approximately five weeks after the sighting. Further technical information was provided by Dr. Richard Haines.

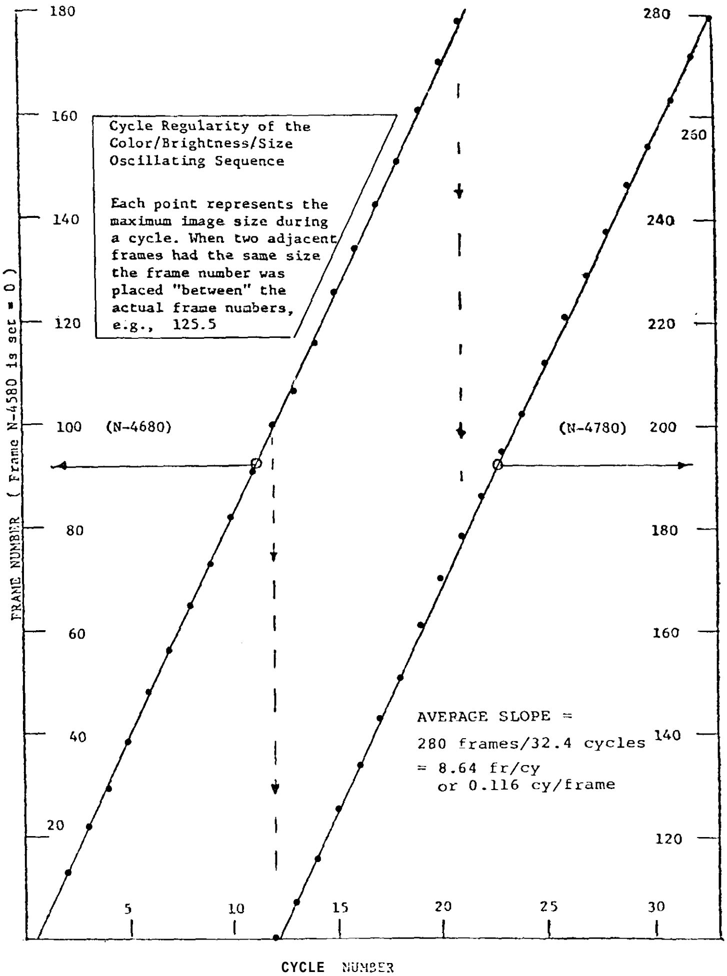


Fig. 2. New Zealand film of December 31, 1978,

frames/cycle or 0.116 cycle/frame. The Bolex H10 EBM electric camera was operated at the 10 frame/sec setting, which should have been accurate to within 10%.[2] Thus the nominal flash rate was 1.16 cycle/sec.

Figure 3 is a more direct illustration of the periodicity and also of the intensity variation of the lights, assuming that the image size variations were largely caused by intensity variations. Figure 3 is a graph of the image widths from frame to frame without regard to the color(s) of the image(s) in each frame. The image widths were plotted, rather than the maximum image dimensions or mean dimensions, in order to minimize the effect on these mea-

[2] *Ihid.*

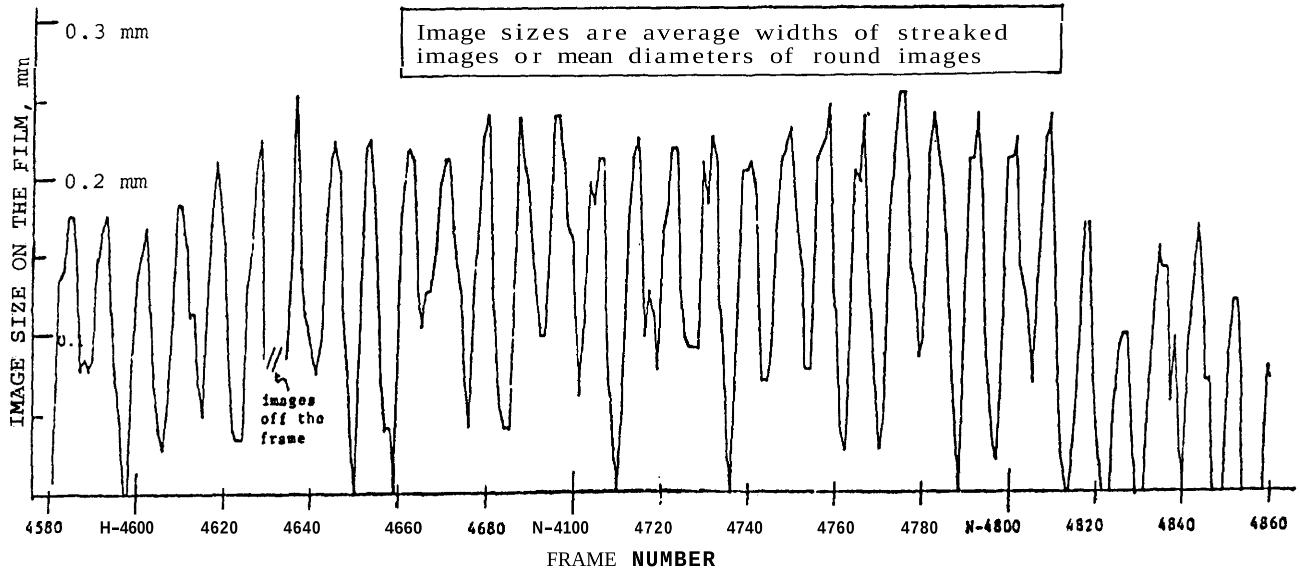


Fig. 3. Temporal dependence of the image sizes during the oscillating light sequence in the film.

surements of random camera vibration (which occurred because the cameraman held the camera on his shoulder). (The width of an image, measured transverse to the direction of the instantaneous camera motion or image elongation, is largely unaffected by camera motion.)

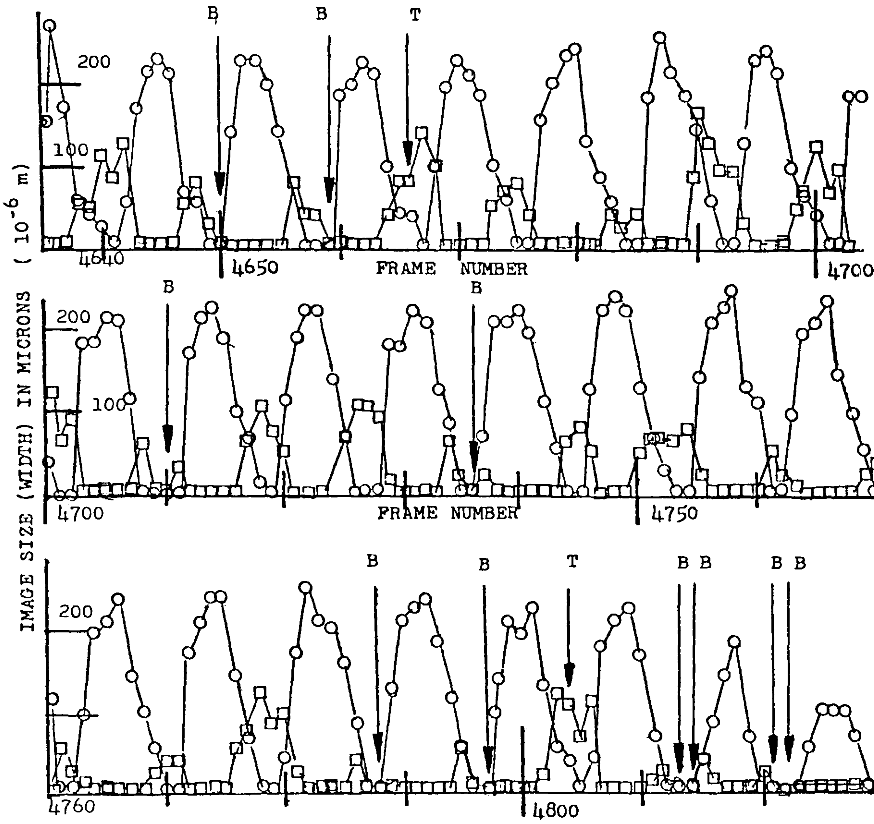
Figure 3 shows that the maximum image width changed during the film sequence. There was a definite overall increase during the first several cycles and a definite decrease at the end of the series of cycles. The increase and decrease in maximum image width is consistent with either (a) a decrease and then an increase in the distance between the camera and a light source of constant maximum intensity in each cycle, or (b) an increase and then a decrease in the maximum intrinsic intensity of a light source which is at constant distance, or (c) changes in the optical transmission of the atmosphere, or (d) a combination of these. (Changes in the camera optics could also produce such an effect but there is no evidence to suggest that any such changes occurred.)

Figure 4 is a close-up of several of the cycles. In this figure the widths of the R and PY/O images have been treated separately, rather than in combination as in Figure 3, in order to illustrate the phase difference between the R and PY/O oscillations. The R images very often reached their maximum widths when the PY/O images were at their minimum size or zero (no PY/O light). However, a careful study of the graph will show that the R and PY/O light sources were not exactly 180 degrees out of phase since very often the R image size reached a maximum before the PY/O image size reached zero. Moreover, there seems to have been some irregularity in the red oscillation since in 10 of the cycles both the R and PY/O lights were at minimum intensity (no image on the film) at the same time. In nine other cycles the minimum intensity frame contained only a very small, faint red image. Some of these features of the red and PY/O oscillations are illustrated in Figure 4. (Only 23 of the 32 cycles are shown for illustration.)

Figure 4 shows that the PY/O light cycle was not completely symmetric: the rise to a peak intensity (maximum image size) was generally faster than the subsequent fall to zero intensity. Occasionally the rise to peak intensity took only two frames but usually it took three, and occasionally four frames. On the other hand, the fall to zero intensity from the peak generally took four or five frames, although in several instances it required only three, or even two frames. This effect is illustrated in Figure 4.

III. Characteristics of the Triangular Image Cluster

The Appendix presents tracings of most (about 73%) of the images. The boundaries between regions of decidedly different color within each image are indicated in the tracings, but the tracings do not accurately reproduce the amount of color structure that is apparent in the movie film. The tracings also accurately depict the shapes of the outer boundaries of the images. However, the relative positions of the tracings on the pages in the Appendix are



LEGEND: ○ - PY/O IMAGES □ - RED IMAGES
B - Both types are zero at the same time (frame)
T - Triangle images

Fig. 4. Size of the red and PY/O film images. The size of the smeared or streaked image is its width.

not related to the relative positions of the images as they occur within the film frames. The introduction to the Appendix describes how the tracings were made, the magnification factor that was used, and it also defines the notations used to describe the image colors. The reader should refer to the Appendix at this time in order to understand the following discussion of specific images.

When viewing the film one sees that the location of the image usually shifts, sometimes by a rather large amount (several millimeters), from frame to frame. The shift from frame to frame is attributed to random camera motion that occurred because the cameraman held the camera on his shoulder. The camera generally vibrated randomly up, down, left and right over an angular range of several degrees. Whenever the shutter was open to create a frame of the film the camera motion during that time caused the true image shape to be elongated or "stretched" by an amount that depended upon the speed and direction of the motion. Furthermore the random vibration caused the image position (relative to the frame boundaries) to shift from one frame to the next, with the amount of image shift depending upon the speed of the camera motion between frames. The random vibration caused most of the image positions to shift from one frame to the next and it caused most of the images to be elongated. However, any vibration about a mean position has short periods of time during which there is no motion (analogous to the pauses in motion at the ends of the swing of a pendulum). The images obtained during these short times were only slightly distorted or elongated. The minimally distorted images were located using the following criteria: (a) there should be little or no image position shift in successive frames and (b) in a series of images with varying amounts of elongation, the minimally distorted images are those which are the most compact. About 10% of the total number of frames were found to have images that are consistent with these criteria. The frames which contain minimally distorted images are called "stationary frames" and the images in these frames are called "stationary images" since they are the most like what one would obtain with a stationary (tripod-mounted) camera. Although many of the elongated images are important for a complete understanding of the film, the key photographic results are based on the stationary images.

Many of the stationary images are overexposed and a few are properly exposed or slightly underexposed. The overexposed images will be discussed in a later section. This section presents a discussion of some of the properly exposed or underexposed images in the stationary frames. It also includes a discussion of a few of the images in the non-stationary frames.

Of particular interest are each of the stationary frames which contains three small round "dot" images arranged in a triangular cluster. These frames are numbered 4666, 4752, 4804, 4806, and 4838 in the numbering scheme of the Appendix. Non-stationary frames which are also worthy of study are those which contain a pale yellow-orange (PY/O) elongated image that lies parallel to and above a similarly elongated red (R) image. These frame numbers are 4613,4638,4639,4673,4674, and 4699, 4717 and 4725.

A straightforward interpretation of the triangular cluster of "dot" images in frame 4838, for example, is that the cameraman filmed a triangular cluster of lights (!) and that the camera and film resolved the spacings between the lights. In frame #4838 the spacing between PY/O round "dot" image at the apex of the traingle and the center of a line joining the lower two R "dot" images is about 0.084 mm (84 microns). The center-to-center spacing between the R images is about 0.049 mm (49 microns). Since the focal length of the camera lens was 100 mm the angular separations of the images were 0.84 mr (milliradians) and 0.49 mr, respectively. The actual separations cannot be determined unless the distances of the lights from the camera are known. What can be determined from the angular separations are the spacings as projected onto a plane perpendicular to the line of sight (i.e., parallel to the film plane) if the mean distance to the lights is known or assumed. Assuming that they were all at the same distance, i.e., lying in a plane parallel to the film plane, and assuming that they were 10 km away then the separations would have been 8.4 m and 4.9 m respectively. If they were at the distance of the radar target that was reported at 0251 (see map), that is, at 20 nm (37 km), the spacings would have been about 30 m and 18 m respectively. (The radar target will be discussed later.) Of course, if not all of the lights were at the same distance from the camera then the separations would be greater than calculated here.

The first triangular cluster in the film appears in frame #4666. In this frame the PY/O and R images are not distinctly separated, as they are in later clusters. From the center of the PY/O image to the center of the baseline joining the centers of the R images is about 0.07 mm (70 microns). The spacing of the centers of the R images is also about 0.07 mm. The next triangular cluster is found in frame #4804. In this frame the vertical spacing is 0.085 mm and the horizontal spacing (of the R images) is 0.065 mm. The most clearly resolved cluster is in frame #4838. It was described in the preceding paragraph.

Each of the non-stationary frames listed above contains a horizontal or nearly horizontal elongated PY/O image above a similarly elongated R image. These elongated images are consistent with what would be expected if the camera line of sight were moved laterally (i.e., the camera rotated) while the camera filmed a triangular array of lights with a PY/O light above two R lights (forming a horizontal base). The first such frame is #4613. In this frame the center-to-center vertical spacing of the streaks is about 0.058 mm. The next frames are #4638 and 4639. In these frames the vertical spacing is about 0.056 mm. The next frames are #4673 and 4674, for which the vertical spacing is about 0.07 mm. Finally there are parallel (bent) streaks in frames #4699, 4717 and 4725 in which the vertical spacing is estimated at 0.077 mm.

Figure 5 illustrates the changes with frame number (i.e., with time) of the

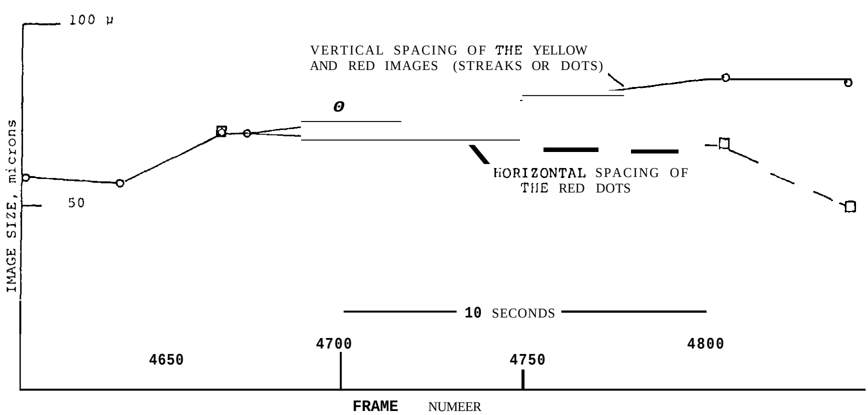


Fig. 5. Dimensions of the triangular images.

vertical and horizontal spacings of the images based on the measurements given above. The graph in Figure 5 shows that the vertical spacing of the PY/O image from the R images (circles; upper line) increased as time went on, while the horizontal spacing of the R images decreased (squares; there are only three data points).

The increase in angular separation between the apex and the base of the trangular cluster is consistent with the testimonial information that indicates that the plane was approaching the lights, assuming that the vertical spacing of the lights was constant. The fact that the vertical and horizontal spacings changed differently suggests that there may have been a slight change in the viewing aspect. If the three lights were attached to a single object, the decrease in spacing between the R lights could be attributed to a slight rotation of the object about a vertical axis. Another possibility is that the light cluster remained fixed in space and the distance decrease (as the plane approached) was accompanied by the rotation of the line of sight to the lights, such as would happen if the plane did not fly directly toward the cluster. Unfortunately the film does not provide sufficient information to determine whether the viewing aspect changed or the light cluster itself rotated. However, the descriptive information on Fogarty's tape, which will be discussed in a later section, suggests that rotation of the cluster itself could have actually occurred.

A general discussion of proposed explanations will be presented in a later section of this paper. However, a brief discussion will be given here of those explanations which to apply to the triangular image clusters.

The initial explanation for this section of film was proposed by Quentin Fogarty when he first saw the film: the cameraman had filmed a flashing beacon. However, a study of the nautical and aircraft beacons within view of the airplane at any place along its flight path failed to turn up any beacon with the appropriate basic characteristics (a triangular arrangement of one white and two red lights and a flash rate of about once per second). There were beacons found which flash red and white, but the periods of these beacons are four seconds or longer and each such beacon flashes with only a single color, red or white, at any one time. Also there is no beacon with two red lights side by side. This author then considered the possibility that there was a chance alignment of beacons, say a rapidly flashing (i.e., once per second) bright white beacon aligned with two rapidly flashing red beacons. This sort of coincidence could explain the periodicity, although it would be difficult to explain the synchronism (i.e., maintaining a phase difference of about 180°) during 32 cycles by independently flashing beacons. If the red beacons did not flash, the synchronism between the bright white and the red images could be explained if the white beacon got so bright that its image increased in size and blotted out the red beacons once per cycle. However, again no such alignment was found. Then this author investigated the possibility that there were flashing lights on another aircraft. However, the air traffic controller stated that there were no other aircraft anywhere near the Argosy freighter. Finally this author considered the possibility that some emergency vehicle near Blenheim had been filmed. However, a check with the local police and fire departments showed that there were no emergency vehicles out that night. Furthermore, it was learned that emergency vehicles in New Zealand use blue lights. Thus no conventional explanation was found for the triangular image clusters.

IV. Discussion of the Transition and Red Images

The previous section contains a discussion of the frames with triangular clusters and parallel elongated R and PY/O images. The frames with bright overexposed PY/O images will be discussed in the next section. This section contains a discussion of those frames in which the R and PY/O colors are mixed within a single, usually distorted, image. These are the "transition images" which lie between the minimum and maximum intensity images in each cycle. This section also contains a discussion of the frames which contain only R images.

A study of the transition images shows that the PY/O light and the R lights remained adjacent to one another (at least from the point of view of the camera) throughout each cycle. The study also shows that the PY/O source intensity decreased uniformly from the maximum value in a cycle, generally taking four or more frames to reach zero, but that it increased from zero very rapidly, generally taking only two frames to reach a value close to the maximum (see, for example, Figure 4). Thus the intensity did not change discontinuously, such as would happen if the light had been quickly switched on and off, like a strobe light, or abruptly occulted by some opaque object. The transition images also show that the R intensity increased and decreased uniformly rather than discontinuously (see Figure 4). Unfortunately the camera motion distorted most of the transition images making a more detailed interpretation quite difficult.

There are also a number of frames with only R images. These occurred when the PY/O intensity was zero. At their brightest the R light sources were much dimmer than the PY/O light at its brightest. At their dimmest the R lights either barely made images (as in frames #4606, 4623, 4624, 4649, 4658, 4676, 4684, 4685, 4709, 4735, 4762, 4770, 4787, 4796, 4797, 4812, 4820, and 4839) or were not even bright enough to make detectable images on the film (as in frames #4597, 4598, 4630, 4631, 4632, 4633, 4650, 4659, 4710, 4736, 4788, 4813, 4814, 4821, 4822, 4823, 4829, 4830, 4831, 4847, 4848, 4849,4854,4855,4856,4857, and 4858). A study of the above frame numbers will show that the frames with faint red images or with no images at all occurred most often at the end of the film sequence, and next most often at the beginning of the sequence, when the maximum brightness in each cycle of the overexposed images was lower than the maximum reached in the middle of the sequence of cycles. Referring to Figure 3 we see that the tendency for the red images to be very dim near the beginning and end of the film correlates with the tendency for the maximum image brightness to be lower at the beginning and end of the film.

V. Estimates of the Maximum Intensities of the PY/O and R Light Sources

The PY/O images present the greatest possible range in film exposure, varying from zero (no image) to completely overexposed. The central portions of the bright images are completely devoid of color (overexposed) and appear to be "white" or the color of the incandescent projection bulb. Around the central portion of each image is a highly exposed, pale yellow band or annular region. Surrounding the pale yellow annular region is a very narrow (10 to 20 microns wide) "color gradient region" (CGR) which forms the boundary between the highly exposed area and the surrounding unexposed (black) area. The CGR exists because of the variations of exposure level in the three layers of film emulsion. It is visible around the edges of overexposed images of known incandescent light sources (e.g., airport lights) as well around the edges of the overexposed images of the unusual light. The width of the CGR is roughly independent of the image exposure level, growing to a maximum of about 20 microns wide around overexposed images that are about 200 microns in diameter. The CGR is surrounded by "perfect" blackness (no exposure). (A discussion in Section VII shows that this fact by itself is sufficient reason to reject the anticollision beacon hypothesis that has been proposed to explain the unusual flashing light images.)

Because the central portions of the images are overexposed it is difficult to determine the exact color of the PY/O light source. It could have been pale yellow or very pale orange, hence the notation PY/O. In the Appendix the notation used is BYW (bright yellowish white), rather than PY/O, to convey in words the impression one gets from looking at the images. When the overall image is relatively dim, the PY/O portion of the image is found at the apex of a triangular cluster of images (described in Section III). At this time it looks pale orange or pale, *very slightly* reddish, yellow. By way of comparison, the R images which form the base of a triangular cluster are "pure" red and none of them are overexposed.

There are several possible explanations for the periodic changes in the sizes of the PY/O images, only two of which are worthy of some discussion. These are **(a)** periodic changes in the size of the light source while the source intensity remained substantially constant and (b) periodic changes of intensity while the size remained constant. The reason for the first possibility is that the size of an image increases with increases in the size of an object, all else being constant. The reason for the second possibility is that the size of an image on film increases with increases in the intensity of the object or light source, all else being constant. (This is a fact well known to astrophotographers.) More specifically, the image size generally increases beyond the geometric size, with the amount of increase (the image "growth") being proportional to the logarithm of the *exposure level*[3] (Mees, *1944).* (The size of the geometric image

[3] This author has conducted numerous experiments which confirm that color reversal film of the type under discussion obeys the logarithmic image growth law over a wide range of exposure levels starting with the lowest level which will produce a visible image and ranging upward for four or more decades in exposure level.

of an object or a light is equal to the actual size of the object, projected onto the line of sight to the camera, multiplied by the focal length and divided by the distance from the camera to the light source.) Therefore, since the exposure level is proportional to the intensity (all else being constant). the amount of growth in the size of the image is generally proportional to the logarithm of the intensity.

Although the first possibility (a periodic size change by a factor of ten or more) cannot be positively ruled out, it is more reasonable to assume that the intrinsic size of the PY/O light source reamined constant. Therefore the analysis in this paper assumes that the PY/O and R lights which form the triangular arrangement were effectively point sources of constant size and that their intensities changed periodically.

One can calculate the luminous intensity in lumens/steradian (lm/st), or candelas (cd), of a point source using the following equation:

(1) $$I = \frac{Q \times R^2 \times e^{(b \times R)}}{T \times A \times t}, \qquad \text{cd } (=\text{lm/st}).$$

This equation can be found by inverting standard photometric equations which give the image exposure in terms of the source intensity. In this equation, Q (lm X sec) is the photometric energy deposited within the boundary of the image (within the CGR) and t (sec) is the exposure duration (the "frame time"). The value of Q is determined from the image in a manner to be described. Also in the equation, R is the range from the camera to the light source in meters (m), b, is the atmospheric extinction coefficient in m^{-1}, T is the transmission of the camera lens and the aircraft window, and A (cm^2) is the area of the lens aperture. The area is given by the following equation:

(2) $$A = (\pi/4) \times (F/f\#)^2.$$

where $\pi = 3.1416$, F is the focal length of the lens (10 cm in this case) and f# is the aperture setting on the camera (1.9 in this case).

Of the quantities in the above equations only R is completely unknown. Since R is completely unknown the procedure for using the photographic data is as follows: (a) for a given image determine Q in the manner to be presented; (b) using Q along with the camera coefficients (t, A, T) and an estimate for b (see below), calculate a set of intensity values corresponding to various R values and produce a graph of I versus R; (c) choose a value of R and read from the graph the light intensity *which* is *required at that distance to make the film image.* Besides providing intensity levels that correspond to various assumed distances this graph allows one to compare the intensity of a known light source at known distance with the intensity at that distance as *required* by *the film image.*

The camera coefficients in Eq. (1) are $t = 0.044$ sec (0.1 sec/frame with a rotating shutter efficiency of 44%: 0.1 X 0.44 = 0.044) and $A = 0.00196$ m^2 (from Eq. (2) using F = 100 mm and $f\# = 1.9$). The transmission factor, T, is estimated to be 0.8 (80%).

The atmospheric extinction, b, has been estimated from weather data which include upper altitude data on temperature, wind direction and the relative humidity. Unfortunately these data were measured several hours before the sighting and at a location about a hundred miles from the sighting area. Nevertheless, using atmospheric models (LOWTRAN code), using knowledge about the weather patterns preceding the sighting (e.g., a cold front passed through the area several hours before the sighting) and using estimates of the aerosol content of the atmosphere, it has been possible to estimate reasonable maximum and minimum values of b at the time and location of the sighting.[4] Values of b were found for a slant (visual) path from 4 km (the airplane altitude) to the ground and for a horizontal path at 4 km.[5] The reason for considering a slant path to the ground is to compare the calculated maximum intensity with the maximum intensities of various (ground level) beacons. There are two reasons for considering a horizontal path. One is that the witnesses claimed that the unusual lights were above ground. The second reason for considering a horizontal, or even an upward, path is that the film shows no lights other than the flashing light, although at ground level there were numerous lights, both flashing and steady. The absence of other images therefore implies that the field of view of the camera was totally above the horizon (ground level).

The maximum and minimum b values for the slant path to the ground are 1×10^{-4}/m and 5×10^{-5}/m, respectively. The estimated value for the horizontal path is $b = 1 \times 10^{-5}$/m. If the visual path had been upward from the plane the value of b would be even lower (Menat, 1980) but not zero ($b = 0$ corresponds to the situation with no atmosphere).

Because the value of b is not precisely known there are three curves of I versus R corresponding to the above three values of b. To use the graph one should decide first upon the value of b, and then use the curve for that value of b to find I at some chosen value of R.

The final quantity needed to calculate the source intensity is the quantity Q, which is the spectrally weighted (according to the color response of the film) energy collected by the camera lens and deposited within the boundary of the film image. Q is the product of two other quantities which can be measured or estimated: the film exposure level, H, in lm $\times$ sec/cm^2, and the image area, A_i in cm^2. More accurately, Q is the summation (or integral) of the product of H and A_i over small subareas of the image. Unfortunately densitometry equipment that would conveniently measure H in a large number of small subareas of the image was not available for use in this investigation. Therefore the summation has been approximated by using an estimate of the average H over the whole image.

The average value of H has been estimated in two ways. The first way is the "traditional" method which makes use of the empirical relation between

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[4] An unpublished paper on the estimate of the extinction coefficient at the time of the New Zealand sightings is available from the author.

[5] *Ibid.*

the image density and the exposure level, H, for the particular type of film. The second method, which provides a very convenient way to estimate H values, makes use of the image size to estimate H.[6] Since both methods yield the same value of Q only the traditional method will be discussed.

The relation known as an "H & D" curve is provided by the film manufacturer. On this curve (or family of curves) image density, D, the negative of the logarithm to the base ten of the film optical transmission, is plotted as a function of the logarithm of H. For positive transparency (color reversal) film, such as slides and movie film, the density is high in unexposed regions and low in exposed regions. A densitometer is a device which directly measures D. A scanning densitometer was used to measure the average densities of overexposed images on Crockett's film. Then the H & D curves for the film (Fujicolor 8425 color reversal type) were used to find the corresponding H values. Since the curves supplied by the Fuji Film company do not provide accurate information about the density of overexposed images, the curves were supplemented by experimental data obtained by this author.

A large number of overexposed images are candidates for this type of analysis. The densities of these images lie in the range 0.12 to 0.16, with the clear leader having a density of about 0.10. A conservative choice that leads to a lower bound on the maximum image exposure is D = 0.16, which, according to the commercial H & D curves supplemented by experiments carried out by the author, corresponds to an exposure level of about 5×10^{-5} lm X sec/ cm^2. If a lower density value were assumed, say 0.12, the exposure level would be considerably greater since, in the region of overexposure (film saturation), the relationship between exposure and density is highly nonlinear.

The maximum intensity of the PY/O light source can be estimated by combining the above value of H with the area of the largest overexposed image which has a density of 0.16 (or less) and which was not smeared by camera motion. (Smearing can increase the area of the image and cause the image to have a distorted shape, while decreasing the exposure level slightly, making it difficult to calculate Q). Assuming that the light was a point source, an unsmeared, overexposed image should be round. Therefore, only images which are round or very nearly so have been considered for this calculation. There is a considerable number of large images of very similar areas which are nearly round (in frames #4618,4628,4636,4644,4645,4646,4652,4653, 4662, 4694, 4748, 4774, 4775, 4782, and 4792). There are also two large images that are almost perfectly round (in frames #4687 and 4758). Although Q could have been calculated using the area of any of these, it has been calculated only for #4758 because of its simple round shape. It has a diameter inside the CGR of about 250 microns so its area, A_i, is about 4.9×10^{-4} cm^2. Multiplying this by the average value of H given above yields $Q = H A_i = 2.5 \times 10^{-8}$ lm X sec. This is actually a lower bound on Q since the exposure level used corresponded to a film density of 0.16, whereas some of the large overexposed images had densities as low as 0.12.

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[6] *Ibid.*

Figure 6 has been created using this value of Q along with the previously listed values of the other quantities in Eq. (1). The figure shows that for any assumed distance greater than 5000 m the source intensity needed to make an image as large and bright as #4758 must be greater than 10^4 cd. Similarly, if the source were at a distance greater than 50 km the intensity must have been greater than 10^7 cd if the PY/O light were on the earth's surface, or greater than 10^6 cd if the source were at the altitude of the plane.

Similar estimates of the maximum intensity of the red light source show that it was, at its brightest, about one one thousandth as bright as the PY/O light at its brightest.

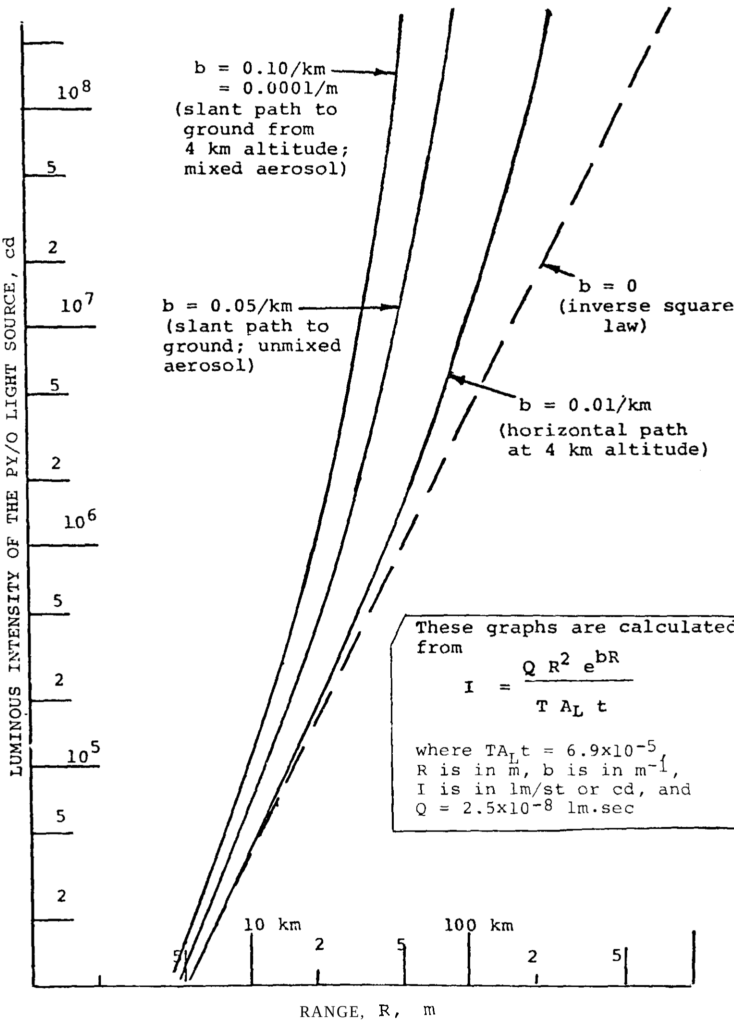

Fig. 6. Source intensity for various distances.

VI. A Discussion of the Witness Testimony

The information provided thus far has been derived from the analysis of "hard" photographic data. This section presents a summary of the "soft" information supplied by the witnesses. This information is worthy of serious consideration because it comes from tape recorded statements made at the time of the sighting supplemented by the recollections of the witnesses. Thus, unlike the situation with most UFO sightings, it is not necessary to totally rely on the memories of the witnesses.

The exact time (to within half a minute) of the visual sighting, which, it is argued here, was coincident with the previously described film, has been determined from the tape recording made at the Wellington Air Traffic Control center[7] (WATCC). The tape shows that, about five minutes previous to the sighting, the plane turned westward at Kaikoura East and headed toward Cape Campbell (see Fig. 1). The time was about 0246:30 (30 seconds after 0246). In the following two minutes the WATCC gave a weather report for Blenheim which included the statements that the visibility was 60 km and that the cloud coverage was $\frac{1}{8}$ of the sky over the Blenheim airport. The WATCC also reported several radar returns (radar "targets") near the South Island which were showing on the search radar that was monitoring the flight of the plane. The WATCC reported the unidentified radar targets at this time because in several instances earlier that morning there had been correlations in the appearance, disappearance and apparent location of visual objects (lights seen from the plane) and radar targets. However, the crew on the plane did not see lights associated with the radar targets that were reported between 0246 and 0248.

Then, at 0251, the copilot contacted the WATCC to report a visual sighting. The portion of the tape transcript which is pertinent to this sighting is given below. Times are given in 24 hour notation, with seconds following the colon, and directions are given in "clock notation" with 12:00 straight ahead, 3:00 at 90" to the right, 9:00 at 90" to the left, etc. Words in parentheses have been added by this author for clarification.

TIME	STATEMENT
0251	—(plane) Wellington, do you have (a target) in my 12:00 position (i.e., straight ahead), probably somewhere near Grassmere or perhaps a little east of Grassmere?
	—(WATCC) Affirmative. I have a strong target at 12:00 to you at 20 (nautical) miles and, uh, that's 2 miles off the coast, 10 miles south of Cape Campbell.
	—(plane) Roger. We have that one, also, and quite a good visual display at the moment.
	—(WATCC) It's showing lights?
	—(plane) Say again?
	—(WATCC) It's showing light, is it?
	—(plane) Affirmative. It looks like a collection of lights. I wonder, can you

[7] A copy of the Wellington Air Traffic Control Center tape record was supplied to this author by Geoffrey Causer, the air traffic controller who was on duty that night.

establish (contact) and ask the flight service man (at Blenheim airport) to turn his rotating beacon off just in case we're mixing it up with that'?

0252 —(WATCC) OK

—(At this point the WATCC called Blenheim and asked for the beacon to be shut off.)

0252:20 —(WATCC) The beacon is going off now.

—(plane) Thank you.

0253 —(WATCC) Two further targets showing well on radar, one at 9:00 at 8 miles and one at 10:00 at 10 miles.

—(plane) Roger.

0253:20 —(WATCC) The one just south of Cape Campbell is now gone off the radar.

—(plane) Roger.

Although the statements by the copilot give only a frustratingly brief, description of the events occurring at the time, a significant amount of information can be derived from the above transcript. First and foremost is the apparently simultaneous appearance of a radar target in the same direction from the plane as the visual display. Figure 1 shows that the location of the radar target was in the same direction as the copilot indicated (toward Lake Grassmere) but about 10 miles closer to the plane. The copilot's error in estimating the distance is not surprising since this was a nighttime sighting of lights of unknown intrinsic size.

The copilot described what he saw as a "collection of lights." This implies several lights in close spatial association. The copilot then asked for the Blenheim Beacon to be turned off "in case we're mixing it up with that." This was a reasonable precautionary measure since the direction to the Blenheim beacon (see Fig. 1) was close to the direction to Lake Grassmere. The beacon is a single white light that flashes once every 3.5 seconds so that the implication of this request is that the lights he saw were flashing. In a tape recorded free-recall statement made four days after the sighting the copilot recalled seeing "two big orange lights" as the plane headed toward Cape Campbell. "One of them was flashing a little, so we got a message through Wellington to Blenheim flight service to turn the aerodrome beacon off. We were told it was off, but this thing was still flashing." (Subsequently the unusual flashing light did disappear, as will be described). In this statement, which was made before he heard the WATCC tape, the copilot inadvertently combined some details of the sighting of the "collection of lights" with the details of a subsequent sighting of two bright lights that appeared in the sky ahead of the plane after the flashing "collection of lights" had disappeared. (Crockett remembered seeing these two lights appear but he was not able to film them because the airplane started turning into an orbit at about 0258 to lose altitude in preparation for landing before he could align his camera properly.)

It is interesting to note the copilot's statement that the "collection of lights" was still flashing after the beacon went off. It is interesting because, according to the WATCC tape, the beacon went off at about 0252:20 or 0252:30 and about 45 seconds *later* the large target south of Cape Campbell disappeared from the radar screen. Thus when the WATCC tape is compared with the copilot's statement it appears that the flashing "collection of lights" and the radar target disappeared at about the same time, perhaps even simultaneously, although simultaneity cannot be proven with the available information.

The second major source of testimonial information is the tape recording made by reporter Quentin Fogarty.[8] Fogarty had tape recorded his impressions of the previous sightings that night. He had taped several descriptions of what he saw during the sighting that took place between about 0218 and 0235 while the plane was within about 50 miles of Christchurch. After that sighting was over Fogarty, along with the air crew and the other passengers, continually scanned the skies for unusual lights. A few minutes after the plane passed Kaikoura East he recorded the following statement:

> We've now just passed Kaikoura East and, uh, there's been no further activity. There are pinpoints of light in the sky but nothing's been confirmed on radar. I, for one, am hoping really that, uh, we've seen enough, and, uh, the rest of our journey back to Blenheim will be uneventful. I've had just about enough of UFOs for one night.

Fogarty's next taped message is reproduced below. It is broken into individual statements to facilitate the following discussion. Elapsed times, accurate to within a second or so, are given in parentheses.

1. "About 30 seconds after that last message and, of course, we've got another one . . . right in front of us (8 sec)
2. very bright . . . it seems to be quite a long way away (12.5 sec)
3. and another one flashed just to the left of it. (14 sec.)
4. That one flashed extremely brightly. (17.5 sec)
5. They've now both faded. The other one's flashing again. (20 sec)
6. It's . . . giving off . . . an orange flashing light (25.5 sec)
7. It looks like an aircraft beacon . . . and it's moving . . . off (32 sec)
8. It's extremely bright. (34.5 sec)
9. It fades and it's dropped. (37 sec)
10. It seems to have just dropped at an incredible speed and it's . . . (40 sec)
11. It seems to be rolling and turning. (41 sec)
12. In fact there's one light, there's another light beside it. (46 sec)
13. Oh, I don't know . . . I really don't known what is going on. (53.5 sec)
14. It appears to be over the hills. (58 sec)
15. There appears to be a whole cluster of them in fact. (In the background Crockett yells "I can't see anything.") (65 sec)
16. You can see orange and red among the lights. There's one particular one that keeps flashing to the right hand side of it. (74 sec)
17. You can see three distinct lights . . . In fact it looks very much like the same sort of pattern we saw . . . when we came down over the Kaikoura

[8] A copy of the tape recording made during the flight by Quentin Fogarty was supplied by TV Channel 0 (now channel 10) in Melbourne. This author transcribed the tape and Quentin Fogarty reviewed and corrected the transcription.

coast on the way down, but, um, there wasn't quite as much flashing . . . It really is, uh, . . . quite strange," (98 sec)

Because Fogarty did not keep track of the exact times of his taped messages, the time of the message quoted above can only be determined by correlation of its content with the content of the WATCC tape. Since it is very likely that Fogarty saw what the copilot reported directly ahead of the plane at 0251 (the sudden appearance of a collection of lights), it is the contention of this author that this message describes the 0251 sighting. This contention is supported by the comparison of Fogarty's next (and last) message, which reports what happened after the beacon was turned off, with the copilot's statement at 0255, as recorded on the WATCC tape. First consider Fogarty's last recorded statement (elapsed times are measured from the beginning of his last statement):

18. "Well, you can't be right all the time. It appears that the last flashing light that we saw was a beacon at Blenheim and they asked . . . the pilots asked for the beacon to be turned off and we're no longer seeing that light. (15 sec)
19. But at the same time as they turned the beacon off, Wellington radar told us that he had targets coming over to the left of us. In fact, as I speak now, we have another one right above Blenheim. Extremely bright. (30 sec)
20. And that's not a beacon because it's not in the same positions as the lights were before and these sightings at the moment are right in the position were Wellington radar says they should be" (46 sec)

To recapitulate, according to the Wellington tape the Blenheim beacon went off at about 0252:20, but, according to the copilot the "collection of lights" was still flashing. At about 0253 WATCC reported "Two further targets showing well on radar" at the left of the plane (9:00 and 10:00). (These do not appear to have been related to the sighting. They were probably weather "angels," spurious temporary ground returns caused by atmospheric refraction of the radar beam. Such spurious returns are common along the Kaikoura coast and had been reported earlier in the evening.) At about 0253:30, the "strong target" south of Cape Campbell disappeared from the radar screen. Presumably the "collection of lights" disappeared at the same time as the "strong target," but this is only conjecture. About 45 seconds later Wellington reported four targets at 9:00, 9:30, 10:00, and 10:30 to the plane (probably more spurious returns). Then, shortly after 0255 the copilot reported as follows:

We had a pretty bright light. We have it again now. It appears to be behind Woodbourne from where we are. Probably towards, uh, between us and Nelson North in that direction. Do you have anything at all in that direction?

Woodbourne is the name of the airfield at Blenheim and Nelson North is a non-geographic aircraft reporting point somewhat north of the town of Nelson (logical!), so the copilot was indicating that the "pretty bright light" was also in the direction of Blenheim. Although the WATCC had no target that would correlate with the copilot's report, the light described in Fogarty's last message does correlate: ". . . we have another one right above Blenheim. Extremely bright." (statement 19 above). Thus it appears that Fogarty's last message was taped at about 0255. It is therefore quite likely that the previous message, which describes the orange and red flashing lights, was recorded at 0251, as claimed by this author.

In his last taped message Fogarty identified the "last flashing light" (statements 6 through 12) as the Blenheim Beacon (see statement 18). When thinking about the sighting afterward Fogarty realized that this identification was clearly erroneous (Fogarty, 1982). He could see coastal beacons and the city lights of Blenheim, so he had numerous fixed reference points by which he could judge azimuthal directions, movements of lights and also the depression angle (the angle below horizontal) of the horizon. (At the 4 km altitude of the plane the horizon was about 242 km away, including atmospheric refraction effects, at a depression angle of about 1". The lights of Blenheim were about 93 km away at a depression angle of 3.6°, or slightly below the true horizon.) He was therefore able to determine that a light seen "above Blenheim" was considerably above ground level. The unusual light which had been "rolling and turning" (statement 11) was apparently in the sky above ground level and perhaps "over the hills" (see statement 14 above) east of Blenheim (see Figure 1). Fogarty realized that no beacon could suddenly be "moving off' (statement 7), then drop downward "at an incredible speed" (statement 10) and then go into a "rolling and turning" maneuver (statement 11). (Fogarty described this maneuver as being a rotation in space, roughly like a ball tied to a string and swung about a center point, except that the rotation was in an elliptical rather than a circular orbit.) Furthermore, he realized that there are no orange beacons (statement 6). Therefore he realized that his last message (statement 18) was obviously wrong.

Considering all of these reasons why it could not have been a beacon, Fogarty (1982) explained his immediate "identification" in the following way. In the "heat of the moment" he was impressed by the fact that the flashing light went off at about the same time that he was told that the copilot had asked for the beacon to be turned off. He therefore accepted the beacon explanation for lack of anything better at the time, and went on to describe the next sighting which he knew could not have been the beacon because the beacon was already off (statement 20).

Thus far the relationship between the WATCC radar targets, the copilot's sightings and Fogarty's tape recorded statements have been discussed. The relationship between the film and the visual sightings will now be discussed.

Crockett's camera was not synchronized in any way with Fogarty's tape or the Wellington tape. Therefore it is impossible, without resorting to the testimony of Fogarty and the copilot, to show that Crockett filmed the lights reported at 0251. However, it is quite reasonable to assume that he did film these lights for two important reasons. First, it is very difficult to imagine that he would not have seen the unusual lights which appeared directly ahead of the plane. Considering his state of mind and alertness it is extremely likely (certain?) that he would have seen them and tried to film them. Second, there are clear similarities between the lights described by Fogarty and the images on the film. The similarities are between the triangular cluster images on the film and Fogarty's description (statements 15, 16, and 17 above). Fogarty reported seeing a "cluster" of lights, that he saw "orange and red among the lights" (i.e., orange and red lights), that he observed flashing and that he could see "three distinct lights." (Note that the latter part of statement 17 refers to sightings that occurred several hours earlier as the plane flew from Wellington to Christchurch.) The descriptive terms "cluster," "orange and red," "flashing," and "three distinct lights" can also be applied to the images in Crockett's film. Therefore this author claims that Crockett filmed what Fogarty saw.

There are three possible objections to this claim. One objection is that Crockett could not see what Fogarty saw. This objection is based on Crockett's recorded statement (in a voice sufficiently loud to be heard over the noise of the airplane engines, indicating frustration on his part) "I can't see anything" (see statement 5 above). However, this statement probably refers to the difficulty he was having in keeping his camera pointed at the lights while looking through his 100 mm lens because of the rapid relative motion between the lights and the camera. Crockett had made a similar statement during the earlier sighting near Christchurch when he and all the other witnesses were watching a bright light as the plane turned. The turning created a rapid apparent motion of the object relative to the plane. At that time Crockett had trouble keeping the camera pointed at the light while he was viewing through his lens and, shortly after the plane started turning, he yelled "I can't see it." Yet there is no doubt that the light was clearly visible to all of the other passengers on the plane. (Moreover, analysis of that portion of the film suggests that Crockett actually did film that light during the turn.)

Even if Crockett had not started filming the flashing lights until five seconds after he yelled "I can't see anything," he still could have obtained the 28 seconds of film before Fogarty ended his taped description (see the elapsed times). If he had not started filming until more than five seconds after he yelled, then his filming would have continued after Fogarty stopped recording. However, if the flashing light cluster actually was the cause of the large radar target that appeared at 0251 and disappeared at about 0253:20, then he would have had about a minute to film it after Fogarty ended his message. Thus the fact that Crockett yelled that he could not see the lights does not mean that he could not have started filming them immediately after he yelled.

Another objection to claiming that Crockett filmed what Fogarty saw is based on the possible color difference between Fogarty's "orange flashing light" and the PY/O images in Crockett's film. However, as pointed out previously, the exact color of the light which made the PY/O images is difficult to determine from the photographic data. A sufficiently pale shade of orange could appear orange to a viewer and at the same time cause images on color reversal film, especially overexposed images, to be pale yellow.

The third objection is based on Crockett's failure to recall, in an interview about five weeks later, exactly when he filmed the flashing light cluster. However, the final portion of the film shows the landing at the Blenheim airport. The unusual flashing light cluster was not part of the landing field display of lights. Therefore the film proves that the cluster was filmed at some time before the landing, and the most likely time was at 0251 when the others on the plane saw the unusual lights which have been discussed above.

Thus, in spite of the above objections, it appears to be very reasonable to conclude that Crockett saw and filmed the lights that Fogarty described in his tape recording.

If one accepts the claim that the copilot and Fogarty described the lights which Crockett filmed, then the following technical information can be added to that which has already been gleaned from the film: (a) the light source which made the PY/O images may have been tinted more toward orange than the film indicates, (b) the unusual lights were considerably above the ground (this is consistent with the film which shows no ground lights during the flashing light sequence of frames), and (c) the lights moved rapidly at times, even dropping downward and "rolling and turning." It may be impossible to determine whether or not some of the motion of the images on the film is related to actual motion of the lights because the camera rested on Crockett's shoulder and not on a stable tripod. However, there is a short section at the begining of the film in which the image motion seems difficult to ascribe to random camera motion alone. The image undergoes a rapid cyclic motion that requires about four frames to complete each cycle. The image motion describes a very narrow ellipse with the major axis being nearly vertical. The motion lasts for at least five cycles with an oscillation period of about 4 frames/cycle, corresponding to 2.5 cycles/sec. The peak to peak amplitude of the motion is about 11 mr (0.6 degree). This motion is similar to what Fogarty meant when he said in his taped message that the one of the lights he saw dropped downward and went into a "rolling and turning" maneuver.

If the light cluster that was filmed was also the cause of the radar target reported at 0251, then the distance to the cluster would be the distance to the radar target, 20 nautical miles or 37 km. At that distance the maximum intensity of the PY/O light (see Figure 6) would have had to have been greater than 5×10^5 cd if it had been at the altitude of the plane and greater than 2×10^6 cd if it had been near (but above) the ground. Also, at that distance the spacings between the triangularly arranged light sources, projected onto a plane perpendicular to the line of sight, would have been as follows: about 30 m between the PY/O source at the apex and line joining the red lights and about 18 m between the red lights themselves.

VII. Discussion of The Suggested Explanations

Eight hypotheses have been offered to explain the film. These hypotheses reject the conclusion that Crockett's filming was correlated with the 0251 radar target and visual sighting and assume, instead, that the film can be treated independently of the visual and radar sightings. Therefore this section will therefore concentrate on proposed explanations for the film alone and treat the visual and radar sighting information only tangentially.

Fogarty was the first person to "explain" the film because he was the first person to see the it after it had been developed (Crockett did not see it until a week or more later). Because the images flashed at a steady rate his immediate impression was that Crockett had filmed a beacon. He therefore ignored this section of the film and publicized, instead, the section of film shot earlier (between 0218 and 0235) while the plane was still near Christchurch. Had he spoken to Crockett before deciding that it showed a beacon he might not have been so hasty because Crockett was certain that he hadn't filmed a beacon at any time during the flight. Crockett stated that whenever he saw a light which he thought might be worth filming he asked the copilot to identify it, thereby avoiding beacons. The copilot confirmed that he had repeatedly been asked by Crockett and the other passengers to identify navigation beacons, stars and other ordinary lights.

In spite of Crockett's claim that he did not film a beacon the most obvious hypothesis is that he *did* film a navigation beacon or a combination of beacons. This hypothesis requires that there was, *at some point along the known path of the aircraft*, a navigation beacon or a combination of beacons that was within view of the aircraft and that had the flash rate and color structure of the film images, The hypothetical beacon or combination of beacons could be placed, for purposes of explanation, at any point along the flight path between Kaikoura East and the Blenheim airport because Crockett did not remember exactly when he filmed the flashing light cluster. The *New Zealand Nautical Almanac* (1979) lists all the marine and aviation beacons and gives the intensities (in cd) of the marine beacons. There are no yellow or orange beacons. There are beacons which flash white only, beacons which flash red only, and beacons which alternate white and red, with the white color being much brighter than the red, but both colors are not visible at the same time. Allowing for the possibility that an incandescent white light source could make the overexposed images in the film, a search of white-red flashing beacons was made. The fastest white-red flashing marine beacon that could have been seen from the plane flashes at a rate of 4 sec/cycle (1/4 Hz). It's peak white intensity is only about 1×10^3 cd which is much too low for the beacon to have created overexposed images even at the closest distance of the airplane to the beacon. All the other, more powerful, white-red flashing beacons flash much at slower rates. Furthermore, each of these beacons has only a single red light, not two side-by-side.

It has been suggested that the red images were made by two steady red lights that at one time during the flight happened to be aligned with a bright white beacon in such a way as to produce the triangular arrangment. The pulsation of the red images would then be a photographic artifact of the large change in size of the image of a white beacon as its intensity oscillated. However, as Figure 4 shows, there are a number of frames (labelled "B") in which there is neither a PY/O nor an R image. This means that decrease in the brightness and size of R images could not always have been caused by increases in the PY/O intensity. Instead the pulsation of the R images must have been caused by pulsation in the red lights themselves.

The only beacons that flash at rates around 1 Hz are strictly red or strictly white "quick flashing" lights. Therefore the following possibility was investigated: at some point on the aircraft flight path there happened to be a triangular alignment of one white and two red quick flashing marine or aircraft beacons. However, no such configuration was found. Furthermore, the *New Zealand Nautical Almanac* (1979) indicates that the quick flashing beacons have intensities lower than 1×10^4 cd. These intensities are too low because at all times during the flight the airplane was so distant from each quick flashing white marine beacon that even the intensity of the closest beacon would have had to have been greater than 1×10^6 cd to produce the overexposed images. Only the quick flashing lights which are part of the Blenheim airport lighting would have been close enough to the airplane, during the landing, to cause overexposed images of the sort found on the film. However, there is no triangular arrangement of white and red lights at the airport, nor was there any possibility of a temporary triangular alignment that could explain both the flash rate and the duration of the film segment (28 seconds). Furthermore, because of the several degree field of view of the camera lens, any film of those lights would also have shown numerous other airport lights and even some city lights of Blenheim, because the landing pattern took the airplane directly over Blenheim. For these reasons the beacon hypothesis was ruled out.

The possibility that an internal (in the cockpit) flashing light caused the images was considered and ruled out because (a) there are no such flashing lights in the cockpit, and (b) the pilot turned off all the lights except steady dim red panel lights to make it easier to see lights outside the plane.

The possibility that the flashing lights were on another airplane in the area was ruled out by the WATCC radar operator who stated that there were no other scheduled aircraft in the vicinity of the sighting area, nor were any unscheduled aircraft detected by the search radar. The only conventional aircraft radar target detected at WATCC during the sighting period was that of the Argosy freighter which carried Crockett, Fogarty, and the other witnesses.

Ireland (1979) suggested that while the plane was at the location indicated by 0251 on the map Crockett filmed one particular quick flashing white beacon in the entrance to Wellington Harbor (see Fig. 1). In making this suggestion Ireland completely ignored the red images in the film, he did not fully appreciate the implications of the degree of overexposure of the PY/O images, and he did not consider the consequences of the fact that the camera had a field of view of about 4" by 6".

The light suggested by Ireland flashes white about once every second, which is the proper rate. Nevertheless, it can be ruled out for several reasons. First, there are no adjacent red flashing lights which are bright enough to make images on film at the distance of the airplane from the harbor entrance. Second, within the field of view of the camera there were numerous other flashing and steady white lights, including some city lights of Wellington and some lights at the Wellington airport. These lights should have made numerous faint images, but there are no images on the film except those of the flashing light cluster discussed in the previous sections. Third, at the distance of the plane at 0251 from the beacon its intensity would have had to have been greater than 1×10^9 cd in order to saturate the film, but according to the *New Zealand Nautical Almanac* (1979), the actual intensity is rated at about 7×10^3 cd. Even at the distance of closest approach of the plane to the beacon, about 60 km, its intensity would have had to have been about 2×10^7 cd in order to produce overexposed images. (See Figure 6 for $b = 0.05/\text{km}$, since the beacon was at ground level.) Since the publication of his paper Ireland (private communication, 1984) has claimed that by the time of the sighting in December 1978, the beacon in Wellington Harbor had been replaced with a quick flashing strobe with a rated candlepower of 1×10^6. However, as pointed out above, even this intensity would not be bright enough to create overexposed images if photographed from the point of closest approach of the aircraft to the beacon. Furthermore, a strobe creates very short flashes of light, so one might expect to have PY/O images created by the strobe in one or at most two frames per cycle, not the six to eight frames per cycle in which they actually appear. Thus, in spite of Ireland's recent claim, the harbor beacon hypothesis still fails for the above reasons.

T. W. Rackham (private communication, May 15, 1980) has suggested that atmospheric turbulence and extinction effects modified the light from some distant source on the surface of the earth. He made this suggestion because, as an astronomer at Jodrell Bank in England, he was aware that atmospheric refraction and turbulence effects can distort a light source both spatially and spectrally. He pointed out that, for example, elongated and even multiple images of Venus have been photographed (through telescopes). The elongated images tend to be whitish on top and red at the bottom, which is roughly similar to the red/white images in the film. Rackham did not suggest an astronomical source for the light, and in fact he ruled out the brightest astronomical source, Venus, because it was at or below the eastern horizon at the time, it would not have been bright enough to make images as large as the overexposed images on the film, and its intensity would not have pulsated in a regular manner.

In order to make Dr. Rackham's suggestion compatible with the film one would have to assume either a distant pulsating light source, or a steady source which was distorted by a steady pulsation of atmospheric refraction. Aside from the beacons discussed before, there were no distant pulsating sources. There were, however, in the Tasman Bay, two to four intense steady light sources that might have been in view of the plane at the time, if they were not obscured by the known cloud cover. These sources were Japanese squid boats which carry large numbers of steady incandescent light bulbs to lure squid to the surface where they can be netted. Using information about the nature and number of the lights used on the largest squid boats one can calculate that the largest intensity expected from such a boat would be 5×10^5 cd. However, at the distance of closest approach of the plane to the squid boats, about 100 km, the intensity required to create overexposed images on the film would have been more than 1×10^8 cd (see Figure 6 for b = 0.05/km). Thus, they could not have made the overexposed images. If one nevertheless assumed that these boats somehow did create the overexposed images, then one would still have to explain the large amplitude periodic oscillation of the boat intensity and the color change. Periodic (and even transient) atmospheric effects of the magnitude required by this hypothesis are completely at odds with theory and experience related to atmospheric optics. Atmospheric turbulence causes minute refractive index variations in the atmosphere and these refractive index variations can create very rapid intensity pulsations (scintillation) and slight changes in color, but turbulence is known to be random rather than periodic. Moreover there is neither observational nor theoretical support for the idea that atmospheric reddening, which is a result of frequency selective extinction as light travels over long paths (100's of km) in the atmosphere, could "convert" white light to red over a path of only 100 km. Therefore, for these reasons atmospheric effects on distant lights can be ruled out.

Because there are geological faults running through New Zealand, Brady (Pye, 1981) has suggested that the witnesses saw earthquake lights caused by the geological stress along a fault line. Traditionally such lights are associated with imminent earthquakes. However, there were no earthquakes immediately, or even for a long time after the sighting discussed here. Unfortunately the earthquake light hypothesis is not sufficiently well developed to allow one to make quantitative predictions as to the size, color, luminosity and dynamics of any small glowing regions that might be created by earth stresses. Therefore this theory (and similar "ball lighting" theories) cannot be tested against the photographic data. However, it seems highly unlikely that this hypothesis, or a "ball lightning" hypothesis, could explain the steady pulsation of the filmed lights, the extreme intensity of the PY/O light, the presence of the red lights, and the triangular arrangement.

During the initial search for known flashing lights this author considered the possibility that an emergency vehicle or police vehicle was filmed. Sheaffer (1981) independently advanced this hypothesis. For example, one might imagine an ambulence with a flashing white light on top and two flashing red tail lights. One might further imagine that the red and white flashes were accidently out of phase and flashing at the rate 1.16 Hz. If such a vehicle were filmed from directly behind, it might make images similar to those on the film.

A rather detailed analysis of the consequences of this hypothesis showed that there are several problems related to distance of the vehicle from the plane, the alignment of the vehicle with respect to the flight path of the plane, the probable presence of other lights near the vehicle, etc. However, all of the analyses became moot when it was found, by checking with Blenheim police, that there were no police or emergency vehicles on the roads around Blenheim during the early morning of the date of the sighting, and that emergency vehicles in New Zealand have flashing blue lights.

The most recent explanation is that Crockett filmed a reflection of the red flashing anticollision beacon (AB) which is on the top of the aircraft[9] (Klass, 1983; Sheaffer, 1981). The AB was suggested as a source of the light because it flashes at a rate compatible with the flash rate of the filmed light. (There is also another AB at the bottom of the aircraft. It is not considered here, but the arguments presented apply to the lower beacon as well as the upper.) This hypothesis was published (Klass, 1983) as being an acceptable explanation in spite of the following facts: (a) the overexposed images were clearly made by a pale yellow or pale orange light, not by a red light, (b) the single red AB could not simultaneously create red and PY/O images, and (c) the single red AB could not produce a triangular arrangement of images. The reasons for rejecting the AB hypothesis are made explicit in the following paragraphs.

Crockett did film the upper AB about six hours before the 0251 sighting. At that time the plane was on the ground at Blenheim airfield and had not yet taken off on its historic flight. The AB film shows (a) that the AB is red, as expected, (b) that the AB is intense enough to overexpose the film when it is shining *directly at the camera* from a distance of forty feet or so, and (c) that it flashes at a rate of 1.3 Hz. This flash rate is quite accurately known because Crockett filmed the AB with the camera running on crystal control at 24 fr/sec.

It is of great importance in evaluating the AB hypothesis to know the following facts: (a) each *properly exposed* image of the AB is "pure" red, as is expected, and (b) each *overexposed* image of the beacon has a bright pale yellow center that is *surrounded* by *a wide annual region* or "fringe" that is *red.* The width of the fringe is generally comparable to or larger than the width of the central area.

Crockett's filming of the upper AB was an unintentional but very important experiment with the type of color reversal movie film he used (Fuji 8425). This author has conducted numerous similar experiments with other types of color reversal (slide) film. In these experiments a red light was photographed at various high exposure levels. The resulting overexposed images always have red fringes around the pale yellow central areas. The fact that the color of the annular fringe is the same as the color of the light which made the image is

[9] Sheaffer (1981) discussed the hypothesis of P. J. Klass that the anticollision beacon light was reflected off a mist around the airplane or off a propellor, but provided counterarguments for that hypothesis. Instead, Sheafferproposed that "almost any object on the ground such as an emergency vehicle could conceivably be responsible for the UFO that was captured on film but not noticed at the time."

expected since the fringe is made by light which *diffuses sideways within the film material.* As the light diffuses radially sideways from the intensely illuminated central region of an overexposed image, eventually, at some distance from the edge of the overexposed region, the intensity is reduced to a value that is too low to overexpose the film. Beyond this distance the diffusing light *properly exposes the film* and creates a fringe that is the color of the light source. Eventually the sideways-diffusing light intensity reaches a value so low that the film is not exposed at all. At this distance, and beyond, the film is unexposed (black). The clear result of these experiments is that *if* a red light overexposes a film, *then there will be a red fringe around the overexposed region.* Conversely, if there is no red fringe then the light was not red.

The first step in analyzing the possibility that the AB was the source of the flashing cluster of lights is to point out that the cluster was filmed when the camera was running *without crystal control* at a speed of about 10 fr/sec. The accuracy of the speed control when the camera is operated without crystal control is about (±)10%. Therefore the 1.16 Hz flash rate, calculated previously for the cluster by assuming a frame rate of exactly 10 fr/sec, could actually have been as high as the 1.3 Hz rate of the beacon.

The second step is to point out that there is no way of knowing, independently of other information that could be compared with the film (e.g., Fogarty's taped description), exactly when Crockett filmed the cluster or where he was looking when he filmed it. Nor is there any way of knowing in which direction the camera was pointing during the filming.

The third step is to propose a mechanism by which Crockett could have filmed light emitted by the AB. The initial suggestion was that light from the AB was reflected off a mist surrounding the airplane (Sheaffer, 1981). However, this was ruled out because such a reflection would be highly diffuse and very weak. The more recent suggestion is that light from the beacon was reflected off the rotating propellor blade (Klass, 1983). It is supposed by the author of this hypothesis, without independent proof, that such a reflection might be sufficiently specular (mirror-like, as opposed to diffuse) to create a very bright reflection of the AB. However, even granting that a sufficiently bright reflection might occur, this hypothesis fails on physical grounds for the reason cited above: the overexposed PY/O images *have no red fringes around them* even though, as pointed out above, experiments have shown that the *overexposed images of red lights always have red fringes around the overexposed central areas.*

The only way to explain the lack of red fringes is to assume that the red light was in some way "converted" to bright PY/O light as it travelled from the beacon to the camera lens. The only way for the red beacon light to be "converted" to PY/O is to have the color spectrum changed. Such a change is possible to accomplish, in principle, because the red beacon light is not spectrally "pure" red, but is actually a broad continuum of colors that is strongly biased, or "weighted," toward the red end of the color spectrum. (The beacon uses a red filter to "convert" incandescent white light by selectively transmitting colors at the red end of the spectrum while absorbing other colors.)

The spectrum could be changed by a filter that would be (nearly) the inverse of the filter that converted the white light to red light in the first place. However, since the airplane window is clear glass it could not have filtered the red light. Moreover, although the reflection of the red light off the metal of the propellor might change the spectrum very slightly, it would not change the spectrum suffiently to convert red light to PY/O light. Therefore there is no way that the spectrum could have changed in traveling from the beacon to the camera.

The AB hypothesis also fails to explain the two-colored triangular images that consist of a PY/O "dot" image above two red "dot" images. Neither reflection off one (or two) blades of the propellor, nor passage through the window glass, could cause light from a single red beacon to split into three parts, triangularly arranged and of different colors (PY/O and R). In short, this hypothesis fails on physical grounds to explain the overexposed images and the triangular image clusters.

This hypothesis also requires it to have been possible for Crockett to film in the direction of one of the propellors. However, the size and shape of the cockpit and the locations of the backs of the seats of the aircrew would have made it very difficult, and perhaps impossible, for Crockett, who supported the camera on his shoulder, to film one of the propellors. In order to film out the right (or left) window along a sighting line about 115° from straight ahead (to film a propellor) he would have had to sit in the copilot's (or pilot's) seat. He couldn't do this without actually displacing copilot (or pilot) from his seat. However, no such displacement occurred at any time during the flight.

To summarize, the only support for the AB hypothesis is the apparent coincidence between the flash rate of the unusual light cluster and the rate of the AB. On the other hand the AB is contradicted by photographic image data and other information and therefore fails for the following reasons: (1) neither a reflection off a propellor nor passage through the clear glass window would convert the spectrum of the red AB light to a PY/O color; (2) there is no way to explain how red light from a single beacon, after reflection from a propellor blade (or two such blades at the same time) and subsequent passage through a clear glass window, could make a triangular cluster of three images such as appears on the film; and (3) Crockett probably could not have filmed any of the propellors even if he had wanted to because of the structure of the cockpit and the locations of the side windows.

In his description of the film images Klass (1983) ignored the problem of explaining how a red beacon could make PY/O images without making red fringes as well. Instead, he concentrated on trying to explain the changes in shape of the images from frame to frame. He argued that the only way to explain the image shape changes was to assume that the light (from the AB) was reflected off a propellor. According to Klass one can "readily" explain how the film images change rapidly from large round or oval blobby shapes to "banana shapes," to thin parallel streaks ("string bean shaped") and back to round blobby shapes in a periodic manner if one assumes that there was a lack of synchronization between the AB flash rate and the propellor rotation rate. In making this argument Klass has ignored the much more likely explanation that the natural tendency of the camera, which was held on Crockett's shoulder, to vibrate randomly would cause image shape changes similar to what he describes. Such changes are evident in all portions of Crockett's film, including portions of the film which show landing field lights. (Should one imagine that Crockett filmed the reflection of landing field lights off the propellor?) Random camera motion combined with the intensity pulsation of the cluster of lights can explain all the image shape changes in the film.

Some other explanations in terms of "natural" phenomena have been proposed for the New Zealand sightings, but these are far more bizarre than the ones mentioned already. One person suggested that a portion of the sun's corona or plasma had somehow gotten into the atmosphere where it glowed. Another suggested that volcanic vapors had something to do with the sightings. These and other bizarre hypotheses (a miniature black hole, an "anti-matter meteorite") are completely untestable. However, the photographic evidence of the flash rate and the triangular structure would seem to rule out any conceivable natural phenomenon.

VIII. Conclusion

The New Zealand UFO sightings of December 31, 1978 are unique in the annals of "ufology" in that they are multiple witness sightings that are supported by two tape recordings made at the time of the sightings and by a 16 mm color movie film. Several of the visual objects reported by the crew and passengers were correlated, in terms of the times of appearance and the directions from the plane, with radar targets reported by the WATCC. One of the unusual objects, a very bright source of light that was seen between 0218 and 0235, was also correlated with an airplane radar target.

The sighting discussed here was one of many during the early morning of December 31, 1978. It is unique because of the two color images, the triangular structure and the regular flash rate of the filmed cluster of lights. Moreover, it was the only sighting that was not discussed publically. The initial news stories mentioned the sightings which occurred during the flight from Wellington to Christchurch and concentrated on the sighting which took place just after the plane left Christchurch because Crockett had more film of that unusual light than of any of the other unusual lights. There was no mention of the periodically flashing light. After the initial news stories appeared, explanations were offered by numerous experts in the fields of astronomy, meteorology and geophysics (e.g., Venus, Jupiter, atmospheric refraction of squid boat lights, earthquake lights, unburned meteors, etc.). However, these explanations only applied to the 0218-0235 sighting and not to the sighting discussed here (Fogarty, 1982; Startup & Illingworth, 1980).

This paper has presented a discussion of some of the technical data derived from Crockett's film and of the tape recorded descriptions by Fogarty and the copilot. It has been argued that Fogarty and the copilot saw the same "collection of lights" that Crockett filmed. The coincidence between the radar target at 0251 and the visual sighting has also been discussed. Explanations for the film itself, without reference to witness testimony, have been presented. It has been argued that, when confronted with all of the technical details derived from the film, each explanation is found to either fail completely (e.g., the anticollision beacon hypothesis) or to be highly unlikely (e.g., the earthquake light hypothesis).

The only suggested explanation for the visual sighting reported by Fogarty and the copilot is that the witnesses failed to recognize ordinary flashing navigation beacons and city lights in the area (Ireland, 1979; Klass, 1983; Sheaffer, 1981). However, this explanation is not convincing. To accept this explanation one has to assume that the air crew did not recognize the usual navigation beacons in spite of years of flying experience in the area. Nor does this explanation account for Fogarty's description of a flashing light which suddenly appeared high in the sky "over the hills," dropped to a lower altitude and then went into a rapid rolling and turning maneuver. Obviously no navigation beacon could move in such a manner. To accept this explanation one also has to assume that Crockett did not film the cluster of lights that was reported by Fogarty and the copilot in spite of the high probability that Crockett did see what the others saw and that he would have tried to film it.

This author is not aware of any explanations which have been suggested for this particular sighting other than the ones listed here. If there are any other reasonable explanations which are consistent with the data the author would appreciate learning of them.

Since this sighting falls into the general category of "UFO" sightings it can be compared with other reports. One does not have to search very far in the UFO literature to find reports of multicolored objects moving through the skies (Fowler, 1974; Story, 1980; Hall, 1964). The colors red, white and orange or yellow/orange are frequently reported, sometimes along with other colors such as green and blue. Furthermore, triangular shapes are reported, although not as often as other shapes.

Fowler (1974) lists a number of sightings of lights in geometric arrangements, including triangular. Of particular interest is the sighting late in the evening of March 9, 1967 of a triangular "cluster" consisting of a white light and two red lights with the white light at the apex above the red lights. The lights were steady in this sighting. The report of a multiple witness sighting during the late evening of April 19, 1966 states that the witnesses saw a "large disc shaped object which was accompanied by two smaller objects of the same shape. They flashed red and white lights, hovered and swung back and forth like a pendulum."

In some UFO reports the dynamical characteristics (movements) of the UFO have suggested intelligent control and even sometimes reactions to the witnesses and crude "communications." The crudest form of communication is mimicry. The cluster of lights flashed steadily at a rate comparable or equal to the rate of the anticollision beacon. Was it mimicking the flashing anticollision beacon?

This brief comparison with other UFO reports does not prove that the flashing cluster of lights discussed here are in fact related to whatever phenomena have been reported as UFOs in the past. However it does establish the similarities.

It has been the intent of this paper to demonstrate that, at least to the present time (nearly nine years after the event), there is no satisfactory explanation based on known phenomena for the lights that Crockett filmed. (There has also been no satisfactory explanation for what Fogarty described, whether or not it was what Crockett filmed.) Therefore it appears that the sighting was of something truly unknown-to science, i.e., it remains "unidentified." Furthermore, the verbal descriptions suggest that this phenomenon was actually an object that was moving or "flying," in which case it was a true UFO.

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Appendix
Tracings of Images in the Flashing Light Sequence of Film

This appendix presents a sample of the 279 frames within the flashing light sequence of Crockett's film. Not all frames of the film actually have images that are visible to the naked eye. Frames without visible images are marked "gone" in this set of hand sketches of the images. Visible images were projected onto white paper and traced. Thus they are presented as the viewer would have seen them while looking out through Crockett's lens if there had been no image position shift from frame to frame caused by the camera vibration. When the film is viewed at the filming speed, 10 fr/sec, the images are blurred by the motion from frame to frame and by the persistence of vision. What is most obvious under these circumstances is the pulsation of the PY/O images, which change from "zero" brightness to very bright at what appeares to be a high rate (actually about 1 Hz). The red images are also visible when the film is run at full speed but they are not as impressive as when the film is run at very slow speed or frame-by-frame. Of course, one does not detect any structure in the images when the film is viewed at full speed.

The images are depicted here as if they had infinitely thin outer boundaries, but in fact the boundaries are very slightly diffuse. The "thickness" of the boundary of overexposed images (the "Color Gradient Region") is about 20 microns. The thickness of the boundaries of images with lower exposure is about 10 microns.

Regions of different color within a single image are indicated by clear and crosshatched areas as appropriate. However, the use of a single color designation for a particular area of an image does not necessarily mean that the color is constant throughout the area. In fact, there are generally gradations of color and brightness within any particular area of an image.

Color notations are as follows: BYW = bright yellowish white, R = red, Y = yellow or pale orange, etc. BYW areas of images appear to the naked eye to be the brightest, being very pale yellow or "pure" white (the color of the clear film base, which is maximally overexposed film). R areas are red and Y areas look pale yellow, or they could be very pale orange. Other color notations have straightforward interpretations. However, one should remember that the color rendition of the film is not perfect, since it is made up of layers that respond differently to different intensities of a particular color light. For example, tests of color reversal film show that when an incandescent white bulb is photographed at good exposure the color could be called a slightly greyish white. At high exposure the same light will cause a "pure" white image (the color of the projection bulb), but at very low exposure it will have a very slight reddish hue. A red light, on the other hand, always produces red within the film image, although when the light is so bright it overexposes the film the center of the image becomes bright yellow, and there is a wide red fringe around the central area.

These images were magnified 71 times during the projection onto the tracing paper. A length scale corresponding to 0.14 mm (140 microns) on the film plane is illustrated along with the tracings. The widest image (image width is measured transverse to the direction of maximum extension for non-round images) is about 0.25 mm (250 microns) wide and the smallest images are around 0.014 to 0.028 mm wide. The smallest images are about 2 to 4 times the film grain size, which appears to be about 0.005 to 0.010 mm.

The camera was held on the cameraman's shoulder because a tripod would not fit within the cockpit. The resulting random motions of the camera caused most of the images to be elongated and also caused the image positions to shift from frame to frame. Elongated images are a result of camera motion in the direction of elongation during the time the shutter was open. The random motions of the images from frame to frame are not apparent in the sketches, which are presented as if all the images had been shifted to the center of the frame.

Since the camera vibrated randomly about a mean pointing direction there were times when the camera moved very little while the shutter was open. Thus there are several instances for which two or three successive frames have very little or no the image position shift from frame to frame. The images in these frames, "stationary images," are not distorted by camera motion and they are what would have been obtained if a tripod had been used. Most of the analysis in this paper is based on these stationary images.

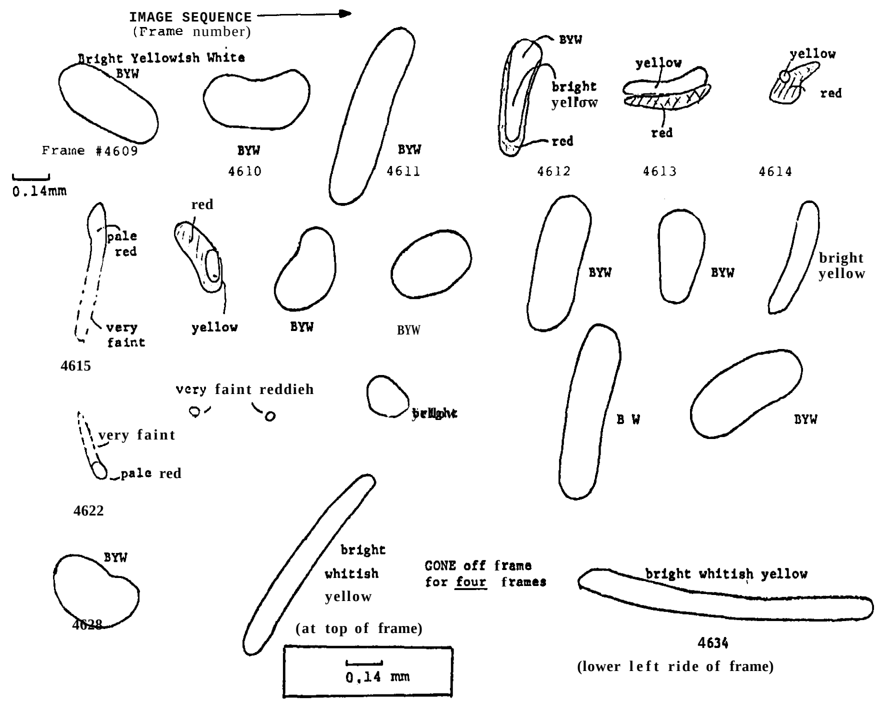
IMAGE SEQUENCE
(Frame number)
Bright Yellowish White
BYW
Frame #4609
0.14mm
BYW
4610
BYW
4611
BYW
bright
yellow
red
4612
yellow
red
4613
yellow
red
4614
red
pale
red
very
faint
4615
yellow
BYW
BYW
BYW
BYW
bright
yellow
very faint reddieh
very faint
pale red
4622
B W
BYW
BYW
4628
bright
whitish
yellow
(at top of frame)
0.14 mm
GONE off frame
for four frames
bright whitish yellow
4634
(lower left ride of frame)

Fig. A1

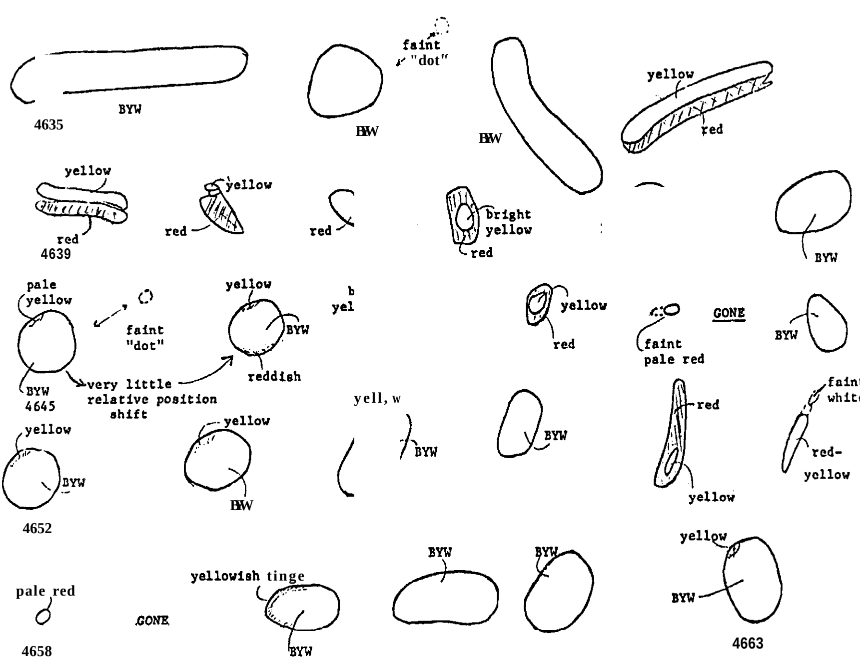
4635
BYW
faint
"dot"
BW
BW
yellow
red
yellow
red
4639
yellow
red
red
bright
yellow
red
BYW
pale
yellow
BYW
4645
faint
"dot"
very little
relative position
shift
yellow
BYW
reddish
b
yel
yellow
red
GONE
faint
pale red
BYW
yell, w
BYW
BYW
red
yellow
faint
white
red-
yellow
yellow
BYW
4652
yellow
BW
pale red
4658
GONE
yellowish tinge
BYW
BYW
BYW
yellow
BYW
4663

Fig. A2.

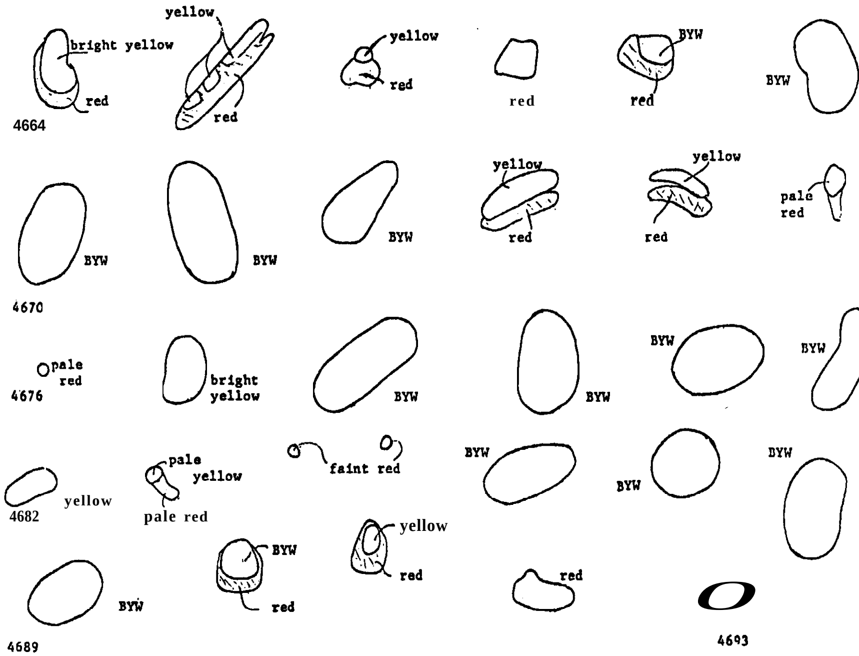
yellow
bright yellow
red
4664
red
yellow
red
red
BYW
red
BYW
yellow
yellow
red
red
pale
red
BYW
BYW
BYW
4670
pale
red
4676
bright
yellow
BYW
BYW
BYW
BYW
yellow
4682
pale
yellow
pale red
faint red
BYW
BYW
BYW
yellow
red
BYW
red
red
BYW
4689
4693

Fig. A3.

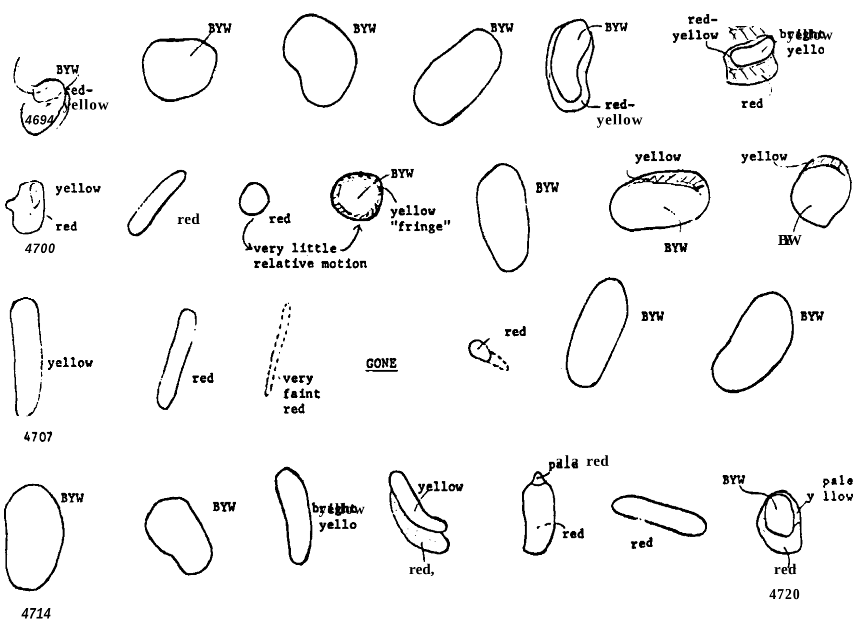
BYW
red-
yellow
4694
BYW
BYW
BYW
BYW
red-
yellow
red-
yellow
red
yellow
red
4700
red
red
BYW
yellow
"fringe"
very little
relative motion
BYW
yellow
BYW
yellow
yellow
red
very
faint
red
GONE
red
BYW
BYW
4707
BYW
BYW
yellow
red,
pale red
red
red
BYW
pale
red
4714
4720

Fig. A4.

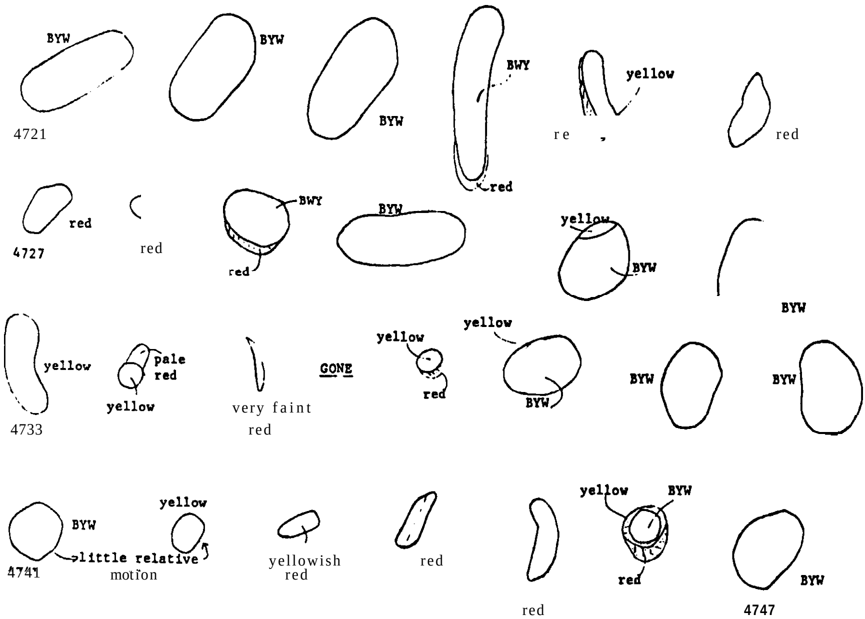
BYW
BYW
BWY
yellow
4721
BYW
re
red
red
4727
red
BWY
BYW
yellow
red
BYW
red
BYW
yellow
pale
red
GONE
yellow
yellow
yellow
very faint
red
red
BYW
BYW
BYW
4733
yellow
BYW
yellow
BYW
little relative
motion
yellowish
red
red
4741
red
BYW
red
4747

Fig. A5.

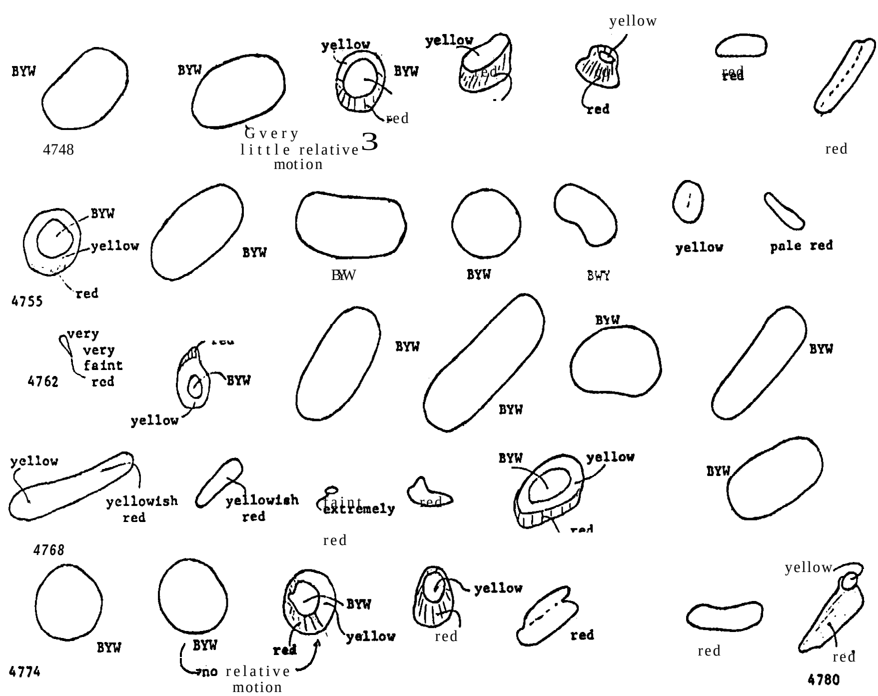
yellow
yellow
yellow
BYW
BYW
BYW
red
red
red
red
very
little relative
motion
4748
red
BYW
yellow
BYW
BYW
BYW
BWY
yellow
pale red
red
4755
very
very
faint
red
BYW
BYW
4762
yellow
BYW
BYW
BYW
yellow
yellowish
red
yellowish
red
extremely
faint
red
red
BYW
yellow
red
BYW
4768
BYW
yellow
yellow
BYW
BYW
red
yellow
red
red
red
red
4774
no relative
motion
4780

Fig. A6.

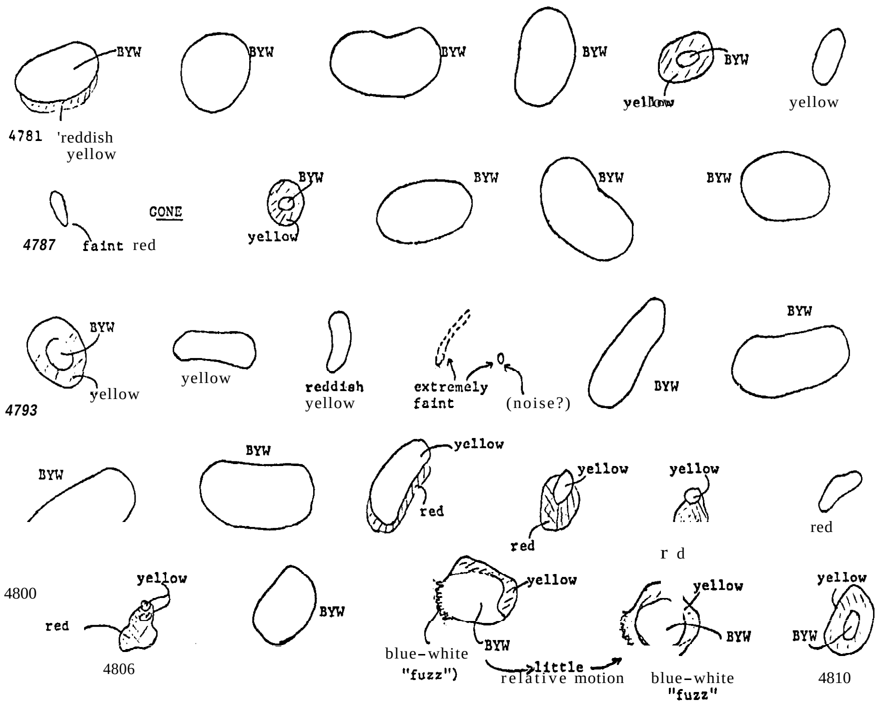
BYW
BYW
BYW
BYW
BYW
yellow
yellow
4781 'reddish yellow
4787 faint red
GONE
BYW
yellow
BYW
BYW
BYW
BYW
yellow
4793
yellow
reddish yellow
extremely faint
(noise?)
BYW
BYW
BYW
BYW
yellow
red
yellow
red
yellow
r d
red
4800
yellow
red
4806
BYW
yellow
BYW
blue-white "fuzz")
little relative motion
yellow
BYW
blue-white "fuzz"
yellow
BYW
4810

Fig. **A7.**

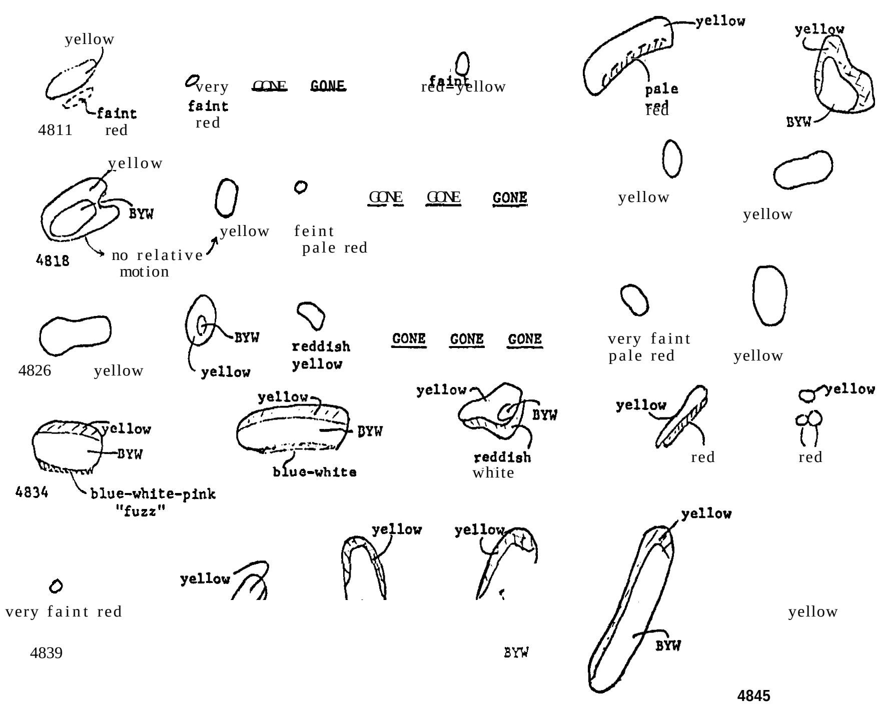
yellow
faint
4811 red
very faint red
GONE GONE
faint red-yellow
yellow
pale red
yellow
BYW
yellow
BYW
4818
no relative motion
yellow
feint pale red
GONE GONE GONE
yellow
yellow
4826 yellow
BYW
yellow
reddish yellow
GONE GONE GONE
very faint pale red
yellow
yellow
BYW
4834
blue-white-pink "fuzz"
yellow
BYW
blue-white
yellow
BYW
reddish white
yellow
red
yellow
red
very faint red
4839
yellow
yellow
yellow
BYW
yellow
BYW
yellow
4845

Fig. A8.