TIME INTERVALS FOR AERIAL PHOTOGRAPHY

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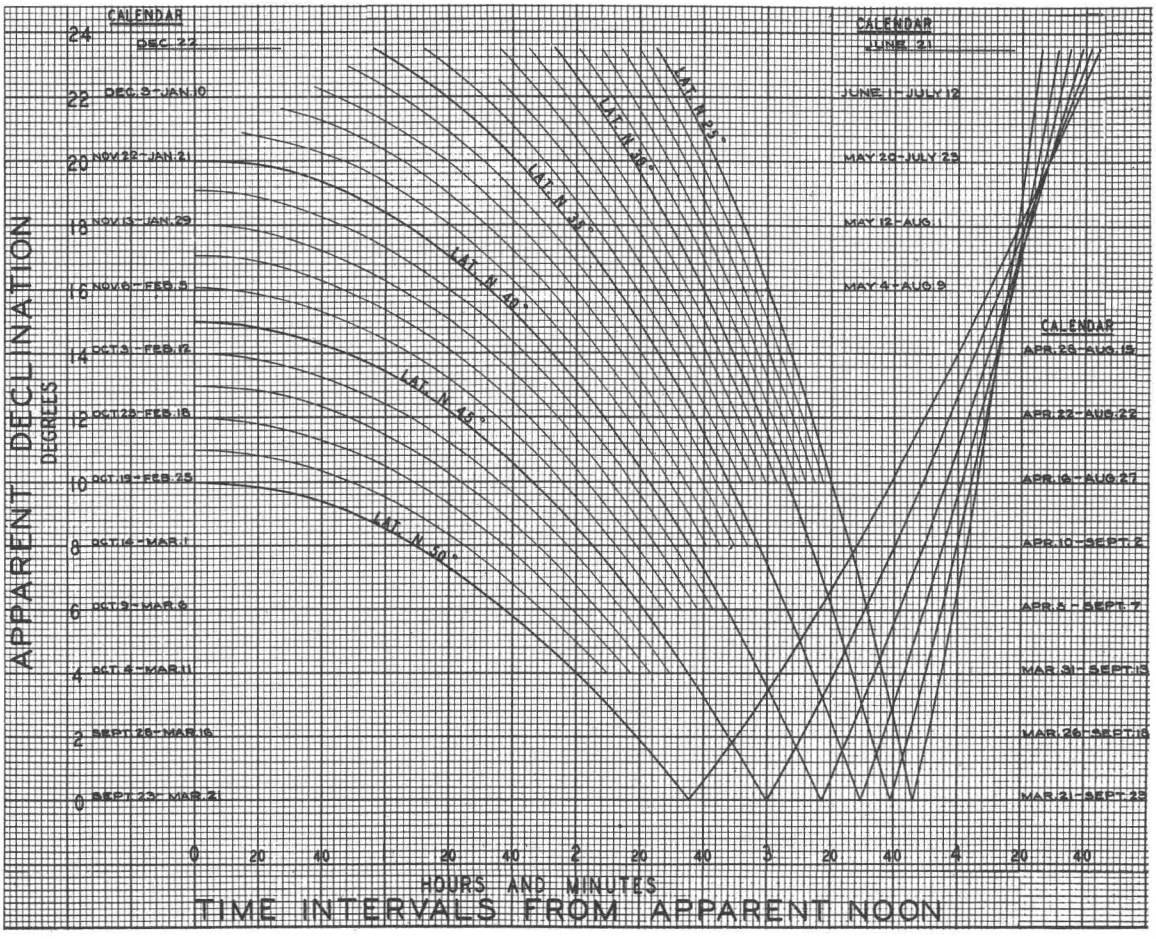
IN THE compilation of topographic maps from aerial photographs in districts where the terrain is mostly rugged, irregular and wooded, difficulty has occasionally been encountered in recovering the ground features obscured, to some extent, by shadows. Particularly have these shadows been troublesome since the advent and use of the Multiplex Aeroprojector, as it seems practically impossible to bring out this faint detail sufficiently clear on the diapositive and yet obtain suitable definition and density over the remainder of the plate. Of course, the use of proper emulsions and developers in printing the diapositives will partially correct this condition, but it is doubted that any procedure will give results entirely satisfactory. The remedy would then seem to be in executing the aerial photography only at such times as troublesome shadows do not exist. Accordingly, it has been customary to specify that no negatives shall be exposed when the sun is less than a stated altitude above the horizon. This minimum sun altitude was usually specified to be 25° or 30°, depending on the nature of the terrain to be photographed and the time of the year when it was expected to be accomplished. Now, if this requirement were strictly adhered to, the loss of detail due to shadows would be eliminated, but it has been our experience in the past to discover some few deviations from the specifications in this respect. These deviations from the strict letter of the specifications were undoubtedly due to a misunderstanding by the contractor of their full portent and the difficulty of finding the time necessary to make the required calculations previous to photographing when weather conditions suddenly became satisfactory for the work. With this in mind, a set of curves showing the time intervals for aerial photography under various conditions was prepared, and is presented here with the hope that it may be of some use to contracting agencies or contractors, especially as there is an apparent advantage in furnishing both contracting parties with the same means of making photographing time calculations thus facilitating an easy agreement between them.

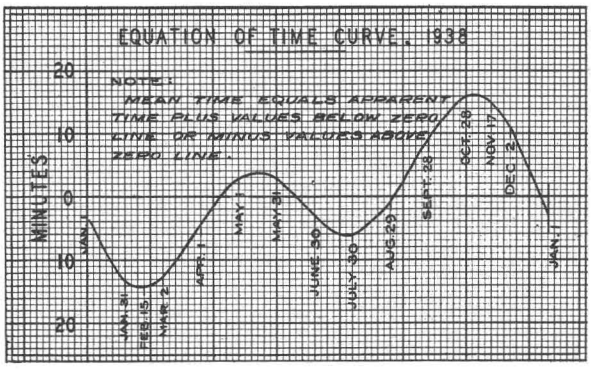
These time interval curves, appearing elsewhere in this paper, were computed by the hour angle formula, derived from the cosine law of Spherical Trigonometry, and used in the natural function form:

$$\cos t = \frac{\sin h - \sin L \sin d}{\cos L \cos d}$$

where h = Minimum altitude of the sun above the horizon
L = Latitude
d = Declination of the sun above or below the equator
t = Hour angle in degrees

The hour angles for each even degree of declination were computed for a band of latitudes covering the entire United States. The minimum sun altitude was chosen as 30° since that value is believed to be the most suitable to average conditions. To eliminate the need for an Ephemeris in deriving the sun declination for the date or dates desired, the mean day for each two degrees of declination has been placed in the graph. While these dates vary slightly from year to year, they may be considered as being sufficiently accurate for the purpose of the graph. In making corrections for time intervals, as read from the curves from values of Apparent Time to Mean Time, and hence to Standard Time, the Equation of Time Curve, the table of correction for longitude which accompany





TIME CORRECTION FOR LONGITUDE IN MINUTES OF TIME

LONG. DIFF. & CORRECTIONS DEGREES	0 MIN.	15 MIN.	30 MIN.	45 MIN.
0	0	1	2	3
1	4	5	6	7
2	8	9	10	11
3	12	13	14	15
4	16	17	18	19
5	20	21	22	23
6	24	25	26	27
7	28	29	30	31
8	32	33	34	35
9	36	37	38	39
10	40	41	42	43

1938 Time Intervals for Aerial Photography in the United States with Minimum Sun Altitude of 30 Degrees

this paper and a map of the United States should be consulted. In order to clarify the method of using this data it is thought an example of the interpolations and conversions would be worth-while.

Let us suppose that bids are invited on photographing an area, the mean latitude and longitude of which are approximately 40° and 100°, respectively. The specifications require all negatives to be exposed when the sun is at least 30° high, and liquidated damages are to be in effect, in case of failure on the part of the contractor to complete the photography within a certain number of photographic days. A photographic day is defined in these specifications as one containing three or more consecutive hours suitable for photography. The date of notification to proceed under the contract is expected to be about October 14. With these stipulations in mind, the prospective contractor then consults the graph and tables for certain information which will influence his bid, and complete agreement between the contracting agency and the ultimately successful bidder, as to limits of flying time, is afforded. The bidder first wishes to know the probability of completing the photography before such time as the sun is at a minimum altitude of 30° for less than three hours per day. On the Time Interval scale of the graph, the line representing 1 hour and 30 minutes is followed upward to its intersection with the curve designated as latitude 40°; this intersection is projected to the Declination scale on the left, and the corresponding date noted. In this instance, November 6 is thus determined to be the last date of the current year which could be considered a photographic day, and, in case the photography has not been completed by that date, February 5 of the following year is seen to be the date when operations would be resumed. Of course, photography could be accomplished, at the discretion of the contractor, until November 22 or after January 21, but the time intervals suitable for such activity would decrease from 3 to 0 hours. The next thing to be determined is the limiting times on any particular day when photographing would be permissible under the specifications. For the starting date, October 14, the line representing the declination corresponding to that date is followed from the Declination scale to its intersection with the 40° latitude curve; this intersection is projected downward to the Time Interval curve, and it is noted that the time interval for that day is 2 hours and 36 minutes on each side of Apparent Noon, or from 9:24 A.M. (Apparent Time) to 2:36 P.M. (Apparent Time). It will then be desirable to convert the limits of this interval to terms of Mean Time. This is accomplished by applying the correction for October 14 as taken from the Equation of Time Curve, in this case minus 14 minutes, or 14 minutes earlier. The limits expressed in Mean Time are then 9:10 A.M. and 2:22 P.M. Finally, to convert these limits to terms of Standard Time, the correction for longitude is applied. The difference in longitude between the center of the area to be photographed and the nearest standard time meridian is seen on a map of the United States to be 5°. Referring to the table of Time Correction for Longitude, a 5° difference necessitates a 20 minute correction. Since the standard time meridian in this case is west of the mean longitude of the area, this correction is minus. The limits of the time interval for October 14 are then 8:50 A.M. and 2:02 P.M., Standard Time. The time limits for any other day can be computed in a similar manner.

In the preparation of these curves and tables, no attempt has been made to obtained astronomical exactness. That is, corrections having no appreciable effect on the desired accuracy of the results have been ignored. Values have been computed for 1938 but within the precision needed can be used for several years.