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(71) Applicant(s)
Atlantis Solar Systeme AG

(72) Inventor(s)
Mario Posnansky

(74) Agent/Attorney
PHILLIPS ORMONDE and FITZPATRICK,367 Collins Street,MELBOURNE VIC 3000

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(71) Anmelder *(für alle Bestimmungsstaaten ausser US)*: ATLANTIS SOLAR SYSTEME AG [CH/CH]; Lindenrain 4, CH-3012 Bern (CH).

(72) Erfinder; und
(75) Erfinder/Anmelder *(nur für US)*: POSNANSKY, Mario [CH/CH]; Lindenrain 4, CH-3012 Bern (CH).

(74) Anwalt: SALGO, R., C.; Töbelistrasse 88, CH-8635 Dürnten (CH).

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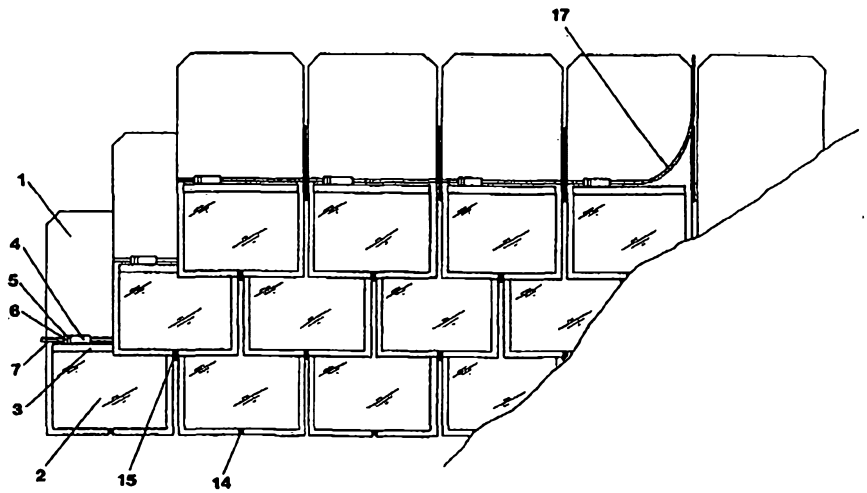
(54) Bezeichnung: PHOTOVOLTAISCHES SOLARDACH

(57) Abstract

This invention concerns a solar roof consisting of unmodified mass-produced roofing elements (1), for example of fiber cement, upon which solar cells (2) which have also been mass produced have been made fast using adhesive or clamps. Each solar cell (2) has a border element (3) on its upper edge upon which a connecting terminal (4) is placed. This connecting terminal (4) has at least one receptacle (5) into which can be inserted an asymmetrically formed plug (6) at the end of a cable (7). All of the named elements (1 to 7) rest on the roofing elements (1) so that no ducts of any kind need to be provided through the roofing elements (1), for example, a longer cable (17) leads from the final roofing element (1) of a row under the next higher overlaying roofing element and under the roof to a converter or direct consumer. The switch type (series or parallel) of the individual solar cells (2) is established by the wiring in the connecting terminal (4). The roof can be laid by a roofer with no electrotechnical expertise.



A PHOTOVOLTAIC SOLAR ROOF

The present invention relates to an arrangement for the photovoltaic generation of electrical current on or by means of roofs and facades.

The present invention has resulted from a desire to employ roofing surfaces which are already covered and shaded for the installation of photovoltaic elements, than to cover new surfaces in the style of a solar farm. Thus, it has been found for instance, that approximately 10% of existing roofs and facades in any typical area, is sufficient for the generation of approximately 20% of the electrical current supply requirement for an industrialised country.

Prior art relevant to this area of technology is found in the specifications of DE 44 38 858 (D1), FR 2 354 430 (D2), JP 07 02 6664 (D3), JP 07 062 802 (D4), JP 05 05 2004 (D5), DE 42 27 929 (D6) and DE 41 39 753 (D7).

D7 discloses only a general method of procedure, and no specific instruction on technical handling. D6 describes a roofing tile, which is suitable for accepting solar cells, but which, however, apart from the actual work of laying the tile, still requires a large outlay for the production of the necessary connections. Similarly the solar roof system according to D1 requires a large expense for the creation of the necessary roof tiles or slates required. The specifications of D2 to D5 all describe the special production of roofing elements.

The above prior art is deficient because it generally describes special production techniques for limited applications, which as a rule, introduces significant expenses, particularly in relation to the roofing technology of the present application.

In the prior art, the electrical connections and links are taken either directly or with the aid of special borings or openings in the roofing elements into the inner parts of the roof, or they are facilitated by contact strips and/or rails. These

arrangements are employed in order to house the electrical elements within the weatherproof interior of the roof. However, Borings or other openings in roofing elements on the one hand require expensive production, and on the other hand are potentially not watertight. Pressure contacts to the roofing elements are similarly expensive and require labour intensive production techniques, and are very liable to corrosion.

Thus, the prior art requires expensive, labour intensive special production techniques, which significantly exceed typical requirements of a producer of roofing elements. Moreover, it is not unusual that individual roofing elements have to be replaced, either because the roofing element itself or the solar cells upon it have become damaged. None of the known solutions has so far led to practical fabrication and introduction of cost-effective roofing elements of this kind to the market.

It is an object of the invention to provide photovoltaic solar roof or solar facade that can reduce the price for a photovoltaic generated kilowatt/hour by simplifying the production of roofing and facade elements.

According to the invention there is provided a solar roof or facade including a plurality of overlapping roofing elements wherein each of said plurality of roofing elements includes:

a roofing element portion having an upper portion and a lower portion;

a photovoltaic solar cell assembly positioned on top of said lower portion, said photovoltaic solar cell assembly including a transparent cover positioned on top of a semiconductor assembly along with a waterproofing/vapor proofing layer laminated to the underneath of said semiconductor assembly;

a current conductor connected to said photovoltaic solar cell assembly; and

a connecting terminal, connected to said current conductor, positioned in a location that is offset with respect to a center vertical line of said roofing element and on said upper portion of said roofing element portion, said connecting

terminal electrically connecting said roofing element to at least another roofing element.

The present invention further provides a solar roofing shingle including:

a roofing element having an upper portion and a lower portion;

said lower portion of said roofing element including:

a waterproofing layer;

a semiconductor layer including at least one photovoltaic solar cell on top of said waterproofing layer;

a transparent layer on top of said semiconductor layer;

said upper portion of said roofing element including:

a conducting terminal for conducting electricity between said solar roofing shingle and at least a second solar roofing shingle, said conducting terminal including a connector that is positioned away from the vertical center and the edge of said roofing element.

The present invention further provides a solar energy generating roofing shingle including:

a roofing shingle element having an upper and lower portion;

a photovoltaic solar cell assembly attached to the surface of the lower portion of said roofing shingle;

a connector positioned on the upper portion of said roofing shingle, said connector being electrically connected to said photovoltaic solar cell assembly for connecting adjacent solar energy generating roofing shingles electrically together, said connector being located away from the vertical center line and the edges of said shingle.

The invention advantageously results in photovoltaic generation that compares favourably with thermally or hydraulically generated energy from newly installed power stations. Furthermore the laying and repair of a solar roof or solar facade according to the invention can be undertaken by the normal roofing worker or facade builder.

The attached drawings show example embodiments of the invention of the foregoing kind. The particularity of those drawings and the associated description does not supersede the generality of the preceding broad description of the invention.

Fig. 1 shows a first example of construction of a solar roofing element,

Fig. 2 shows a longitudinal section through a first solar cell according to the invention,

Fig. 3 shows a longitudinal section through a second solar cell according to the invention,

Fig. 4 shows a modification of the example of construction from Fig. 1,

Fig. 5 shows several solar roofing elements in combination,

Fig. 6 shows a part of a solar roof,

Fig. 7 shows a partial section through a solar roof,

Fig. 8 shows a second example of construction of a solar roofing element,

Fig. 9 shows a third example of construction of a solar roofing element,

Fig. 10 shows a modification with regard to Fig. 1.

Fig. 1 shows a plan view of a first example of construction of an element of the arrangement according to the invention. Reference 1 designates a roofing element which can be obtained in various dimensions in the trade, made for example from fibre cement. Throughout the whole of the following description the designation roofing element always also means a facade element. Roofing and facade elements can be similarly or identically constructed and/or formed; often only the fastening technique is different, which is because the direction of the static forces is different and the

damming and capillary water relationships are different. The lower part of the roofing element carries a photovoltaic solar cell, for instance made of monocrystalline, polycrystalline or amorphous silicon. The construction of the solar cell 2 itself is shown in Fig. 2. The solar cell 2 is integrated into the roofing element 1. In construction it is fastened by gluing or using clamps (not shown in Fig. 1), which are attached to the roofing element 1. Thus the roofing element 1 and the solar cell 2 form a static unit in the sense that the stability function is essentially taken over by the roofing element. The solar cell 2 has, for instance, a finishing strip 3 on its upper edge, which represents the mechanical structure for the transfer of the internal to the external electrical connections. A connecting terminal 4 is fastened on the upper edge of the finishing strip 3. This is - for reasons to be described later - preferably offset eccentrically, for instance to the left of the centre line of the solar cell 2. It has, as in the example of construction according to Fig. 1, a socket 5 to the left and right, whereby each is set up to accept a plug 6, which for its part terminates in a two core cable 7. The type of circuit - series or parallel connection - of the individual solar cells 2 is established by the internal wiring of the connecting terminal 4. The roofing element 1 has for example a cut

out 14 on its upper edge for a hook (not shown), which is for its part fastened into the battens, on which the roofing elements 1 lie and are fastened.

A modification drawn in Fig. 4 shows a connecting terminal 4 with only one socket 5. The cable 7 leading to the adjacent solar cell is fastened directly into the connecting terminal 4 without a plug connection. The concept of plug and socket is basically here extended such that the connection is easily created, but can only be broken again by operation of an element, which for instance is attached to the socket 5. The concept of spring loaded connection is thus included in the sense of the invention, similarly to plug and socket.

Fig. 2 is the representation of a longitudinal section through the upper part of a first example of construction of a solar cell 2. A thin transparent glass plate 8 - or a similar of glass ceramic - is the carrier of a silicon semiconductor assembly designated with the reference 9. On the rear side, the semiconductor assembly 9 is covered by a multilayer laminate foil 10, which includes at least one aluminium or glass foil as a moisture excluder, against all sorts of vapour. This laminated foil can be applied by gluing, welding, full-fusion welding or a similar process. The semiconductor

assembly 9 is provided with contacts in a basically known manner and is taken via the current conduction 11 to two receptacles 12, 13 of the socket 5. It is not necessary to describe the type of circuit employed. The coating with the laminate foil extends as far as under the connecting terminal 4, so that the element is completely flat on the under side, which also includes the connecting terminal 4. The two receptacles 12, 13 are asymmetrically positioned in the assembly drawing with the corresponding connector 6; this ensures that the connection together of individual solar cells 2 can be undertaken only in the intended manner. The asymmetry of the receptacles 12, 13 can be effected by different sizes or shapes, provided only that incorrect mating is thereby prevented by a suitable chicane. At the upper end - to the right in the drawing - of the solar cell 2 the laminated foil 10 grips around the glass plate 8; the finishing strip 3 is applied tight against the laminated foil 10 and the glass plate 8.

In a second example of construction of a solar cell according to Fig. 3 the connecting terminal 4, together with the socket 5 is assembled with the socket 5 flexibly. The finishing strip 3 is here dispensed with. The covering by the laminate foil 10 at the same time assumes the function of strain relief for the current conductor

11, which both in the example of construction according to Fig. 2 as well as shown here is constructed flexibly.

Fig. 5 shows several roofing elements 1 with solar cells 2 adjacent to each other and thus the construction of mutual electrical connection by means of plugs 6 and cables 7. The manner of laying the roofing elements 1 is carried out fully conventionally: between two roofing elements there is always a hook 15 for the next layer of roofing elements I above; the hooks 15 each engage in the cut outs 14. When a row of roofing elements 1 or a part thereof is laid - or indeed during the laying operation - the plug 6 from the roof tile of the (here) left hand side roofing element 1 is plugged into the socket 5 on the connection terminal 4 of the (here) right hand side roofing element 1. Installation knowledge is not necessary for this.

In Fig. 6 a part of a roof covered with the roofing elements according to the invention is shown. An upper row of roofing elements 1 covers in each case the finishing strips 3 of the row lying beneath it. The asymmetrical position of the connecting terminal 4 moves this away from the direct influence of rainwater, which penetrates into the intermediate space between two adjacent roofing elements 1.The finishing elements 3 are

- as indicated by a dashed line 16 in Fig. 2 - bevelled off upwards, so that they are run over by rainwater. The connecting terminals are, of course, fabricated watertight.

On the right hand edge of Fig. 6 it is shown how the connecting cable of the last roofing element 1, indicated by the reference 17, which is equipped with a solar cell 2, is led upwards in the space between two roofing elements and under the roof. An additional bore in the roofing elements is thus unnecessary. Under the roofing the cables 17 are assembled according to the intended circuit and taken to one or more inverters, to a battery or directly to a load.

Fig. 7 shows the situation as in Fig. 6, in longitudinal section. Technical details of a purely roofing nature, because they are the known state of the art, are omitted here or shown in reduced detail.

What is shown here for roofing elements applies in analog fashion also for facade elements. Facade elements, for instance made of fibre cement, are often of a larger size than roofing elements, as shown in Fig. 8 and 9. This requirement can be met in that several solar cells 2 as shown in the previous Figures for roofing elements can be

connected together (see Fig. 8) or that they are manufactured similarly to a larger size, (see Fig. 7). The fastening means for facade elements are by and large similar to those for roofing elements; the laying technique is also similar in principle.

The roofing element 1 according to Fig. 8 has two solar cells 2 of the construction described. Although each finishing strip 3 also has a connecting terminal 4, however only the left hand one has a socket 5. The two connecting terminals are joined to each other by a fixed mounted cable 18. In a modification of the example shown the right hand connecting terminal also has a socket 5; the associated cable 7 then has a plug 6 at both ends.

A cladding element 1 of larger format is shown in Fig. 9, which carries a correspondingly larger solar cell 2; the connections are constructed as described against Fig. 1, 4, 5. Fig. 10 shows a modification in construction of Fig. 1. Here the finishing strip 3 is reduced to two short finishing strips 31. Each of these terminating elements carries a connection terminal 41. The type of connection to the adjacent solar cells 2 is effected either using a cable 7 in each case, which can be constructed as pluggable on one or both ends. In Fig.

10 the right hand connection terminal 41 has a socket 5 with a plug 6, the left hand one is connected directly with a cable 7.

The advantages and characteristics of the invention include one or more of the following points:

- The roofing element itself is essentially an unchanged mass-produced product, which can be favourably obtained in different forms, sizes, materials and colours.

- Fastening elements are not a part of the solar cells but are undertaken by the conventional roofing element.

- Static stability is not the responsibility of the solar cells but of the conventional roofing elements, i.e. the solar cell is thin walled and has a minimum material cost, such that mechanical loads of all sorts can be accepted by the roofing element.

- The solar cells foreseen can be created in several popular dimensions as a mass-produced product.

- The solar cells are put together with the roofing elements as a mass-produced product.

- The solar roofing element produced in this way will be laid by roofing tradesmen using their own trade knowledge and rules; additionally there is only the

plugging together of the individual electrical connections, for which no tools of any sort or special knowledge are required.

- The electrical connections of each individual solar roofing element are on the roofing element itself; lead-throughs are not intended. Only the connection to the load (inverter, battery, direct load) leads to the inside; as a rule one connection per row of roofing or facade elements is foreseen. The connection can be made without a bore to the solar roofing elements, by leading a longer cable upwards between the roofing elements.
- The cabling, plug connections and the electrical wires lie protected underneath the overlapping roofing elements lying above them.
- In this way the replacement of individual roofing or facade elements is easily possible, since no electrical connectors lying beneath the roof skin have to be broken and freshly installed.
- The whole of the structural costs as well as the arrangements for stability and retention are borne by the roof or facade - which need to be produced in any case - which is a considerable cost reduction when compared with solar farm type arrangements or photovoltaic installations mounted on or in contact with the roof.

- With the present invention possibility of reduction in the prime cost of a photovoltaic system are very largely realised by the simultaneous application of roofing and facade elements and thus for the first time the possibility is obtained of generating cost-effective and economic solar current by suitable mass production. This substantial cost reduction results from the arrangement according to the invention by largely eliminating all additional costs for installation and retaining structures and from assembly and installation costs.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the spirit and scope of the above description.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A solar roof or facade including a plurality of overlapping roofing elements wherein each of said plurality of roofing elements includes:

a roofing element portion having an upper portion and a lower portion;

a photovoltaic solar cell assembly positioned on top of said lower portion, said photovoltaic solar cell assembly including a transparent cover positioned on top of a semiconductor assembly along with a waterproofing/vapor proofing layer laminated to the underneath of said semiconductor assembly;

a current conductor connected to said photovoltaic solar cell assembly; and

a connecting terminal, connected to said current conductor, positioned in a location that is offset with respect of a center vertical line of said roofing element and on said upper portion of said roofing element portion, said connecting terminal electrically connecting said roofing element to at least another roofing element.

2. The solar roof or facade according to claim 1, wherein each of said plurality of roofing elements further includes a finishing strip positioned adjacent to said photovoltaic solar cell assembly horizontally with respect to said roofing element portion, said finishing strip serving as a cover for said connecting terminal.

3. The solar roof or facade according to claim 1 or claim 2, wherein said lower portion of one roofing element is positioned on top of an upper portion of another roofing element such that said plurality of roofing elements are overlapped in a manner similar to a shingle roof, said connecting portion being underneath an overlapped lower portion of said another roofing element.

4. A solar roofing shingle including:

a roofing element having an upper portion and a lower portion;

said lower portion of said roofing element including:

a waterproofing layer;

a semiconductor layer including at least one photovoltaic solar cell on top of said waterproofing layer;

a transparent layer on top of said semiconductor layer;

said upper portion of said roofing element including:

a conducting terminal for conducting electricity between said solar roofing shingle and at least a second solar roofing shingle, said conducting terminal including a connector that is positioned away from the vertical center and the edge of said roofing element.

5. A solar roofing shingle according to claim 4, further including a finishing strip for separating said upper portion from said lower portion, said conducting terminal positioned adjacent to said finishing strip.

6. A solar roofing shingle according to claims 4 or 5, wherein said connector is used to electrically connect said solar roofing shingle with said at least second solar roofing shingle.

7. A solar roofing shingle according to any one of claims 4 to 6, wherein said conducting terminal is electrically connected to said semiconductor layer.

8. A solar roofing shingle according to any one of claims 4 to 7, wherein said waterproofing layer includes at least one layer of a laminate foil.

9. A solar energy generating roofing shingle including:

a roofing shingle element having an upper and lower portion;

a photovoltaic solar cell assembly attached to the surface of the lower portion of said roofing shingle;

a connector positioned on the upper portion of said roofing shingle, said connector being electrically connected to said photovoltaic solar cell assembly for connecting adjacent solar energy generating roofing shingle electrically together, said connector being located away from the vertical center line and the edges of said shingle.

10. A solar energy generating roofing shingle according to claim 9, wherein said photovoltaic solar cell assembly includes a plurality of photovoltaic solar cells with a transparent covering provided on top of said plurality of photovoltaic solar cells.

11. A solar energy generating roofing shingle according to claim 9 or 10, further including a finishing strip that covers a horizontal portion of said roofing shingle element between said upper and lower portions of said roofing shingle element.

12. A solar energy generating roofing shingle according to any one of claims 9 to 11, further including a waterproofing laminate between said photovoltaic solar cell assembly and said lower portion of said roofing shingle element.

13. A solar energy generating roofing shingle according to any one of claims 9 to 12, further including a vapor proofing laminate between said photovoltaic solar cell assembly and said lower portion of said roofing shingle element.

14. A solar energy generating roofing shingle according to any one of claims 9 to 13, wherein said connector is positioned such that it will not be located in use, in an intervening space between overlapping sections of overlapping roofing shingle elements and will be located under said overlapping section of said overlapping roofing shingle elements when said solar energy generating roofing shingle is incorporated into a roof or facade.

15. A solar energy generating roofing shingle according to any one of claims 9 to 14, wherein said roofing shingle element is of fiber cement construction.

16. A solar energy generating roofing shingle according to any one of claims 9 to 15, wherein said solar energy generating roofing shingle can be connected to a

plurality of other solar energy generating roofing shingles in at least one of a parallel and a series circuit layout.

17. A solar roof or facade substantially as herein described with reference to the attached drawings.

18. A solar roofing shingle substantially as herein described with reference to the attached drawings.

DATED: 30 September 1999

PHILLIPS ORMONDE & FITZPATRICK
Patent Attorneys for:
ATLANTIS SOLAR SYSTEME AG

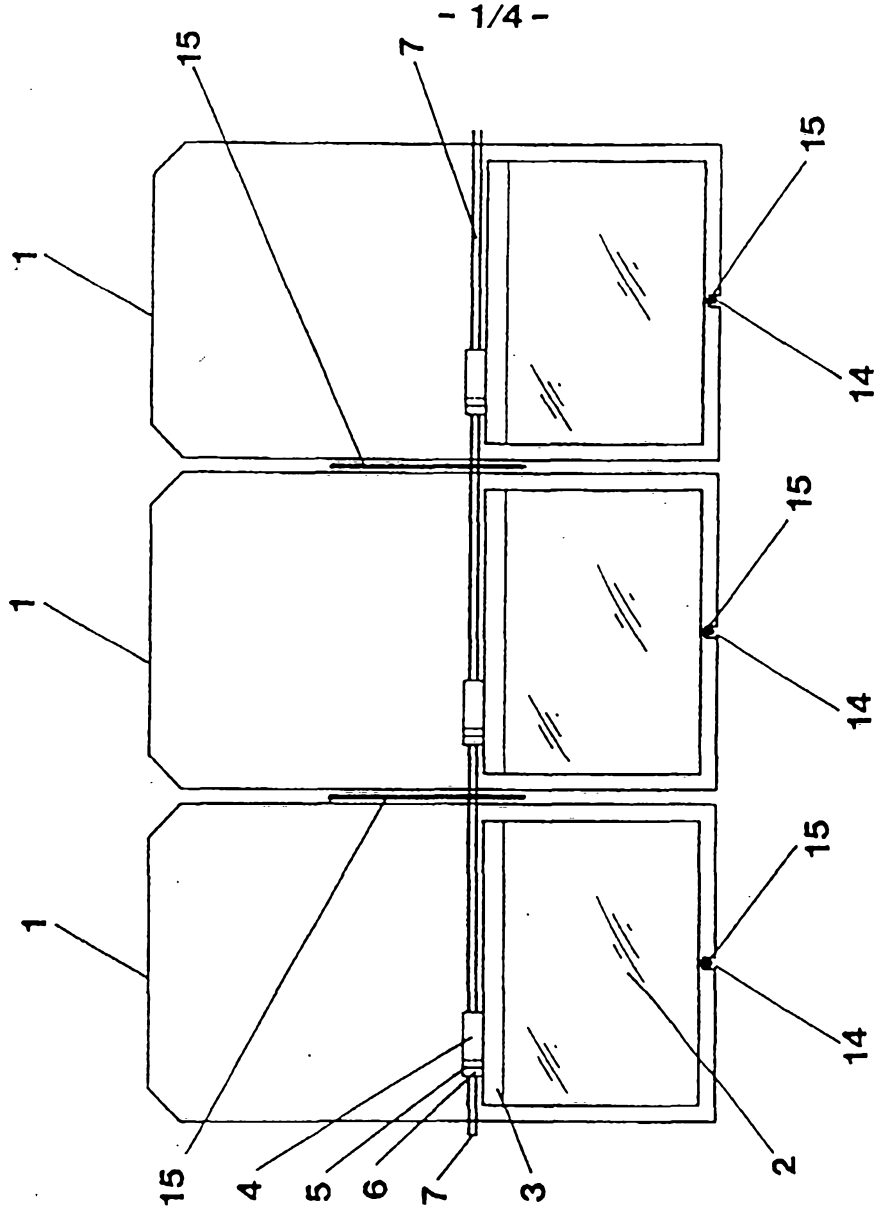


Fig. 5

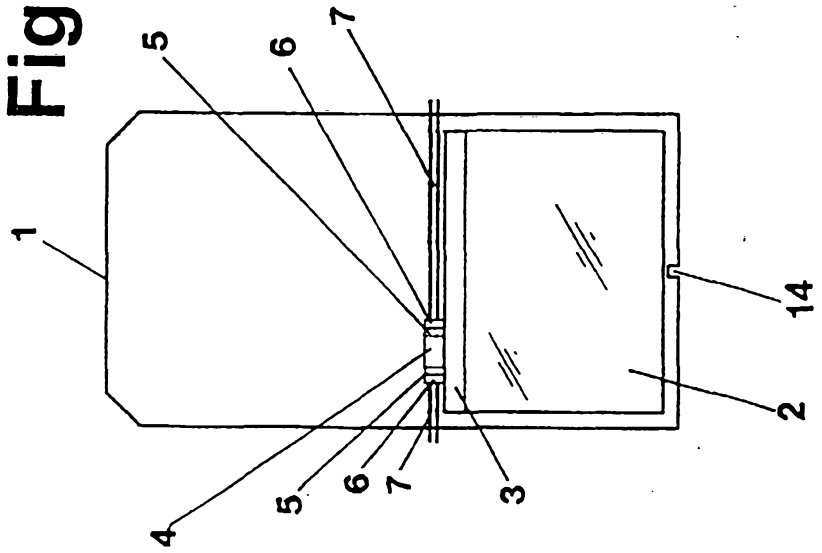


Fig. 1

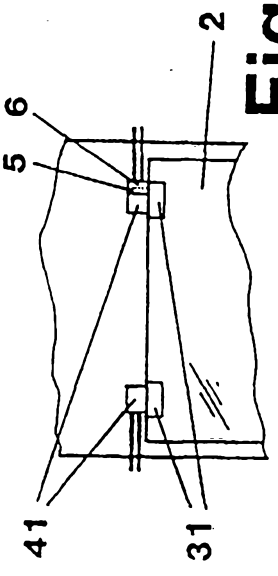


Fig. 10

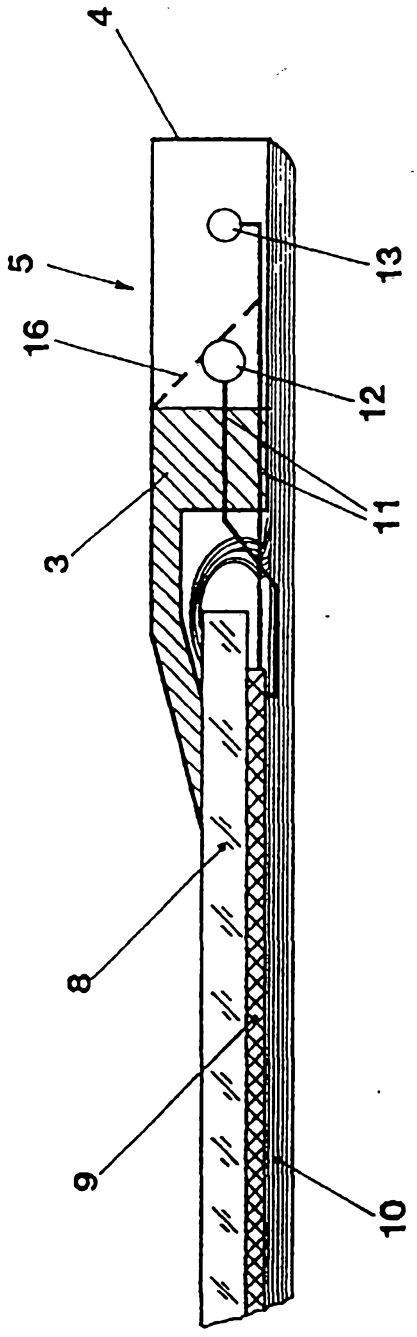


Fig. 2

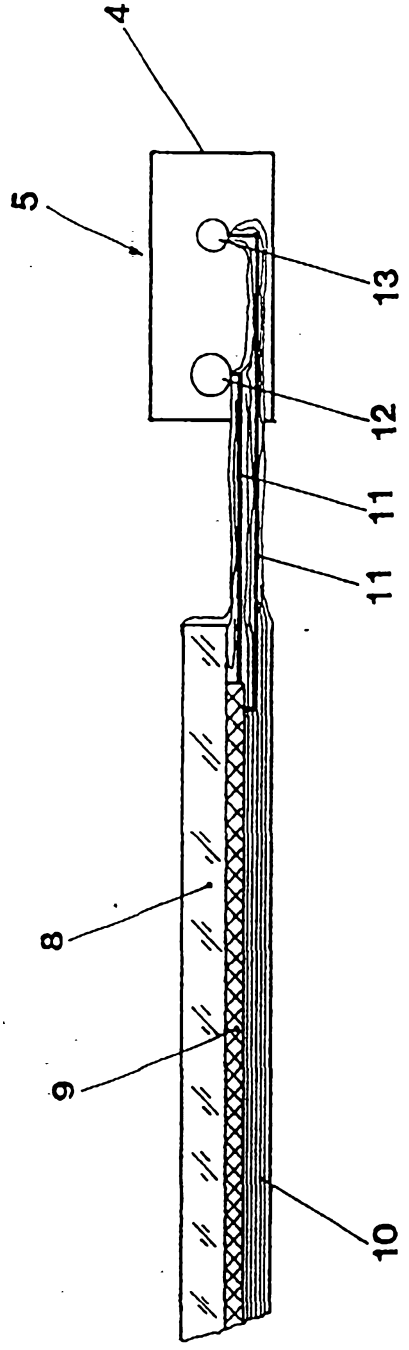


Fig. 3

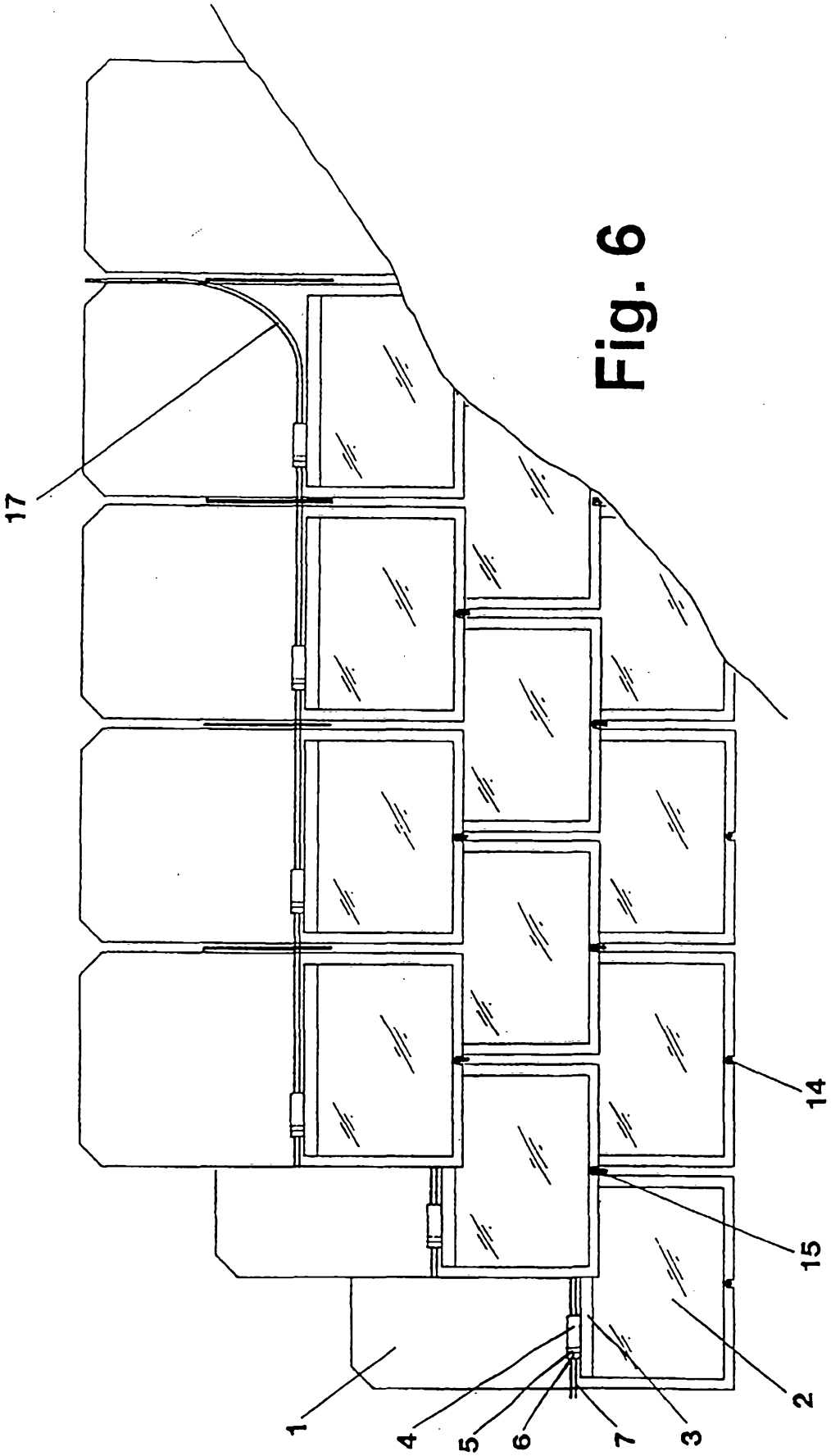


Fig. 6

Fig. 4

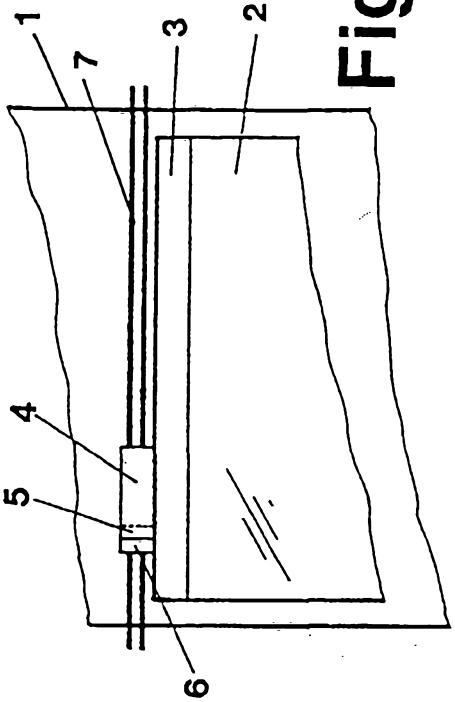


Fig. 7

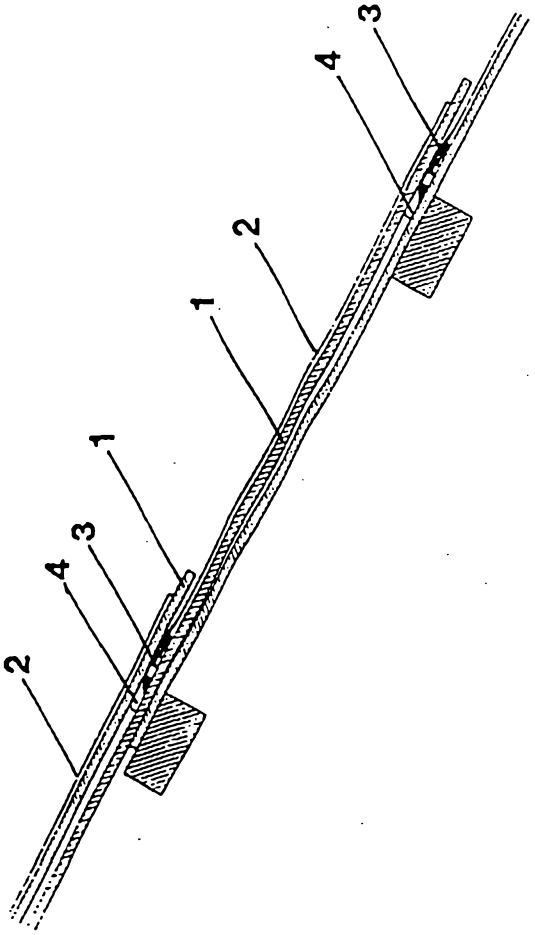


Fig. 8

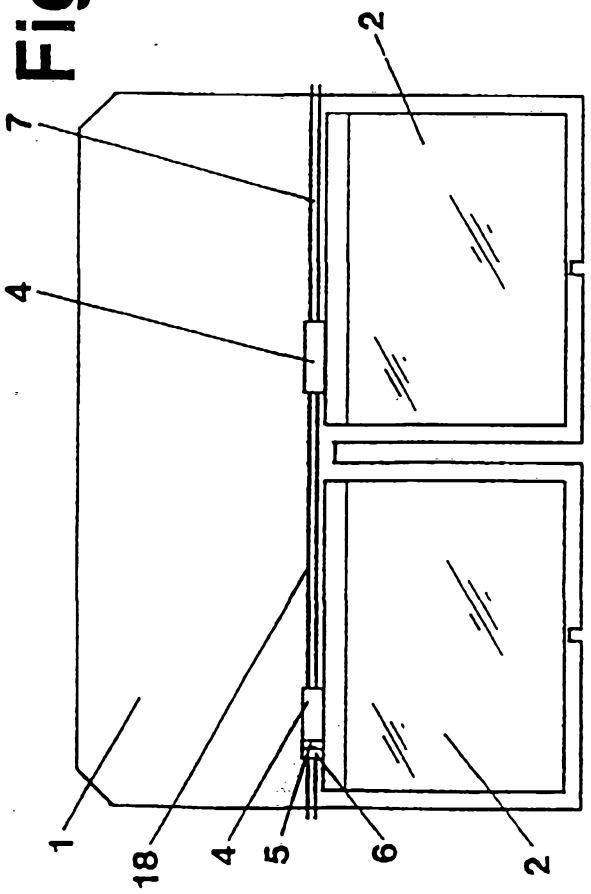


Fig. 9