MGT Docket No. 36110

DEVICES AND METHODS

USING STRUCTURED CONVECTION CURRENTS

TO SEPARATE FLUID FLOWS

IN MECHANISMS FOR SOLAR ENERGY COLLECTION,

FLUID HEAT EXCHANGE AND FLUID MASS TRANSPORT

FIELD OF THE INVENTION

This invention relates generally to heat and mass transfer involving thermal fluids and particularly to the stimulation and exploitation of natural micro-structures in convection currents to separate fluid flows with application to mechanisms for solar heat collection, process heat exchange and heat assisted fluid transfer.

BACKGROUND OF THE INVENTION

Objects submerged in fluids tend to come into thermal equilibrium with the fluid around them. Conduction transfers heat between an object and thin films of fluid adjacent to its surface, which then mix with the surrounding fluid by convection. Convection is the process by which the surface films collect into currents and exchange places with some of the surrounding fluid. Fluid mechanics provides well understood parameters for this process given standard laboratory conditions, but the detailed mechanics of how conducted heat becomes the complex motions of convection is not fully understood. Most fluid heat transfer mechanisms are designed according to the standard laboratory conditions. The designs disclosed in this application are based on observations of naturally occurring non-standard conditions.

In fluid heat transfer it would be ideal if the thin films of heated or cooled fluid that form near the transfer surface could be extracted without letting them mix with the body of the fluid immediately surrounding them. At the temperatures of interest the convection currents that develop from surface films usually subdivide explosively in turbulence, making that impossible. This turbulence mixes the input and output portions of the fluid and degrades both the quantity and quality of heat transfer.

All heat collection and exchange devices are effected by the inefficiencies that result from thermal mixing within the working fluid. They can allow a lower than ideal output temperature or require larger than ideal surfaces for heat exchange, along with more expensive containments, insulation and supporting structures.

Counter-flow heat exchangers, such as ventilation economizers, and core/extremity blood stream heat exchange structures, address this problem by introducing the fluids at opposite ends of very long and usually circuitous paths of intimate thermal contact. The mixing of input and output fluids during heat exchange has minimal effect because the fluid channels are small and thermal contact between the fluid and the exchange surfaces is maintained over a long distance and period of time. High cost in terms of intricate construction is accepted in exchange for highly efficient heat transfer. Each fluid exits such heat exchangers at nearly the temperature the other fluid entered with.

In fluid bath heat exchangers, such as hot water heaters, air conditioners, furnaces, etc., high heat transfer rates using smaller surface areas and higher temperature gradients are accomplished along with reduced heat and/or temperature transfer efficiency. Generally a winding tube carrying a primary working fluid is immersed in a secondary working fluid.

Blowers are sometimes used to accelerate the movement of a plentiful medium like air. This breaks up surface boundary layers that offer heat transfer resistance and results in a higher heat transfer rate. A secondary result is that the two fluids will retain a large percentage of their original temperature difference. The low thermal quality of exchange may be of little concern when, as in disposing of waste heat with air cooled coils, the secondary fluid is plentiful and continually discarded.

In other circumstances both highly efficiency and high quality heat transfer are desired at lower cost. When those are the objectives, thermal mixing of the fluids becomes a controlling factor and devices using structured convection currents may be advantageous.

Structured convection devices potentially offer the efficiency of counter flow exchangers, without as much added expense, and the performance of fluid bath heat exchangers, without their inefficiencies. This is done by achieving a close approximation to directly extracting the thermally charged films at the heat transfer surface, their point of origin, without letting them mix with the surrounding fluid medium. What is special about this invention is the discovery that self-contained convection structures can extend considerable distances from a well constructed point of control to the current's point of thermal origin.

While the engineering specifications for sustaining structured convection for most fluids and temperatures are not yet developed, the principle has been demonstrated with some generality. For many surface materials, fluids, and temperatures it is possible to develop structured convection currents that prevent the thermally charged fluid from mixing with its immediate surroundings while being transferred .

In radiant energy heat collectors, (solar collectors, furnace chambers) the energy input from the radiant source has no temperature, and the temperature of the output depends strongly on how rapidly the working fluid removes heat from the absorber surface. The ideal collector would heat the working fluid to the optimal temperature for the intended use, and no energy would be transferred elsewhere. With solar heat collectors, this generally means seeking to raise the collector output temperature as high as possible, while minimizing radiation and conduction losses through the glazing.

The reason for enclosing solar collectors, with single, double or triple glazings, is that the collector chamber normally heats up due to turbulent mixing of thermal currents within the collector chamber. Stimulating a structured current near the absorber surface allows the heated air to be isolated and drawn away without mixing. That potentially eliminates the primary normal source of heat loss. It also reduces the need for glazing and other enclosure and support structures. The result is higher gain and higher efficiency at a lower cost. Examples of how others have addressed this problem are provided below:

Patent 3,875,925 (Johnston) reduces convective losses in a solar hot air collector by using a porous absorber and routing air flow through it in a direction away from the glazing. This will be effective in preventing convective transfer of collected energy to the glazing if the velocity of air flow is high enough. A high air flow will also result in a corresponding lower temperature output. If the rate of air flow is reduced and high absorber temperatures are allowed to develop, rapid convection currents will develop and find their own way to exchange with those on the coldest nearby surface, the near-by glazing, rather than follow the gentle drift of air through the collector .

Patent 4,346,694 (Owens-Illinois) reduces convective losses by placing the absorber surface inside an evacuated tube. The tube is then suspended over a light-concentrating reflector element in a fixed array. The high operating temperature and overall operating efficiency are quite attractive but the expense and maintenance requirements are high.

Patent 4,323,054 (Hummel) is a collector using a technique somewhat similar to the one claimed here. Hummel uses a selective surface absorber to reduce radiant heat loss and provides horizontal slits in the absorber so that surface hot air films can be drawn away before they travel toward the glazing. The specific design and claims, however, limit the application to the simple entrainment of laminar air flows. As with Johnson, mentioned above, at sufficiently low output temperatures the desired effect may be achieved, but at a cost of output quality. The desired effect will not be achieved at the higher temperatures when stubborn turbulence develops.

A further distinction is found in the theoretical discussion offered. Air movement and its control are described in the conventional terms of fluid dynamics, as a matter of passive bodies responding to fluid pressure following the principles of mechanics. The means described of drawing hot air currents away from the absorber surface is purely mechanical and does not display any awareness of the potential for causing organizational changes in the dynamic structures of the convection currents themselves, as a means of isolating them while in transit....

BACKGROUND ON STRUCTURED CONVECTION CURRENTS

Thermal fluid currents in the vicinity of a heated or cooled surface, such as in air near a warm wall, are described in terms of 'pocket flow' and 'vortex rings', by R.E. Falco, 1982, “A Synthesis Model of Turbulence Structure in the Wall Region: Structure of Turbulence in Heat and Mass Transfer Hemisphere Publishing Corp. NY NY 1982 , and in terms of in-rushing 'sweeps' and outward 'ejections' across 'turbulent boundary layers' by Smith and Abbott 1978 Coherent Structure of Turbulent Boundary Layers AFOSR/Lehigh . Also pertinent are 'vortex rolls' as studied by Chang et al. 1991 ”Spanwise 1991 Pairing of Finite-Amplitude Longitudinal Vortex Rolls in Inclined Free-Convection Boundary Layers” Journal of fluid Mechanics, Vol. 231, Oct. Pp. 73-111, and the applicant's work with and observations of 'discrete rushes', 'current networks', 'self-organizing flues', 'sheer layer boundaries', 'sheet currents' and 'slip streams', Henshaw 1978 ”Air 1978 Current Networks: A study of Two Classic Solar Homes” ISES Annual Conference Proceedings 1978, RAIN 1979, and P.F. Henshaw, 1979 “engineering Principles and Designs for Discrete Fluid Current Heat Exchange Devices” U.S. Patent Office Registered Disclosure 076899 , 1979 . Here the general term ‘’structured currents’ or ‘structured convection’ refers to higher organizational states of thermal convection that develop from the spontaneous coordination of primitive individual currents. Applications of the conventional mathematical models of convection do not appear to be available for the structured current phenomena readily observable in the study of micro-climates. Work in the field is a matter of careful empirical detective work.

One of the basic principles is that motion in any one direction within a fluid generally requires counter flow movement around it Thus, the simplest form of spontaneous thermal movement within fluids is a vortex ring current. A smoke ring is one of a variety of tightly structured vortex rings, one that has become detached from its generating source of motion and is hollow. A normal thermal vortex ring has a central column which acts as its driving force. Vortex rings may start when a parcel of air is pushed or pulled toward an adjacent location as a result of an object or another parcel of air moving nearby. They may also begin with a thermal instability where a buoyant warmer layer is trapped below relatively cooler layers (figures 8a to 8f). The primary means of visualizing these structures is with smoke or fog tracers, or in laboratory conditions, with an optical device called a “Schlerin” which makes a shadow of thermal gradients in an otherwise transparent medium.

The central portion of a thermal vortex ring moves as a column in the direction of current motion. When it approaches the front of the current it spreads, serving to open a path in the surrounding fluid, and becomes a sheath covering the outside of the current as the central portion proceeds forward. Once parts of this outer sheath are passed by the tail of the current, most of it will be drawn back in toward the center. Then they again proceed toward the front of the current , but now as an outer sheath wrapping the new material in the central column.

This complex circulation is a continuous internal stretching and folding of an originally plane surface. Sometimes a current individual takes on a mushroom-like shape (on the verge of turbulent division) and sometimes it takes on a more torpedo-like shape that may proceed intact, leaving only a fine wisp of a trail, FIG. 8e. Once separated from their source, this latter type, call them 'free' currents, tend to propagate as if swimming, rather than following either a strictly predictable or chaotic path.. These are what structured currents seem to be aggregations of and are what are being symbolically represented in the technical drawings by the ovals with short tails.

The applicant's engineering experiments and observations in nature support the hypothesis that free currents will tend to travel in the wake of, or in parallel synchrony with, other free currents having similar dynamics. This is a key to understanding the micro-structures of convection, and must be understood to progress in research. Sometimes individual currents will become completely merged in a structured current that flows as a uniform mass, similar to a laminar flow in being uniform, but with the distinct difference of having sharply defined surface boundaries. At other times free currents combine to form an ordered network and remain distinct individuals, sometimes wandering out of and back into a looser collective structure.

SUMMARY AND OBJECTS OF THE INVENTION

In the devices and methods disclosed here, free currents that would otherwise become turbulent are drawn into current networks that have characteristics both of collections of separate vortex ring individuals and of uniform fluid sheets. These structures have the property of being permeable to the flow of other currents. While they entirely cover the surface they are generated from, the passage of ambient fluid needed to continuously replenish the surface contact layers can bread through the sheet and pass through without disrupting its organization. This special state is what is established and maintained by drawing fluid into an exhaust plenum through a relatively narrow control opening placed in the correct manner above the heat exchange surface. The opening is sized so that the velocity at this control point slightly exceeds the normal free propagation velocity of the intended structured current.

If you consider the world from the viewpoint of an individual convection current, when the currents in front of them are dodging out of the way, in perfect rhythm with their own natural propagation there is no better path to follow. This condition can be established over a large area from a single line of control. Thus, given other proper conditions, the shape of the exhaust opening serves as an attractor for establishing a particular regional form of structured current network. The same principle should apply broadly to surface thermal currents in most fluids at most temperatures. So arranged the extraction efficiency of surface layers is virtually perfect because any trails of the convection structure which are left behind become the first fluids to be drawn through the current sheet for resupplying the surface contact layers. In the end, virtually no fluids that have come into thermal contact with the surface escape into the surroundings.

The behavior and determinants of structured convection currents are not yet well established. Micro-currents are generally quickly changing, silent and invisible, and therefore not easy to document. Even when you know what to look for the presence of a structured current in not always obvious. One indication, for example, is the unexplained absence of turbulence where it might be expected. Structured currents act like 'short circuits' in the normal paths of energy transfer, moving large amounts of energy with little commotion, and tending to form specifically at locations that otherwise would be significant sources of turbulence. For example, sometimes the reason air movement in a greenhouse is noticeably quiet is that the bulk of heat transfer is taking place via structured currents.

From a theoretical point of view these issues may be somewhat difficult to understand. From a practical view, though, using structured convection is not very different from building a cook fire near a flue so that when its draw takes hold the fire will burn hotter and without turbulent smoke conditions. The more hidden forms of structured convection have effects that are just as dramatic. The distinguishing features of the devices and methods claimed here are:

a) concern with organizationally self-contained, rather than physically contained fluid currents.

b) employing them to prevent the mixing of working fluids

c) using fluids of various temperatures and compositions.

It may be clear but needs to be emphasized, the present invention is not a device or method for 'entrainment' or other ordinary mechanical manipulation of the heated portion of a working fluid. The substance of the present invention concerns designs and methods that cause, and make use of, basic changes in the internal flow structure of natural convection.

Stable networks of free currents, of various heights, widths and thicknesses , located near walls and other types of surfaces, are the principal structured currents employed in the claimed applications. Other types of structured currents such as vortex rolls and other kinds of current sheets, trees and trains have also been observed and may also be exploitable using the devices and methods of the present invention. The form of current network that develops may be effected by any feature of the surroundings. They appear to be most directly effected by the dynamic match of the individual currents that join and/or weave together, and their direct connection with the currents or mechanism at their destination. These factors may be effected by:

1) the thermal and physical characteristics of the exchange surface and adjacent surfaces

2) size, shape, position and mass flow rate of the control opening(s)

4) the type of fluid or suspension

5) the energy flux and fluid temperatures

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its uses, reference is made to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF DRAWINGS

In the drawings:

Fig. 1a is a cross sectional view of a rudimentary heat transfer device under normal thermal current conditions and without key elements of the present invention;

Fig. 1b is an elevational view of a rudimentary heat transfer device under normal thermal current conditions and without key elements of the present invention;

fig. 2a is a cross sectional view of a heat transfer device using the principal embodiments of the present invention;

Fig. 2b is an elevational view of a heat transfer device using the principal embodiments of the present invention;

Fig. 3a is a cross sectional view of a working structured convection demonstration cell constructed and operated by the applicant;

Fig. 3b is a cross sectional view of a cell with structured convection control elements removed;

Fig 3c is a cut-away perspective view of the working demonstration cell constructed and operated by the applicant;

Fig. 4a is a detailed cross sectional view of a hanging solar shade and collector according to the present invention;

Fig. 4b is a elevational view of a hanging solar shade and collector according to the present invention;

Fig. 5a is a perspective view of a concentrating solar collector according to the present invention;

Fig. 5b is a detailed section view of a concentrating solar collector according to the present invention;

Fig. 6 is a section detail of a reversible action submerged coil heat exchanger according to the present invention;

Fig. 7a is a perspective view of a chemical reagent bath delivery system according to the present invention;

Fig. 7b is a cross sectional view of a chemical reagent bath delivery system according to the present invention;

Fig 8a-f are six illustration sketches of a primitive thermal vortex ring developing from a static thermal instability.

DETAILED DESCRIPTION
OF THE PREFERRED EMBODIMENT

Referring now to FIG 1a, 1b, 2a and 2b, the principal embodiment of the invention consists of the condition illustrated in FIG 1a and 1b as modified in FIG 2a and 2b, including an exhaust plenum with a control opening so shaped and positioned in relation to a fluid heating or cooling surface that a structured convection current develops in the working fluid when a heat differential and appropriate draw into the exhaust are applied. The essential working elements are presented in relation to components of a rudimentary solar collector with the working fluid being air and the exchange condition being one of heating the working fluid. It is intended that these elements also represent the comparable functional parts of other fluid heat and mass transfer devices that may benefit from incorporating structured convection..

The energy source 101 is symbolically represented as the sun and the thermal barrier 102 between the energy input and output environments is symbolically represented as an insulated wall. The heat exchange surface 103 receives energy input from the energy source and transfers that energy as heat to the working fluid by natural conduction. Fluid 106, 107 from the space around the exchange surface 103 is drawn toward the exchange surface 103 as heated currents 109, 209 rise away from the exchange surface 103 by natural convection .

Convection motion starts as laminar flow in the fluid layers nearest the heat transfer surface, and in the conditions of interest is followed by the development of more complex convection currents 109, 209. When there is a pressure drop at the thermal barrier 102 and a fluid transfer opening 104 some or all of the rising convection currents 105, 109, 205, 209 may be drawn into the transfer current 108. In the normal case, as in FIG 1a & 1b, the rising vortex ring currents 109 become turbulent and much of the collected heat is either not drawn into the transfer current 108 and becomes lost, or it is diluted and degraded by mixing. When a structured convection current is to form as in FIG. 2a & 2b, the exhaust plenum housing 211, which may include adjustable control vanes 213 to vary the exhaust pressure drop along the length of the control gap 212. The shape and tuning of the control gap 212, the pressure distribution in the plenum and the mass flow rate of fluid transfer are adjusted by experiment to cause a structured convection current 209 to extend over the heat transfer surface and through the control opening and be entirely drawn into the transfer current 108, except perhaps for trace edge condition losses.

The greatest output at the highest temperature will be achieved when the mass flow rate of the transfer current is at the low end of the range of natural propagation rates of the structured thermal current. This tunes the system to minimize the amount of other fluid that will be drawn into and dilute the output and to maximize the residence time of fluid in contact with the heat transfer surface . Normal operation may be tuned for a slightly higher mass flow rate. This would ensure that the entire structured current is drawn into the exhaust, though there may be a minor sacrifice in final output temperature due to drawing in other fluid as well.

The exchange surface 103 may be flat, smooth and vertical, with a control vane 213 as a single rectangular strip and the control opening 212 being of constant width and horizontal, as shown and tested. The absorber, control vane(s), if present, and control opening(s) may be of any other type, shape, texture, orientation, structure or operating configuration as may be useful in establishing and collecting a structured current from any source of thermal differential. Structured convection devices may consist of single or multiple dependent stages or dependent combinations of these elements.

The energy source, means of conveying it to the exchange surface, the working fluids, the exhaust plenum housing, exhaust duct, thermal barrier and means of drawing and replacing fluid may all be of any convenient material, mechanism or construction. Various automated or manual control methodologies may be applied to adjust the variables of current control, such as the mass flow rate, the composition of working fluid or the tuning or movement of the exhaust opening, in response to changes in the design conditions, such as changes in energy input, desired output temperature or changes in thermal current conditions.

APPLICATION A: A Working Demonstration Cell

A Working Demonstration Cell and a group of four (4) other proposed applications are based on and demonstrate the application of the Principal Embodiment. Each applies structured convection design to a device to improve the efficiency of thermal fluid heat and/or mass transfer by allowing the segregation of heat and fluid flows within a fluid mass.

Referring now to FIG. 3a and 3c a flat-plate structured current solar collector and testing apparatus consists of the basic elements of a structured convection current device as in the Principal Embodiment. An insulated enclosure of suitable construction 324 with central divider 302 and an open side fitted with a suitable glazing material 320, is oriented so as to be exposed to the sun 101 . The dividing partition 302 is positioned across the enclosure with openings 304 and 316 for mass flow along the top and bottom respectively. The glazed half of the enclosure, the collector space, houses a normally vertical radiant energy absorber surface 303, such as 'black chromium' coated sheet metal, which is suspended an appropriate distance in front of the dividing partition 302, above the floor of the enclosure and below the adjustable current control vanes 311a, 311b. The control vanes 311a and 311b span the width of the absorber surface 303 and, along with connecting parts of the partition 302 and enclosure 324, form a reasonably air-tight exhaust plenum 313 connected to the exhaust opening 304 at the top of the partition 302. The passive sides and bottom surfaces of the collector space 318, 322 and opp. 322 (cut away in the view as shown, but implied), are covered with material having a high specular reflectance.

A driving force for mass air flow between the sides of the enclosure may consist as shown of a passive thermal storage mass made of pitched tiers of stones stacked loosely to permit free exchange of air currents to and from the front and back air channels 314a & 314b, or may alternately consist of an electrically powered fan 315 or other mechanism. Return air 317 is introduced in a manner not to cause unnecessary turbulence in the vicinity of the absorber 303, as by introducing the return fluid flow through a screened opening 319 as shown. Thin film back draft dampers 308, 329 may be provided to prevent reverse convection of stored heat during non-gain periods.

A detection means is used in order to measure and assist in controlling the operation of the system, including thermocouple temperature and hot wire anemometer probes 325 and openings for injecting color media 326 such as smoke tracers. Continuous recordings of temperature and air flow were taken using a 24 point chart recorder. A solar Schlerin device and imaging screen were found to be feasible for direct visualization of the currents but installation was not completed. A measured collection efficiency estimated at 78% was recorded for full day operation with an average outdoor temperature of about 20°F and an average absorber surface temperature during gain periods of about 155°F.

Under intended operation , see FIG. 3a and 3c the control openings 312 a, 312b and mass air flow 308, 317 are tuned for the energy flux 310 to cause structured convection currents 309a and 309 to form on the front and back of the absorber 303.

General indicators of achieving this behavioral state include a sharp increase in output temperature and decrease in ambient collector space temperature, turbulence and stratification. The speed and orderliness of the currents near the absorber surface increase dramatically. The specific indicator of the presence of a full surface structured convection current is a uniform secular drift of the central collector space air mass 307 toward the collector surface. A control means adjusts the control opening 312a 312b, vane or vanes 311a, 311b, if present, and the driving force of the working fluid in accordance with the detection means to increase the output temperature, decrease the ambient collector space temperature, turbulence and stratification in order to form a substantially uniform secular drift of the central collector space air mass 307 toward the collector surface.

Referring now to FIG 3b, the air current pattern that develops when the current control vanes are detuned or removed is typical of solar collector spaces without current control.

Warm currents 325, 309, 329 rising from the absorber surface 303 mix with cool air currents 321 falling from the glazing 320 and may collect at the top of the collector space as a warm air reservoir. The warm reservoir at the top is , separated from the portion of the air mass at inlet temperature 307 by a relatively stagnant warm layers 328. A related mixing condition develops in the space behind the absorber surface 327. The exhaust flow at 308 draws from air at the top of the space which has been mixing with the cool currents 321 at the glazing. . This will be the general case even for collectors where the absorber is porous and is made to cross the stream of the air flow. Unless a structured convection current is formed and isolated, the output will be a mixture of air currents from many sources.

All elements not specified and those used to adapt the application to particular circumstances may be of any convenient material, manufacture or mechanism. The present invention specifically includes the development of structured convection currents by this method for passively or actively driven collectors of radiant energy, with or without any type or configuration of glazing or its equivalent, as part of a devoted piece of equipment or multi-purpose architectural or other construction or mechanism, using working fluids from any source and delivering heat or fluid mass for any purpose.

APPLICATION B: Proposed Solar Shade and Collector

Referring now to FIG 4., a Proposed Roll Down Shade and Collector consists of the basic elements and operation of a structured current device as in the Principal Embodiment and all necessary or useful system integration and adaptation as in claimed Application A, and consisting specifically of a roll-down sun shade of suitable material 403 suspended from an operable roller 402 inside an insulated exhaust plenum housing 413 and passing through control opening 412 between fixed or tunable current control vanes 411 and positioned to receive radiant heat from the sun 101. The driving force for mass air flow is provided by mechanical equipment or passive thermal mass (not shown) connected in a suitable manner to the exhaust plenum by a duct 404. The current control vanes 411 and mass flow are tuned to cause the formation of a structured current 409 under design thermal conditions and for it to be drawn into the exhaust plenum space 405. The screen may be extended by manual or automatic means such as pull chain or internal motor, and may be positioned vertically as shown or at an angle compatible with maintaining a structured convection current..

This application may be used for evacuating excess heat as in a sun-space or picture window in summer, or as a collector to be extended during times when a sun-space is not in use, or for other suitable purpose.

APPLICATION C: Concentrating Solar Collector

Referring now to FIG 5a & 5b., a Concentrating Solar Collector consists of the basic elements and operation of a structured convection current device as in the Principal Embodiment and all necessary or useful system integration and adaptation as in claimed Application A, and consisting specifically of a radiation reflector 515 shaped to concentrate the rays 110 of a radiant energy source 101 and using the surfaces of the supply 506 and return 508 plenums as an absorber 503 , located within a reasonably tight enclosure which may be primarily formed as shown by the reflector 515, its end panels 514 and a covering of glazing film 507. The transfer plenum absorber core carries working fluid supply 506 and return 508 plenums which are tapered respectively narrower and wider in the direction of flow, perhaps, as shown, by graduating the vertical position and thickness of the plenum divider 513. The absorber core also incorporates openings to the collector space through the top and bottom current control slits 515a, 515b. The reflector and absorber core may be tilted as shown or not, and the remote supply (and return) piping 504a (and opposite 504b implied) may be from either end.

The principal objective is to efficiently generate high temperature output for industrial process heat, cooking, air conditioning or other purposes. High temperatures are largely achieved by concentrating the energy with a reflector. The principal current control objective is to maintain collector space ambient temperature well below the working fluid inlet temperatures by extending the structured convection currents 509a 509b all the way from the control opening

505a to the inlet slit 505b, rather than using the collector space as its reservoir. This would allow inlet return temperatures to be quite high relative to environmental temperatures without proportional heat loss.

When the surrounding air mass is not used as the primary reservoir for the structured current, it is not known whether the trailing wisps of currents within the structured current network would be fully entrained in the uptake of fluid for the surface heating layers. The expected optimal condition is for there to be some excess draw at the control opening 505a and for a shell of current trail fragments 511 to build up around the core which would support gentle low temperature convection in the collector space 512.

APPLICATION D: Submerged Coil Heat Exchanger

Referring now to FIG 6., a Submerged Coil Heat Exchanger consists of the basic elements and operation of a structured convection device as in the Principal Embodiment and all necessary or useful system integration and adaptation as in claimed Application A, and consisting specifically of a fluid to fluid heat exchanger primary coil 607 with connections 601, 614 to supply and return the primary working fluid, submerged in secondary working fluid within an enclosure 602 with connections 610, 615 to supply and return a secondary working fluid, plenum spaces 606 and 608 with control gaps 610, 612 at the bottom and top control openings 611, 613 respectively.

As shown, in FIG. 6. the working fluid flow directions and indicated thermal current paths are those preferred for using the primary fluid to heat the secondary fluid. These would normally be reversed for primary coil cooling. The current control plenums 606, 608, and control gaps 610, 612 , at the bottom for cooling and at the top for heating may be independently are tuned for the design condition to be served. In addition to tuning the relationships between the flow rate of secondary fluid, the current control openings and the heat flux, adjustments to obtain the desired structured current 609 would also involve adjusting the coil spacing 618 and potentially using other configurations for the primary fluid containment in place of the simple coil of metal tubing illustrated.

The principal objective of the application is to reduce the length of primary coil and the response time of the exchanger and to increase the thermal quality of the output. For a hot water heater, current control would allow a smaller coil in a smaller tank to provide ready and continuous hot water at a lower cost. For application as a thermal storage pond heat exchanger, current control would result in using a shorter coil with a shorter response time that would produce greater thermal stratification, and therefore greater effective thermal capacity.

APPLICATION E: Controlled Reagent Bath

Referring now to FIG 7., a Controlled Reagent Bath consists of the basic elements and operation of a structured convection device as in the Principal Embodiment and all necessary or useful system integration and adaptation as in claimed Application A, and consisting specifically of a reagent bath 702, an initially or continuously heated target surface 703 suspended in the reagent bath from a supporting material handling arm 710 with current control elements including: a spent reagent exhaust plenum 713, control vanes 711a & 711b, supply and return piping 704, 708, and current control opening(s) 712a & 712b. The target material and the control openings are submerged below the reagent surface 714, and the extraction of reagent through the plenum causes structured currents 709a & 709b to form when the control veins are correctly adjusted for the residual heat in the target material, or supply of heat from a remote source 701. The reagent level in the bath could be kept constant, as spent reagent is isolated and withdrawn by supplying fresh reagent 708.

The objective of this application is to efficiently supply continuously fresh reagents over entire working surfaces as in a chemical etching, curing or deposition process. Such a device might be part of a process of automated manufacture where the material handling arm 710 is part of a robotic device that transfers the control mechanism and target material between reagent baths. The bath itself 702 could either hold a stationary reagent pool as displayed, in which materials of various size can be immersed, or might feasibly be a vapor chamber such as an exhaust scrubber, or could itself be the reaction target such as the inside of a mold or a passageway within in a manufacturing product or other structure.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles .

WHAT IS CLAIMED IS: CLAIMS

(see hard copy mark-up)

ABSTRACT

The central working element and applications are described, showing the means of causing and using structured convection currents having stable self-organizing pathway structures. A discussion of the general and specific physical theory and research methods required is included. The essence of the invention is the counter intuitive discovery that appropriately reducing the size of an opening near the natural path of a convection current can dramatically increase the quantity and quality of the thermal currents that travel through it. Under the proper conditions self-contained micro-current flow structures develop to extend from the point of convection current origin through the opening.. These make it possible to isolate convection currents within working fluids themselves and increase the output temperature differentials and heat flow rates. Potential applications include: solar energy collectors, fluid heat exchange mechanisms and other kinds of heat-assisted fluid transfer mechanisms. These claims originate from work done by the applicant in Denver Colorado from 1976 to 1980 as then recorded in the writings of the author and in U.S. Patent and Trademark Office disclosure documents 076899 of Jan 1, 1979 and 076693 of Dec. 26, 1978.