

# PATENT SPECIFICATION (11) 1 581 253

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## (54) AN IMPROVED SOLAR ENERGY COLLECTING DEVICE

(71) We, AAI CORPORATION, a corporation organised and existing under the laws of the State of Maryland, United States of America, of York Road at Industry lane, Cockeysville, Maryland 21030, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a solar energy collecting device, and more particularly to such a device that may form part of a building and that is capable of movement to various positions for maximizing of the collected solar energy as the altitude of the sun varies diurnally and seasonally.

10 Various solar energy collectors are known. Many use a parabolic mirror with a collector located at its focus. Such mirrors and collectors usually move as a unit to track the movement of the sun.

15 Several other prior collectors use a stationary mirror or mirrors with a movable collector or collectors. Among these are a generally spherical mirror construction with a movable centrally spaced collector arranged to move angularly about a fulcrum according to the position of the sun and the season of the year. The spherical mirror has a complex curvature which is difficult, expensive, and impractical for manufacture on a large scale. A second arrangement which is shown in German Patent Specification No. 527, 417 uses an oblong laterally symmetrical parabolic mirror with its horizontal focus directly and vertically above

20 its centre. To accommodate small variations in sun angle away from the vertical, the collector is moved both laterally and vertically by a pivoted telescoping arm and cam guideway arrangement. The compass orientation of this system is not clear in view of various inconsistencies in the description. However, in any event it appears that as a practical matter very little angular movement of the sun away from the vertical (as viewed from the end of the reflector and collector) can be accommodated with this system, and certainly not the extent of

25 seasonal change in the altitude of the sun relative to the horizontal. In addition the system is relatively complex and to a considerable extent unwieldy on a large scale in view of the guide cam and telescoping arm requirements. It appears that to use this arrangement over any extended period of days or seasons, and even during large diurnal changes of sun angle during

30 some days of the year, the reflector would also require some form of rocking or pivoted reorientation to vary the angular position of the mirror to complement the cam and telescoping collector-support arm arrangement.

35 According to a first aspect of this invention a solar energy collecting device comprises a reflector having three part-cylindrical segments arranged side-by-side, the middle segment having a larger radius of curvature than the other two and the principle axes of the other two segments being inclined towards that of the middle segment, the reflector being held, in use, in a fixed position, and an elongate thermal energy collector which is parallel to the reflector and which is arranged, in use, to be movable across the reflector to follow the maximum confluence of the sun's rays reflected by the reflector as the altitude of the sun changes.

40 A number of devices in accordance with the first aspect of this invention may be arranged side-by-side with fluid conduit means connecting in fluid flow relationship the collectors of the devices for commonality of fluid heating by the devices.

45 Alternatively, according to a second aspect of this invention, a solar energy collecting arrangement comprises a number of devices including a concave, part-cylindrical reflector which is held, in use, in a fixed position, and an elongate thermal energy collector which is

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parallel to the reflector and which is arranged, in use, to be movable across the reflector to follow the maximum confluence of the sun's rays reflected by the reflector as the altitude of the sun changes, arranged generally side-by-side, and fluid flow conduit means connected in fluid flow relationship between the collectors of the devices for commonality of fluid heating by the devices. 5

Preferably, arrangements of devices form at least part of the roof surface of buildings. In this case, the devices are usually used to provide at least some of the energy requirements of the buildings. 5

A particular example of a device and various modifications in accordance with this 10 invention will now be described with reference to the accompanying drawings; in which:-

Figure 1 is a perspective view of a building; 10

Figure 2 is a perspective view of a portion of the roof of the building; 10

Figure 3 is an enlarged fragmentary perspective view of one end of the device; 10

Figure 3a is a further enlarged cross-section through the collector of the device; 15

Figure 4 illustrates a modified collector support arm; 15

Figure 5 illustrates a joint between adjacent devices; 15

Figure 6 is a diagrammatic end elevation of two adjacent devices; 15

Figure 6a is a diagrammatic end elevation showing the modified collector arm support; 15

and, 20

Figures 7 and 8 are diagrammatic end elevations illustrating of the mode of operation of a single device at various times during the year, Figure 8 also showing various angle and dimensional relationships for the particular device. 20

Referring now in detail to the Figures of the drawings, a heat utilizing building structure, for example a house, a school, or a factory, generally indicated at 11, has a roof 21, formed by 25 a plurality of individual reflector-concentrators 31 and may also have a further roof surface or surfaces of any other configuration. 25

The extent of roof/reflector-concentrator surface 21 is generally dependent upon the amount of solar energy required. 30

For maximum energy collection, the entire roof is formed as a reflector-concentrator assembly 21, as generally illustrated in this example. Windows 15 and doors 17 may be provided in walls 13, if required. 30

The roof/reflector-concentrator surface 21 is formed by a plurality of laterally adjacent individual reflector-collectors 31 which form water-tight effective roof sections and which are connected together at their lateral edges in substantially laterally adjoining relation to effect a water-tight roof construction. The interconnected reflector-collectors may be suitably mounted and carried on the various upright and cross members forming the load-bearing building framework 101, as through the medium of complementary concave cradles generally indicated at 36, which may be suitably spaced at the ends of the individual reflectors 31, and otherwise located if desired or needed for a given size or load. Side and end covers 32, 35

32a may be suitable secured along the respective sides and ends of the roof/reflector-concentrator surface 21 in order to effectively seal the sides and ends of the roof against rain entry, and gutters 111 may be provided along the ends of each bank of reflector-concentrators 31, the illustrative embodiment having two banks of reflector-concentrators 31 forming the roof 21, with three gutters at the respective outboard opposite and adjacent 40

45 opposing ends of the two banks of reflectors. Rain water will thus be drained along the troughs formed by the reflectors 31 and into the gutters, from which the drain water may be discharged to the ground as through suitable downspouts or down-guttering (not shown) as necessary or desired. 45

A suitable facia generally indicated at 19 may be provided as an aesthetic enclosure and 50

wind break around the reflector-concentrator roof 21, as desired, although there will be a small sacrifice in overall efficiency due to end shadowing from the facia on the reflectors 31 with the facia extending above the reflectors to any appreciable extent. 50

Each reflector-concentrator 31 may be formed of any suitable solar reflective material, such as metal, glass, plastics and such materials may be of load-bearing type and provide 55

some, a major portion, or all of the roof surface construction strength or may be of nonload-bearing substrate. The desired curvature of each roof/reflector-concentrator 31 may be formed as a smooth curve or as straight or curved line segments. For instance, a curved metal roof surface may be formed in one continuous sweep, or in several panels, or various normally straight panels of metal, glass, plastics, etc. may be utilized in suitably joined relation for form 60

the desired overall curved shaped roof/reflector-concentrator surface 31. The roof 21 may also be only partially reflective in parts thereof or in whole, if so desired, in order to provide for natural lighting of the interior of the building by light passage through the roof 21. Similarly, the section 31 of the roof may also transmit light to the building interior if so desired. 60

65 The roof/reflector-concentrators 31 face upwardly preferably with their opposite ends 65

oriented directly East-West for maximum energy utilization, although other compass orientations may be utilized with less efficient operation.

Each roof/reflector-concentrator 31 reflects and concentrates solar energy into a zone of maximum confluence which varies in position as a function of the angle of the sun with respect to the horizontal, as measured in a North-South vertical plane passing through the roof 21. A solar energy collector 51 is movably mounted, as by pivot arms 45, for back-and-forth movement in a North-South direction above each respective reflector-collector 31.

The collector pivot support arms 45 are pivoted along a horizontal East-West line which may extend beneath, above or at the surface of the respective reflector-concentrator 31, with generally only small differences in effectiveness of the reflector/collector assembly 31, 51. In the illustrative embodiment, the arms 45 are mounted on pivot support bearings 81c which lie beneath the surface of the roof reflector 21. In the illustrative embodiment, as generally shown, the ratio of the reflector chord/length subtended area versus the effective collection area of the collectors 51 is approximately 15 to 1, thereby providing a maximum feasible concentration or amplification factor of no more than approximately 15 for an individual reflector/collector unit 31, 51 considered alone, although some spurious reflection from adjoining reflectors 31 may increase the pickup to some extent. Other factors, such as angle of inclination, interference of the collector 51 in passage of the sun's rays to the reflector 31 (as at summer periods), reduce the maximum possible value to a lesser possible value for various solar angles. This factor further depends upon the extent of interception of the zone of solar reflection confluence by the collector 51, as will be subsequently discussed in more detail.

The pivoted support arms 45 are preferably suitably ganged together as by linkage rods or beams 71 or the like to provide simultaneous ganged motion of the various collectors 51 relative to their respective reflector-concentrators 31. Ganged parallelogram movement of the pivoted support arms and horizontal linkage beams 71 may be suitably effected as by pivoted drive arms 81 connected through a torque tube 91 and pivotally mounted in pivot support bearings 81c on cross-members of the building framework 101, under one of the reflector-concentrators 31, as more particularly shown in Figure 3. A support brace 83 may extend to aid in stabilizing the pivot pin 81a for drive arm 81. Pivoted back-and-forth motion of the drive arm 81 about its pivot 81a may be suitably effected by a drive motor M and screw jack 84, the screw jack being preferably of the circulating ball screw motion type, and this assembly M, 83 may be pivotally pinned and carried between a pivot pin 83a carried by the building framework and a pivot pin 83b at the lower short legend of the drive arm 81.

The pivoted support arms 45 may be suitably pivotally mounted as indicated at 45a in respective bearings secured to the building framework 101, and the upper ends of the arms 45 may be pivotally secured to the horizontal linkage 71 through respective pivot pins 45b. The effective lengths and angles of arms 45 and 81 are the same, whereby effective parallelogram motion may be effected for this collector movement assembly.

In the preferred embodiment of Figures 1-3 and 6, the collectors 51 are maintained horizontal in their various positions above the respective reflector-concentrators 31, through the securement of the ends of the collectors 51 to the horizontal linkage beams 71, as through the medium of bolts 73. This horizontal facing of the collectors 51 down toward their respective reflectors aids in energy retention by the collectors 51 by minimizing heat losses particularly from convection loss which is greater with a tilted altitude of the collector receiving face.

Alternatively, through less desirably, the collectors 51 may be secured to the respective pivoted arms 345, as shown in Figures 4 and 6A, and parallelogram motion of the arms 345 and gainging linkage beam 371, pivotally interconnected as by pin 345b, will effect tilting movement of the collectors 51 as a function of pivoted movement of the arms 345.

A preferred reflector-concentrator construction is illustrated in Figure 3, in which glass mirror segments 31a are cemented to a suitably curved sandwich formed of sheet metal 33, rigid insulating foam 35, and sheet metal 37. This construction enables the formation of a suitably rigid mirror reflector with a desired curvature, and which will withstand the necessary weather loads. The various layers of the curved sandwich 31a, 33, 35, and 37 may be suitably bonded together as a unit through cement or the like, and multiple layers of foam 35 may be employed to enable ease of curve formation thereof particularly if such is not precast in the desired curvature. The glass mirror segments 31a may be omitted, with decrease in reflection efficiency being effected for most other effectively utilizable surfaces such as polished aluminium, steel, or other sheet metal or the like as the reflector surface which might thus be formed by the sheet 33 of the reflector 31 sandwich construction. Other constructions for reflector-concentrators may be utilized, as desired.

The reflector-concentrators 31 are suitably interconnected at their adjoining edges to effect a water-tight joint. A suitable connecting arrangement is illustrated in Figure 5, including male and female edge moldings 41, 43, which may be formed as metal (e.g.

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aluminium, magnesium, steel, etc.) extrusions extending along all or a major portion of the length of the adjoining reflector-concentrators 31. The male edge molding 43 has an upper male edge 43a which nests within a rubber sealing gasket 44b disposed within a reverse lip 41a of the female edge molding 41, and interfitting spacer ridges 41 $\ell$ , 43 $\ell$  run along the intermediate lower ends of the respective moldings. A further rubber sealing and mounting gasket 44a is compressed between the moldings 41, 43 within the space above ridges 411, 431, and the entire assembly 41, 43, 44a, 44b is secured together through multiple longitudinally spaced bolts 47 and nuts 47a. The longitudinal edges of adjoining reflector-concentrators 31 are retained between upper and lower angled flanges 41fu, 41fu and 43fu, 43fu on the respective interfacing edge moldings 41 and 43.

Each collector 51 may be suitably formed with a plurality of laterally side-by-side fluid flow heat transfer tubes 57a, 57b through which a suitable fluid, such as water, gas, etc. may be flowed for collection of the reflected solar energy from its respective reflector-concentrator 31. These tubes 57a, 57b may be connected for in-flow at one end and out-flow at the other end of the collector 51, or preferably as shown, may be reverse-flow interconnected at one end of the collector for increased fluid flow path length within the concentrator as well as simplified external fluid interconnection thereto and therefrom. The parallel flow tubes 57a, 57b may be suitably connected, as through flexible hose conduits 49a, 49b carried in a common protective insulating sheath or jacket 49 with common feed and return conduits 47a, 47b. Feed and return conduits 47a, 47b may be connected in parallel with in-flow and out-flow side-by-side conduits 57a, 57b of each of the collectors 51, and a heat exchange fluid, preferably liquid, such as water may be pumped through the conduits 47a, 47b, 49a, 49b and 57a, 57b.

As shown in Figure 3, the collectors 51 are formed with their respective reflected energy absorption elements 59, 57a, 57b facing downward toward the respective reflector-concentrator, and thereby enabling the interception of the solar reflection thereto from reflector 31 at a given proper angle of this assembly. Collectors 51 preferably are insulated at their outer surfaces facing away from reflector 31, as by rigid or other plastics foam or other suitable insulation 55, with a rigid opaque wrap-around generally U-shaped structural beam-like cover element 53, which may suitably be formed as a metal extrusion. A solar energy transparent cover glass plate or plates 58 may be secured beneath the energy absorption tubes 57a, 57b, with a downwardly finned black body heat-absorbing heat-sink block secured in spaced relation above the cover glass 58, as by anchoring in the plastic foam insulation with a longitudinal ridge anchor connector running along the length of the block 59. Elastic shock-resistant seals such as soft rubber gasket seals 56 may suitably retain the cover glass 59 within the beam cover element 53. The fluid conduit tubes 57a, 57b are carried in intimate direct contact with the finned black body heat-sink block 59, as by embedding in the heat-sink block 59 or laying the tubes 57a, 57b in longitudinal grooves in the upper side of the block 59 and crimping longitudinal lips adjoining the grooves down around the tubes 57a, 57b, as illustrated. Heat absorbed by the black body finned heat-sink block will be conducted directly to the intimately held fluid passage tubes 57a, 57b and the fluid passing therethrough. This construction together with the horizontal positioning of the collectors 51 in their various lateral positions aids in effecting a desired efficiency of energy collection and transfer at the collectors while also minimizing energy losses which may occur through convection with a tilted collector altitude.

Fluid feed and return lines 47a, 47b may be suitably connected to a desired heat utilization system, such as a heat storage and building interior heating arrangement, and/or a cooling system, such as one based on absorption cooling principles. Alternatively, various machinery may be caused to perform work by the solar heat transferred to the fluid in collectors 51, or other desired and suitable heat derived work may be performed. With this invention, liquid temperatures, such as for water as the liquid may be raised to as high as 300°F or more, dependent on liquid flow rate, relative sizes of collector and reflector, etc. Practical heating and absorption cooling may be accomplished well within and below this temperature extent for the liquid L flowed through the collector 51.

As shown particularly in Figures 7 and 8, the individual reflector-concentrators 31 each have a semi-cylindrical concave reflecting surface which is formed of adjoining arcuate segments S1A, S2, and S1B, the opposite outermost arcuate segments being preferably identical in radius and arcuate length and being of lesser radius of curvature R1, R3 than the radius of curvature of the central arcuate segment S2. Thus the concavely curved trough segments S1A and S1B curve up at a sharper rate than does the central segment S2, and thereby aid in maximizing overall confluence of the reflected solar rays into a zone for interception by the respective collector 51 at various sun angles encountered throughout the year. Also, by providing a symmetrical trough-like concave reflector-concentrator unit 31 the adjoining reflector-concentrators 31 may be simply interconnected to form a roof of an overall flat, though obviously more detailedly undulating, envelope configuration for use on

building structures where such a roof is most desirable, including particularly institutional, industrial, and some residential buildings.

The vertically facing symmetrical three-radii reflector-concentrator configuration is effective to provide a substantial degree of concentration of solar energy onto the collectors 51, the precise degree of concentration varying with the sun angle, and varying generally from approximately 6:1 to approximately 10 or 11:1 concentration ratio in the illustrative embodiment for a latitude of approximately 28° North latitude. As an illustration of the effective reflected sunlight envelope intercepted by the collectors 51 at various times of the year, Figure 8 diagrammatically shows the effective reflected solar energy envelope zones intercepted by the collector in the illustrative embodiment for various periods of the year, namely at mid-day summer solstice, mid-day spring/fall equinox, and mid-day winter solstice. The zones of effective reflection on the mirror surface of reflector-concentrator 31 are indicated respectively at SESM, SEF/SM and SEWM on this diagram.

A particular illustrative embodiment of the individual reflector-concentrators 31 and collectors 51 for a latitude of approximately 28°, such as generally illustrated, may suitably employ the following relationships, referring to Figure 7 for reference characters and elements:

20	Radii R1 and R3 of front and rear arc segments S1A and S1B	62	units	20
	Radius R2 of center arc segment S2	81	units	
	Effective width CW of collector 51	6	units	
	Length of pivot arm 45	40-3/4	units	
25	Length a	24	units	25
	Lengths b and c, each	21	units	
	Length d	24	units	
	Length e	15-1/3	units	
	Length f	6-1/4	units	
	Length g	4	units	
30	Arc segments S1A and S1B	27	units	30
	Arc segment S2	43	units	
	Minimum sun angle MNS desired to be accommodated by collector 51	17	degrees	
35	Maximum sun angle MXS desired to be accommodated by collector 51	104	degrees	35
	Minimum required angle MNC for collector/arm assembly 51, 45 to accommodate maximum desired sun angle (of approximately 104 degrees)	7	degrees	
40	Maximum required angle MXC for collector/arm assembly 51, 45 to accommodate minimum desired sun angle (of approximately 18 degrees)	147	degrees	40
45	For other latitudes, particularly within the range of 0 to 40 or 50° latitudes, the same dimensions of this illustrative reflector may be utilized, if desired, with a simple change in the length of the pivot arm and the location of the pivot position 45a for movement of collector 51 as determined by a plot of the reflection angles of the sun from the various curved surfaces of the reflector-concentrator at the various sun angles encountered at the given latitude, and thereupon selecting the optimum arcuate motion path for the collector 51, which will thus dictate the arm 45 length and pivot 45a position. For instance, for a latitude of approximately 39° North the length of arm 45 is shortened to 32 units, with length f being lengthened to 21 units and length g being zero, in order to obtain a desired extent of concentrated energy collection day by day throughout the year, in this latitude location.			45
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55	Determination of location of collectors 51 for each solar angle may be precisely determined for a given reflector 31, either by empirical plotting, or computer or other mathematical analysis of the confluence lines along the front-to-back extent of the reflector with the collector positioned for the particular desired maximizing of reflected solar energy interception at the various sun angles, with such compromises between maximums at various angles as may be desired for a given location and utilization. Positioning of the arms 45 and collectors 51 may be effected either on a predetermined control basis, or by energy sensing and feedback control of the drive means for movement of the collectors 51. An example of a suitable energy-sensing and feedback control means for the collector movement drive is illustrated in British Patent Specification Number 1506057. As all of the reflector-concentrators 31 have preferably substantially identical curvatures and collectors, a single			55
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common control may thus be suitable employed for the bank of reflector-concentrators 31 forming the roof 21, with its associated collectors 51, based for instance on reflected energy-sensing pickup at one of the collectors 51, or several such pickups may be employed and utilized as a common control. Obviously, each arm 45 and collector 51 might also be 5 separately driven and controlled if so desired, though such will not normally be desirable.

Desirably, arc segments S1A, S2 and S1B are smoothly joined at a common point of tangency, a common tangency radius line extending through the centers of radius R1C and R2C as well as R2C and R3C for the three radii R1, R2 and R3.

As previously noted, various zones of reflected solar energy confluence for the illustrative embodiment are schematically shown in Figure 8, the zones being only approximately shown and representing the midday times at approximately 28°N latitude for the sun's position at noon on each of the winter solstice, summer solstice and spring and fall equinoxes. I have found that a good ratio of energy concentration and collection can be obtained over the major insolation periods of each day of the year by utilization of three or more radii for respectively 10 three or more of the sections of the roof reflector 21, the radii being lesser in length for arc segments increasingly spaced from the lateral center of the respective reflector-concentrator 31. In the illustrative example, three radii are satisfactorily employed, the smaller R1 and R3 defining the central vertically facing reflector surface arc segment S2, as shown schematically 15 in Figure 7. Referring again to Figure 8, it will be noted that at no sun angle or reflection zone 20 does the multiple-radii generated reflector-concentrator 31 form a single focus line, but instead forms various zones of confluence, and the size and location of the zones of confluence vary with the sun angle, which in turn varies both over the period of a year and during 25 each day. In this respect, inspection of the sun positions for the illustrative 28°N latitude location readily show the requirements imposed on the system in given days over the period 30 of a year. These zones are illustratively indicated in Figure 8, and designated as daily movement zones for the collectors 51 and their supporting pivot arms 45. It will be noted from Figure 8 that the reflector can and does accommodate solar angles to a limited degree behind the 90° vertical. Of course, the side or end angle of inclination must also be considered, and in order to maximize solar energy collection at low end angles the same as 35 measured in the East-West vertical plane, the reflectors 31 and collectors 51 should desirably be relatively long along their length, particularly with respect to the distance of the collectors 51 from the reflectors 31.

As the days approach the spring and fall equinoxes the daily excursions of movement required for the ganged arm/collector assemblies 45, 51 decrease, until at the respective two 35 equinoxes the ganged arm/reflector assemblies 45, 51 require no angular movement as the sun rises and sets on the East-West orientation line of the reflector axes, and forms a constant angle throughout the day as measured in a North-South vertical plane passing through the reflectors 31.

In the illustrative embodiment, the solar concentration factors, or amplification factors, 40 vary with the solar angle. The concentration or amplification factor is a function of the extent of coverage or interception of the zone of confluence of the reflected solar energy at a given sun angle, and it is therefore desirable to maximize this extent of interception at the various angular positions of the sun and the collector/arm assemblies 51, 45, insofar as is practical and economical.

45 We have found that by mounting the arms 45 on respective pivot axes near the surface of reflectors, as at, above or preferably beneath the reflector surface, an adequate extent of interception of the various zones of solar energy confluence may be obtained for the collector 51. In the illustrative embodiment the horizontal pivot line for pivot support arms 45 is disposed slightly beneath the effective reflective surface of respective reflectors 31, and is 50 spaced from the center of longitudinal center line of the reflector 31 in a direction away from the Equator, the extent of desired displacement varying with the latitude of the user location. However, this arm pivot line may if desired be otherwise located for a given embodiment, as for instance above or at the surface of reflector 31.

In the modification illustrated in Figure 2A, the common center pivot arms 45 for the 55 longitudinally paired collectors 51 of the two banks of reflectors 31 are replaced by separate individual center zone individual pivot support arms 245, and the respective longitudinally paired collectors 51 of the two side-by-side banks of reflector/collector units are individually tied together only through the common drive torque tube 91 which serves to impart pivotal movement to the parallelogram linkage 45, 81, 71, 245, 271, 81, 245, 271, 81, etc. for each 60 end of the ganged groups of collectors 51, 51 etc.

It will, of course, be appreciated that all of the drawings are only illustrative and are not 65 themselves intended to be illustrated necessarily in true size relationships, although such is to some extent approximately the case, as particularly in Figure 7. This observation applies also to the zones of solar reflection confluence and the collector 51 interception zones, although such are shown to give a fairly indicative illustration of the principles and mode of operation

and practice involved.

The typical specific illustrative example proportions as previously shown and described, particularly with respect to Figure 7, are, as previously noted, for an embodiment and practice of the invention primarily within a latitude of approximately 28°. Also, as noted, the embodiment is arranged such that the concentration factors for summer, spring and fall solar energy collection are maximized, to some extent at the expense of winter concentration factors, in order to maximize available solar-derived heat energy for air conditioning, (although still enabling the satisfaction of minimum requirements for heating during at least the major portion of most winter conditions).

5 While the invention has been illustrated and described with respect to particular illustrative 5 10 embodiments and modes of practice, and various possible modifications have been described, it will be appreciated that various further modifications and improvements may be made without departing from the scope of the invention. For instance, the reflectors 31 may be 15 formed as a single or multiple reflector assembly only, and not as a roof of a building, although this is normally the most advantageous and preferred embodiment. Further, while a pivoted support arm arrangement 45, and particularly a ganged movement arrangement, is 20 illustrated and preferred for supporting and moving the collectors 51 through the desired zone of movement, various other collector supporting and movement arrangements may be employed. Also, while three radii R1, R2 and R3 are employed in the illustrative example, especially for simplicity of design and construction, more than three radii may be suitably 25 employed, graduating from shortest at the front and rear to the longest at the center zone of the reflector-concentrator 31, and may in fact be constructed with a continuously varying radius from front to back of the reflector 31. Such a continuously varying radius reflector 31 may, however, be beyond the desired complexity for normal construction and the triple 30 radius construction is considered to be adequate and most easily constructed from a practical standpoint. Accordingly, the invention is not to be limited to the particular illustrative embodiment and mode of operation and practice, but only by the scope of the appended 35 Claims.

WHAT WE CLAIM IS:-

30 1. A solar energy collecting device comprising a reflector having three, part-cylindrical segments arranged side-by-side, the middle segment having a larger radius of curvature than the other two and the principle axes of the other two segments being inclined towards that of the middle segment, the reflector being held, in use, in a fixed position, and an elongate thermal energy collector which is parallel to the reflector and which is arranged, in use, to be 35 movable across the reflector to follow the maximum confluence of the sun's rays reflected by the reflector as the altitude of the sun changes. 30

2. A device according to claim 1, in which the adjacent edges of the middle segment and each of the other segments have a common tangent. 40

3. A device according to claim 1 or 2, in which all three segments are contiguous to one another along their length. 40

4. A device according to claim 1 2 or 3, in which the radius of curvature of the other two segments is substantially equal. 45

5. A device according to any one of the preceding claims, including means for moving the collector across the reflector. 45

6. A device according to claim 5, in which the means include pivotally mounted support arms connected to the collector. 50

7. A device according to claim 6, in which the support arms have their pivot support means adjacent the reflector. 50

8. A device according to claim 7, in which a pivot axis of the pivot support means lies beneath the reflecting surface of the reflector. 55

9. A device according to claim 7, in which a pivot axis of the pivot support means lies along the reflecting surface of the reflector. 55

10. A device according to claim 7, in which a pivot axis of the pivot support means lies above the reflecting surface of the reflector. 60

11. A device according to any one of claims 7 to 10, in which the axis of the pivot support means is parallel to the axes of the or each part-cylindrical segment and is positioned off-centre with respect to the reflector. 60

12. A device according to any one of the preceding claims, in which the or each part-cylindrical segment is formed from a number of individual elongate mirror elements secured side-by-side to form an overall effective part-cylindrical reflector. 65

13. A solar energy concentrating and collecting arrangement comprising a number of devices in accordance with any one of the preceding claims, arranged generally side-by-side, and fluid flow conduit means connected in fluid flow relationship between the collectors of the devices for commonality of fluid heating by the devices. 65

65 14. A solar energy concentrating and collecting arrangement comprising a number of 65

devices including a concave, part-cylindrical reflector which is held, in use, in a fixed position, and an elongate thermal energy collector which is parallel to the reflector and which is arranged, in use, to be movable across the reflector to follow the maximum confluence of the sun's rays reflected by the reflector as the altitude of the sun changes, arranged generally 5 side-by-side, and fluid flow conduit means connected in fluid flow relationship between the collectors of the devices for commonality of fluid heating by the devices.

15. An arrangement according to claim 13 or 14, in which the edges of the reflectors of adjacent devices are connected together.

16. An arrangement according to claim 13, 14 or 15, in which the collectors are ganged 10 for common movement across their respective reflectors.

17. An arrangement according to claim 16, in which the collectors are ganged together through a parallelogram movement linkage including a number of pivoted lever arms.

18. An arrangement according to any one of claims 13 to 17, in which the attitude of the 15 collectors with respect to their respective reflectors is maintained during their movement across their respective reflectors.

19. An arrangement according to Claim 18, in which the collectors are held generally horizontal and face downwards towards their respective reflectors.

20. An arrangement according to any one of claims 14 to 17, in which the collectors are mounted for pivotal movement, and in use, are tilted during their movement across their 20 respective reflectors.

21. A building having a roof surface at least part of which is formed by a solar energy concentrating and collecting arrangement according to any one of claims 13 to 19.

22. A building according to claim 20, in which the axes of the partly-cylindrical segments of the individual devices are arranged in a generally East-West direction.

25. 23. A device according to claim 1, constructed substantially as described with reference to the accompanying drawings.

24. An arrangement according to claim 14, constructed substantially as described with reference to the accompanying drawings.

25. A building according to claim 21, constructed substantially as described with reference 30 to the accompanying drawings.

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1581253      COMPLETE SPECIFICATION  
6 SHEETS      This drawing is a reproduction of  
                    the Original on a reduced scale  
                    Sheet 1

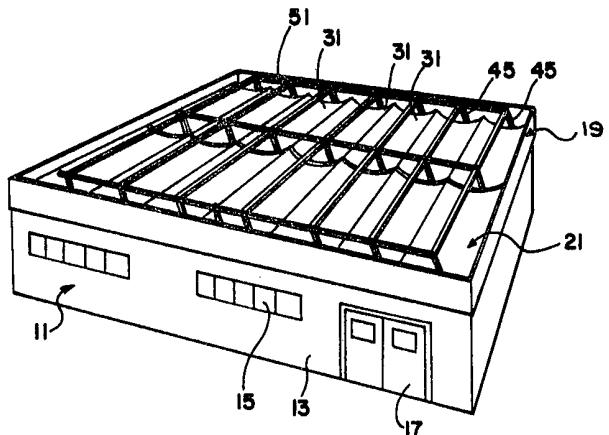


FIG. 1

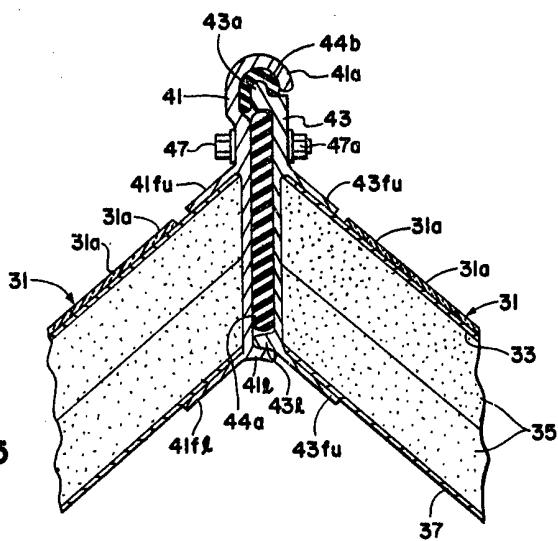
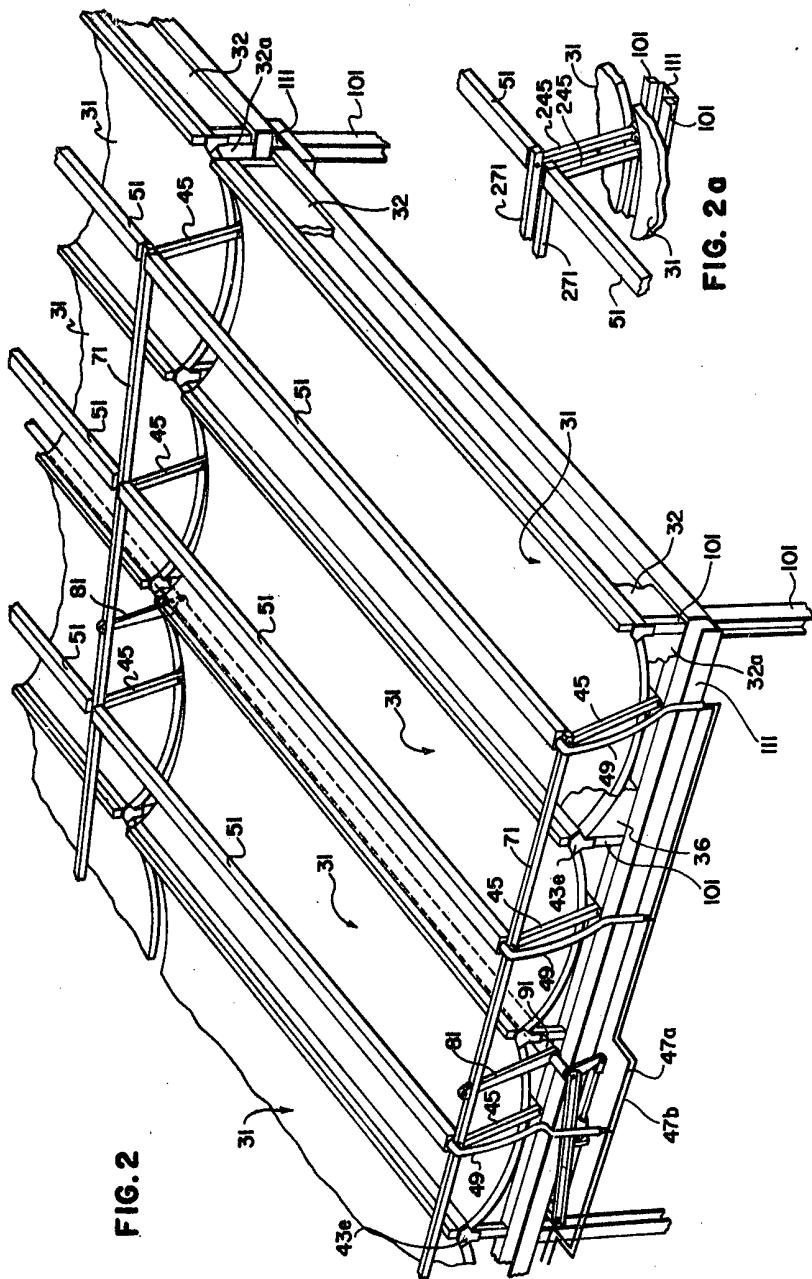


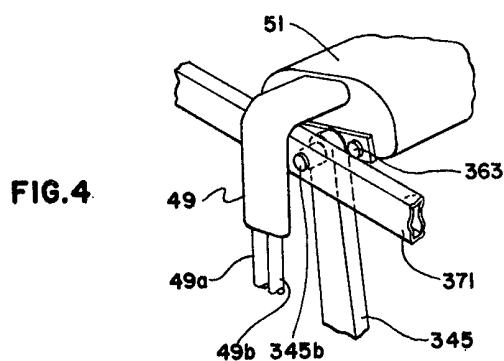
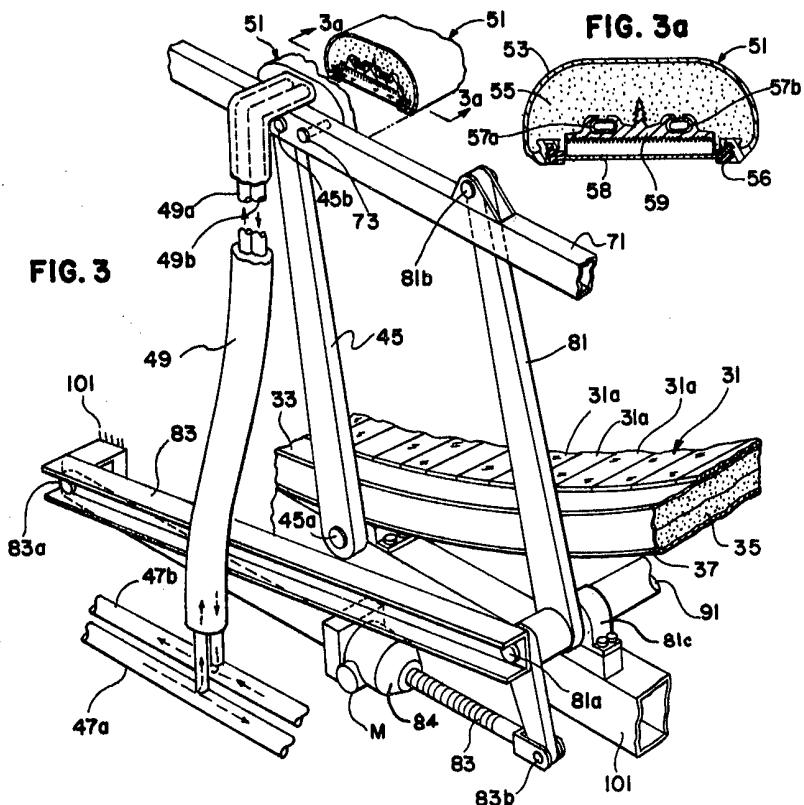
FIG. 5

**1581253**      **COMPLETE SPECIFICATION**

6 SHEETS

**6 SHEETS** This drawing is a reproduction of  
the Original on a reduced scale  
Sheet 2





1581253 COMPLETE SPECIFICATION

6 SHEETS *This drawing is a reproduction of  
the Original on a reduced scale  
Sheet 4*

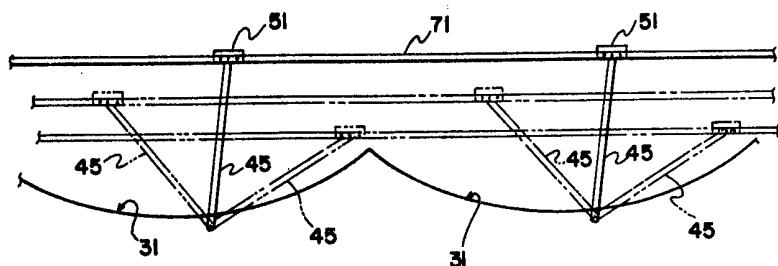


FIG. 6

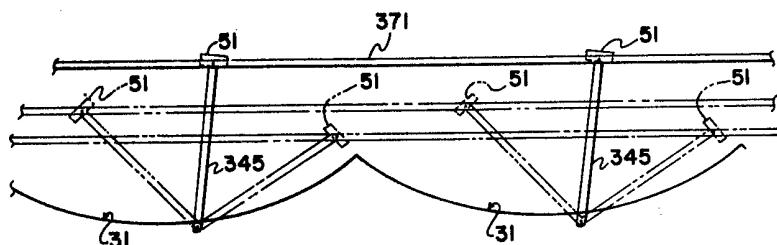


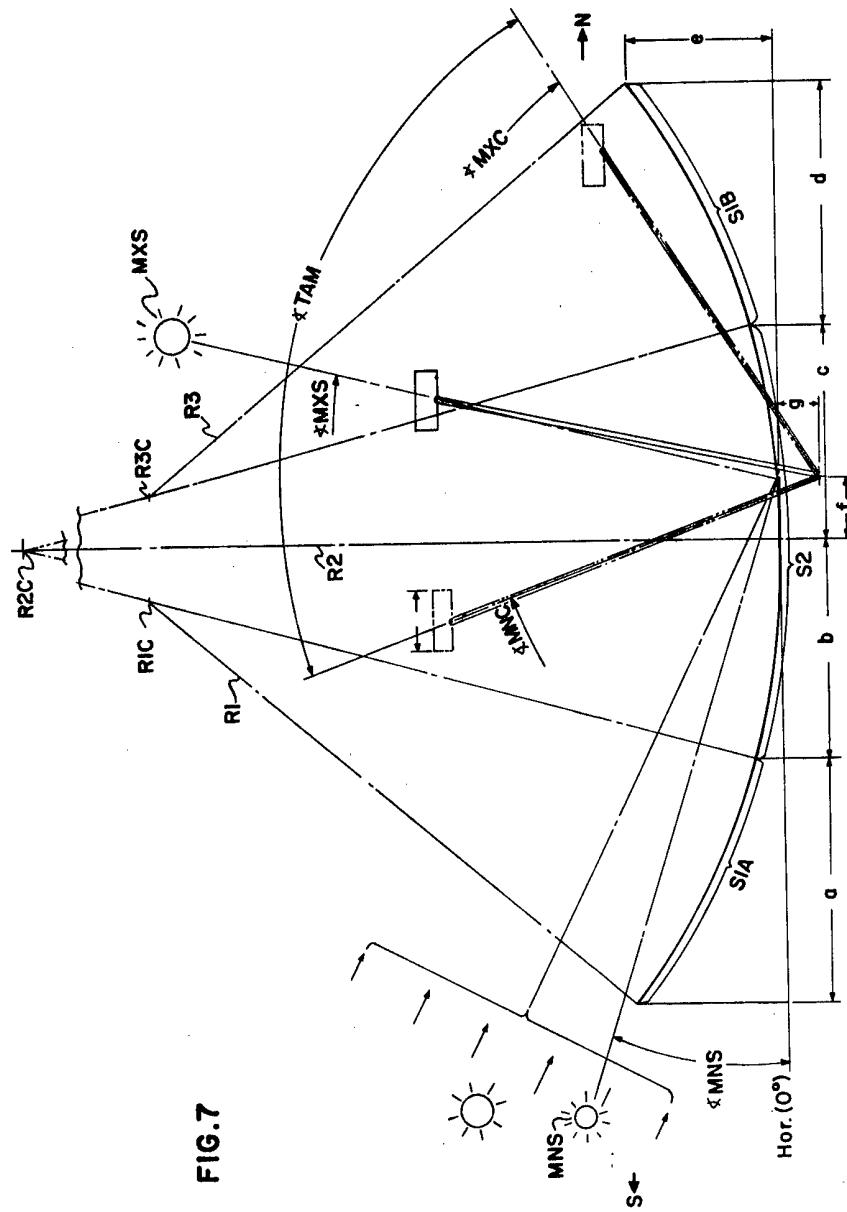
FIG. 6a

1581253 COMPLETE SPECIFICATION

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the Original on a reduced scale

Sheet 5



**1581253 COMPLETE SPECIFICATION**

**6 SHEETS** This drawing is a reproduction of  
the Original on a reduced scale  
Sheet 6

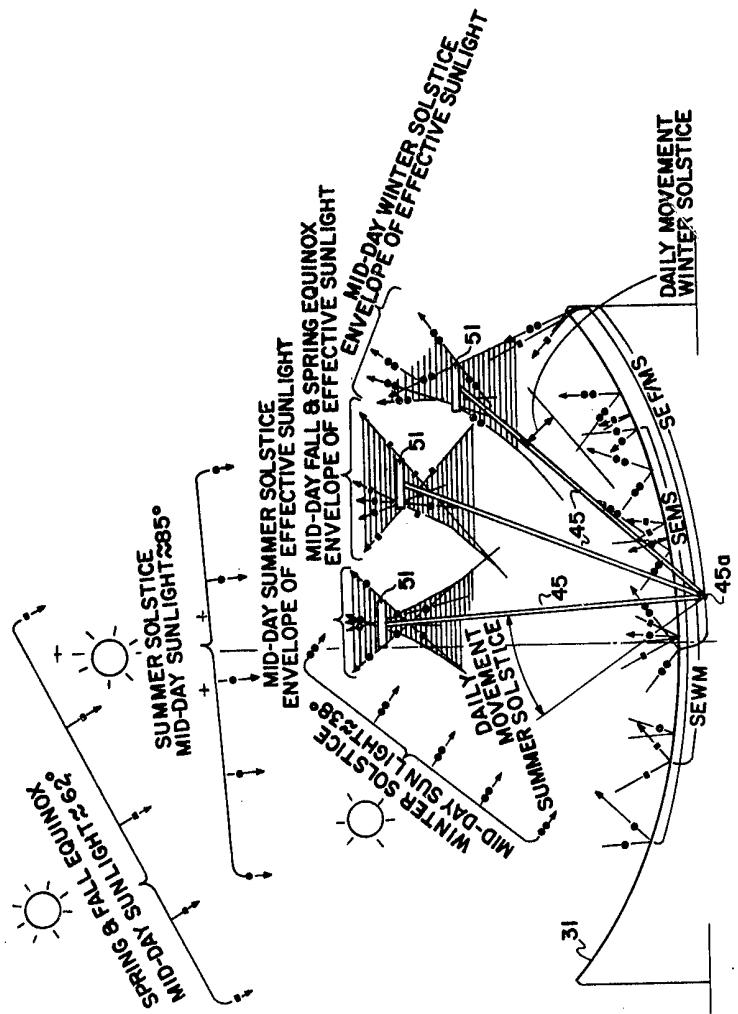


FIG. 8