ICPVS

Integrated Concentration Photovoltaics System

U.S. Provisional Patent Application

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1 Background

In high concentration CPV systems (Concentration Photovoltaics) it is mandatory that concentrators are aligned to the sun within certain optical acceptance angle characteristic to those modules. This means that the optical system has some tolerance to tracking deviation.

Each CPV technology has an inherent design acceptance angle dependent on the concentration ratio and the optical design of the concentration system.

Concentrators are basically composed of a PV cell on which solar radiation is concentrated by an optical system. Those concentrators are normally integrated into modules, each module containing a group of concentrators arranged in an array pattern.

CPV systems are composed of multiple CPV modules mounted on top of a solar tracking structure.

It is obvious that in order for the system to work properly it is necessary that all the modules, and therefore all the concentrators within each module, are kept within the design acceptance angle.

A common practice has been to isolate CPV module design from solar tracker design, so that each of these critical components are manufactured independently and system integration is done at the latest stage of the value chain, on the field.

In this de-integrated approach, system installation basically consists in first erecting the solar tracker structure on the field and then mounting individual CPV modules on top of that tracking structure.

It is obvious that field conditions can be very variable and so the skills of personnel involved in field system integration. This has multiple disadvantages which can increase the installation cost and reduce the quality and reliability of the integrated system.

The main problems arising from this de-integrated approach are:

- Need for on field alignment of structural elements in order to assure tracking structure co-planarity or for individual alignment of mounted modules in order to assure module co-planarity on top of a no co-planar structure.
- Tracking structure deformation and unexpected deflections due to assembly or component quality (due to local resourcing) variability on the field.
- Field integration of multiple tracking components, like sensors, motors, drives and control system, introduce multiple potential failure points and increase the requirement of skilled manpower on the field.
- Slow commissioning process as each CPV system must be integrated and tested on the field.
- High maintenance costs due to incidences derived from field integration.
- Many CPV trackers use a fine tuning solar sensor, which is field mounted to the tracking structure, and the field alignment and calibration of this device is a common source of installation and maintenance incidences.
- The fact that modules are field mounted on to of the tracking structures implies a certain degree of structural redundancy between.

Besides these disadvantages, this de-integrated deployment approach has driven the CPV industry to believe that CPV systems would be the larger the better, as under this approach there are obvious economies of scale if the number of trackers per MW is minimized, both on the installation and operation phases.

2 Summary of the Invention

Our invention objective is to obtain an integrated CPV system (ICPVS) which can be manufactured and tested as a single unit and rapidly deployed on the field without requiring skilled personnel.

Also, we have designed a system with optimized logistics and which can be very efficiently transported from the assembly line to the destination installation site.

Yet another basic objective is to use components requiring zero maintenance for 25 years.

Another objective is to use a very fast to deploy foundation and interconnection system having a low environmental impact, and which would be eventually easy to dismantle.

Main characteristics of the invention are:

1) A horizontal tube passing through and supporting two CPV super-modules, using maintenance free polymer bearings.
2) A rectangular box holding the previous tube and mounted on a bottom assembly.
3) A bottom assembly composed of a higher rotating part and a fixed lower part, which is bolted to a ground post, being also its bearings polymer made and maintenance-free.
4) Using square posts driven into the ground as system foundation, by mechanized means.
5) Having connection masts bolted to the bottom assembly which allow for aerial electrical and signal interconnection.

Using our ICVPS system, we estimate that it is possible to install 1 MW of solar power per day using a field team of just 10 people.

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3 Detailed Description

The concept is based on using super-modules 1, containing a plurality of CPV modules or concentrators each.

The main invention characteristic is that it uses a horizontal tube 2 passing through the inside of CPV super-modules 1. This tube acts as main structural element and also as elevation pivoting point.

Most efficient optical concentration systems are based on refractive optics having 1 or higher F-number (ratio between focal length and aperture), this meaning that there is a significant distance between the front and the back of CPV super-modules, this distance being proportional to concentration ratio, cell size and optical F-number.

By using tube 2 as central structural element, we actually take advantage of the empty space inside super-modules 1 and the vertical structural elements of these can rely on the tube itself as main supporting point. This yields a very clean design which avoids any structural redundancies.

This central horizontal tube 2 is fixed to a central structural box 3, the ensemble having a cross shape, as can be seen in figure 3.

There are two super-modules 1 per system, each pivoting on horizontal tube 2 at each side of central box 3, and they are assembled between them by two union brackets 7, bracket 7a over and bracket 7b below the tube. Bracket 7a has a whole 7c on it which allows it to be bolted to central box 3 in order to secure the system during transportation.

The design allows central box 3 to have a rectangular section, as wind forces parallel to the horizontal tube will always be lower than those normal to it. Thanks to this feature the distance between the two super-modules 1 can be minimized.

The ensemble of both super-modules 1 rotates in elevation pivoting on the central horizontal tube 2 on polymeric maintenance-free bearings 4. These horizontal bearings are mounted inside the super-modules, which have only one side perforated to allow the horizontal tube penetration. This perforation is protected using o-ring seals 5, so that the ensemble of two super-modules and the inside of the horizontal tube are protected from the environment (see figure 5).

Horizontal tube 2 is perforated to allow for power and signal cables to pass through it. Also, the inside air masses of the two super-modules, the horizontal and the central box tube are thus communicated. A single passive vent or active blowing system is installed in central box 3.

A screw/bolt actuator 6 is used as elevation drive. One of the elevation actuator‘s extremes is attached to central box 3. The other elevation actuator extreme is attached to top union bracket 7b.

All this components constitute the top assembly 8.

This top assembly is attached to the bottom assembly 9, containing the azimuth drive. This part also uses polymeric maintenance free bearings.

The azimuth mechanism is composed of a wheel to which a chain or belt is attached or fastened. This chain or belt is actuated by a sprocket or pulley driven by an azimuth motor.

All power and control cables are driven down to bottom assembly 9, where system’s control and power electronics are placed for better accessibility. Almost all cabling runs through the inside of the machine, so no cables are visible except the one connecting to elevation actuator 6.

Another important feature of our invention is that a thin central connection mast 10 is attached to the fixed part of the bottom assembly, solidary to the ground, and then passes through horizontal tube 2 and central box 3 (see figure 9). This allows for an aerial cable 14 electrical and communications connection, instead of a terrestrial one which would require additional field work and materials.

System can be shipped to the field as a single unit or divided in the two described units: top assembly 8 and bottom assembly 9.

Field installation consists on first driving steel posts 11 into the ground 12. These posts can actually be H beams, square tubes or any other suitable steel profile able to withstand not only tilting and radial forces but also torque. An alternative is to use round steel tubes to which several plates had been welded like wings. In the drawings square tubes are shown.

These posts can be very efficiently installed using mechanised post-driving machines 16 designed for road guard-rail installation, as shown in figure 10.

Once the posts have been driven into the ground, bottom assemblies 9 are transported by small trucks and bolted on top of posts 11 through attachment plates (figure 11).

Top assemblies 8 are shipped on large trucks to the field (figure 12), where they will be picked by small cranes and bolted to previously installed bottom assemblies 9.

The central cross design allows top assembly 8 to be transported by bolting its bottom to the truck trailer platform and to be hoisted from the top of central box 2.

Grid connection is done using an aerial cable 14 running through the central connection mast 10 (figure 13).

Systems are interconnected in the north-south direction, making strings of several systems which are connected to a final pole 13 from which underground cables 15 can be connected to a field bus.

This aerial connection system minimizes material and installation time costs compared to an underground solution. It requires no civil works other than just cleaning and flattening the field.

As it can be seen, the installation process minimizes the usage of skilled personnel on the field and allows for an industrialized, fast, repeatable and error free installation and commissioning tasks.

Fig. 1

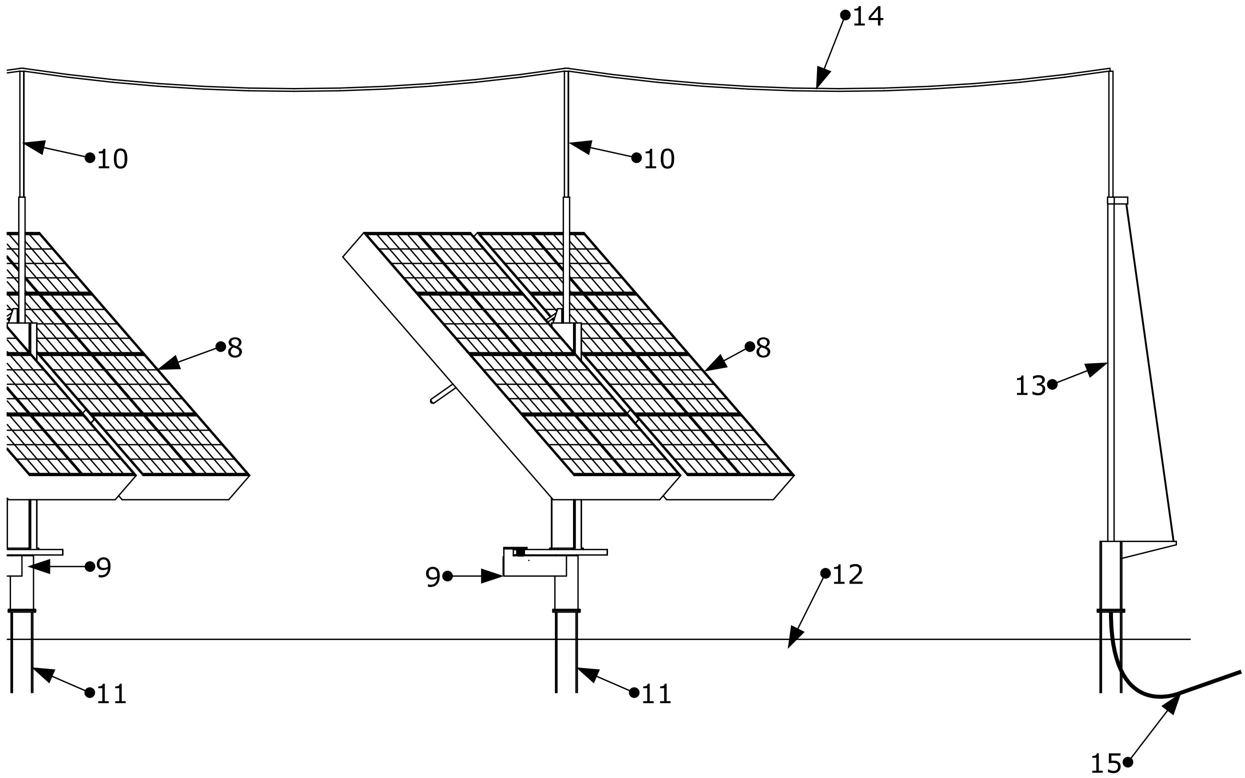

Fig. 2

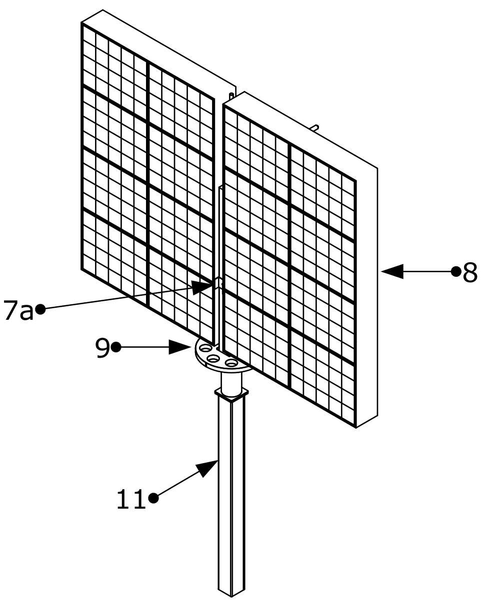

Fig. 3

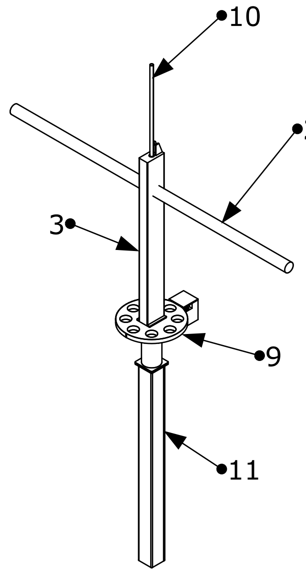

Fig. 4

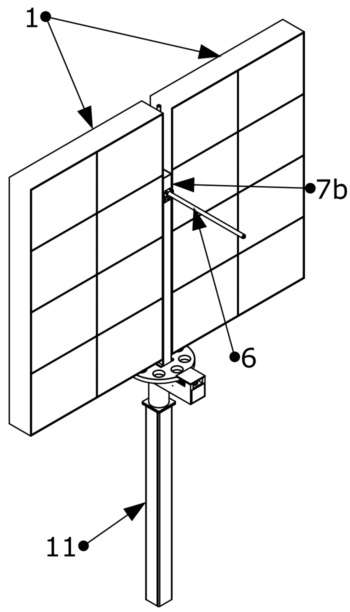

Fig. 5

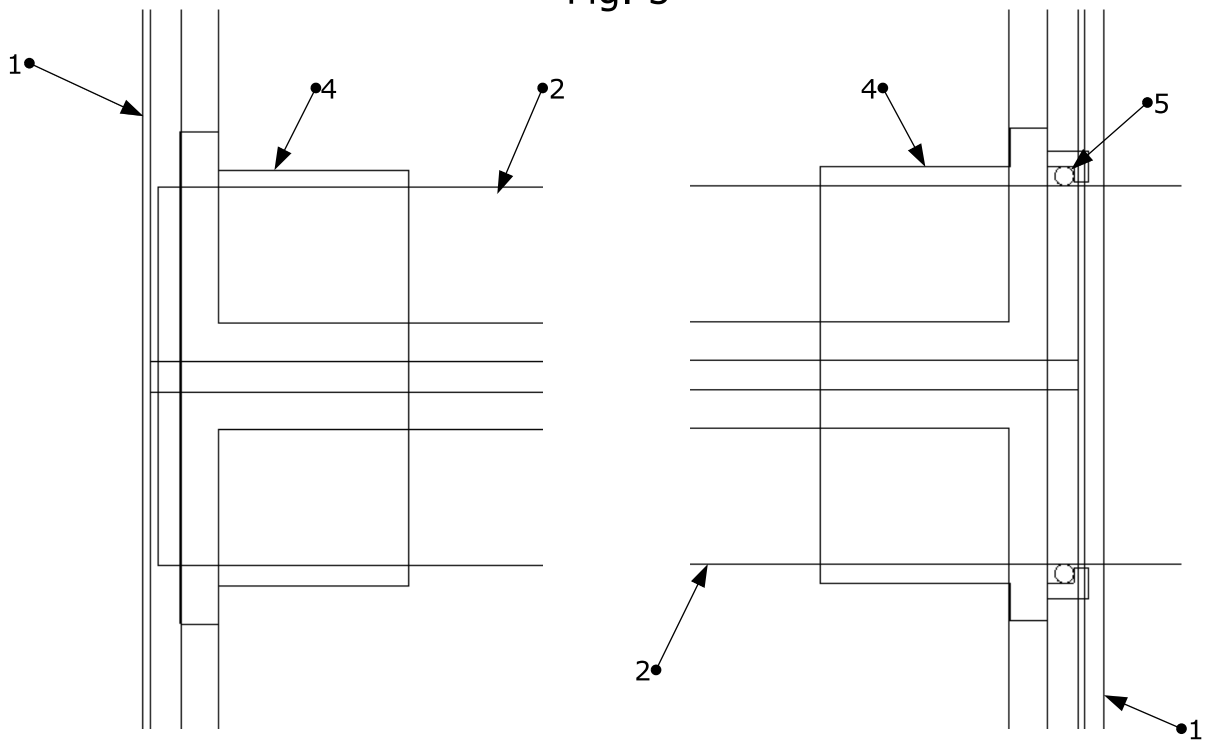

Fig. 7

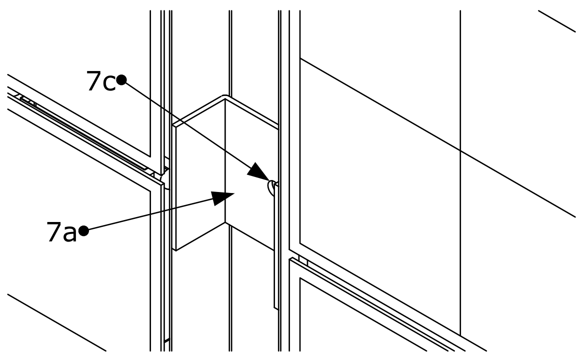

Fig. 6

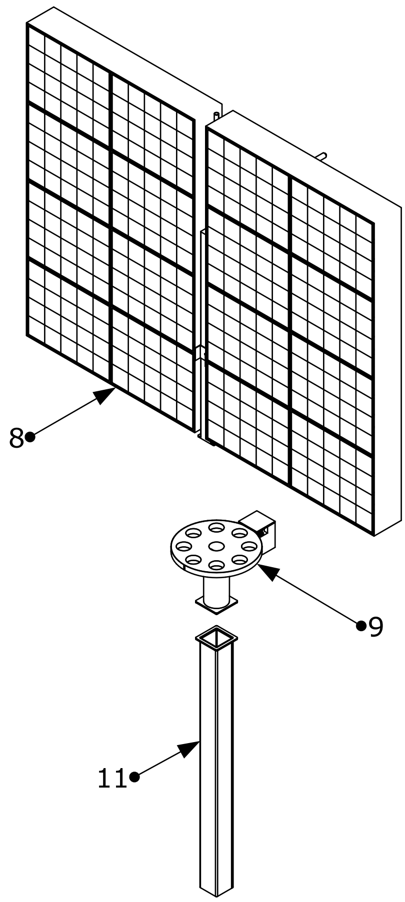

Fig. 8

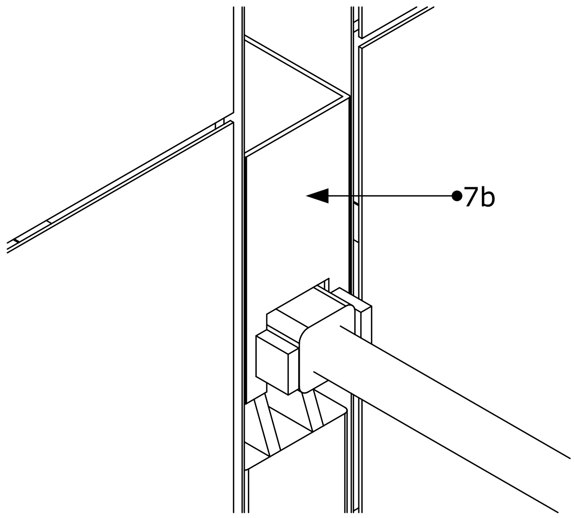

Fig. 9

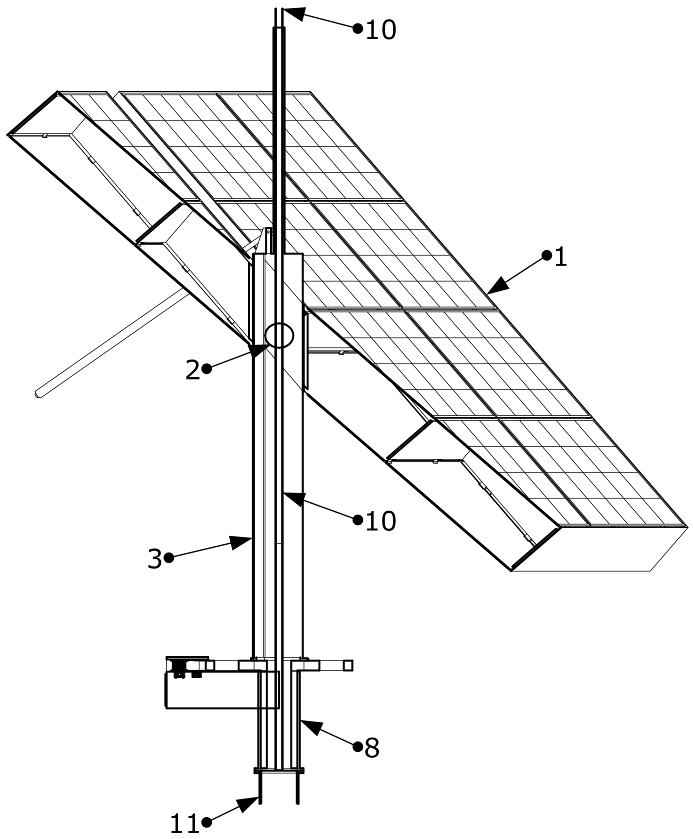

Fig. 10

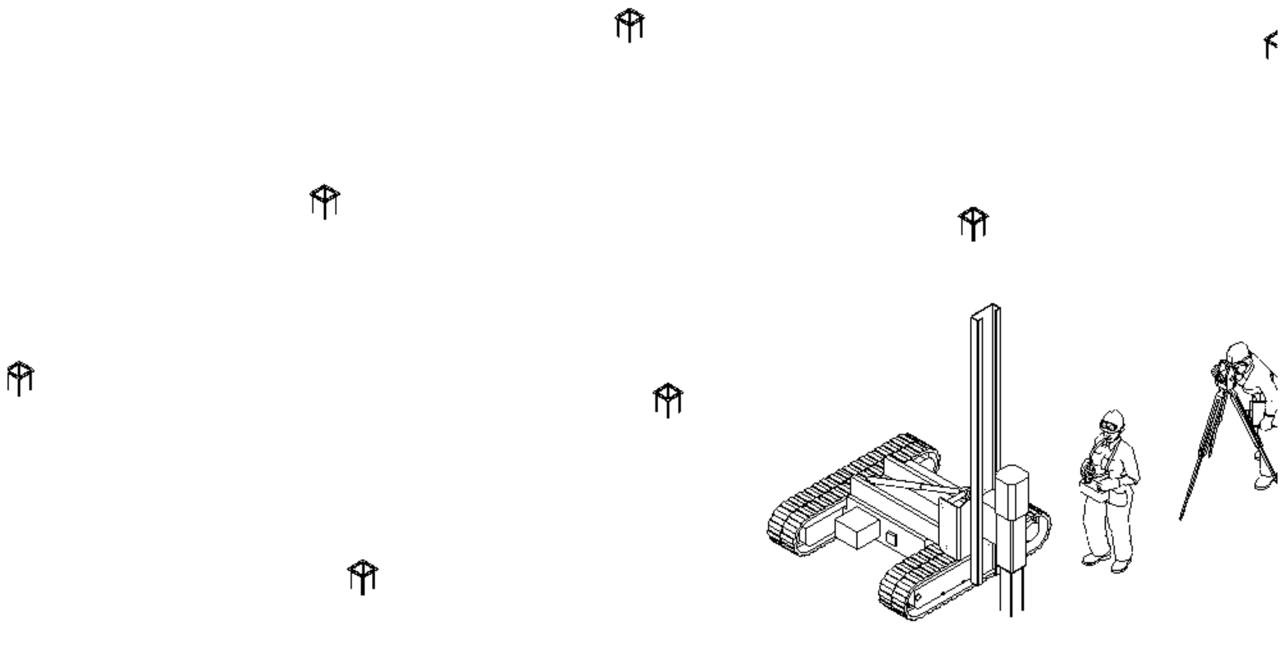

Fig. 11

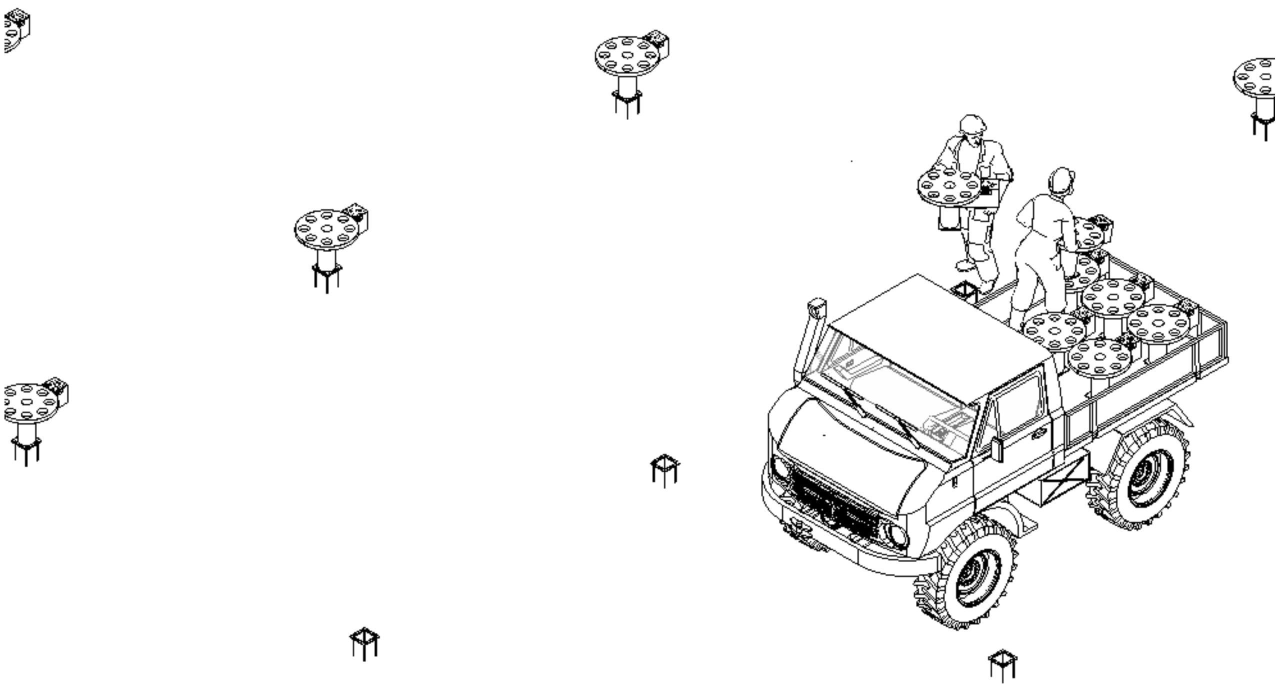

Fig. 12

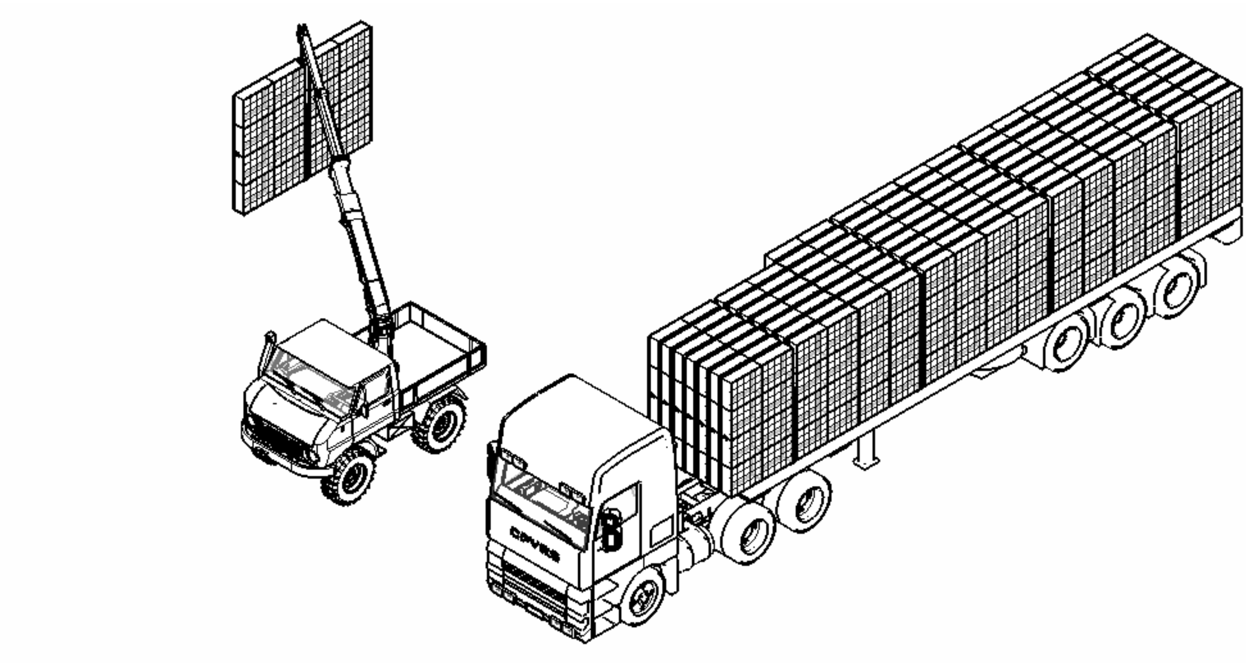

Fig. 13

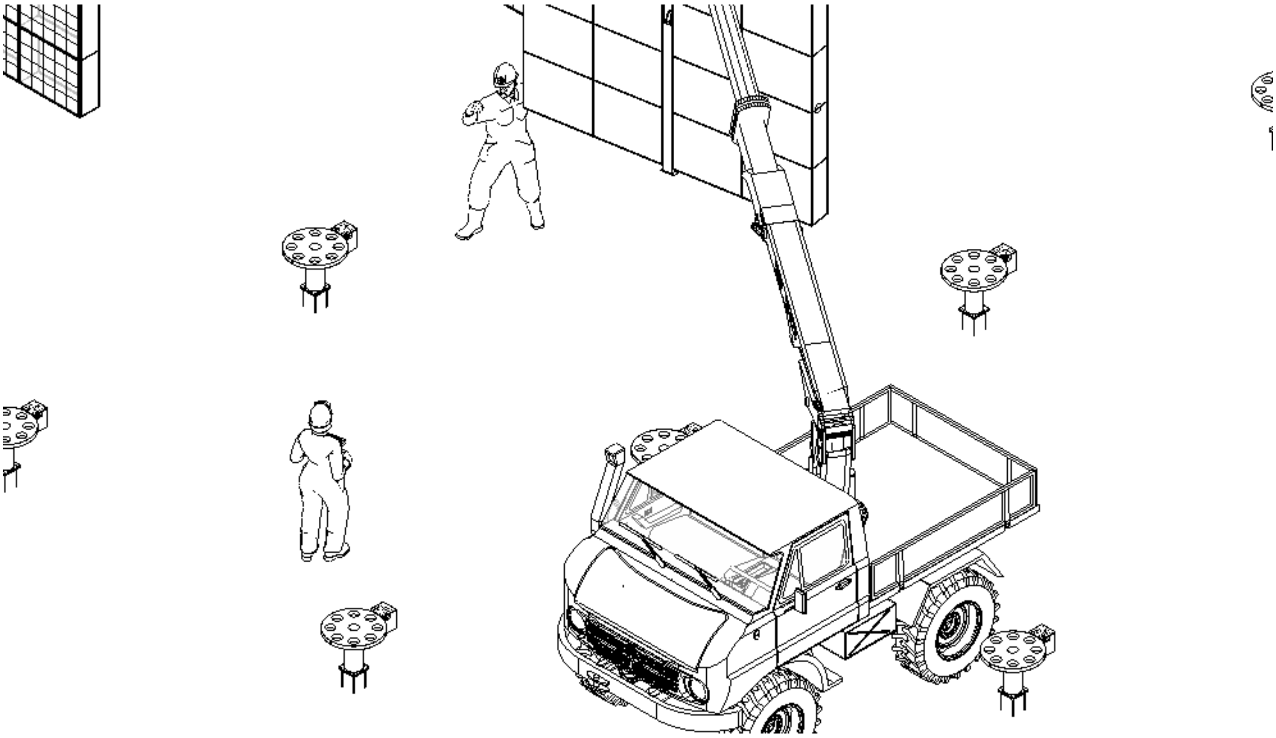

Fig. 14

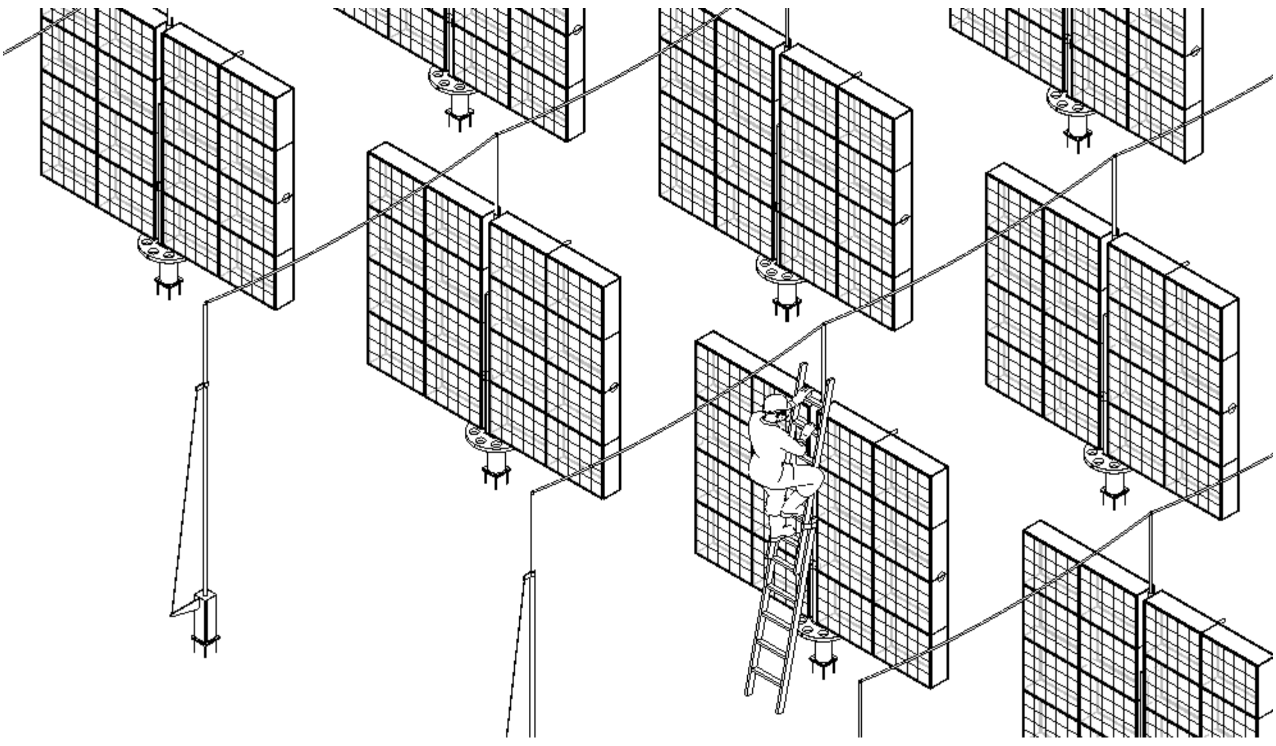

Fig. 15