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IDAPS Color Film Characterization

Draft for Review

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WORK OBJECTIVE

The focus of this effort was to determine the utility of color imagery in the GADS environment. In particular, we were looking for improved edge extraction. The underlying assumption driving this investigation was that desirable edges could be detected using color when their presence was either weak or imperceptible in the monochrome imagery.

Presumably, the stronger edges from color exploitation would enhance the performance of Auto-GADS, or at least aid an operator in manual operations. It is reasonable to assume that along with more desirable edges there will be an increased presence of undesirable edges, i.e., clutter. The sensitivity of GADS operations to clutter were not addressed in this particular effort.

GADS operations rely upon matching a wireframe model to edges in the data. The accuracy requirements of this match are quite strict. Thus, any bias or distortion of extracted edges arising from the color exploitation process could result in a failure to meet accuracy specifications. While this possibility appeared remote, a significant portion of this effort was directed towards determining if any shifts were present and the nature of their origin.

In summary, the objective of this was to determine whether edge information extracted using single or multiple spectral bands, (i.e. color), could be used to enhance manual or automated GADS operations. Considerable care was given to determine whether differing spectral bands introduce biases in the GADS estimation process. No spectral shifts were found using step changes of color. The familiar sources of physical shifts to the data were noted and avoided in our procedures.

DATA COLLECTION

Several procedures were used to collect images. They represented different approaches for obtaining color balanced data. From these various procedures the following items were noted.

1. The halogen light source is not evenly distributed. Specifically, the intensity fluctuates at lower settings. The illumination across the film is not equal. The spectral intensity is considerably greater in the longer wavelengths (red) with little energy available in the shorter wavelengths (blue). Thus, illumination is uneven spatially and spectrally, as well as in intensity as a function of power setting and time. None of these factors significantly affect edge signature.

2. The Nikon F-mount lens (bayonet type) allows movement which is noticeable for film frames digitized at our current 8.81 microns per pixel. Eglin personnel have previously noted this phenomenon. Thus, attempts to change light intensity for different color filters by changing the lens f-stop can introduce shifts in the data.

3. The film transport allows significant movement. The design and precision available from this equipment (both film and transport) make this an expected result. This phenomenon was observed after accidently

bumping the film when setting the light intensity dial. Subsequent digitization revealed a shift in the data.

None of these factors should be surprising. All of them can be overcome or ameliorated with appropriate operating procedures. The collection conditions chosen in this study are as follows.

1. Light intensity was left constant at 4 turns on the 10-turn dial (400 on a scale of 0 -> 1000). This level reduced the relative intensity changes from power fluctuations and provided sufficient illumination in the blue spectral region. It also provides a setting with sufficiently low thermal load and bulb stress that it could be used in normal operations.

2. The lens f-stop was fixed at f8. This setting was chosen as a reasonable compromise between allowing more light through the lens and avoiding distortions commonly found at low f-stop settings.

3. Neutral density filters and camera integration time were varied to obtain imagery with similar statistics. The ND filters and integration time used for each of the four spectral conditions (red, green, blue, mono) are as follows.

	IT (millisec.)	ND filter	%Transmitted
Mono	31	0.8	16%
Red	52	0.8	16%
Green	64	none	100%
Blue	180	none	100%

A single film frame was selected for study of color edges. The frame chosen came from the leader on the film which documents the ordinance drop. Part of this frame contains a grey scale bar, a color bar, and some dark text on a white background located near the top of the film image. The film was manually advanced to position this area near the center of the camera field of view and a 256 line by 512 column image was digitized. Four images were collected, one each for red, green, blue, and mono. In order to reduce digitization noise, each image was average over 256 frame grabs. The resulting statistics are as follows.

	Mean	Std. Dev.	Min	Max
Mono	127	72	0	242
Red	126	71	1	234
Green	128	71	3	251
Blue	127	58	14	235

The dark counts associated with the integration time for each of these colors was also determined. Averaging 256 frame grabs with the lens cap on gave the following results.

	IT (msec)	Mean	Std. Dev.	Min	Max
Mono	31	0	0	0	0
Red	52	0	0	0	3
Green	64	0	0	0	5
Blue	180	6	2	0	29

These dark counts are within expected results based upon Videk's documentation of the camera. The long integration time needed to obtain the blue filtered image does result in higher dark counts than may be acceptable in an operational setting. For purposes of this study, to determine relative edge strength and position, these noise counts were not a problem.

COLLECTION RESULTS

The film frame used in digitization is shown in Figure 1. This image was made by ERIM's photolab by taking a color negative of the film positive, magnifying and cropping around the area of interest. No effort was made to exactly crop the image as in the digitized data. Figure 1 simply provides an analog color reference to the digital results in Figures 2 through 11.

Figures 2 and 3 show the digitized frames for the red, green, blue, and no filter conditions. The filter used can be determined by the color of the border around the image, with the monochrome (no filter) image bordered in white.

Figures 4 and 5 show the results of extracting edges using a 3x3 Sobel operator. The absolute value of the edge strength was used. The Sobel was selected simply because it is a well understood operator and familiar to most individuals.

Figure 6 repeats the data given in Figures 2 through 5 on a single page. It is included to facilitate comparison of the filtered imagery and their corresponding edge strengths.

Figure 7 compares the edge strength of the monochrome image with the maximum edge strength over all four images. The monochrome is bordered in white. The maximum edge strength image is bordered in yellow. The max-edge image was obtained by comparing the data from each of the four images on a pixel by pixel basis. The maximum pixel value from this comparison was placed in the max-edge image.

Figure 8 shows the max-edge image on top with the source of each edge pixel colored on the bottom. The color coding indicates which of the four images, (red,green,blue,mono), had the maximum edge strength at that location. The number of pixels each image contributed, (as measured by area), is given in the table below.

	%Area	Comments:
Mono	5	Current operating mode
Red	15	Brightest spectrum for light
Green	40	Best spectrum for camera
Blue	30	Best spectrum for film (last layer)

Videk documentation indicates the characteristics of their camera are such that the sharpest images will be obtained by using a green filter. Kodak states that the blue emulsion is the last layer placed on the film used (7239 Video News Film). The top layer suffers the least amount of light scattering and would therefore provide the sharpest image. These empirical results support both claims.

Figure 9 shows the balance and alignment for each of the four images. The top image show a color coded profile plot through the grey bar for the data values between the two parallel white lines. The bottom image is similar to the top, except the data being plotted falls across the lettering in the bottom half of the image. The background image in both profile plots is the monochrome data dimmed by 50% to minimize interference with reading the plot lines. It is provided for visual reference only. The data values plotted are from the original four images.

Figure 10 gives another profile plot, this time for a line through the color bar. The color coded plot lines correspond to the color coded borders of the images in the lower half of the figure. The background image in the plot is from the monochrome data (white border) dimmed by 50%.

Finally, Figure 11 repeats the first half of Figure 10 and the bottom half of Figure 8. It is intended to provide an easy reference to which images provided the strongest edges through the color bar.

CONCLUSIONS

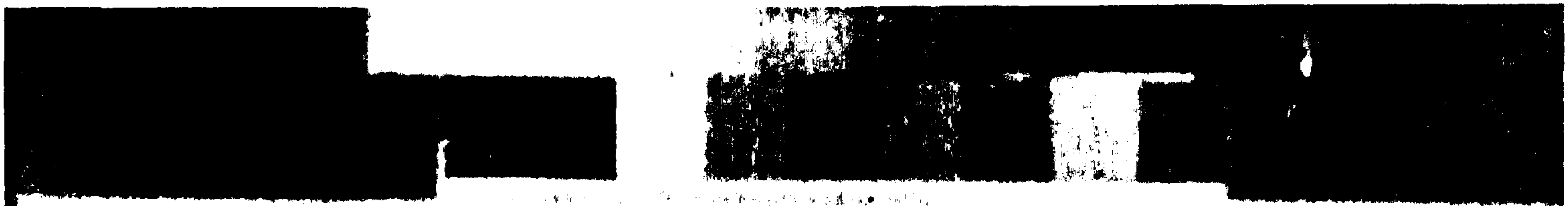
There are no deficiencies in the current system that preclude operational usage of color imagery. In particular, the edges are not shifted by peculiarities in the film, optics, or camera. In order to avoid mechanical shifts, (i.e., lens, camera, or film movement), neutral density filters and varied integration times would be used to collect all the desired spectral data on a single frame before advancing the film.

Use of color filters may be beneficial in improving edge strength. While a multispectral approach could be supported, it is not clear from the available data that multiple colors would significantly improve performance over a single filter approach. We readily acknowledge that Eglin may possess films which justify the use of multispectral approaches, but no film reviewed for this study leads to a present requirement for multispectral processing.

Mulitspectral data acquisition where multiple images are digitized from a single film frame should not be confused with multispectral techniques in which a single image is digitized through an appropriately chosen filter. The film reviewed to this point does suggest that multiple single spectral bands may be productively used to enhance a broad range of data. Furthermore, circumstances can arise in which multispectral processing will be necessary. For these reasons, ERIM recommends that the color filter wheel be included in the current IDAPS upgrade program.

Operationally, we would expect a single filter to be put in place that is appropriate for the drop being analyzed. All frames would be digitized through this filter and processed as in the monochrome system. Based upon our current data, a reasonable default would be to use a green filter. It provides the greatest overall contrast and should be an improvement over no-filter operations. In drops where color may be helpful, (and the color of interest is not already green), a red or blue filter could be used.

This report should provide sufficient explanation and presentation of results for the reader to draw their own conclusions. Commentary concerning edge or image characteristics was deliberately minimized as either superfluous or potentially biasing. At this point, ERIM personnel would welcome a discussion with the sponsor concerning these results. Further activity on this topic will be conserved until such a discussion has occurred.



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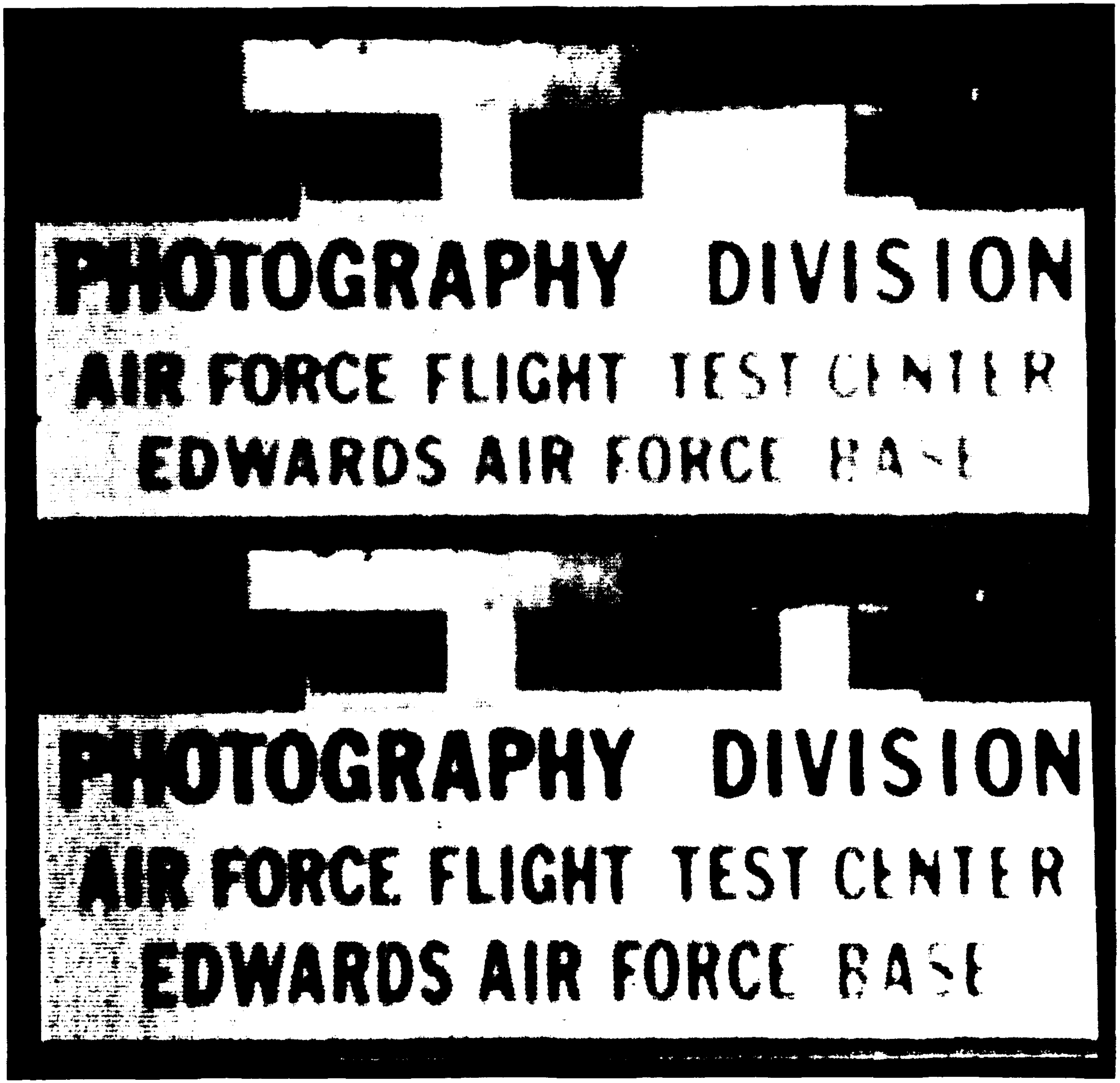
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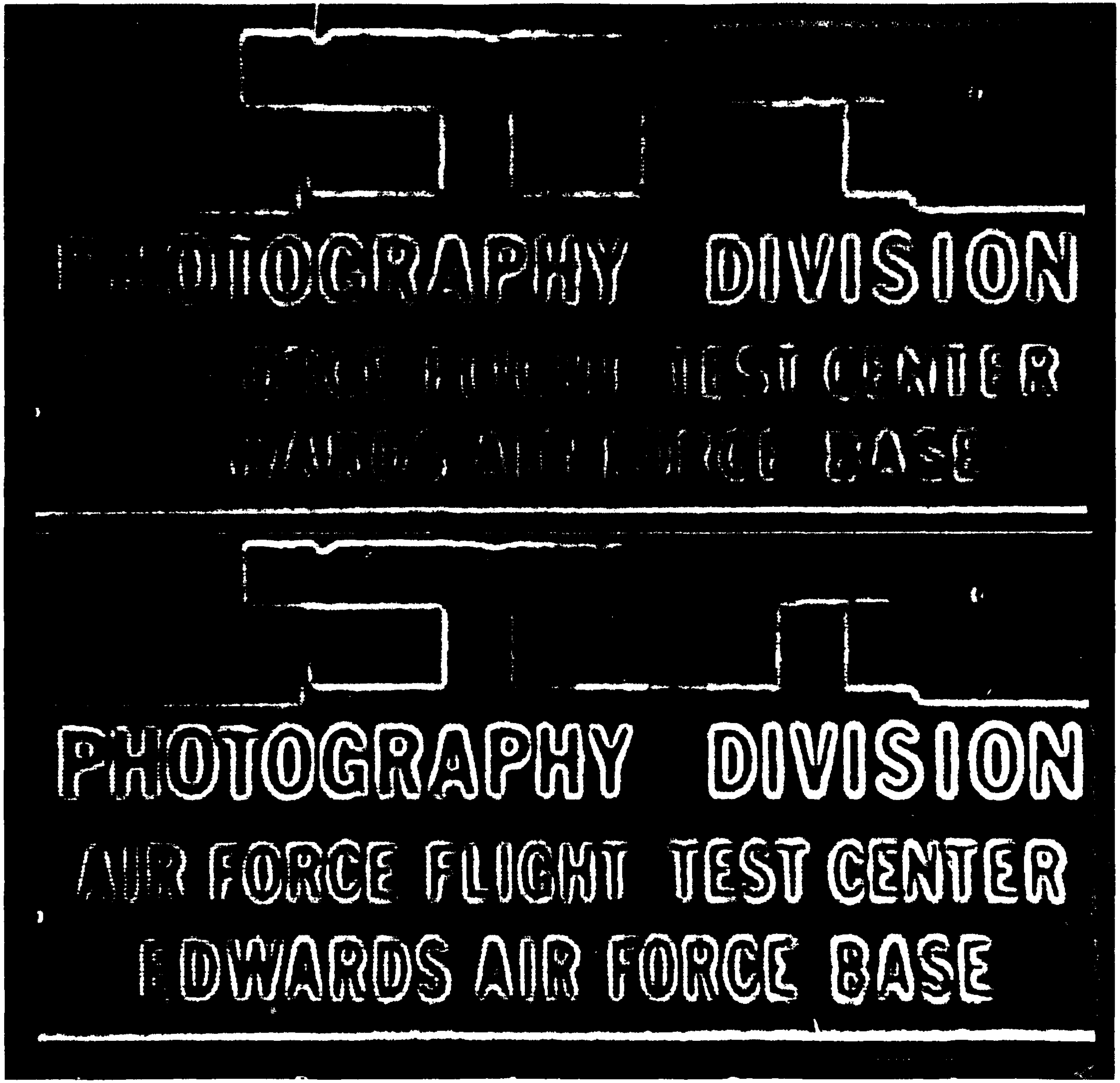
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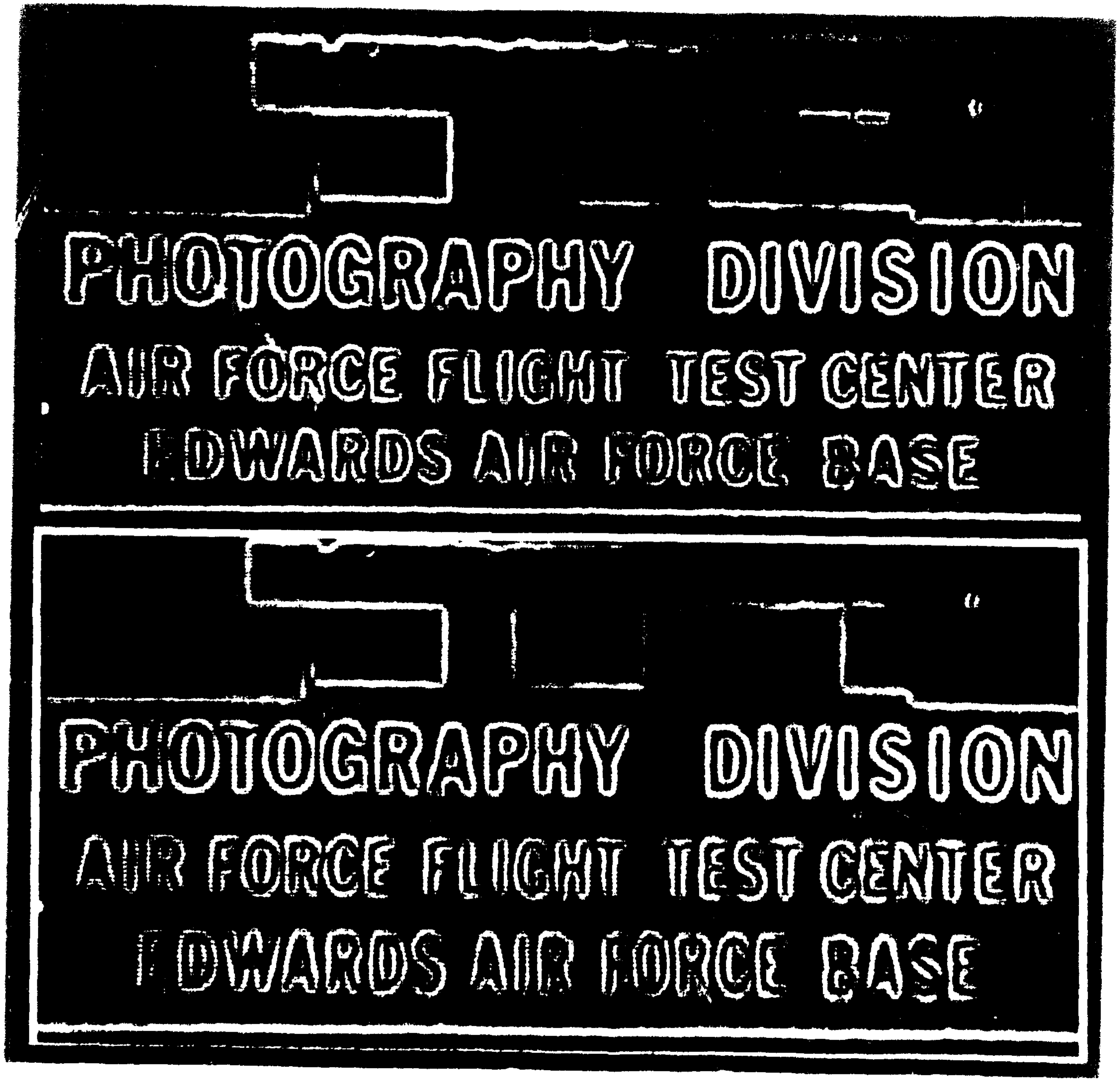
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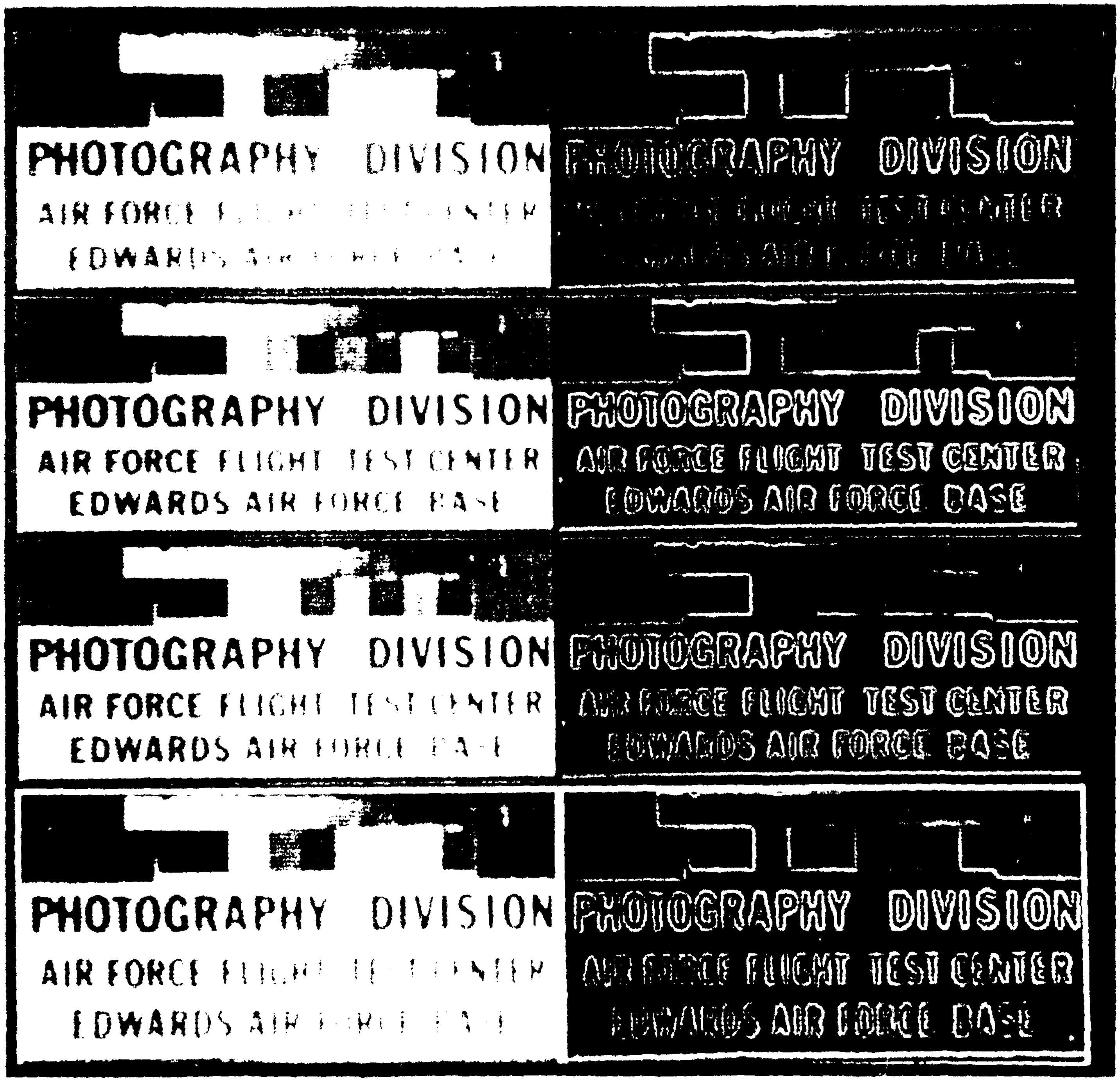
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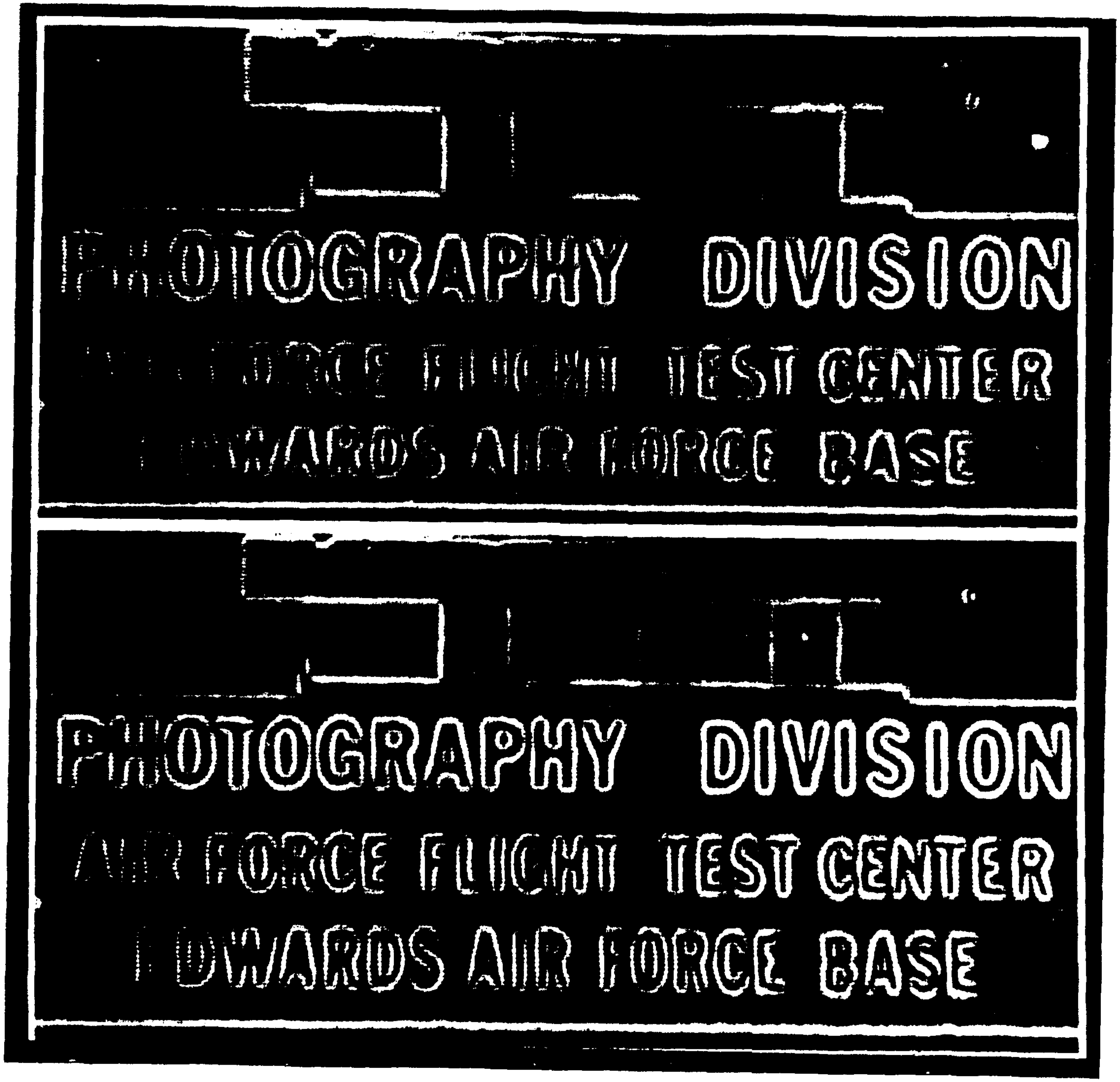
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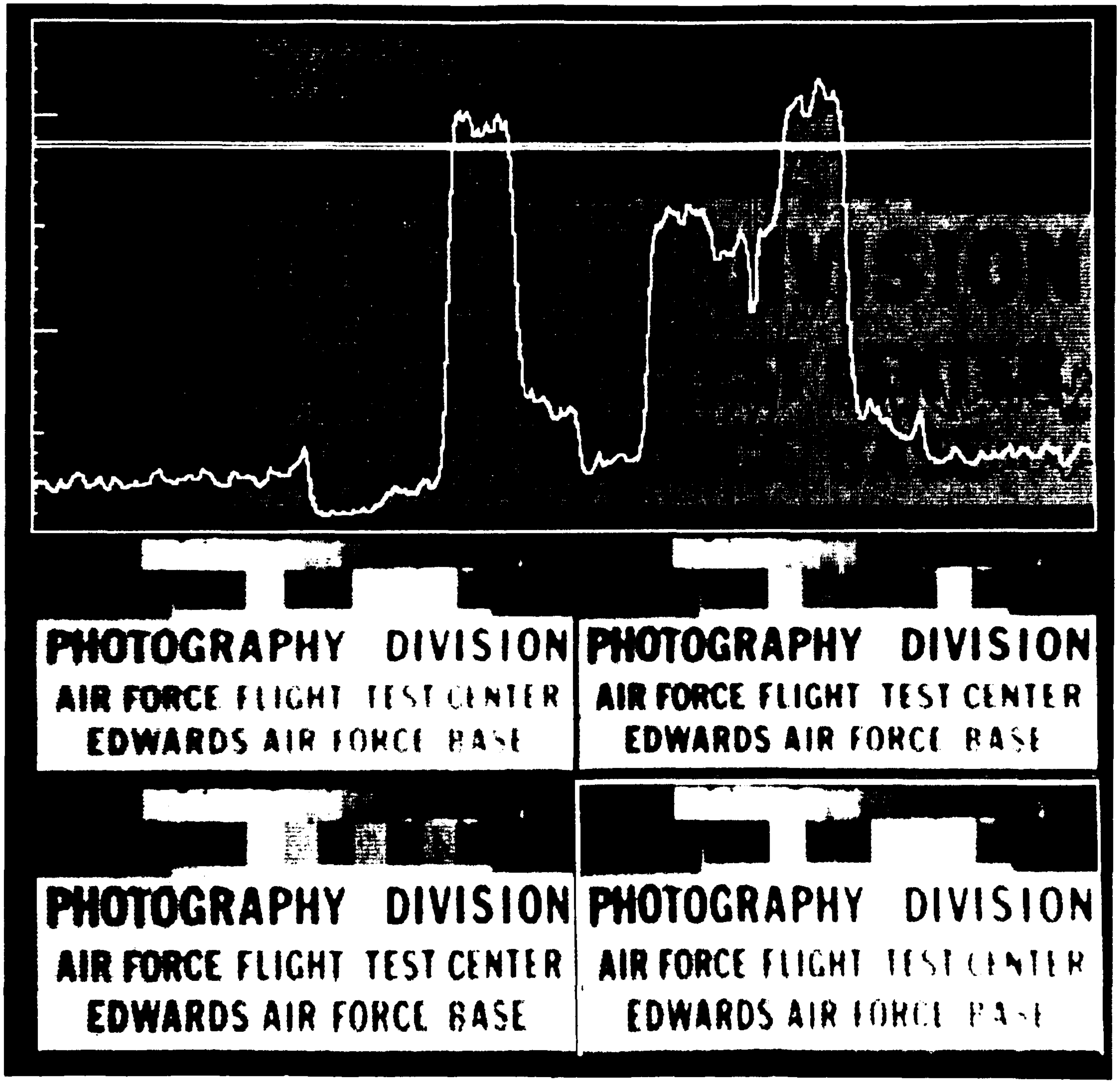
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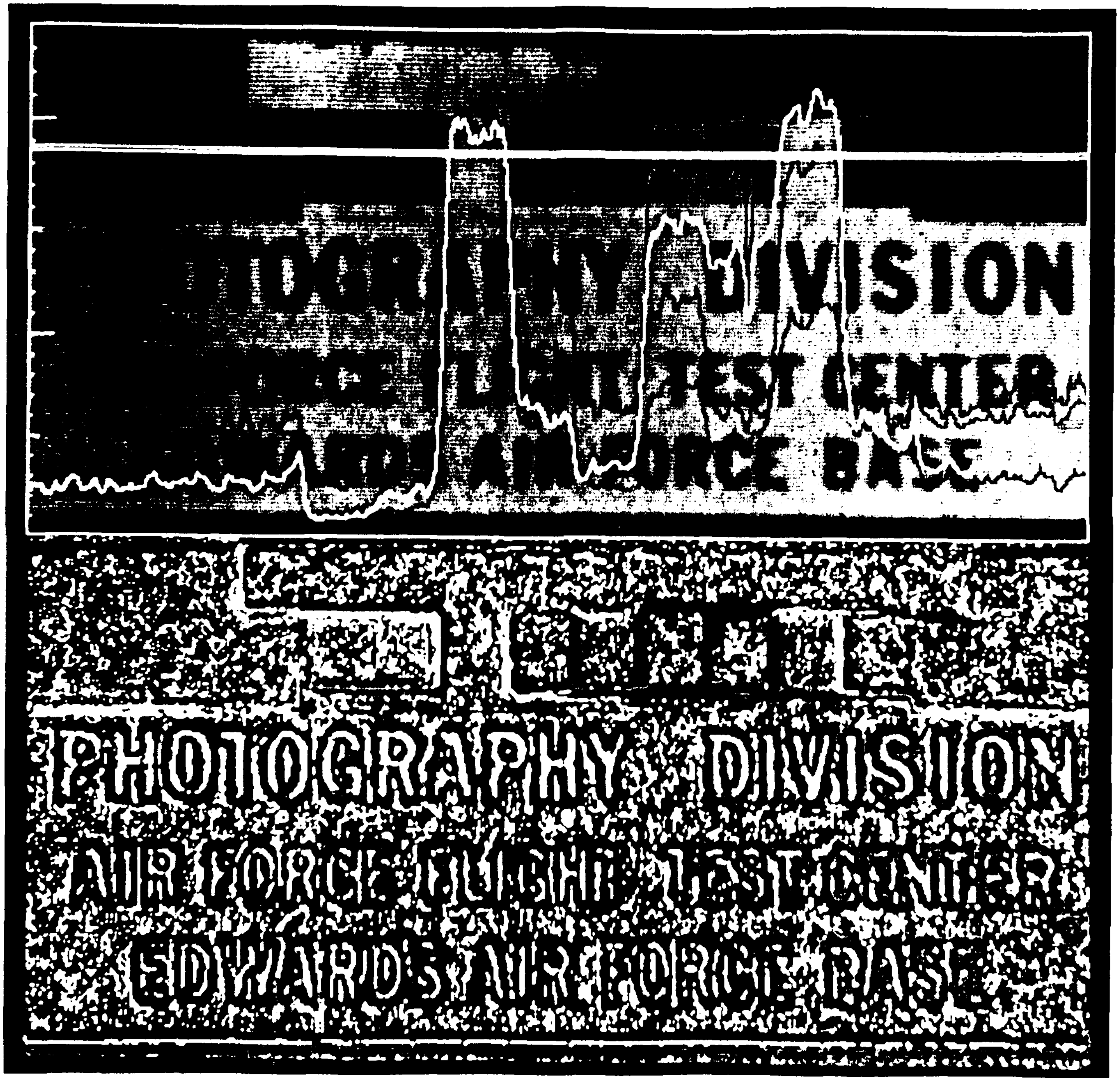
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