A PORTABLE NANOGONAL ROTATING HUT FOR OBSERVATIONAL ASTRONOMY ACTIVITIES IN SCHOOLS AND COLLEGES

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Any systematic study of celestial bodies usually necessitates a series of observations spread over several days or even weeks. Thus, if serious use of a telescope is being planned in an educational institution, it would be better to permanently install it at the desired point (terrace or open field), at least for the duration of a particular project.

Need for a Low Cost Observation Hut

The appearance of Halley's Comet in 1985 has aroused much interest in observational astronomy activities among school and college students in India. However, lack of proper guidance materials and facilities has been one of the major constraints to sustain this interest. Thus, there is an urgent need for providing necessary facilities for observing the night sky within the school/college premises or at another suitable venue. The proposed observation hut would not only fulfil this requirement but would also provide scope for conducting many activities based on astronomical observations. The salient features of the observation hut are:

(i) preventing any health hazard to children from cold winds, and

(ii) preventing vibration of the telescope caused by wind, in case its stand is not strong enough.

This need is particularly important in Northern India. It is because that the proper season when the sky has minimum dust and clouds and when children also have time for co-curricular activities is after the rains, that is, from October to January, which is also the coldest part of the year.

Apart from providing protection from the vagaries of weather, the observation hut also provides facility for permanent and proper setting of the telescope besides its easy manoeuvring for making systematic astronomical observations. Theoretically, a telescope can be used just by carrying it to an open place which can be an open compound or the terrace of the school. However, in order to make a meaningful use of the instrument, its polar axis has to be set parallel to the axis of rotation of the earth. To make this adjustment accurately is a bit time consuming task. Time and effort spent in making this adjustment can discourage some students who wish to attempt some activity or do project work with it. Any systematic study of celestial bodies usually necessitates a series of observations spread over several days or even weeks. Thus, if serious use of a telescope is being planned in an educational institution, it would be better to permanently install it at the desired point (terrace or open field), at least for the duration of a particular project. In such situations it may become necessary to protect it from adverse weather conditions like rain, dust, excess humidity, etc. A suitable housing for the telescope is, thus, quite necessary.

The nanogonal shaped observation hut described below combines maximum usable inside space with light weight, stability and easy transportability. It uses simple technology which is available everywhere in India. It can be easily constructed by any school with the help of local craftsmen.

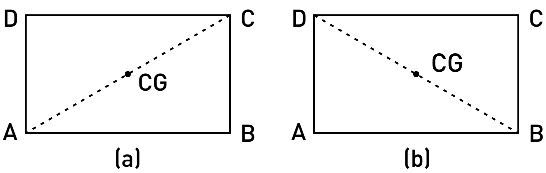

Fig. 1. Possible triangular bases of a four-legged object

This observation hut can also be used as a general purpose circular tent, when its wheels are not fitted in it and the circular wall-cum-bench, about which it rotates, is not constructed.

Why the Nanogonal Shape of Observation Hut?

(a) 3-, 4- and 5- legged objects: Consider first the case of a common item of furniture like a table or a chair, having four legs. Quite frequently, when it is placed on an uneven ground, it is found to be swinging on one of its diagonals. It happens as follows. On an uneven ground, only three legs touch the ground at one time. All possible combinations of three legs in a furniture whose four legs make a rectangle, are right angled triangles. We may take any of these triangles
(Fig. 1), the centre of gravity (CG) of that item of furniture lies on the diagonal of that triangle. Thus any slight force swings that furniture over to another triangular base.

Solution of this particular problem is found commonly in having three or five legs, as in case of tripods used in science laboratories and five- legged executive chairs with wheels. At this point it would be interesting to discuss the use of pentapods instead of tripods in the science laboratories. It may be argued, referring to Fig. 2, that in case of pentapod a triangle like ACE (Fig. 2-a) always forms the triangular base on which apparatus stands. In addition, the two legs B and D serve as a second line of defence against toppling over of the apparatus. If by any chance the apparatus tends to topple, say, over the line AC, then the leg B touches the surface of table and thus attempts to prevent the toppling. In case of tripod, there exists no such second line of defence.

(b) The Case of Rotating Observation Hut: Consider now the structures which serve the purpose of circular structures. Octangular tables are so common alongside the circular ones. Amateur astronomers have used octangular rotating huts. The author too, first tried the model of an octangular rotating hut. When it was put on various uneven surfaces, it was found that frequently, though not always, it swings about a line vertically below its CG. Hence the need for a septangular or nanogonal shape of rotating observation hut arose. A hut which keeps swinging by slightest wind would be quite distracting and may cause minute vibrations of telescope, which may make astrophotography impossible.

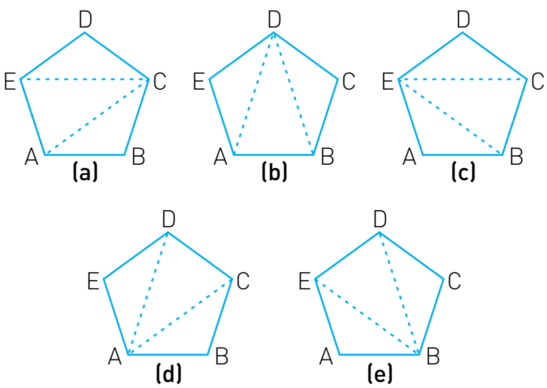

Fig. 2. Possible triangular bases of a five-legged object

To decide between the two options (7 or 9 sided hut), three criteria were considered:

(i) What are the various possible triangles (which include the C.G. within it) made by joining any three corners of the polygon? Does the C.G. lie on a side of any of the possible triangular bases? If it so happens in a particular shape, then that shape would be unacceptable. On this criterion, all regular polygons with even number of sides are unacceptable.

(ii) What is the probability of each possible triangle becoming the base of the observation hut on an uneven ground? What is the weighted average area of these triangles? The larger the weighted average area, the better it is.

(iii) What fraction of the area of circumscribed circle of the polygon constitutes the inscribed circle? Only the inscribed circle is the usable area in which the students can work. Hence, the greater this fraction, the better it is.

An analysis of the various shapes in consideration here, with odd number of sides, on criterion (ii) is given in Table 1. Figure 3 shows the various possible triangular bases with vertex V, for each shape of observation hut. On this criterion, the triangle comes at the top, which justifies the use of this shape in science laboratories where criterion (iii) is not relevant.

Sl. No.	Observatory Shape		Sides of Base Triangle (m)	Area (m^2)	No. of Triangles for Each Vertex	Probability of Occurence	Weighted Average Area of Triangle (m^2)	Incircle	
								Circum Cirle	Figure No.
1	Triangle		4.33 4.33 4.33	8.119	1	1	8.119	25%	3(a)
2	Pentagon		2.939 4.755 4.755	6.645	1	1	6.645	65%	3(b)
3	Septagon	(a)	2.169 4.875 4.875	5.157	1	1/2	6.303	81%	3(c)
		(b)	4.875 3.909 3.909	7.450	1	1/2			3(d)
4	Nanogon	(a)	1.710 4.924 4.924	4.146	1	1/4			3(e)
		(b)	4.330 4.330 4.330	8.119	1	1/4	6.492	88%	3(a)
		(c)	4.330 4.924 3.214	6.852	2	1/2			3(f)

Table 1

Possible Triangles formed by Wheels in Contact with an Uneven Ground for Various Observatory Shapes

Diameter of circumscribed circle = 5 metre

Area of circumscribed circle = 19.635 sq. metre

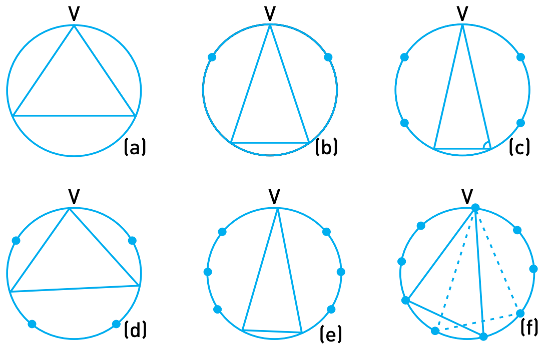

Fig. 3. Possible triangular bases with vertex V for 3-, 5-, 7- and 9- legged observation huts

Between septagon and nanogon, the latter is better on criterion (ii). Hence it was decided that nanogon is the appropriate shape for rotating observation hut.

Last column in the table gives the fraction of area of circumcircle, which constitutes the inscribed circle. This fraction also is the highest for the nanogon. With this fraction at 25%, the triangle shape seems to be totally unacceptable for the rotating hut.

It is noteworthy that both on criterion (ii) as well as on (iii), there are no vast differences among pentagon, septagon and nanogon. For use in a school/college, where there may be occasions when you want 25 to 30 students at a time to be in the observation hut and thus a diameter of 5 metre is needed, the author recommends the nanogonal shape. But in smaller diameters, septagon and pentagon may prove economical in terms of time and labour spent in its construction.

Description of the Nanogonal Observation Hut

It is built on the base nanogon AB....HI (Fig. 4). This nanogon bears the entire weight of the observation hut. Each corner also carries a short bar (not shown in the figure), which functions as a bracket so that the angle between the adjacent sides of the nanogon meeting at that corner remains rigid at 140^0. Each short bar also has a wheel fixed below it. On these nine wheels, the entire hut can rotate around a circular wall-cum-bench. The load bearing wheels move on a circular iron track, or on a cemented floor (in which case the wheels must have rubber tyres too).

There is a horizontal decagon JK......RS, in which the side RS (S. No. 18) is just a thin wire. All the other sides are strong bars, i.e., thick hollow pipes so that these are strong and yet of light weight. This horizontal decagon is supported on the base nanogon by 20 bars, serial nos. 33 to 52. Out of the 19 triangular faces made by these 20 bars, 17 are almost equilateral triangles and two are right angled triangles, so that the last face RSWV is a rectangle. All the 20 standing faces are close to vertical, but slightly inclined inwards. The rectangle RSWV forms the gate through which students and teachers can enter the observation hut. Its width can be kept whatever desired up to about 75% of the length HI.

The horizontal bar TU is the highest component of the entire hut. It is supported above the horizontal decagon JK....RS by twelve bars (serial nos. 21 to 32). Rectangles TUSR and RSWV together form the slit through which telescope, placed inside at the centre of the base nanogon, can se the sky from horizon to zenith, Z. The thin wire RS does not form on obstruction in the field of view of the telescope, whose objective may be of 62 mm or more in diameter.

The entire hut, except for the slit TVSWVR, is covered with a water-proof tapaulin cover of light weight. With wheels having ball bearings, the hut can be quite easily rotated by two persons in order to change its orientation whenever desired, so that the telescope can be fixed to observe another part of the sky.

When the hut is not in use, the slit TUSWVR can be closed by two tarpaulin curtains, one covering the rectangle TUSR and the other covering the rectangle RSWV. Each curtain opens at the wire RS, so that when observations are done, only the thin wire RS is in the field of view of the telescope.

In spite of this covering on the slit, the telescope inside the hut cannot be considered to be completely safe when not in use. Hence it is advisable to remove it when it is not being used. The stand of the telescope can be left undisturbed inside the hut, so that its polar alignment need not be done again, at the time of next observation session. The stand should further be covered by a large polyethelene bag, in order to minimise any chance of water drops or dust reaching it.

Sturdiness Considerations

The basic structure of the observation hut is almost as sturdy as a geodesic structure, though it does not in any way resemble the geodesic structure. All the faces of this structure are triangles. Seventeen of the twenty standing faces are approximately equilateral triangles.

The tarpaulin cover is, of course, a weak cover. It is alright for a short period of a month or so, when the weather is expected to be fine. It has to be properly maintained too. It must be mended, if and when it gets torn at some spot. Thus the hut is basically a circular movable tent.

If so desired, a sturdy permanent observatory of similar design as this hut can also be constructed by:

(i) covering it by metal sheets instead of by tarpaulin;

(ii) using angle iron and T-iron bars in place of hollow pipes for making the structure, because when holes are drilled in pipes and metal sheets are screwed on them, seepage of some water into the pipes will cause much rusting as it cannot evaporate; and

(iii) welding the joints of the bars instead of making them by nuts and bolts.

The study structure made in this manner can withstand a wind storm too. However, its weight becomes inconveniently large for moving it manually. Hence, either it may be driven by an electric motor, or it may be constructed in a smaller diameter of 4 metre or 3 metre for fewer students to be inside at one time.

Due to the large slit in it, this structure may be considered to consist of two halves WIABCD and DEFGHV. The two halves are held together by the nut-bolt D, the wire 18 and the bars 8, 20, 13, 31 and 32. The stresses are such that the wire 18 is almost always in tension. Thus a thin wire serves well at this spot, instead of thick bars used in the rest of the structure.

Lift Due to Wind

In spite of all the standing faces of the structure being slightly inclined inwards, there is a lift acting on it when there is wind blowing. Suppose at some occasion wind is coming from the left (Fig. 4). Then over the right half WIABCD, a reduced pressure is developed due to Bernoulli's principle. Thus the right half of the hut tends to lift up. So we have to make some arrangement by which the structure can be prevented from lifting off the circular track in strong wind. A simple arrangement is as under.

Outer diameter of the circular wall-cum-bench

= Diameter of inscribed circle – 2 X size of horizontal wheel.

Let this be the diameter of the lower part of the wall only. About 2 cm or 3 cm above the base nanogon, diameter of the wall may be increased and made more than the diameter of the inscribed circle. It has still to be less than the diameter of the circumscribed circle, because the superstructure rests on the nine corners of the base nanogon. Thus the lower part of the wall has a sort of groove into which horizontal wheels and centre point of each side of the base nanogon moves.

Transportability of the Observation Hut

The structure is capable of being used as a portable observatory, when constructed by light weight bars and tarpaulin cover. It can be easily dismantled by opening just 32 nuts and bolts, and can be easily reassembled at any venue where observation work is desired to be done. Nuts and bolts are not just 23, as would appear from Fig. 4. At each corner there is a short bar carrying the wheel for that corner. One end of the short bar is welded and the other is fixed by nut and bolt.

The circular wall-cum-bench, which anchors the hut in strong wind and around which the hut rotates, is obviously an immovable structure. Thus in transporting the hut to a new venue temporarily, this wall has to be constructed at the new venue. Afterwards, this wall-cum-bench can serve some other purposes in that institution. If that institution does not like to have this wall constructed, then the hut can be used in not-so-strong wind, which does not lift it up. When not in use, the hut can be anchored by simpler means, e.g., tying it down to three heavy objects which make approximately an equilateral triangle.

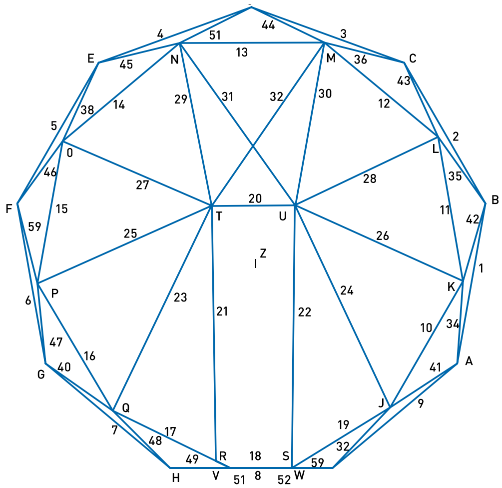

Fig. 4. The basic structure of bars, as seen from above, for constructing the Nanogonal Rotating Observation Hut.

Guidance to Institutions for Constructing a Rotating Observation Hut

If any institution proposes to construct an observation hut of design as discussed above, the author and Shri Anurag Gupta, a reputed architect of Delhi, are in a position to provide guidance with the help of a fully functional scale model. A decision must first be taken by that institution about

(a) venue of the observatory (terrace or an open area where maximum sky is visible);

(b) whether it is intended to be a portable observatory or a sturdy permanent one;

(c) what is the maximum expected number of students who will be inside the observatory at one time;

(d) what size of observatory (diameter of inscribed circle) is desired in view of information (c) above and in view of the size of telescope available in that institution.

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Reference

Appleton, A.K., 'A Home-built Rotating Observatory'. J.B.A.A. vol. 68, No. 6. page 217.

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