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(71) **Applicant: SMARTE TEKNOLOJI VE ENERJI SANAYI TICARET ANONIM SIRKETI** [TR/TR]; Resit Pasa Mah. Katar Cad. ARI 4 Binasi No:2/50/6, 34467 Sariyer/Istanbul (TR).

(72) **Inventor: BALLIKAYA, Melih**; Smarte Teknoloji Ve Enerji Sanayi Ticaret Anonim Sirketi, Resit Pasa Mah. Katar Cad. Ari 4 Binasi No:2/50/6, 34467 Sariyer/Istanbul (TR).

(74) **Agent: SEVINC, Erkan**; Istanbul Patent A. S., Plaza-33 Buyukdere Cad. 33/16, 34381 Sisli/Istanbul (TR).

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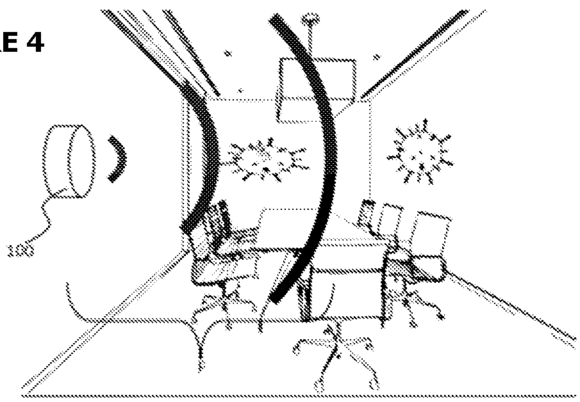
(54) **Title:** VIRUS DISINFECTION WITH MICROWAVES

FIGURE 4



(57) **Abstract:** The present invention proposes a disinfection device (100), comprising at least one antenna (1) or magnetron (17) arranged to emit microwave radiation in a frequency range of 8 GHz to 9.5 GHz. In addition, the present invention proposes a disinfection system comprising a plurality of said devices (100). Furthermore, the present invention provides a method for disinfecting an environment or the surfaces in the environment from viruses having envelopes with an original diameter (Dl) in the range of 80 to 140 nm by exposing them microwave radiation in a frequency range of 8 GHz to 9.5 GHz.

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VIRUS DISINFECTION WITH MICROWAVES

Field of the Invention

The present invention relates to a disinfection device and method. In particular, the present invention relates to a device, system and method for the disinfection of viruses having a certain diameter by acoustic resonance using microwave technology.

Background Art

Chemical agents are generally used for disinfection processes, especially in the disinfection of viruses. These include chemical agents such as alcohols, chlorine derivatives, aldehydes, hydrogen peroxide, and peracetic acid. These substances can be applied directly to a surface in liquid form, or they can be applied to aerosol volumes (gaseous volumes, e.g., air) or surfaces. Some chemicals such as hydrogen peroxide can also be applied to surfaces in vapor form.

In other words, among the disinfection methods in the state of the art, disinfectant chemicals solutions are used to clean surfaces, or the vapors/aerosols of the disinfectant chemicals are applied to surfaces or volumes. Both options are susceptible to user errors because when the concentrations of solution, vapor or aerosol mixtures are inadequate, or when the mixtures are not consumed in sufficient quantities, the efficiency is insufficient, and when the concentration of the chemical or the amount of consumption of the mixture is excessive, it may cause harm to the environment or health or at least cause irritating effects such as odor.

When a chemical is used as a disinfectant, in addition to the disadvantages above, the rate of impact remains quite low since there is no feedback mechanism.

Chemical agents have limited effectiveness in disinfection. For example, when using a hydrogen peroxide solution, the disinfection rate cannot exceed 90% although it varies depending on the hydrogen peroxide concentration in the solution. For the disinfection of the bacteria or especially the viruses that are exposed to hydrogen peroxide, the contact time of hydrogen peroxide with the microorganism or especially the virus, i.e., the application time, requires a long period of time such as 150 minutes.

In addition, it is not possible to use automation systems effectively in any one of the above-mentioned methods.

For the reasons listed above, there is still a need for further improvements in the disinfection field.

Objects of the Invention

Principal object of the invention is to provide solutions to the problems mentioned in the prior art.

Another object of the invention is to provide a disinfection device, system and method that are easy to manufacture, cost-effective and have a high disinfection efficiency.

Another object of the invention is to provide a disinfection device, system and method that are harmless to the environment and health while having a high disinfection efficiency.

Brief Description of the Drawings

The drawings, whose brief description is provided below are just given for better understanding of the present invention and as such, are not intended to determine the scope of the claimed subject matter, in the absence of the description, wherein:

Figure 1 shows a generally spherical structure of a virus (envelope) sampled from a coronavirus and an original diameter of this sphere.

Figure 2 shows an instantaneous local diameter smaller than the original diameter resulting from an instantaneous compression of said spherical structure when the same virus resonates in the electromagnetic field in an appropriate frequency range.

Figure 3 shows an exemplary layout of a device according to the present invention in a volume sampled from a room.

Figure 4 represents a disintegration and inactivation of a virus falling into the electromagnetic field of the microwaves emitted by the device, wherein the device in Fig. 3 is activated.

Figure 5 shows an exemplary layout of a system comprising a plurality of devices according to the present invention, in a volume sampled from a room.

Figure 6 represents a disintegration and inactivation of viruses falling into the microwave electromagnetic fields emitted by the devices, wherein a plurality of devices incorporated into the system in Fig. 5 are activated.

Figure 1 is a schematic block diagram illustrating the elements that can be incorporated into an example of the device according to the present invention.

Figure 2 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Figure 3 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Figure 4 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Figure 5 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Figure 6 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Figure 7 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Figure 8 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Figure 9 is a schematic block diagram illustrating the elements that can be incorporated into another example of the device according to the present invention.

Summary of the Invention

Microwave technology is used in telecommunications, radar, and for heating objects/surfaces. However, it is not used for disinfection.

With the present invention, microwave technology has been put into use for disinfection. Thus, it is made possible to reduce or eliminate the deficiencies and problems resulting from the disinfection methods in the prior art.

Detailed Description of the Invention

Each object has a natural frequency depending on its various mechanical properties. When subjected to a force from an electromagnetic field at this frequency, the objects start to vibrate. This causes said objects to resonate. The present improvement serves to put these effects into use.

Figure 1 shows a generally spherical structure of a virus (envelope) sampled from a coronavirus and an original diameter (D1) of this sphere. Figure 2 shows an instantaneous local diameter (D2) smaller than the original diameter (D1) resulting from an instantaneous compression of said spherical structure when the same virus resonates in an electromagnetic field in an appropriate frequency range. Since the instantaneous local diameter (D2) is smaller than the original diameter (D1), the internal volume of the sphere is not sufficient to contain the biological material within the envelope, thus the envelope is damaged, which is visually represented as a crack. As a result of the damage, the virus becomes ineffective, thus disinfection is successful.

According to the present improvement, the physical structures of viruses are disrupted by applying vibration at a resonance frequency with microwave technology. As shown schematically in Fig. 2, Fig. 4 and Fig. 6, the virus entering the impact area of the microwave (active electromagnetic field (F)) is subjected to mechanical stress, the original diameter (D1) of the generally spherical envelope (the protein-lipid layer enclosing the biological materials in the virus, e.g. RNA and enzymes) may decrease locally and instantaneously to 75% of its original value, thereby yielding instantaneous local diameter (D2) values having an instantaneous low value. Assuming that the envelope represents a sphere surface and this surface has a constant area, it is clear that the highest value of the volumetric capacity, which is supposed to contain the biological material within the envelope, corresponds to the geometry of the sphere. The envelope capacity of the spherical geometry can be referred to as the original capacity. In cases where the geometry of the sphere is crushed and instantly takes, for example, the form of a geoid, or, for example, has an elliptical cross-section (see Fig. 2), an instantaneous volumetric capacity that the surface can compensate is below the original capacity. In this case, the envelope will be torn as symbolized in Fig. 2 and the virus will become ineffective. Thus, disinfection is achieved. The electromagnetic field having the characteristics (electromagnetic field intensity, wavelength, energy, power density) suitable for ensuring disinfection is called "effective electromagnetic field (F)" in the context of this specification. The effective electromagnetic field (F) is made possible by the disinfection device, briefly the device (100) comprising at least one antenna or magnetron arranged to emit microwave radiation in a frequency range of 8 GHz to 9.5 GHz. For indoor health safety, in an embodiment, the device (100) includes at least one antenna or magnetron configured to provide a power density of 564 W/m^2 or less, for example at a distance of 1 m from the antenna. The power density in W/m^2 can be calculated according to the following Formula-1, for frequency values in the range of 3 GHz to 96 GHz in the case of dry air and for a distance in the range of 0 to 5 m from the antenna/magnetron surface. Wherein, f is the frequency value in GHz. The result from the formula can be adapted by the methods known in the relevant technical field, taking into account the dielectric coefficients of the environments other than dry air:

Formula-1 Power density $(W/m^2) = 100\ (f/3)^{1/5}$

Therefore, the power density values that are provided by the frequency ranges preferred within the scope of the present specification are even below 126 W/m^2 and are sustainable for human health.

In an outdoor environment, for example, in the disinfection of squares, country border lines, etc. or in the disinfection of large areas such as factories when there is no one around, it may not be necessary to rely on these power density values. In such cases, it is not necessary to adhere to the power density upper limits specified in IEEE or other standards.

For example, viruses in spherical form with a diameter (D1) of around 120 nm (80 to 140 nm), such as SARS-COV-2, (for example) experience instant shrinkage/compression of approximately 30nm such that the envelope is crushed, and the envelope is torn, when exposed to microwaves, preferably in the frequency range of 8 GHz to 9.5 GHz (gigahertz). In this way, the virus population becomes ineffective such that the disintegrated part is not below 95%. Thus, the area where the microwaves are applied is disinfected with an efficiency higher than 95%. When said frequency is kept in the range of 8.2 GHz to 8.8 GHz, the efficiency is not below 98%. Therefore, said frequency range is preferably 8.2 GHz to 8.8 GHz, for which the device (100) preferably includes at least one antenna or magnetron arranged to emit microwave radiation in this range. When the frequency is kept in the range of 8.3 GHz to 8.5 GHz (around 8.4 GHz), the efficiency is practically 100%. Therefore, viruses in spherical form with a diameter of around 120 nm (in the range of 80 to 140 nm) can be disintegrated with 100% efficiency using the present technical improvement, and the environment can be completely disinfected. Therefore, in a more preferred embodiment, said frequency range is in the range of 8.3 GHz to 8.5 GHz; in order to ensure it, the device (100) includes at least one antenna or magnetron arranged to emit microwave radiation in this range.

Although a peak frequency is 8.2 GHz, an electromagnetic radiation absorption occurs by 10% to 20% in the frequency range of 6 GHz to 12 GHz. In this frequency range, depending on the microwave frequency emitted in dry air under standard conditions, an electric field is generated in the range of 86.9 V/m to 236.3 V/m. The power equivalent of this electric field density corresponds to a power density in the range of 82.3 W/m^2 to 564 W/m^2, which is below the limit values mentioned in the IEEE standard; that is, it does not cause harm to human health.

The V/m value and W/m^2 values are to be understood to mean an electric field (V/m) (i.e., power density) and electromagnetic power (W/m^2) (i.e., magnetic field density or power density), emitted by a device according to the following standards or to which a device is exposed during operation. For example, Table 1 below can be taken into account for power density and magnetic field density limits at given frequencies.

Table 1. Power density (V/m) and electromagnetic (EM) field density (nT, i.e., nanoTesla) limit values for various frequency ranges (measuring bands) (Hz, i.e., Hertz, i.e., 1/s).

Measuring Band (Hz)	Power density (V/m)	EM field density (nT)
6 – 2000	4.397 +/- 0.053	534.5 +/- 20.4
30 – 2000	3.464 +/- 0.024	534.0 +/- 11.3
5 – 32000	5.734 +/- 0.036	562.6 +/- 34.4
30 – 32000	5.451 +/- 0.019	540.2 +/- 10.7

As illustrated in Table 1, since the frequencies of general use are low frequencies, for high frequencies in the order of GHz, especially used for microwave devices, the following IEEE standards are taken into account:

- IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, C95.1–1991, and
- IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields — RF and Microwave, IEEE C95.3–1991 can be considered.

A comment on these standards is available in the article available at https://www.who.int/peh-emf/meetings/southkorea/IEEE%20EMF%20HEALTH%20-%20Mason.pdf, as from the filing date of the present application.

For the range of 30MHz-6GHz, the IEEE standard for calculating SAR values can be accessed at https://standards.ieee.org/standard/1528-2013.html.
For the range of 4MHz-10GHz, the IEEE preliminary standard for calculating SAR values can be accessed at https://standards.ieee.org/project/62209-1528.html.

With respect to the electromagnetic compatibility for the device, system and method of the present improvement, the versions of the following standards may be considered which were valid at the time of application: EN61000-4-2, EN61000-4-4, EN61000-4-5, EN61000-4-6, EN61000-4-11.

Figure 7 is a schematic block diagram illustrating the elements that can be incorporated into an example of the device according to the present invention. Wherein, the device (100) includes one (or more) control units (2) associated with a power supply, one (or more) presence sensors (8) to cooperate with the control unit, one (or more) automation interfaces (9) to cooperate with the control unit and one (or more) notification means (10) to cooperate with the control unit. In this exemplary embodiment, there is a phase lock loop (3) and a voltage control oscillator (4), which are interconnected in a group (18) to cooperate with the control unit (2). There is a reference crystal (5) cooperating with the group (18). The group (18) is also connected to a power amplifier (7) through a band-pass filter (6), while the power amplifier (7) is connected to the antenna (1).
In the respective embodiments, the control unit (2) can be, for example, a multipoint control unit (MCU). In the respective embodiments, the presence sensor (8) may be, for example, an LDR, i.e., a photosensitive sensor. Alternatively, or additionally, the device may also include a motion sensitive presence sensor (8). In the respective embodiments, the automation interface (9) may be BACNET mstp / Modbus RTU / MqTT; or a wireless communication module, e.g., a Bluetooth (wi fi, zigbee etc.) module. In the respective embodiments, the notification means (10) may be, for example, a light indicator (e.g.,

LED), and/or an audio indicator including a sound generator. In the respective embodiments, the antenna (1) may be a patch antenna.

Figure 8 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. Wherein, the device (100) includes one (or more) control units (2) associated with a power supply, one (or more) presence sensors (8) to cooperate with the control unit, one (or more) automation interfaces (9) to cooperate with the control unit and one (or more) notification means (10) to cooperate with the control unit. In this exemplary embodiment, there is a phase lock loop (3), a voltage control oscillator (4) and a reference crystal (5), which are interconnected in a group (18) to cooperate with the control unit (2). The group (18) is also connected to a power amplifier (7) through a band-pass filter (6), while the power amplifier (7) is connected to the antenna (1).

Figure 9 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. In this exemplary embodiment, the device (100) includes one (or more) control units (2), a phase lock loop (3), a voltage control oscillator (4), and a reference crystal (5), which are interconnected in a group (18) associated with a power supply. There is one (or more) presence sensors (8), one (or more) automation interfaces (9) and one (or more) notification means (10), each is to cooperate with said group (18). The group (18) is also connected to a power amplifier (7) through a band-pass filter (6), while the power amplifier (7) is connected to the antenna (1).

Figure 10 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. In this exemplary embodiment, the device (100) includes one (or more) control units (2), a phase lock loop (3), a voltage control oscillator (4), and a reference crystal (5), as well as a band-pass filter (6) associated with the phase lock loop, which are interconnected in a group (18) associated with a power supply. There is one (or more) presence sensors (8), one (or more) automation interfaces (9) and one (or more) notification means (10), each is to cooperate with said group (18). The group (18) is also connected to a power amplifier (7), while the power amplifier (7) is connected to the antenna (1).

Figure 11 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. In this exemplary embodiment, unlike to the embodiment in Fig. 7, there is a digital direct synthesis (12) mechanism instead of the phase lock loop (3), the voltage control oscillator (4) and the reference crystal (5).

Figure 12 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. In this exemplary embodiment, unlike to the embodiment in Fig. 11, there is a dielectric resonance oscillator (13) instead of the digital direct synthesis (12) mechanism.

Figure 13 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. In this exemplary embodiment, unlike to the embodiment in Fig. 12, there is a Gunn diode (14) and an external power supply (16) supplying the former, instead of the dielectric resonance oscillator (13).

Figure 14 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. In this exemplary embodiment, unlike to the embodiment in Fig. 13, there is a general oscillator circuit (15) instead of the Gunn diode (14).

Figure 15 is a schematic block diagram illustrating the elements that can be incorporated into the context of another example of the device according to the present invention. In this exemplary embodiment, unlike to the exemplary embodiments shown in Fig. 7 to Fig. 9, there is one (or more) magnetron (17) instead of the antenna (1). As exemplified herein, the magnetron (17) can be directly connected with the control unit (2).

An exemplary operation of the device (100) (and thus a system comprising a plurality of devices (100)) and a corresponding exemplary disinfection method are presented below:

– Testing the suitability of ambient conditions to initiate a disinfection process:

A volume that will fall into the effective electromagnetic field (F) when the device (100) is activated, i.e., the volume to be scanned by the antenna (1) or the magnetron (17), will be referred to as the "environment".

The human "presence" in the environment corresponds to the motion of other movable living creatures such as humans or pets. The presence status can be monitored with the presence sensor (8). If the presence status is negative, i.e., if there is no human (or mammal) in the environment, it is allowed to activate the device (1), i.e., the ambient conditions are suitable for disinfection. When the conditions are suitable, the device (100) can be automatically activated.

Alternatively, or additionally, the device (100) may be automated such that it is automatically activated between the predetermined activation hours, in which the conditions are predicted to be suitable. The presence sensor (8) is not necessary for this mode of operation, said function can be provided by providing the device (100) with a time relay (not shown), for example. The device (100) works in its automated or non-automated state, even if the presence sensor (8) is not present.

A device provided with a presence sensor (8) is preferred in that it is suitable for automatization with increased security. Thus, the device (100) will not be activated in cases where the suitability of the environment is not as predetermined, for example there is an unexpectedly positive presence in the environment, so that health safety will be more precisely ensured.

– Visual and/or aural monitoring of the instant status of the device (100):

Whether or not the device (100) has been activated can be indicated by one (or more) notification means (10). Preferably, in addition, whether the power input (11) is enabled/connected so that the device (100) is suitable to be activated can also be indicated by said one (or more) notification means (10). Each of these states can be provided with different visual and/or audio notification codes, so the device (100) may be configured to provide this. When the device is activated, in a first mode, for example, in an embodiment where the notification means (10) is a visual one (for example, including a LED or a display screen), each of the states/modes may be indicated with a color code different from the other or by having a notification light on, blinking, off. For example, in an embodiment wherein the notification means (10) is a visual one (for example, including a LED or a display screen), a green light may be illuminated if the device (100) is in passive state (the device is not activated, no disinfection is performed, power is supplied), a yellow light may be illuminated if the environment needs to be cleaned (e.g. if the device has not been activated for a while) and a red light may be illuminated if the device is activated (in disinfection mode), to visually indicate the status of the device.

Alternatively, or additionally, for example, in an embodiment wherein the notification means (10) is an aural one (e.g., equipped with a sound generator), an audible notification may be released to the environment more frequently or continuously when the device (100) is activated than the time when the device (100) is not activated. In this case, it can be understood from outside of the environment (for example, a room equipped with the device) that the device (100) has been activated, and said notification can be evaluated as a warning stating that "do not enter!", so that health safety can be improved. In such an embodiment, thanks to the aural notification, even if the notification means (10) is not capable of emitting visual notification, even if the device (100) or the system is not automated, health safety can be provided at a very low cost.

Based on the above examples, said one or more notification means may be configured to act in a first notification mode in which the device is in a passive mode where it does not emit said microwave radiation although it is energized, and in a second notification mode different from the first notification mode in which the device is energized and is in an active mode where it emits said microwave radiation. In addition, said one or more notification means may be configured to act in a third notification mode different from said first notification mode and second notification mode, in which the device is in a standby mode where it does not emit said microwave radiation even though it is energized, but it is time to perform a disinfection. In addition, said one or more notification means may be configured to act in a fourth notification mode that is different from the others, in the event of a power failure.

– Disinfection process:

As can be inferred from the examples in Fig. 7 to Fig. 15, the device (100) obtains the energy required for its operation and activation from a power input (11). For example, with the triggering of the presence sensor (8) and/or a timer, the control unit (2) (for example, an MCU provided inside the device) generates a signal when the conditions suitable for activating the device (100) are materialized.

With this signal, a magnetron (17) emits electromagnetic waves, providing an effective electromagnetic field (F).

If the device (100) is equipped with an antenna (1) (i.e., microwave antenna) instead of a magnetron (17), the signal can be filtered through a band-pass filter (6) in order for the device (100) to operate at the appropriate frequency to generate an effective magnetic field, and the filtered signal is amplified by a power amplifier (7), for example, and sent to the antenna, and the antenna emits electromagnetic waves to provide an effective electromagnetic field.

– Terminating the disinfection process:

The device (100) may be equipped with a timer arranged to deactivate it by cutting the radiation of electromagnetic waves after a predetermined period of time.

Figure 3 shows an exemplary layout of a device (100) according to the present invention in a volume sampled from a room. Objects in the form of tables, chairs, walls, ceilings and floors as illustrated in all the drawings through Figs. 3 to 6 represent surfaces that can be targeted for disinfection.

Figure 4 represents a disintegration and inactivation of a virus (V) falling into the effective electromagnetic field (F) of the microwaves emitted by the device, wherein the device (100) in Fig. 3 is activated. The virus population in the volumes and on the surfaces falling into the effective electromagnetic field (F) of the device is disintegrated, and a local disinfection is carried out within the area in question. In the context of this specification, the term effective electromagnetic field (F) refers to the microwave electromagnetic field having the characteristics suitable to ensure that:

- the envelope of the viruses in spherical form with a diameter of around 120 nm (in the range of 80 to 140 nm) such as SARS-COV-2, is subjected to an instant shrinkage/compression of about 30nm so that the viruses are crushed and their envelopes are torn, thereby providing disinfection.

Figure 5 shows an exemplary layout of a system comprising a plurality of devices (100) according to the present invention, in a volume sampled from a room. The elements as illustrated in the drawing as tables, chairs, walls, ceilings and floors represent surfaces that can be targeted for disinfection. Said layout can be arranged to ensure that, in the activated state, the electromagnetic fields of the discrete devices (100) are spliced or overlapped with each other such that a continuous effective electromagnetic field (F) is obtained.

Figure 6 represents a disintegration and inactivation of viruses falling onto the microwave electromagnetic fields emitted by the devices (100), wherein a plurality of devices (100) in the system in Fig. 5 are activated. When the devices (100) in the system are disposed in such a way that their effective electromagnetic fields (F) have geometric/volumetric continuity (e.g., overlap) with each other, the system disintegrates the virus population in a respective volume (e.g., room) and on all the surfaces in this volume, and a "general disinfection" is made possible in terms of its effect on the entire volume.

With the inventive improvement, the following objectives have been achieved:

- the disadvantages in the state of the art have been eliminated, problems have been solved;
- the disinfection process can be automated;
- a contactless and residue-free disinfection is possible without using any chemicals;
- a disinfection can be performed without requiring a mechanical contact with the surface;

- it is possible to inactivate viruses not only on the surfaces but also in the volumes (air) corresponding to the effective electromagnetic field (F);
- an effective disinfection (inactivation of 95% or more of the virus population in the effective magnetic field) can be completed in 15 minutes (which may be longer or shorter depending on the virus density), which is much shorter than 150 minutes as required in the state of the art;
- the aim of neutralizing 99.9% or more of the virus population in the effective magnetic field can be achieved, which is very high compared to the maximum disinfection efficiency of 90% that can be achieved with chemical disinfectants.

Reference numerals:

1	antenna
2	control unit
3	phase lock loop
4	voltage control oscillator
5	reference crystal
6	band-pass filter
7	power amplifier
8	presence sensor
9	automation interface
10	notification means
11	power inlet
12	digital direct synthesis
13	dielectric resonance oscillator
14	Gunn diode
15	general oscillator circuit
16	external power supply
17	magnetron
18	group
100	device
D1	original diameter

D2	instantaneous local diameter
F	effective electromagnetic field

CLAIMS

1. A disinfection device (100), comprising at least one antenna (1) or magnetron (17) arranged to emit microwave radiation in a frequency range of 8 GHz to 9.5 GHz.

2. The device (100) according to claim 1, comprising at least one antenna (1) or magnetron (17) arranged to emit microwave radiation in the range of 8.2 GHz to 8.8 GHz.

3. The device (100) according to any one of claim 1 or 2, comprising at least one antenna (1) or magnetron (17) arranged to emit microwave radiation in the range of 8.3 GHz to 8.5 GHz.

4. The device (100) according to any one of claims 1 to 3, comprising at least one antenna (1) or magnetron (17) configured to provide an electromagnetic field intensity of 564 W/m^2 or less at a distance of 1 m.

5. The device (100) according to any one of claims 1 to 4, comprising one or more notification means (10) that emit visual and/or aural notifications.

6. The device (100) according to claim 5, wherein said one or more notification means (10) are configured to act in a first notification mode in which the device (100) is in a passive mode where it does not emit said microwave radiation although it is energized, and in a second notification mode different from the first notification mode in which the device (100) is energized and is in an active mode where it emits said microwave radiation.

7. The device (100) according to claim 6, wherein said one or more notification means (10) are configured to act in a third notification mode different from said first notification mode and second notification mode, in which the device (100) is in a standby mode where it does not emit said microwave radiation even though it is energized, but it is time to perform a disinfection.

8. The device (100) according to any one of claims 5 to 7, wherein said one or more notification means (10) comprise one or more LEDs.

9. The device (100) according to any one of claims 1 to 8, comprising one or more presence sensors (8).

10. The device (100) according to claim 9, wherein said one or more presence sensors (8) comprise a photosensitive sensor.

11. The device (100) according to claim 9, wherein said one or more presence sensors (8) comprise a motion sensitive sensor.

12. The device (100) according to any one of claims 1 to 11, wherein the device (100) is provided with an automation interface (9) configured to enable it to be activated when predetermined suitability conditions are materialized and to be deactivated when a predetermined disinfection period is completed.

13. A system comprising a plurality of devices (100) according to any one of claims 1 to 12.

14. A method for disinfecting viruses having envelopes with an original diameter (D1) in the range of 80 to 140 nm, comprising exposing an environment to microwave radiation in a frequency range of 8 GHz to 9.5 GHz.

15. The method according to claim 14, comprising exposing said environment to microwave radiation in a frequency range of 8.2 GHz to 8.8 GHz.

16. The method according to any of claims 14 or 15, comprising exposing said environment to microwave radiation in a frequency range of 8.3 GHz to 8.5 GHz.

17. The method according to any of claims 14 to 16, comprising exposing said environment to microwave radiation at a frequency of 8.4 GHz.

18. The method according to any one of claims 14 to 17, comprising applying said microwave radiation from an antenna or a magnetron to provide an electromagnetic field intensity of 564 W/m^2 or less at a distance of 1 m.

19. The method according to any one of claims 14 to 17, comprising starting said microwave radiation taking into consideration the suitability of the environment and terminating it at the end of a predetermined disinfection period.

20. The method according to claim 19, wherein said suitability of the environment comprises detecting an impact area of microwave radiation using a motion sensor and/or photosensitive sensor.

FIGURE 1

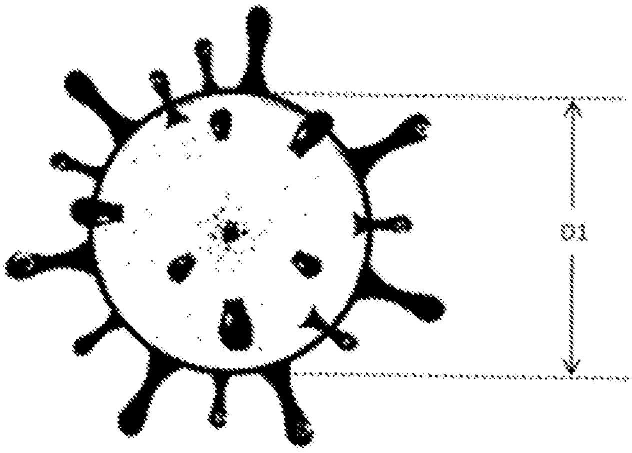


FIGURE 2

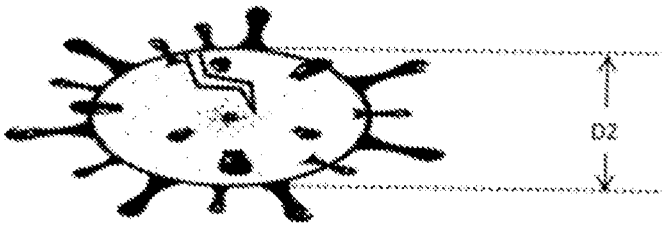


FIGURE 3

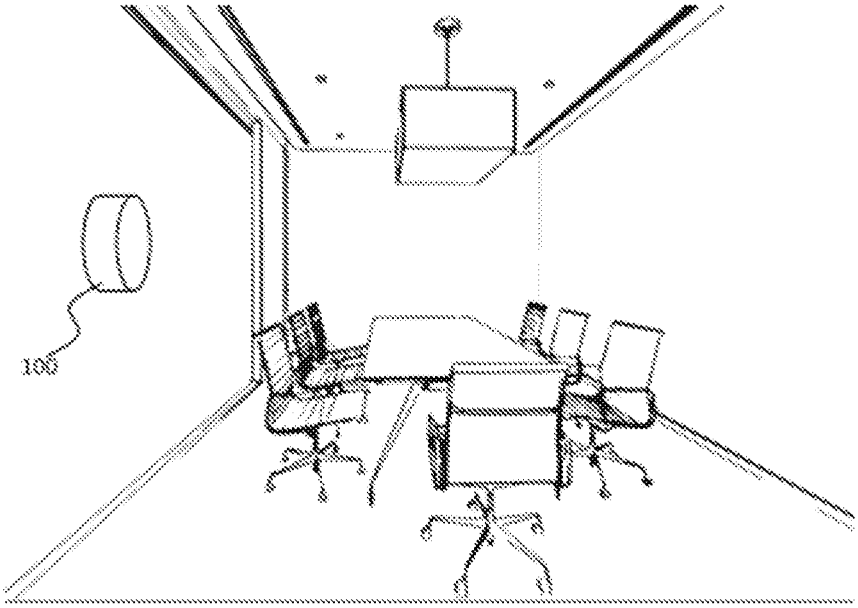


FIGURE 4

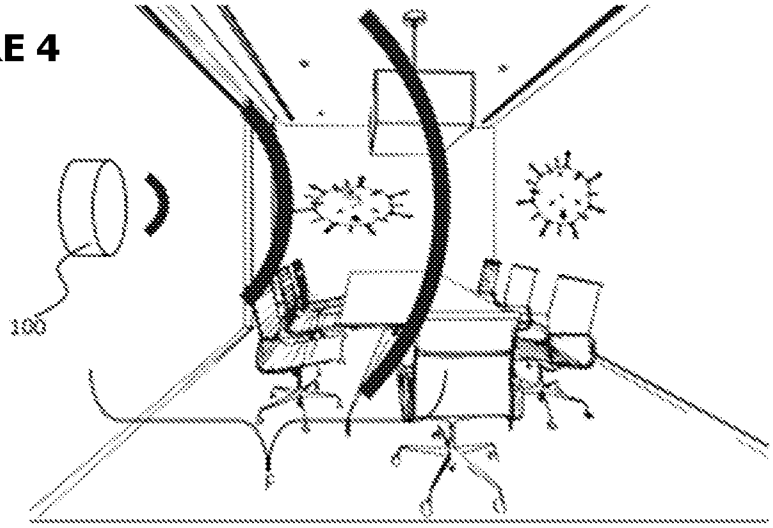


FIGURE 5

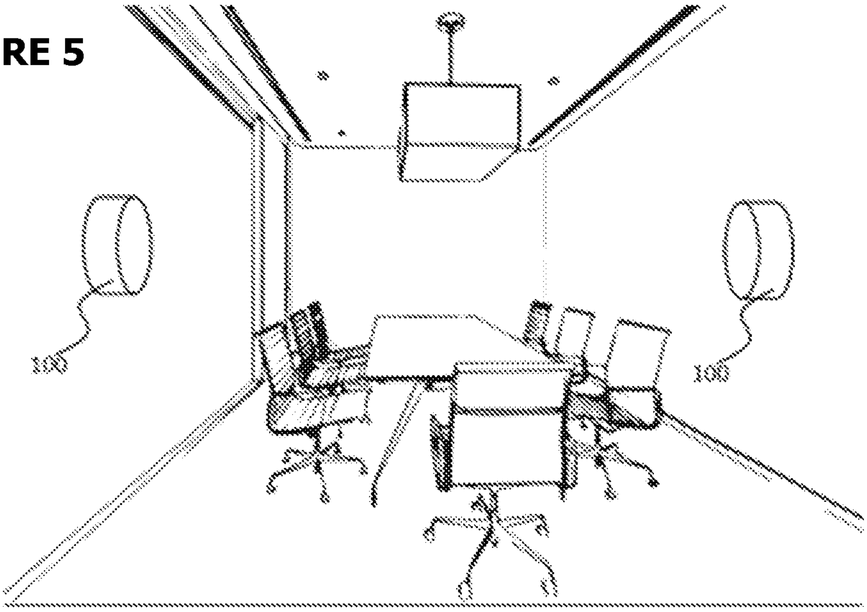


FIGURE 6

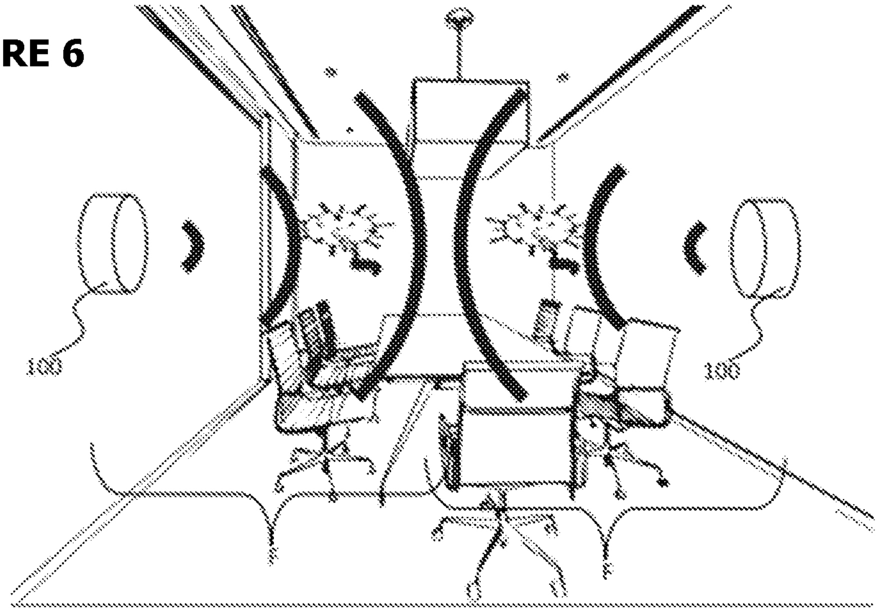


FIGURE 7

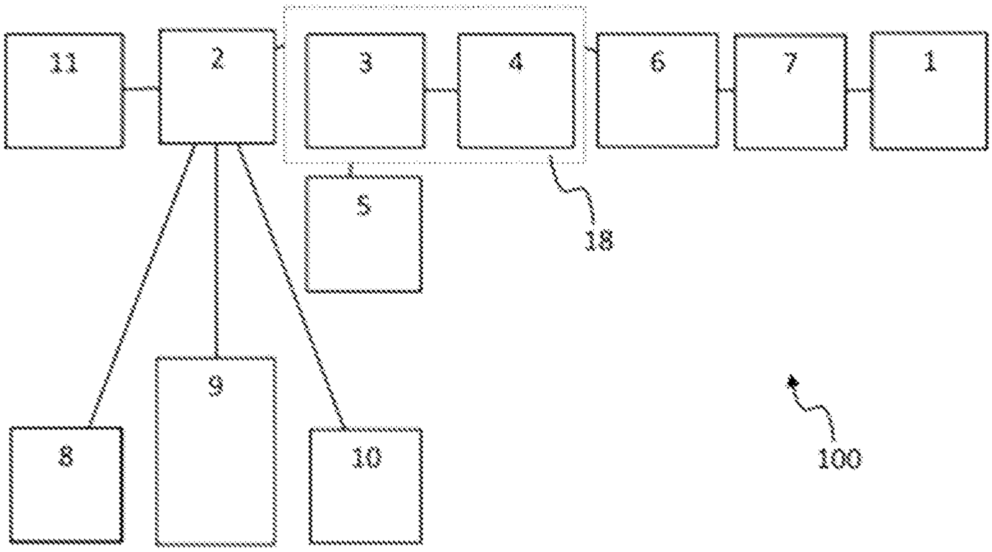


FIGURE 8

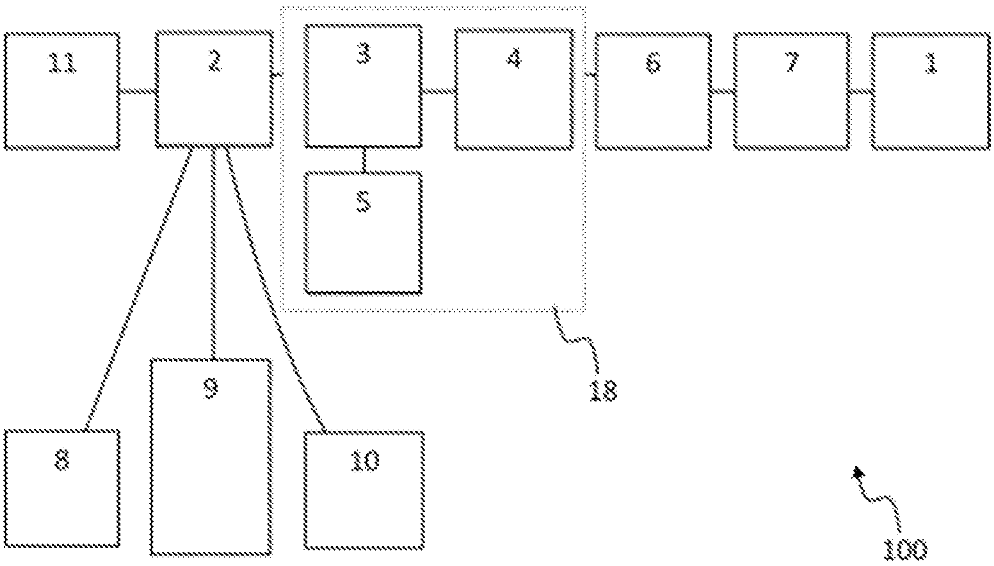


FIGURE 9

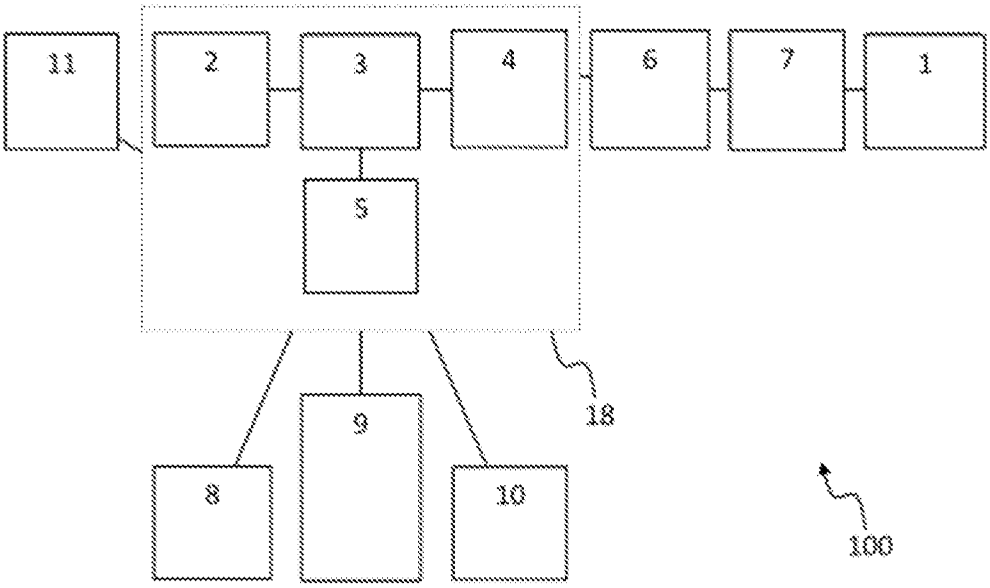


FIGURE 10

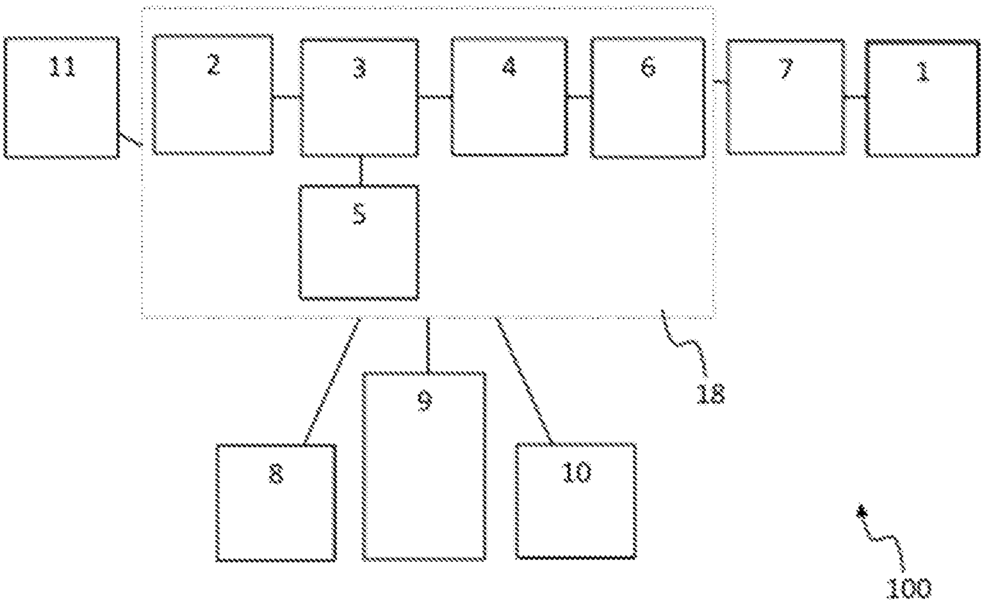


FIGURE 11

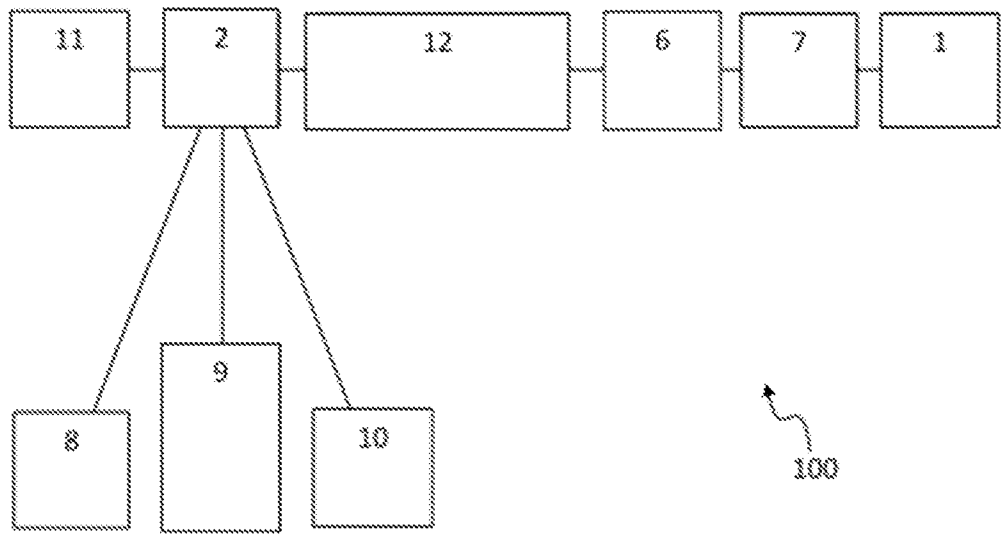


FIGURE 12

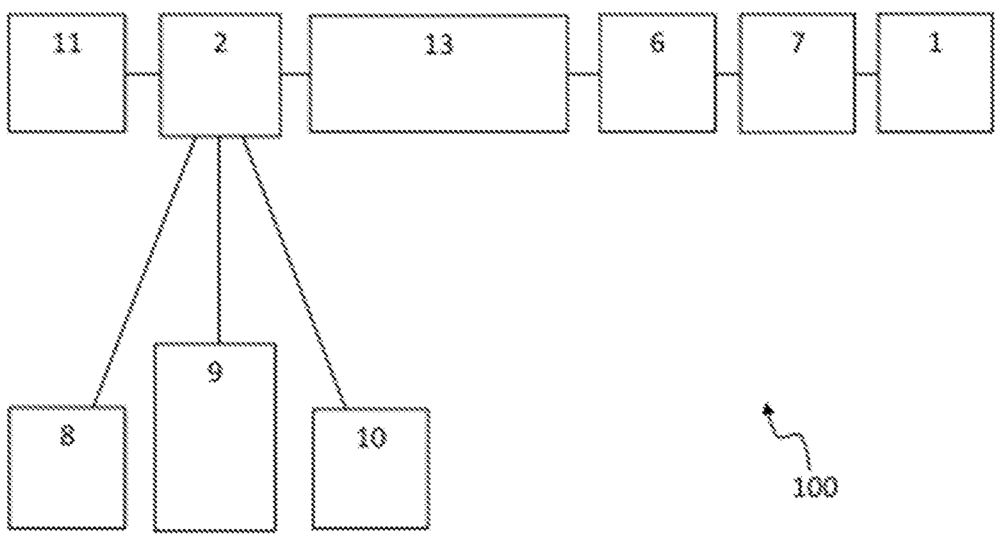


FIGURE 13

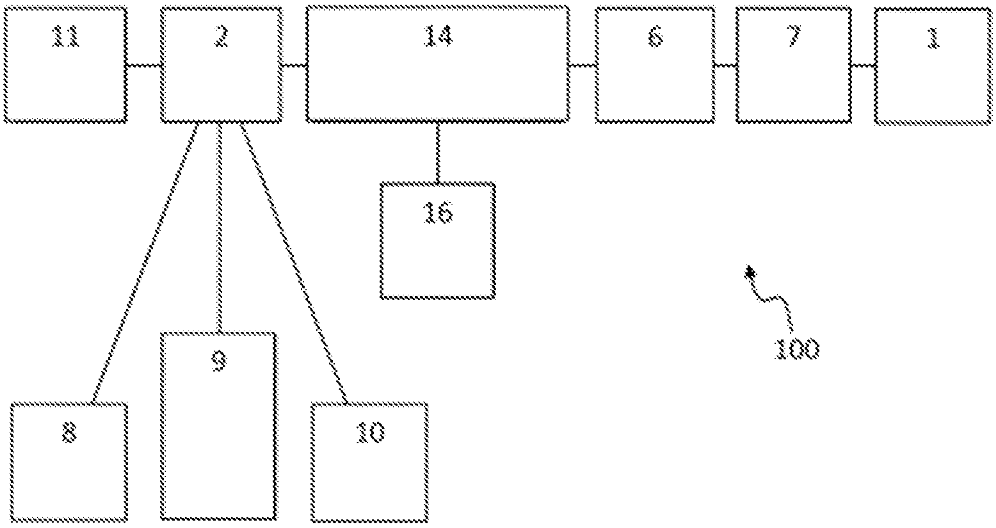


FIGURE 14

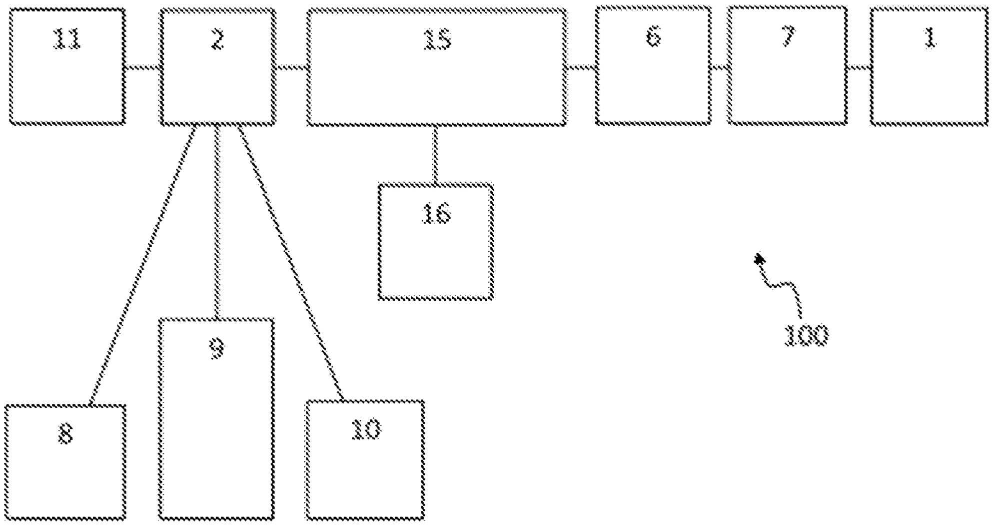
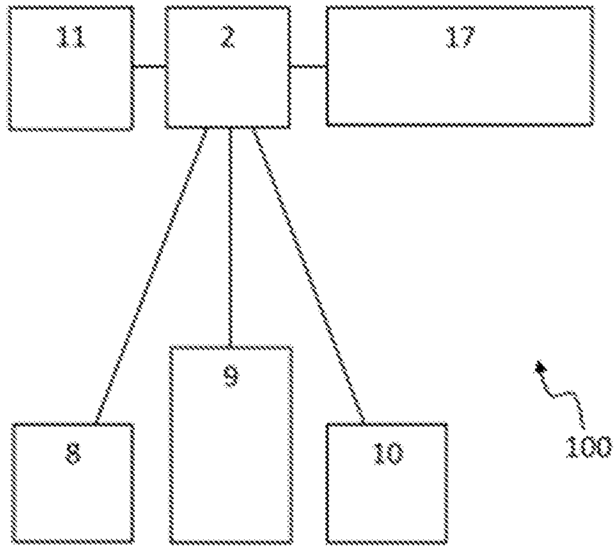


FIGURE 15



INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR2021/050307

A. CLASSIFICATION OF SUBJECT MATTER

A61L 2/12 (2006.01)i

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)

A61L

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 practicable, search terms used)

EPODOC, Google Patents, Espacenet Keywords: microwave, disinfection, sterilization, antenna, magnetron, frequency

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Yang et al., "Efficient Structure Resonance Energy Transfer from Microwaves to Confined Acoustic Vibrations in Viruses", Scientific Reports volume 5: 18030, 09 December 2015 (2015-12-09)	1-20
X	CN 200945263Y Y (ZHANG JILI [CN]) 12 September 2007 (2007-09-12) The whole document	1-20
X	CN 101732741 A (UNIV CHINA AGRICULTURAL) 16 June 2010 (2010-06-16) The whole document	1-20
A	US 2017246331 A1 (LLOYD RALPH BIRCHARD [US]) 31 August 2017 (2017-08-31) paragraphs [0067], [0070], [0074], [0144]	1-20

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"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
16 July 2021	**16 July 2021**

Name and mailing address of the ISA/TR	Authorized officer
Turkish Patent and Trademark Office (Turkpatent) **Hipodrom Caddesi No. 13** **06560 Yenimahalle** **Ankara** **Turkey** Telephone No. **(90-312) 303 11 82** Facsimile No. **+903123031220**	**Nurhan ÖZTÜRK** Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/TR2021/050307

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	200945263Y	Y	12 September 2007	NONE			
CN	101732741	A	16 June 2010	NONE			
US	2017246331	A1	31 August 2017	WO	2017147460	A1	31 August 2017
				WO	2017147433	A1	31 August 2017
				US	2017246329	A1	31 August 2017
				US	10639390	B2	05 May 2020
				US	2020254125	A1	13 August 2020