EVALUATION OF THE RS-14 LINE SCANNER IMAGERY FROM A USER'S POINT OF VIEW

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FOREWARD

This report has been put together to compile, into a meaningful story, a series of measurements made on RS-14 thermal imagery in the course of our remote sensing programme at CCIW.

It is intended to be an informative rather than a critical evaluation of the imagery. However, it is our hope that the problems we have encountered will be looked into by interested workers at the Canada Centre for Remote Sensing.

INTRODUCTION

If infrared imagery is to be of value to user agencies, then its quantitative potential must be exploited to the utmost extent. This report describes a quantitative evaluation of high altitude RS-14 infrared imagery collected over Lake Ontario during the 1972 CCIW field season.

The infrared surveys were carried out by the Airborne Sensing Unit of the Canada Centre for Remote Sensing as part of the CCIW IFYGL Remote Sensing program.

The report will only deal with the aspects of the imagery pertaining to its quality and ability to produce quantitative temperature estimates of the water surface. The limnological aspects of this imagery are reported elsewhere (Thomson 1973).

For details of the scanner the reader is referred to the RS-14 Technical Manual.

The Imagery

The first set of imagery examined was obtained on June 7, 1972. A "first look" at this data was encouraging, in that good contrast was apparent on the imagery and important lake thermal features were readily identifiable (see figure 1).

A check of the mission flight logs showed that the gain and D.C. level were constant over flight lines 13 - 21.

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Using this as a starting point, measurements of film density were carried out for all these flight lines. The measurements were made along the nadir points for each flight line. Using available ground truth (see Thomson 1973) two temperatures were assigned to two corresponding density values, and,assuming a linear interpolation of density vs temperature, a map of isotherms was constructed for the western basin of Lake Ontario.

While the absolute values of the temperature did not agree too well with the ground truth data, the relative temperature patterns were in very good agreement (see Figure 2).

The Calibration Temperatures

The RS-14 line scanner is equipped with two black body calibration sources. In theory these two sources provide two temperature references for calibration of the imagery. In practice, however, the optical design of the instrument permits the detector to view a source of some equivalent black body temperature that is not directly related to the actual temperature of the reference body. This effect is brought about principally by emission and absorption from optical components in the optical path between detector and the calibration source.

For example, the temperatures of the calibration sources for June 7 lines 13-21, were 24.5° and 1.5° respectively. By measuring the density of the two calibration signals, one can then estimate, by

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assuming a linear relation between density and temperature, the temperature of the lake surface. When this measurement was applied, we found that the area corresponding to 3°C water, came out to be 20°C. It is obvious that one cannot use the calibration sources with the present available information. The only method of estimating surface temperatures is to utilize ground truth data as calibration points.

Asymmetry on the Imagery

The density measurements were all made along the nadir line of the film. Over areas of the lake where the surface water temperatures are homogeneous, the variation in density across the film transverse to the nadir line should have a parabolic shape. This is because the atmospheric effects will be the same as the detector scans out from either side of the nadir position.

Figure 3 shows transverse density traces across the film for three areas where we would expect a symmetrical response of density as a function of distance from the nadir. With reference to the figures, it can be seen that this is not the case. The nature of the asymmetry must be due to miss-alignment of the optical system as the slope of the curve was found to be independent of aircraft orientation.

The important point about this asymmetry in the optical system is that it makes the position of the nadir line a very critical element in any analytical procedure. It also makes excursions from the nadir line rather dangerous in terms of the interpretation problems that will be encountered.

Calibration Step Wedges

A series of ten grey step wedges are located along the edge of the film (see Figure 1). These provide a means of checking non-linearities in the film processor. The wedges are generated by a series of calibration voltages fed into a CRT.

The criteria for the stability of the step wedge is that corresponding grey levels must lie within 0.05 for different V/H settings of the scanner. Figure 4 shows densitometric measurements of step wedges for three different flight lines taken from the August 28 data. This particular example indicates that the differences here lie within the 0.05 range.

Figure 5 shows the values for optical wedge steps 5, 6, and 7 for a large number of flight lines taken from the June 7 mission. Also shown in Figure 6 are a number of measurements of the variation on individual flight lines. Again, the variation here is within the $\pm$ 0.05 range. However, somewhat disturbing is the large variation along a single flight line i.e. line 17.

A further examination of the grey steps show that there is considerable variation over the small square (see Figure 6) itself. This non-uniformity must be either due to variations in the reference voltage, non-uniformity of illumination, or a combination of the two.

It is not clear at the present time whether the $\pm$ 0.05 density variation in the step wedge can be directly applied as an error to the density on the film. Should this be the case, then we estimate a basic error of ± 1.5°C as a result of this variation.

While this error may not be too serious when large temperature ranges are present, it certainly is critical when applied to quantitative measurements of small temperature ranges, such as occurred in the August 28, and 29 data.

Conclusions

This brief examination of the RS-14 imagery has made us aware of the inherent problems of this scanner system. Great caution must be applied when any quantitative examination of the imagery is made.

A number of the problems noted by us could be answered by a thorough test and calibration of the system, both in the laboratory and under field conditions.

We feel that this approach is vital if the full potential of this instrument is to be realized.

REFERENCES

THOMSON, K. P. B. 1973. Remote Sensing and its application to the study of the Great Lakes, in preparation.

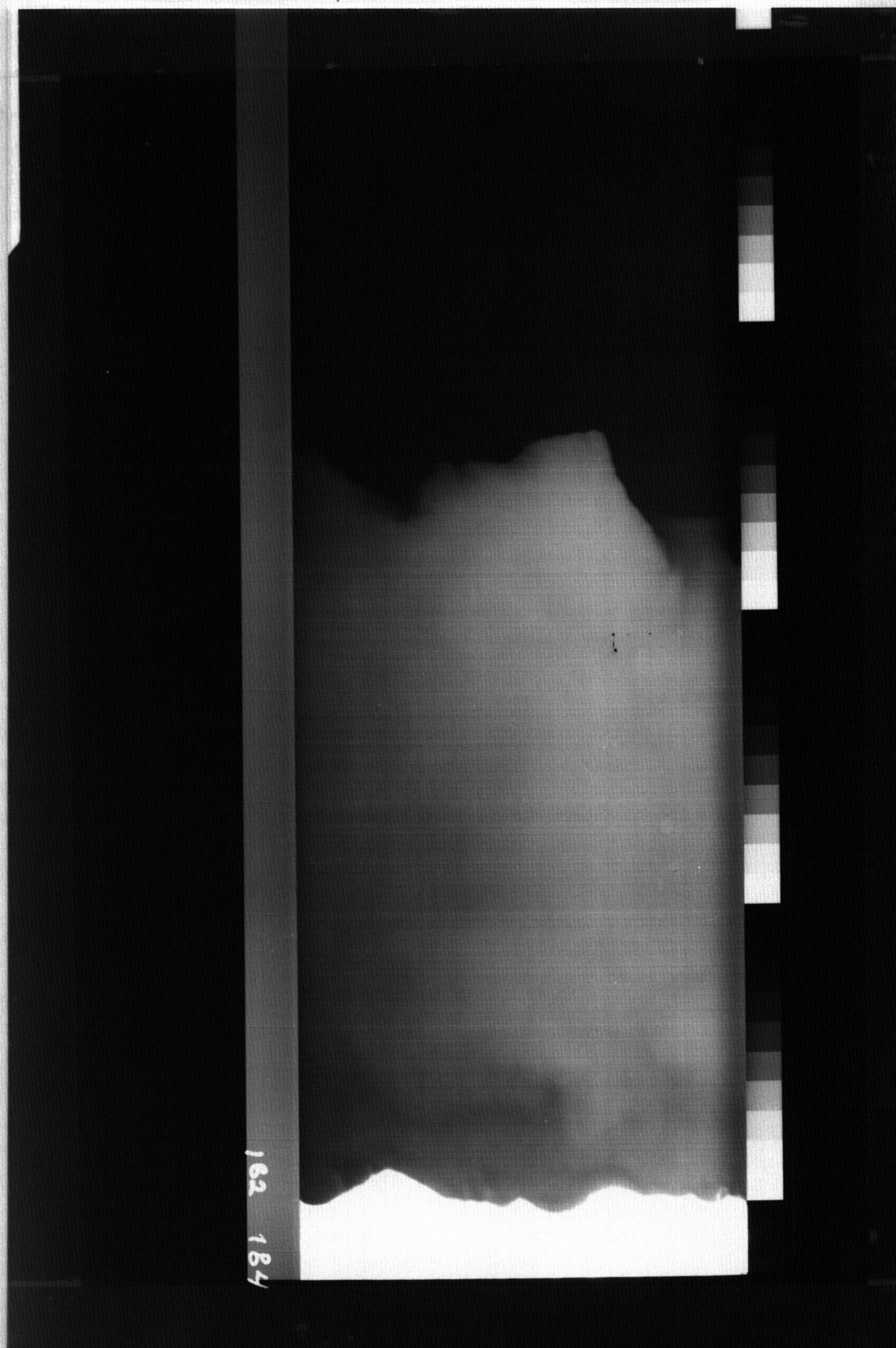
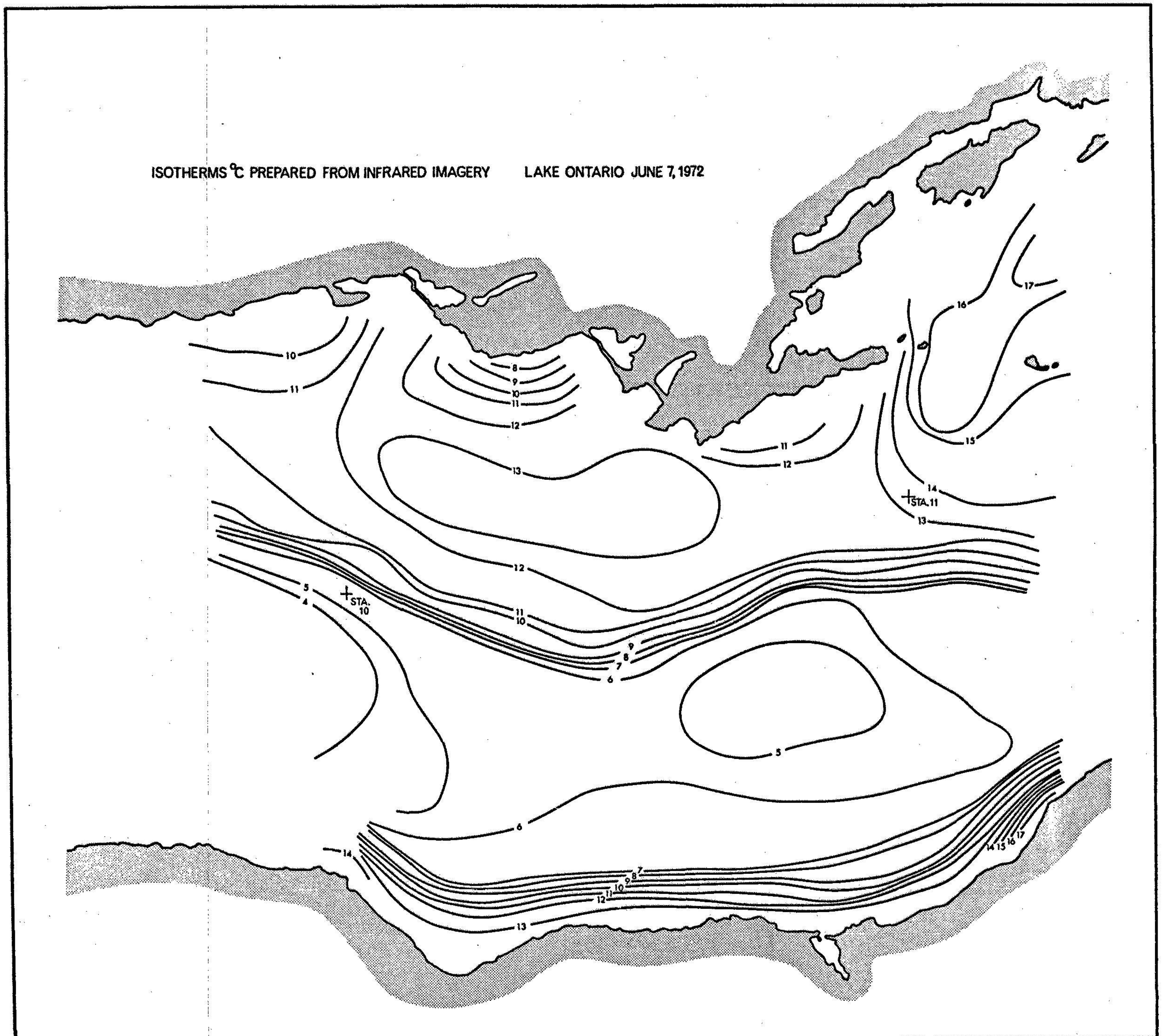


Figure 1. Thermal Imagery, RS-14 Scanner Lake Ontario - 35,000 ft. Altitude



ISOTHERMS °C PREPARED FROM INFRARED IMAGERY
LAKE ONTARIO JUNE 7, 1972
STA. 10
STA. 11

Fig. 2

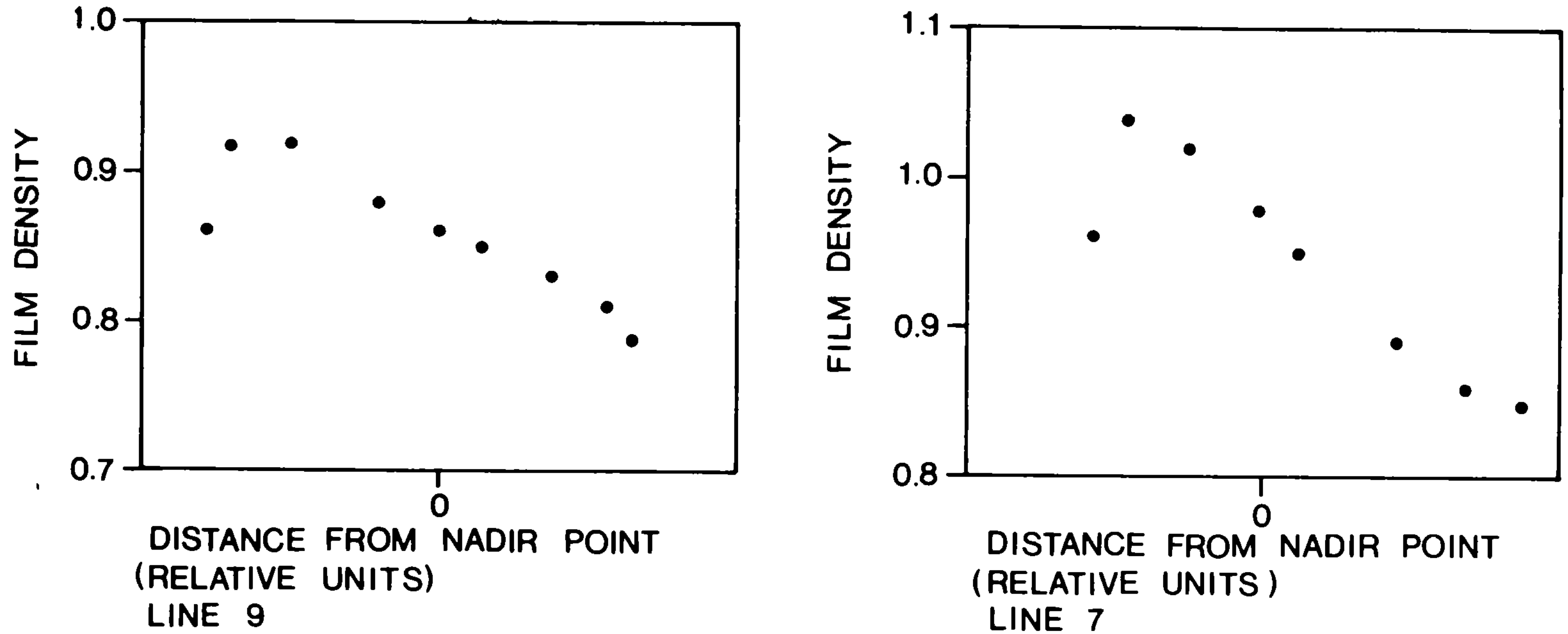


FIG. 3 FILM DENSITY TRANSVERSE TO NADIR LINE
TAKEN FROM AUG. 29 DATA

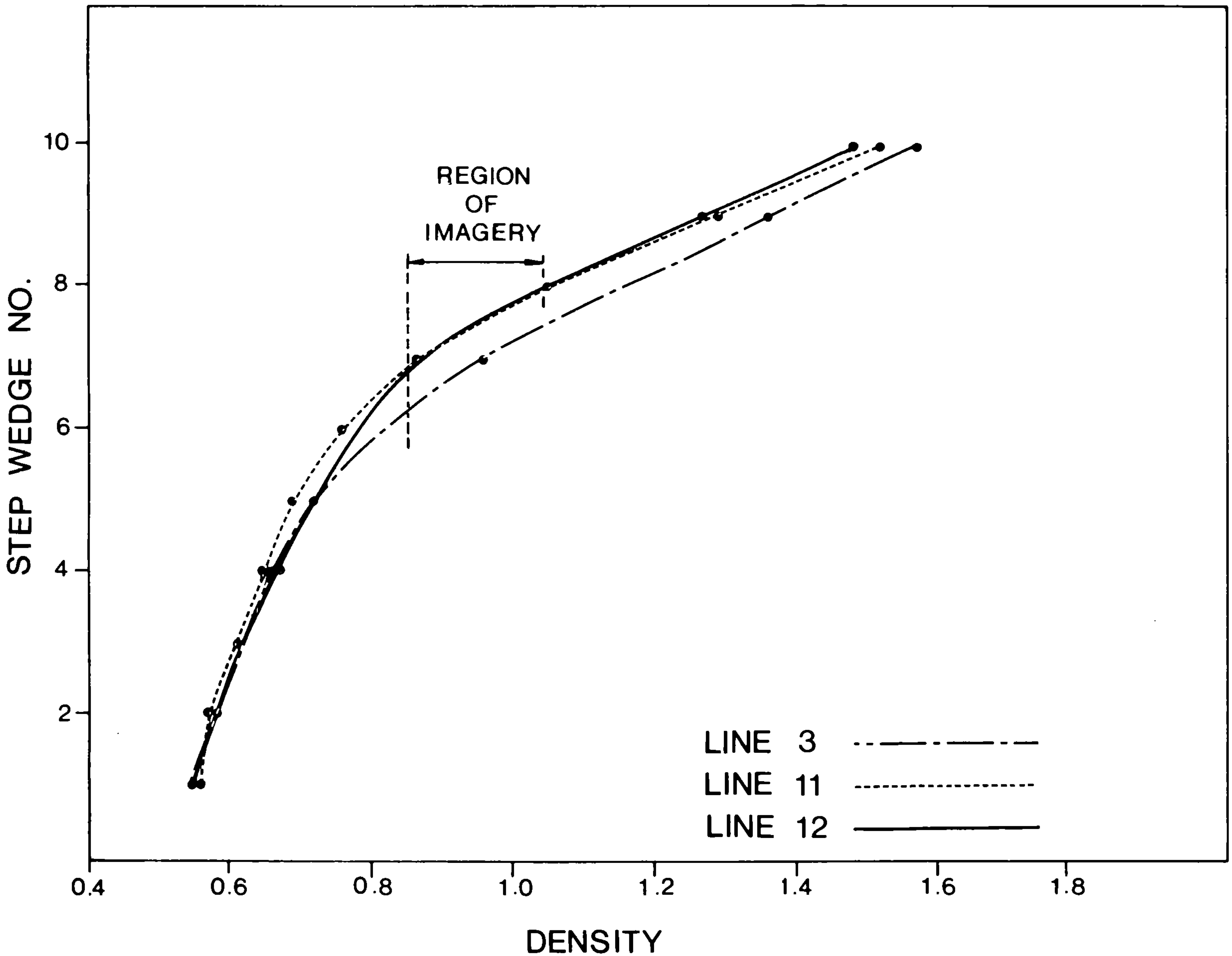


FIG.4 CALIBRATION WEDGE Vs DENSITY
AUG. 28, 1972
FALCON

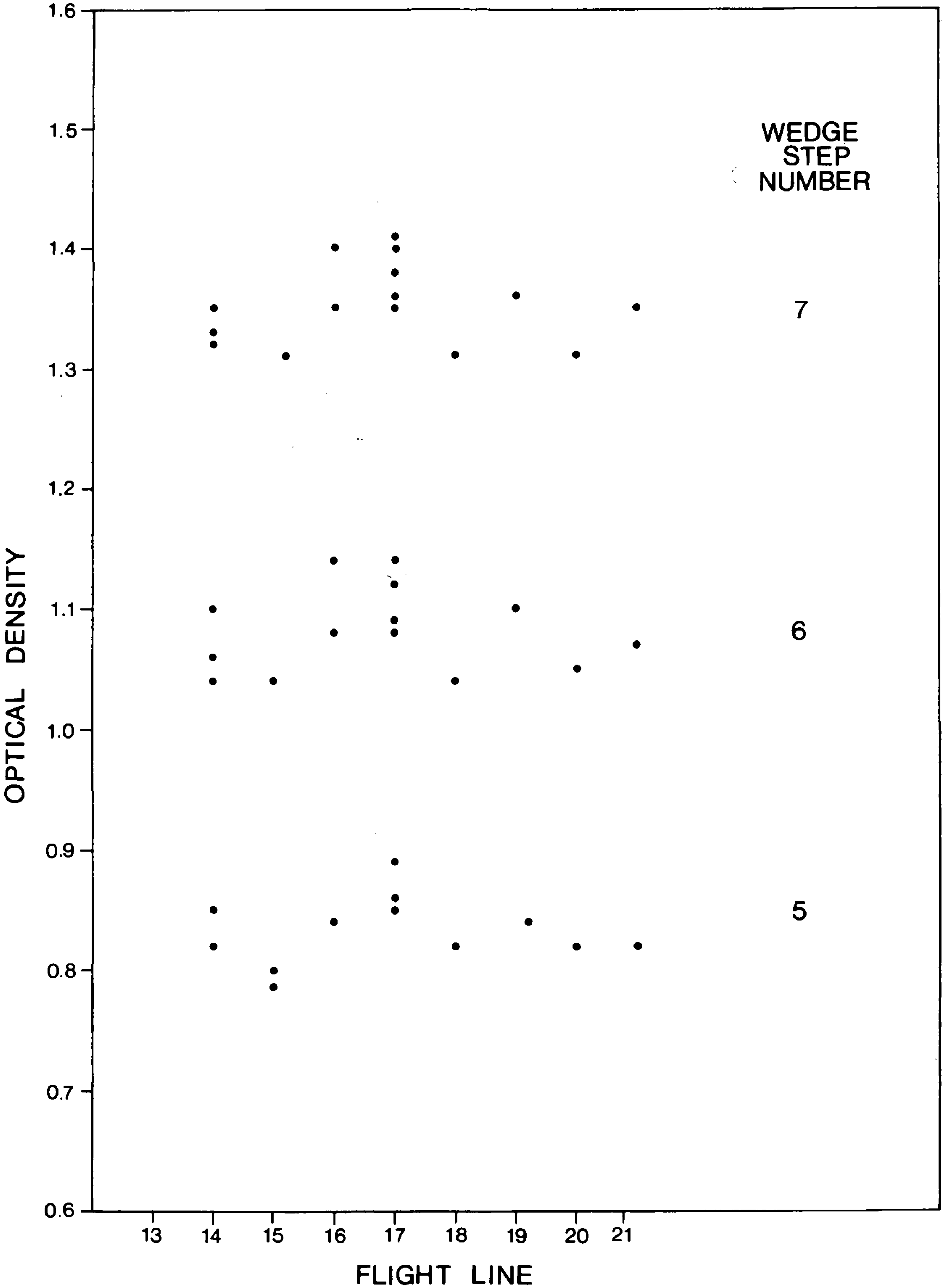
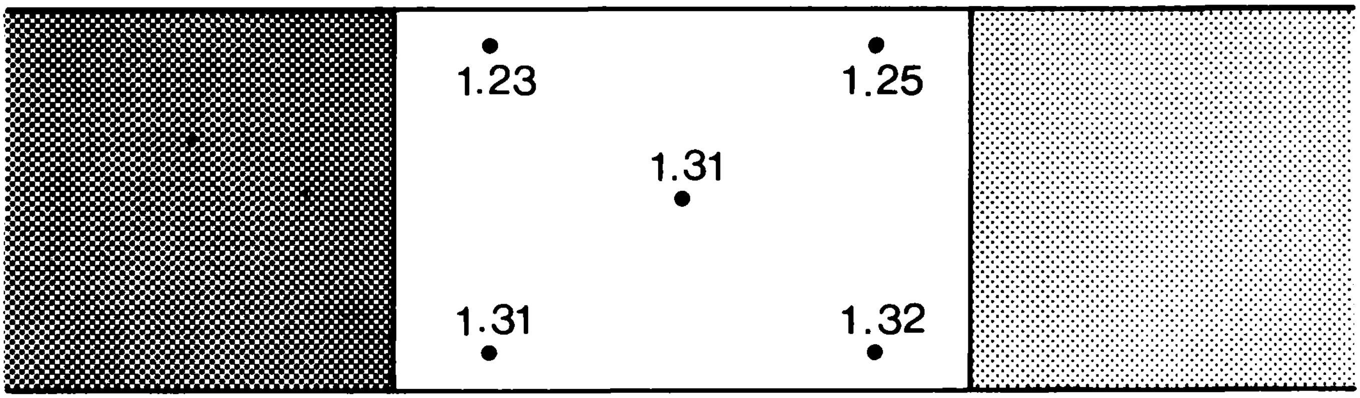
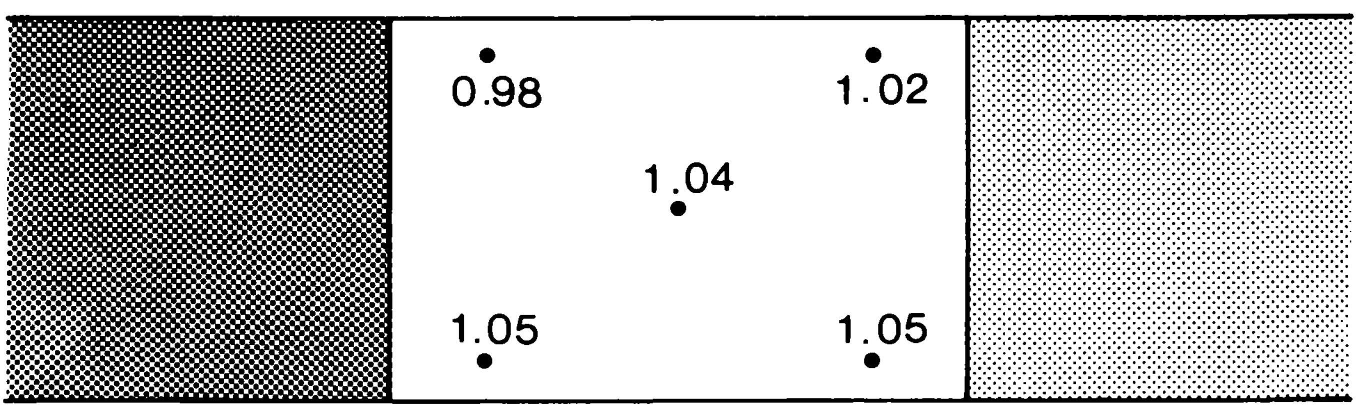


FIG.5 FILM DENSITY Vs FLIGHT LINE NUMBER FOR OPTICAL WEDGE STEPS 5,6,7



(A) DENSITY VARIATION ACROSS STEP WEDGE No. 7
LINE 15 JUNE 7, 1972



(B) DENSITY VARIATION ACROSS STEP WEDGE No. 6
LINE 15 JUNE 7, 1972

FIG.6 OPTICAL DENSITY VARIATIONS WITH POSITION PLOTTED ON ONE STEP OF THE OPTICAL STEP WEDGE