A CHART FOR USE IN INSPECTION OF AERIAL PHOTOGRAPHY FOR THE DETERMINATION OF TILT

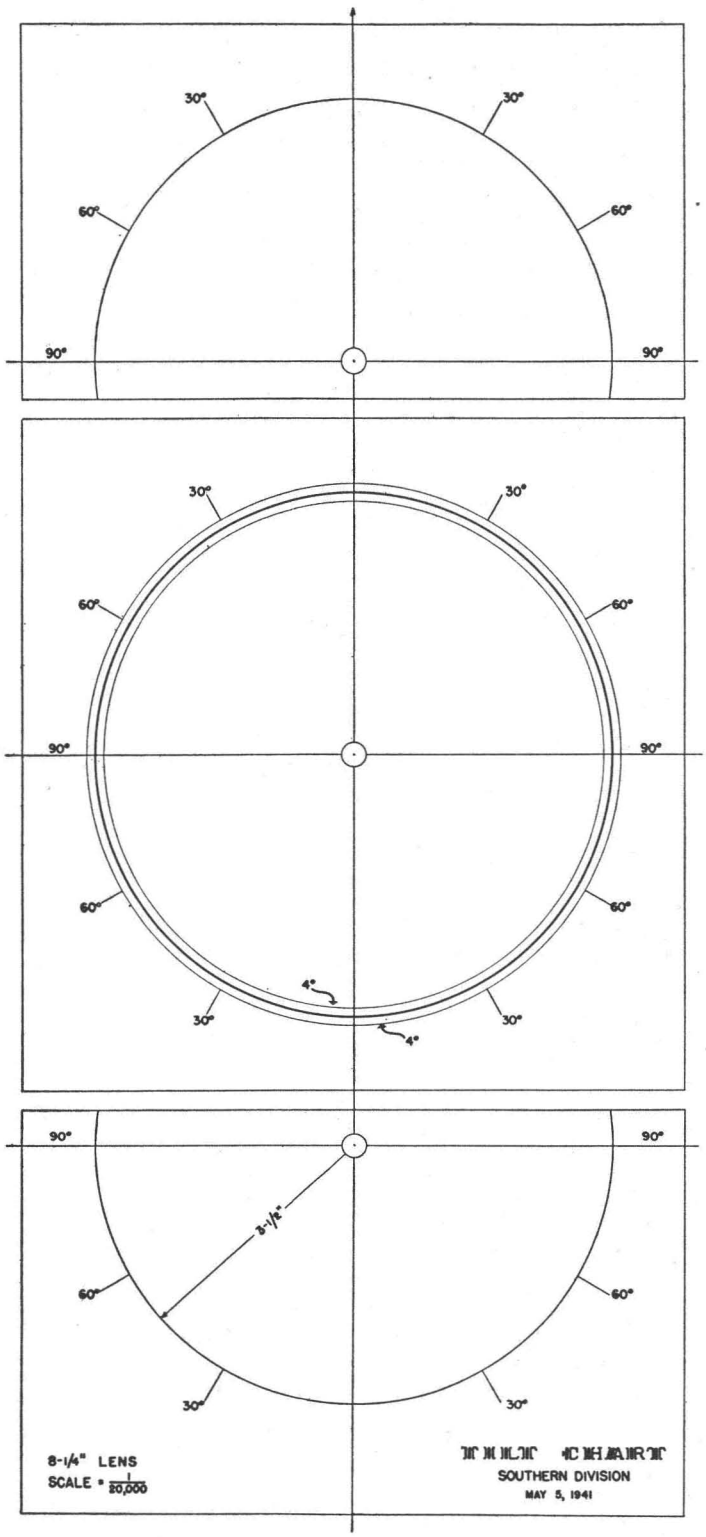
J. A. Stevenson
Agricultural Adjustment Administration
Agriculture Department

A LARGE amount of photography has been inspected and is being inspected in the Southern Region of the Agricultural Adjustment Administration to determine if such photography meets certain standards set up in the specifications for aerial photography. All of these materials are furnished by contractors who are awarded the contracts for furnishing vertical negatives, contact prints, and photographic indexes on the basis of a unit price per square mile. Most of this photography is obtained at a scale of 1:20,000 with lenses having a focal length of $8\frac{1}{4}$, 10, or 12 inches.

The preliminary inspection of the aerial photography is made by employees in the State offices. This preliminary inspection is made to determine coverage, quality, and scale. The part of this inspection which has been difficult to report in a definite way is with reference to the amount of tilt in the photographs. The specifications now require that the tilt about any axis shall not exceed 4 degrees for any individual photograph and shall not exceed an average of 2 degrees in a 10-mile flight line. The State office inspectors have been making the determination for this tilt by matching identical image points on successive prints by flipping, judging by such inspection the amount of tilt.

In order to provide a more uniform determination of the amount of tilt, a tilt chart has been prepared. This chart is reproduced on film base and it is used as an overlay over three successive photographs in a flight line. It provides a definite comparison line, which is in the form of a circle, to determine the amount of displacement from the center of the photograph and thus give a definite result for the amount of tilt evident in the inspected exposures. (A tilt chart is shown on page 182.) In operation this device is placed over three exposures with the center circle oriented over the central exposure in a group of three consecutive exposures. The horizontal and vertical lines crossing the center circle are placed over the collimating marks so as to bring the small center circle over the center of the exposure. There is a dot in the middle of the small center circle which will then fall over the center of the photograph. If this center does not fall on an identical point on the photograph, the print is shifted until an identifiable point is covered very near the center of the photograph. The adjacent prints are then placed under the semi-circles so that the identical image point appears under the center of the semi-circles. This operation places the three consecutive prints in order, with the same image point being under the center of the circles. A comparison is then made of the location of images found under the semi-circles with the location of the same images with respect to the circle over the center exposure. The location of these image points selected are studied to determine in what quadrant the maximum displacement is found. If an outward displacement is indicated in one quadrant, a corresponding displacement inward will be found at 180 degrees and a coincidence of images will be found at 90 degrees.

The base circle used is $3\frac{1}{2}$ inches in radius. This radius was selected in order to provide as large a circle as practicable so that the displacement will be large enough to be evident when the comparison is made. On the center circle con-


30°
30°
60°
60°
90°
90°
30°
30°
60°
60°
90°
90°
60°
60°
4°
4°
30°
30°
90°
90°
8-1/2"
60°
60°
30°
30°
8-1/4" LENS
SCALE = 1/20,000
SOUTHERN DIVISION
MAY 5, 1941

centric circles have been drawn both inside and outside of the $3\frac{1}{2}$-inch circle, to outline and define a tolerance zone within which the images must fall if the photography is within the tolerance limits specified. The width of this zone for a $3\frac{1}{2}$-inch circle is approximately .22 of an inch for an $8\frac{1}{4}$-inch lens (.11 outside and .11 inside) and displacements at one-half the interval or one-fourth the interval are readily determined by inspection, so that it is practicable to read relative tilt by the use of this chart to one degree, and when the tilt approaches the tolerance limit it is very definitely shown whether it is within the tolerance limits or outside the tolerance limits.

The device has advantage over matching images by the flipping method in that a comparison of the displacement of all points around the circle is obtained with the tilt chart. The points where the maximum displacement occurs can readily be determined. The use of this chart gives a further check that the displacement is plus on one side and at 180 degrees it is minus, and, further, at 90 degrees we have a check because the selected image points will coincide with the circles at those positions on the circle. The device can be used by the average draftsman and it does not require the special skill that is required by the flipping method.

Of course the displacement of images is affected by relief, but where relief affects a displacement of the image the chart will show that a displacement occurs at that particular location with regard to the circle without a corresponding negative (or positive) displacement at the opposite side of the circle. We can check on the succession of tilted photographs by moving the device progressively to three forward or backward exposures until it seems evident that we have under the device a level exposure.

The tilt in evidence from one comparison will, of course, be the relative tilt between exposures. The difference between the displacement of images at 180 degrees apart on the tilt circle will indicate the difference between the relative tilt and the tilt with the vertical axis. When the comparison has been extended to cover a 10-mile section of the flight line the evidence of relative tilt will approach the actual average tilt in the exposures. When, as in most cases, appreciable or measurable tilt is present only in one exposure, the determination will give the tilt with the vertical axis. The width of the tolerance zone is plotted for that side of the tilted exposure showing the maximum displacement.

It would appear that this device has possibilities for use in the rectification of photography.

The first charts prepared were for use with $8\frac{1}{4}$-inch lens photography but we have since prepared charts for use with 10-inch and 12-inch lenses, since we have some lenses of that focal length being used on our photography.

Copies of this chart were delivered to the nine State offices in the Southern Region shortly after it was prepared on May 5, 1941. Those charts are being used at the present time on an experimental basis in the inspection of aerial photography. A light-table used in connection with the chart provides for a more accurate determination of image location with respect to the center point and the base circles.