THE GRID EFFECT IN AERIAL PHOTOGRAPHY*

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ABSTRACT

Grid-shaped images, superimposed on aerial photographs, sometimes occur under conditions which are not always predictable. Heretofore various phenomena, including "reflex printing," have been used to explain this effect. In the work described herein, the grid effect is shown to be caused by local differences in film sensitivity, associated with complex temperature-moisture patterns on the emulsion during the time of exposure. Means of eliminating the effect, and precautions which may be taken against it, are given.

INTRODUCTION

INFREQUENTLY, but unpredictably, aerial photo missions have resulted in negatives having an "image" of the vacuum grid focal plane plate superimposed on the main pictures. For many years this "grid effect" has been considered to be simple reflex printing caused by light reflected from the squares on the metal vacuum frame of the aerial camera magazines. Since this effect appears fairly rarely it has not heretofore received much attention. Attempts have been made to reproduce it under flight conditions, but not successfully.

Laboratory experiments have been conducted to study the grid effect, using simple equipment which gave a wide and continuous range of temperature and humidity conditions. The experimental conditions were such as might conceivably be encountered in aerial photographic practice under service conditions. In these investigations the effect has been intentionally reproduced for the first time, under controlled conditions. It has also been "reversed." That is, it has been made to appear both as dark lines on a lighter background (which is the normal effect), and also as lighter lines on a darker background. In one experiment, both the normal effect and the reversal were made to appear on the same piece of Tri-X Pan Aerial film.

Because the effect described has not been very well understood, it has not been known how to take any precautions to assure a given photo mission not being affected by it. The results of these experiments should be of value to aerial photographers in helping to understand and to avoid this effect by taking certain precautions before and during photo flight missions.

DISCUSSION

In order to arrive at some understanding of the "grid effect" without using an elaborate quantitative approach, it was decided to use methods which would give a wide and continuous range of temperature conditions, varying with time, length, or some other suitable parameter. The investigation was therefore of a semiquantitative nature, but it produced definite results in a relatively short time.

Figure 1 is a photograph of a hollow, black anodized, aluminum cylinder with fine and coarse grooves. This apparatus, with a suitable thermometer, was the only laboratory equipment used in the experiments. On one portion of this "grid tank" the grooves and squares are of the same size as the standard ones on Air Force camera magazines. Alongside these is a similar pattern but with much coarser grooves. These were provided on the assumption that they would exaggerate the effect, making it easier to produce. This assumption later proved to be correct; without the coarse grooves, the laboratory reproduction of the effect with the standard grooves might have been more difficult and taken much more time than it did.

In the first experiment, the grid tank was filled with clean, white sand and stored in an incubator at 120°F., at less than 10% R.H., for one week, to allow the sand to reach a constant temperature and become

* On Nov. 12, 1954, the Air Force Security officials at Wright Air Development Center released this paper for publication.

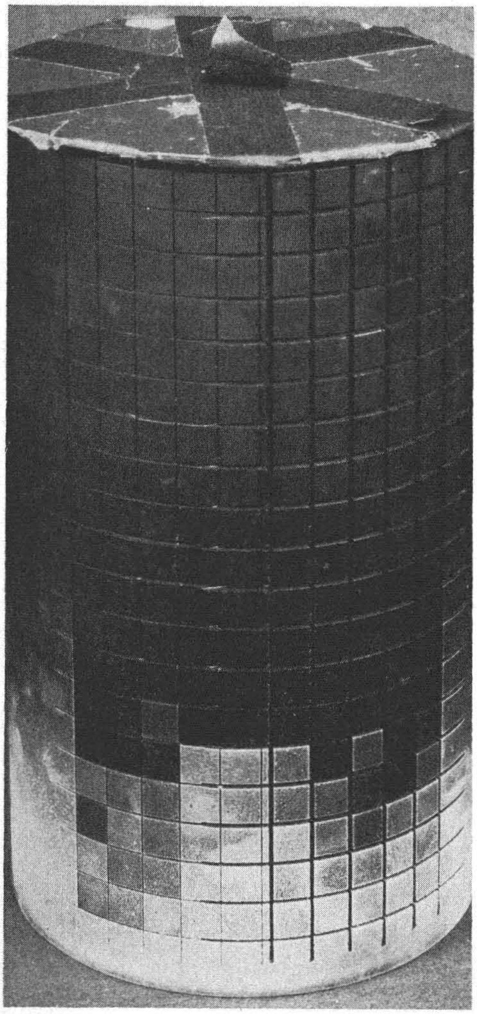

FIG. 1.—Grid tank, 10 minutes after adding 150 gms of dry ice.

very dry. The warm tank, insulated with cellulosic material, was then taken to a darkroom having a temperature of 75°F., R.H. about 50%. Pieces of Tri-X film were held in contact with the grid for a few seconds, and exposed for 2 to 3 seconds to the light from a "book" match 5 meters away. Two of the films later proved to have been fogged before exposure but one showed no fog. None seemed to show any grid patterns, but on later examination, very faint grid lines were found on one piece when viewed on a "light table."

After the first experiments, tap water at 150°F. was substituted for the sand in the grid tank. A cooling curve was run and it was found that the tank radiated 86 watts at 147°F., dropping gradually to 37 watts at the end of about 2 hours, the temperature change being about 47°F. The slow, gradual temperature change allowed experiments to be made at a normal rate with a temperature range simulating that of a heated camera magazine. Good, strong reproductions of the "normal" grid effect (dark lines on lighter background) were obtained with this technique. A faint grid pattern was obtained at as low as 100°F. The film used in these experiments was Tri-X (Class N) Panchromatic. It was developed 6 minutes in a tray of D-19 at 68°F. Figure 2 shows a positive print made from a test film showing the normal grid effect.

One technique found useful in these studies consisted of applying a prepared sheet of clear fixed-out aerial film to the grid tank. This film had been prepared by bathing in a solution of cobalt chloride, then drying. This film gives a test indication for moisture. When dry, the film is blue—when moist the color is pink. This indicator film at relative humidities of 40% or higher, when applied to the warm grid for short intervals not in excess of 10 seconds, gave pink lines and blue squares. The pink lines indicate moisture in the grooves of the gridworks. If the film re-

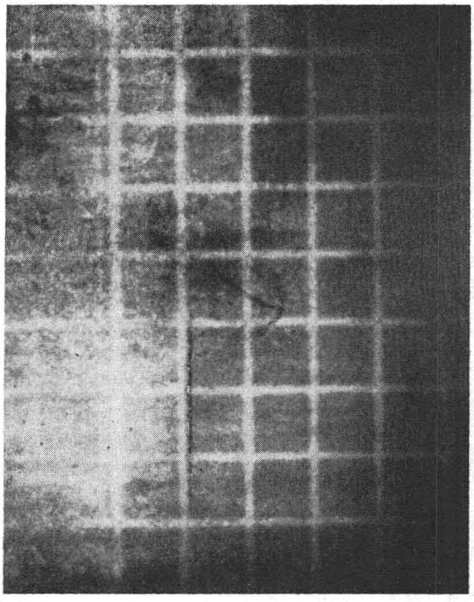

FIG. 2.—Positive print from experimental film showing normal "Grid effect."

mains on the warm grid more than 5 seconds or so, depending on the tank temperature and film moisture content, the grid effect disappears. This was found to be true both with indicator film and with standard aerial film. This means that a uniform temperature-moisture equilibrium is reached after a few seconds.

Mr. Raymond Davis of the National Bureau of Standards has published information and photographs of apparatus which can be used to show the rapidity with which a gelatine silver-halide emulsion "soaks up" moisture. This rapid moisture take-up is one of the reasons why it is very difficult to study the behavior of emulsion speed with regard to variations with temperature and humidity. Observations on film in humidifiers of the type used by Davis show that moisture take-up by the gelatine emulsion is very ıapid, while the film base responds much more slowly.

In these experiments it was found that cool film on a warm grid very easily gave the normal grid effect (dark lines). This re-emphasizes the fact that film should undergo a "tempering" or warming period of several hours after removal from refrigeration before it is used in a camera, especially in a heated camera, in order to minimize the chances of grid effect.

For temperatures of the order of 150°F., about 2 seconds contact with the warm grid produces the most grid effect. As the temperature decreases to 100°F. the contact time for optimal effect increases to 5 seconds or more.

A reversal of the grid effect was obtained but with difficulty. Figure 3 is a positive print from one piece of film which showed both effects, i.e., the normal dark lines with lighter squares, and also the reversal with light lines and darker squares. These reversals were obtained by using a grid tank cooled with dry ice so that a graduated pattern of temperatures existed on it as shown in Figure 1 which is a photograph of the grid tank cooled with dry ice. Class N (Tri-X Pan) film was first warmed on a separate, smooth tank to 150°F. for 10 seconds, then quickly held in contact with the cold grid tank and flash exposed. Parts of the grid tank were above the dew point of the air in the room, some parts at the dew point, some at various temperatures below the dew point and even below

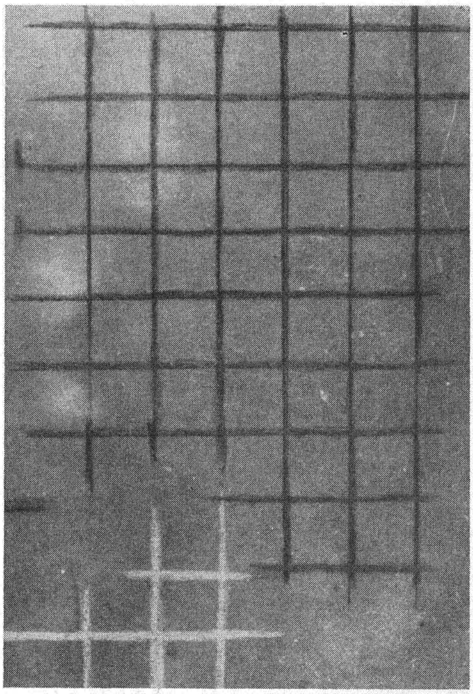

FIG. 3.—Print showing both the normal and reversed grid effects, both on same experimental film.

freezing. As seen in the photograph, the grooves act as thermal barriers and the squares act as heat reservoirs which tend toward a uniform surface temperature. Heat will be conducted to or away from film quicker when in contact with the metal squares than when contacting the air space in the grooves. Consequently, a temperature-moisture pattern, similar to latent image, is set up in the film. This modifies the film sensitivity locally and can result in a grid image superimposed on an aerial picture. The image may be normal or reversed, as has been shown experimentally, depending on the temperature conditions of the grid and the temperature and moisture contents of the film and ambient air.

Conclusions

It is concluded that the grid effect is associated with localized variations in moisture and temperature of the film. First, there is formed, in effect, a moisture-temperature pattern corresponding to the shape of the vacuum plate grid which holds the film in the focal plane.

Then, during exposure, this is changed to a photographic latent image because of the localized differences in emulsion sensitivity caused by the moisture-temperature variations. Upon development it is changed to a silver deposit in the form of a picture of the grid.

The grid effect is of an elusive and transient nature and is only obtained during very critical intervals of time. It is dependent upon the rapidity with which the emulsion reaches moisture equilibrium. If film with normal moisture content is in contact with a hot grid for more than about 10 seconds, the effect does not show up. This explains why it has heretofore not been possible to reproduce the effect during flight tests, because this fact has not been recognized.[3]

A reversal grid effect can be obtained, i.e., light lines on darker background, but this is not so easy to produce as the normal grid effect. See Figure 3.

Film which is at low temperature, such as film exposed in a camera directly after removal from a refrigerator, is most likely to cause the grid effect. This is especially true when it is used in cameras having heated magazines, and the exposure is made when the film has had only a few seconds contact with the warm grid.

The very narrow grid lines on modern aerial cameras are less likely to cause the grid effect than coarser lines. However, the same conditions causing the effect with the coarse grid lines will also tend to cause it with the finer lines.

The grid effect is associated with variations of film speed with temperature and humidity, which is a problem on which very little research has been done. More work needs to be done in the laboratory to find out how film performs at all humidities and temperatures likely to be encountered under service conditions.[1,2]

In an aerial camera having the same relative humidity and temperature as the film, no grid effects will be produced.

The same conditions which tend to cause the grid effect are also likely to cause local irregularities (distortions) of the film. This is undesirable from the standpoint of precision mapping.

The grid effect, thought by some to be of very little importance, or of only aesthetic importance, could act to obscure important details in an aerial picture. As one example, a motor convoy on a highway could be completely obscured by this effect.

The experimental results obtained lend further support to an idea which has been advocated of late years; that aerial cameras should be completely air conditioned, especially for precision mapping work. Otherwise, unequal moisture-distribution, as shown by these experiments, may result in local distortions of the film, as well as grid images.

Acknowledgment

The author wishes to acknowledge the very competent assistance received from Mr. Jack N. Thelen, photo-technician, who carefully processed the experimental test films, helped with the lighting and in other ways facilitated the experimental work.

References

1. "Measurement of Radiant Energy" edited by W. E. Forsythe, McGraw-Hill, 1937, pp. 263, 264.

   This reference quotes Dr. Lloyd A. Jones, Eastman Kodak Research Laboratory, as follows: "The literature relating directly to the dependence of sensitivity on moisture content (relative humidity of the atmosphere with which the photo emulsion is in equilibrium at the time of exposure) is rather meager."
2. Sheppard, S. E.: *Journal, Society of Motion Picture Engineers*, June 1930, pp. 500–518, "Some factors in Photographic Sensitivity."

   In this article Sheppard and his co-worker, Wightman present limited data to show that increased humidity causes speed loss, and increased temperature causes a speed gain for some photographic emulsions. No general conclusions regarding the dependence of film speed on moisture and temperature are given.
3. Davis, Raymond: Research Paper RP1051, *Journal of the National Bureau of Standards*, Vol. 19, Fig. 20, December 1937.