STUDY 4

The Bell & Howell 414PD 8mm Movie Camera Image Capture Characteristics

Objective: Conduct film tests using a Model 414 PD Bell & Howell Zoomatic Director Series camera to determine whether the recognized anomalies in the Zapruder film theoretically attributed to claw flare, claw shadow, development turbidity, first frame inertial effect, and the design of the photo-electric cell are borne out by actual tests with film—i.e. create a "control" against which to compare the film identified in the Archives as the "out-of-camera original." Subsequently, write a report evaluating the likely meaning of similarities and/or differences observed between the newly created "control" film and the film in the archives designated as the "out-of-camera original". (Per ARRB)

In summary: To provide a thorough understanding of the specific image capture characteristics of the camera used by Mr. A. Zapruder to film the assassination of president Kennedy in 1963.

Introduction

Just after noon on November 22, 1963, Mr. Abraham Zapruder, a woman's clothing manufacturer, climbed onto a small concrete pedestal in Dealey Plaza with his 8mm movie camera. After President Kennedy's motorcade came into view and passed, Mr. Zapruder's 26 second film record of the assassination became the most significant amateur recording of a news event in history.

The Bell & Howell 414PD 8mm camera was, in 1963, a top of the line, high quality 8mm amateur movie camera. The optics were outstanding, the drive mechanism provided consistent long-run exposure time/per wind, the automatic exposure mechanism was of award winning design that yielded excellent results and the camera had a power zoom lens. The "P" in the model reference stood for "Power Zoom" and the "D" for "Dual Electric Eye". The image formed within the standardized projectable area had no flaws or faults. Why

then have we made an extensive study of the camera's image capture characteristics?

The camera used is not untypical of several models that position the film with its claw moving in an aperture cutout area adjacent to the image forming picture area. Consequently, scene information falls into this unmasked area due to the excess (circular) imaging area produced by the lens. For normal home movie projection this additional recorded scene information would be of no consequence as the projector aperture would hold back or mask-out this area.

From the standpoint of viewing all information available of the assassination scenes, it simplifies analysis if we consider the images captured in two parts. There is the typical camera aperture area (i.e. the images that would be viewed by standard projection), and the images that fall into the area between the perforations which add to the total scene content. To some students of the assassination, the Zapruder original film contains several image anomalies - almost all being related to the scene information being recorded or imaged into the area between the perforations.

Because some image anomalies are present, there is great significance attached to this area by various researchers who speculate that the anomalies may represent not the peculiar optics of Zapruder's Bell & Howell camera, but rather, evidence of film alteration. It is important, therefore, to understand how the camera optics record images in this area and why certain anomalies are present - which is part of the objective of this study.

Identifying the Recognized Image Anomalies:

What are the image anomalies of concern to researchers and the students of the assassination and where and why do they occur?

My first introduction to the issues of concern occurred during our first visit to the ARRB and NARA where the anomalies were verbally described to us and we had only a brief look at the Zapruder original film. Primarily based on ARRB's need to resolve the image characteristics in the perforation area, I outlined possible causes from seeing the Warren Commission black and white images, the verbal description by ARRB and the brief look at the Zapruder film. My brief

description of theoretical causes was incorporated into the program of work developed by the ARRB and defined in the "Objective" statement above. Transposing the hypothesis to factual description or plausible theory will follow in the course of our analysis.

A parallel objective is to ensure that future archivists and historians can have a thorough understanding of how this important tool of image capture functioned. There are several design considerations that led to the development of the Bell & Howell 414PD camera; therefore, some historical and tutorial information is interlaced with discussions of fundamental operational characteristics.

In my research I have been very fortunate to locate several former Bell & Howell engineering management and staff who were in key positions during the development and manufacture of the Bell & Howell 414PD camera. The information and help they have provided contributed materially to ensure that this monograph is the representation of valid features and characteristics of this model camera.

An appended copy of the owner's manual describes the general operating characteristics of the camera. Also enclosed are some camera reports and technical articles on specific camera characteristics. We have been fortunate to also locate directly applicable Bell & Howell patents that detail key features. The reader is encouraged to take a few moments now and quickly scan the enclosed photographs and drawings to gain a perspective of the scope of the detailed discussion that will follow.

Overview of Image Anomalies:

The image characteristics that have been identified as "those of concern" are inconsistencies; i.e. they are not the same density, color and quality as those contained in the primary image area. The cause of those inconsistencies thus provides a focus for our review of camera characteristics. A look at a few frames from the Zapruder "in camera" original, Figure 4-1 and 4-2, provide a "picture" of the image characteristic that will be the bases of detailed discussions.

Before we begin our description of the camera, to gain the knowledge of how the identified image anomalies occurred let us simply identify each anomaly together with other image capture

characteristics we believe need study, appraisal, and a descriptive analysis.

Image anomalies or characteristics that shall be addressed are:

- *Claw Shadow"* Between the perforations there is a broad bar where the image has more density (darker) than the primary image area.
- *Claw or aperture Flare*- Sometimes adjacent to the dark (claw shadow) bar and between it and the primary image is a "streak" lighter than the dark bar and the adjacent image.
- *Multiple Exposure Areas Adjacent to Perforation* - Sometimes there appears a lighter image area resembling images of perforation holes.
- *Ghost Images* - Sometimes there appears to be *"ghost"* images such as a motorcycle fender. These are real images, which because of the design of the claw cutout area occur simultaneously above and below the perforation holes of the primary image being formed.
- *Development turbidity* - Initially considered a possible contributor to density disturbances in the area between the perforations. However our investigation revealed that at the time of the processing of Zapruder's Kodachrome II films, processing velocities had increased to 40 fpm or greater. Therefore, the impact of the perforation holes possibly increasing the development activity in the area between the perforations and causing significant density change was considered negligible and dropped as a topic for review.
- *First Frame Overexposure* - Occurs in the Zapruder original with his first exposure of the motorcade and at least twice in his filming of the first half of the roll. The possible causes of the fogged or lesser density first frame are reviewed, to the best extent possible – recognizing the limitation that we could not conduct a practical test with the Zapruder B&H 414 PD camera.

Other important imaging characteristics will be incorporated into the description of the optical and mechanical features of the camera, and are preliminary to discussing the identified anomalies in detail.

Figure 4-1 & 4-2 Multiple Exposure Images, Claw Shadow and First FrameOver Exposure (See Text)

Part 1

Mechanical - Camera Mechanism, Film Intermittent, Image Forming Aperture and Shutter

To provide a full understanding of the mechanical design parameters of a motion picture camera is a textbook size challenge not possible within the scope of this monograph. However many readers will need a conceptual understanding of some of the mechanical features that directly contribute to image related issues raised by some who have studied and written about the Zapruder original 8mm film.

The references to selected mechanical characteristics that follow address, in simple overview, those components of the camera and its function that at some time have been identified as important. The film intermittent and aperture area have received special attention, the motor and governor receive a "broad-brush" but a thorough discussion of measured film velocity. Other components, if not directly related to an analysis of the film, are not even mentioned. We are fortunate however to have two key patents to provide the reader an opportunity to study and to interpret most of the camera's mechanical features. Patents relating to optical components will be identified in Part 2.

Film Intermittent:

The camera mechanism for normal motion picture photography has a dual function. First, to provide a withdrawal of film from a supply spool and its windup on a take-up spool, and second to position each frame of film successively to single picture accuracy in an aperture to provide for exposure by image forming light. Cinematography is based on a series of still pictures requiring the film in the aperture to be alternately stationary and moving to bring the next frame into position. Thus the intermittent movement is at the heart of motion picture photography.

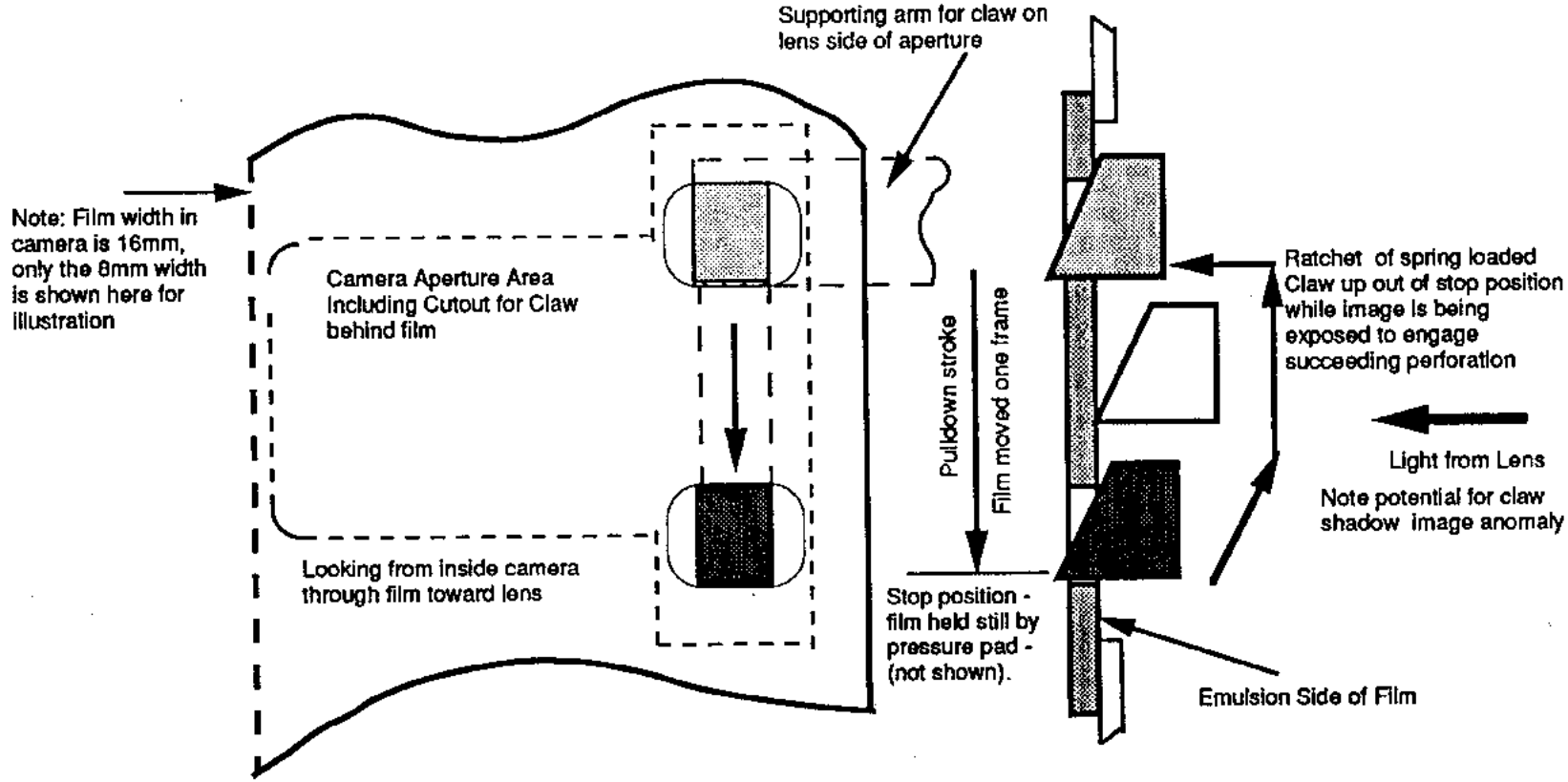
In the early days of cinematography designers developed many individual approaches. Today, although the mechanical design may have unique features, the required positioning of the film has become standardized. A very common form of intermittent film feeding mechanism comprises a reciprocally-mounted claw which is adapted to engage a film perforation at the top of its stroke, advance the film a

frame on its downward stroke, release the film perforation for its upward stroke and again engage a subsequent perforation for the next downward stroke. There are two general types of claw mechanisms to achieve this basic objective - the ratchet type and the positive type.

A principle difference between amateur and professional systems is the precision of repeat positioning of a frame of film for exposure. In most professional systems (and some amateur cameras), the claw(s) movement is a positive action in and out of the film plane from the base side of the film. Typically a cam means for moving the claw into and out of the film perforation as well as reciprocating the claw up and down so that the claw does not engage the film during the return or upward stroke. Further, the intermittent usually moves the film with perforation holes that are not adjacent to the light limiting camera aperture and the film may be held with fixed or moving register pins. The only image forming light that reaches the emulsion of the film from the lens is that which is closely defined by the camera aperture.

In the 1930's, following the introduction of Kodachrome, Eastman Kodak introduced 8mm photography, an affordable means for amateur home movie making. Two concepts gained in popularity, the established supply and take-up roll concept, and the newly introduced magazine load that required no thread-up. The magazine load concept mandated that the intermittent enter the film perforations from the front and because of magazine design, encouraged the claw of the intermittent to be adjacent to or near the camera aperture. In the interest of design and manufacturing simplicity and efficiency, it is possible to conceive that a film intermittent designed to have the claw enter the film from the front or emulsion side adjacent to the camera aperture would equally serve both roll-film as well as magazine cameras.

In the ratchet type, the claw is normally brought into contact with the film by the action of a light spring. The claw can reciprocate (out of one perforation into the next) in a single plane because its upper edge is tapered so that it will ratchet or cam out of engagement with a perforation at the beginning of the upward movement. The claw will ride along the surface of the film through its entire upward or return stroke until it drops into the succeeding perforation hole (See Figure 4-3). This type of mechanism is the simplest form of the two mentioned, and is the type employed in the Bell & Howell 414PD Camera.



Ratchet Claw Action of Bell & Howell Model 414PD 8mm Camera

Figure 4 - 3

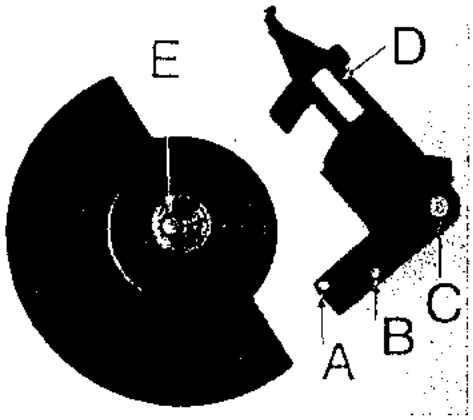


Figure 4-4

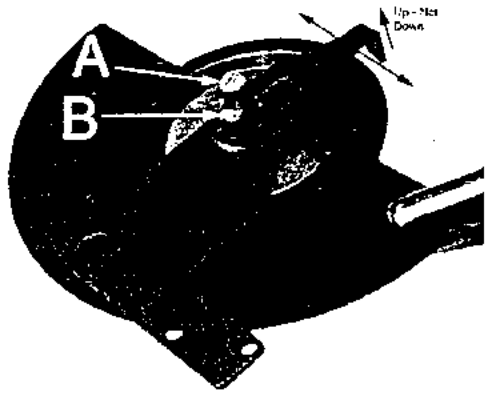


Figure 4-5 Claw Arm Over Crank Pin

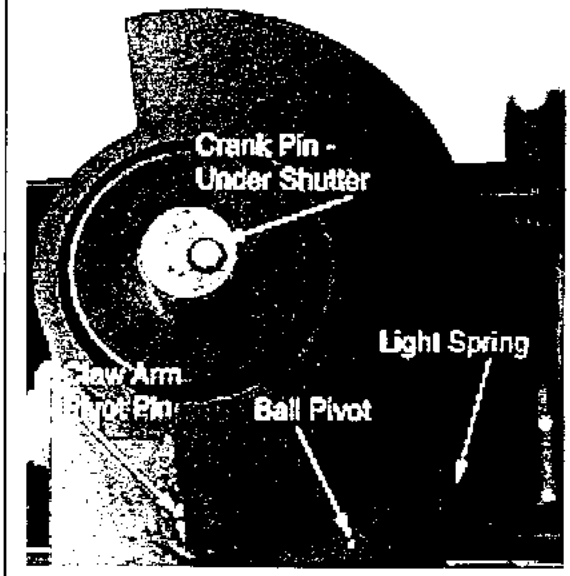


Figure 4-6 Claw Arm Under Shutter

Although the drawing is sufficient for a conceptual appreciation of a ratchet type of intermittent, photographs of the actual camera components will aid in visualizing the Bell & Howell 414PD movement. These photographs are combined on the following page and described as follows.

Figure 4-4 shows the rotary shutter and the claw/arm. The rectangular slot "D" receives the shutter crank pin "E" (protruding through on the opposite side and shown as "B" of Figure 4-5) for the reciprocating shuttle action. Two small holes "A" and "B" are shown. "A" receives the end of a light spring and the "B" a ball pivot, which combined provide about 2-3 grams of pressure against the film surface. The large hole is "C" for the shuttle arm pivot pin.

Figure 4-5 shows the claw arm engaging the rotary shutter crank pin "B". (Note: inadvertently I placed the claw arm on the crank upside down - the claw should point away from the shutter.) As the shutter rotates around an axis established by "A". The crank pin moves the claw up in 180° of rotation and down in the following 180° of rotation.

Figure 4-6 shows the shutter, with the bottom portion of the blade covering the claw arm attachment. Looking carefully, the slotted screw of the claw arm pivot pin can be just seen to the left, the ball bearing for the pressure pivot and the attachment of a light coil spring in the last hole.

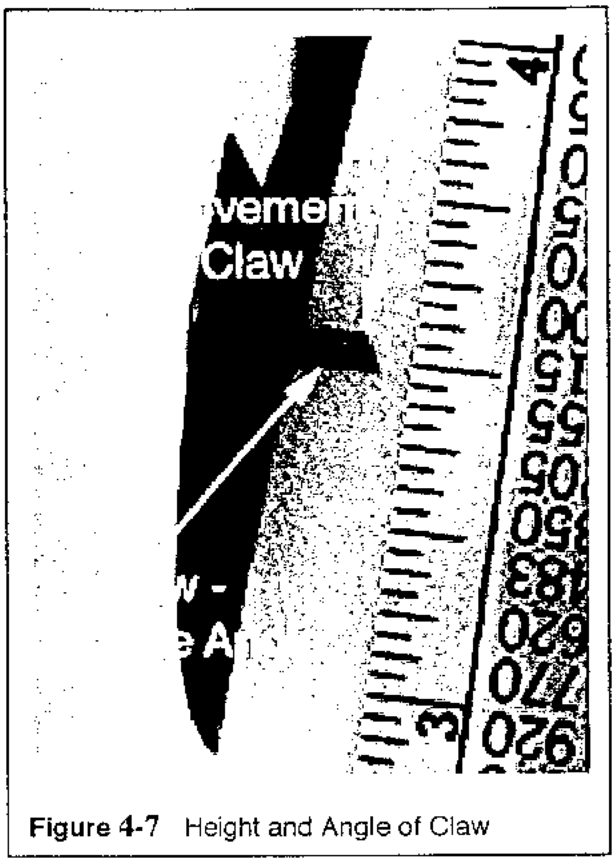


Figure 4-7 Height and Angle of Claw

Figure 4-7 shows the height and angle of the claw. For proper function, the claw must be higher than the perforation hole, to ensure it will ratchet out on the up stroke. (Conceptually shown in drawing Figure 4-3.)

In my review of the literature, one of the earliest references I found for positioning a ratchet type of intermittent mechanism adjacent to the image forming aperture and having the claw enter from the front to the near-side perforations is in a patent by Henry N. Fairbanks for Kodak[1]. There he has an excellent drawing of a ratcheting claw and acknowledges the corresponding need for a modified image-forming aperture as *"providing an exposure opening large enough that the claw may extend therein"*.

Camera Aperture:

Camera aperture dimensions and specifications are established by Standards to ensure interchangeability of films among the various devices of hardware for commercial reproduction (printing) and presentation (projection). The Standard in place when the Bell & Howell 414 camera was designed was American National Standard PH22.19, 8mm Camera Aperture (copy appended). These specifications established the location of the image relative to the perforations and the reference edge of the film, and established a vertical and horizontal angular tolerance. The height of the aperture must be maintained to ensure a real (unexposed) frame line. The horizontal distance is not critical and was given as a nominal value in the early 60's and subsequently modified in later Standards to a

[1] Fairbanks, H.N., Patent 2,153,142, April 4, 1939. Appended. (See figures 2,3, and 4 and text.)

minimum value. These values are shown in drawing Figure 4-8 and represent the standard dimensions plus camera features.

An objective of the camera aperture specification is to ensure sufficient image area to permit reproduction printing, and subsequent projection, taking into account tolerances required for film weave, aging and processing shrinkage. The drawing, Figure 4-9, provides the representative dimensions of the aperture which limits image height, inside edge and shows the cutout are for the intermittent claw.

The characteristics of the aperture cutout are directly related to our study of image anomalies, note the size and location of the cutout for the pulldown claw adjacent to the Standardized (0.192 in. nom. width) image area. One of my cameras has a measured aperture opening of 0.190 inch for the image width plus an additional 0.078 inch (total 0.268 inch) for the claw cutout. Note that the height of the opening for the claw movement is necessarily greater than the perforation pitch (0.150 inch) plus one perforation height (0.050 inch), and the significance of the size of this opening will be discussed in Part 3 under *Multiple Exposure Areas.*