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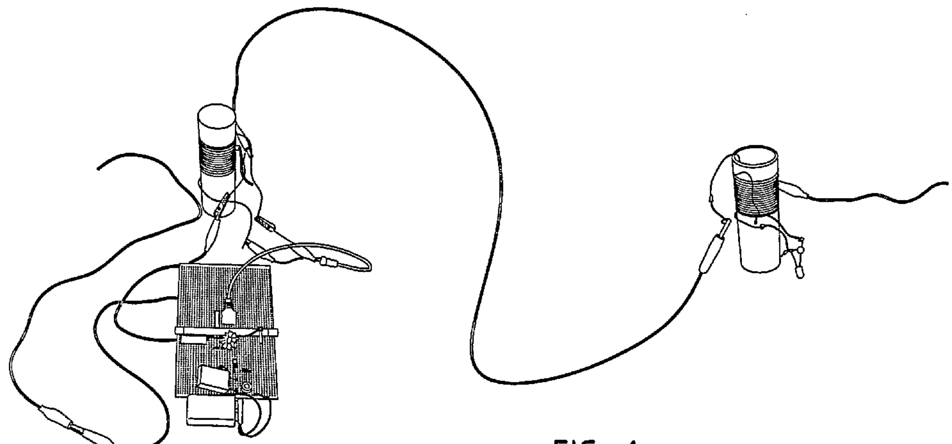

FIG. 1

(57) **Abstract:** Method for transferring electromagnetic waves in a liquid by a first device, preferably for use in controlling micro-organisms in a liquid, controlling properties of membranes, preferably the filtration properties, and/or controlling biotechnological processes, wherein the electromagnetic waves comprise a first frequency, wherein the electromagnetic waves preferably comprise through modulation at least a second frequency, wherein the second frequency is at least substantially lower than the first frequency.

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METHOD FOR TREATING LIQUIDS WITH ELECTROMAGNETIC WAVES

The present invention relates to a method for treating liquids with electromagnetic waves and/or an alternating electric field and, if desired, the use of these liquids for unidirectional or multidirectional energy and information transfer.

Introduction

In the water sector and the processing industry large quantities of water are used, among other purposes, for producing drinking water, as cooling water and as process liquid. Closely associated with these processes is the purification of large quantities of water in order to recover chemicals, reuse or safely reintroduce water into the environment.

The drinking water chain consists for instance of a collection step, a production step in which the water is purified, and a distribution step in which the water is transported to the consumer via a complex pipe network. It is important in the production of drinking water to minimize, or even wholly prevent, the adverse effects of a number of processes which may disrupt the production, such as biofouling, scaling and corrosion in the pipe network and/or in purification plants such as reactors, filters and membrane installations, and in the pipe network. A "low cost, low investment" sensor network of measuring equipment in the distribution network can further provide a wealth of information concerning for instance the water quality and the state of the pipes, using which the drinking water production process can be optimized.

The present invention makes it possible to control scaling, biofouling and corrosion processes without the use of chemicals, and to thus optimize processes in the water sector, the processing industry, chemical industry and drinking water production. The invention also makes it possible to transfer multidirectional information and to provide sensors connected to the pipe network with energy through conduits in which liquid is transported. In this way a sensor network can be supplied with power from a central point without electrical wiring and the sensors in the network can be read from the same point.

As set forth below, the developed technology is not limited to the above stated applications. The technology according to the present invention can also be used to treat liquids with the purpose of controlling the biochemical processes taking place in these liquids. With the present invention it is possible to make micro-organisms suitable for decomposition or formation of organic molecules which cannot be decomposed or formed by these organisms under normal conditions. An unexpected advantage here is that the processes in the micro-organisms can be controlled without introducing measurable other effects on the rest of the system. This in contrast to the applying of a low-frequency alternating voltage between two electrodes in the process liquid which can also bring about other effects such as undesirable decomposition of chemicals, deactivation of enzymes and adsorption of ions. It will be apparent to the skilled person that this offers unprecedented possibilities for the bioprocessing industry and the pharmaceutical industry. With the new technology it is further possible to apply selection of micro-organisms and to sustain the thus obtained culture.

Description of the technology

In the open literature it is known that energy can be transferred through a single wire. The literature gives two explanations as to why this energy transfer may be possible:

1. Classic antenna theory, which describes energy transfer in an asymmetrically powered dipole.
2. Transfer by means of so-called "scalar waves", wherein the single wire is applied as a type of "earth wire".

The inventors of the present invention have performed a large number of experiments which show that the energy and signal transfer through a single wire or through a liquid as described in the present invention can be described using classic radiotechnology, and in particular theory of a dipole antenna powered on one side. The description by means of classic radio technology is therefore taken as starting point in the following observations. However, the inventors expressly do not rule out a possible role for scalar waves in the operation of the present invention.

Figure 1 shows a non-optimized arrangement for energy transfer through a single wire.

The part of the arrangement in the left-hand drawing consists of a Colpitts oscillator powered with a 9V battery and operating at a frequency of 7.14 MHz, a class A connected linear amplifier and a 1:1 air transformer which is wound onto a piece of PVC piping with a diameter of 4 cm. The primary and secondary coils of the 1:1 air transformer each have 83 windings of 0.5 mm insulated copper wire. The primary side of the coil is connected to the outlet of the class A connected linear amplifier. On the secondary side of the primary coil one terminal is connected to a wire with a length of about 1 metre. The other side of the coil is connected to a wire with a length of 6 metres. The outer end of this latter wire is connected to the 1:1 transformer, which can be seen on the right in the drawing of figure 1. One of the terminals of the primary winding of this transformer is connected to the wire with a length of 6 metres. The other terminal of this primary winding is connected to a piece of wire with a length of about 1 metre. The secondary winding of the air transformer on the right in the drawing of figure 1 is connected to two anti-parallel connected LEDs.

When the 9V battery is connected, both LEDs are found to light up. Energy is transferred in this case via one wire. This is possible because the wire with a length of 6 m behaves as a dipole antenna. This antenna is powered at the outer end via the air transformer, and the wire of about 1 metre connected to the primary side of the winding ensures that the RF signal is coupled at the correct position into the antenna or, in other words, that the impedances of the end stage of the linear amplifier and the feed point of the antenna are roughly equal. The right-hand air transformer in figure 1 transmits the RF signal to the LEDs and the wire with a length of about 1 metre here also ensures that the transformer is coupled to the antenna at the correct position. Both LEDs go out when one of the two wires of 1 metre is removed, which indicates that hardly any power is being transferred.

If the arrangement in figure 1 is in operation and both LEDs are on, they will go out as soon as the wire with a length of 6 m (this being the connection between the two drawings in figure 1) is cut. If however the wire is interrupted and a capacitor is then placed between the two wire ends, both LEDs will light up again provided the capacitor has a sufficiently high capacity. In the specific case of the arrangement in figure 1 the minimum capacity required to illuminate the LEDs amounts to about 25 pF. In antenna terms a shortening capacitor has now been arranged. The capacitor between the two cut wire ends is now replaced by a receptacle with water in which two electrodes are situated. Since water has a conductivity and also a capacity, both LEDs are in this case also found to light up again. It is noted that both the conductivity and the capacity of the water are greatly dependent on the nature and concentration of the ions present in the water. For the arrangement in figure 1 the LEDs were found to light up when tap water was applied in a receptacle with a length of 25 cm and electrodes in the receptacle, each with a surface area of 42 cm^2, wherein the electrodes were spaced at a distance of 23 cm from each other. After placing of a measuring head at two locations in the water it was determined using a 10 MHz oscilloscope that an RF signal with a frequency of 7.14 MHz is displaced through the water and is converted further along in the arrangement into electrical energy, this being demonstrated by both LEDs being illuminated. Follow-up experiments have shown that it is possible to modulate the 7.14 MHz signal amplitude and in this way transfer information through the water. This is demonstrated with an audio signal (music) and with a sine at a frequency of 100 kHz.

It is noted for the sake of completeness that in the open literature which refers to energy transfer through one wire by making use of scalar waves the coils in arrangement 1 are replaced by transformers with spirally wound coils. This can for instance be realized in simple manner by printing one side of a printed circuit board with the primary coil and the other side with the secondary coil. In the literature relating to energy transfer by means of scalar waves the wires, which in both the left-hand drawing and the right-hand drawing in figure 1 are attached to one wire end of the primary coil and have a length of 1 metre in the example, are further replaced by a wire having on the outer end a metal ball which is situated in the air and thus makes no contact with the earth. A device which makes use of the above described spirally-wound coils and metal balls expressly forms part of the present invention.

It will further be apparent to the skilled person that the arrangement in figure 1 is only one of the many configurations which can be chosen for the purpose of applying the present invention in practice. The transformer to which the transmitter is connected can thus be replaced for instance by an antenna tuner to which commercially available transmission equipment is connected. The receiver in the receiving part can likewise be connected to an antenna tuner. Use can also be made of types of antenna wholly different from the dipole antenna, or parts or the whole of for instance a tube, a container filled with a liquid, a reactor from the processing industry, a washing machine can be connected directly to the output of a transmitter. By making use of a Faraday cage it is also possible to choose to expose only a specific part of a device to the desired RF signal. This creates the option of subjecting a device such as a membrane installation to great RF powers without radiation to the environment.

The present invention is now explained with the above experiments as introduction. If an RF signal is sent through a (plastic) water conduit using the above arrangement, this signal will then be transmitted. In this way energy can be transported through the water conduit and sensors arranged further along in or on the conduit can be provided with energy. Information, i.e. commands, can further also be transmitted to the sensors by modulating the carrier wave and demodulating the signal in the sensor. Suitable modulation techniques are amplitude modulation, frequency modulation, phase modulation and single-sideband modulation. Since the sensor can also transmit, the measurements performed by the sensor can be transmitted to the main station continuously or after an instruction. It is noted that the transmitter power output of the sensors can be many times smaller than the power of the main station since the sensors only have to transfer information and not energy. It is further also noted that communication between sensors is also possible, so that artificially intelligent networks can be created. It will be apparent to the skilled person that this can be realized in simple manner by making use of protocols such as also applied in packet radio. The great advantage of the technology described here is that the sensors do not have to be supplied with power by means of electrical wiring, and that the communication takes place wirelessly with water as transport medium. This technique also provides the option of arranging sensors inside the conduit network, without the utility of these sensors being limited by a limited lifespan of a battery in the sensor, as this battery becomes unnecessary due to the remote energy supply.

The present invention is not limited to a method of energy and signal transfer through water (conduits). By sending an RF signal through a conduit containing water the surface of this conduit will also be exposed to the high-frequency signal. It is hereby possible to prevent processes such as the adhesion of biomass to the inner side of the conduit and to apply the RF energy for disinfection. The formation of scaling, for instance of $CaCO_3$, can also be prevented in this manner. The occurrence of corrosion can also be inhibited. It is known from the open literature that micro-organisms can be killed efficiently by means of an alternating voltage if the applied frequency of the alternating voltage is about 100 kHz. Since adsorption and desorption of ions on surfaces can be influenced particularly well at frequencies of this order of magnitude, application of an RF signal in the order of magnitude of 100 kHz is preferred to signals in the MHz range or the GHz range. These latter signals do however have a number of advantages, including the advantage that they can displace better in conduits and are suitable for broadband signal transfer. A particular application of the present invention is the modulation of signals in the MHz or the GHz range at much lower frequencies, i.e. frequencies in the 1 Hz range to 100 kHz range and/or the 100 KHz range to the 1 MHz range and/or the 1 MHz to 20 MHz range and/or the 20 MHz to 100 MHz range and/or the 100 MHz to 1 GHz range. Depending on the application, the carrier wave can be modulated with a signal in one of the above ranges or with combinations of signals from different ranges. Amplitude modulation is particularly suitable as modulation form, although frequency modulation, phase modulation and single-sideband modulation are also preferred embodiments. Particular preferred embodiments are pulse amplitude modulation, in which the measure of modulation depth is optionally chosen such that the carrier wave disappears and so-called splatter occurs, and square-wave and sawtooth modulation. Another preferred embodiment is the application of non-linear components in a receiver of the RF signal which receives a significant part of the power generated by the transmitter. An example of such non-linear components are LEDs in the circuit of figure 1. Owing to the presence of the LEDs the voltage over the LEDs amounts to about 2 V due to their specific properties.

Under determined conditions this non-linear behaviour of the receiver causes production of higher harmonics of the carrier wave, and even chaotic behaviour in the antenna wire. Another preferred embodiment of the present invention is sending an RF signal for energy transfer to a sensor network, modulating the signal in order to actuate the sensor network, and simultaneously also modulating the signal with a further one or more other desired frequencies, which are chosen such that biofouling and/or scaling and/or corrosion are prevented. Since it is of great importance in the control of water purification and distribution to prevent biofouling, scaling and corrosion, it is in this way simultaneously possible to detect scaling, biofouling and corrosion and to then optimize the process using the same system through specific modulation of the carrier wave.

Without any limitation being imposed on the scope of the present invention by the following explanation, the inventors provide the following possible explanation for the operation of an amplitude-modulated carrier wave in conduits for disinfection purposes, for preventing biofouling, for countering corrosion and for countering scaling on the conduits. Micro-organisms are almost always to be found on the surface of a conduit through which water flows. These micro-organisms have ion-selective membranes with very special properties, including an asymmetric mobility of the ions over the membrane. In short, this means that a cell membrane can be construed as a parallel circuit of a diode, a resistor and a capacitor. One of the consequences hereof is that these membranes can demodulate RF signals. This means that amplitude modulation of a 5 MHz carrier wave with a frequency of for instance 100 kHz results in the biomass in the water being subjected to an alternating voltage with a frequency of 100 kHz. This is exceptional since a 5 MHz carrier wave amplitude-modulated with 100 kHz can be construed as a sine with a frequency of 5 MHz and sidebands with a frequency of 4.9 MHz and 5.1 MHz. In this case the micro-organism itself thus ensures that the lethal 100 kHz alternating voltage is generated by demodulation. It is noted that in a particular preferred embodiment the carrier wave has a frequency of less than 10 MHz and the amplitude modulation takes place with waves in the range of 1 Hz to 500 kHz.

It must also be noted that in the case of disinfection it is best to work with frequencies below 10 MHz, although there is no limitation thereto. Communication in broadband preferably takes place with carrier waves above 100 MHz, and more preferably above 1 GHz, although there is no limitation thereto either (if only little data need be sent, communication via carrier waves below 100 MHz and even below 1 MHz is still acceptable). It is further also important that communication and disinfection can be realized simultaneously with modulation at more than one frequency.

The result of the demodulating action which the micro-organisms have on amplitude-modulated RF signals is that an alternating voltage is generated in the water at the position where the most micro-organisms are situated, i.e. on the surface of the conduit. Killing of biomass hereby takes place precisely at the position where it is desired. Because the generated alternating voltage has a relatively low frequency, adsorption of ions onto the surface of the conduits is inhibited. Corrosion and/or scaling can hereby be prevented. It is also noted that furring on conduits, also referred to as scaling, consists of a complex mixture of biomass, inorganic crystals and adsorbed ions. It is very well possible that, as well as living biomass, this complex system also has demodulating properties for RF signals, which enhances the effect of the present invention. It is further possible in exceptional cases that, depending on the properties of the scaling on the conduit, unmodulated carrier waves can also have a disinfecting action or can prevent scaling and corrosion. Finally, it is noted that the propagation of the RF signal can take place through the water and along the boundary surface between water and transport conduit. Propagation along the boundary surface makes the present invention additionally effective. It is further noted that use can also be made for transport of the RF signal of the wave pipe principle known in radiotechnology. In a wave pipe the electric field runs between the walls of the pipe and wave propagation takes place in that the waves enter at an angle and are always reflected by a wall they meet. The lowest frequency which can be applied in the use of wave pipe propagation, the so-called cut-off frequency, follows from this wavelength in the case of a round wave pipe, wherein the diameter of the wave pipe is equal to half the wavelength. Propagation through use of the wave pipe principle will in practice thus be applied particularly at very high frequencies (GHz range). The use of "normal propagation" and propagation by means of the wave pipe principle both form part of the present invention. The "normal propagation principle" and the wave pipe principle can be applied in both metal and non-metal conduits, and in most but not all cases a high conductivity of the liquid in the conduits increases the effectiveness of the signal transport.

Use is preferably made in the invention of an antenna, such as for instance a dipole antenna according to the definition in this document, a dipole antenna with a metal spherical body at both outer ends, a dipole antenna with built-in filters (so-called traps), a parabolic antenna and/or an object for treating which contains water, or the water in this object is coupled to a transmitter directly or via an antenna tuner or via a transformer. The transmitting means, for instance the antenna, are preferably designed such that more than 1% of the electromagnetic energy emitted by the transmitter is realized by propagation according to the wave pipe principle.

A device according to the invention preferably comprises a device which prevents entry into the environment of a quantity of electromagnetic waves unacceptable in accordance with legislation and/or to the immediate vicinity, for instance by applying a Faraday cage or by using conduits which lie below ground.

Now that the present invention has been explained in detail on the basis of water purification, it will be apparent to the skilled person that the invention is not limited to water purification. The invention can for instance be applied to disinfect swimming pools, to keep membrane modules clean, wherein these modules form part of a dipole antenna or are operated as a wave pipe, to prevent scaling and/or corrosion and/or biofouling in conduits used in salt extraction by solution mining, conduits used in oil extraction and in the ore-processing industry, to clean hulls of ships, to optimize ecosystems in horticulture by sending RF signals through the ground, particularly in greenhouses, to clean conduits in greenhouses, the use of water conduits for broadband internet applications, to send measurement data in factories via the process liquid instead of via wiring and/or to provide sensors in the factory with energy via the process liquid instead of via wiring, to control regulating valves in the process industry via the process liquid, to prevent corrosion and/or biofouling on lock gates, to clean conduits, the turbine and other processing plant in water power applications, to apply steel constructions in harbours below and at the water line in order to protect vessels in the harbour wirelessly against biofouling, corrosion and scaling, to prevent so-called "accelerated low water corrosion" in old constructions by protecting these constructions with modulated carrier waves, to prevent concrete constructions in the tropics being affected by micro-organisms, to realize wireless and battery-free sensor networks at sea in order to map the ecosystem and current, to supply energy to implants such as pacemakers, to provide in vivo biosensors with energy and to read these biosensors, to influence the metabolism of micro-organisms or to selectively destroy micro-organisms using selectively modulated carrier waves, data transmission via train rails, to send energy and information via groundwater, to disinfect food products in non-destructive manner, to disinfect and/or treat body parts and injuries by immersion thereof in a liquid treated with the present technology, to improve wood, to (partially) replace washing powder in cleaning equipment including washing machines and to replace softening equipment or softening chemicals since scaling can be prevented with the present technology, to control the nucleation, crystal growth rate, crystal size, crystal form and crystal modification in crystallization processes which include but are not limited to the production of salt, sodium sulphate, soda, magnesium sulphate.

A particular application is the control of biotechnological reactions. By means of a preferably modulated RF signal, but not limited thereto, it is possible inter alia to influence the permeability of the cell membranes of micro-organisms. This means that components enter the cell of the micro-organism which would not be there under normal conditions. This influences the metabolism of the cell, whereby biotechnological processes can be optimized, components can be decomposed by micro-organisms not capable thereof under normal conditions, and components can also be produced which the micro-organism cannot make under normal conditions. The latter is particularly interesting for the pharmaceutical industry. It is also possible using the present invention to select micro-organisms with desired properties by applying a preferably modulated radio signal, though not limited thereto, and to optionally sustain the thus obtained culture with a radio signal by suppressing the multiplication of undesirable micro-organisms therewith. The great advantage of applying a modulated RF signal is that this signal acts selectively on the micro-organisms since they demodulate the RF signal to an alternating voltage of a considerably lower frequency, while the signal has a limited effect on other components in the system.

Another particular application is the selective control of the filtration properties of microfiltration, ultrafiltration, nanofiltration, reverse osmosis membranes in general and ion-selective membranes in particular. Without any limitation being imposed on the scope of the present invention by the following explanation, the inventors have the following possible explanation for the phenomenon that the filtration properties of membranes can be adjusted using modulated RF waves. Analogously to membranes of micro-organisms, many commercially available membranes have an asymmetric mobility for ions over the selective part of the membrane. A membrane can be construed as a parallel circuit of a diode, a resistor and a capacitor. The consequence hereof is that these membranes can demodulate (for instance amplitude-modulated) RF waves, whereby an alternating voltage occurs on and in the membrane which influences the properties of the membrane. Through a correct choice of one or more frequencies with which the RF carrier wave is modulated the selectivity of the membrane for different components can be set to a desired value, as can the apparent diffusion coefficient of different components in the membrane. It will be apparent to the skilled person that the present invention can also reduce or wholly prevent undesirable effects such as concentration polarization and/or biofouling on membrane surfaces and/or the formation of scaling on and/or in membranes, particularly for but not limited to salts of polyvalent ions. The selectivity of the membranes hereby increases and this selectivity can be set so that one type of commercially available membrane can be made suitable for many different applications. The present invention further increases the productivity of the membranes, i.e. the amount of liquid which can be filtered per square metre of membrane per unit of time per bar of transmembrane pressure increases so that an application with lower energy costs, lower investment costs and less maintenance can be realized. The lifespan of the membranes further also increases through application of the present invention. It is noted that this technology is not only of great importance for the purification of water and process flows in the chemical industry, but particularly also for the optimization of electrolysis processes, electrodialysis processes and reverse electrodialysis processes. The efficiency of a chlorine-alkali membrane electrolysis can for instance thus be increased, using the present technology, by simultaneously increasing both the selectivity of the applied membranes and the apparent diffusion coefficient of ions transported through the membrane. The result is a greater purity of the sodium hydroxide which is produced and lower energy costs per tonne of product. A preferred embodiment for treating membranes situated in a liquid is a carrier wave with a frequency of less than 100 GHz, which is modulated with at least one wave having a frequency lower than 1 GHz, more preferred is application of a carrier wave with a frequency lower than 1 GHz which is modulated with at least one frequency lower than 100 MHz, and even more preferred is a carrier wave with a frequency of less than 10 MHz which is modulated with at least one frequency in the range of 1 Hz to 5 MHz.

It is noted that changing the properties of spirally-wound membranes expressly forms part of the present invention. The inventors of the present invention have discovered that spirally-wound membranes can be construed as a system of coils and capacitors. This system of coils and capacitors has at least one and often a plurality of resonance frequencies. The use of modulated carrier waves on one or more of these resonance frequencies changes the properties of these spirally-wound membranes. It has been found possible to adjust the selectivity of the membranes by means of radio waves as well as to suppress concentration polarization.

Several examples of use of the present invention are given hereinbelow.

Example 1

A Sommerkamp FT-77 transceiver was set to a frequency of 7.15 MHz and FM modulation. The antenna output of the transceiver (inner terminal of the coax coupling) was connected to a copper wire d1 with a diameter of 1 mm and a length of about 710 cm. The outer terminal of the coax coupling was not connected. The outer end of wire d1 was connected to a circuit consisting of a variable capacitor C1 with a capacitance of 280 pF, an air-core coil L1 with inductance of about 8 μH, a diameter of 44 cm and 12 windings of enamelled copper wire with a diameter of 1 mm and a lamp B1 of the OSRAM, 6-7 volts / 2 watts type. The circuit was then connected in turn to a wire d2 with a length of 235 cm. For further elucidation see also figure 2. The transceiver was then set to transmit. Lamp B1 was here found to light up provided variable capacitor C1 was set to the correct value. This demonstrates that energy transfer through one wire is realized. If a person spoke loudly into the microphone, the brightness of lamp B1 changed according to the rhythm of speech. This demonstrates that simultaneous energy and information transfer is possible. In a subsequent test use was made first of only a carrier wave of 7.15 MHz in order to illuminate the lamp. This was realized by not supplying an audio signal to the microphone of the transceiver. A loud and continuous audio signal was then supplied to the microphone by holding the microphone close to a loudspeaker producing a loud tone with a frequency of 2 kHz. The lamp was visibly less bright at this frequency modulation of the signal. This demonstrates that the operation of the system is greatly dependent on the width of the radio-frequency spectrum. This is because the occurrence of the sidebands in frequency modulation is detrimental to the amplitude of the carrier wave. The resonance frequency and quality factor of the circuit are essential for an efficient energy transfer. The transceiver was then set to single-sideband modulation (USB) at a frequency of 7.5 MHz. When a person spoke into the microphone, the lamp illuminated according to the rhythm of speech. This demonstrates that energy and information transfer by means of single-sideband modulation through one wire is possible. It is noted that no attention was paid in the experiments described here to the optimization of the energy efficiency with which signal transfer takes place. Antenna wire d2 is used in this example to ensure that impedances of lamp B1 and the wire at the position of the connection to the tuned circuit are roughly equal to each other. It will be apparent to the skilled person that much better energy and signal transfer can be obtained by applying an antenna tuner between transceiver and antenna wire d1. It will also be apparent to the skilled person that the lamp in the resonance circuit can be replaced by a different load, such as a circuit which converts the high-frequency current into a direct voltage and which then optionally charges a capacitor, battery or accumulator with this direct voltage. It will also be apparent to the skilled person that the information which is co-transmitted by modulation of the high-frequency signal can be demodulated with standard radio technology and can then be applied to selectively switch on equipment, including a valve in a conduit or a sensor or sensor-transmitter combination. The sensor and the transmitter can be supplied with energy using the concept according to the present invention and the transmitter can then send information collected by the sensor to the main station via the single wire d1. On the basis of this example a number of commercial applications of the above stated concept is now mentioned:

In a first embodiment antenna wire d1 consists of a hollow metal tube, such as a conduit in the processing industry through which a process liquid flows. The conduit comprises one or more valves which can be opened or closed. Each valve is optionally equipped with a receiver which can demodulate a high-frequency signal. Preferably situated at each valve is a tuned circuit which is connected to hollow tube d1 and optionally to a wire d2 as according to the diagram in figure 2. Instead of lamp B1 in figure 2, an electrical circuit is arranged in this embodiment as load which rectifies the high-frequency current. The valve can be opened or closed by now applying a carrier wave on antenna wire d1. By equipping a conduit with a plurality of valves plus receiver and by modulating the high-frequency signal it is possible to co-transmit a code with the high-frequency energy. Valves can hereby be opened or closed selectively. It will be apparent to the skilled person that a whole pipe network or a processing plant can in this way be controlled from a central point without installing electrical wiring.

In a second embodiment antenna wire d1 consists of a hollow tube, such as a conduit in the processing industry through which a liquid flows, wherein the material from which the tube is made is a poor electrical conductor or even an insulator. Flowing through this conduit is a process liquid which is conductive to high-frequency signals. Examples of such process liquids are drinking water, brackish water and seawater, and an example of such a conduit is for instance a PVC tube or a garden hose. It will be apparent to the skilled person that this embodiment displays behaviour similar to the first embodiment. It is hereby possible to transfer energy and information wirelessly through plastic conduits through which a conductive liquid flows. In a third embodiment the valve described in embodiments one and two is replaced by a sensor. The sensor is optionally also equipped with a transmitter. In this manner it is possible to supply power to the sensor with a modulated carrier wave and to switch it on or off selectively. If the sensor is equipped with a transmitter, this transmitter can also be switched on periodically for the purpose of sending the information measured by the sensor to the main station. The transmitter preferably sends the information through antenna wire d1 or the conductive liquid serving as antenna wire d1.

In a fourth embodiment antenna wire d1 consists of a construction which comprises at least a long steel tube or wire or drill or rod with which objects can be anchored on the seabed. The length of d1 can amount in this case from several hundred metres to several kilometres. Situated at the end of d1 is a device, such as a valve, to which it must be possible to supply energy, and optionally a sensor and a transmitter which takes measurements in the vicinity of the seabed and sends these measurements back to the main station on command by means of a modulated carrier wave.

In a fifth embodiment antenna wire d1 consists of a tubular membrane, such as a reverse osmosis membrane, or a nanofiltration membrane, or an ultrafiltration membrane, or a microfiltration membrane. Arranged in the membrane are sensors which measure the situation in the membrane module, and preferably also transmitters. In this respect it is possible to envisage pressure sensors, temperature sensors, pH sensors, conductivity measurements and movement sensors. The sensors are provided with energy by means of a carrier wave. By making use of modulated carrier waves the sensors can be selectively set into operation and, if desired, the measurements of the sensor can be sent back to the main station by the transmitter coupled to the relevant sensor. In this way it is possible to continuously and remotely monitor a very large number of membrane modules. Leakages or other defects in a module can hereby be detected early. Only a limited part of the installation hereby need be taken out of operation in the case of malfunctions, and production losses or trading loss remain limited. It is also possible in this manner to continuously check whether all membrane modules are being operated under the correct process conditions. By equipping membrane modules for the processing industry as standard with a monitoring system according to the present invention it becomes possible for a membrane supplier to provide an optimal remote service and to optimize the process quickly and efficiently in the case of new applications of membranes. It will be apparent to the skilled person that the tubular membranes do not have to consist of conductive material since the liquid in the tubular membranes can serve as antenna. It will be further apparent to the skilled person that not only the tubular membranes themselves but also the housing of such membranes can be applied as antenna d1. This latter comment will also make it apparent to the skilled person that the invention according to this embodiment can also be applied for spirally-wound membranes, since the housing of these membranes or the liquid in the housing of these membranes can be used as antenna d1. Finally, it will be apparent to the skilled person that a whole system of membrane modules which are in mutual electrical connection via the process liquid and/or the process conduits and/or the processing plant can be simultaneously supplied with energy and read from a central point. A low energy efficiency can be tolerated here since actuation and reading of the sensors need only take place periodically.

In a fifth embodiment antenna wire d1 consists of a drilling device with which drillings are carried out in rock, in the seabed or in the ground. It is possible to envisage devices for drilling for oil, gas, salt and ores. In many cases it is important to be able to perform measurements close to the drill head. Measurements which give information about the conditions and/or nature of the material in which drilling is taking place are for instance the temperature, vibration intensity and vibration frequency of the drill head. By equipping the drilling device with (micro)sensors which are built into the drilling rod, and which are thus situated in the metal, it is possible using the concept according to the present invention to obtain information wirelessly about the local conditions under which drilling takes place.

In a sixth embodiment the technology according to the present invention is combined with commercially available RFID (Radio Frequency Identification) technology, which is applied in practice to remotely store information and read so-called RFID "tags" located on or in objects. These tags can be "active" or "passive". Active RFID tags are powered with a battery and can be read and written with a remote transceiver which sends and receives radio waves using an antenna. Antenna wire d1 or a liquid equivalent can function as such an antenna. Particularly suitable in combination with the present invention is RFID technology at low frequencies, since such technology operates better in combination an environment in which water is present.

In a seventh preferred embodiment the arrangement of figure 2 is applied wherein at least a part of antenna wire d1 consists of liquid, so that this liquid serves as conductor for the radio waves. The arrangement is then tuned such that a maximum amount of power is transferred to lamp B1 or another load. The result hereof is that a large quantity of high-frequency energy is transported through the liquid. It has been found that disinfection of the liquid progresses optimally under these conditions, and that the metabolism of micro-organisms can also be influenced under these conditions. Since trees and plants consist of channels with liquid, the present technology can also be applied to treat plants which are infected with parasites, including insects such as the leaf miner, and micro-organisms. This is for instance possible by having the trees or plants form part of antenna wire d1. Cell membranes of plants can also demodulate radio waves since the cell membrane of a plant cell can be construed as a parallel circuit of a diode, a resistor and a capacitor. For this reason it is possible to influence the metabolism of plant cells, analogously to bacteria and other micro-organisms, using modulated radio waves in general and amplitude-modulated radio waves in particular. The metabolism of plants is preferably influenced by applying a carrier wave frequency of less than 10 MHz and a frequency of the modulation of 20 kHz to 200 kHz. It is noted that not only cell membranes but also organelles can demodulate radio waves, whereby the metabolism of plants is influenced. In this respect influencing the metabolism of plants is understood to mean: killing plant cells by means of electroporation, enhancing transport of chemical substances through the cell membrane, accelerating the metabolism of plant cells, decelerating the metabolism of plants cells, an accelerated absorption of nutrients by the root system of the plants, disturbing the moisture balance in plants. Enhancing plant growth by making use of modulated radio waves in the growing medium in greenhouses, by placing electrodes against the plant or round the stem of the plant, for instance in the form of gauze which also provides the plant with support, expressly forms part of the present invention.

It is known that photosynthesis takes place via a complicated system of redox reactions, wherein light energy collected by pigment molecules is the driving force behind the conversion of carbon dioxide and water into carbohydrates and oxygen. If a plant cell is now exposed to modulated radio waves, the cell membrane and/or organelles in the plant cell can then demodulate these radio waves, whereby an alternating voltage occurs with a frequency which is the same as the modulation frequency. Owing to the asymmetrical character of a cell membrane, and also of the organelles in the cell, transport of chemical compounds and the levels of different chemical compounds are different on either side of the membrane or inside and outside an organelle. The consequence hereof is that the cell membrane or organelle can be charged with a net alternating direct voltage. The result hereof is that redox reactions in the photosynthesis cycle are influenced by these potential differences. The photosynthesis can hereby be accelerated or decelerated by making use of modulated radio waves. The use of radio waves to enhance or inhibit photosynthesis of plants or cyanobacteria expressly forms part of the present invention.

In a seventh preferred embodiment at least a part of antenna wire d1 consists of a tube with liquid. The tube can be a good conductor for radio waves, but also an insulator. During the experiments it was observed that the properties of antenna wire d1 change in such a situation if a biofilm forms on the inside of the tube and/or biocorrosion and/or corrosion and/or scaling occurs. In the case one or more of these phenomena occur, changes can be observed in the energy transfer through antenna wire d1 and/or the optimum frequency at which this energy transfer is maximal. This means that the arrangement in the perspective outline of figure 2 can be applied to detect a biofilm and/or biocorrosion and/or corrosion and/or scaling at an early stage. In the case electrodes are arranged in a liquid 2 the electrical properties of these electrodes also change when biofouling, biocorrosion, corrosion or scaling occur, such that these phenomena can be detected at an early stage. The transfer of energy and information by means of the present invention and the simultaneous analysis of the signal transfer for the purpose of characterizing biofouling, biocorrosion, corrosion or scaling at an early stage expressly forms part of the present invention. The use of impedance spectroscopy with the systems for wireless energy and information transfer as described in the present invention for the purpose of measuring biofouling, biocorrosion, corrosion or scaling also forms part of the present invention. It will be apparent to the skilled person that biofouling and scaling in tubular and spirally-wound membranes, as well as concentration polarization, can also be measured in this way.

In an eighth preferred embodiment antenna wire d1 consists at least partially of a tree trunk, i.e. a piece of wood which must be preserved. By sending a high RF power through the tree trunk in accordance with the technology in the present invention as described in figure 2, but not limited thereto, this tree trunk will be disinfected. If there is sufficiently great energy dissipation in the tree trunk, particularly the outside of the tree trunk, i.e. an outer covering with a diameter of about 1 cm, will be heated and the wood on the outside will harden. A high RF power is understood to mean a carrier wave with a frequency which is preferably lower than 10 MHz and which is amplitude-modulated with a frequency which preferably lies in the range of 10 kHz to 200 kHz. The output of the end stage of a transmitter can optionally be connected to both ends of the tree trunk. This can take place directly or by making use of an antenna tuner. It is noted that, if desired, this technique can be combined with application of a low-frequency high voltage between the two ends of the tree trunk. Is noted that trees which are applied as part of antenna wire d1 can also function as transmitting antenna.

Example 2

A carrier wave with a frequency of 2 MHz was generated with a Voltcraft 2 MHz sweep/function generator. The output of this function generator (FG-dg) was connected to a linear tube amplifier specially designed for the application according to the present invention and consisting of a single-ended driver stage with an E88CC tube and single-ended end stage (E) with an EL84M tube, which is connected in triode. Connected between the anode of the EL84M and the high-voltage power supply is a transformer with which the carrier wave can be amplitude-modulated. The amplitude-modulated signal is drawn off via a coupling capacitor on the anode connection of the EL84M. The RF power which the output amplifier can produce amounts to about 3 watts. For the amplitude modulation use is made of a second function generator (FG-am) which generates a sine with a frequency between 7 kHz and 100 kHz. The output of this function generator is connected to a Raveland XCA 1200 audio amplifier (AV). The output of this audio amplifier is connected to the modulation transformer of the linear output amplifier situated between the anode of the EL84M and the high-voltage power supply. For the sake of clarity figure 3 shows a schematic view of the arrangement. It is noted that use is made in the test setup of tube technology because a transmitter based on this technology is, with few aids, still considerably robust and has long-term resistance to short-circuiting of the outlet or great differences between output impedance and impedance of the load. It will be apparent to the skilled person that for most practical applications solid-state technology is preferred to tube technology. The output of the linear end stage with E88CC and EL84M (E) was connected to two vertically placed parallel stainless steel electrodes, in the liquid/object (0) for treating, each with a length of about 15 cm and a diameter of 12 mm. The stainless steel electrodes were placed in an 800 ml glass beaker. About 600 ml of a suspension of micro-organisms in water was added to this beaker. A part of the suspension was kept as control sample. The suspension of micro-organisms consisted of a mixture of baking yeast and a glucose solution which has stood for 10 days in an open beaker at about 20 degrees Celsius, in a space which was otherwise not conditioned. Inspection of a sample of this suspension under the microscope showed that not only baking yeast cells were present in this suspension, but also bacteria and fungi. The installation of figure 3 was then activated. The function generator for the carrier wave (FG-dg) was set to a frequency of 2 MHz. The function generator for amplitude modulation (FG-am) was set to a frequency of 90 kHz. The amplitude of the output signal of the function generator for the carrier wave was set such that the amplitude of the carrier wave amounted to 20 volts at the output of the linear amplifier. The amplitude of the modulation was then set by means of the audio amplifier (AV) such that it amounted to 17 volts. The micro-organisms in the beaker (0) were then treated with the radio waves for 3.5 hours while being continuously and carefully stirred with a magnetic stirrer. It is noted that the power dissipated in the liquid during the treatment with radio waves was very low, and that no change in the liquid temperature (this temperature was about 18 degrees Celsius) was detected during the treatment. At the end of the experiment a sample was taken of the suspension in the beaker using a sterile syringe. A petri dish with a sterile culture medium with plate count agar was then opened and four droplets were dripped onto the plate count agar using the syringe. This test was carried out in duplicate. The beaker was then refilled with a suspension of micro-organisms and this suspension was stirred for 3.5 hours without the micro-organisms being exposed to radio waves. This test is referred to as the control measurement. In the control measurement a sample was also taken with a syringe and four droplets of the control sample were added to a petri dish. The petri dishes were kept in an incubator for seven days at 27 degrees Celsius and then visually inspected. The petri dish with control sample, i.e. the sample which had only been stirred for 3.5 hours and not treated with radio waves, looked clearly different from the two other petri dishes. The culture medium with plate count agar in the petri dish with untreated sample was completely discoloured and micro-organisms had grown over the whole volume. The petri dishes with samples treated with radio waves were found to also contain micro-organisms, but only in the vicinity of the location where the droplets had been arranged, and only on the surface. The nature and form of the discolouration of the treated samples moreover differed considerably from those of the untreated sample. The colour of the untreated sample was darker. It is concluded from this that a different population of micro-organisms was present in the treated samples than in the untreated sample. It is concluded from the experiment that the treatment of a mixture of micro-organisms with amplitude-modulated radio waves has the result that at least part of the micro-organisms are killed or inhibited from multiplying after the treatment with radio waves. The experiment also shows that determined micro-organisms are killed or inhibited selectively in a mixture of micro-organisms. On the basis of this example a number of commercial applications of the above concept is mentioned here:

In a first preferred embodiment a population of micro-organisms is held stable in a bioreactor by exposing the content of the bioreactor continuously to (modulated) radio waves with properties such that the multiplication of undesirable micro-organisms in the bioreactor is prevented, while the desirable micro-organisms can readily multiply and survive in the bioreactor.

In a second preferred embodiment a population of micro-organisms is treated with radio waves in a fermentation reactor for energy production and the metabolism of the micro-organisms, and optionally also the composition of the population of the micro-organisms, is influenced such that the biogas production is maximal.

In a third preferred embodiment the selectivity of a chemical conversion in a bioreactor is increased by exposing the content of this bioreactor to (modulated) radio waves. The increase in the selectivity of the chemical conversion is caused by a change in the metabolism of the micro-organisms responsible for the conversion and/or by selective killing of determined undesirable micro-organisms and/or by changing the permeability of the cell membrane of micro-organisms for chemical components which influence the metabolism of micro-organisms.

In a fourth preferred embodiment the energy production of a microbial fuel cell and/or a biologically assisted electrolysis cell is increased by exposing the content of the fuel cell and/or the electrodes of the fuel cell to (modulated) radio waves.

In a fifth preferred embodiment harmful micro-organisms, including salmonella, in food products are killed by exposing these food products to (modulated) radio waves.

In a sixth preferred embodiment legionella is killed in water by (modulated) radio waves, this optionally taking place selectively.

In a seventh preferred embodiment water is disinfected by exposing this water to modulated radio waves.

In an eighth preferred embodiment a waste water cleaning is optimized by applying modulated radio waves.

Example 3

In this experiment use is made of the setup described in example 2 and shown schematically in figure 3. Use is however made in this test of a different object for treating, which is described in the following passage. Two pieces of sheet piling (iron) with dimensions of about 42 cm X 24 cm X 2 cm were placed in a plastic vessel with dimensions length X width X height = 34 cm X 24 cm X 13 cm. Each piece of sheet piling was bent at about 1/3 of the length to an angle of slightly less than 90 degrees and at about 2/3 of the length to an angle of slightly less than 90 degrees in the other direction. The result hereof was that one part of each piece of sheet piling was situated on the bottom of the plastic vessel, one part protruded vertically upward and was situated partly above the liquid, and one part lay horizontally on the edge of the vessel and was situated partly outside the vessel. Both pieces of sheet piling were placed in the liquid such that they made no electrical contact with each other. Each piece of sheet piling was connected to a pole of the end stage of the transmitter by means of crocodile clips and a copper wire. Exactly the same setup was constructed as reference measurement, although in this latter case the pieces of sheet piling were not connected to the end stage of the transmitter. A plant growth lamp of the brand Arcadia original tropical aquarium lamp FO18 (24 inch, 600 mm) was suspended about 40 cm above each plastic vessel, therefore above the reference measurement and above the measurement in which the pieces of sheet piling were connected to the end stage of the transmitter. Using this lamp daylight was simulated and conditions were created in which algae can grow. After the pieces of sheet piling were positioned in identical manner in both plastic vessels, the vessels were filled with mains water. Added to the mains water was a quantity of 10 ml per litre of "Terras en Balkon (Terrace and Balcony)" liquid fertilizer of the brand Pokon - Chrysal (Naarden, Holland). The Pokon solution contained NPK fertilizer and micronutrients. At the start of the experiment both solutions were inoculated with a sample of algae and bacteria from the same source (an aquarium in which algae and bacteria were cultured for a number of weeks). A small quantity of air was also continuously bubbled through the solution in both plastic vessels by making use of a dual aquarium pump "Cranfish 3500 type M104 double output aquarium pump, Pmax = 2.4 Watt". The growth lamps and the setup of figure 3 were then switched on. The frequency of the carrier wave was set to about 1.8 MHz and the carrier wave was amplitude-modulated with a frequency of about 100 kHz. When the transmitter was switched on the amplitude of the carrier wave amounted to about 20 volts at the output of the amplifier. The amplitude of the modulation was then slowly increased and set to 17 volts. After about a week a visual inspection of the pieces of sheet piling in both plastic vessels shows that the corrosion speed of the pieces of sheet piling is considerably higher in the case of the control measurement than that in the vessel where the pieces of sheet piling are connected to the end stage of the transmitter. After about 2 weeks the differences between the pieces of sheet piling in the vessel with the control measurement and the vessel connected to the end stage of the transmitter have increased further. It is now clearly visible that the pieces of sheet piling in the control measurement comprise more light-brown spots than the pieces of sheet piling connected to the end stage of the transmitter. Some algal growth is further visible after about 2 weeks. This algal growth becomes particularly visible on the wall of the plastic vessel at the position of the water level. It can be clearly discerned that the algal growth in the plastic vessel with the control measurement is less than that in the vessel in which the pieces of sheet piling are connected to the end stage of the transmitter. It is concluded from the experiments that connecting the pieces of sheet piling to the end stage of the transmitter results in a clearly discernible decrease in the corrosion speed compared to the control measurement. In addition, less algal growth occurs under the influence of the amplitude-modulated radio waves. A number of commercial applications of the concept according to the present invention is now mentioned on the basis of this example. In a first embodiment electrodes are placed in a pond and these electrodes are connected to the end stage of a transmitter, which preferably produces amplitude-modulated radio waves. The frequency of the carrier wave and the amplitude of the modulation are such that the metabolism of the algae differs (this can be lower or higher) compared to the situation where the electrodes are not connected to a transmitter.

In a second embodiment electrodes in a metal vessel or reactor are connected to the end stage of a transmitter and in this way the corrosion speed of the vessel or the reactor is reduced. It is noted that the wall of the vessel or the reactor can be used as electrode.

In a third embodiment a pipeline (network) is protected from corrosion by using this pipe as electrode or antenna and supplying a modulated carrier wave to this antenna.

In a fourth embodiment a sheet piling, lock gate or other metal construction is treated with radio waves, and corrosion of the relevant construction is in this way prevented. It is noted that use is made in this case of an alternating voltage in contrast to the direct voltage which is applied in the prior art and which can result in problems in harbours. An example of problems occurring when direct voltage is applied is accelerated corrosion of ship's hulls due to a potential difference with the sheet pilings.

Example 4

In a first beaker of transparent plastic with a volume of 300 ml are arranged two iron electrodes with a length of 8 cm, a width of 1 cm and a thickness of 5 mm. Both electrodes are placed at a distance of 5 cm relative to each other. Identical electrodes are arranged in the same way in a second beaker. About 80 ml of demineralized water is added to both beakers. The electrodes in beaker 1 are connected to the end stage of the transmitter in figure 3 and the transmitter is set to the same conditions as in example 3. The electrodes in beaker 2 are not connected to a transmitter and beaker 2 serves as control experiment. After a week the electrodes in beaker 1 and beaker 2 are found to be corroded. It is however clearly discernible that the electrodes in beaker 1, which are connected to the end stage of the transmitter, are less corroded than those in beaker 2. This is a remarkable result seeing that no micro-organisms were present in the water during the tests. No biocorrosion can thus have occurred in this case. The adsorption and desorption of ions on the electrode surface is evidently influenced by the radio waves such that corrosion is suppressed.

Another possible explanation for the corrosion-inhibiting effect of the amplitude-modulated radio waves on iron is that the oxide skin which is created during corrosion has demodulating properties whereby a low-frequency alternating voltage is applied to the electrodes, which has a possible effect on adsorption and desorption of ions which are present on the electrode surface and which possibly inhibits corrosion.

In a first preferred embodiment a metal alloy or a metal surface is subjected to modulated radio waves in order to suppress corrosion, and optionally also biofouling and scaling. If desired, a metal alloy is chosen such that the corrosion-suppressing effect is maximal. A non-limitative list of metals or metal alloys which are preferably applied is: Al, Ti, Fe, Mn, Cr, Mb, Ni, Zn, Ag, Pt, Au, Cu, Sn, Mg, Si, Ge. In a particular embodiment a modulated radio wave (in this application this is also understood to mean a radio frequency alternating voltage) is applied periodically to the surface for protecting, for instance with a frequency of 10 times per minute, and the modulation depth is then increased in each case such that splatter occurs.

In a second preferred embodiment a (modulated) radio wave is superimposed on the potential difference applied between two electrodes in order to bring about electrolysis, for instance for disinfection purposes. The result hereof is that the electrodes age less rapidly and so have to be replaced less quickly, and that the specific energy consumption in the electrolysis process decreases. In a particular embodiment a modulated radio wave (in this application this is also understood to mean a radio frequency alternating voltage) is applied periodically to the surface for protecting, for instance with a frequency of 10 times per minute, and the modulation depth is then increased in each case such that splatter occurs.

In a third preferred embodiment a coating such as a paint is applied to a surface for protecting (this can be a conductor as well as an insulator). The coating comprises conductive particles such as metal particles and/or active carbon and/or graphite and/or semiconductors and/or conductive polymers. The volume fraction of the conductive particles in the coating is chosen such that this coating is an insulator for direct voltage but a conductor for high-frequency alternating voltage. Examples of surfaces to be protected are ship's hulls, pipes through which oil, gas, water, brackish water, seawater flows, heat exchangers, pump impellers, reactors in the processing industry. By now applying a (modulated) radio wave to the surface for treating, for instance by simply attaching two electrodes some distance from each other to the coated surface, it is possible to protect this surface from biofouling, scaling, corrosion. In this respect biofouling is understood to mean not only a biofilm of bacteria, but also the adhesion of mussels, algae and other living creatures to the surface.

Example 5

In this example use is made of two commercially available, so-called powernet ethernet adapters, which are applied in normal use to effect communication via the mains electricity between an internet modem or router on the one hand and a PC on the other. For this purpose the internet modem is connected by means of an ethernet cable to a powerline ethernet adapter, which is then inserted into the socket outlet. By also connecting the PC to a powerline ethernet adapter via an ethernet cable and then also inserting the adapter into the socket outlet, an internet connection can be realized via the mains electricity. The software and hardware required for this purpose are present in the powernet ethernet adapter, whereby both the modem and the PC "know" no better than that both are directly connected by means of an ethernet cable. Using this introductory information the experiment is now described. A 12V lead battery for starting motorcycles, of the type Elro maintenance-free rechargeable battery SA214, is mounted in a first plastic case, referred to hereinbelow as case 1. A commercially available sine-wave generator of the Turbo Car Accessories type is connected to this lead battery. This sine-wave generator converts the 12V direct voltage into a 230V / 50 Hz alternating voltage. A plug station is connected to the socket outlet present in the output of the sine-wave generator. A "plug and play" powerline ethernet adapter of the type Trust 14 Mbps Powerline Link is plugged into this plug station. The powerline ethernet adapter in case 1 is connected to a first laptop, referred to hereinbelow as laptop 1. This laptop 1 comprises a UMTS modem and is thereby connected to the internet. As with case 1, a 12V lead battery, a sine-wave generator and an ethernet adapter are mounted in a second case, referred to hereinbelow as case 2. As with case 1, a plug station is connected to the socket outlet present in the output of the sine-wave generator. The powerline ethernet adapter is plugged into this plug station. In case 2 a second laptop, referred to hereinbelow as laptop 2, is also connected to the powerline ethernet adapter. A UMTS modem is not connected to this laptop, and this laptop is therefore not connected to the internet. Since the powerline ethernet adapter in case 1 and the powerline ethernet adapter in case 2 are not connected to the mains electricity due to the use of the batteries with sine-wave generator, it is found to be impossible to have laptops 1 and 2 communicate with each other via the ethernet adapters in case 1 and case 2. In a follow-up experiment a semi-plug is plugged into the plug station in case 1. It is noted for the sake of clarity that the powerline ethernet adapter is plugged into this same plug station. The semi-plug is connected to a single wire. In case 2 a semi-plug is likewise plugged into the plug station and connected to a single wire. Both wires are then connected to each other. After mutual connection of the wires it is found to be possible to have the two laptops communicate with each other by means of the powerline ethernet adapters. The two wires can otherwise be touched without danger since the voltages are "floating". After configuration of the laptops, contact is in this way made with internet on laptop 2 making use of the UMTS connection on laptop 1. In a subsequent experiment a wire with a length of 25 metres and a diameter of 0.5 mm is connected between the two semi-plugs in case 1 and case 2, and both cases are removed a distance of 25 metres from each other. It was also found possible in this case to realize a connection between laptop 1 and laptop 2 by making use of the powerline ethernet adapters in case 1 and case 2. Finally, the connection between the two semi-plugs of case 1 and case 2 was cut and a plastic hose with a diameter of 1.5 cm and a length 200 cm was placed between the two terminals. The plastic hose was filled with a saturated brine (300 g NaCl per 900 ml water). Graphite electrodes with a length of about 5 cm were arranged on either side of the plastic hose. The hose was first sealed on one side with thermoplastic glue from a glue gun. The hose was then filled with the saturated brine and the other side of the hose was subsequently also sealed with the thermal glue from the glue gun.

After the hose had been placed between the open wire ends of the connection to the semi-plugs, the connection between the two laptops was restored. An internet connection through a plastic hose with a solution of salt in water is thus realized in this case. A number of commercial applications of the concept according to the present invention are now mentioned on the basis of this example.

In a first embodiment communication is realized between two computers using standard commercially available powerline ethernet adapters, wherein the connection between the two ethernet adapters, which normally runs via the powerline, is now brought about through a liquid. This liquid can be situated in a metal tube or a plastic tube. Internet connections can also be established on a factory site by making use of liquid conduits instead of wireless LAN connections.

In a second embodiment the powerline ethernet adapter technology is combined with the technology for supplying power to and equipping sensors with a transmitter for information transfer.

In a third embodiment an internet connection is realized via a water conduit or recirculation system of a CH system. This is a commercially interesting solution for realizing internet connections, particularly in blocks of flats, apartment buildings, hotels and business premises. The use of the technology according to the present invention is however not limited to wireless internet, but can also be utilized for security purposes such as camera surveillance and gas measurements. These alarm systems do not then have to run via a wireless LAN connection but can run via a conduit through which water flows. This is recommended in a number of cases in connection with greater safety and greater reliability. Use of the technology according to the present invention for taking meter readings in buildings including blocks of flats also forms part of the present invention.

The combination of the technology according to the present invention, i.e. applying (modulated) radio waves for the purpose of disinfection and/or controlling the metabolism with micro-organisms and/or suppressing biofouling and/or preventing scaling, with more common technologies such as the dosing of chemicals including biocides and anti-scaling agents and/or disinfection by electrolysis and/or disinfection through dosing of ozone and/or disinfection by means of UV light and/or by applying ultrasonic vibrations, expressly forms part of the present invention. Such combinations are commercially interesting because they have synergistic effects. In short, this means that the techniques of for instance ozone dosage and the treatment of a liquid with modulated radio waves in order to disinfect this liquid reinforce each other when they are applied simultaneously. It is hereby found possible to kill all micro-organisms in the liquid with a lower energy consumption than if each of these techniques were to be applied separately.

As will be apparent from the discussed examples, the exposure of a surface to radio waves is here also understood to mean applying a radio-frequency potential difference between two points on a surface. Instead of directly connecting to an end stage of a transmitter it is therefore also possible to make use of propagation of electromagnetic waves which are received by a surface to be treated, also functioning as antenna.

According to the invention a paint layer, which is not conductive to direct voltage but is conductive to high-frequency alternating voltage, can also be provided as coating on an object such that this object can function as transmitting antenna.

CLAIMS

1. Method for transferring electromagnetic waves in a liquid by a first device, wherein the electromagnetic waves comprise a first frequency.

2. Method as claimed in claim 1, wherein through modulation the electromagnetic waves also comprise at least a second frequency, wherein the second frequency is at least substantially lower than the first frequency.

3. Method as claimed in claim 1 or 2, wherein the second frequency lies between 1 Hz and 500 kHz, preferably between 50 kHz and 200 kHz, and more preferably between 90 kHz and 110 kHz.

4. Method as claimed in claim 1, 2 or 3, wherein the first frequency is lower than at least 10 MHz and wherein the first frequency is preferably about 5 MHz.

5. Method as claimed in any of the foregoing claims 1-4, wherein the frequencies lie between 1 kHz and 100 GHz.

6. Method as claimed in any of the foregoing claims 1-5, wherein at least a frequency comprises a resonance frequency at which micro-organisms demodulate the electromagnetic waves.

7. Method as claimed in any of the foregoing claims 1-6 for use in transferring electric energy through a liquid, wherein current from a power supply is converted in a first device into electromagnetic waves,

and wherein at least a second device receives the waves and wherein the received waves are converted into current for power supply to the second device.

8. Method as claimed in any of the foregoing claims 1-7 for communication between at least two devices, wherein the first device is adapted to supply a communication signal through modulation in at least a frequency of the electromagnetic waves and wherein at least a second device is adapted demodulate the communication signal.

9. Method as claimed in any of the foregoing claims 1-8, wherein at least a part of the electromagnetic energy propagates in the liquid in accordance with the wave pipe principle.

10. Method as claimed in any of the foregoing claims 1-9 for controlling micro-organisms in a liquid.

11. Method as claimed in any of the foregoing claims 1-10 for controlling properties of membranes, preferably the filtration properties.

12. Method as claimed in any of the foregoing claims 1-11 for controlling biotechnological processes.

13. Device for use in a method as claimed in any of the foregoing claims 1-12, comprising
   a. transmitting means for transmitting and/or receiving electromagnetic waves;
   b. converting means for converting electromagnetic waves into electric current.

14. Device as claimed in claim 13, wherein the transmitting means comprise a dipole antenna.

15. Device as claimed in claim 13 or 14, wherein the converting means comprise a transformer.

16. Device as claimed in claim 13, 14 or 15, wherein the device is further provided with (de)modulating means for (de)modulating the communication signals.

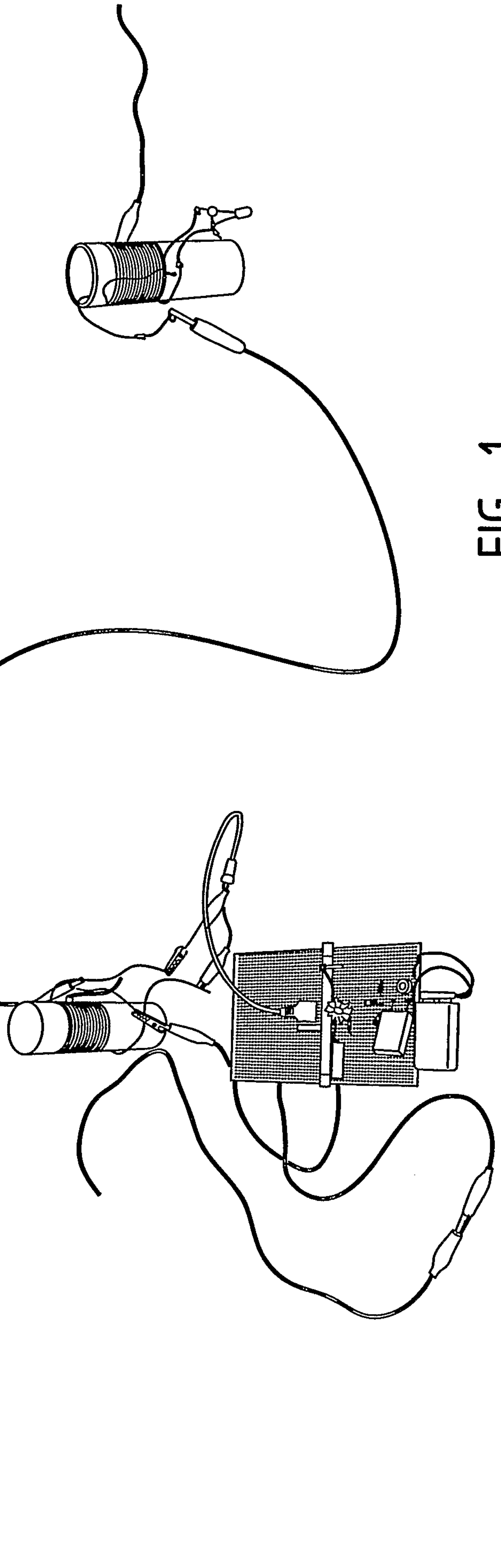

FIG. 1

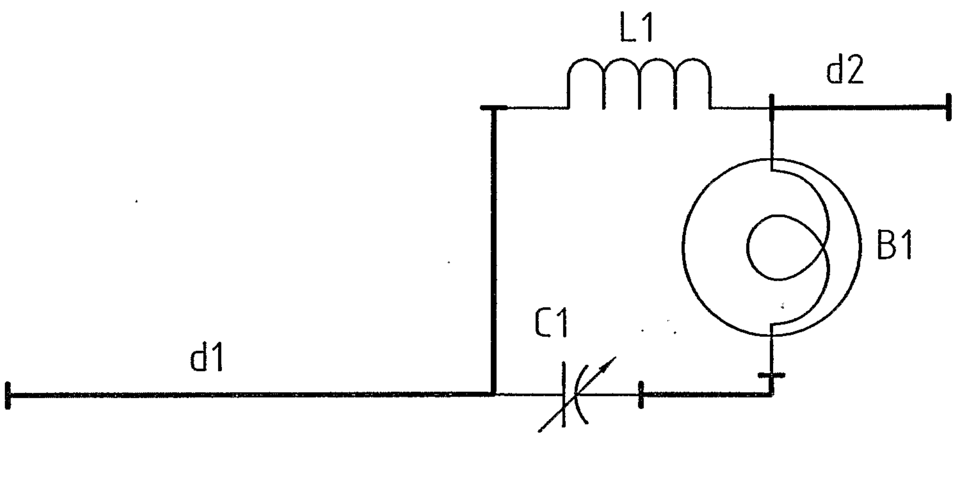

FIG. 2

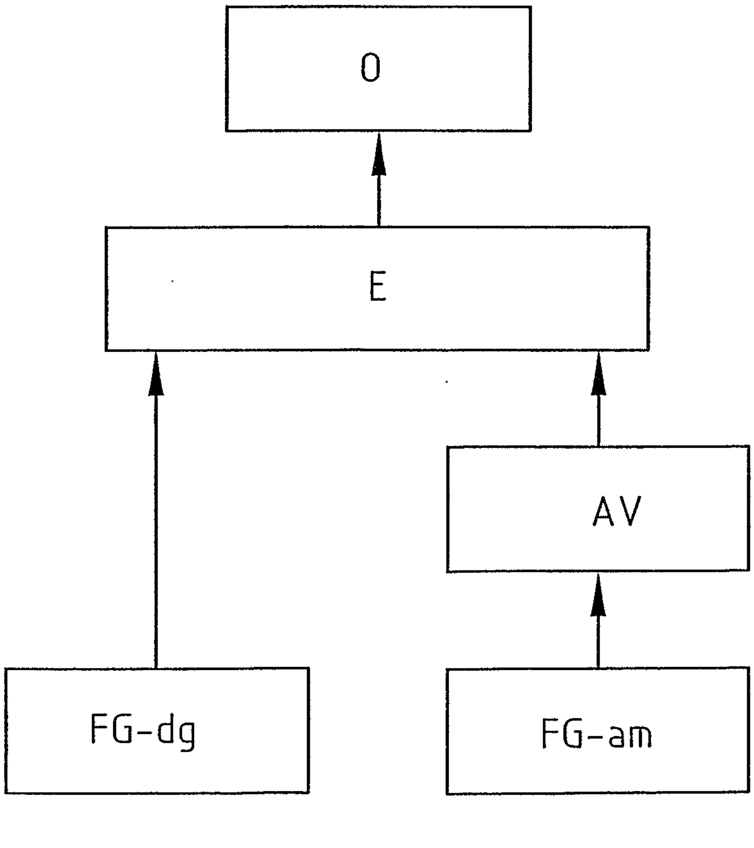

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2008/000193

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B7/00
ADD. C02F1/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99/29058 A (DIVECOM LTD [IL]; SONNENSCHEIN MENASHE [IL]; WULICH DOV [IL]; SONNENSC) 10 June 1999 (1999-06-10) figure 1	1-16
X	US 5 141 308 A (DANCKWERTH THOMAS M [US] ET AL) 25 August 1992 (1992-08-25) figure 1	13-16
X	US 6 272 072 B1 (WULICH DOV [IL] ET AL) 7 August 2001 (2001-08-07) the whole document	1-16
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 January 2009	12/01/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Janssens, Christophe

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2008/000193

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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