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The Sunshade Table

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SYNOPSIS

The Sunshade Table can be described as an apparatus by the use of which the apparent position of the sun is depicted on a table where orientation and shading devices of a building can be studied. The table is about 2½ ft. square which can hold a model of about the same size in any orientation. The table is versatile, simple, cheap and can be conveniently used at any place to represent the sun of any place. Although principally meant for outdoors, it can be used indoors without any modification provided the source of light is strong and far enough. The apparatus is useful to the architects, engineers and the research workers; it can also be used as a solar clock, if necessary.

INTRODUCTION

It was probably Bacon who propounded an idea, about 300 years ago, that the design of a building should be so conceived as to enable one to have rooms for winter warmth and also rooms for summer cooling in the same dwelling. These remarks are apparently meant for the tropical and sub-tropical regions where winters are cold enough to demand heating of a house and summers hot so as to require its cooling for comfort. The discomfort in tropical summer is primarily due to excessive radiation from the sun; protection from which is a great help and solves a part of the problem, at least. On the other hand, sunshine is a great blessing in winter and a building which allows the winter sun to come in, is comfortable. These are two completely opposite requirements and peculiar only to tropical regions having predominance of a clear sky, as against cold countries which generally have an overcast sky. The architects are well seized of the problem and its requirements, and accordingly there is an increasing tendency now in modern buildings of providing shading device to save the walls and windows from the onslaught of direct solar radiation in summer and at the same time to provide a minimum obstruction to the winter sun. The task is quite difficult if a graphical or a

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mathematical solution is adopted. The model studies are comparatively easy provided the device too is inexpensive and simple to use.

Previous work

Graphical methods due to Molesworth (1902) and Waldram (1923) are available by use of which periods of insolation for unobstructed vertical and horizontal planes can be read off. But the more recent method of using solar charts and shadow angle protractor, developed by Phillips (1948) in Australia, is rather handy. By superposition of the protractor on the solar chart, relating to a particular latitude, the horizontal and vertical shadow angles of the sun can be read off directly. Having found the shadow angles, a minimum depth of overhang is calculated by trigonometry to cut off the hot sun. The calculations become laborious when an economical design of louvers or a complete survey of a building for various orientations and various seasons is desired. Julian (1919) described a method which was later developed by the Germans (Küttner and Grobler 1930-31) by which the shadow cast upon a horizontal plane by a vertical rod could be calculated. The tip of the shadow cast was found to trace a hyperbolic curve. In principle, this method has been followed in the present device.

The model study was attempted before World War II by Marks and Woodwell (1914), through a device consisting of a hemispherical wire framework on which sunpaths are marked for a given latitude. This instrument was later developed by Connel (1931) in the name of 'Orientator'. The well known Heliodon shown in Fig. 1, due to Dufton and Becket (1932) is more simple. The Heliodon is designed on the basis of an artificial 'sun' at a fixed distance from a revolving table. The declination of sun is provided by moving the position of 'lamp' on a vertical scale while the rotation of board and its tilt provides solar time and latitude of a place respectively. The instrument is not really mobile in the sense that it has to be placed at a fixed distance from the lamp in a given line, at a fixed height. A serious draw-back lies in the error due to diverging rays of the lamp, as compared to the actual sun which emits parallel rays. On bigger models, of say 2 ft. length, the error in the sun's direction may be as high as 7°—35′ if the lamp is 7½ ft. away from the table and about 3° if the lamp is 20 ft. away. These limitations have probably stood in the way of popularity of the Heliodon.

The little Sundial shown in Fig. 2 devised by Pleijel, a Swedish architect, essentially consists of a small box with open top and inclined sides having a pin fitted at the centre of the dial. The Sundial is placed on the model which is tilted and turned till the tip of the pin's shadow touches the desired time on the Sundial. As one requires a different Sundial for each latitude, it makes the

apparatus slightly unweildy. The Australian 'Solarscope', shown in Fig. 3, due to Phillips (1948) is designed on the principle that the model is stationary while the sun (beam of light in this case) tilts and rotates according to the settings for latitude, season and time of the day.

The Sunshade Table

The Sunshade table now devised makes a partial use of the principles underlying all the above devices. The sun is stationary while all other movements of the sun and earth are provided by the table which is capable of rotating and tilting in any direction; in effect, it is a reverse solarscope. An equatorial curve fitted at one side of the Sunshade table is tilted to any angle up to 60° for use in the Southern or Northern hemisphere up to 60° latitude. The Sunshade table is tilted and rotated until the shadow tip of the 2 in. long pin, fixed at the centre of the equatorial curve, touches the desired time on the equatorial curve. The model placed on the main table in the orientation of prototype then depicts the sunshade pattern at the solar time indicated on the curve. If the protection or penetration of the sun is found inadequate, a correction in the orientation is easily possible which can be checked and rechecked quickly. The Sunshade table is about 2½ ft. square and has eight cardinal directions marked on it for placing a model in any desired orientation (see Fig. 4). The Sunshade table has the mobility of being used both indoors and outdoors at the same time without any difficulty. Although principally designed for Northern Hemisphere, it can also be used in the Southern Hemisphere merely by reversing the North and South of the table and of the equatorial curve. The instrument is handy and very simple to use; it reduces the architects' work to observing the efficiency of his design and orientation and to correct them there and then, if necessary.

The Equatorial Curve

The present device is designed on the theory advanced by Julian, the modification being that, instead of calculating mathematically all the ordinates of a hyperbolic curve, a graphical solution has been adopted. This method is simpler as it merely involves calculations of Altitude and Azimuth of the sun from which the length and direction of shadow of a pin is computed for any latitude and time of the day. If the tip of shadows on a particular day is joined together, a hyperbolic curve is obtained. In order to draw the equatorial curve to cover the entire year, a careful selection of appropriate dates is necessary so as to avoid congestion in the chart. It is universally known that the sun's path oscillates in the great celestial sphere during the year. It moves southwards in winter in the northern hemisphere reaching an extreme southernly position on a winter solstice *i.e.*, 22nd December. On a summer solstice

(22nd June) the position of the sun is, however, directly opposite being extreme northernly. In the Southern hemisphere the whole process is reverse; that is the sun is on extreme northernly position in winter and its exact opposite in summer. The other cardinal dates in respect of movement of the sun are equinoxes when the sun rises and sets exactly East-West. This position is repeated twice in a year *i.e.*, 21st March and 23rd September.

The apparent oscillatory tendency of the sun's position in the course of a year automatically suggests that the path of the sun on any day is capable of repetition. The corresponding dates to give nearly the same solar declination chosen for the equatorial curve, is given in Table 1. The total number of shadow traces to represent a whole year for an equatorial curve can thus be reduced from twelve to seven as shown in Fig. 5, where the position of the sun is marked at one hour interval within which linear interpolation is possible.

Model Study

The Sunshade table, like all other solar devices, is based on solar time and the geographical (or true) North. The North usually obtained by surveyors with the help of a magnetic compass is different from the true North. The angular deviation of the true North from the magnetic North is known as 'magnetic declination' which is given in Appendix 1 and 2 for all major towns of Pakistan, to enable location of the magnetic North from the true North given by

TABLE 1

Solar Declination for Equatorial Curve

Date	Declination		Date	Declination	
	Due	Degree Minute		Due	Degree Minute
22 June	N	23—26.5	22 December	S	23—26.5
24 July	N	19—54.5	20 May	N	19—56.1
24 August	N	11—10.7	19 April	N	11—06.1
23 September	N	0—00.6	21 March	N	0—09.4
19 October	S	9—54.3	23 February	S	9—54.0
16 November	S	18—41.3	26 January	S	18—45.6

the Sunshade table. The orientation of a model on the table is then set according to the magnetic North. For instance, if it is desired to study the efficiency of louvers on a building facing 28° West of South, in Lahore, where magnetic declination is about 1.1° Eastwards, the actual orientation of the model on the Sunshade table will be at an angle 29.1° (=28+1.1) West of South. In this particular example, note how the sun has been eliminated in summer in Fig. 6 when it is not required, while Fig. 7 shows the position of the sun on the same building in winter when it is welcome in Lahore. In order to be able to use the table for a standard time of place, a difference known as 'equation of time' has to be added algebraically to get local mean time to which another correction due to difference of local mean time and the standard time is also added or subtracted, as the case may be. The 'equation of time' correction is constant for all places and is shown in Fig. 8, but the correction due to local mean time and the standard time depends on the difference between the longitude of a place and the standard meridian.

Other applications

The Sunshade table promises a much wider scope than may appear at first sight. When the orientation of a building is fixed by other considerations, the Sunshade table assists in arriving at the correct design of louvers *i.e.*, the depth of overhang and distance apart of the horizontal and vertical louvers. The most popular use of the Sunshade table by the architects will probably be in arriving at a correct orientation of a building in a given plot. Having observed the admission or exclusion of the sun in the desired seasons of a year, the building orientation on the table is adopted for the prototype after applying correction due to magnetic declination. In the design of louvers or choice of orientation of a wall, it is not necessary to make a complete model of a building. What is required is only a face of the external wall to be studied. The Sunshade table is a great asset in the research institutes when periods of insolation of sun are required for walls of different orientations at any place. It can also be used to study the intensity of light in a proposed building at a given time. The Sunshade table will be useful in landscape designing and for fixing a correct position of trees in the precincts of a building or the township as a whole. The Sunshade table can also be used as an inexpensive solar clock when the North on the equatorial curve points to the true North of a place and the table is horizontal.

ACKNOWLEDGEMENT

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APPENDIX 1

Magnetic Declinations of Important Cities of West Pakistan.

Sl. No.	Name of City	Longitude (degrees East)	Latitude (degrees North)	Magnetic Declination (degrees East).
1	Abbotabad ..	73.20	34.20	1.90
2	Bahawalnagar ..	73.25	30.00	0.70
3	Bahawalpur ..	71.65	29.38	0.87
4	Bannu ..	70.58	32.97	1.73
5	Campbellpur ..	71.70	32.57	1.47
6	Dadu ..	67.77	26.78	0.42
7	Dera Ghazi Khan ..	70.62	30.10	0.97
8	Dera Ismail Khan ..	70.85	31.80	1.28
9	Gujranwala ..	74.17	32.17	1.15
10	Gujrat ..	74.07	32.60	1.20
11	Hyderabad ..	68.42	25.37	0.10
12	Jacobabad ..	68.43	28.28	0.45
13	Jhang ..	72.32	31.47	1.10
14	Jhelum ..	73.70	32.97	1.33
15	Kalat ..	66.58	29.05	1.07
16	Karachi ..	67.03	24.87	0.13
17	Khairpur ..	68.77	27.53	0.43
18	Kharan ..	65.47	28.57	0.97
19	Kohat ..	71.47	33.60	1.83
20	Lahore ..	74.30	31.55	1.10
21	Larkana ..	68.20	27.00	0.58
22	Las Bella ..	66.33	26.23	0.45
23	Loralai ..	68.58	30.37	1.27
24	Lyallpur ..	73.05	31.40	1.13
25	Mardan ..	72.07	34.20	2.03
26	Mianwali ..	71.53	32.58	1.47
27	Mirpur Khas ..	69.03	25.53	0.17
28	Montgomery ..	73.10	30.63	0.87
29	Multan ..	71.48	30.18	0.92
30	Muzzafargarh ..	71.17	30.07	0.95
31	Nawabshah ..	68.43	26.22	0.23
32	Noshki ..	66.07	29.55	0.08
33	Peshawar ..	71.52	34.00	2.00
34	Quetta ..	67.00	30.20	1.37
35	Rahimyar Khan ..	70.28	28.42	0.67
36	Rawalpindi ..	73.05	33.62	1.70
37	Sanghar ..	68.95	26.03	0.22
38	Sargodha ..	72.67	32.12	1.50
39	Sialkot ..	74.50	32.50	1.25
40	Sibbi ..	67.85	29.52	1.07
41	Sheikhupura ..	73.95	31.68	1.20
42	Sukkur ..	68.85	27.70	0.43
43	Thatta ..	67.92	24.75	0.02
44	Turbat ..	63.08	25.98	0.80

Note:—Magnetic declination in West Pakistan is Easterly throughout and therefore the declination is to be added to the magnetic North to get true North.

APPENDIX 2

Magnetic Declinations of Important Cities of East Pakistan.

Sl. No.	Name of City	Longitude Degrees East	Latitude Degrees North	Magnetic Declinations Degrees West
1	Barisal	.. 90.4	22.7	1.02
2	Bogra	.. 89.4	24.8	0.83
3	Cherrapunji	.. 91.7	25.2	0.78
4	Chittagong	.. 91.8	22.3	0.92
5	Dacca	.. 90.4	23.7	0.93
6	Dinajpur	.. 88.6	25.6	0.78
7	Faridpur	.. 89.8	23.6	0.82
8	Feni	.. 91.4	23.0	0.90
9	Jessore	.. 89.3	23.2	0.95
10	Khulna	.. 89.6	22.8	0.98
11	Kishorganj	.. 90.8	24.4	0.83
12	Kishtia	.. 89.1	23.9	0.87
13	Maijdi	.. 91.1	22.9	1.00
14	Narayanganj	.. 91.5	23.6	0.95
15	Nasirabad	.. 90.4	24.7	0.82
16	Pabna	.. 89.3	24.0	0.82
17	Patuakhali	.. 90.4	22.3	1.03
18	Rajshahi	.. 88.6	24.4	0.88
19	Rangamati	.. 92.2	22.7	0.90
20	Rangpur	.. 89.4	25.7	0.80
21	Sylhet	.. 91.9	24.9	0.82
22	Tangail	.. 89.9	24.3	0.92

NOTE:—Magnetic declination in East Pakistan is Westerly throughout and therefore the declination is to be subtracted from the magnetic North to get true North.

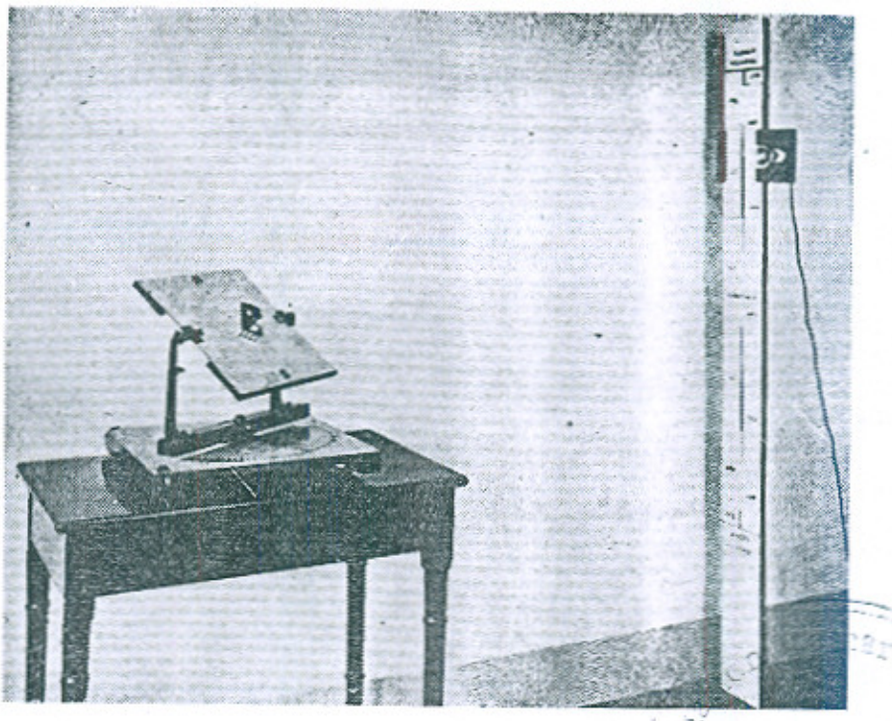


Fig. 1. HELIODON—A British instrument in which the model is placed on top of table shown inclined. The vertical scale on the right is meant to fix the lamp according to date of the month.

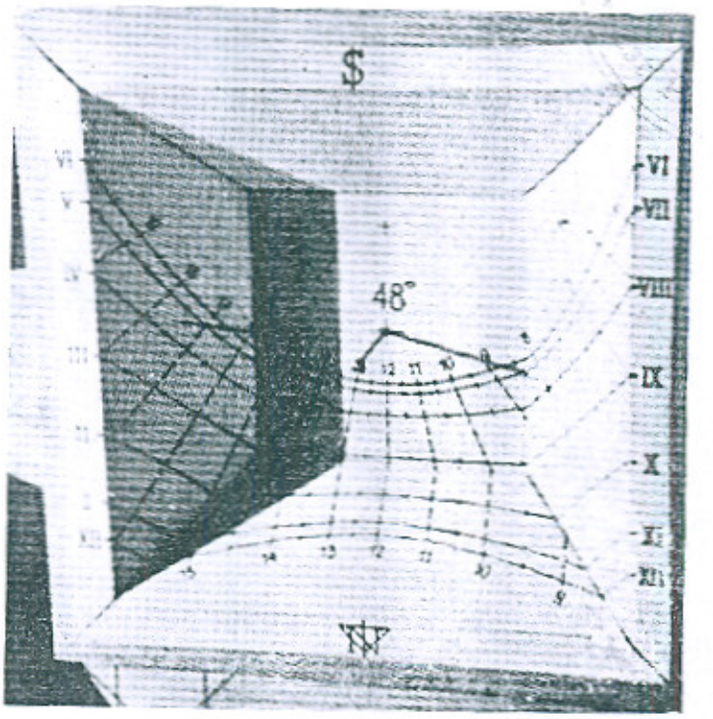


Fig. 2. The little Sundial designed by G. Pleijel (a Swedish Architect is placed on the model in a correct orientation. The desired time is obtained by twisting and turning the model. The illustration shows the sundial for 48° latitude depicting the position of Sun in April and August at 8 A.M.

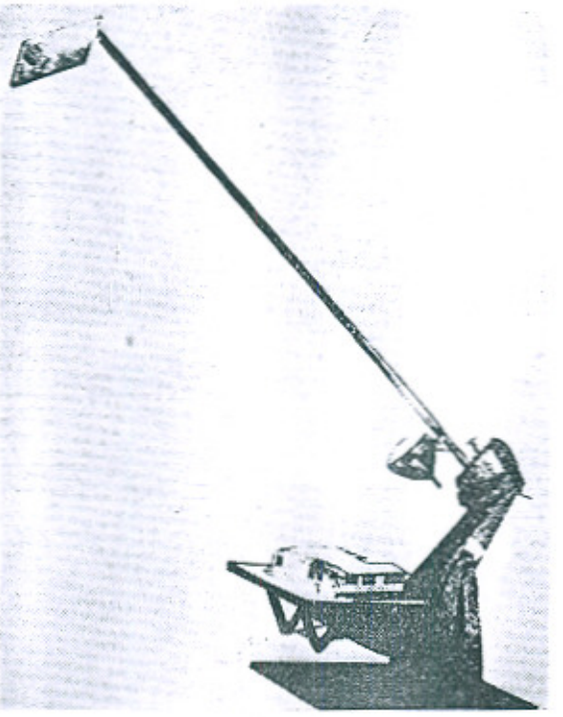


Fig. 3. The Australian Solarscope in which model is stationary while the light source is movable—in this case a mirror attached to the revolving arm.

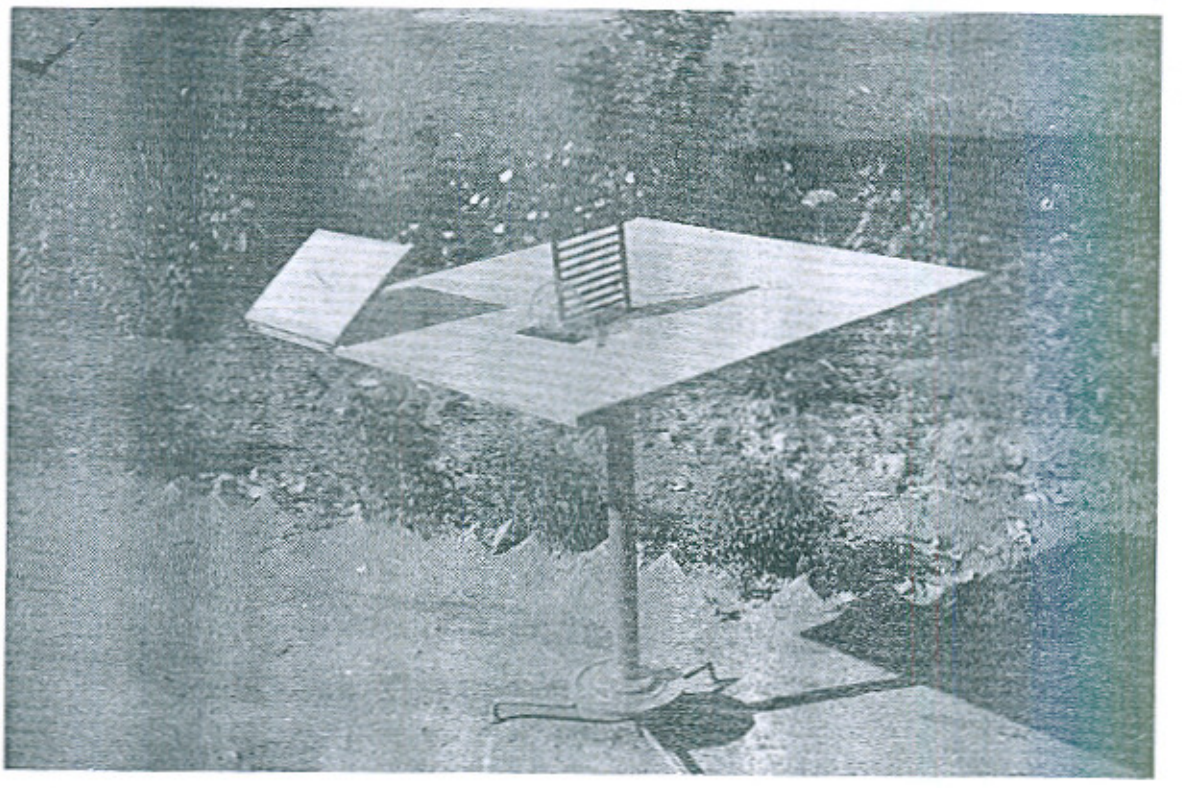


Fig. 4. The Sunshade Table designed in Pakistan. The illustration shows the equatorial curve fitted at the side of the table and a louver model, fixed in the middle of table under study.

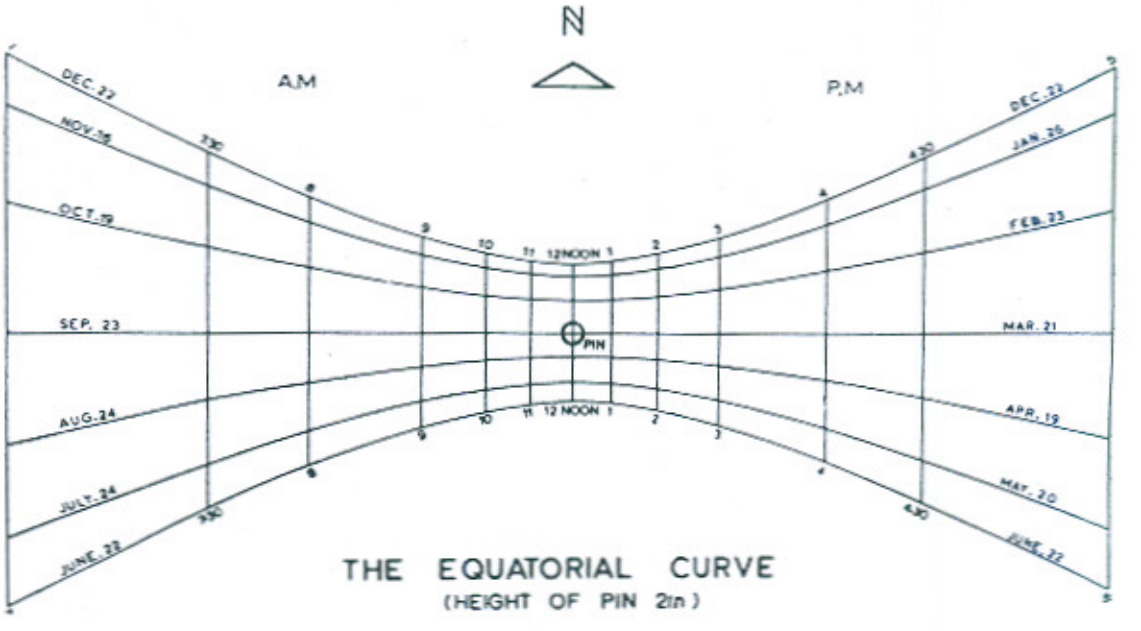


Fig. 5. The equatorial curve is designed on the basis of 2" height of a pin but the illustration shows the scale reduction of the curve and the pin size.

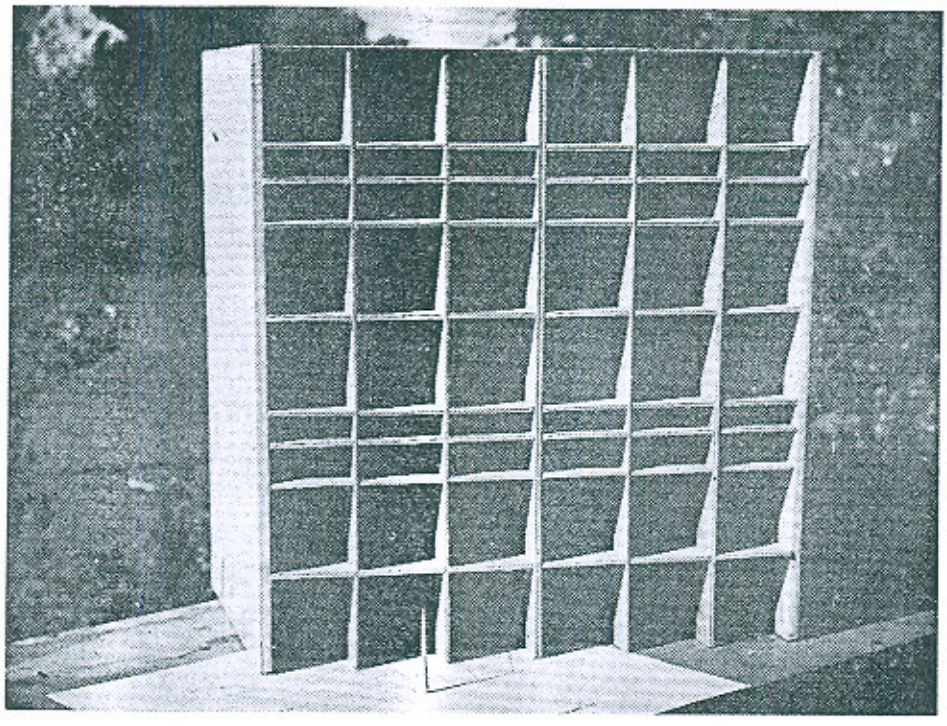


Fig. 6. Pattern of Sunshade on a building model facing 28° West of South in Lahore on 22nd June at 4 p.m. Note how the sun has been completely eliminated from the building.

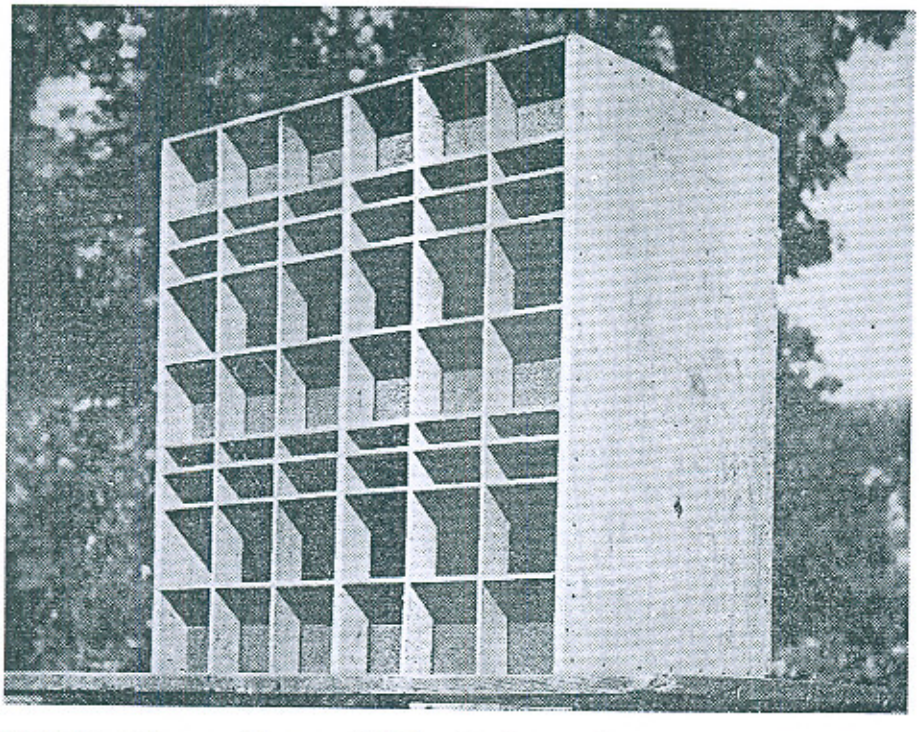


Fig. 7. Sunshade pattern on the same building (as in Fig. 6) in the same orientation on 27th November at 12 noon. The louvers are 4 ft. apart with an overhang of about 2 ft.

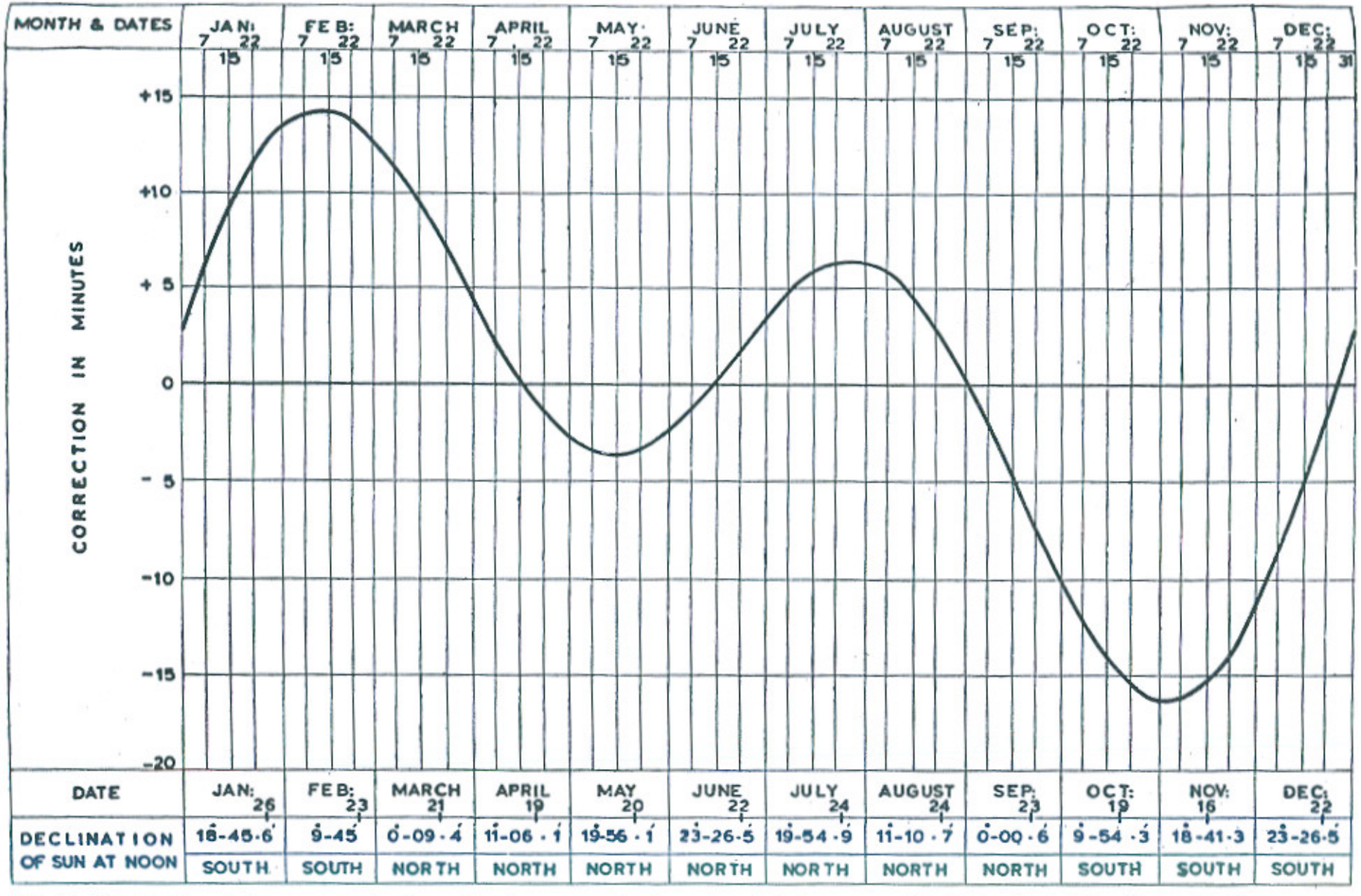


Fig. 8. The equation of time curve showing solar time correction for various dates in a year. To obtain standard time from solar time, on say November 1 at Lahore, a total of 13 m. 33 sec. will have to be subtracted from solar time as shown below :

Correction due to equation of time	... =	(−) 16 m. 21 sec.
Due to difference in longitude of Lahore and standard time	=	(+) 2 m. 48 sec.
Total correction	... =	(−) 13 m. 33 sec.