Altitude and Azimuth of the Sun

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ALTITUDE AND AZIMUTH OF THE SUN

The position of the sun in the sky at different hours of the day at any place and its variation in different parts of the year are of considerable interest to architects and building engineers. To meet the requirements of designers of buildings in India diagrams (Figs. 1—6) have been prepared which give the altitude and azimuth of the sun for five particular hours of the day, namely, 0600, 0900, 1200, 1500 and 1800 hrs local apparent time throughout the year at 5° latitude intervals from 5°N to 35°N (excepting Fig. 5, where curves are drawn only at 10° latitude intervals to avoid congestion). The values of altitude and azimuth for any intermediate latitude can be obtained with sufficient approximation by interpolation. A knowledge of the position of the sun at these five specified hours is also sufficient to give a good idea of the diurnal movement of the sun across the sky and to locate approximately the position of the sun at any intermediate hour.

The values of altitude have been calculated with the help of the cosine formula of spherical astronomy:

$$\text{Cos } z = \text{Sin } \phi \text{ Sin } \delta + \text{Cos } \phi \text{ Cos } \delta \text{ Cos } h$$

where z = zenith distance of the sun
$=90°$—altitude,
ϕ=latitude of the place,
δ=declination of the sun,
h=hour angle of the sun.

The azimuth can also be calculated from a similar cosine formula, but it has been found more convenient for computational purposes to use the four-parts formula:

$$\text{Sin } \phi \text{ Cos } h = \text{Cos } \phi \tan \delta - \text{Sin } h \text{ Cot } a$$

$$\text{or Cot } a = \frac{\text{Cos } \phi \tan \delta - \text{Sin } \phi \text{ Cos } h}{\text{Sin } h}$$

where a = azimuth of the sun. Figs. 2, 3 and 4 give the altitude of the sun at 0600 and 1800, 0900 and 1500, and 1200 hrs local apparent time respectively. Figs. 5 and 6 give the azimuth of the sun at 0600 and 1800, and 0900 and 1500 hrs local apparent time respectively. At 1200 hrs local apparent time the sun will always be on the meridian, its azimuth being either zero or 180°; at any latitude the azimuth will be zero, *i.e.*, the sun will be north of the zenith for the periods indicated by the dotted portion of the curve for that latitude in Fig. 4, and for the rest of the year the azimuth will be 180°, *i.e.*, the sun will be to the south of zenith.

To determine the position of the sun in the sky at a given place on any day at any of the specified hours, one has to find out from the two relevant figures, which give the altitude and azimuth respectively for that particular hour, the values of altitude and azimuth for that day given by that particular curve which corresponds to the latitude of the place. For example, at 1500 hrs local apparent time on 15 August at a place at 10°N latitude, the altitude (obtained from Fig. 3) is 45° 53′ and the azimuth (obtained from Fig. 6) is 79° 50′ west of north. Again, at 1200 hrs local apparent time on the same day at the same place, the sun will be (as obtained from Fig. 4) at an altitude of 85° 47′ (measured from the south point) on the meridian.

Fig. 1 gives the equation of time. To obtain the local mean time corresponding to any local apparent time, the equation of time for that particular day should be algebraically subtracted from the apparent time. For instance, in the above example the local mean times corresponding to 1500 and 1200 hrs apparent times on 15 August at 10°N latitude, are 15 h 04 m 30 s and 12h 04 m 30 s respectively (the equation of time from Fig. 1 being —4 m 30 s). To convert local mean time to Indian Standard Time, the appropriate longitude correction will have to be applied.

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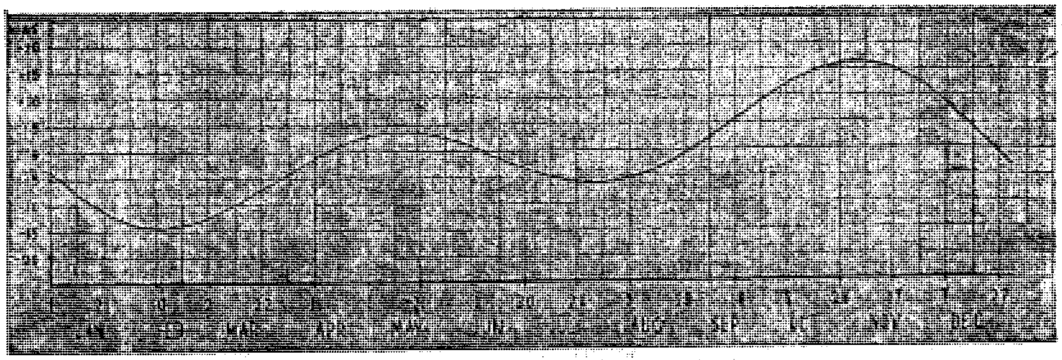

Fig. 1. Equation of time (Apparent—Mean)

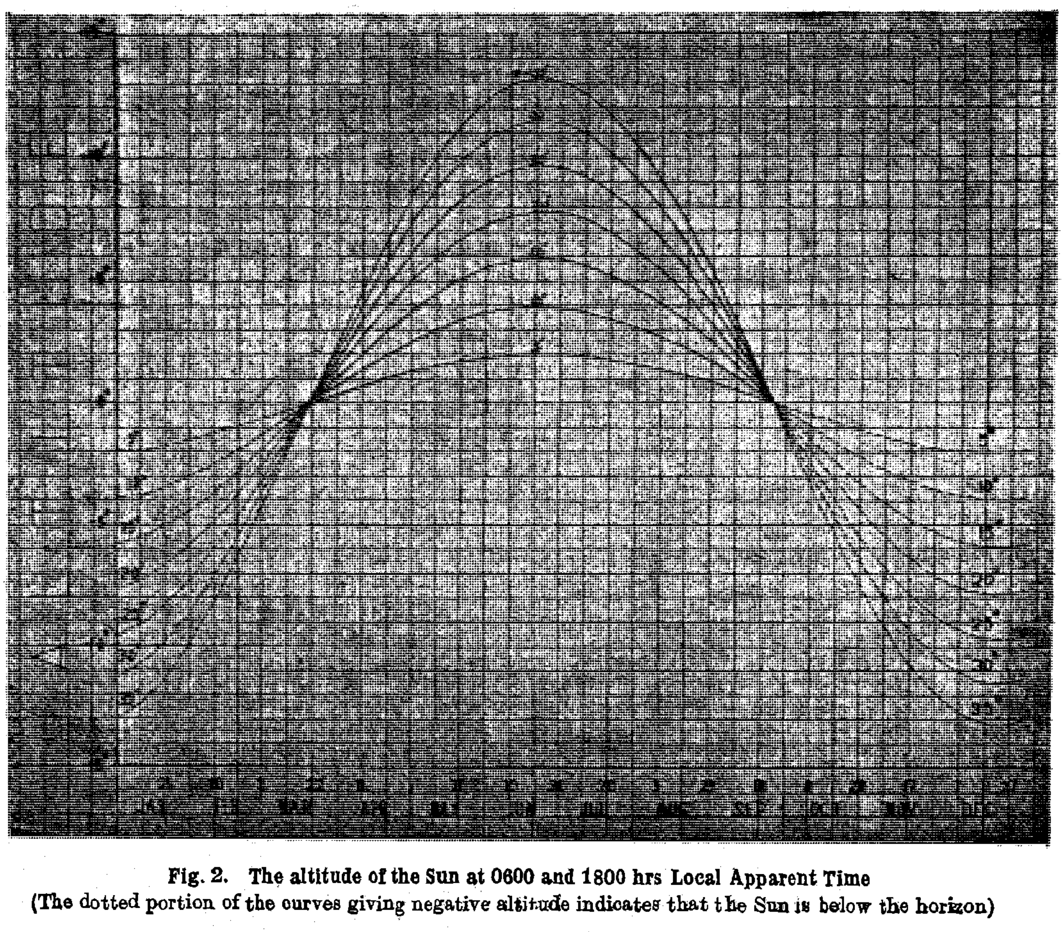

Fig. 2. The altitude of the Sun at 0600 and 1800 hrs Local Apparent Time
(The dotted portion of the curves giving negative altitude indicates that the Sun is below the horizon)

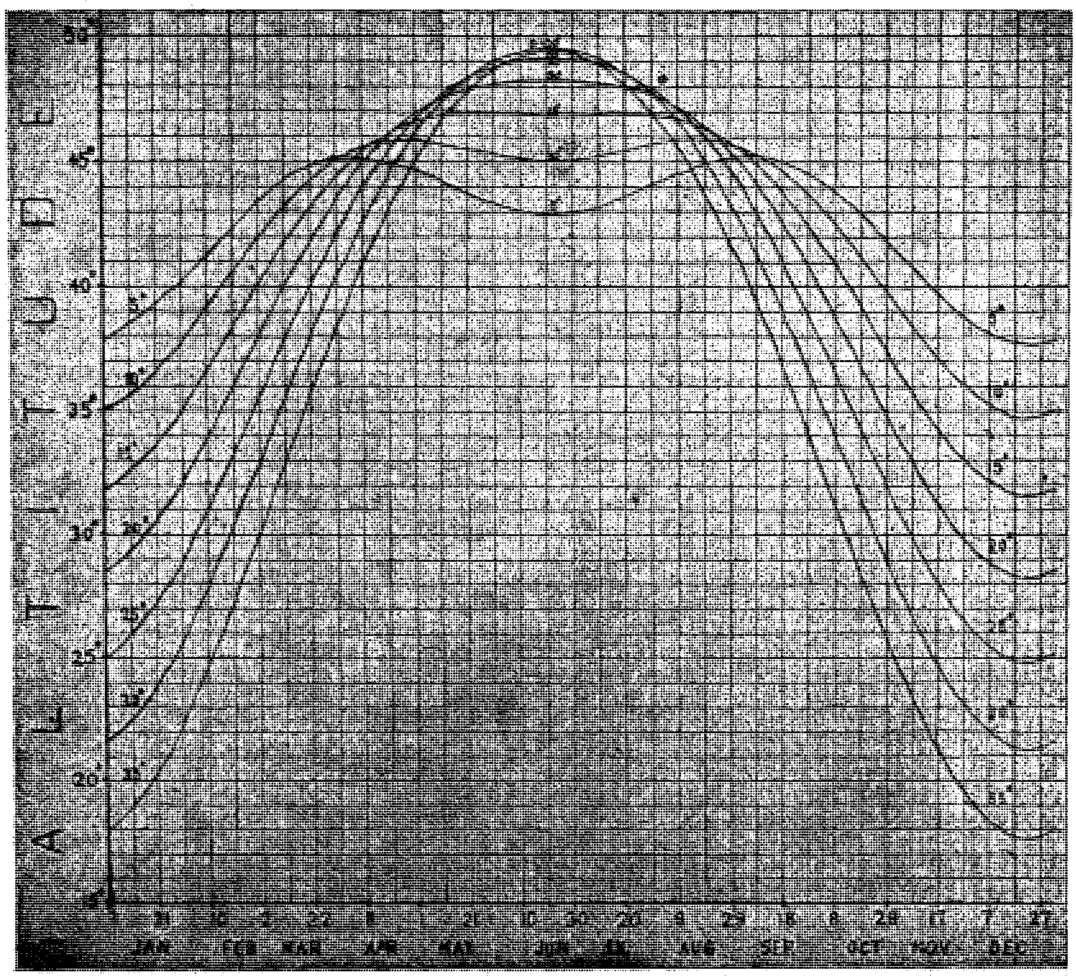

Fig. 3. The altitude of the Sun at 0900 and 1500 hrs Local Apparent Time

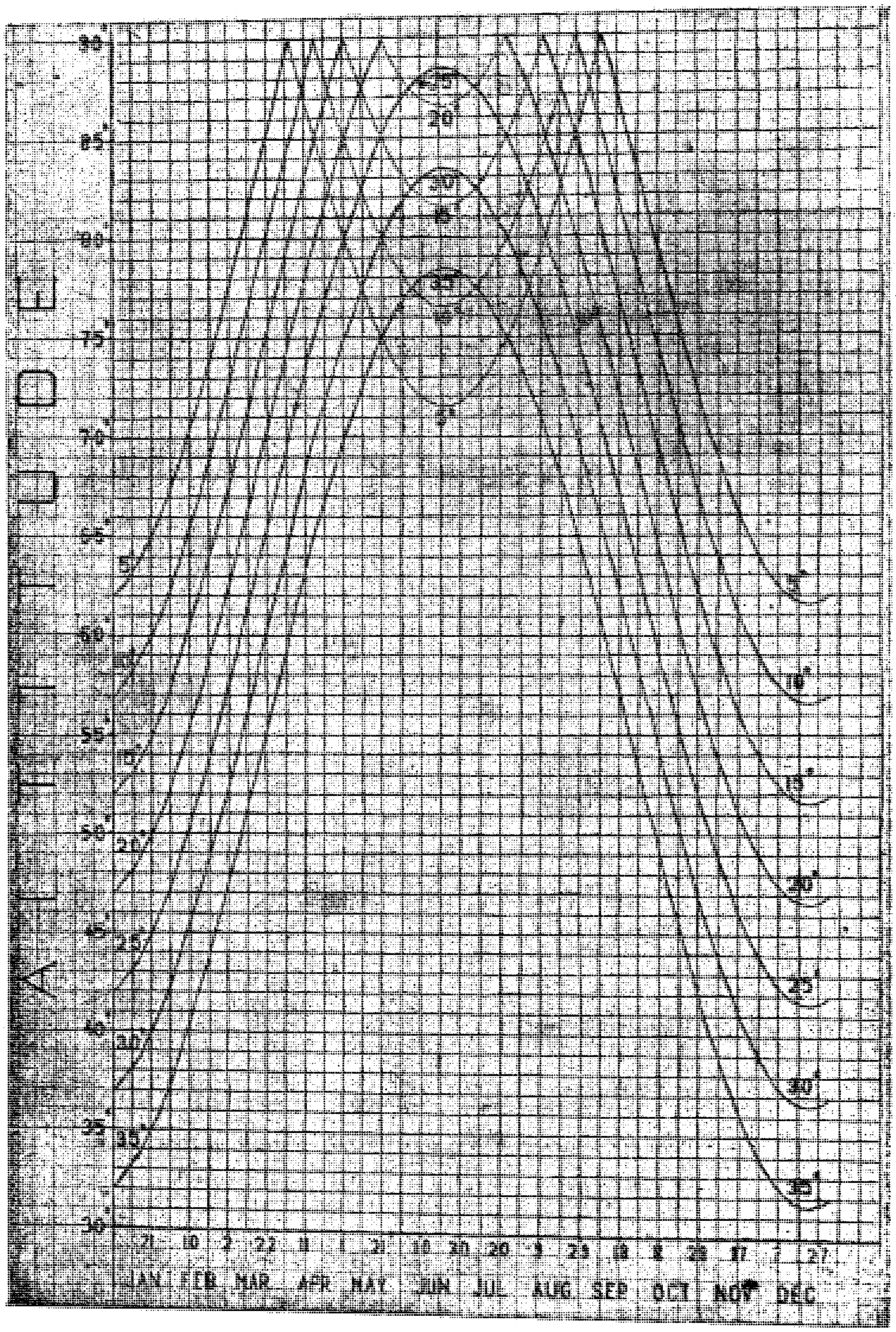

Fig. 4. The altitude of the Sun at 1200 hrs Local Apparent Time
(The altitudes indicated by the dotted portions should be reckoned from the north point of the horizon and those given by the continuous lines from the south point)

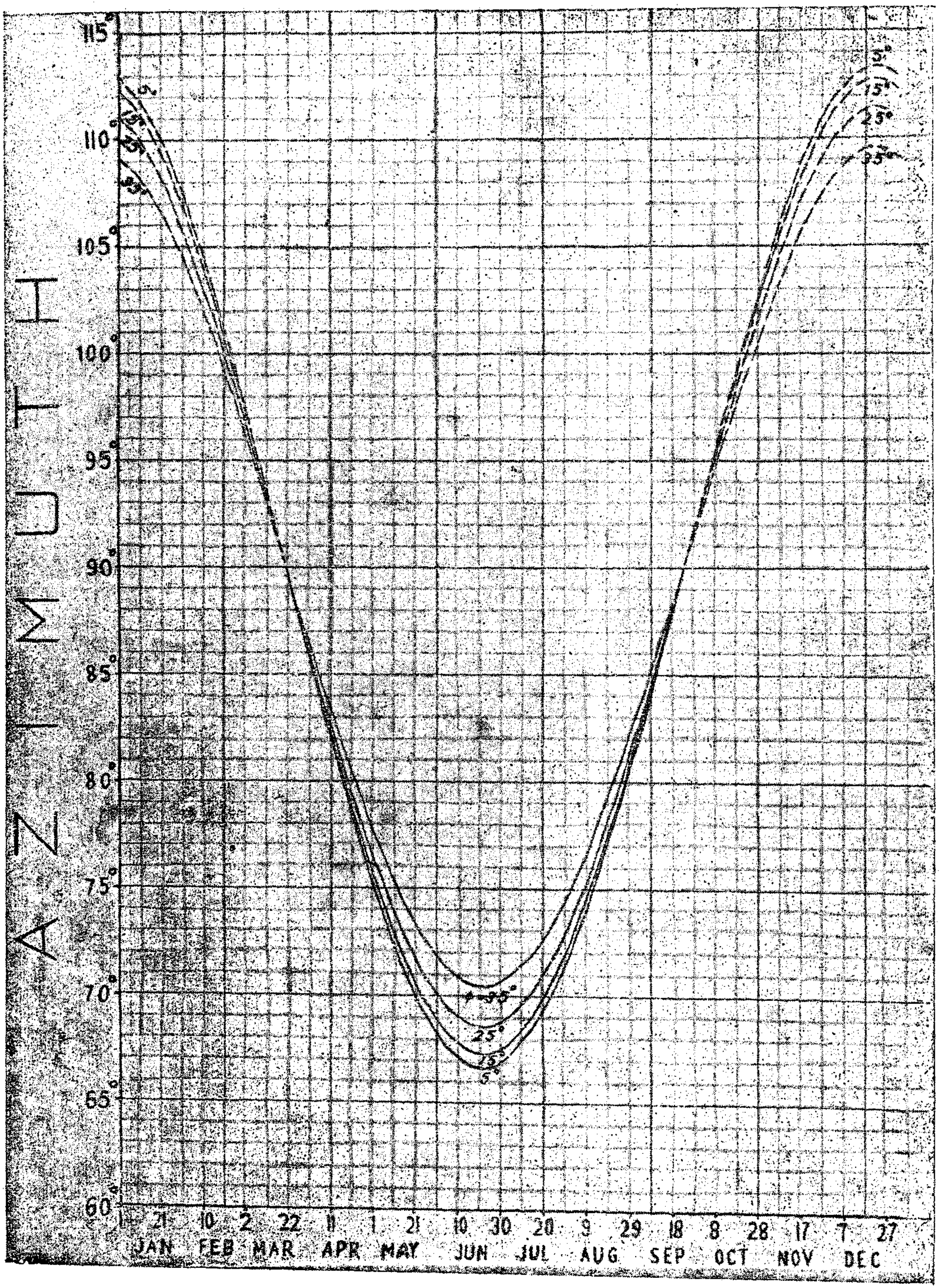

Fig. 5. The azimuth of the Sun at 0600 and 1800 hrs Local Apparent Time

For 0600 hrs, the azimuth should be reckoned east of north and for 1800 hrs, west of north. The dotted portions indicate that the Sun is below the horizon)

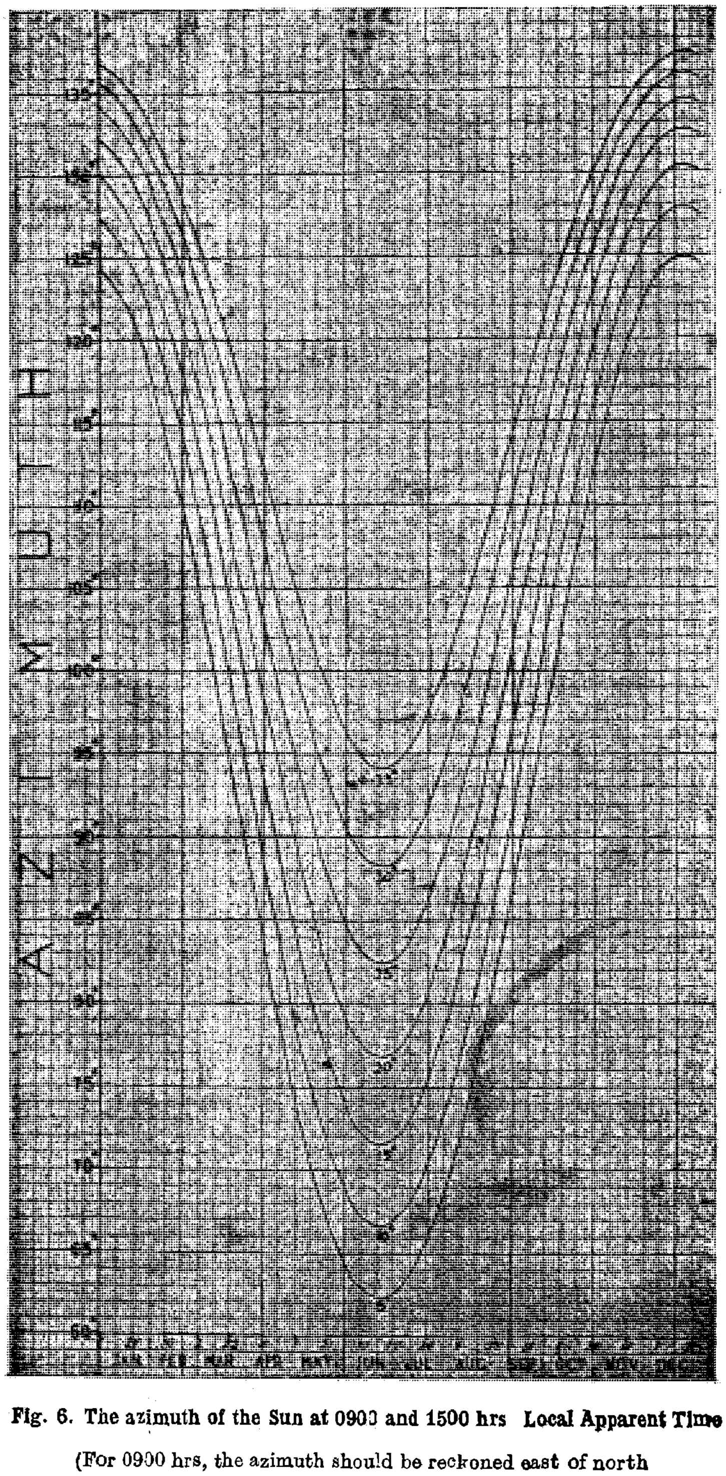

Fig. 6. The azimuth of the Sun at 0900 and 1500 hrs Local Apparent Time

(For 0900 hrs, the azimuth should be reckoned east of north
and for 1500 hrs, west of north)