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Reflectors Bowl & Hood shape, spherical segment in solar energy concentration in heat form with unidirectional tracking for medium & high temperature more than 150 degree Celsius uses/applications

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Abstract: Shape generated from hemi sphere as hood (vertical cut) and bowl (horizontal cut) of spherical circle arc whose centre is 45 degrees point spherical circle when fixed with reflector material, when rotates eccentrically wrt sphere circle centre moving focus & fixed focus combination junction forms. Keeping the heat absorber at focus junction the heat absorbed or extracted for medium and higher temperature uses.

Key words: **1) Mathematical interpretation of 3 dimensional shapes**
2) Light rays concentration variation wrt ray angles
3) Sun Rays details
4) Tracking of sun by eccentric motion arrangement
5) Formation of moving focus& fixed focus
6) High temperature generation
7) Domestic & Industrial uses

Mathematical interpretation of 3 dimensional objects in 2 dimensions:

Sphere forms by rotating a circle about axis. Sphere also represented by arranging frustums of different slopes vertically from zero radius to maximum radius and maximum radius to zero radius of sphere circle.. It can also be represented frustums of from zero radius to maximum radius and maximum radius to zero radius of sphere circle with constant slant height at varying heights .(Slant height of frustum is equal to arc length spherical circle L=RQ L-arc length , R- spherical circle radius, Q- angle of arc wrt to centre) . If difference of height at two different radii's delta H & difference of radius delta R at height delta H then arc length is equal to square root of sum of square of delta Hand square of delta R). Refer fig-.1. Keeping constant arc length the development of segment can be arrived for petal segment pattern better accuracy. For paraboloid also represented mathematically like case of sphere. By rotating curves like parabola or hyperbola or ellipse the different shapes by rotation paraboloid, ellipsoid or hyperboloid forms. In the above method segments can be developed.

Segments of sphere/paraboloid/hyperboloid are in bowl shape if cut horizontally and cut vertical hood type sections can be developed. .Light concentration varies and focal lengths also vary wrt to shapes (curvature profile -circle, parabola, hyperbola etc.) in the bowl, with hood type sections.

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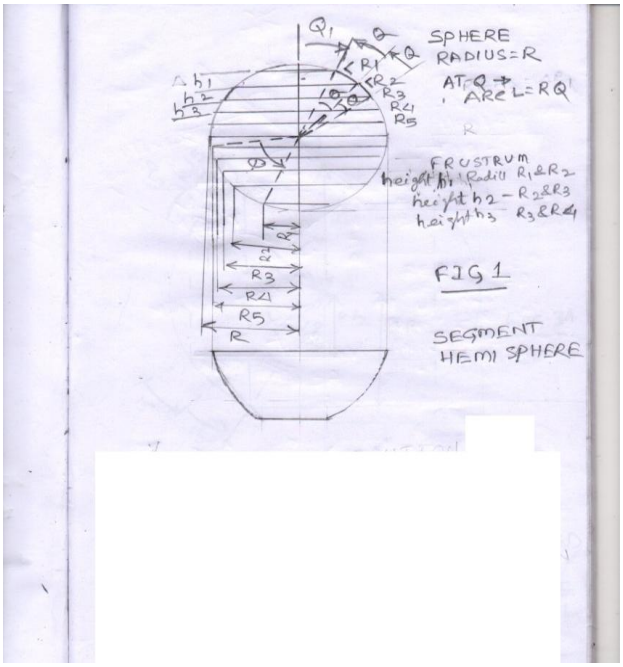

Fig. 1

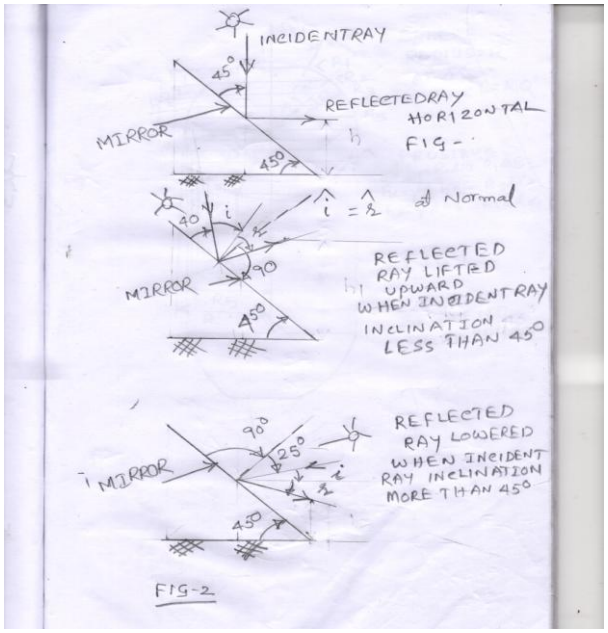

Fig. 2

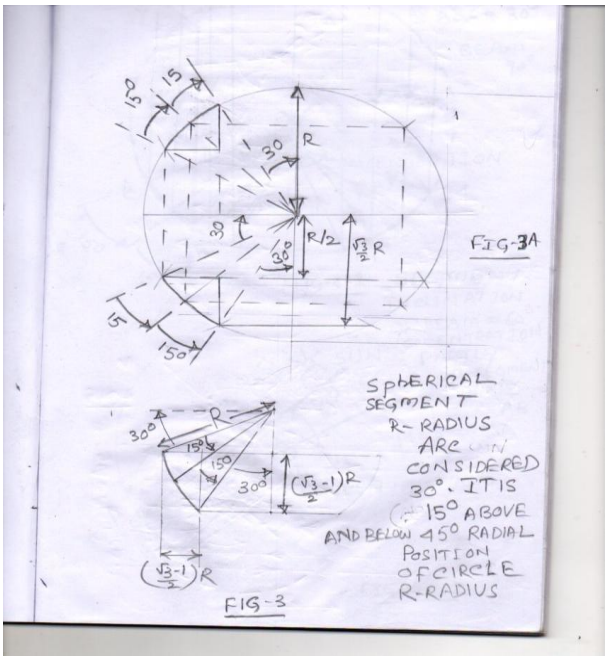

Fig. 3

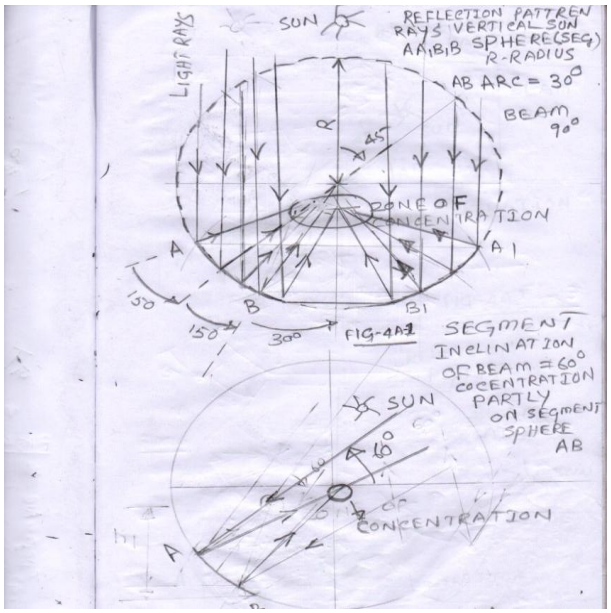

Fig. 4A-1& 4A-2

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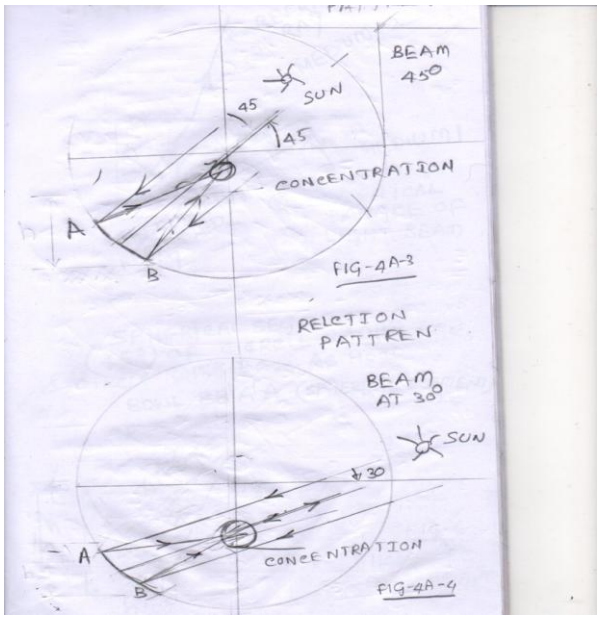

Fig. 4A3& 4A4

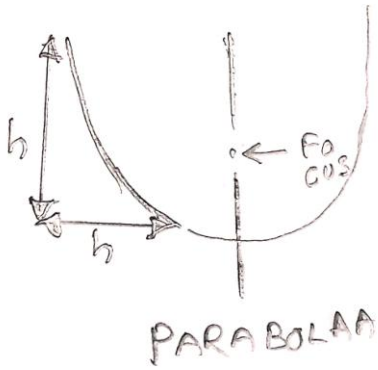

Fig. 4A5

Light concentration Variation of incident & reflected light rays on inclined surfaces/curved shapes:

If a light ray falls on inclined mirror kept stationery at an inclination 45 degrees (fig-2) by varying the incident ray angle wrt to vertical axis the reflected ray height will be varying. If we observe the figures 2 reflected ray angle varies in vertical axis .If mirrors segments in a 3 dimensional solids shapes incident beams when reflected beams concentration sharp or spread focus forms. By varying inclination of incident beam the focus shifts...(Refer photo fig- 10,9)

It can be concluded that varying inclinations of incident rays will vary the reflected rays focus size/heights of stationery curved objects like bowls. Circular arcs as shown fig-3 (arc when formed equilateral right angle triangle drawn from base circle of sphere) which are having different light concentrations due to varying inclinations. It can be interpreted as drilling hole in hemisphere whole center is at 45 degrees point of spherical circle. The hole dia 15 degrees above and below of spherical circle arc (fig-3), dia of hole equal to - R (v^3-1)/2, {R (Square root 3 minus one divided by two)}.This hole formed is of section ellipse whose minor dia ' is equal to hole dia & major dia is equal to square root two times of minor dia (v^2 D).Maximum depth of elliptical segment will be at centre (depth of 45 degrees arc).

It can be concluded ellipse forms by drilling hole in hemisphere vertically. The hole centre (axis) at 45 degrees point of spherical circle. At 45 degrees centre ellipse is having maximum area. If hole centre is above or below 45 degree point the ellipse formed is flattened one and Focus reduces and will not occur.

Spherical segments shown in Figs 4A-1, 4A-2, 4A-3, 4A-4 are similar to Circular arcs as shown fig-3. The reflection patterns vary with incident ray angles. This influenced the concentration of reflected rays. ***For paraboloid the segment arc (Fig 4A 5 the vertically cut segment Parabolic Arc coordinates difference of X & Y ordinates when it is same or difference of X ordinates/difference Y ordinates is equals to one (Slope: Difference X/Difference Y=1) then the arc/segment of paraboloid) rays reflection also behaves like in the above said pattern with changes in concentration. The intensity of focus is more in paraboloid segment.in comparison to spherical segment (***Figs 4A-1, 4A-2, 4A-3, 4A-4).

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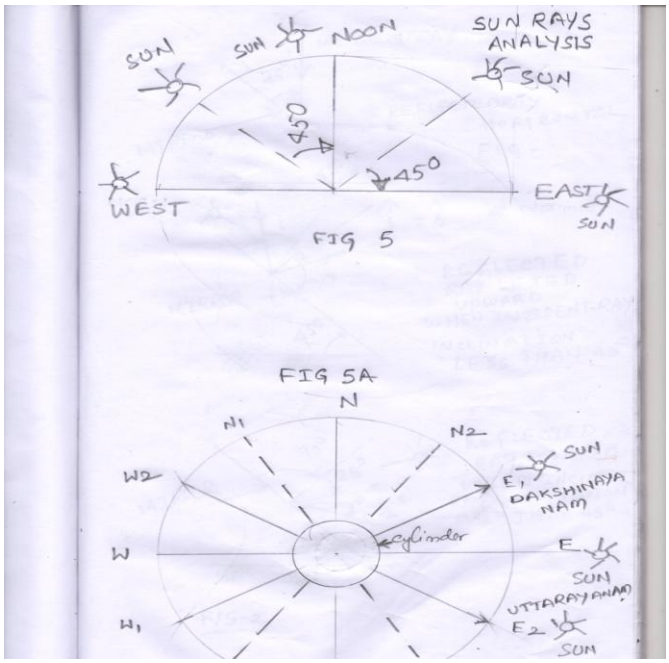

Fig. 5 &5A

Sun rays details: **(refer fig-5& 5A)**

Sun rays travels from east to noon and noon to west .The sun rays position morning to noon raising sun rays inclination varies from zero to ninety degrees (wrt to vertical) and noon to west lowering sun inclination varies from 90 deg to zero .The shade length of object/ cylinder reduces as sun moves east to noon and at noon minimum length and sun movement noon to west shade length increases .The shade rotation varies season wise ...If we observe the position of East it will be varying wrt to season. This indicates rotary part of sun rays component. The extreme positions of East are called Uttarayanam E2, Dakshinayanam E1 as mentioned in Srimad Bhagavata Puram of Indian Sage Veda Vyasa.

If we observe light falling on cylindrical surfaces(fig-5A) some surface area(certain arc portion) receive direct beam radiation of incident sun radiation. This can be observed from rays falling of cylindrical surface. The shade of cylinder rotates as direction of East changes varies (fig-5A) uttarayanam E2 to Dakshinayam E1.Similarly other directions changes. The shade physical dimensions are minimum at noon in comparison to morning hours or evening hours. But comparing shade dimensions at noon it is more at E2 than E1. ***It can be conclude that reflector shape/design should cater vertical rays of sun and inclined rays of sun also***.

Tracking of sun rays:

If the rays fall in a bowl the vertical portion of light is concentrated which forms sharp focus depending upon surface profile -spherical/parabolic etc.. For inclined portion of light due to rotation Sun rays focus shifting and size focus and sharpness of focus varies .Focus cannot be maintained at a focal axis . And frequent shifting of focus will affect the absorber performance .This can be reduced by using 2 dimensional tracking of reflector. This is major constraint in design of solar reflectors. ***By extending hood like reflector segment above bowl reflector, (refer fig 6) this shape will reduce tracking to one direction tracking in spherical surfaces by moving the reflector eccentrically wrt to centre of sphere circle in vertical circle/axis. Using mechanism like crank /screw and nut type straight line mechanism eccentric movement is achieved in vertical circle .In this focus will remain***

same. But the focus will be moving due to eccentric movement various spheres formation at different planes for hood but the focal point/ radius remains same but moving focus forms.For bowl fixed focus forms. The actual focus forms are combination of fixed and moving focus. Heat collection is done by placing absorber at this focus junction.

In paraboloid (refer fig6A) hood like (reflector) segment above bowl segment (reflector), this shape will reduce tracking to one direction tracking in paraboloid/parabolic surface(as mentioned like hood & bowl spherical segments) by moving the reflector eccentrically wrt to focus of parabola in vertical circle/axis. Using mechanism like crank /screw and nut type straight line mechanism eccentric movement is achieved in vertical circle .In this focus will remain same. But the focus will be moving due to eccentric movement various paraboloid formation at different planes for hood moving focus forms but the focal point remains same. For bowl fixed focus forms. The actual focus forms are combination of fixed and moving focus. Heat collection is done by placing absorber at this focus junction

The absorber designed suitably to care of variations of focus. Absorber optimum height is to be judged by making trials at different seasons of year. Temperature generated at focus is more than 150 degrees Celsius. In case of paraboloid segment this as shown in Figure-6 for spherical segment and paraboloid segment figure 6A cross section. It is a combination of bowl and hood .The segment development (fig 7) easily obtained with common man knowhow. For spherical segment and paraboloid segment .The focus of spherical hood section (fig 10, 11 hood has been fabricated separately) will be in triangular shape and peak at centre. But in parabolic surface Fig-9 cone type focus forms with sharp and pointed focus at tip.(Hood type reflector focus for paraboloid Fig 9 and spherical segments as mentioned in photo graph Fig 10,11).. .

The incident light used for generating heat is hood portion area in morning period .As the sun raises light used for generating heat is the hood area as well as part portion of bowl is(from 1030 to 1200 hrs.) .At noon the bowl incident area plus hood area is used for generating heat.

Noon to evening the hood area and part portion of bowl afternoon to 1330 hrs. After 1330 to evening only hood area is used for light concentration and heat generation.
The absorber is to be located at focus designed suitably with minimal heat loss.

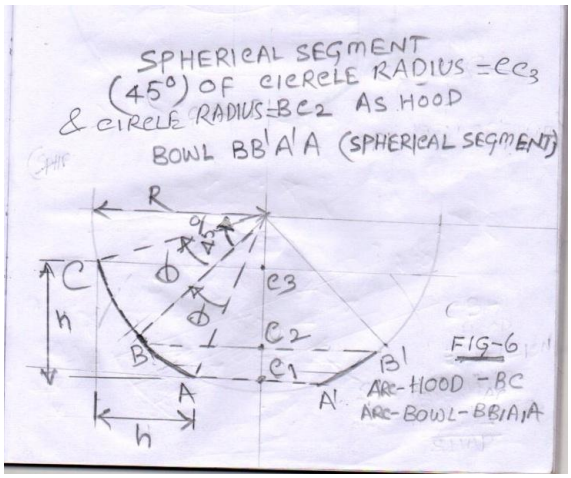

Fig 6

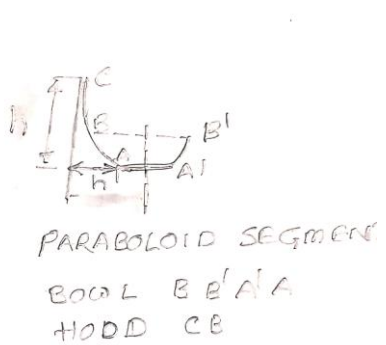

Fig 6A

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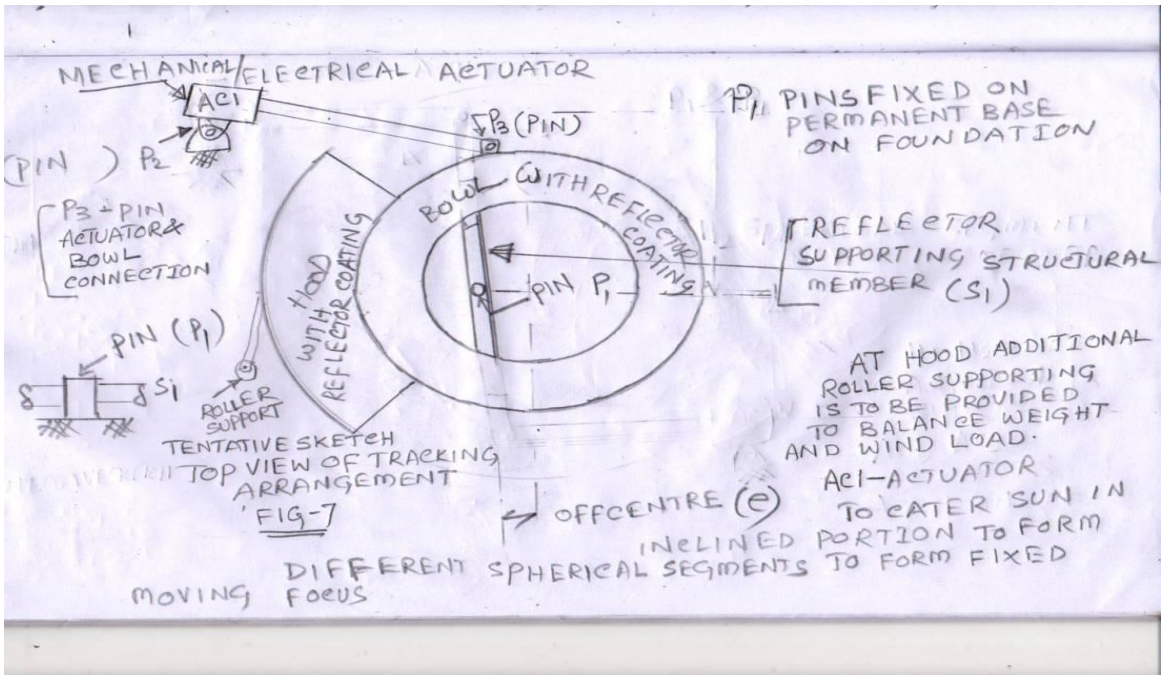

Fig 7

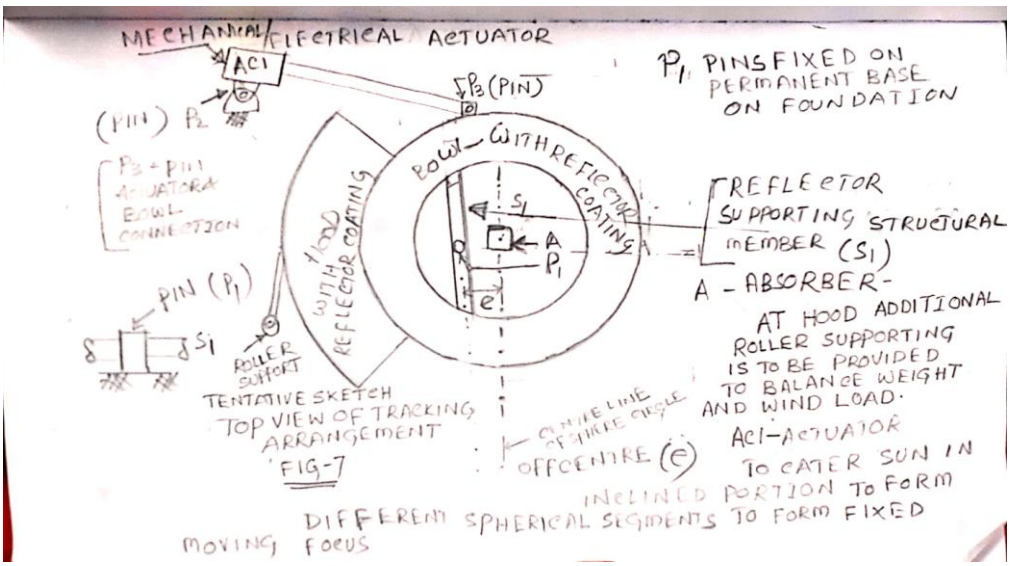

Fig 7A

Reflector arrangement & Tracking fixation arrangement:

Refer fig-7 & 7A Template of of above (hood plus bowl) shape is fabricated and fixed with reflecting material. .The reflector faces sun (east) it is to be rotated north south axis in vertical direction to align with sun position. Moring to noon. Afternoon the reflector assembly face the sun in West to be rotated north south axis in vertical direction to align with sun position ...The above reflector bottom edge of bowl (lesser dia side) is mounted/fixed on structure S_1 .The structure with reflector assembly can be easily rotated about the pin (P_1).The pin centre and centre of bowl is off centre by distance" e" as shown in thefig-7. The pin P_1 permanently fixed / grouted. The other end bottom edge of bowl is fixed to the pin P_3 of (for linear movement caused by screw and nut mechanism or crank mechanism) electrical/mechanical actuator (AC_1). Actuator AC_1 is fixed through pin P_2, P_2 is connected to base which is fixed permanently/grouted. .In this arrangement when the actuator is activated the position of

hood varies wrt to fixed pin (P_1). When the stroke length of actuator varying various spheres forms in different planes with same radius/focal point. The focal distance/radius will not vary. In this way moving focus is easily generated during inclined portion of sun rays. As sun raises fixed focus formation occurs in by bowl. At noon focus in combination of fixed and moving focus. At mid noon the reflector is to be positioned to west side and connected to tracking mechanisms

The absorber A is to be located at focus (fig7). Center of bowl. But the height is chosen /selected so that at all the season's year it receives optimum concentration of sun rays season wise. While placing flash locating the absorber shift of focus due to tilt of different seasons of sun position is to be considered. This is because there is a shift of focus due to sunrays tilt variation from September middle to April middle of calendar year.

As experiment is carried at residence due to less availability of space at residence pilot model parabolic bowl (fig-13) & hood spherical segment hood & paraboloid(fig8,9,10,11,12) were tested as shown in photograph item wise. The segment paraboloid & segment hemisphere models were fabricated as shown photographs fig (8, 9, 10, and 11)

It can be observed in parabolic segment (fig 8& 9) point focus forms, but reflection in spherical segment (fig 10&11) triangular focus forms and at centre focus is bright.
Focus spreads due to rotation of sun light both parabolic segments as well as spherical segments (Fig-12).The bowl portion is made from light weight sheet to lessen the dead weight of equipment. While designing the bowl area and hood area are to be selected suitably so that at lower inclination of sun hood area is reflection is predominant and bowl area is less effective.

This method is also utilised for bowl & hood shape segment generation from sphere &paraboloid etc. Paraboloid segments developed hood for better focus.(hood segment of paraboloid as shown in fig-8&9).

In winter due to low angle of sun in fixed arrangement of the reflector usage time is less than in comparison to summer.

The basic advantage of this are 1) one direction tracking 2) It is easily constructed with simple knowhow 3) Spherical or parabolic reflectors used as per the requirement for medium and high temperature requirements. 4) This is operated in manual mechanical mode or auto mode with simple electrics & sensor devices. 5) This is used for utilities temperature requirement more than 150 degrees Celsius domestic as well as industrial uses.

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Fig. 8
Parabolid segment as hood (area) 1.17 mt square As it kept part tilted tested for concentration/focus observation the focus.

Fig. 9
Parbolid segment part tilted and sharp focus

Fig. 10
Spherical segment part tilted focus is triangular shape. maximum brightness at centre.. focus is of triangular shape Area 1.089 square meters

Fig. 11
Spherical segment reflector with slight distributed focus

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Fig. 12
Spherical segment with wider focus than fig-11 more misaligned with sun

Fig. 13
Bowl reflector for catching vertical portion sun rays

Reference: 1) "SRIMAD BHAGAVATHA PURANAM" by Indian Sage Sri VEDA VYASA

2) SAUNDARYALAHARI" by Indian Sage Sri ADI SANKARA

3) INDIAN TEMPLE Architecture

4) Aryabhattiyam written by Sri Arybhatta ancient Indian Mathematician