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(54) **Title:** DEVICE FOR HEATING BUILDINGS AND DOMESTIC HOT WATER

(57) **Abstract:** A device for heating buildings and domestic hot water, consisting of brine/water heat pump (5) with ground collector unit (4) and solar collector unit (1) with forced ventilation of the heat-transfer medium, connected to energy storage cell (2) by means of exchanger (6), with secondary energy exchanger (3) inset in the discharge - secondary circuit of energy storage cell (2), with the secondary exchanger's inlet side connected to the outlet pipe of ground collector unit (4) and its outlet pipe connected to the inlet of the primary side of heat pump (5) and the cooled outlet of the primary side of heat pump (5) connected to the inlet of ground collector unit (4). Solar collector unit (1) fitted with a temperature sensor and energy storage cell (2) fitted with another temperature sensor, the sensors being connected to the circulation pump of the solar circuit by means of a control element.

Device for heating buildings and domestic hot water

Technical field

The technical solution concerns a device used to heat buildings and domestic hot water by means of a device for collecting solar energy, a heat accumulator and a brine/water heat pump.

Background art

The known devices for heating buildings and preparing domestic hot water, which employ solar collectors, are designed as devices that provide the heating of domestic hot water, directly or using heat exchangers usable for heating, or cooperate with the collector section of a brine/water heat pump by sharing the heat-carrying medium of the collector section - ground traps of low-potential heat. For most heat pumps, however, the application of a shared medium for the collector and the solar device is not feasible - the collectors have to be filled with an antifrost mixture compatible with the required properties of the heat pump type. Circulation in the primary circuit is usually stabilized at a temperature of about 0°C, but the low-pressure part of the compressor circuit after expansion works at a temperature of about -25°C. In order to share the circuits on the other side, it is necessary to use mixer valves, an electronic control system and backup sources that can reduce the energy benefits and the efficiency of such systems.

Disclosure of the invention

The shortcomings mentioned above are eliminated to a large extent by a device for heating buildings and domestic hot water, consisting of a brine/water heat pump with a ground collector unit and a solar collector unit with forced circulation of the heat transfer medium, connected to an energy storage cell through a primary exchanger, with a secondary energy exchanger inset in the discharge - secondary circuit of the energy storage cell, the secondary energy exchanger's inlet side being connected to the outlet pipe of the ground collector unit, the outlet pipe being connected to the inlet of the primary side of the heat pump and the cooled outlet of the primary side of the heat pump being connected to the inlet of the ground collector unit, as specified in this technical solution. Its principle is that the solar collector unit is fitted with a thermal sensor and the energy storage cell is fitted with another thermal sensor, which are both connected to the circulation pump of the solar circuit via a control element, e.g. a comparator. There is a control element placed advantageously at the outlet from the secondary energy exchanger to restrict the temperature of the outgoing heat transfer medium based on the specific parameters of the heat pump. The collector unit is advantageously comprised of a non-rotating part, placed in the focal point of the rotating focusing mirror, fitted with a drive to adjust its position in relation to the Sun in order to obtain the maximum profit from solar energy.

The stationary non-rotating part can have the shape of a small-area collector, comprising a hot-water vacuum collector for collecting heat, or can consist of a combined photovoltaic

cell, adjusted to collect power from sunlight focused by a rotating focusing mirror.

The benefit of this solution is the use of renewable sources of energy for the purposes of domestic heating and heating of domestic hot water in apartments, family houses, residential buildings, civic facilities and social care facilities as well as accommodation facilities, but also in the municipal areas of education and healthcare and in the non-profit sector for special-purpose facilities. The solution allows to decrease significantly the operating costs of such facilities. In general, certain rules can be set for the utilization of renewable sources of energy to account for the complex evaluation of the sum of investment costs, the demands on the provision of the sources, the exhaustibility of the sources as such, the need to solve support programs, e.g. to ensure biomass for burning, in particular in terms of the required parameters of wood.

The comparison of all aspects and the assessment of the yearlong provision of the required standards of heating and preparation of domestic hot water result in the most progressive utilization of the Earth's geothermal energy using ground geo-energy traps - drawing low-potential circulation water - from which energy is collected using a heat pump. Although the investment demands of this method are rather high, after acquisition it offers a significant reduction in operating costs for each place where this method of collecting energy for heating and preparation of domestic hot water is used, so the return of this solution is highly progressive, particularly because it can be used all year round.

Another method, often preferred, is to obtain solar energy to heat and prepare domestic hot water. In this case it is necessary to consider the rather significant limitation of usability, stemming from the physiology of solar radiation. In summer approximately 3 to 3.3kWh per sq m are available each day. The lowest value of approximately 0.27kWh per sq m a day is achieved in December and January, when heating consumption is the highest, not to mention the preparation of domestic hot water.

From a technical point of view, if the economically available accumulation of a large excess of energy in summer and its utilization at times of insufficiency in winter are not solved, the heating system using solar devices cannot be satisfactorily designed today with acceptable investment demands. Since in winter a standard solar system in the solution, used to prepare domestic hot water in summer, is not able to provide a sufficiently high temperature of domestic hot water in the boiler, but is able to collect solar energy in the low-level temperature range of up to 25 to 30°C, there is a way to use this low-level energy for heating and preparing domestic hot water, and therefore to support the overall condition of utilization of natural sources of energy with reasonable investment costs to provide a sufficiently short time of return of the investment and to increase the yearlong usability of the solar systems.

The proposed solution uses a property of heat pumps - or generally the Carnot cycle - where efficiency, expressed as heat factor "k", depends on thermal rise - cycle. In practice this means that the machine - heat pump - has a higher heat factor under the conditions of decreasing differential between the temperature of the heat transfer medium on the source, or

primary, side and the heat transfer medium on the consumer, or secondary, side. In other words - with the same conditions of the supplied energy, the machine is able to produce a larger quantity of energy with a lower temperature differential between the primary and the secondary circuit because the efficiency of the transfer grows. If the temperature of the primary circuit is successfully increased while the temperature of the secondary circuit is the same, the heat factor of the heat pump will rise.

Ordinary systems utilizing energy from the nature (i.e. renewable sources) use for example ground collectors or deep geothermal energy traps. These methods of collecting the Earth's energy for the purposes of heating civic facilities and housing units, currently used most widely, have certain advantages over other methods, e.g. solar collectors, because they are not dependent on weather or season of the year. Solar collectors, on the other hand, have an expressly seasonal nature and supply most energy at a time when it cannot be used for heating buildings. And vice versa, when the need for heating is the biggest - in fall, winter and spring - solar energy cannot be utilized because the heat transfer medium does not reach the temperature needed for the heating system. This is due to the shorter time of daylight and the lower ambient air temperature as well as the reduced efficiency of solar collectors as a result of thermal losses of the collected energy and the lower trajectory of the Sun.

A solar system commonly used for the preparation of domestic hot water in summer produces energy that can be used in a bivalent or trivalent boiler. In terms of design, the boiler is supplied from the solar collectors and if heat from the solar collectors is not available, supplementary heating is

provided by bivalent source or the second of the trivalent source, which is usually a power resistor element submerged in the boiler and controlled by the control system.

Based on this technical design - instead of supplementary electrical heating of the insufficiently heated water in the boiler, which should be at least 39°C for use, the "insufficiently heated" water of 38°C or less will be used to heat the incoming - primary water for the heat pump from the ground trap. By means of an increased heat factor of the heat pump, domestic hot water will be produced in the boiler of the heat pump by achieving a lower thermal rise of the Carnot cycle with significantly lower energy demands. The energy from the solar boiler or, alternatively, from a dedicated reservoir collecting solar energy is drawn using an additional secondary exchanger of a special design and with an adjusted heat-transfer area, where the source antifrost mixture flows through one branch of the exchanger, by means of forced circulation, from the outlet of the ground trap and the heated water flows through the other branch from the reservoir or the boiler, connected to the solar collectors. This heated primary antifrost mixture serves as a source heat transfer medium for the heat pump. The additional exchanger shall have a design conforming to the required functionality under gravity water circulation. The utilization of energy stops automatically when the temperatures of both types of media level out and the heat pump again starts working with the energy supplied by the ground collector until the new replenishment with solar energy. This way will utilize every temperature gradient created by solar energy and valuated in the heat pump with a multiple depending on the heat factor $k = f (T_2 - T_1)$ - where T1 is temperature of primary-side water, T2 is temperature of the heating side, - which is a function of temperature

gradient, and the low-potential heat obtained during non-sunny days in summer and the whole heating season, when the usable solar energy drops at less than 10% of its summer value, but still can improve the heat factor of the heat pump, will be also utilized.

Connecting the solar device for collecting solar energy to the heat storage cell using a suitable heat exchanger will create conditions for collecting solar energy by the primary circuit of the heat pump, which is adjusted to store the energy from the solar device connected to the heat storage cell in the storage cell by means of the first exchanger, and the energy storage process is regulated by forced circulation controlled by a sensor reading the temperature of the medium leaving the solar device depending on this temperature, and removes the stored energy by means of the secondary exchanger to the primary collection loop of the heat pump, which has its own circulation pump.

Brief description of drawings

The technical solution will be described in greater detail on a specific embodiment using the attached drawings, where figure 1 shows a connection diagram and figure 2 a diagram of the design of the secondary heat exchanger. Figure 3 shows a chart of dependence of heat factor $k = f (T_2 - T_1)$ and figure 4 displays a chart of the average daily energy collectable from 1 sq m of the solar device in an ordinary year; figure 5 shows an outline of the collector unit and figure 6 its plan view.

Examples of the design of the invention

The device for heating buildings and domestic hot water contains brine/water heat pump 5 with ground collector unit 4 and solar collector unit 1 with forced circulation of heat transfer medium, which are connected to energy storage cell 2 by means of collector 6. The discharge - secondary circuit of energy storage cell 2 incorporates secondary energy exchanger 3, whose inlet side is connected to the outlet pipe of ground collector unit 4 and whose outlet pipe is connected to the inlet of the primary side of heat pump 5, with the cooled outlet of the primary circuit of heat pump 5 being connected to the inlet of ground collector unit 4. Solar collector unit 1 is fitted with a temperature sensor and energy storage cell 2 is fitted with another temperature sensor, both sensors being connected by means of a control element to the primary circuit's circulation pump. A control element is installed at the outlet of secondary energy exchanger 3 to restrict the temperature of the incoming heat transfer medium based on the specific parameters of heat pump 5.

Solar collector unit 1 with forced circulation of the heat transfer medium charges suitable storage cell 2 with heat obtained from sunlight by means of suitably designed exchanger 6. A small battery-type differential electronic system evaluates the condition of the charging set using two contact sensors. In case of a positive difference between the temperature at sensor 1, placed in solar collector unit 1, and sensor 2, placed in storage cell 2, the electronic unit triggers the circulation pump of the solar circuit using a simple relay and the charging of storage cell 2 starts until the temperatures at both sensors are equal (with hysteresis + - 2°C). In practice it means that there is no discharge of

storage cell 2 at night and in times when the solar device does not provide any usable energy.

The outlet from storage cell 2, which serves to collect low-potential energy usable only by heat pump 5 e.g. in the range of 0 to 35°C, is special-design hot-water secondary exchanger 3, which meets two fundamental conditions. The discharge of the stored energy from storage cell starts automatically when heat offtake commences, for example when the compressor of heat pump 5 starts up, leading to the automatic actuation of the circulation pump of the circuit of ground collector units 4 for heat pump 5. In addition, the discharge of energy automatically stops as soon as the temperature of the media in the two circuits of secondary exchanger 3 is the same, in practice when the temperature of +4°C is reached, i.e. when water in storage cell 2 reaches the highest density and the gravitational medium circulation ceases. Circulation can revert in the opposite direction if the medium continues to be cooled from ground collector unit 4. This circulation, however, can restrict the freezing of the heat-transfer area of secondary exchanger 3 and is not detrimental.

The gravitational mechanism of utilization of the heat stored in storage cell 2 will come into action if the height of secondary exchanger 3 is sufficient and the active cross-section of the hydraulic circuit of secondary exchanger 3 - side connected to storage cell 2 - is sufficient. The outlet side of secondary exchanger 3 must have the largest heat-transfer area possible to allow an optimum transfer of heat to the circuit at heat pump 5. The heat-transfer area can be increased by connecting disks along the length of secondary exchanger 3. This constitutes the so-called wire exchanger, whose various designs are known in technical practice. The

geometrical parameters of secondary exchanger 3 depend on the volume of the transferred energy.

To restrict the situation that can appear in summer, when there is a risk of exceeding the maximum permitted temperature of the primary water entering heat pump 5 so that the protection system of heat pump 5 could be activated and would be periodically disconnected, it is possible to use two options during this season of the year. Activating the circulation pump of the circuit of ground collector units 4 for continuous operation, which will provide the removal of excessive solar energy at a time when heat pump 5 only prepares domestic hot water, regeneration of ground collector units 4 for use in the subsequent heating season and utilization of heat pump 5 for heating swimming-pool water, which will bring about additional effects in the cost efficiency of operation and the return of investments.

It has to be noted that these situations can be solved individually only if there is a good knowledge of the structural parameters of solar unit 1, of the capacity of storage cell 2 and the performance parameters of heat pump 5, especially its collector unit, and the transfer parameters of soil in the place of installation of the collectors and the deep energy traps.

Solar energy F is transferred by means of the heat-transfer medium in solar collector 1 to storage cells 2, where it is stored. The stored energy is independently removed from secondary exchanger 3 and is used to warm up the heat-transfer medium from the geothermal trap and, after warming up, enters heat pump 5, where the collected energy is transferred to hot water usable for heating or preparation of domestic hot water;

at the same time it is possible to remove heat from storage cell 2 until the temperature is equal to the medium of ground collector unit 4 - i.e. 0°C in practice.

The process of discharging the energy from solar collector unit 1 stored in storage cell 2 stops automatically when a thermodynamic balance is reached in the heat-transfer area of secondary energy exchanger 3 due to the balancing temperature of the heat-transfer medium in the periphery of ground collector unit 4 with the temperature of the heat-transfer medium used in energy storage cell 2.

The energy obtained from the solar device is used all year round to prepare heat and domestic hot water, with the energy yield transformed by means of the heat factor of heat pump 5 until the temperature of the heat-transfer medium of storage cell 2 is equal to the temperature of heat-transfer medium of ground collector unit 4 in a range that cannot be used for the purposes of heating or preparation of hot water.

Figure 3 shows a chart of dependence of heat factor $k = f(T_2 - T_1)$.

For orientation purposes, figure 4 shows the chart of average daily energy collectible from 1 sq m of area of the solar device in the current year.

Collector unit 4 comprises non-rotating part 7, placed in the focal point of rotating focusing mirror 8, fitted with a drive unit to adjust the position in relation to the Sun in order to achieve the maximum profit from the energy of sunlight. Stationary non-rotating part 7 has the shape of a small-area

trap, comprising a hot-water vacuum collector for collecting heat.

In another embodiment stationary non-rotating part 7 comprises a combined photovoltaic cell, adjusted to obtain power from sunlight focused by rotating focusing mirror 8.

The flow of sunlight impacts the focusing surface of rotating mirror 8, whose focal point is identical with the location of the small-area collector comprising for example one long pipe of the vacuum collector or a photovoltaic collector adjusted to collect energy from the focusing mirror. Rotating focusing mirror 8 is positioned based on the position of the Sun using a hydraulic rotation system, where the energy necessary for rotating is provided by ether-filled hydraulics, similar to the ventilation systems in greenhouses. Rotating focusing mirror 8 has a light structure, which allows to use this device independently of electric drive.

Utility of the patent

The device as specified in this technical solution can be designed, if a clear investment plan is submitted, for use in family houses and residential developments as well as in the industry for heating industrial facilities.

C L A I M S

1. A device for heating buildings and domestic hot water, consisting of bring/water heat pump (5) with ground collector unit (4) and solar collector unit (1) with forced ventilation of the heat-transfer medium, connected to energy storage cell (2) by means of exchanger (6), with secondary energy exchanger (3) inset in the discharge - secondary circuit of energy storage cell (2), with the secondary exchanger's inlet side connected to the outlet pipe of ground collector unit (4) and its outlet pipe connected to the inlet of the primary side of heat pump (5) and the cooled outlet of the primary side of heat pump (5) connected to the inlet of ground collector unit (4), **characterized by the fact that** solar collector unit (1) fitted with a temperature sensor and energy storage cell (2) fitted with another temperature sensor, the sensors being connected to the circulation pump of the solar circuit by means of a control element.

2. A device under claim 1, **characterized by the fact that** a control element incorporated at the outlet from secondary energy exchanger (3) to restrict the temperature of the incoming heat-transfer medium based on the specific parameters of heat pump (5).

3. A device under claim 1 or 2, **characterized by the fact that** a collector unit (4) consisting of non-rotating part (7), placed in the focal point of rotating focusing mirror (8), fitted with a drive to adjust the position in

relation to the Sun to achieve the maximum profit from the energy of sunlight.

4. A device under claim 3, **characterized by the fact that** a stationary non-rotating part (7) being shaped as a small-area collector, composed of a hot-water vacuum collector to collect heat.

5. A device under claim 3, **characterized by the fact that** a stationary non-rotating part (7) consisting of a combined photovoltaic cell, adjusted to collect power from sunlight focused by rotating focusing mirror (8).

Fig. 1

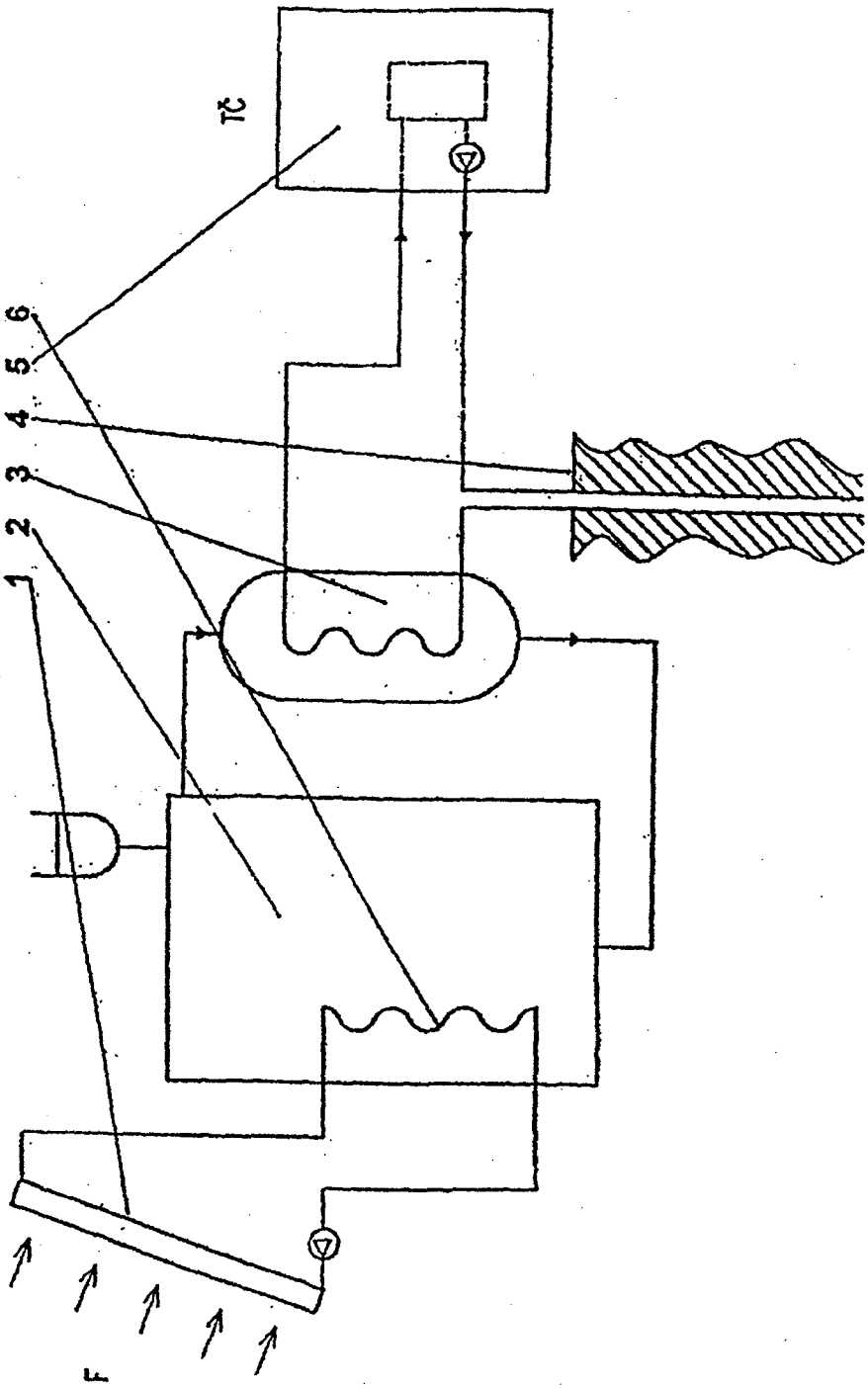


Fig. 2

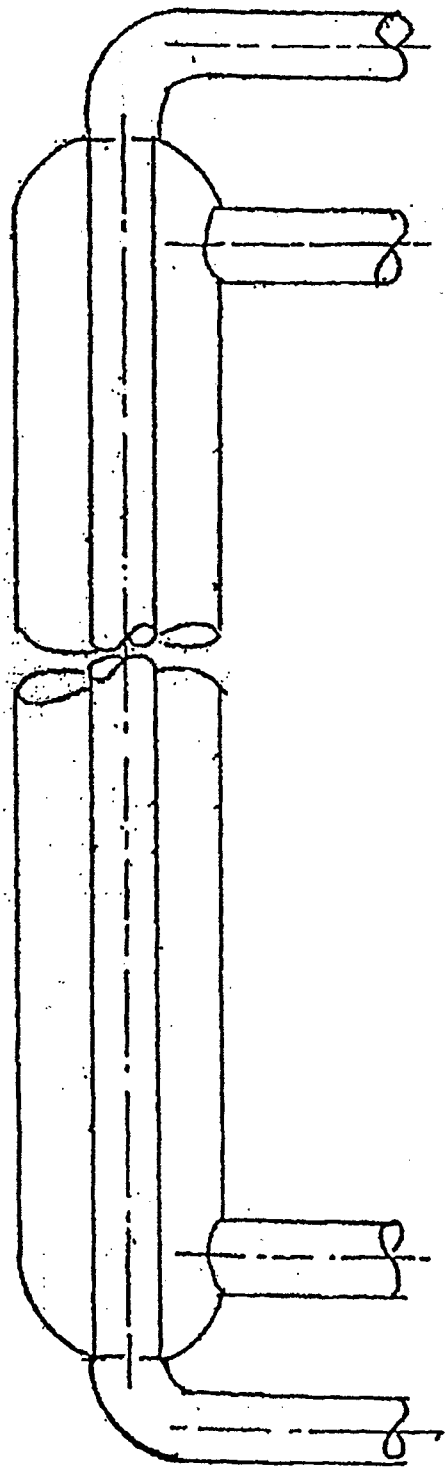
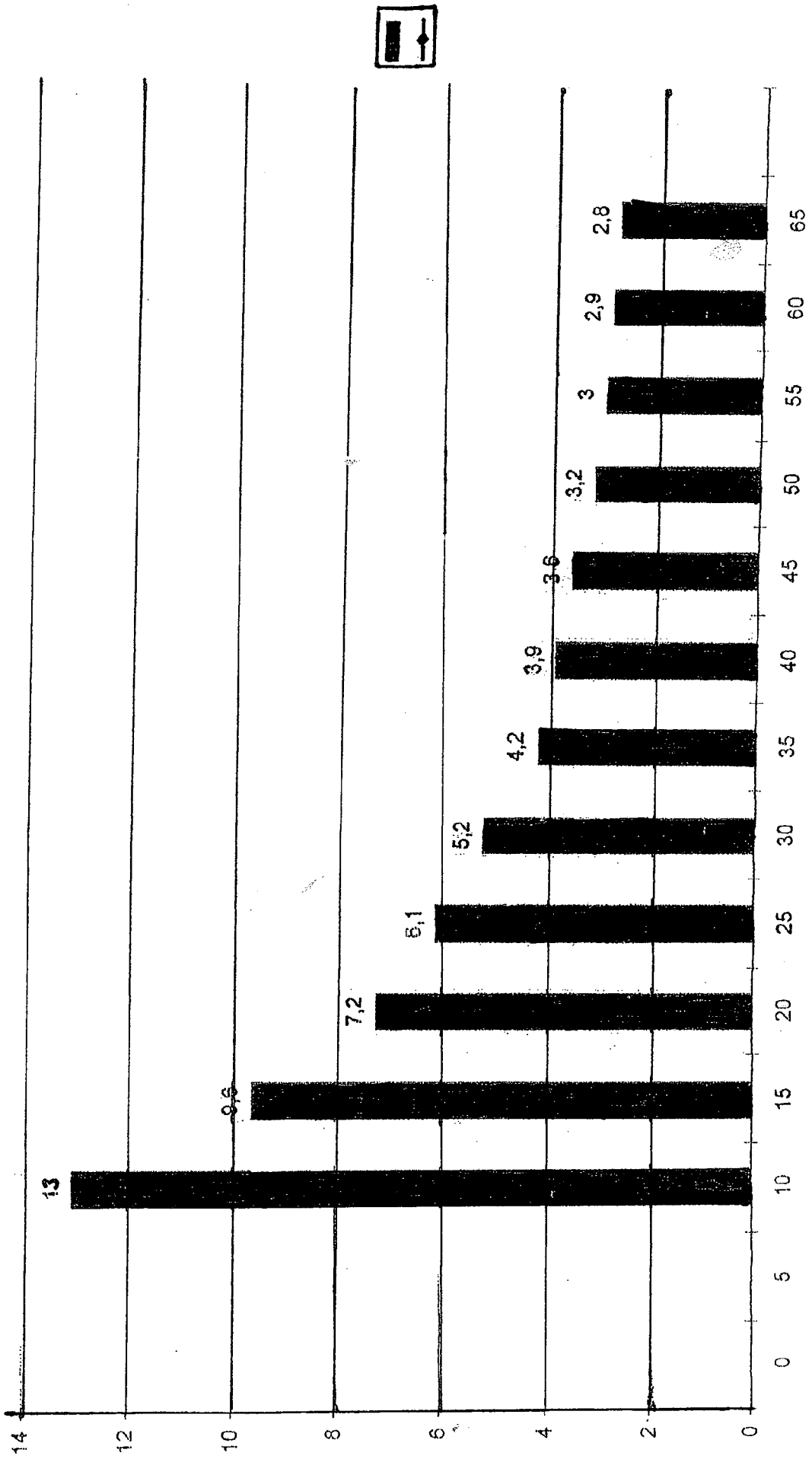


Fig. 3


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9,6
7,2
6,1
5,2
4,2
3,9
3,6
3,2
3
2,9
2,8
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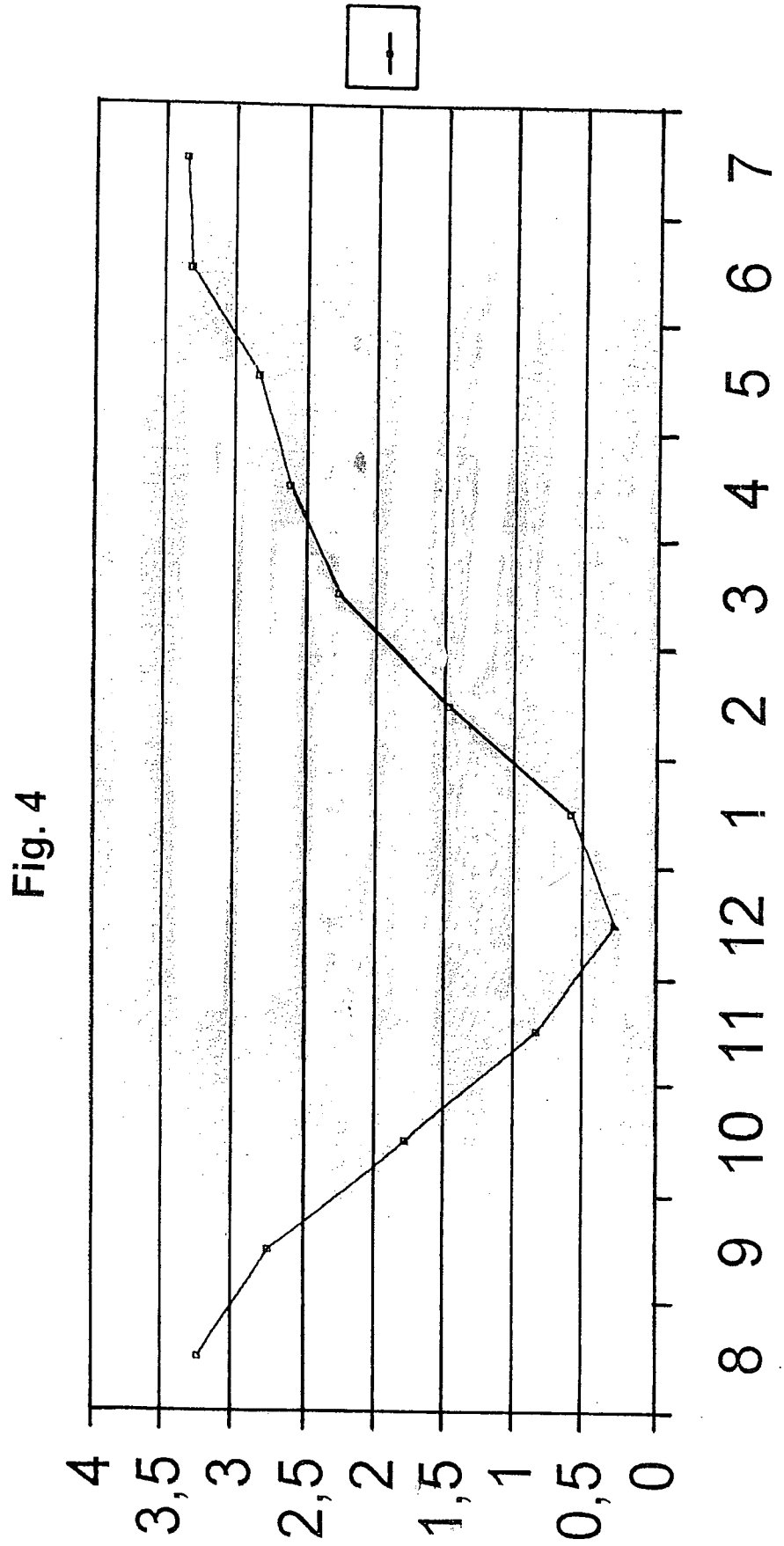


Fig. 4

Fig. 5

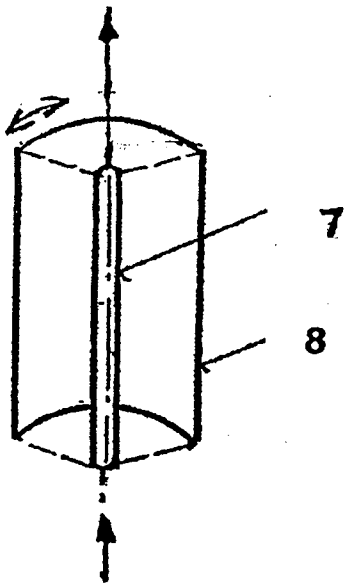


Fig. 6

