Технічні науки

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MODULAR SYSTEMS FOR REGENERATION AND RECIRCULATION OF PROCESS FLUIDS

Principles of formation of modular structures of systems for regeneration and recirculation of process fluids, including water and aqueous solutions

Summary. *Modularity, unification and multifunctional interchangeability in innovative technical solutions can be presented as a key analytical interpretation of the issue of creating smart technologies for cleaning and regenerating wastewater, especially in developed leather production;*

Technical creativity and its highest manifestation - inventive activity aimed at creating original self-sufficient technical solutions - which have become the basis for effective inventions in demand by society - requires enormous labor and creative impulse, time expenditures that are incommensurate with the time expenditures on only the technical or technological components of any project and, moreover, an innovative project.

At the same time, inventive activity in modern conditions is inseparable from the processes of unification and, to some extent, standardization of components of technical solutions, which, on the one hand, seems to contribute to an increase in the level of obviousness, but on the other hand, ensures the reality of using standard component solutions for innovative compositions in a new quality with non-obvious technical characteristics.

In addition, in the conditions of globalization of the modern market, when the final stage of real use of an invention can only be a product for which there is a

stable demand within the framework of specific conditions that have developed in the consumer sectors of countries and regions of the world with different technological cultures, the need for cooperation with specialists in the comprehensive commercialization of innovations becomes a reality for practical inventors.

As the practice of the last decade shows, the most commercially successful technical solutions are those that are not oriented towards the existing and well-understood consumer demand, but rather those that generate new, unusual, previously unknown demand.

Key words: *Principles of forming modular structures, Integrative and complex solutions, Technical level of technology and engineering, Technical creativity, Inventive activity, Newly emerged circumstances, Innovative compositions in demand by society, Adaptation to the principles of standardization and unification, Stage of idea generation, Recirculation infrastructure, Commercial value of the invention, Jet metallization technologies, Integrative inventions, Balanced formation of a technical solution.*

Since in such, as a rule, integrative and complex solutions, the technical level of technology and technology is constantly growing and technical requirements and technical conditions are constantly changing and improving, following the laws, postulates and principles of TRIZ and ARIZ requires constant comparison of existing provisions with newly emerging circumstances.

And even after realizing the need for systemic modification and optimization of the ideological, computational and technical-technological base of such multi-stage cooperation between idea generators - technical and innovative interpreters of global and partly even abstract ideas into really solvable and implementable technical solutions, after realizing the need for deep cooperation with specialists in

the commercialization of new technological ideas and solutions, there remain specific, but in principle absolutely strategic questions that can only be solved by the inventor himself, who understands and knows the features of his invention better than anyone else.

The author of this publication believes that, precisely to help inventors in the process of identifying and deepening their understanding of the possibilities and features of their inventions, the adaptation of TRIZ and ARIZ to the principles of standardization and unification and other modern conditions can provide all the necessary analytical tools.

The developments and methods proposed by Viktor Knyaz play a huge role in this process;

The opening of new markets, internal and external, and the development of economic organization from the craft shop and factory to concerns like U.S. Steel, illustrate the same process of economic mutation—if one may use the biological term—which continually revolutionizes… the economic structure *from within* , destroying the old structure and creating a new one.

This process of "creative destruction" is the very essence of capitalism. Every capitalist concern has to exist within its framework...

The behavior of a particular enterprise should be assessed only against the background of the overall process, in the context of the situation it has generated. It is necessary to clarify its role in the constant flow of "creative destruction"; it is impossible to understand it outside this flow...

In the future series of articles offered to readers, the author set the goal of linking future work on the commercialization of any invention with the initial stages of work on its creation, especially at the stages of idea generation.

An inventor, starting the process of forming basic ideas and principles for creating his future invention, even without knowing the principles of TRIZ and ARIZ, whether he wants it or not, uses them, even intuitively

At the same time, TRIZ and ARIZ in their historical and classical versions do not help the inventor to determine the expected commercial value of his future invention.

Unlike the unique, repeatedly tested in practice techniques and principles, laws of development of technical systems, which are basic for TRIZ and ARIZ, the techniques of commercialization and analysis of potential possibilities of inventions - as commercial products do not have a systematic theoretical basis

As an example, it is important to cite the original version of the development complex of the well-known initiator of innovative optimization of infrastructure processes of irrigation technologies, Viktor Knyaz, aimed at the innovative formation of the recirculation infrastructure of the water treatment system, primarily in greenhouse farms, but not only

Let us consider a part of this multifunctional technological process - Electrochemical regeneration of aqueous solutions containing heavy metals.

The project is based on the following information arrays and experience from previous developments:

- inventions related to high-speed metallization technology;
- inventions relating to jet metallization technology;
- inventions concerning methods for controlling high-speed electrochemical processing processes;

- patents for inventions on electrochemical correction of acidity or alkalinity of water or aqueous solutions;

- patents for inventions on electrochemical disinfection of water and aqueous solutions and on antibacterial treatment of water and aqueous solutions;

- patents for inventions on electrocoagulation in water and in aqueous solutions, including heterocoagulation;

- patents for inventions on the control and synchronization of energy supply processes for electrochemical processes in water and aqueous solutions;

Experimental developments on the use of carbon-graphite non-woven materials in technologies for extracting heavy metals from water and aqueous solutions;

Experimental developments in the use of composites based on coal and graphite, including carbon-carbon composites, including those obtained by methods of sequential thermal pyrolysis of carbon on a fabric base, such as viscose;

Pilot-industrial development of equipment for water purification from radioactive isotopes, including the use of combined technologies that combine electrochemical extraction with sorption in biological materials in the form of specially modified seaweed (OZOLA);

The technology proposed to solve this problem is comprehensive and includes:

- preliminary treatment of water or aqueous solutions using the turbo-flotation method with the help of aerodynamic activators (this is a patentable technical solution for which there is a prototype of an activating head, tested and showing more than satisfactory results in purifying water from industrial oils and organic matter of all types);

- electrochemical treatment of water or aqueous solutions, carried out in the flow of purified (regenerated) liquid and representing the electrochemical deposition

of heavy metals contained in it on the active working surface of the cathode (electrode connected to a negative electric potential); this type of treatment is the basis for the proposed technological complex and has a high potential for patentability, including a pioneering invention on composite permeable contacts for electrodes of an electrochemical reactor;

- a method of pulsed power supply for the process of electrochemical deposition of heavy metals, taking into account that the electrodes and contacts for them are permeable to liquid; made of non-metallic materials; have a three-dimensional active, developed working surface and are not an element of the design of an electrochemical reactor for multiple use

Such a comprehensive approach to solving modern technological problems is characteristic of the works of Viktor Knyaz and, as numerous examples of his projects show, with such an approach there is a significant gain in all component aspects and parts of projects, in which, based on the system proposed by Viktor Knyaz, the necessary level of unification of components, while maintaining the originality and fundamental novelty of complex solutions, in addition to a purely economic effect, also provides the necessary level of novelty to ensure full patentability at all levels.

Recently, many publications have appeared that provide recommendations for commercialization, and on their basis, a decision was made to use one of them, in order to, firstly, give inventors operational information that they can, if desired, adapt to the technical characteristics and advantages of their invention, and, what is especially important, secondly, to show one of the possible versions and principles of practical actions, showing how to change and adjust the technical characteristics and parameters of a future innovative development depending on market requirements.

Taking into account the conditions and all sorts of limitations formed by the peculiarities of the innovation process in the globalization mode of the world economy, it can be assumed that it is the systemic unification of elements of innovative products at the component level that can help gradually form a library of components, units and basic parts from which inventors can form the technological embodiment of their ideas.

It seems to me that taking into account possible market requirements will allow, at the stage of generating an innovative idea, to form such a technical characteristic of a new product that will contribute to a more confident and economically advantageous implementation of the innovation, but also in the event that the assessment of the commercial significance of the generated idea is low, to abandon this idea and turn your attention to something else or, through modulation and unification, return the idea to an economically advantageous channel.

In my articles devoted to TRIZ and ARIZ, I had to repeatedly note that the majority of inventions being created at the present time are integrative, since any modern effective technical solution includes digital control systems, composite materials, nano-coatings and various integrative combinations, such as a program, system, method and apparatus.

For such complex, combined and integrated systems, principles of system analysis of their commercial value have yet to be formulated and publication of information on methods, techniques and working schemes of commercialization will help inventors working today in the field of innovative projects.

At the same time, many examples have emerged of how the structure and system of a modern large enterprise levels out innovative projects and concentrates on what appear to be the most effective innovative ideas at the time of decision-making, often leaving behind equally effective solutions, the inventors and authors of which receive (and often undeservedly) serious psychological trauma.

A systemic approach to the comprehensive, balanced formation of such an innovative technical solution or a group of local unified innovative ideas linked by a single innovative integrative idea is very important.

The systems approach is a reflection and development of the dialectical principles of "universal interconnection" and "development" and, in fact, is one of the principles of the dialectical method of cognition.

The methodology of the systems approach involves representing any object as a system and its comprehensive consideration.

2. A system is a complex of elements, regularly organized in space and time, interconnected with each other and forming a certain integral unity. The system is characterized by the composition of elements, structure and performs a certain function.

3. Elements are relatively indivisible parts of a whole; objects that together form a system. An element is considered indivisible within the limits of preserving a certain given quality of the system.

4. Structure is a regular, stable connection between the elements of a system, reflecting the form, the method of arrangement of elements and the nature of the interaction of their aspects and properties.

The structure makes the system a certain qualitatively defined whole, distinct from the sum of the qualities of its constituent elements (since it assumes the interaction of elements with each other in different ways, only by certain aspects, properties, and not as a whole.)

5. Function – external manifestation of the properties of an object (element) in a given system of relations; a certain way of interaction of an object with the environment, the "ability" of an object. Systems have many functions.

6. Subsystems (subsystems) are parts of the system that represent some arbitrarily or naturally selected groups of elements. The selection of subsystems is carried out according to a functional feature.

One element can sometimes coincide with a certain subsystem or be included in several different subsystems at once.

In this case, the connection between elements within subsystems and within the system differs from the nature of the connection between the subsystems themselves. Elements and subsystems are united by the concept of system components.

7. Supersystem (metasystem) – a system of a higher order in relation to a given one, and into which the given system is integrated and functions "as" a subsystem.

8. A technical system (TS) is an artificially created material unity of elements that are regularly organized in space and time and are in mutual connection, the purpose of which is to satisfy a certain social need. TS elements can be both artificial and natural.

Any TS is part of two systems of relations. On the one hand, it is an object of the material world, subject to the laws of nature (primarily the laws of physics as the most general), on the other hand, the TS acts as an element of social relations, since technology is only a means for achieving social goals.

If the TS is characterized by the spatial arrangement of elements, then the TS is a device or substance. If the TS is characterized by the organization of elements in time, then we are dealing with a method.

The concept of TS allows us to formulate the main feature of a technical solution (TS): TS indicates a specific TS, the functioning of which allows us to achieve the set goal, i.e. it indicates the relationship of the TS to a certain goal.

From the standpoint of systems engineering, the TS can be represented as:

INPUT – PROCESSOR – OUTPUT.

The processor provides the conversion of input into output and at the same time is a component (constant) of the input.

INPUT and OUTPUT – reflect the interaction of the system with the environment. From a physical point of view, the TS has space, time, mass, energy and information at the output and input.

From a socio-technical point of view, at the input we have the "needs" of the TS – the costs of society for its creation, and at the output – the "capabilities" of the TS, the main part of which are the functions of this system.

Acting in the form of action, the functions of the TS in unity determine the composition and structure of the system's activity, show what the TS can do: move in space, carry out heating, resist the action of the wind.

The remaining "capabilities" characterize how actions are performed: reliably, easily repairable, etc. For each function in the TS, a corresponding subsystem can be identified.

9. Useful functions (UF) are functions corresponding to the purpose of the system, characterizing the most important components of useful outputs. In real TS, not all output is useful.

The usefulness of one or another part of the TS output can be determined only from a social standpoint. Those "abilities" of the TS that correspond to its purpose, i.e., social needs at the level of the supersystem, are useful.

Other abilities may be useless or harmful, and harmful is considered to be something that actively interferes with the implementation of useful "abilities", for example, by destroying elements of the vehicle, etc.

10. Main useful function. For the set of useful functions performed by a TS, it is always possible to find a more general useful function that directly reflects the purpose of the TS, the goal of its existence and activity (and coincides with them).

This general function is called the main useful function – MUP of the entire TS, in contrast to the elementary useful functions (hereinafter – simply useful – PF), in total

ensuring the implementation of the GPF. The relationship between the GPF and the PF is the same as between the system and its subsystems. The GPF refers to the system as a whole, and the PF to its subsystems.

11. Positive effect. Any change in the TS that increases the capabilities of this TS to satisfy the needs of supersystems (including society) is an improvement of the system.

The improvement of the TS is manifested in the following changes of the system at the level of external functioning:

– quantitative growth of useful "abilities" of the TS – transformation of unuseful "abilities" into useful ones;

– elimination of harmful "abilities" up to their transformation into useful ones;

– increasing the ratio of useful output to input, i.e. increasing the efficiency of the TS.

14. Dialectical contradiction. The source of development of the TS, as well as any object of the material world, is the law of unity and struggle of opposites – the universal law of development of nature, society, technology.

Opposites are the sides of an object that are in mutually exclusive relationships. In this case, the side of an object or phenomenon is understood to be everything that is somehow inherent in the object or phenomenon, characterizes it and can be known.

Opposites in TS are "input" and "output", useful functions of cost and "ability".

The interaction of opposites, when they simultaneously mutually presuppose and at the same time deny, exclude each other, constitutes a dialectical contradiction.

15. Technical contradiction (TC) is a dialectical contradiction that manifests itself in a technical system in the form of deterioration of one side of the TS at the level of external functioning (from the standpoint of the needs of the supersystem) with improvement of the other side of the TS.

In other words, TP can be defined as a dialectical unity of interdependent positive and undesirable effects in the TS. TP is always associated with some component of the TS (element, group of elements or interaction of elements), which is usually called the nodal component (NC).

This component of the TS is connected with two sides of the TS at once, and a quantitative change in some parameter (or state) of this component leads to an improvement of one side of the TS and a deterioration of the other.

Therefore, TP should be more precisely defined as a dialectical unity of positive and undesirable effects, interdependent on quantitative or qualitative changes in the nodal component of the TS.

16. An inventive task arises when the TP inherent to the TS is aggravated. In this case, the improvement of some TS "abilities" by means of a quantitative change in some parameters becomes impossible due to a significant deterioration of other "abilities".

Attempts to preserve the TS by means of a compromise between the opposing parties are unsuccessful in this case. The resolution of the TP is possible in the event of the transition of the TS to a new qualitative state - a dialectical leap. This is an invention.

When considered from a more general position, the problem of resolving the contradiction between a social need and the possibility of satisfying it can be reduced to one of two tasks:

a) the search for a material form based on the laws of nature and allowing the performance of a function corresponding to a specific social need – an information task (search for a new system);

b) resolution of an internal dialectical contradiction in a technical system that satisfies a certain social need – a contradictory problem.

These two types of tasks are related to each other and in the practice of technical creativity they flow into each other.

17. Physical contradiction. Technical contradiction in its form appears in the TS at the level of its external functioning. At the level of internal functioning, mutually exclusive relations between the parties of the system are not observed: from a physical point of view, the TS is in a certain state determined by the laws of nature.

But if we set the task of eliminating the TP within the framework of a given TS, affirming the positive and denying the undesirable effects, then mutually exclusive relations will manifest themselves at the level of internal functioning, in the form of incompatible requirements for the parameter (state) of the nodal component of the TS, or more precisely, for the physical state of the MC.

Such contradictions are called physical (PC). PC is manifested when the task of eliminating TP is set, in other words, PC is a form of expression of the problem of eliminating TP within the framework of a given TS. The resolution of PC consists in establishing new forms of organization and movement of matter in the TS, in which both incompatible requirements for the state of the MC are implemented, or, in the words of K. Marx, in establishing such a "form of movement in which this contradiction is simultaneously realized and resolved."

Introduction to the theory of inventive problem solving (TRIZ), modified on the basis of the recently emerged conditions for the development of unified innovative systems and complexes

1. Creative activity is usually defined through the result . As an example, one of the most common definitions can be given: "Creativity is a human activity that creates qualitatively new material and spiritual values."

If we try to formulate a definition of creativity as a process, we will see that creative activity is a process of finding a solution .

In essence, all human activity can be divided into two large areas: the area of routine operations and the area of problem solving.

The idea of creativity as a problem-solving process makes the conclusion self-evident: in order to scientifically organize creative activity, it is first necessary to put the problem-solving process on a scientific basis. In other words, TRIZ is needed.

2. There are two types of solutions to problems: strict and non-strict. Strict solutions are based on complete reliability, accurate information and, as a rule, are quite unambiguous. Solutions obtained on the basis of incomplete, inaccurate information, under conditions of uncertainty, are called non-strict.

Accordingly, the methods of obtaining solutions are divided into strict and heuristic methods. When solving problems put forward at the current level of development of society, these methods complement each other.

As science develops, many heuristic methods of solution are formalized and move into the class of strict ones according to the scheme: accumulation and systematization of knowledge - development of "gut feeling", intuition - formalization, development of theory - algorithm.

3. The existing problem-solving apparatus is adapted to search for strict, quantitative solutions. It includes such sciences as systems analysis, the

theory of search for solutions, and the theory of decision-making. The main idea of systems analysis is the following statement: "The solution to any problem is the process of creating a new system."

Systems analysis is the basis for: systems engineering (design of large technical systems) and organizational systems engineering (system design of organizations).

Decision theory examines methods for finding optimal ways to achieve goals.

Includes such disciplines as operations research (the use of mathematical, quantitative methods to justify decisions in all areas of targeted human activity), the linear programming method (selecting the optimal solution from a large number of possible ones).

The theory of decision search considers the process of finding a solution under conditions of uncertainty in terms of information.

4. TRIZ is engaged in the search for heuristic solutions. Its main features include the following: a) the theory should provide a significant increase in the probability of obtaining correct solutions; b) the theory should search for solutions at a qualitative level; c) the theory should take into account the characteristics of the object and subject of creativity.

TRIZ meets all the above requirements. In addition, it is based on two main provisions:

1. A new, truly creative solution in technology corresponds to the next stage of development of the object to which the solution relates.

2. The patterns of the development process of a technical object are knowable and can be used to search for new technical solutions.

A factor of peculiarity is something that is inherent only to a given theory, is most characteristic of it and distinguishes this theory from similar areas of knowledge. For TRIZ, the factors of peculiarity are:

– use of identified patterns of construction and development of technical systems;

– the presence of optimal logic for identifying a problem and searching for new technical solutions.

List of references, patent and license materials:

Appendix 1

United States Patent Application **20100224506**
Kind Code **A1**
September 9, 2010

PROCESS AND APPARATUS FOR COMPLEX TREATMENT OF LIQUIDS

Abstract

Methods and apparatus for complex treatment of contaminated liquids are provided, by which contaminants are extracted from the liquid. The substances to be extracted may be metallic, non-metallic, organic, inorganic, dissolved, or in suspension. The treatment apparatus includes at least one mechanical filter used to filter the liquid solution, a separator device used to remove organic impurities and oils from the mechanically filtered liquid, and an electroextraction device that removes heavy metals from the separated liquid. After treatment within the treatment apparatus, metal ion concentrations within the liquid may be reduced to their residual values of less than 0.1 milligrams per liter. A Method of complex treatment of a contaminated liquid includes using the separator device to remove inorganic and non-conductive substances prior to electroextraction of metals to maximize the effectiveness of the treatment and provide a reusable liquid.

Appendix 2

United States Patent Application **20100224497**
Kind Code **A1**
September 9, 2010

DEVICE AND METHOD FOR THE EXTRACTION OF METALS FROM LIQUIDS

Abstract

A volume-porous electrode is provided which increases effectiveness and production of electrochemical processes. The electrode is formed of a carbon, graphitic cotton wool, or from carbon composites configured to permit fluid flow through a volume of the electrode in three orthogonal directions. The electrode conducts an electrical charge directly from a power source, and also includes a conductive band connected to a surface of the electrode volume, whereby a high charge density is applied uniformly across the electrode volume. Apparatus and methods which employ the volume-porous electrode are disclosed for removal of metals from liquid solutions using electroextraction and electro-coagulation techniques, and for electrochemical modification of the pH level of a liquid.

Appendix 3

United States Patent Application **20110069579**
Kind Code **A1**
March 24, 2011

FLUID MIXER WITH INTERNAL VORTEX

Abstract

The present disclosure generally relates to a fluid mixer, a system for mixing fluids utilizing the fluid mixer, and a method of mixing fluids using the fluid mixer or the system for mixing fluids, and more specifically, to a compact static mixing device with no moving parts and capable of mixing any fluid, such as air, nitrogen gas, water, oil, polluted water, and the like. A first pressurized, incoming fluid is accelerated locally by a section reduction, is split into streams, and then is released into a second fluid found in a closed volume or an open volume after a period of stabilization. The directed and controlled first fluid slides along an insert up to

directional and angled fins at a vortex creator where suction forces from a self-initiating vortex in an internal cavity draws in at least part of the first fluid to fuel the vortex. The compactness and simplicity of the fluid mixer with internal vortex can be used alone within a closed volume in a conduit, in a sprayer, or within a fixed geometry to direct the mixing vortex to specific dimensions. One or more fluid mixers can also be used in an open volume such as a reservoir, a tank, a pool, or any other fluid body to conduct mixing. The technology alone, as part of a multi-mixer system, or as a method of mixing using the fluid mixer with internal vortex is contemplated to be used in any field where mixing occurs.

Appendix 4

United States Patent Application **20100193445**
Kind Code **A1**
August 5, 2010

FOAMING OF LIQUIDS
Abstract

Methods and systems for processing of liquids using compressed gases or compressed air are disclosed. In addition, methods and systems for mixing of liquids are disclosed.

Appendix 5

United States Patent Application **20150130091**
Kind Code **A1**
May 14, 2015

FOAMING OF LIQUIDS

Abstract

A foaming mechanism configured to receive a plurality of streams of gas and generate a foamed liquid, having an aerodynamic component and an aerodynamic housing disposed around at least a portion of the aerodynamic component. The aerodynamic housing includes a plurality of first channels and a plurality of second channels connected to the plurality of first channels at regular intervals on a distributed plane. The distributed plane is about perpendicular to the plurality of first channels, wherein the plurality of first channels and the plurality of second channels are configured to transform an axial stream of the gaseous working agent

into a plurality of radial high-speed streams of the gaseous working agent by channeling the gaseous working agent through the plurality of first channels and into the plurality of second channels on the distributed plane. A hydrodynamic conical reflector and a hydrodynamic housing form a ring channel in an area between the hydrodynamic conical reflector and the hydrodynamic housing. An accumulation mechanism is configured to disperse the plurality of radial high-speed streams of the gaseous working agent into the ring channel and create turbulence to foam the liquid.

Appendix 6

United States Patent **6,139,714**
October 31, 2000

Method and apparatus for adjusting the pH of a liquid

Abstract

A process for adjusting the pH of an aqueous flowable fluid includes an electrochemical mechanism for adjusting the pH of an aqueous flowable fluid and a mechanism for then electrochemically stabilizing the adjusted pH of the fluid. A device for performing the process is also included. The device includes an inlet and a channel in fluid communication with the inlet. The channel has the appearance and properties of a U-shaped connected vessel. The U-shaped connected vessel includes an inlet accumulating passage in fluid communication with an active zone between two spaced electrodes wherein the active zone has a small volume relative to the passage for accelerating fluid flow from the passage through the active zone complying with the physics of connected vessels.

Appendix 7

United States Patent **9,144,774**
September 29, 2015

Fluid mixer with internal vortex

Abstract

The present disclosure generally relates to a fluid mixer, a system for mixing fluids utilizing the fluid mixer, and a method of mixing fluids using the fluid mixer or the system for mixing fluids, and more specifically, to a compact static mixing device

with no moving parts and capable of mixing any fluid, such as air, nitrogen gas, water, oil, polluted water, and the like. A first pressurized, incoming fluid is accelerated locally by a section reduction, is split into streams, and then is released into a second fluid found in a closed volume or an open volume after a period of stabilization. The directed and controlled first fluid slides along an insert up to directional and angled fins at a vortex creator where suction forces from a self-initiating vortex in an internal cavity draws in at least part of the first fluid to fuel the vortex. The compactness and simplicity of the fluid mixer with internal vortex can be used alone within a closed volume in a conduit, in a sprayer, or within a fixed geometry to direct the mixing vortex to specific dimensions. One or more fluid mixers can also be used in an open volume such as a reservoir, a tank, a pool, or any other fluid body to conduct mixing. The technology alone, as part of a multi-mixer system, or as a method of mixing using the fluid mixer with internal vortex is contemplated to be used in any field where mixing occurs.