

DOCUMENT MADE AVAILABLE UNDER THE PATENT COOPERATION TREATY (PCT)

International application number:	PCT/US2017/062558
International filing date:	20 November 2017 (20.11.2017)
Document type:	Certified copy of priority document
Document details:	Country/Office: US
	Number: 62/423,814
	Filing date: 18 November 2016 (18.11.2016)
Date of receipt at the International Bureau:	02 December 2017 (02.12.2017)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-bis)

892633

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

December 01, 2017

THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY FROM THE RECORDS OF THE UNITED STATES PATENT AND TRADEMARK OFFICE OF THOSE PAPERS OF THE BELOW IDENTIFIED PATENT APPLICATION THAT MET THE REQUIREMENTS TO BE GRANTED A FILING DATE.

APPLICATION NUMBER: 62/423,814

FILING DATE: November 18, 2016

RELATED PCT APPLICATION NUMBER: PCT/US17/62558

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS US62/423,814



Certified by

Michelle K. Lee

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

Inventor(s)

Inventor 1

[Remove](#)

Given Name	Middle Name	Family Name	City	State	Country i
Brian		Plourde	St. Paul	MN	US

Inventor 2

[Remove](#)

Given Name	Middle Name	Family Name	City	State	Country i
Andrew		Gikling	St. Paul	MN	US

Inventor 3

[Remove](#)

Given Name	Middle Name	Family Name	City	State	Country i
John		Abraham	Minneapolis	MN	US

Inventor 4

[Remove](#)

Given Name	Middle Name	Family Name	City	State	Country i
Richard		Pakonen	Birchwood	MN	US

Inventor 5

[Remove](#)

Given Name	Middle Name	Family Name	City	State	Country i
Douglas		Plourde	Somerset	WI	US

All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.

[Add](#)

Title of Invention SOLAR HEATING SYSTEM

Attorney Docket Number (if applicable) 18493.12.2.US.P1

Correspondence Address

Direct all correspondence to (select one):

☒ The address corresponding to Customer Number

☐ Firm or Individual Name

Customer Number

94740

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

• No.

Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:

Yes, the invention was under a contract with an agency of the United States Government. The name of the U.S. Government agency and Government contract number are:

Entity Status**Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29**

- ☒ Applicant asserts small entity status under 37 CFR 1.27
- ☐ Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
- ☐ No

Warning

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

Signature

Please see 37 CFR 1.4(d) for the form of the signature.

Signature	Brett A. Klein/		Date (YYYY-MM-DD)	2016-11-18	
First Name	Brett A.	Last Name	Klein	Registration Number (If appropriate)	64448

This collection of information is required by 37 CFR 1.51. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **This form can only be used when in conjunction with EFS-Web. If this form is mailed to the USPTO, it may cause delays in handling the provisional application.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that : (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Solar Heating System

Inventors

Brian Plourde
Andrew Gikling
John Abraham
Rich Pakonen
Douglas Plourde

Related References

The content of each of the following references is incorporated herein by reference herein in its entirety:

- U.S. Patent Application No. 14/954,383, entitled "Method of Calculating Pathogen Inactivation for a Fluid Heating System," and filed November 30, 2015;
- U.S. Patent Application No. 14/954/318, entitled "Control Valve Assembly for a Fluid Heating System," and filed November 30, 2015;
- U.S. Patent Application No. 14/954292, entitled "Fluid Heating System," and filed November 30, 2015;
- U.S. Patent Application No. 14/954,091, entitled "Dual-Axis Tracking Device," and filed November 30, 2015;
- U.S. Patent No. 8,484,974, entitled "Dual-Phase Thermal Electricity Generator," and filed October 28, 2009;
- U.S. Provisional Patent Application No. 62/085,699, entitled "Mathematical Model for the Inactivation of Biological Contaminates Using Solar Heating," and filed December 1, 2014; and
- U.S. Provisional Patent Application No. 62/259,748, entitled "Fluid Heating System," and filed November 25, 2015.

ABSTRACT

This invention deals with a system that uses solar energy to heat fluids. The solar heating system involves specially shaped reflective surfaces, piping which conveys the fluid along the focal axis of the surfaces, a valving system that allows fluid to flow after it has reached a desired temperature, a novel heat exchanger that improves the thermal performance of the system, a computerized control method that automatically focuses the system at the sun and tracks the sun through the day and controls the fluid temperature and the fluid residence time in the system. An external smartphone or computer that allows remote access, monitoring, calibration and management of the system performance can be used. An option for electrical power generation through TEG (thermoelectric generators using the Seebeck Effect), and a highly accurate mechanism to point the system at the sun and minimize power requirements are incorporated. The system can be used for the pasteurization of water as well as to heat liquids for other purposes such as temperature management within buildings and houses, electrical generation, or solar-thermal cooling through an absorptive cooling cycle. The device allows either manual or automatic calibration of the orientation of the solar components toward the sun. The calibration is based on a single stellar object. The device includes optional fill and/or temperature sensors on fluid supply and storage tanks. Information from these sensors can indicate when insufficient storage or supply is provided and sets the system into a sleep mode accordingly. The system incorporates an optimization algorithm that maximizes the amount of heated fluid based on a mathematical model (such as a pathogen inactivation calculation).

BACKGROUND OF THE INVENTION

There are many situations where heating of fluids (liquids or gases) is beneficial. Heating liquid water can be used for pasteurization, cooking, creating steam for power generation, manufacturing, providing indoor comfort, or other applications. Heating of gases can similarly be used for cooking, manufacturing, curing of chemical applications, power production, or others. Typically, the heating is accomplished through combustion of fuels such as coal, wood, natural gas, or other fuels.

These fuels are costly to purchase and use, require flow distribution and storage systems (pipes and tanks), and lead to the emission of pollutants which are hazardous to human health or the global environment.

An alternative to fossil fuel use is the application of solar-energy heating for these situations. Here, solar-energy heating refers to the use of generally concentrated solar electromagnetic energy to provide the thermal energy to increase the fluid temperature.

One area that solar energy can be used to increase fluid temperature is the pasteurization of water. Water, which is necessary for human life, is not uniformly available throughout the planet. In some areas, water is scarce while in some areas water is plentiful but not safe to drink.

Ingestion of pathogens from water is a major global health risk with billions of diarrheal episodes each year and millions of deaths for children of young age (under 5 years old). Consequently, creation of potable water would result in a substantial increase in quality of life and health care in many parts of the world, especially those where industrial water treatments systems are not used.

The quality of water depends on its origination. Some wells, particularly deep wells that are capped, often have drinkable water. Shallower wells and surface water sources are often unclean. The types of pathogens which may exist in water depend on the environment and climate but include bacteria, viruses, worms, and protozoa.

Treatment for these pathogens is important for the creation of safe water. Often, treatment involves two stages. One, a termination of the pathogens and second, a removal of the pathogens from the water.

The first stage is usually accomplished by chemical means but can be achieved using other techniques such as the application of heat or ultraviolet light. The second step is achieved by filtration.

SUMMARY OF THE INVENTION

Here, focus is given to the first step which is the deactivation of living pathogens. The proposed system exhibits a number of novel features that have not yet been disclosed.

First, the proposed system has a novel parabolic reflecting surface construction which creates a focal axis through which fluid flows. Second, the system has a novel heat exchanger which preheats fluid entering the system and thereby increases thermal efficiency. Third, the system has a set of digitally or thermally activated valves that are designed to open when a targeted pathogen reduction has been achieved. The valve system prohibits or mitigates the passage of untreated water through the device.

Fourth, the system contains electronics which connect to an external smartphone or other digital control mechanism such as a computer.

Fifth, the connection enables remote access, monitoring, calibration and management of the system.

Sixth, the system allows the inclusion of a power generation device using the excess heat to generate electricity from a TEG (thermal-electric generation system) which is comprised of ceramic chips which work on the Seebeck Effect in order to take the incoming cooler fluid as the cold side and the exiting hot fluid as the hot side. The temperature difference drives a current within the TEG to create electricity during the heat reclaiming portion of the system.

Seventh, wireless radios can be used in conjunction with tank monitoring devices to track the presences or absence of input or output water sources. This information is important for ensuring the system only runs automatically when required system inputs are met.

Eighth, the system allows for either automatic or manual calibration of its orientation to ensure that it points at the sun. The automatic calibration system is based on GPS coordinates and date/time information. The manual calibration is based on a visual observation of the concentrated solar ray compared to a target. The manual calibration is based on a single stellar object as reference.

Ninth, the system enables an optimization algorithm that maximizes the heated fluid. The algorithm is based on a pathogen deactivation rate (for pasteurization applications) or other suitable mathematical model. The algorithm performs a search function across all temperature/time combinations which will provide treated fluids. It then selects the temperature/time combination which provides a maximum of fluid.

Tenth, the system and its structure can be used for other solar products such as photovoltaic electricity generators, satellite orientation, or others.

Eleventh, the system can be used with radiant sensors to detect situations where sunlight has ceased. In these occurrences, the system enters a low-power sleep mode to conserve power.

The system is modular and can be used as a single solar collection system or as part of an array with multiple collectors. The system can be used in conjunction with solar PV systems which provide electrical power to pumping systems.

The system is designed to break down into multiple sub-assemblies, such as 5 sub-assemblies, for easy transportation and distribution. It is then very easy to erect, reassemble, calibrate and run. This is very important for disaster relief zones where drinking water is scarce.

The invention includes a reflecting surface which directs solar energy to an axis. When used for fluid heating, a pipe transports fluid along the axis.

The system is designed to allow connection to water supply systems including municipal piping or residential/commercial water storage tanks. Water (or other fluids) pass through the system and are heated to appropriate levels as desired by the user. The heated fluid may be water, air, oils, or other fluids. The thermal energy may be used for pasteurization, providing the thermal environment within buildings and houses, heating for electrical power generation, or other purposes.

The system is designed to be wirelessly connected to an external smartphone or computer. This data link between the device's onboard computer system to the external smartphone or computer relays system state information to the external smartphone or computer.

The wireless connection enables access, monitoring, calibration of the control algorithms and management of the system remotely. Consequently, the operating and management of the system has reduced costs compared to other systems that require regular on site interaction with users. The calibration method handles orientation of the solar system toward the sun. In addition, data is collected from temperature sensors, solar radiant sensors, and sensors within supply or storage tanks to update the operation of the system. In some scenarios, when the system is not functioning properly, when there is insufficient fluid supply or storage capacity, a low-powered sleep state will occur.

The structural components include a reflective surface, a support system which maintains the curvature of the surface, piping which brings fluid from a source to the device, further piping which conveys the fluid through the system, a heat exchanger which transfers heat from one stream to preheat incoming fluid and increase the thermal efficiency, a valve system which is designed to open when targeted temperature/duration targets are reached, and a finely controlled dual linear-motor system which maintains the position of the system with a high degree of accuracy.

An algorithm is used to find temperature/time combinations which result in a maximum amount of treated fluid. For water pasteurization applications, the optimization algorithm is preferably based on pathogen inactivation calculations.

OBJECTIVES

One object of the invention is to heat fluids such as water or air to elevated temperatures. The heating may be for various purposes, such as pasteurization, power generation, thermal management of buildings or residences, or others.

Another objective of the invention is to heat with minimal interaction from human users. The interaction is minimized through the system's automation software and is designed to autonomously produce hot fluid when system inputs and environmental conditions are met. The onboard computer acquires its location on earth and date/time information via its GPS radio or through the external smartphone or computer. The software uses this GPS information to calculate the sun's daily trajectory and thereby allowing accurate control of the linear motion system to align the mirror's focal axis on the heating pipe throughout the day.

Another objective of the invention is to accurately deactivate pathogens by controlled heating. The system is designed so that through-flow is enabled when target temperature/durations are reached that result in deactivation of pathogens. The software is designed to incorporate the thermal tolerance of different pathogens so that any level of safety can be achieved.

The software allows the system to operate with maximum efficiency based on the desired temperatures of the fluids or the targeted pathogen counts. In the case of water pasteurization, the software takes measured temperatures and durations. It searches possible temperature/time combinations that lead to treated water. It then selects a unique combination which results in maximum or relatively high performance and instructs valves to operate to achieve the desired temperature/time results. For other fluid heating applications, the software uses appropriate performance criteria to run an optimization algorithm but the general process is similar.

Another objective of the invention is to perform the above tasks with high thermal efficiency. Means to achieve high efficiency include a carefully shaped reflective surface that creates a focal axis through which fluid passes. Another aspect is a heat exchanger that transfers heat from outgoing hot fluid to incoming cool fluid. Consequently, the incoming fluid is preheated. Another aspect is that the tracking system is in idle most of the time (optimally more than 90% of the time) so that battery power consumption is minimized.

Another aspect of the invention is a power generation system contained within the piping that uses the temperature difference between the incoming and exiting fluid to drive a TEG (thermal-electric generation system) which is comprised of ceramic chips which work on the Seebeck Effect which uses a temperature difference to create electricity.

Another aspect of the invention is that it can be employed as a stand-alone unit or in an array with multiple units. The single units or arrays can be combined with solar photovoltaic (PV) energy to power the pumps or other fluid generation devices.

Another aspect of the invention is that the onboard computer system can be quickly and easily calibrated to accurately point at the sun via the data link to an external smartphone application or other computer system. The calibration is performed with a single stellar object. When the system is setup, it is possible that installation is imperfect error due to lack of tools, training, resources or otherwise. These imperfections would regularly render the system's solar pointing controls too inaccurate to focus the sun's rays onto the desired focal axis. Furthermore, natural error stack up in the manufacturing process can adversely affect the system's pointing controls. A calibration routine can be executed via the external smartphone application or other computer application to correct for this solar-pointing error. The ability to calibrate dramatically reduces the time and effort it takes to deploy the unit which is important in disaster relief zones or anywhere the unit isn't necessarily a permanent fixture.

Another aspect of the invention is the optional inclusion of sensors in source or storage tanks. These sensors measure the fill level of these tanks and can also sense the temperature. If there is inadequate fluid supply, or inadequate storage capacity, the system enters a low-power sleep state to save energy and increase safety. If the temperatures within these tanks are outside of operation protocols, the system can also enter a low-powered sleep state.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 – A schematic image of a single-system module

Figure 2 – Flow directions for fluid passing through the system

Figure 3 – Section plane of digital fluid control system

Figure 4 – Auxiliary equipment to control system and store heated Fluid

Figure 5 – An array of systems, with fluid supply and auxiliary PV system

Figure 6 – Preferred TEG placement

Figure 7 – Exploded TEG

Figure 8 – Energy flow through TEG

Figure 9 – Schematic diagram of water pasteurization system, can be used for heating other fluids

Figure 10 – Digital storage tank system diagram

Figure 11 – Maximization of flowrate, finding optimized time/temperature relationships

Figure 12 – The algorithm for optimizing throughput of treated water

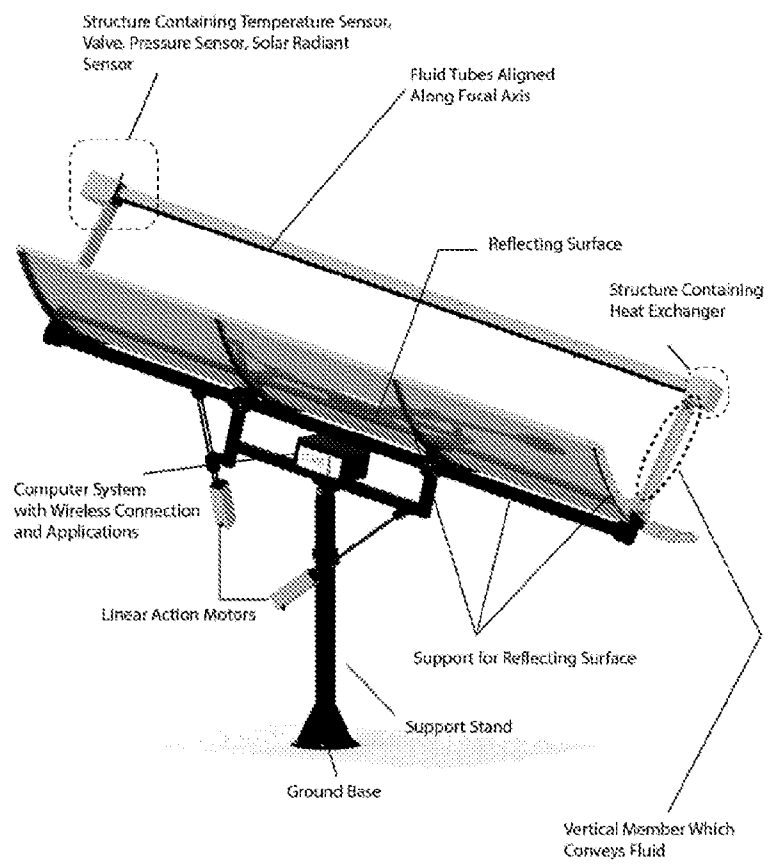


Figure 1 - A schematic image of a single-system module

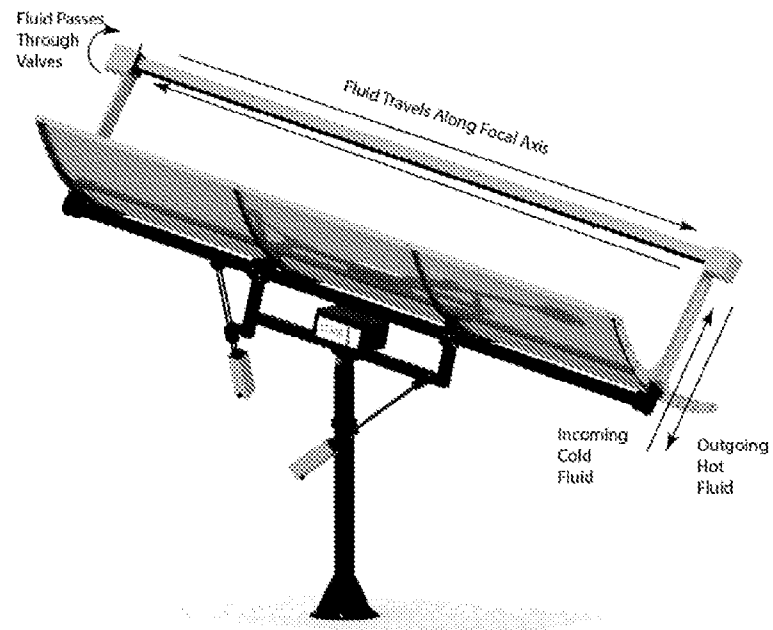


Figure 2 - Flow directions for fluid passing through the system

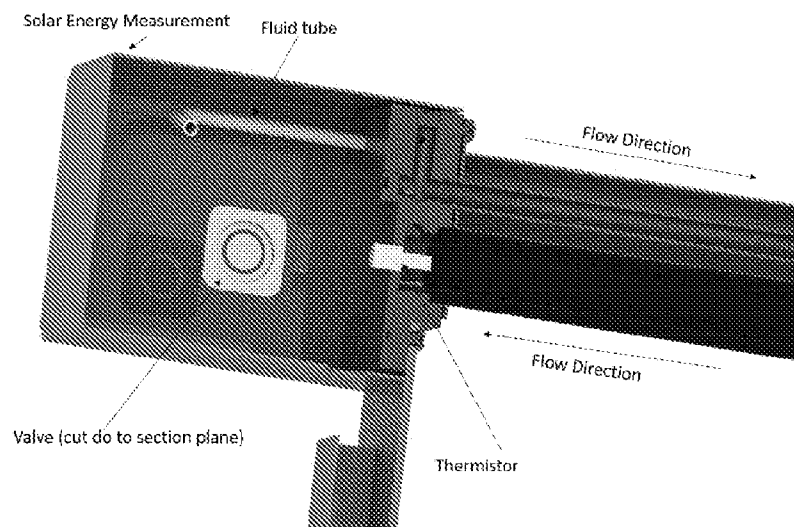


Figure 3 - Section plane of digital fluid control system

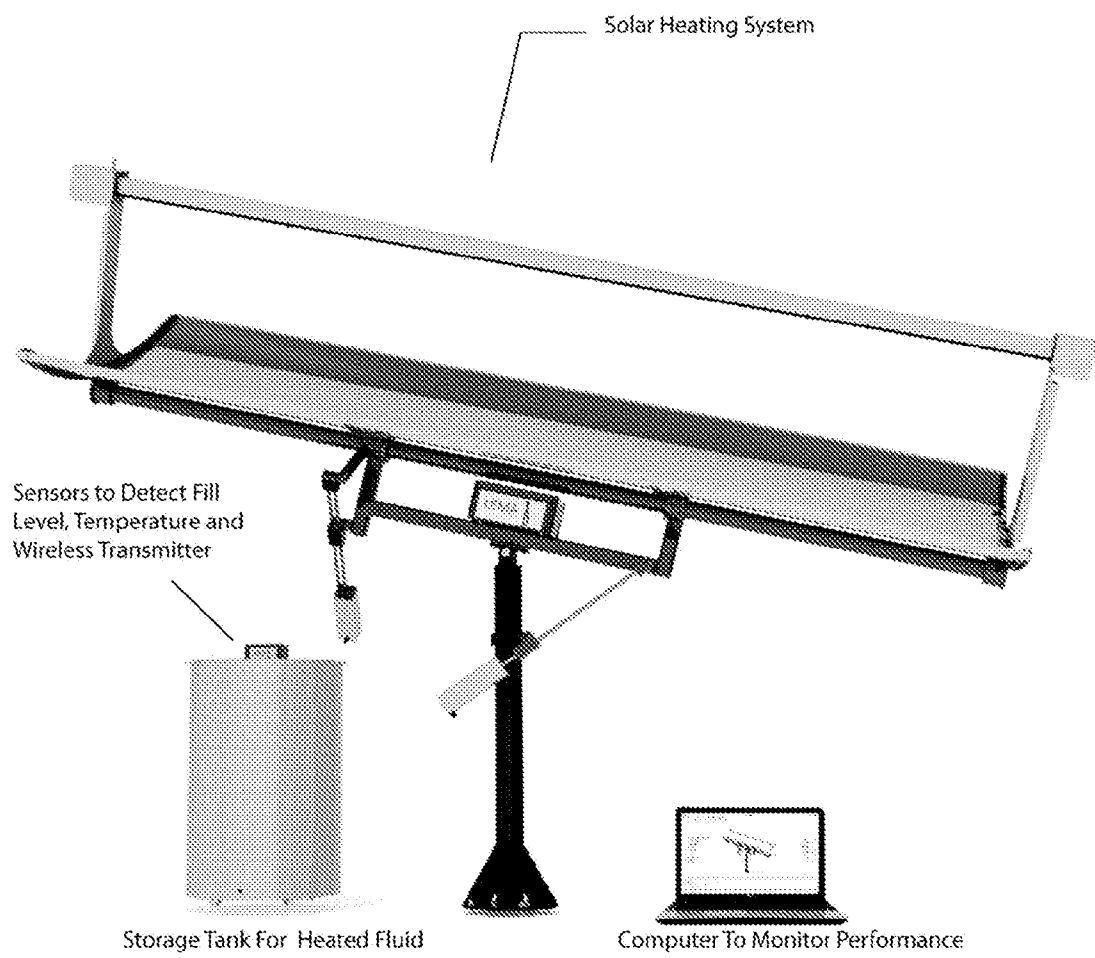


Figure 4 - Auxiliary equipment to control system and store heated Fluid

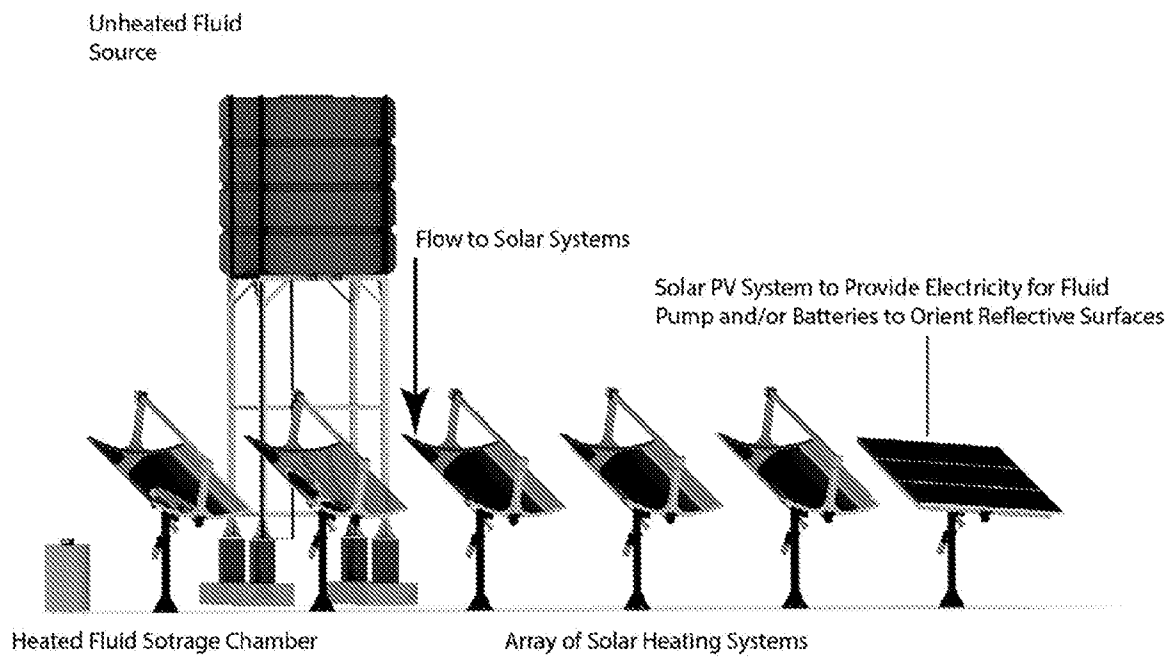


Figure 5 - An array of systems, with fluid supply and auxiliary PV system

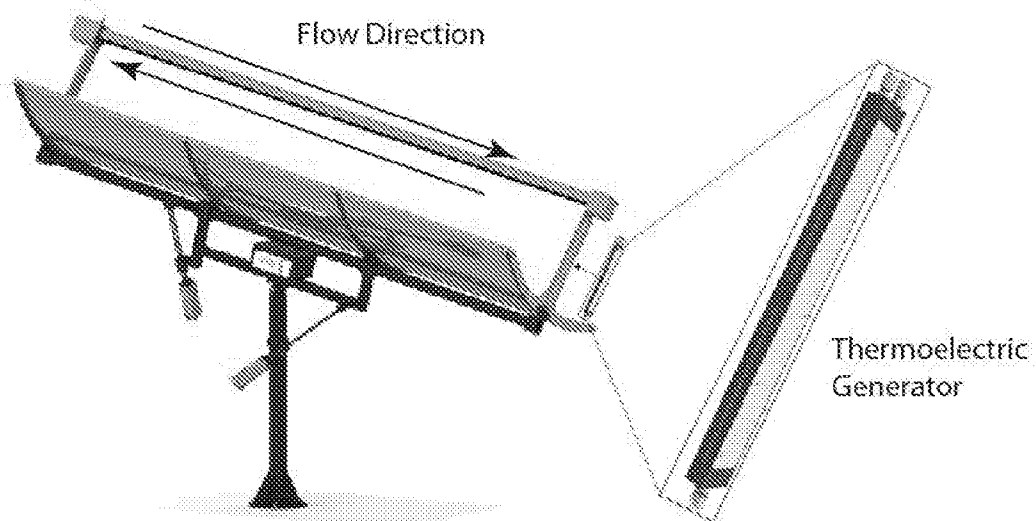


Figure 6 - Preferred TEG placement

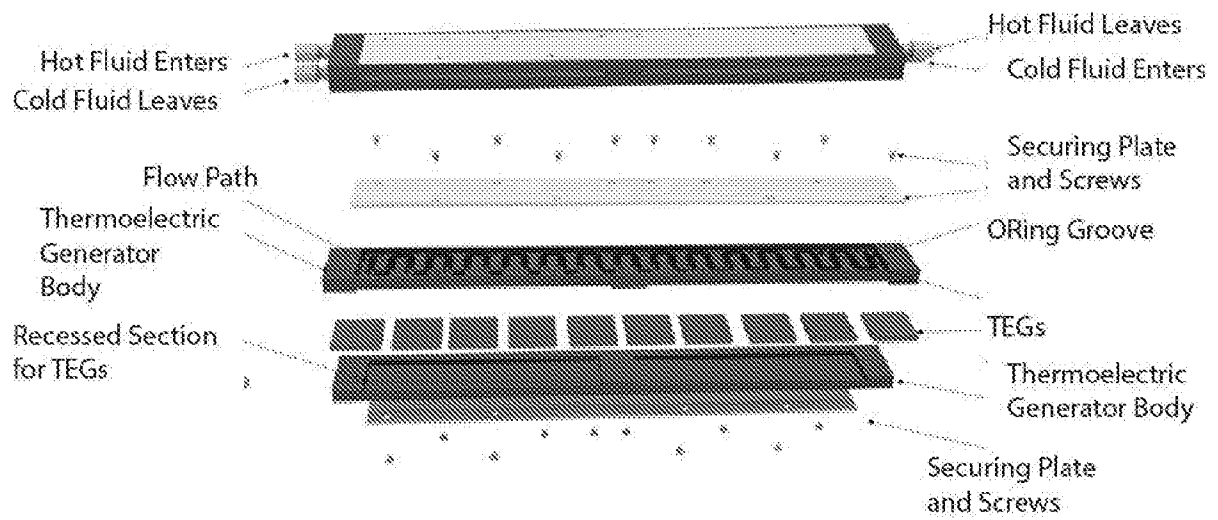


Figure 7 - Exploded TEG

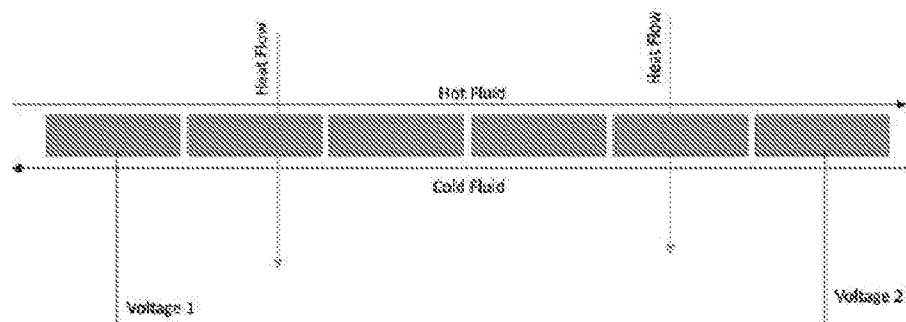


Figure 8 - Energy flow through TEG

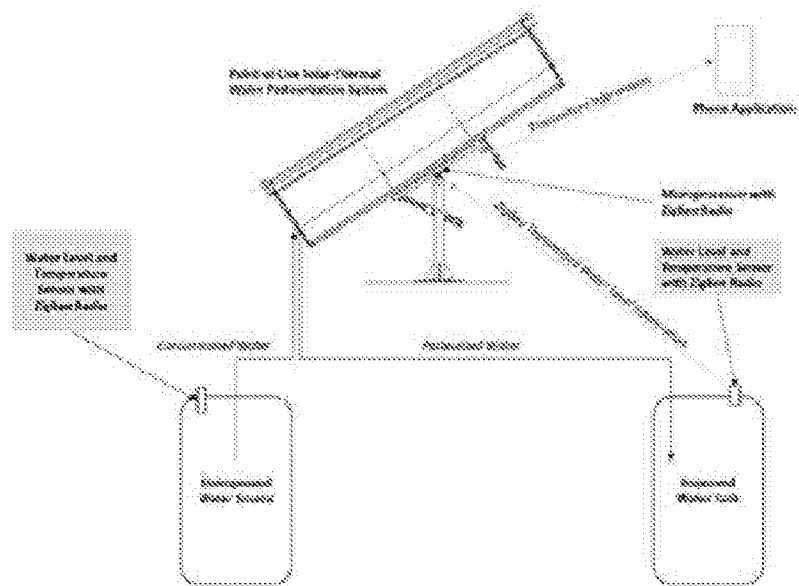


Figure 9 – Schematic diagram of water pasteurization system, can be used for heating other fluids

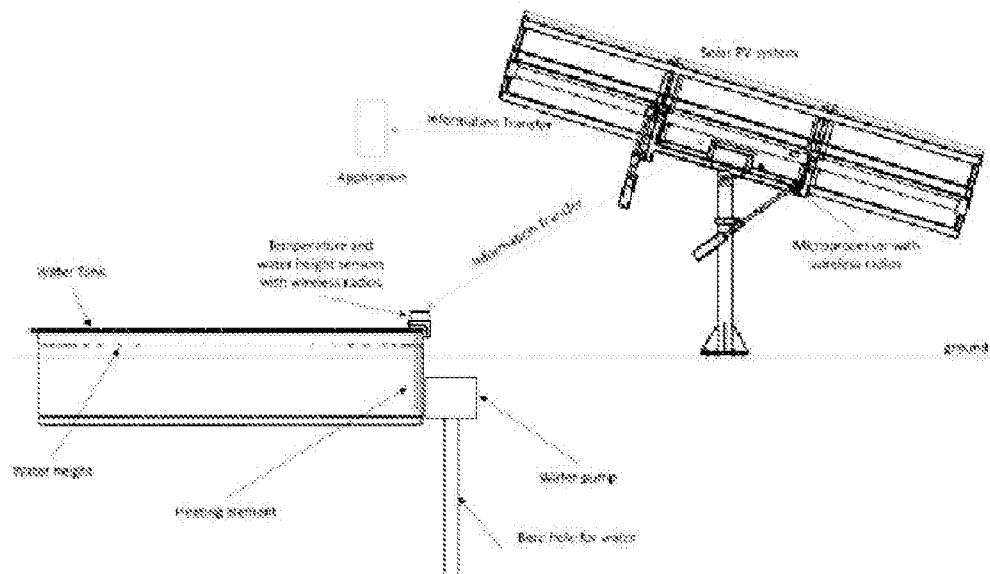


Figure 10 - Digital storage tank system diagram

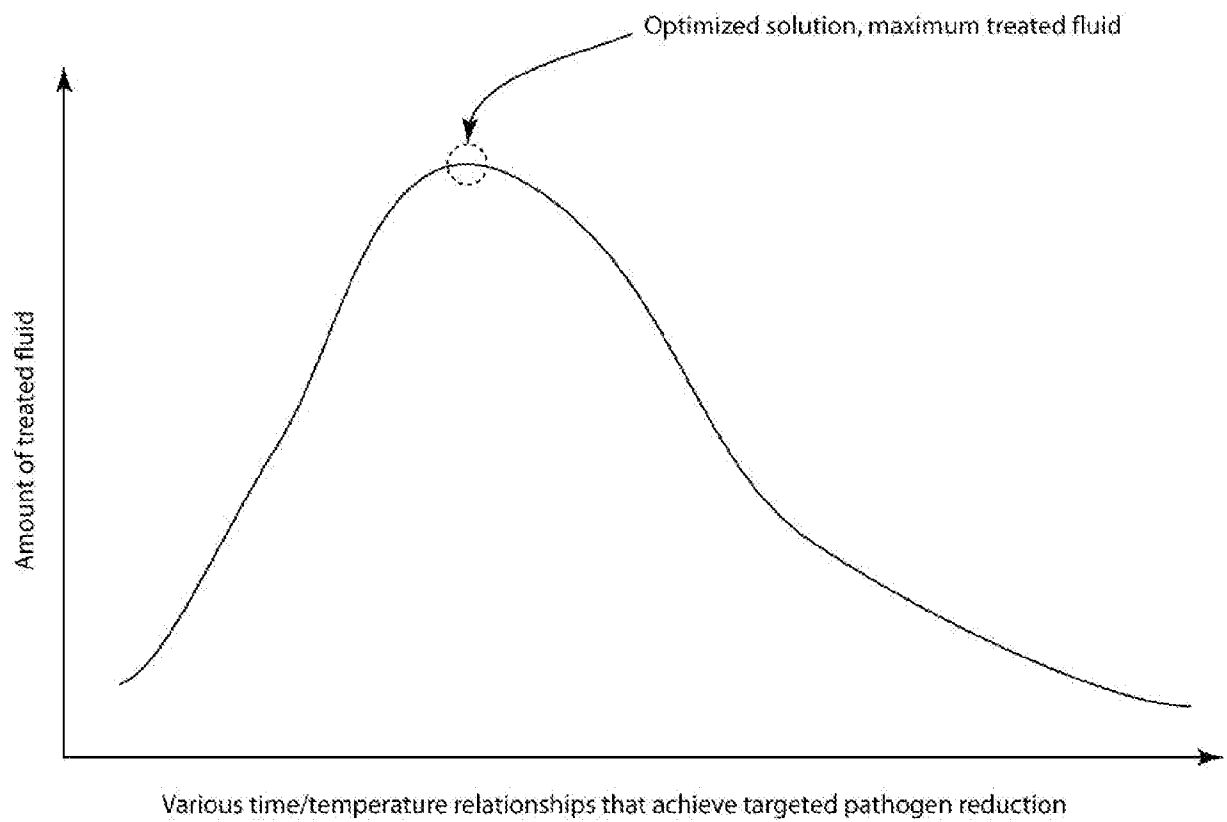


Figure 11 – Maximization of flowrate, finding optimized time/temperature relationships

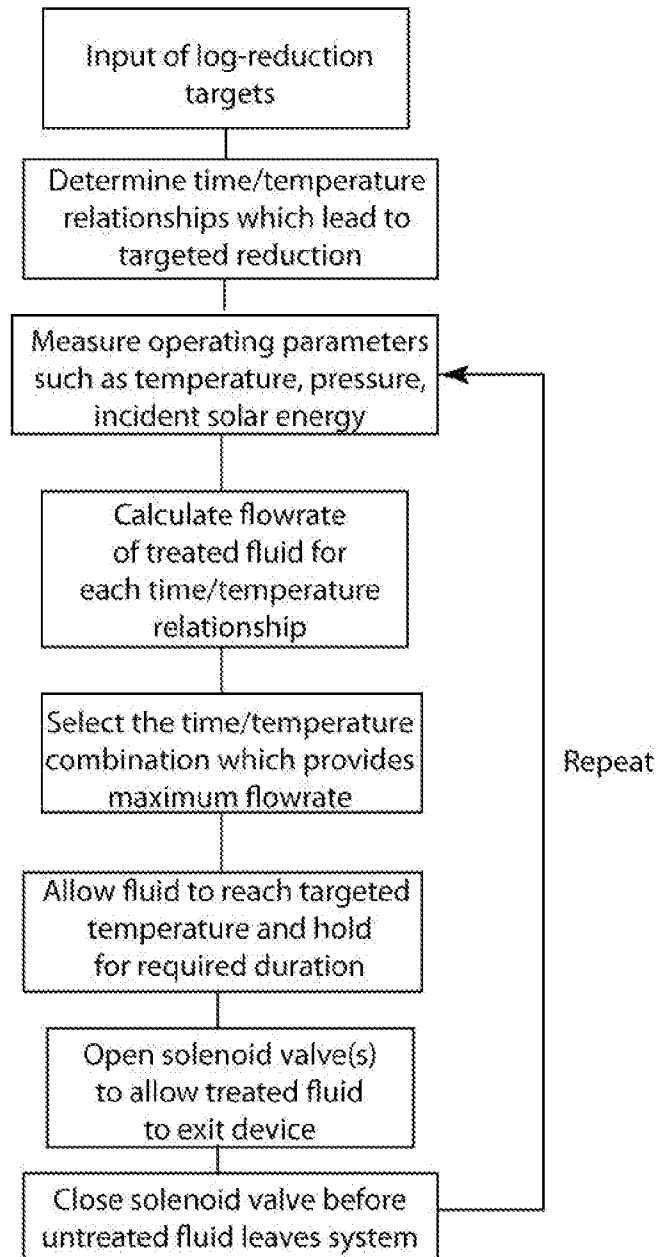


Figure 12 – The algorithm for optimizing throughput of treated water

DETAILED DESCRIPTION OF THE INVENTION

The invention operates by heating water or other fluids to elevated temperatures using sunlight that is focused along a focal axis. Typically the reflecting surface will be a parabolic trough and the focal axis will be at the focal location of the parabola.

Water or other liquids enter the system from an external source. For instance, for water pasteurization applications, water may enter from a storage tank that may or may not be elevated. This water may include various living pathogens such as bacteria, viruses, protozoa, or worms.

The fluid system, for example a water tank, is connected to an inlet end of the pasteurization device by means of a flexible conduit or tube. Water flows into the tube which is aligned with the focal axis. After reaching one end of the axis, the water turns around and passes back along the focal length. Figure 1 shows a depiction of the device with major components annotated.

Figure 1 shows an embodiment of the system with important components annotated. In this embodiment, a vertical member conveys unheated fluid into a system from an external source. Atop this member is a structure which houses a heat exchanger. A fluid tube is aligned along the focal axis. At the opposite side of the tube is another structure which contains valves and various sensors to be described. Beneath the reflecting surface are supports which maintain the curvature of the surfaces, motors which orient the system toward the sun, a support stand and base and an onboard computer system equipped to receive information from the system's sensors and wirelessly transmit data to an external smartphone or computer.

The embodiment in Figure 1 includes a vertical member through which fluid flows in a counter-flow arrangement. In this embodiment, it is possible to position an electrical energy generator such as a system based on liquid phase change or thermoelectric power generation (TEG) which will be discussed later.

At the inlet/outlet end of the device, there is a fluid-to-fluid heat exchanger. The purpose of this exchanger is to transfer heat from existing hot fluid to incoming cool fluid and thereby to preheat the incoming liquid. This preheating results in increased thermal efficiency.

At the opposite end of the device, there is a housing which contains temperature sensitive valves or digitally controlled solenoid valves that open after prescribed temperature/duration goals have been achieved. For pasteurization applications, these goals are based on the types of pathogens to be inactivated by the system.

Temperature sensors within the valve assembly provide continuous or intermittent temperature information to the onboard computer. Pressure sensors may also be used to sense dangerous pressure levels or the pressure of trapped air or steam pockets. The onboard computer, with use of an inactivation algorithm, calculates the rate of pathogen destruction. When a sufficient number of pathogens have been destroyed, the onboard computer opens one or more valves to allow fluid flow. The fluid control system is designed to allow a portion of the heated fluid to flow through the system. This fact ensures that little to no unheated fluid can pass through the system.

Temperature sensors, pressure sensors, and solar energy sensors are incorporated to improve efficiency of the device and to provide safety and detect faulty states that may occur. These processes will be discussed later.

The algorithm optimizes the performance so that the amount of heated fluid is maximized. The algorithm performs the optimization step by searching through temperature/time combinations which will reach a desired treatment goal. It then selects the temperature and time combinations that results in maximum or relatively high fluid output.

Figure 2 shows the path of fluid flow. In this embodiment, incoming unheated fluid enters at the base of the vertical structure, travels upwards into the heat-exchanger structure and is warmed by the outgoing hot fluid. Fluid travels twice down the co-linear pipes which are aligned on the focal axis. It reverses

direction at one end of the device where digitally or thermally actuated valves are located along with previously mentioned temperature and pressure sensors. A section view of the valving structure is provided in Figure 3 where a temperature sensor is shown used to measure fluid temperatures within the structure.

For other non-pasteurization applications, the control algorithm which is managed by the onboard computer control system will output fluids which are at the temperature desired by the user and the application. Figure 4 shows a storage chamber which is used to store heated fluid. In some embodiments, the storage chamber is equipped with wireless temperature and/or fluid level sensors to determine when the storage chamber is filled to capacity. In some applications, such as for water pasteurization, the storage chamber may be disinfected so that repopulation of pathogens does not occur. In other applications, such as for power generation or thermal management of interior building or residential spaces, this tank may be omitted because the heated fluid will likely be used immediately after heating.

The pasteurization system is modular and can be operated as a stand-alone system or in an array with multiple devices operating together. Typically, the systems operate in parallel to increase the output of heated fluid. Each system within the array can be programmed similarly or to different temperature/duration levels depending on the specifics of the application.

Figure 5 shows an embodiment with multiple solar heating systems, a solar PV electrical power generator for powering a fluid pump and/or for charging the batteries which electrify the onboard computer, sensors and reflective surface motors. Fluid enters the systems from a fluid source. In the imaged embodiment, the source is an elevated fluid tank. It could be another source in different embodiments. The fluid, after heating, is stored in a storage tank(s) where it is used later. For other applications, such as power generation, there may not be a storage tank.

Whether the system is operated individually or in an array, typically battery power is used to operate the motors and move the reflectors. In normal operation, the system is powered down for most of the time (more than 90% for instance) and periodic alterations of the orientation are used to realign the system with the sun. These alterations may be performed every 2-3 minutes or more or less frequently.

When skies are cloudy the alterations are typically performed less often or not at all. A solar radiation sensor is employed in one embodiment which can sense the presence or absence of clouds. In the presence of clouds, the device can remain in a low power sleep mode to preserve battery life.

In some embodiments, at night, the system is moved to a safe position and put into a low power sleep mode and electrical power is conserved. During sleep mode, the device points toward zenith.

In some embodiments, the water supply system may be intermittent and the system may be equipped with a flow or pressure sensor that determines whether adequate flow is available. If adequate flow is not available, the system will orient itself away from the sun so that dangerous excess heat transfer does not occur.

In some embodiments, either as stand-alone systems or in arrays, a photovoltaic electricity generator may be used. The generator can supply electrical power to fluid pumps that may be used to store fluid in a holding tank (for instance pump water into an elevated water tank). In other instances, the PV generator may provide power to the batteries which operate the onboard computer, sensors and reflecting surface motors, thereby extending battery lifetime.

In other embodiments, electrical power may be generated by either a thermoelectric power system or a vapor-based power generator such as that disclosed in U.S. Patent # 8,484,974, previously incorporated herein by reference.

The pressure, solar irradiance and temperature sensors within the system are able to detect the presence of air or vapor pockets which may cause a risk of overheating and rupture. This method is disclosed later. Air pockets can be exhausted by opening a purge valve. The purge valve allows air to escape but generally prohibits the transfer of liquid.

The solar tracking algorithm is based on a novel application of trigonometry and the development of actuation triangles. The tracking algorithm has previously been disclosed in patent publication no. 2016/0154082, previously incorporated herein by reference.

Many stellar tracking systems are manually calibrated to accurately track the location of distant locations in the sky. Such is the case with many telescopes. Often methods involve the user manually pointing the tracking system at three different known objects in the sky. With this information, the stellar tracking system can use triangulation to calibrate the stellar tracking system and can therefor track the movement of any subsequent stellar object with relatively high accuracy.

In some situations, manually pointing a system at three distant stars to perform a triangulation calibration of this nature is not possible due to lack of requisite optics, pointing tools and the sun overwhelms any incident light from all other stellar objects during the day. The invention instead allows a user to manually orient the invention to point at the sun. Pointing accuracy to the sun is determined by manual observation of where the parabolic mirror's focal axis lands on the fluid pipe. Once the focal axis is sufficiently aligned with the pipe through manual orientation, this offset position can be saved as system calibration data. Taking multiple calibrations like this using just the sun throughout a single day allows the system to subsequently compensate the system's pointing vector based on the calibration data.

This calibration also corrects for the system's mounting error when it has non-perfect orientation to the local horizon, mechanical and manufacturing dimensional error, stellar calculation error in the on board computer, GPS error or date and time errors. The calibration procedure allows solar tracking of the sun to be significantly more accurate than could otherwise be achieved without calibration.

THERMOELECTRIC GENERATOR

A thermoelectric generator, or TEG (also called a Seebeck generator) is a solid state device that converts temperature differences into electrical energy through a phenomenon called the Seebeck effect. Thermoelectric generators function like heat engines, but are less bulky and have no moving parts. Thermoelectric generators are used in power plants in order to convert waste heat into electrical power and in automobiles as automotive thermoelectric generators (ATGs) to increase fuel efficiency.

Figure 5 shows one possible location of the TEG in the system. The TEG is located where the hot fluid leaves the system and where the cold fluid enters the system. The TEG can be used with or without the current system heat exchanger.

An exploded image of the TEG is shown below in Figure 7. In the figure, locations of hot and cold fluid entrance and exit are shown. Within the body of the TEG is a fluid path which may be a serpentine shape, or a shape which provides a large surface area for heat exchange from the fluid to solid body. The body

of the TEG device includes multiple TEG components which may be placed within a recess in the wall of the TEG. There is an optional outer casing which is used to enclose the device and some closure mechanism, such as screws or bolts are incorporated. The optional encasement may be made from a low-heat transfer material to preserve heat and limit exposure temperatures.

The TEG body includes a recess into which an O-ring or other suitable fluid sealant is positioned. The fluids which are passed through the TEG device also can transfer heat between the hot and cold streams. In this way, the TEG can function simultaneously as an electrical power generator and a heat exchanger. Using the system in conjunction with the systems current heat exchanger system would produce less electrical power but allow for the system to reclaim additional heat due to the heat exchanger aspects of the TEG assembly.

Figure 8 shows a schematic diagram of the power generation process. Hot fluid moves from left to right whereas cold fluid flows from right to left in one embodiment. As the fluid moves, heat is transferred through the high thermal conductivity TEG body and through the TEGs. As heat is transferred through the ceramic TEG bodies, a voltage is created which allows for power generation. The amount of heat transferred through the system is directly related to the amount of power produced. Electronics connected to the voltage outputs (such as a battery charge controller) are able to use or store the generated electrical energy.

DIGITALLY MONITORED STORAGE TANKS

In some embodiments water levels and temperatures in the supply storage tank can be monitored wirelessly to ascertain when the storage tank does not have capacity to allow the water pasteurization system to operate. In addition, temperatures and levels can be measured in the storage output tank to determine when the tank is full (and the system should cease operation).

To accomplish these tasks, devices may remotely communicate sensor data with the onboard computer on the fluid heating system. One tank monitoring device may be mounted on the supply storage tank and contains a wireless communication system (such as a ZigBee radio) to complete the communication with the onboard computer on the fluid heating system.

In one embodiment, the tank monitoring device includes two sensors. One of the sensors measures the water level of the tank and the other optionally measures the water temperature. The data from these sensors will be sent to the onboard computer on the fluid heating system. There the data can be used in control algorithms to ensure the input tank has a sufficient volume of water at a temperature within an allowed range to operate. The system may automatically turn off and point the mirror away from the sun to stop the system from heating when fluid isn't present in the infeed storage tank. A tank monitoring device on the output storage tank provides information to the system to halt operation when the output tank is filled so that it does not overflow. Also, optional temperature readings on the input and output storage tank can be used to calculate system power production. Similarly, measuring input and output tank levels can be used to accurately calculate volumetric water flow over time.

For both tank monitoring devices, information on temperature and fill level are sent to the onboard computer of the fluid heating system. The onboard computer uses the information in control algorithms to operate relay switches to turn on and off the pumps, heating elements, and/or reorients the device to point away from incident solar rays to maintain safe temperatures when fluid supply and fluid output requirements are not met.

An image showing how the system is used for water pasteurization is shown in Figure 9. The figure shows a supply tank (unimproved water source) and the treated tank (improved water tank) along with piping to the fluid heating system.

DIGITAL STORAGE TANK WITH TEMPERATURE CONTROL

The invention described in this patent also enables tracking for other applications, such as solar photovoltaic (PV) electrical generation.

In another embodiment, with the invention's tank monitoring and control capabilities, a fluid storage tank with temperature control can be realized. This application is shown in Figure 11 where the PV system provides energy for a water pump and heating unit. In this case, solar PV creates power which is used for pumping of water to the tank before pasteurization. The onboard computer measures water height and uses relay switches to turn the water pump on and off. The water system can also control a relay switch which turns on and off a heating element to prevent the tank from freezing (for use in cold climates). The water height is controlled by a fluid level sensor and water pump. For use cases where freezing is a concern, the temperature sensor and submerged heating element control the tanks temperature.

Figure 11 illustrates digital storage tank with temperature control embodiment.

OPTIMIZATION METHOD

For applications directed toward the pasteurization of water, special computer algorithms are possible to maximize device performance. In particular, the maximization results in the greatest amount of treated water subject to pasteurization targets for a given solar irradiance.

Pasteurization strategies are based on a log-reduction targets (a factor of how many pathogens are killed). A log-three reduction is standard (meaning 999 of every 1000 pathogens killed) however lower or higher killed rates are sometimes used depending on the application and the danger of the pathogens.

For exposure to an elevated temperature, the following calculation can be used to determine the surviving concentration of pathogens

$$\log\left(\frac{N_t}{N_0}\right) = \frac{-t}{D} \quad (1)$$

Here, N_0 is the initial pathogen population and N_t is the population at a later time t . The value of D depends on the exposure temperature. The following definitions will be used in the description of the optimization method.

$N_t/N_0 = 0.1$ (10% of pathogens remain alive – log 1 reduction).

$N_t/N_0 = 0.01$ (1% of pathogens remain alive – log 2 reduction).

$N_t/N_0 = 0.001$ (0.1% of pathogens remain alive – log 3 reduction).

$N_t/N_0 = 0.0001$ (0.01% of pathogens remain alive – log 4 reduction).

$N_t/N_0 = 0.00001$ (0.001% of pathogens remain alive – log 5 reduction).

$N_t/N_0 = 0.000001$ (0.0001% of pathogens remain alive – log 6 reduction).

During operation, the system monitors the temperature and pressure within the fluid. A clock or timer is used to determine how long the fluid has been held at a target temperature. Once the desired log

reduction is reached (based on Equation 1 or similar mathematical model), the system opens the solenoids and allows now treated fluid to leave the system.

There are multiple time/temperature relationships that can be used to achieve a targeted level of pathogen reduction. For instance, long durations at low temperatures, or shorter durations at higher temperatures could both be used. Because there are multiple possible time/temperature protocols, it is possible to create an optimization algorithm. The algorithm picks the temperature and time combination that results in maximizing the throughput of treated water. A simplified description of the process is provided by Figure 11. The vertical axis represents the treated water and the horizontal axis correspond to different time and temperature relationships. The algorithm finds the peak performance and operates the device at or near this optimized temperature/time relationship.

After the optimal time/temperature has been achieved, the software will open the solenoid valve(s) to allow fluid to pass out of the system. The algorithm is programmed to only allow a portion of the treated fluid through the system in one embodiment. The time duration for opening the solenoid may be based on the measured pressure within the system (which in turn depends on the pressure of the fluid supply). For cases where the incoming pressure is high, the solenoid will open very briefly. For cases where the supply pressure is low, the solenoid will open for a longer duration.

Once the solenoid has closed, the algorithm process starts anew with a reset clock. The basic steps of the algorithm are shown in Figure 12.

While the system can heat fluids and pasteurize water by employing thermally actuated valves, the above discussed optimization strategy may employ digital control of the valves by an onboard computer.

USE OF SOLAR ENERGY DETECTORS

Another novel feature of the invention is the inclusion of a solar irradiance sensor (sometimes referred to as a, pyranometer, solar incident radiation detector or other common terms known by a POSITA). A benefit of including a solar irradiance sensor is that its information is used to improve the safety of the device and to improve the efficiency of its operation.

Information from the solar irradiance sensor can detect, for instance, the passage of sun-blocking clouds. When sun-blocking clouds (or other events that block sun) are present, the fluid heating device loses much of its capacity to treat the fluid. During such an instance, it is not necessary for the system to orient itself at the sun. The system may thus enter a sleep mode and save its electrical power until the sun-blocking event has passed.

Alternatively, if the solar radiant detector is sensing high levels of incoming solar energy yet the fluid temperature is not rising within the system, an error or malfunction has occurred. In this situation, the device may enter an error state and turn its collector to an off-sun direction for safety. The algorithm will continue to monitor inputs (temperatures, pressures, incident solar energy, etc.) and update the user with audible tones.

SOLAR POINTING CALIBRATION METHOD

During normal operation the system orients itself towards the sun by activation of the linear motors. When oriented, the mirror's parabolic focal length is aligned with the heating pipe. The orientation of the mirror is here referred to as a "pointing vector." In some situations, for instance after installation or

movement of the device, the system may be recalibrated. The steps in updating the pointing vector without a calibration procedure may include:

1. Procedure based on GPS location, date, and time initiated to update pointing vector.
2. Software calculates the sun's current azimuth and altitude in the sky based on the date, time and the system's GPS coordinates.
3. Azimuth and altitude coordinates are run through a geometric transformation that maps azimuth and altitude into the season axis and day axis motor positions that will cause the focal axis of the mirror to align with the heating pipe.
4. Motors are indexed to their new linear position thus aligning the mirror's focal axis with the heating pipe.
5. System sets an alarm to instruct user to repeat the process in the future if needed.

It is preferred to orient the pointing vector so that it is precisely pointing at the astronomical object (typically the sun) within some small error (typically ± 1 degree). Any imperfections in the orientation are either associated with astronomical and calculation error (estimated to be ± 0.0003 degrees) or mechanical error. A novel technique has been developed to eliminate (or reduce) both of these sources of error.

To eliminate or reduce these errors, a user may perform the following:

1. On a sunny day, the user first allows the system to complete a pointing vector update as described above.
2. Visual inspection or other means are used to determine if there is error in the pointing vector.
3. In the event the pointing vector is out of tolerance the user can manually jog the motors with the external monitoring and control computer.
4. Jogging the motor causes them to move continuously in one direction. The user can change this direction and control the motion of the season axis and day axis independently.
5. The user can see that the mirror's focal axis is not aligned with the heating pipe and they can correct it in two ways.
 - a. method 1, the user can see the bright focal axis of the mirror hitting the center of the black heating pipe. If the bright focal axis is not centered on the heating pipe the user jogs the motor to correct this and re-center the focal axis onto the heating pipe.
 - b. method 2, the assembly that holds the heating pipe above the mirror casts a shadow down onto the mirror and its support structure. The edge of this shadow can readily be seen on the support structure of the fluid system. If this shadow is not parallel with the metal edge of the support structure this means there is error in the pointing vector and the user can jog the motors until they are parallel. This corrects the pointing error.
6. Corrections to the pointing vector can be made independently for the season and the day motion axes.
7. Once the user has manually jogged the mirror into position to correct pointing error they click a "save calibration point" button in the user interface of the external smartphone application or computer application.
8. This saves the motion system's linear calibration offset for the current angular position.
9. The results of these operations are saved into a calibration table which is stored in the onboard computer's nonvolatile memory or to nonvolatile memory on the external smartphone or computer.

10. The user repeats this procedure as many times as needed throughout the day creating a calibration table with a purity of data points. Each point in the table specifies a nominal angular position for the season axis and day axis, and what linear motion offset is required at that location to align the mirror's focal axis to the heating pipe.

Once the calibration data is taken and the table is saved to nonvolatile memory it can be used to correct pointing vectors in the future. This is done in software as follows.

1. Procedure based on GPS location, date, and time initiated to update pointing vector.
2. Software calculates the sun's current azimuth and altitude in the sky based on the date, time and the system's GPS coordinates.
3. Azimuth and altitude coordinates are run through a geometric transform that maps azimuth and altitude into the season axis and day axis motor positions that will cause the focal axis of the mirror to align with the heating pipe.
4. Before the motors move to the calculated linear position, the calibration data is applied.
5. The nominal position for the season axis and day axis is looked up in a calibration table.
6. Normally there will not be exact entries that match the current nominal calculated pointing vector. A nearest neighbor algorithm is used to find calibration points closest to the current nominal pointing vector coordinates.
7. Interpolation is used in conjunction with the two nearest neighbors in the calibration table to determine a linear season axis offset and a day axis offset appropriate for the nominal calculated pointing vector.
8. The linear season axis offset and day axis offset are added to the nominal calculated position and this result is the linear position where the motors are commanded to, instead of the nominal un-calibrated linear position.
9. Motors are commanded to index to their new calibrated linear position.
10. System sets alarm for when to repeat the process in the future.

The thus-described calibration procedure can be accomplished with a single stellar object (such as the sun or a single star). This is not normally the case with stellar tracking systems which require calibration using multiple stellar objects.

If the system physically changes over time, for example, if the system's mount to the earth sinks into the ground and changes the invention's roll, pitch or yaw, this will impact the calibration. The user can use the external smartphone or computer to erase the current calibration data and run the procedure again thus re-calibrating the system.

It is novel that the invention provides an easy way for a user to maintain the system's pointing accuracy over the course of its lifetime. This feature nullifies or reduces the effect of physical wear on the system over time which would otherwise increase pointing vector error. It also allows the system to easily be moved and remounted in a different location if desired.

ENERGY SAVINGS/SLEEP MODE

The system's control software and electronics spend a considerable amount of time in a low power sleep state. During a low power sleep state the processor turns off electricity to most of the electrical components in the system. Motors, motor drivers, unused communications radios including GPS, Bluetooth, Zigbee, and sensors such as the electrical enclosure temperature sensor, water temperature sensor, solar irradiance sensor, and solenoid valve may be turned off. The processor core itself stops or

runs at a much smaller frequency than when it is active. In this low power sleep state the electrical system consumes orders of magnitude less electrical energy than when the system is awake and driving motors.

Electrical system sleep state can be induced by a number of things. For instance, when the sun's position is past the mechanical limits of the mirror's motion, the system sleeps. This can occur every night.

When the system is actively tracking the sun the motion system may remain off for most of the day as described previously. During the pointing vector update interval which is typically 3 to 5 minutes the electrical system may remain asleep, saving power. When a pointing vector update occurs, the system may wake up the electronics, run the calculations and drive the motors to their new position. This typically only takes 15 seconds in one embodiment.

During the time between pointing vector updates the system may remain asleep. In one embodiment, it only wakes up momentarily to take measurements of its sensors.

Waking to take measurements and open the valve only takes milliseconds in some embodiments. This results in the electrical system remaining in a low power state for the majority of its lifetime. More than 90% of the time the system is powered on it can remain in this low power state while still maintain the system's automation goals.

This is important because in some embodiments the system might be run on batteries in an area of the world where electrical grid energy is not reliable. Prolonging the life of the battery's charge by sleeping the electrical system adds days to its charged lifetime.

Furthermore, in some embodiments the system's batteries will be charged with a thermoelectric generator or small photovoltaic solar cell. TEG's and small photovoltaic solar cells such as these do not have large power outputs. Sleeping the electrical system for most of the day allows the total power consumption of the electrical system to be less than the power output of the TEG or photovoltaic solar cell, thus allowing the batteries to remain charged indefinitely. This would not be possible without running the electrical system in a low power state while maintaining automation.

The descriptions of the system are preferred embodiments and are not intended to limit the invention.

THE INVENTION CLAIMED IS:

1. The claimed invention is a system that utilizes concentrated solar energy to heat fluids by passing fluids through a focal location of a reflecting surface. The system includes:
 - a. An onboard computer control system that tracks the sun during its trajectory
 - i. The control system is connected to a GPS device, an external smartphone, or equivalent to provide location and date/time information to the system and enable solar tracking.
 - b. A mechanical structure to maintain the curvature of the reflecting surface
 - c. Digitally or thermally actuated valves which are preprogrammed to open at certain temperature/duration setpoints which provide pasteurization or thermal heating as desired for the application.
 - d. A calibration method that can be automated or manually performed. The automatic method utilizes GPS positioning, date/time information to orient the device toward

the sun. The manual method uses a visible marker of the concentrated sunlight to orient the device.

2. The device of claim 1 where actuation of valves occurs so that the volume of treated fluid is maximized by a control optimization algorithm.
3. The device of claim 1 with a fluid to fluid heat exchanger that extracts heat from the outgoing hot fluid to preheat incoming cool fluid and increase the thermal efficiency.
4. The device of claim 1 with an electrical power generation system based on fluid flow or vapor within the piping system.
5. The device of claim 1 with an electrical power generation system based on thermoelectric power.
6. The system of claim 1 wherein the electrical power and motors are normally off (90% of the time for example) to preserve power.
7. The system of claim 1 wherein the calibration is performed using a single stellar target.
8. The system of claim 1 wherein a solar radiant sensor is utilized to determine whether there is incident solar energy.
9. The system of claim 1 which can be used in an array with multiple systems to increase the – through-flow of heated fluids.
10. The system of claim 1 with the incorporation of a solar photovoltaic system to provide electrical energy to the pumps.
11. The system of claim 1 with the incorporation of a storage tank for holding the heated fluid.
12. The system of claim 1 with a supply tank the provides fluid to the system
13. The system of claims 11 or 12 with sensors installed within a water supply tank to assess whether sufficient water or storage is available for operation.
14. The system of claim 9 where the sensor information from within the tank is output to the motor control. If the water within the tank or the supplied pressure or fluid temperature are outside of specified ranges to operate the pasteurization system, the computer algorithm turns the reflecting surface away from the sun.
15. The system of claim 10 where the batteries are charged by PV generators.
16. The system of claim 4 where the batteries are charged by vapor power generators.
17. The system of claim 5 where the batteries are charged by thermoelectric generators
18. The system of claim 8 wherein the system is put in a low power sleep state if the solar irradiance sensor measures low incident energy (such as a cloudy day).
19. The system of claim 1 wherein the device is automatically put in a low power sleep state at night.
20. The system of claim 1 wherein performance and other information is stored using cloud storage via the onboard computer's connection with an external smartphone or other computer connected to the internet.
21. The device of claim 5 where the thermoelectric generators are contained with a vertical fluid conveyance structure.
22. The device of claim 1 where measured information from sensors within the system are transmitted wirelessly to an external smartphone or external controlling computer system or to a data storage system.
23. The system of claim 1 that can be calibrated to correct for a multitude of error sources in the system's solar pointing vector via feedback data taken from the sun only.

12741447v2

Electronic Acknowledgement Receipt

EFS ID:	27551816
Application Number:	62423814
International Application Number:	
Confirmation Number:	1010
Title of Invention:	SOLAR HEATING SYSTEM
First Named Inventor/Applicant Name:	Brian Plourde
Customer Number:	94740
Filer:	Brett A. Klein/Stacy Brooks
Filer Authorized By:	Brett A. Klein
Attorney Docket Number:	18493.12.2.US.P1
Receipt Date:	18-NOV-2016
Filing Date:	
Time Stamp:	10:27:30
Application Type:	Provisional

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	\$ 130
RAM confirmation Number	111816INTEFSW10285000
Deposit Account	505637
Authorized User	Stacy Brooks
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)
37 CFR 1.20 (Post Issuance fees)
37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Provisional Cover Sheet (SB16)	12742103_1.pdf	1485411	no	4
			b14a194a66505561211accabbe2f3ad319e4b579		

Warnings:**Information:**

2		12742108_1.pdf	898248	yes	24
			840d944e2f98b6989d3ce6273eeab14b9994ede0		

Multipart Description/PDF files in .zip description

	Document Description	Start	End
	Specification	1	5
	Drawings-only black and white line drawings	6	13
	Specification	14	22
	Claims	23	24

Warnings:**Information:**

3	Fee Worksheet (SB06)	fee-info.pdf	29770	no	2
			80ac635c4409d77453a41f70c573dac0a8d42be4		

Warnings:**Information:**

Total Files Size (in bytes):			2413429
------------------------------	--	--	---------

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

From the INTERNATIONAL BUREAU

PCTNOTIFICATION CONCERNING SUBMISSION,
OBTENTION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

KLEIN, Brett A.
Winthrop & Weinstine, P.A.
Capella Tower, Suite 3500
225 S 6th Street
Minneapolis, Minnesota 55402
ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 08 December 2017 (08.12.2017)	
Applicant's or agent's file reference 18493	IMPORTANT NOTIFICATION
International application No. PCT/US2017/062558	International filing date (day/month/year) 20 November 2017 (20.11.2017)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 18 November 2016 (18.11.2016)
Applicant WTS LLC	

The applicant is hereby notified of the date of receipt (or of obtaining by the International Bureau) of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to the date of receipt, **the priority document concerned was submitted or transmitted to or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-bis)**. This Form replaces any previously issued notification concerning submission, transmittal or obtaining of priority documents.

Priority datePriority application No.Country or regional Office
or PCT receiving OfficeDate of receipt
of priority document

18 November 2016 (18.11.2016)

62/423,814

US

02 December 2017 (02.12.2017)

The letters "NR" denote a priority document which, on the date of mailing of this Form, had not yet been received or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-bis). Where the applicant has failed to either submit, request to prepare and transmit, or to request the International Bureau to obtain the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

An asterisk "*" next to a date of receipt, denotes a priority document submitted or transmitted to or obtained by the International Bureau but not in compliance with Rule 17.1(a), (b) or (b-bis) (the priority document was received after the time limit prescribed in Rule 17.1(a); the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b) or the request to the International Bureau to obtain the priority document was made after the applicable time limit under Rule 17.1(b-bis)). Even though the priority document was not furnished in compliance with Rule 17.1(a), (b) or (b-bis), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Mineko Mohri e-mail pct.team8@wipo.int Telephone No. +41 22 338 74 08
Facsimile No. +41 22 338 70 10	