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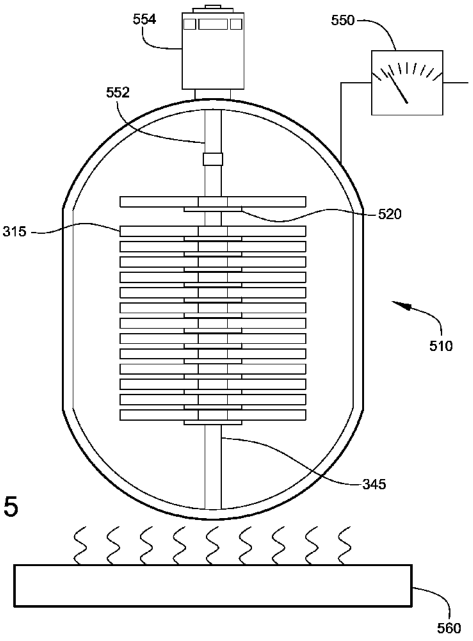

FIG. 5

(57) **Abstract:** Hydrogen energy systems for obtaining hydrogen gas from a solid storage medium using controlled laser beams. Also disclosed are systems for charging/recharging magnesium with hydrogen to obtain magnesium hydride. Other relatively safe systems assisting storage, transport and use (as in vehicles) of such solid storage mediums are disclosed.

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HYDROGEN ENERGY SYSTEMS

BACKGROUND

This invention relates to providing hydrogen energy systems. More particularly, this invention relates to providing hydrogen energy systems using magnesium hydride for hydrogen storage. Even more particularly, this invention relates to such hydrogen energy systems using laser excitation to assist adsorption of hydrogen gas from the magnesium hydride.

In using hydrogen energy systems, it is difficult to safely store hydrogen gas for use in providing energy for systems, such as vehicles, given the highly combustible nature of hydrogen. Thus, it would be useful to provide safe storage of hydrogen energy near a location where hydrogen gas will be used for energy purposes.

OBJECTS AND FEATURES OF THE INVENTION

A primary object and feature of the present invention is to provide a system overcoming the above-mentioned problem.

It is a further object and feature of the present invention to provide such a hydrogen energy system wherein such magnesium hydride may be safely stored.

Another object and feature of the present invention is to provide such magnesium hydride in the form of a “disk” resembling a CD. Yet another object and feature hereof is to provide a laser system to cooperate with the magnesium hydride disk to provide release of hydrogen gas therefrom.

Another object and feature of the present invention is to provide controlled coherent light energy to successive portions of a surface of such magnesium hydride disk to provide controlled release of hydrogen gas.

Another object and feature of the present invention is to provide a system for recharging such disks with hydrogen after such controlled release of hydrogen gas.

Another object and feature of the present invention is to provide hydrogen energy for at least one vehicle, preferably an automobile, in the form of hydrogen gas controllably released from such storage in magnesium hydride disks.

A further primary object and feature of the present invention is to provide such hydrogen energy systems that are efficient, inexpensive, and handy. Other objects and features of this invention will become apparent with reference to the following descriptions.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment hereof, this invention provides a process, relating to controlled commercial use of hydrogen gas, comprising the steps of: providing at least one supply of hydrogen gas; and providing at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma; wherein such at least one supply of hydrogen plasma is formed adjacent to at least one metal surface portion capable of storing hydrogen; and wherein such at least one metal surface portion absorbs hydrogen from such at least one supply of hydrogen plasma to form at least one metal hydride; and providing at least one hydrogen storer structured and arranged to store, using such at least one metal hydride, at least one substantial amount of hydrogen so as to permit photonic-excitation-assisted release of stored hydrogen; using at least one photonic exciter to photonically excite such at least one hydrogen storer to assist release of such stored hydrogen as hydrogen gas; and controlling such photonic-excitation-assisted release of such hydrogen gas so as to assist at least one commercial use.

In accordance with another preferred embodiment hereof, this invention provides a hydrogen energy system comprising: at least one hydrogen storer structured and arranged to store at least one substantial amount of hydrogen; wherein such at least one hydrogen storer comprises at least one hydrogen-release permitter structured and arranged to permit photonic-excitation-assisted release of stored hydrogen from such at least one hydrogen storer; and at least one photonic exciter structured and arranged to photonically excite such at least one hydrogen storer to assist release of such stored hydrogen from such at least one hydrogen storer; wherein such at least one photonic exciter comprises at least one controller structured and arranged to control such photonic-excitation-assisted release of hydrogen gas so as to assist at least one commercial use.

In accordance with a preferred embodiment hereof, this invention also provides a hydrogen energy system comprising: at least one hydrogen storer structured and arranged to store at least one substantial amount of hydrogen; wherein such at least one hydrogen storer comprises at least one hydrogen-release permitter structured and arranged to permit photonic-excitation-assisted release of stored hydrogen from such at least one hydrogen storer; and at least one photonic exciter structured and arranged to photonically excite such at least one hydrogen storer to assist release of the stored hydrogen from such at least one hydrogen storer; wherein such at least one photonic exciter comprises at least one controller structured and arranged to control photonic-excitation-assisted release of hydrogen; and at least one hydrogen collector structured and arranged to assist collection of released hydrogen; wherein hydrogen may be stored in such at least one hydrogen storer until controllably released to permit use as desired.

Moreover, it provides such a hydrogen energy system wherein such at least one photonic exciter comprises at least one wavelength of light between about 530nm and about 1700nm. Additionally, it provides such a hydrogen energy system wherein such at least one photonic exciter comprises at least one wavelength of light of about 784nm. Also, it provides such a hydrogen energy system wherein such at least one photonic exciter comprises at least one power between about 200mW and about 2000mW. In addition, it provides such a hydrogen energy system wherein such at least one photonic exciter comprises at least one power of about 200mW.

And, it provides such a hydrogen energy system wherein such at least one hydrogen collector comprises at least one negative pressure environment. Further, it provides such a hydrogen energy system wherein such at least one negative pressure environment comprises at least one pressure between about negative one millimeter of mercury and about negative two atmospheres. Even further, it provides such a hydrogen energy system wherein such at least one negative pressure environment comprises at least one pressure of about negative one atmosphere.

Moreover, it provides such a hydrogen energy system wherein such at least one photonic exciter comprises at least one beam of light with at least one radius of between about 10nm and about 2mm. Additionally, it provides such a hydrogen energy system wherein such at least one photonic exciter comprises at least one beam of light with at least one radius of about 15nm. Also, it provides such a hydrogen energy system wherein such at least one photonic exciter is structured and arranged to excite at least one portion of such at least one hydrogen storer to induce at least one temperature between about 280°C and about 390°C in such at least one portion. In addition, it provides such a hydrogen energy system wherein such at least one hydrogen storer comprises at least one hydride.

In accordance with another preferred embodiment hereof, this invention provides a hydrogen energy system comprising: at least one metal surface portion capable of absorbing hydrogen; at least one supply of hydrogen gas; and at least one electromagnetic field generator structured and arranged to generate at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma; wherein such at least one electromagnetic field generator is located in at least one position such that such at least one supply of hydrogen plasma is located in at least one second position; and at least one metal surface locator structured and arranged to locate such at least one metal surface portion within such at least one second position; wherein such at least one metal surface portion may absorb hydrogen to form at least one metal hydride surface portion.

And, it provides such a hydrogen energy system wherein such at least one electromagnetic field generator comprises: at least one microwave field generator; and at least one radio wave field generator. Further, it provides such a hydrogen energy system wherein such at least one microwave field generator comprises at least two microwave field generators.

In accordance with another preferred embodiment hereof, this invention provides a hydrogen energy system comprising: at least one hydrogen storer comprising at least one disk structured and arranged to store at least one substantial amount of hydrogen; wherein such at least one hydrogen storer comprises at least one central spin axis locator structured and arranged to locate at least one central spin axis of such at least one disk; and wherein such at least one disk may rotate about such at least one central spin axis of such at least one disk; and wherein such at least one disk comprises at least one spinner motor gripper capable of being gripped by at least one motor driven spinner; wherein such at least one spinner motor gripper is substantially concentric to such at least one central spin axis; wherein such at least one spinner motor gripper is structured and arranged to assist enabling such at least one disk to be spun about such at least one central spin axis of such at least one disk by such at least one motor driven spinner; and wherein such at least one disk is structured and arranged to spin substantially stably.

Even further, it provides such a hydrogen energy system wherein such at least one disk further comprises at least one outer diameter between about 50mm and about 150mm. Moreover, it provides such a hydrogen energy system wherein such at least one disk further comprises at least one outer diameter of about 120mm. Additionally, it provides such a hydrogen energy system wherein such at least one central spin axis locator comprises at least one diameter between about 5mm and about 15mm. Also, it provides such a hydrogen energy system wherein such at least one central spin axis locator comprises at least one diameter of about 15mm.

In addition, it provides such a hydrogen energy system wherein such at least one disk comprises at least one hydride disk. And, it provides such a hydrogen energy system wherein such at least one hydride disk further comprises at least one outer diameter between about 50mm and about 150mm. Further, it provides such a hydrogen energy system wherein such at least one hydride disk further comprises at least one outer diameter of about 120mm. Even further, it provides such a hydrogen energy system wherein such at least one central spin axis locator comprises at least one diameter between about 5mm and about 15mm. Moreover, it provides such a hydrogen energy system wherein such at least one central spin axis locator comprises at least one diameter of about 15mm.

Additionally, it provides such a hydrogen energy system wherein such at least one hydride disk comprises at least one thickness of about one millimeter. Also, it provides such a hydrogen energy system wherein such at least one hydride disk further comprises at least one metal hydride. In addition, it provides such a hydrogen energy system wherein such at least one hydride disk substantially comprises magnesium hydride. And, it provides such a hydrogen energy system wherein such at least one hydride disk comprises hydrogenated AZ31B.

Further, it provides such a hydrogen energy system wherein such at least one hydride disk further comprises at least one catalyst structured and arranged to assist hydrogenation of such at least one hydride disk. Even further, it provides such a hydrogen energy system wherein such at least one catalyst comprises nickel. Moreover, it provides such a hydrogen energy system wherein such at least one catalyst comprises palladium. Additionally, it provides such a hydrogen energy system wherein such at least one catalyst comprises titanium. Also, it provides such a hydrogen energy system wherein such at least one hydride disk comprises surface irregularities of less than about two micrometers. In addition, it provides such a hydrogen energy system further comprising at least one disk coating comprising at least one optically clear mineral oil.

And, it provides such a hydrogen energy system further comprising: at least one photonic-exciter structured and arranged to photonically excite such at least one hydrogen storer to assist release of the stored hydrogen from such at least one hydrogen storer; and wherein such at least one hydrogen storer comprises at least one hydrogen-release permitter structured and arranged to permit photonic-excitation-assisted release of stored hydrogen from such at least one hydrogen storer; and wherein such at least one photonic-exciter comprises at least one controller structured and arranged to control photonic-excitation-assisted release of hydrogen; and at least one hydrogen collector structured and arranged to assist collection of released hydrogen; and wherein hydrogen may be stored in such at least one hydrogen storer until controllably released permitting use as desired.

Further, it provides such a hydrogen energy system wherein such at least one disk comprises at least one hydride. The hydrogen energy system wherein such at least one disk is stored in at least one optically clear mineral oil. Even further, it provides such a hydrogen energy system wherein such at least one hydrogen collector further comprises at least one mineral oil condenser structured and arranged to assist collection of mineral oil vaporized during such photonic-exciter-assisted release of hydrogen.

Moreover, it provides such a hydrogen energy system further comprising: at least one hydrogen fuel user structured and arranged to use hydrogen as at least one fuel in at least one vehicle; wherein such at least one hydrogen fuel user comprises at least one energy converter structured and arranged to assist conversion of collected hydrogen through at least one energy-conversion process; and wherein such at least one energy-conversion process provides energy to operate such at least one vehicle. Additionally, it provides such a hydrogen energy system further comprising at least one hydrogen container structured and arranged to contain at least one volume of hydrogen sufficient to supply increased fuel demand from such at least one vehicle during acceleration. Also, it provides such a hydrogen energy system wherein such at least one energy converter comprises at least one combustion engine.

In addition, it provides such a hydrogen energy system further comprising at least one hydrogen container structured and arranged to contain at least one volume of hydrogen sufficient to supply increased fuel demand from such at least one vehicle during acceleration. And, it provides such a hydrogen energy system wherein such at least one energy converter comprises at least one hydrogen fuel cell.

Further, it provides such a hydrogen energy system further comprising: at least one supply of hydrogen gas; and at least one electromagnetic field generator structured and arranged to generate at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma; wherein such at least one electromagnetic field generator is located in at least one position such that the at least one supply of hydrogen plasma is located in at least one second position; and wherein such at least one hydrogen storer further comprises at least one metal surface portion capable of absorbing hydrogen; and at least one metal surface locator structured and arranged to locate such at least one metal surface portion within such at least one second position; wherein such at least one metal surface portion may absorb hydrogen to form at least one metal hydride surface portion.

Even further, it provides such a hydrogen energy system wherein a plurality of such at least one hydrogen storers locate serially through such at least one second position. Moreover, it provides such a hydrogen energy system wherein such at least one hydride disk is stored in at least one optically clear mineral oil. Additionally, it provides such a hydrogen energy system wherein such plurality of such at least one hydrogen storers may remain in such at least one optically clear mineral oil.

In accordance with another preferred embodiment hereof, this invention provides a process, relating to use of hydrogen, comprising the steps of: providing at least one supply of hydrogen gas; and providing at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma; wherein such at least one hydrogen plasma is formed adjacent to at least one metal surface portion capable of storing hydrogen; wherein such at least one metal surface portion may absorb hydrogen from such at least one supply of hydrogen plasma to form at least one metal hydride.

In accordance with another preferred embodiment hereof, this invention provides a process, relating to use of hydrogen, comprising the steps of: providing at least one hydride disk capable of releasing hydrogen through photonically induced heating; removing at least one hydrogen-expended hydride disk from at least one vehicle; replacing such at least one hydrogen-expended hydride disk with such at least one hydride disk; and disposing of such at least one hydrogen-expended hydride disk. Also, it provides such a process wherein such step of disposing comprises recycling of such at least one hydrogen-expended hydride disk.

In accordance with another preferred embodiment hereof, this invention provides a process, relating to use of hydrogen, comprising the steps of: providing at least one hydrogen-expended hydride disk capable of being recycled; purging such at least one hydrogen-expended hydride disk of any unreleased hydrogen; and recharging such purged at least one hydrogen-expended hydride disk with hydrogen forming at least one hydride disk capable of releasing hydrogen through photonically induced heating.

In accordance with another preferred embodiment hereof, this invention provides a hydrogen energy system comprising: at least one hydrogen storer structured and arranged to store at least one substantial amount of hydrogen; wherein such at least one hydrogen storer comprises at least one substantially full state when such at least one hydrogen storer stores such at least one substantial amount of hydrogen; wherein such at least one hydrogen storer comprises at least one substantially empty state when such at least one hydrogen storer stores substantially no amount hydrogen; and wherein such at least one hydrogen storer comprises at least one substantial variation between transparency of such at least one substantially full state and transparency of such at least one substantially empty state; at least one transparency variation detection device structured and arranged to detect such at least one substantial variation in transparency of such at least one hydrogen storer; at least one transparency variation data collector structured and arranged to collect transparency variation data from such at least one transparency variation detection device; and at least one transparency variation data processor structured and arranged to evaluate collected transparency variation data; wherein such evaluation results in at least one value indicative of hydrogen content of such system.

In accordance with another preferred embodiment hereof, this invention provides a hydrogen energy system comprising: hydrogen storer means for storing at least one substantial amount of hydrogen; wherein such hydrogen storer means comprises hydrogen-release permitter means for permitting photonic-excitation-assisted release of stored hydrogen from such hydrogen storer means; and photonic-exciter means for photonically exciting such hydrogen storer means to assist release of the stored hydrogen from such hydrogen storer means; wherein such photonic-exciter means comprises controller means for controlling photonic-excitation-assisted release of hydrogen; and hydrogen collector means for assisting collecting released hydrogen; wherein hydrogen may be stored in such hydrogen storer means until controllably released to permit use as desired.

In accordance with another preferred embodiment hereof, this invention provides a hydrogen energy system comprising: metal surface portion means for providing at least one metal surface portion capable of absorbing hydrogen; hydrogen supply means for providing at least one supply of hydrogen gas; and electromagnetic field generator means for generating at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma; wherein such electromagnetic field generator means is located in at least one position such that the at least one supply of hydrogen plasma is located in at least one second position; and metal surface locator means for locating such metal surface portion means within such at least one second position; wherein such metal surface portion means may absorb hydrogen to form at least one metal hydride surface portion.

In accordance with another preferred embodiment hereof, this invention provides a hydrogen energy system comprising: hydrogen storer means, comprising at least one disk, for storing at least one substantial amount of hydrogen; wherein such hydrogen storer means comprises central spin axis locator means for locating at least one central spin axis of such at least one disk; wherein such at least one disk may rotate about such at least one central spin axis of such at least one hydride disk; wherein such hydrogen storer means comprises spinner motor gripper means for being by at least one motor driven spinner; wherein such spinner motor gripper means is substantially concentric to such at least one central spin axis; wherein such spinner motor gripper means enables such at least one disk to be spun about such at least one central spin axis of such at least one disk by such at least one motor driven spinner; and wherein during spinning, such at least one disk spins substantially stably. And it provides for each and every novel feature, element, combination, step and/or method disclosed or suggested by this patent application.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a partial side view of a preferred hydride disk, illustrating release of hydrogen gas, preferably by laser heating, according to a preferred embodiment of the present invention.

FIG. 2 shows a cutaway perspective view, illustrating a preferred disk player, according to the preferred embodiment of FIG. 1.

FIG. 3 shows a top view, illustrating a preferred disk, according to the preferred embodiment of FIG. 1.

FIG. 4A shows a side view of a preferred disk, illustrating a preferred surface preparation, according to the preferred embodiment of FIG. 1.

FIG. 4B shows a side view of the preferred disk, illustrating introduction of preferred hydrogenation catalysts, according to the preferred embodiment of FIG. 3.

FIG. 5 shows a diagrammatic view of a preferred stainless-steel high-temperature pressure reactor, illustrating hydrogenation of a plurality of the preferred disks on a preferred spindle, according to the preferred embodiment of FIG. 4.

FIG. 6 shows a diagrammatic view, illustrating at least one preferred holding container for a plurality of the preferred hydride disks, according to the preferred embodiment of FIG. 1.

FIG. 7A shows a diagrammatic view of at least one preferred mineral oil removal system, illustrating removal of the preferred optically clear mineral oil from the preferred hydride disk, according to the preferred embodiment of FIG. 6.

FIG. 7B shows a diagrammatic view of the mineral oil removal system, illustrating removal of residual mineral oil from the preferred hydride disk, according to the preferred embodiment of FIG. 7.

FIG. 8 shows a diagrammatic view, illustrating at least one preferred hydrogen supply system, according to the preferred embodiment of FIG. 1.

FIG. 9 shows a diagrammatic view of at least one preferred hydrogen recharging system, illustrating preferred re-hydrogenation of a used hydride disk, according to the preferred embodiment of FIG. 1.

FIG. 10 shows a diagram illustrating at least one preferred refueling method according to the preferred embodiment of FIG. 1.

FIG. 11 shows a diagram illustrating at least one preferred disk exchange method according to the preferred embodiment of FIG. 1.

DETAILED DESCRIPTION OF THE BEST MODES AND PREFERRED EMBODIMENTS OF THE INVENTION

Hydrogen absorption within reversible metal hydrides (including metal alloys) may be used as hydrogen storage devices. Applicant has found, by testing, that adsorbing hydrogen (as by destabilizing hydrogen bonds) from such metal hydrides at reasonable temperatures and with reasonable energy expenditures may be best accomplished by very finely controlled heating. It has been found that this may provide an economical return of greater than about 5% (by weight) of hydrogen from a storage medium, with minimal energy consumption and system weight.

It is desirable to increase the absorbed hydrogen mass within the metal hydride while simultaneously reducing energy required to release the hydrogen. Applicant has found that metallic alloys and metallic capping layers, along with metal-doped chemical and organic carriers, are excellent storage media for hydrogen. However, one primary obstacle to releasing hydrogen, from such storage media, is a need for heat, since decomposition temperatures are typically greater than 200°C.

Applicant has determined that laser heating of magnesium hydride is one preferred method for extracting hydrogen, with available technology and minimal energy cost. Employment of at least one laser diode, using pulsed-power, preferably provides ample heating of magnesium hydride to release hydrogen, as shown in FIG. 1. Applicant has found, including through experimentation, that less than about 80 continuous watts are needed to heat enough magnesium hydride to release about 10 lbs (4.5 kg) of hydrogen at rates of up to about 2 lbs (0.9 kg) per hour. Such rates of hydrogen may theoretically provide internal combustion, hybrid, and hydrogen-fuel-cell vehicles a range in excess of about 200 miles, while adding less than about 330 lbs (150 kg) and about 6.3 cubic feet (1.9 m^3) or about 47 gallons (178 liters). Conventional CD (compact disk) motors, along with modified laser circuitry, may preferably expose at least one magnesium hydride disk to at least one laser beam at rotations of up to about 24,000 rpm.

FIG. 1 shows a partial side view of at least one hydride disk **110**, illustrating release of hydrogen gas **150** preferably by laser heating, according to a preferred embodiment of the present invention. Hydride disk **110** preferably comprises at least one metal hydride, preferably substantially magnesium hydride, as shown. As discussed herein, concentration of hydrogen, stored in hydride disk **110**, preferably should be greater than about 5% by weight, for economical efficiency. Magnesium hydride theoretically maximally stores about 7.6% hydrogen by weight. Upon reading this specification, those skilled in the art will now appreciate that, under appropriate circumstances, considering such things as then available forms of metal hydride, abilities to place such forms in a rotatable "disk" shape structure for use with controlled laser heating, etc., other "disks" than unitary and/or complete "disks", such segmented, liquid, or non-unitary "disks", etc., may suffice.

Heating of hydride disk **110** preferably comprises localized heating by photonic excitation using at least one coherent light source **160**, as shown. Coherent light source **160** preferably comprises at least one semiconductor laser diode **165**, as shown. Upon reading this specification, those skilled in the art will now appreciate that, under appropriate circumstances, considering such things as then available light sources, cost, used hydrogen storage medium, etc., other light sources, such as focused sunlight, phosphorescent light, biochemical light, etc., may suffice. Semiconductor laser diode **165** preferably produces a beam of coherent light **170**, as shown, preferably between about 530nm and about 1700nm in wavelength, preferably about 784nm in wavelength and with preferably between about 200mW and about 2000mW of power, preferably about 200mW of power. Upon reading this specification, those skilled in the art will now appreciate that, under appropriate circumstances, considering such things as then available lasers, cost, used hydrogen storage medium, etc., other wavelengths of coherent light, such as other infrared wavelengths, visible spectrum, ultraviolet, etc., may suffice. To assist keeping semiconductor laser diode **165** from overheating, power is preferably pulsed instead of continuous.

Preferably, as coherent light **170** adsorbs hydrogen gas **150**, size of hydride disk **110** will preferably initially increase due to thermal expansion and then preferably reduce to pre-hydrogenated volumes. Some small amount of hydrogen movement from higher concentration to lower concentration theoretically can be expected in hydride disk **110** after adsorption of a particular track; but applicant has found such movement to be inconsequential in most circumstances.

Preferably, coherent light source **160** further comprises at least one defocusing lens **162**, as shown. Defocusing lens **162** preferably alters focus of coherent light **170** to form at least one defocused laser beam **168**, as shown. Defocused laser beam **168** preferably comprises at least one beam radius **136** at surface **140**, as shown. Beam radius **136** preferably ranges between about 10nm and about 2mm, preferably about 15nm, as shown. Clearance **174** between defocusing lens **162** and surface **140** preferably is about two millimeters, as shown, assisting protecting defocusing lens **162** from impacting surface **140** due to slight deformations that may occur in surface **140**.

Applicant has determined, including by testing, that decomposition of magnesium hydride using at least one surface temperature of about 390°C, in a vacuum at about -5 bar, is reached within about 10ns with enough conductivity to release 100% of stored hydrogen (up to about 7.6 wt %) within beam radius **136**, to a depth of about 20 micrometers. At at least one maximum effective decomposition distance **145** comprising about 1/2mm, the temperature decreases to about 280°C, dropping release of stored hydrogen to about 39.5% of maximum (up to about 3 wt %). Since magnesium typically melts at about 650°C, applicant has found that a surface temperature of about 390°C (60% of melting temperature) roughly minimizes adiabatic evaporation of magnesium.

Coherent light source **160** preferably rides on at least one rail **175,** preferably moving radially, near at least one surface **140** of hydride disk **110**, as shown. Hydride disk **110** preferably spins about a central axis **215** (see FIG. 2), preferably positioning surface **140** for defocused laser beam **168** to induce heating, as shown.

Absorptivity to infrared radiation is inversely proportional to thermal conductivity. Applicant has determined that, unlike for magnesium, thermal conductivity of magnesium hydride increases with rising temperature, attributable to radiation and "the Smoluchowski effect" (described in Marian Smoluchowski's paper 'Zur kinetischen Theorie der Brownshen molekular Bewegung und der Suspensionen' in Annalen der Physik, 21, 1906, 756-780). Heat capacity is also greater in magnesium hydride as compared to magnesium. Magnesium has a specific heat capacity of about 1050 J/(kg·K) (at 298K) and the specific heat capacity of magnesium hydride is about 1440 J/(kg·K) (at 298K). Further, magnesium's thermal conductivity is about 156 W/(m·k), while magnesium hydride's thermal conductivity is about 6 W/(m·k).

One formula, as determined by applicant, for thermal diffusivity (a) (a factor in the depth of thermal penetration), using thermal conductivity (λ), density (ρ), and specific heat (c) is:

$$a = \lambda/\rho c$$

Calculating thermal diffusivity for magnesium hydride gives:

$$a = (6\ W/(m \cdot K))/(0.001450\ kg/m^3 \times 1440\ J/(kg \cdot K)) =$$
$$2.87 \times 10^6\ J/(m^3 \cdot K)$$

Using this calculation of thermal diffusivity for magnesium hydride, applicant estimates thermal penetration (Z), based on a pulse time of 115 ns at 4x rotational speeds and 19 ns at 48x rotational speeds, as:

$$Z=\sqrt{(4 \cdot a \cdot t)} = 36334\ nm\ at\ 4x\ (0.036\ mm)$$
$$Z=\sqrt{(4 \cdot a \cdot t)} = 14769\ nm\ at\ 48x\ (0.015\ mm)$$

Estimated thermal penetration is inadequate for release of all stored hydrogen in hydride disk **110** by a factor of about 30, for a 1mm thickness. Applicant has determined, however, that since magnesium hydride has a refractive index of about 1.96, which provides about 80% transparency, that optical penetration may aid in increasing release of stored hydrogen. Applicant has found that, through modification of power density to find at least one optimal power setting and beam radius **136**, maximum effective decomposition distance **145**, comprising about 1/2mm, may be reached, as shown. In order to instigate hydrogen adsorption substantially through thickness **144** of hydride disk **110**, preferably, defocused laser beam **168** may also be incident upon opposing surface **142**.

Power density, mathematically defined as:

$$E=q/\pi \cdot r^2$$

where q is beam power and r is beam radius, determines peak temperature, near surface **140,** and thermal interaction at interface **172** of hydride disk **110** and defocused laser beam **168**. Applicant has found that a power density capable of adsorbing hydrogen from magnesium hydride need only be concerned with the melting point of magnesium.

For magnesium hydride, coherent light source **160** preferably produces at least one temperature profile **130** in hydride disk **110**, due to thermal interaction at interface **172**, as shown. Temperature profile **130** preferably ranges from about 390°C, near surface **140**, to about 280°C at maximum effective decomposition distance **145**, as shown.

FIG. 2 shows a cutaway perspective view, illustrating at least one preferred disk player **210**, according to the preferred embodiment of FIG. 1. As shown, disk player **210** preferably comprises at least one spinning motor **230**, coherent light source **160** and disk changing mechanics. Such disk changing mechanics preferably accept at least one hydride disk **110**, preferably move such at least one hydride disk **110** to spinning motor, and preferably remove such at least one hydride disk **110,** once expended, from disk player **210**. Spinning motor **230** preferably spins hydride disk **110** to achieve at least one linear motion of up to about 63 meters per second, preferably while coherent light source **160** liberates hydrogen gas **150** from hydride disk **110**, as shown. Disk player **210** preferably operates under vacuum between about -1 torr to about -5 torr. Such vacuum preferably serves to evacuate liberated hydrogen gas **150**, as shown in FIG. 1, and preferably maintains a neutral atmosphere around hydride disk **110**.

At least one control circuit **220**, as shown, preferably adjusts speed of spinning motor **230**, preferably moves coherent light source **160** on rail **175**, and preferably adjusts power output of coherent light source **160** (at least embodying herein at least one photonic exciter structured and arranged to photonically excite said at least one hydrogen storer to assist release of the stored hydrogen from said at least one hydrogen storer) to preferably optimize release of hydrogen gas **150**. Output of hydrogen gas **150** is preferably optimized to demand for hydrogen gas **150** from at least one hydrogen-driven device **830** (see discussion relating to FIG. 8).

Applicant has determined that disk player **210** may preferably be reconfigured from existing compact disc writer (CD-R) technology. Applicant adapted at least one CD writer drive (“Iomega model 52x” CDRW drive) to adsorb stored hydrogen from hydride disk **110**. In order to adapt such at least one CD writer to use hydride disk **110,** at least one control circuit **220**, as shown, preferably bypasses internal feedback controls of such at least one CD writer drive. Rather than relying on feedback information, control circuit **220** preferably uses direct manipulation of controlled components of disk player **210,** preferably allowing precise control. Further, internal laser of CD writer preferably may be used provided such laser fulfills requirements given for semiconductor laser diode **165**.

Manufacturing Magnesium Hydride Disks

FIG. 3 shows a top view, illustrating at least one disk **315** according to the preferred embodiment of FIG. 1. Such at least one disk **315** is preferably formed by cutting from at least one sheet preferably comprising at least one material capable of absorbing hydrogen, preferably metal, preferably made substantially of magnesium, preferably AZ31B (available commercially).

Upon reading this specification, those skilled in the art will appreciate that, under appropriate circumstances, considering such things as available materials, economics, stored hydrogen density, etc. other materials capable of absorbing hydrogen, such as other metals, plastics, glass, etc., may suffice. Upon reading this specification, those skilled in the art will appreciate that, under appropriate circumstances, considering such things as safety, economics, materials used, etc. other disk formation methods, such as using injection molds, machining, laser cutting, etc., may suffice.

Disk **315** is preferably cut using at least one water cutter, alternately preferably using at least one stamp cutter. Disk **315** preferably is about one millimeter thick. Diameter **370** of disk **315** is cut preferably to between about 50mm and about 150mm, preferably about 120mm. A center hole **360** is preferably cut in disk **315,** preferably between about five millimeters and about 15 millimeters in diameter, preferably about 15 millimeters. Preferably, center hole **360** allows disk **315** to be centered for stable spinning. Disk **315** preferably comprises at least one ring **365** concentric to center hole **360** (at least embodying herein wherein said at least one hydrogen storer comprises at least one central spin axis locator structured and arranged to locate at least one central spin axis of said at least one disk) preferably providing at least one friction grippable surface preferably to allow application of rotational torque to spin disk **315**, as shown (this arrangement at least embodying herein wherein said at least one disk comprises at least one spinner motor gripper capable of being gripped by at least one motor driven spinner).

FIG. 4A shows a side view of preferred disk **315**, illustrating surface preparation, according to the preferred embodiment of FIG. 1. Preferably, after fabrication, oxidization layers, vapor deposits and other physical obstructions to hydrogenation must be removed from disk **315**. Surfaces **346** of disk **315** preferably may be smoothed to a mirror-like finish with irregularities of preferably less than two micrometers while incorporating small amounts of hydrogenation catalysts. Additionally, disk **315** preferably is structurally balanced so, when spun, surfaces **346** have minimal wobbling. Irregularities of surfaces **346** may be distorted, by the addition of hydrogen gas **150,** up to approximately 2-1/2 micrometers as disk **315** expands.

Disk **315** preferably is lightly sanded with titanium oxide to remove surface oxidation. Disk **315** preferably is then washed with 2% HF to remove bulk oxides and then preferably with dilute pepsin/HCL cleaning solution to remove residual sub-oxides. A plurality of such disks **315** are preferably stacked on at least one spindle **345** with at least one stainless steel washer **520**, as shown in Fig. 5, between each disk **315**. Dimensions of stainless steel washer **520** preferably comprise about 15.3 mm in inner diameter, about 18mm in outer diameter, and about four millimeters in thickness. Spindle **345** preferably comprises steel, preferably stainless steel.

Spindle **345** preferably comprises a diameter of about 14.9 mm. Spindle **345** preferably is positioned in vacuum chamber **310**, as shown. At least one vacuum chamber **310** is preferably purged with nitrogen. Vacuum chamber **310** is brought to preferably about 0.7 torr (0.014 psi) (0.001 bar) for preferably about one hour. After about 1 hour, the plurality of such disks **315**, on spindle **345**, preferably is rotated at about 18,000 rpm. At least one spray nozzle **330**, preferably designed for blasting at least one powder **340**, preferably is at a fixed distance from disk **315**, as shown. Powder **340** preferably comprises nickel powder, comprising a particle-size range of preferably about 2.6 micrometers to about 3.3 micrometers, preferably nickel powder commercially available as "Inco Type 287". Powder **340** is preferably blasted onto disk **315**, as shown, at about 50 psi preferably using argon gas. Disk **315** preferably is subsequently sandblasted with progressively smaller 99.9+% nickel particles, preferably from about -325 mesh to about -500 mesh (American Elements CAS no. 7440-02-0) at preferably about 40 psi using preferably nitrogen gas.

FIG. 4B shows a side view of disk **315**, illustrating introduction of preferred hydrogenation catalysts **440**, according to the preferred embodiment of FIG. 1. Inside vacuum chamber **310**, disk **315** is preferably further treated with hydrogenation catalysts **440**, as shown. Hydrogenation catalysts **440** preferably comprise at least one submicron powder **445**, as shown. Hydrogenation catalysts **440** preferably are each applied for between about 10 minutes and about 15 minutes at preferably about 35 psi. Each of preferably three submicron powders **445** preferably comprises a purity of greater than about 99.999%. One Submicron powder **445** preferably comprises 99.999+% nickel. Another submicron powder **445** alternately preferably comprises 99.999+% palladium. Yet another submicron powder **445** alternately preferably comprises 99.999+% titanium. Upon reading this specification, those skilled in the art will now appreciate that, under appropriate circumstances, considering such things as then available materials, other catalyst technologies, cost, hydride material used, etc. other catalysts, such as other metals, plastics, resins, slurries, etc., may suffice.

Hydrogenation catalysts **440**, preferably as described, preferably are serially applied such that application of all hydrogenation catalysts **440** comprises between about 30 minutes and about 45 minutes. The amount of hydrogenation catalysts **440** used is insufficient for capping, and instead preferably serves as a "door man" to preferably keep hydrogen moving past outer layer of surfaces **346** where magnesium hydride formation and buildup could prevent further absorption of hydrogen. Surface preparation and treatments with hydrogenation catalysts **440** preferably provides necessary surface smoothness and preferably impregnates, through adhesion, a preferred amount of hydrogenation catalysts **440** without significant ablation of surfaces **346**.

Vacuum chamber **310** preferably is then returned to atmospheric pressure, preferably with nitrogen, and disk **315** preferably is removed to at least one stainless-steel high-temperature pressure reactor **510**, as shown in FIG. 5. Stainless-steel high-temperature pressure reactor **510** preferably is nitrogen-purged with .1 torr on the evacuation cycle, preferably through at least two purging cycles to prepare for hydrogenation. Disk **315** preferably is then ready for hydrogenation.

FIG. 5 shows a diagrammatic view of stainless-steel high-temperature pressure reactor **510**, illustrating preferred hydrogenation of disk **315** on spindle **345**, according to the preferred embodiment of FIG. 1. At least one heating element **560** preferably heats stainless-steel high-temperature pressure reactor **510**, as shown, from preferably about 20°C to preferably about 350°C. The coefficient of thermal expansion (α) of magnesium is about $27 \cdot 10^{-6}$/°C, which provides that disk **315** will expand from a diameter of about 120mm to about 121mm when raised from about 20°C to about 350°C. Because being raised from about 20°C to about 350°C effects closing of diameter of central hole by as much as about 1/2mm, prevention of size reduction of central hole by thermal expansion or hydrogenation is necessary. The plurality of disks **315** are preferably placed on spindle **345**, as shown, in order to prevent central hole closing. The coefficient of thermal expansion of stainless steel is about $17 \cdot 10^{-6}$/°C. Spindle **345** expands from about 14.9mm, at about 20°C, to about 15mm in diameter, at about 350°C. Since magnesium is less dense than stainless steel, spindle **345** preferably constrains disk **315** to expand vertically and radially outward as disk **315** is heated and hydrogenated.

Thermal and internal strain from forced expansion away from spindle **345** theoretically reduces absorption of hydrogen near center hole **360** of disk **315**, approximately within ring **365**. Such reduction in absorption is inconsequential since central area of hydride disk **110**, including ring **365**, is preferably not lased. Furthermore, heating is preferably incremented slowly to allow enough time for thermal equilibrium and expansion without undue stress. Such slow heating is preferably accompanied by slow increases in pressure. Hydrogenating slowly preferably allows greater absorption of hydrogen gas **150** because build up of magnesium hydride does not occur near surfaces **346** impeding complete hydrogenation.

Pressure is preferably raised to atmospheric pressure with hydrogen gas **150** and at least one thermocouple **550**, as shown, is preferably set to about 21.1°C to establish initial temperature. Small increments of temperature and pressure preferably are applied preferably over about 6 hours to preferably raise pressure to about 35 bar (500 psi) and temperature to preferably about 350°C. Final temperature and pressure are preferably maintained for about an additional 2 hours.

At least one step motor **554,** which preferably can rotate disk **315** at about 18,000 rpm, preferably comprises at least one axle **552**, as shown. Axle **552** is preferably passed into stainless-steel high-temperature pressure reactor **510**, as shown. Spindle **345** is preferably attached to axle **552**, as shown, allowing step motor **554** to spin spindle **345** inside stainless-steel high-temperature pressure reactor **510.** Rotation at about 18,000 rpm preferably allows additionally between about 700 and about 3000 psi to be exerted radially on disk **315** once initial hydrogenation is complete, and preferably allows a small amount of hydrogen “over loading”. Step motor **554** is preferably activated to spin spindle **345** and disk **315** at preferably about 18,000 rpm for about 1 hour. Afterwards, disk **315** preferably is slowed to a stop and preferably allowed to remain at full pressure and temperature for about 1 hour more.

Hydride disk **110** preferably is formed as Disk **315** preferably becomes fully hydrogenated to nearly 100% magnesium hydride preferably with a hydrogen content of about 7.6%. Disk **315** theoretically grows dimensionally during hydrogenation by as much as about 17%, but the surface area of hydride disk **110** to be lased preferably remains the same. Hydride disk **110** is highly reactive in air, and great caution should be taken in handling and storage.

Magnesium Hydride ignites spontaneously in air to form magnesium oxide and water. Such ignition is a violent reaction, which cannot be stopped by addition of water or carbon dioxide. Therefore, consideration of the practicality of creating, storing, and transporting hydride disks **110**, comprising magnesium hydride, is important.

Before removing hydride disk **110** from stainless-steel high-temperature pressure reactor **510**, pressure should preferably be allowed to return to atmospheric pressure through release of hydrogen gas **150**. Then, optically clear mineral oil **610** (preferably “Sontex LT-100”) is preferably pumped into stainless-steel high-temperature pressure reactor **510,** preferably to displace any remaining hydrogen gas **150**. Stainless-steel high-temperature pressure reactor **510** may be opened preferably only after a volume of optically clear mineral oil **610**, equal to the interior volume of stainless-steel high-temperature pressure reactor **510** less the volume of hydride disk **110** and spindle **345**, has been pumped.

Optically clear mineral oil **610**, as shown, (preferably C_nH2_{n+2}) preferably comprises a highly purified organic aliphatic hydrocarbon, preferably comprising an index of refraction of about 1.47 and a light transmittance of about 0.99972. Optically clear mineral oil **610** preferably does not interact with hydride disk **110**. Optically clear mineral oil **610** preferably acts as an atmospheric insulator to prevent oxidation and static discharge. Upon reading this specification, those skilled in the art will now appreciate that, under appropriate circumstances, considering such things as wavelength of light source, cost, available materials, etc., other atmospheric insulators, such as resins, other oils, solutions, etc., may suffice.

In addition, flow of hydrogen, due to concentration differences, is minimal due to inherently high hydrogen content of optically clear mineral oil **610**. Preferably, care should be taken to avoid any moisture content in optically clear mineral oil **610,** as well as in manufacturing environment, when stainless-steel high-temperature pressure reactor **510** is opened. Such moisture may cause formation of hydrogen peroxide (H_2O_2) in optically clear mineral oil **610**. In addition, ambient air preferably should be as dry as possible, also to preferably prevent hydrogen peroxide development in optically clear mineral oil **610**. Optically clear mineral oil **610** preferably has a loss of only about 0.028% of light passing through. Preferably, optically clear mineral oil **610** has a molecular weight of about 40.106, a flash point of about 135°C, a specific gravity greater then 0.8, and a boiling point approximately 300°C. Hydride disk **110** preferably may now be removed from stainless-steel high-temperature pressure reactor **510** and preferably immediately placed in at least one holding container **600** of optically clear mineral oil **610**, as shown. Preferably, optically clear mineral oil **610** remains around hydride disks **110** to prevent contact with air. As mentioned, such contact may result in a violent reaction creating a magnesium fire.

FIG. 6 shows a diagrammatic view, illustrating at least one holding container **600** for a plurality of hydride disks **110**, according to the preferred embodiment of FIG. 1. Transfer of hydride disk **110** from stainless-steel high-temperature pressure reactor **510** to optically clear mineral oil **610** in holding container **600** preferably should only be performed with proper safety apparel and adequate fire suppression available. An understanding of proper handling and methods of fire extinguishing of magnesium hydride is paramount. The information provided in this application is not an adequate substitute for proper training. Eye protection should be worn (preferably a welder's mask) because of the brilliance of a magnesium fire. Also, heat and fire resistant clothing should be worn due to the intensity of a magnesium hydride fire. Sand, in plastic bags, should preferably be available to place on a fire should one erupt. Tabletops and flooring should preferably be of soap stone or other inert material, not metal or wood. Carbon dioxide (CO_2) extinguishers or water should never be used on a magnesium fire, since such extinguishers promote the reaction.

FIG. 7A shows a diagrammatic view of at least one mineral-oil removal system **700**, illustrating removal of optically clear mineral oil **610** from hydride disk **110**, according to the preferred embodiment of FIG. 1. The heat of vaporization of optically clear mineral oil **610**, comprising about 214 kJ/kg, is particularly important. The more optically clear mineral oil **610** left on hydride disk **110,** the more power needed to efficiently adsorb the stored hydrogen, since optically clear mineral oil **610** left on hydride disk **110** will absorb a portion of the heat generated by coherent light **170**.

Mineral-oil removal system **700** preferably comprises at least one disk spinner **710**, as shown. Disk spinner **710** preferably comprises at least one spinner motor **715**, as shown. Disk spinner **710** preferably operates in an area of negative pressure. Disk spinner **710** preferably may be adapted from at least one CD drive. To adapt such at least one CD drive, all electronic components preferably must be shielded from exposure to optically clear mineral oil **610**, preferably by at least one polymer, preferably polyvinyl. Prior to use, hydride disk **110** is preferably moved into disk spinner **710**, as shown, and preferably spun by spinner motor **715** to about 24,000 rpm to recover most of optically clear mineral oil **610,** preferably for reuse.

FIG. 7B shows a diagrammatic view of mineral oil removal system **700**, illustrating removal of residual mineral oil **712** from hydride disk **110**, according to the preferred embodiment of FIG. 7A. Mineral oil removal system **700** preferably further comprises at least one residual mineral oil remover **717**, as shown. Residual mineral oil remover **717** preferably comprises at least two opposing suction vacuums **720**, as shown. After spinning, opposing suction vacuums **720** preferably pump off any residual mineral oil **712**, comprising optically clear mineral oil **610,** for reuse, as shown. Opposing suction vacuums **720** preferably substantially cover diameter of hydride disk **110**, as shown. 100% recovery, of optically clear mineral oil **610**, may not be possible without vaporization during lasing of hydride disk **110**. Minimization of vaporization preferably minimizes energy consumption of the lasing process. Vaporized mineral oil preferably should be collected for ecological and safety reasons. After removing optically clear mineral oil **610**, hydride disk **110** preferably is passed to disk player **210**, as discussed in FIG. 8, for hydrogen adsorption, as discussed herein (See FIGS. 1 & 2).

FIG. 8 shows a diagrammatic view, illustrating at least one hydrogen supply system **800**, according to the preferred embodiment of FIG. 1. Hydrogen supply system **800** preferably comprises holding container **600**, mineral oil removal system **700** and disk player **210**, as shown. Hydride disk **110** is preferably moved from holding container **600** to mineral oil removal system **700**, preferably for optically clear mineral oil **610** removal, as shown. After optically clear mineral oil **610** is substantially removed, hydride disk **110** preferably transfers to disk player **210** for hydrogen adsorption, as shown. After completing at least one adsorption process, used hydride disk **910** preferably is returned to holding container **600**, as shown, for safe storage. Processing of hydride disk **110** is preferably conducted under negative pressure (about -1 torr) preferably to allow for hydrogen collection and preferably preventing exposure of hydride disk **110** to air.

Unlike magnesium hydride, exhibiting 80% transparency, magnesium exhibits mirror like opacity, when manufactured as discussed herein. Transparency variation of hydride disk **110** from used hydride disk **910** therefore preferably indicates hydrogen content. Such transparency variation may preferably be used to distinguish at least one used hydride disk **910** from such at least one hydride disk **110**, and may also preferably be used as at least one "gas" gauge **880**. At least one transparency probe **850** preferably polls stored disks **860**. Transparency information passes to at least one processor **870** where quantities of such at least one hydride disk **110** and such at least one used hydride disk **910** are determined. At least one value is then calculated for available hydrogen stores and may be displayed as such at least one "gas" gauge **880**.

Hydrogen supply system **800** preferably further comprises at least one condensing tank **810**, as shown. Gases released from processing may contain vaporized mineral oil, in addition to hydrogen gas **150**. Such gases are preferably collected and preferably pass into condensing tank **810**. Condensing tank **810** preferably comprises at least one cooling environment at atmospheric pressure. Optically clear mineral oil **610** is not dissociated into its constituent elements by vaporization in an anaerobic atmosphere. Optically clear mineral oil **610** is preferably recaptured within condensing tank **810**, as shown.

After condensation of optically clear mineral oil **610** in condensing tank **810**, hydrogen gas **150** is preferably supplied to hydrogen-driven device **830**. Alternately preferably, hydrogen gas **150** is pressurized in at least one pressure tank **820** to at least one atmosphere of pressure, before being supplied to hydrogen-driven device **830**, as shown. Hydrogen gas **150** supplied by hydrogen supply system **800** preferably maintains supply of hydrogen gas required by hydrogen-driven device **830** to operate steadily. Pressure tank **820** preferably acts as a hydrogen gas reserve, allowing accelerated use of hydrogen gas **150**, for a limited time, beyond the hydrogen adsorption rate of hydrogen supply system **800**. Pressure tank **820** may preferably be sized to provide sufficient quantity according to at least one brief increased supply need of hydrogen-driven device **830**.

Hydrogen-driven device **830** preferably comprises at least one vehicle engine adapted for using hydrogen gas **150**. Such at least one vehicle engine preferably comprises at least one combustion engine, alternately preferably at least one hybrid engine, alternately preferably at least one hydrogen power cell driven engine. Upon reading this specification, those skilled in the art will now appreciate that, under appropriate circumstances, considering such things as then availability, cost, purpose, etc., other hydrogen-driven devices, such as cooking devices, generators, heaters, etc., may suffice. For application to such at least one vehicle engine, pressure tank **820** preferably comprises a size of about two liters which may hold up to about 1/2kg of hydrogen gas **150**. Applicant has determined that, under relevant circumstances, an about-two-liter size of pressure tank **820** allows for about a 30-second burst of increased consumption for acceleration. After such 30-second burst, pressure tank **820** may preferably recharge giving, as similarly determined by applicant, about a 50-second recovery time.

For hydrogen-driven device **830** comprising at least one typical vehicle, hydrogen supply system **800** should deliver a supply rate of about 1.3 kg/hour of hydrogen to maintain better than 50 miles per hour. Thickness **144**, rotation speed of hydride disks **110**, power of semiconductor laser diode **165**, and the number of semiconductor laser diodes **165** should be optimized to reach such at least one supply rate. If semiconductor laser diode **165** is too weak, then rotation speed of hydride disks **110** has to be slowed in order to liberate enough hydrogen. The slowed rotation speed of hydride disks **110** will then require a plurality of semiconductor laser diodes **165** and a plurality of disk players **210** to maintain an adequate supply of fuel.

Applicant has determined, including by experimentation, that using one semiconductor laser diode **165** (at about 760nm) at an operating speed of about 2X (about 2.6 m/s) requires about 33 minutes to release about 1.2 grams of hydrogen. Using this operating speed requires about 148 disk players **210** with about 8 semiconductor laser diodes **165** each to deliver such at least one supply rate of about 1.3 kg per hour. This would require an additional 10 kg and 2 cubic feet to accommodate. The total laser power comprises about 236 watts (0.32 horsepower) and such about 148 disk players with disk changing mechanisms would require about 300 watts (0.4 horsepower). Preferably when using a plurality of semiconductor laser diodes **165** each semiconductor laser diode **165** differs in power proportional to the distance from the center of hydride disk **110**, since actual linear speed is a function of the radius.

By comparison, applicant has determined, including by experimentation, that using another semiconductor laser diode **165** (at about 780nm) at an operating speed of about 48X requires only 3 minutes. At about 48X, about 14 disk players **210** with about 8 semiconductor laser diodes **165** each delivers such at least one supply rate. Under these conditions, operating hydrogen supply system **800** requires about 0.25 horsepower.

Applicant has determined that the percentage of the power produced needed to run hydrogen supply system **800,** based on experimental findings and a fuel cell efficiency of about 50%, comprises about one percent.

FIG. 9 shows a diagrammatic view of at least one hydrogen recharging system **900**, illustrating re-hydrogenation of used hydride disks **910**, according to the preferred embodiment of FIG. 1. At least one used hydride disk **910** preferably recharges by passing into at least one hydrogen plasma stream **930**, as shown. Hydrogen plasma stream **930** preferably comprises highly charged hydrogen ions, as shown. Hydrogen plasma stream **930** is preferably created from hydrogen gas injected preferably with at least one microwave **920** and at least one radio wave **925**, preferably at least two microwaves **920** and such at least one radio wave **925**, as shown. Microwave **920** is preferably generated from at least one microwave generator **922**, as shown. Radio wave **925** is preferably generated from at least one radio-wave generator **927**, as shown (these generators at least embodying herein at least one electromagnetic field generator structured and arranged to generate at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma). Hydrogen plasma stream **930** preferably comprises a temperature of about 2000°C. Hydrogen plasma stream **930**, being highly charged, preferably envelops used hydride disk **910**, as shown. As hydrogen plasma stream **930** envelops used hydride disk **910**, hydrogen plasma stream **930** will cool and is preferably absorbed into used hydride disk **910**, as shown. Hydrogen recharging system **900** preferably exposes used hydride disk **910** to hydrogen plasma stream **930** for about 0.15 seconds, preferably resulting in a recharged hydride disk **915**, as shown, preferably substantially similar to and about as useable as hydride disk **110**. Preferably, hydrogen recharging system **900** may proceed while used hydride disk **910** is within holding container **600**, preferably reducing risk of combustion of recharged hydride disk **915**.

FIG. 10 shows a diagram illustrating at least one refueling method **730** according to the preferred embodiment of FIG. 1. Hydrogen gas **150** preferably is stored at and manufactured in at least one factory **732**, as shown, in step Manufacture and Store Hydrogen **735**. Hydrogen gas **150** preferably is transported, in at least one hydrogen transportation vehicle **742,** to at least one refueling center **747**, as shown, in step Transport Hydrogen to Refueling Center **740**. At least one hydrogen-powered vehicle **750** preferably refuels, preferably using hydrogen recharging system **900**, as described in FIG. 9, in step Recharge Magnesium Hydride Disks **745**, as shown. Refueling method **730** preferably allows multiple cycles of refueling and use without replacing hydride disk **110**.

FIG. 11 shows a diagram illustrating at least one disk exchange method **760** according to the preferred embodiment of FIG. 1. When such at least one used hydride disks **910** are insufficiently rechargeable, used hydride disks **910** may preferably be swapped out for hydride disks **110**, as shown. A plurality of such at least one hydride disks **110** are preferably manufactured, as described in FIG. 3-6, in at least one factory **767** in step Manufacture Disks **765**, as shown. Additionally, in step Manufacture Disks **765**, materials required to manufacture hydride disks **110** preferably may be recycled from used hydride disks **910**, as shown. A plurality of such at least one hydride disks **110** are preferably transported, in at least one disk transportation vehicle **772**, to at least one service station **777**, as shown, in step Transport Disks to Service Station **770**. Such transported plurality of such at least one hydride disk **110** (at least embodying herein at least one hydrogen storer structured and arranged to store at least one substantial amount of hydrogen) preferably are immersed in optically clear mineral oil **610** during transport, as during storage in holding container **600** (see FIG. 6). At service station **777**, each used hydride disk **910** in hydrogen-powered vehicle **750** is preferably replaced with new hydride disk **110** in step Exchange Disks **775**, as shown. A plurality of used hydride disks **910** are preferably transported back, in disk transportation vehicle **772**, to factory **767** for recycling, as shown, in step Return Disks for Recycling **785**.

Although applicant has described applicant's preferred embodiments of this invention, it will be understood that the broadest scope of this invention includes modifications such as diverse shapes, sizes, and materials. Such scope is limited only by the below claims as read in connection with the above specification. Further, many other advantages of applicant's invention will be apparent to those skilled in the art from the above descriptions and the below claims.

WHAT IS CLAIMED IS:

1) A process, relating to controlled commercial use of hydrogen gas, comprising the steps of:
    a) providing at least one supply of hydrogen gas; and
    b) providing at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma;
    c) wherein such at least one supply of hydrogen plasma is formed adjacent to at least one metal surface portion capable of storing hydrogen; and
    d) wherein such at least one metal surface portion absorbs hydrogen from such at least one supply of hydrogen plasma to form at least one metal hydride; and
    e) providing at least one hydrogen storer structured and arranged to store, using such at least one metal hydride, at least one substantial amount of hydrogen so as to permit photonic-excitation-assisted release of stored hydrogen;
    f) using at least one photonic exciter to photonically excite such at least one hydrogen storer to assist release of such stored hydrogen as hydrogen gas; and
    g) controlling such photonic-excitation-assisted release of such hydrogen gas so as to assist at least one commercial use.
2) A hydrogen energy system comprising:
    a) at least one hydrogen storer structured and arranged to store at least one substantial amount of hydrogen;
    b) wherein said at least one hydrogen storer comprises at least one hydrogen-release permitter structured and arranged to permit photonic-excitation-assisted release of stored hydrogen from said at least one hydrogen storer; and
    c) at least one photonic exciter structured and arranged to photonically excite said at least one hydrogen storer to assist release of such stored hydrogen from said at least one hydrogen storer;
    d) wherein said at least one photonic exciter comprises at least one controller structured and arranged to control such photonic-excitation-assisted release of hydrogen gas so as to assist at least one commercial use.
3) The hydrogen energy system according to Claim 2 wherein said at least one photonic exciter comprises at least one wavelength of light between about 530nm and about 1700nm.
4) The hydrogen energy system according to Claim 3 wherein said at least one photonic exciter comprises at least one wavelength of light of about 784nm.

5) The hydrogen energy system according to Claim 2 wherein said at least one photonic exciter comprises at least one power between about 200mW and about 2000mW.

6) The hydrogen energy system according to Claim 5 wherein said at least one photonic exciter comprises at least one power of about 200mW.

7) The hydrogen energy system according to Claim 2 wherein said at least one hydrogen collector comprises at least one negative pressure environment.

8) The hydrogen energy system according to Claim 7 wherein said at least one negative pressure environment comprises at least one pressure between about negative one millimeter of mercury and about negative two atmospheres.

9) The hydrogen energy system according to Claim 8 wherein said at least one negative pressure environment comprises at least one pressure of about negative one atmosphere.

10) The hydrogen energy system according to Claim 2 wherein said at least one photonic exciter comprises at least one beam of light with at least one radius of between about 10nm and about 2mm.

11) The hydrogen energy system according to Claim 10 wherein said at least one photonic exciter comprises at least one beam of light with at least one radius of about 15nm.

12) The hydrogen energy system according to Claim 2 wherein said at least one photonic exciter is structured and arranged to excite at least one portion of said at least one hydrogen storer to induce at least one temperature between about 280°C and about 390°C in such at least one portion.

13) The hydrogen energy system according to Claim 2 wherein said at least one hydrogen storer comprises at least one hydride.

14) A hydrogen energy system comprising:

  a) at least one metal surface portion capable of absorbing hydrogen;

  b) at least one supply of hydrogen gas; and

  c) at least one electromagnetic field generator structured and arranged to generate at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma;

  d) wherein said at least one electromagnetic field generator is located in at least one position such that said at least one supply of hydrogen plasma is located in at least one second position; and

  e) at least one metal surface locator structured and arranged to locate said at least one metal surface portion within such at least one second position;

f) wherein said at least one metal surface portion may absorb hydrogen to form at least one metal hydride surface portion.

15) The hydrogen energy system according to Claim 14 wherein said at least one electromagnetic field generator comprises:
   a) at least one microwave field generator; and
   b) at least one radio wave field generator.

16) The hydrogen energy system according to Claim 15 wherein said at least one microwave field generator comprises at least two microwave field generators.

17) A hydrogen energy system comprising:
   a) at least one hydrogen storer comprising at least one disk structured and arranged to store at least one substantial amount of hydrogen;
   b) wherein said at least one hydrogen storer comprises at least one central spin axis locator structured and arranged to locate at least one central spin axis of said at least one disk;
   c) wherein said at least one disk may rotate about such at least one central spin axis of said at least one disk;
   d) wherein said at least one disk comprises at least one spinner motor gripper capable of being gripped by at least one motor driven spinner;
   e) wherein said at least one spinner motor gripper is substantially concentric to such at least one central spin axis;
   f) wherein said at least one spinner motor gripper is structured and arranged to assist enabling said at least one disk to be spun about such at least one central spin axis of said at least one disk by such at least one motor driven spinner; and
   g) wherein said at least one disk is structured and arranged to spin substantially stably.

18) The hydrogen energy system according to Claim 17 wherein said at least one disk further comprises at least one outer diameter between about 50mm and about 150mm.

19) The hydrogen energy system according to Claim 18 wherein said at least one disk further comprises at least one outer diameter of about 120mm.

20) The hydrogen energy system according to Claim 17 wherein said at least one central spin axis locator comprises at least one diameter between about 5mm and about 15mm.

21) The hydrogen energy system according to Claim 20 wherein said at least one central spin axis locator comprises at least one diameter of about 15mm.

22) The hydrogen energy system according to Claim 17 wherein said at least one disk comprises at least one hydride disk.

23) The hydrogen energy system according to Claim 22 wherein said at least one hydride disk further comprises at least one outer diameter between about 50mm and about 150mm.

24) The hydrogen energy system according to Claim 23 wherein said at least one hydride disk further comprises at least one outer diameter of about 120mm.

25) The hydrogen energy system according to Claim 22 wherein said at least one central spin axis locator comprises at least one diameter between about 5mm and about 15mm.

26) The hydrogen energy system according to Claim 25 wherein said at least one central spin axis locator comprises at least one diameter of about 15mm.

27) The hydrogen energy system according to Claim 22 wherein said at least one hydride disk comprises at least one thickness of about one millimeter.

28) The hydrogen energy system according to Claim 22 wherein said at least one hydride disk further comprises at least one metal hydride.

29) The hydrogen energy system according to Claim 28 wherein said at least one hydride disk substantially comprises magnesium hydride.

30) The hydrogen energy system according to Claim 29 wherein said at least one hydride disk comprises hydrogenated AZ31B.

31) The hydrogen energy system according to Claim 28 wherein said at least one hydride disk further comprises at least one catalyst structured and arranged to assist hydrogenation of said at least one hydride disk.

32) The hydrogen energy system according to Claim 31 wherein said at least one catalyst comprises nickel.

33) The hydrogen energy system according to Claim 31 wherein said at least one catalyst comprises palladium.

34) The hydrogen energy system according to Claim 31 wherein said at least one catalyst comprises titanium.

35) The hydrogen energy system according to Claim 22 wherein said at least one hydride disk comprises surface irregularities of less than about two micrometers.

36) The hydrogen energy system according to Claim 22 further comprising at least one disk coating comprising at least one optically clear mineral oil.

37) The hydrogen energy system according to Claim 22 further comprising:

  a) at least one supply of hydrogen gas; and

  b) at least one electromagnetic field generator structured and arranged to generate at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma;

c) wherein such at least one electromagnetic field generator is located in at least one position such that the at least one supply of hydrogen plasma is located in at least one second position; and

d) wherein said at least one hydrogen storer further comprises at least one metal surface portion capable of absorbing hydrogen; and

e) at least one metal surface locator structured and arranged to locate said at least one metal surface portion within such at least one second position;

f) wherein said at least one metal surface portion may absorb hydrogen to form at least one metal hydride surface portion.

38) The hydrogen energy system according to Claim 37 wherein a plurality of said at least one hydrogen storers locate serially through such at least one second position.

39) The hydrogen energy system according to Claim 38 wherein said at least one hydride disk is stored in at least one optically clear mineral oil.

40) The hydrogen energy system according to Claim 37 wherein such plurality of said at least one hydrogen storers may remain in such at least one optically clear mineral oil.

41) The hydrogen energy system according to Claim 17 further comprising:

a) at least one photonic-exciter structured and arranged to photonically excite said at least one hydrogen storer to assist release of the stored hydrogen from said at least one hydrogen storer;

b) wherein said at least one hydrogen storer comprises at least one hydrogen-release permitter structured and arranged to permit photonic-excitation-assisted release of stored hydrogen from said at least one hydrogen storer; and

c) wherein said at least one photonic-exciter comprises at least one controller structured and arranged to control photonic-excitation-assisted release of hydrogen; and

d) at least one hydrogen collector structured and arranged to assist collection of released hydrogen;

e) wherein hydrogen may be stored in said at least one hydrogen storer until controllably released permitting use as desired.

42) The hydrogen energy system according to Claim 41 wherein said at least one disk comprises at least one hydride.

43) The hydrogen energy system according to Claim 42 wherein said at least one disk is stored in at least one optically clear mineral oil.

44) The hydrogen energy system according to Claim 43 wherein said at least one hydrogen collector further comprises at least one mineral oil condenser structured and arranged to

assist collection of mineral oil vaporized during such photonic-exciter-assisted release of hydrogen.

45) The hydrogen energy system according to Claim 42 further comprising:
   a) at least one hydrogen fuel user structured and arranged to use hydrogen as at least one fuel in at least one vehicle;
   b) wherein said at least one hydrogen fuel user comprises at least one energy converter structured and arranged to assist conversion of collected hydrogen through at least one energy-conversion process; and
   c) wherein such at least one energy-conversion process provides energy to operate such at least one vehicle.

46) The hydrogen energy system according to Claim 45 further comprising at least one hydrogen container structured and arranged to contain at least one volume of hydrogen sufficient to supply increased fuel demand from such at least one vehicle during acceleration.

47) The hydrogen energy system according to Claim 45 wherein said at least one energy converter comprises at least one combustion engine.

48) The hydrogen energy system according to Claim 47 further comprising at least one hydrogen container structured and arranged to contain at least one volume of hydrogen sufficient to supply increased fuel demand from such at least one vehicle during acceleration.

49) The hydrogen energy system according to Claim 45 wherein said at least one energy converter comprises at least one hydrogen fuel cell.

50) A hydrogen energy system comprising:
   a) at least one hydrogen storer structured and arranged to store at least one substantial amount of hydrogen;
   b) wherein said at least one hydrogen storer comprises at least one substantially full state when said at least one hydrogen storer stores such at least one substantial amount of hydrogen;
   c) wherein said at least one hydrogen storer comprises at least one substantially empty state when said at least one hydrogen storer stores substantially no amount hydrogen; and
   d) wherein said at least one hydrogen storer comprises at least one substantial variation between transparency of said at least one substantially full state and transparency of said at least one substantially empty state; and

e) at least one transparency variation detection device structured and arranged to detect said at least one substantial variation in transparency of said at least one hydrogen storer;

f) at least one transparency variation data collector structured and arranged to collect transparency variation data from said at least one transparency variation detection device; and

g) at least one transparency variation data processor structured and arranged to evaluate collected transparency variation data;

h) wherein such evaluation results in at least one value indicative of hydrogen content of said system.

51) A process, relating to use of hydrogen, comprising the steps of:

a) providing at least one supply of hydrogen gas; and

b) providing at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma;

c) wherein such at least one hydrogen plasma is formed adjacent to at least one metal surface portion capable of storing hydrogen; and

d) wherein such at least one metal surface portion absorbs hydrogen from such at least one supply of hydrogen plasma to form at least one metal hydride.

52) A process, relating to use of hydrogen, comprising the steps of:

a) providing at least one hydride disk capable of releasing hydrogen through photonically induced heating;

b) removing at least one hydrogen-expended hydride disk from at least one vehicle;

c) replacing such at least one hydrogen-expended hydride disk with such at least one hydride disk; and

d) disposing of such at least one hydrogen-expended hydride disk.

53) The process according to Claim 52 wherein such step of disposing comprises recycling of such at least one hydrogen-expended hydride disk.

54) A process, relating to use of hydrogen, comprising the steps of:

a) providing at least one hydrogen-expended hydride disk capable of being recycled;

b) purging such at least one hydrogen-expended hydride disk of any unreleased hydrogen; and

c) recharging such purged at least one hydrogen-expended hydride disk with hydrogen forming at least one hydride disk capable of releasing hydrogen through photonically induced heating.

55) A hydrogen energy system comprising:
   a) hydrogen storer means for storing at least one substantial amount of hydrogen;
   b) wherein said hydrogen storer means comprises hydrogen-release permitter means for permitting photonic-excitation-assisted release of stored hydrogen from said hydrogen storer means; and
   c) photonic-exciter means for photonically exciting said hydrogen storer means to assist release of the stored hydrogen from said hydrogen storer means;
   d) wherein said photonic-exciter means comprises controller means for controlling photonic-excitation-assisted release of hydrogen; and
   e) hydrogen collector means for assisting collecting released hydrogen;
   f) wherein hydrogen may be stored in said hydrogen storer means until controllably released to permit use as desired.

56) A hydrogen energy system comprising:
   a) metal surface portion means for providing at least one metal surface portion capable of absorbing hydrogen;
   b) hydrogen supply means for providing at least one supply of hydrogen gas; and
   c) electromagnetic field generator means for generating at least one electromagnetic field sufficient to form at least one supply of hydrogen plasma;
   d) wherein such electromagnetic field generator means is located in at least one position such that the at least one supply of hydrogen plasma is located in at least one second position; and
   e) metal surface locator means for locating said metal surface portion means within such at least one second position;
   f) wherein such metal surface portion means may absorb hydrogen to form at least one metal hydride surface portion.

57) A hydrogen energy system comprising:
   a) hydrogen storer means, comprising at least one disk, for storing at least one substantial amount of hydrogen;
   b) wherein said hydrogen storer means comprises central spin axis locator means for locating at least one central spin axis of said at least one disk;
   c) wherein said at least one disk may rotate about such at least one central spin axis of said at least one hydride disk;
   d) wherein said hydrogen storer means comprises spinner motor gripper means for being by at least one motor driven spinner;

e) wherein said spinner motor gripper means is substantially concentric to such at least one central spin axis;

f) wherein said spinner motor gripper means enables said at least one disk to be spun about such at least one central spin axis of said at least one disk by such at least one motor driven spinner; and

g) wherein during spinning, said at least one disk spins substantially stably.

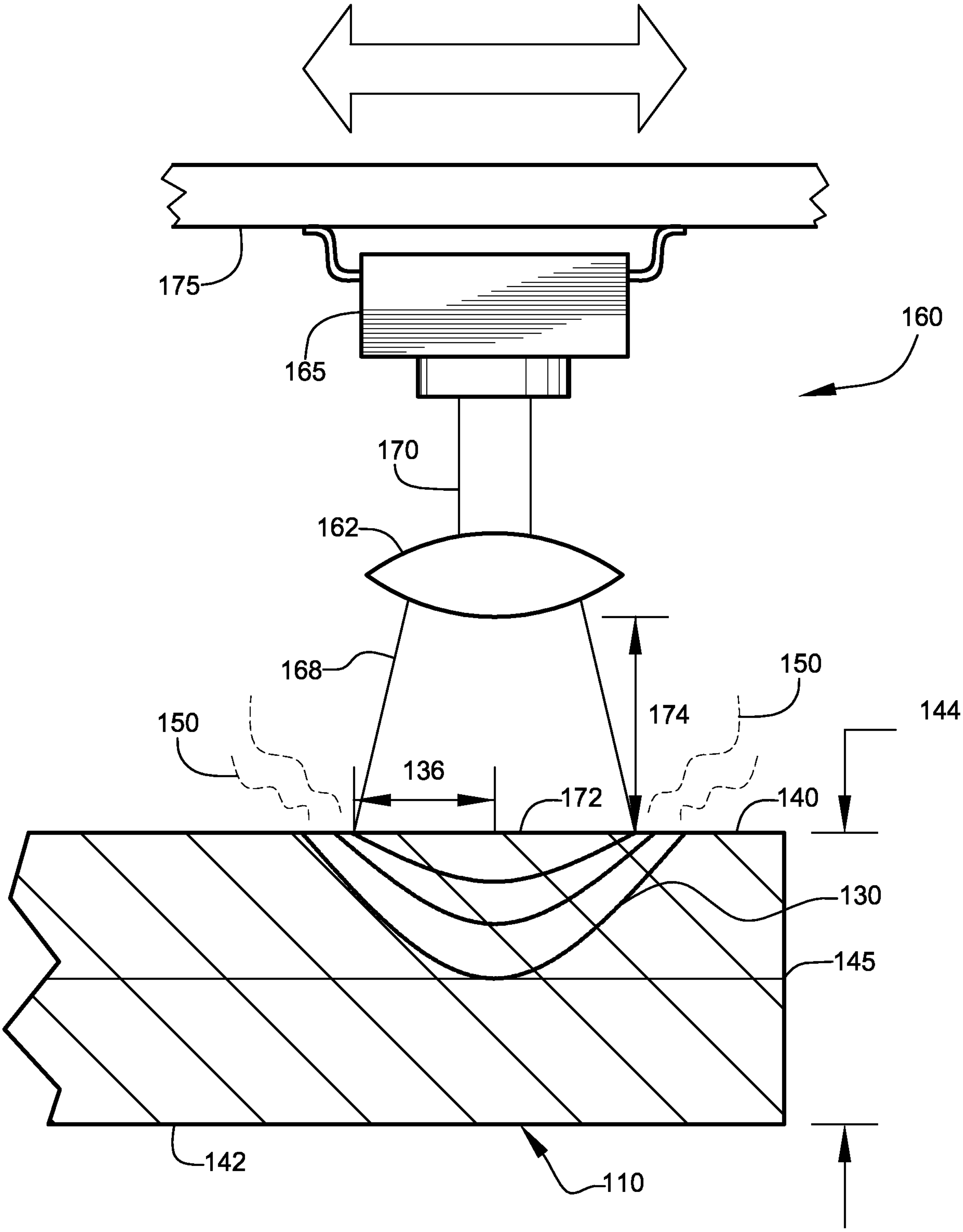
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FIG. 1

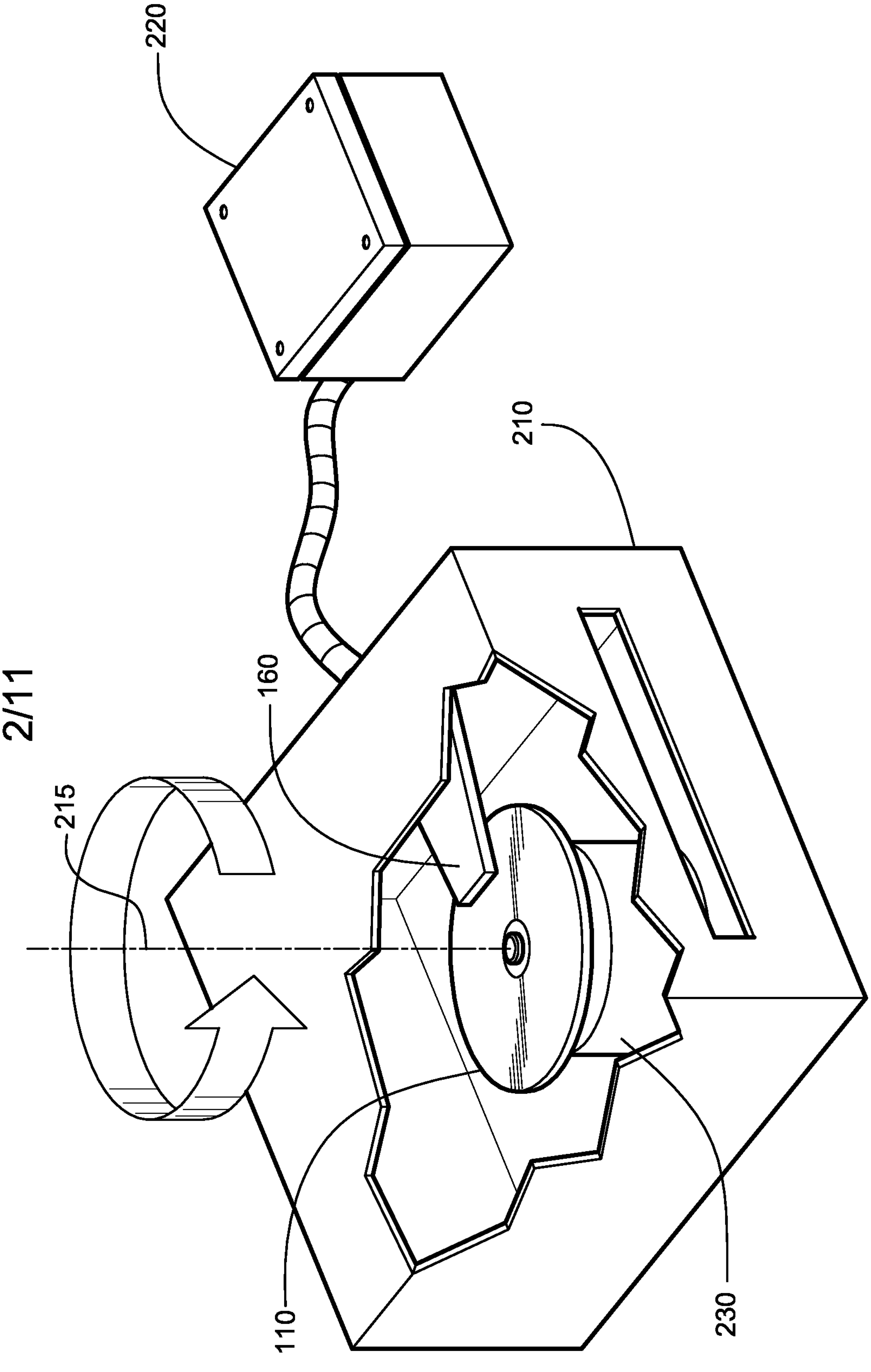

FIG. 2

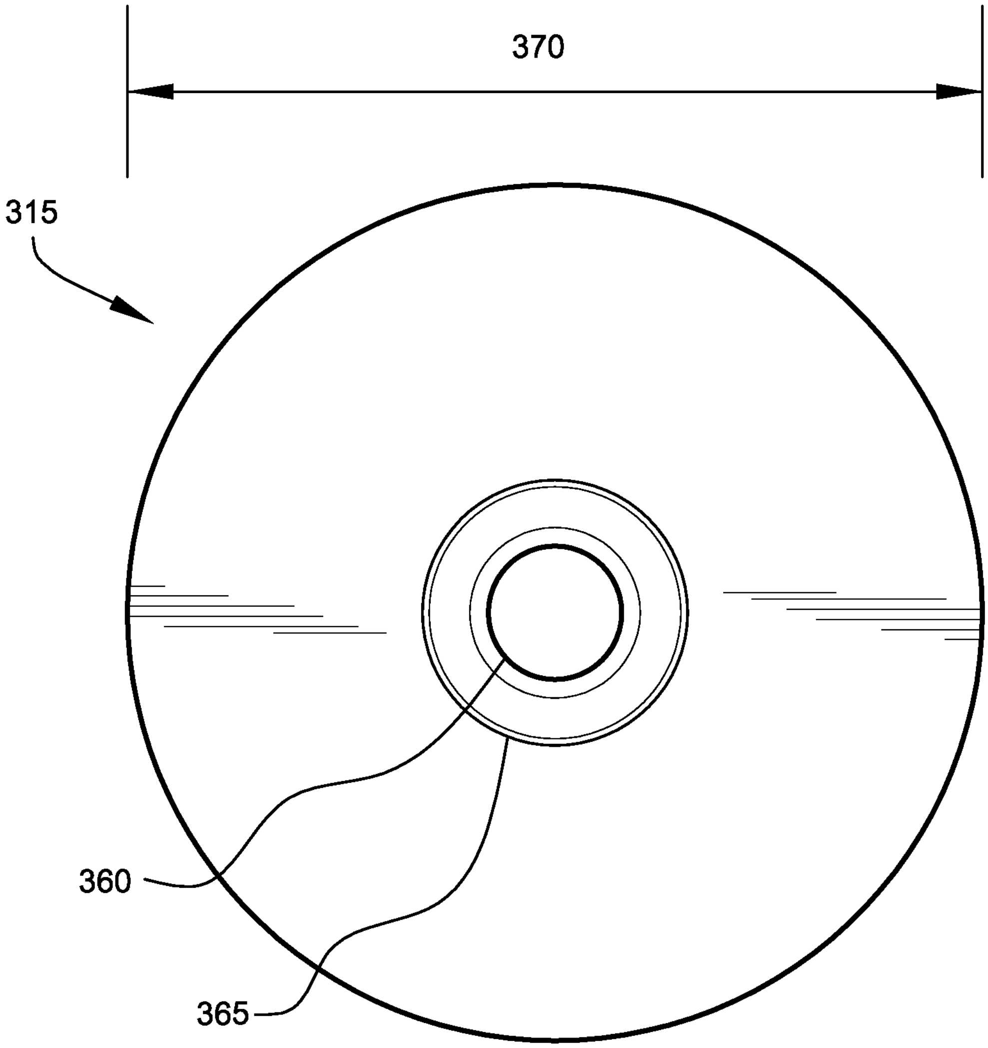

FIG. 3

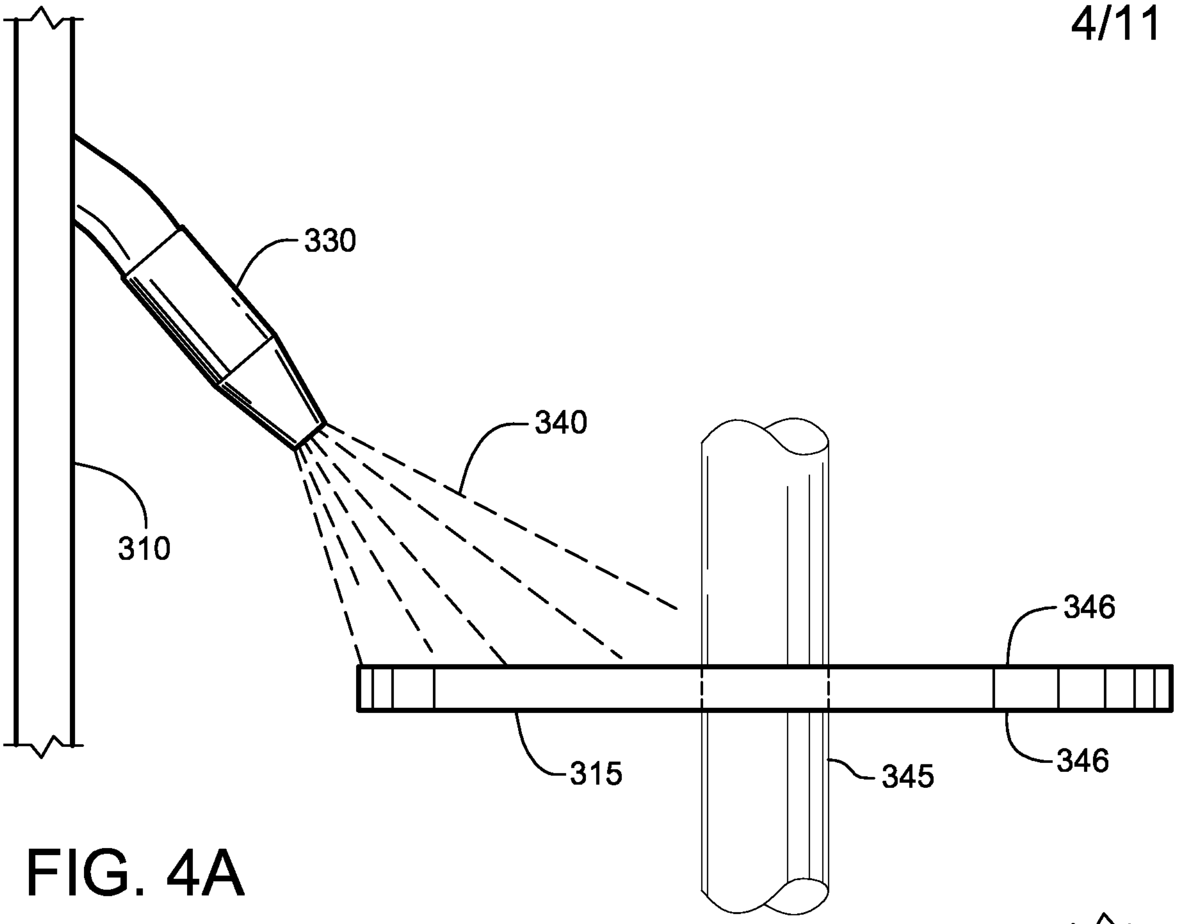

FIG. 4A

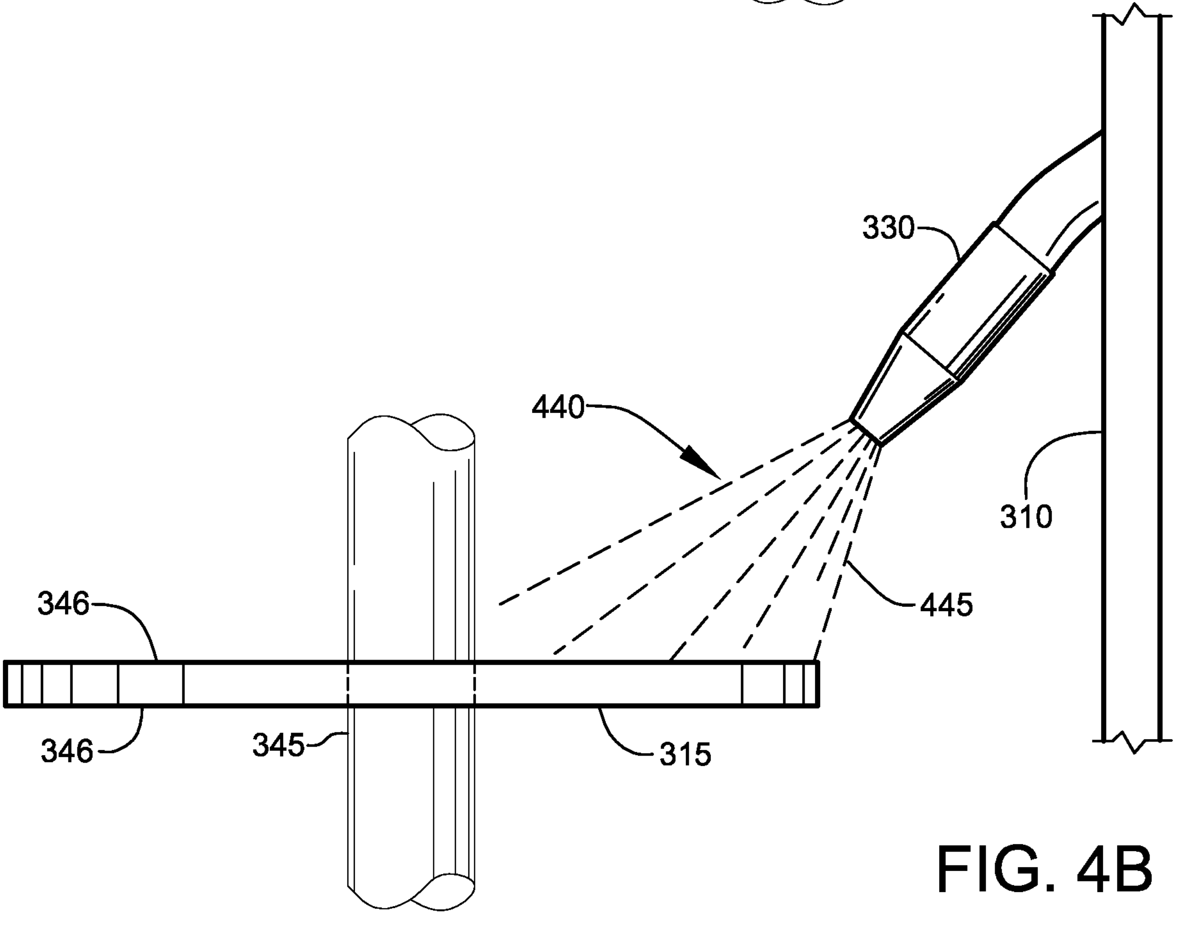

FIG. 4B

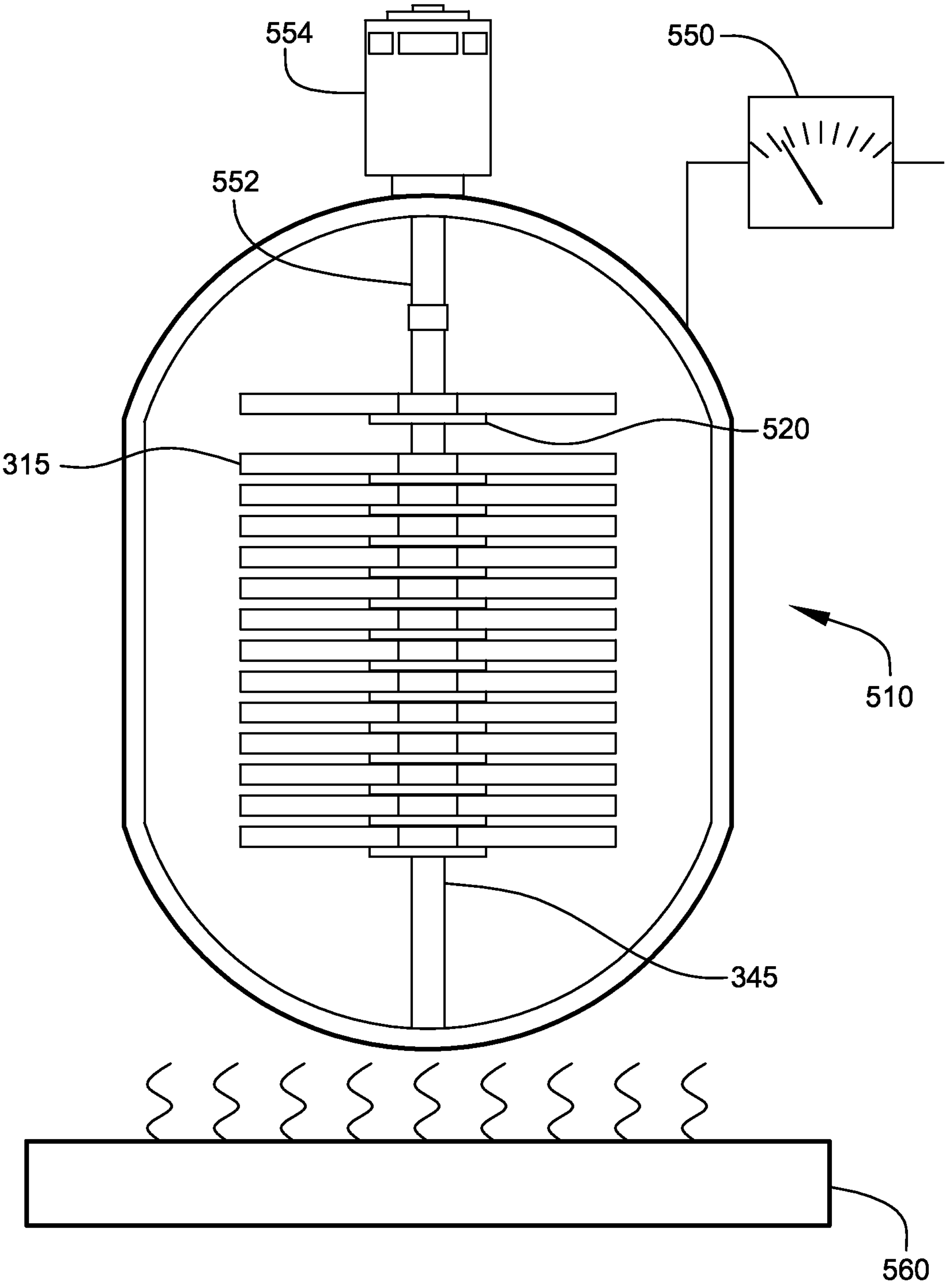

FIG. 5

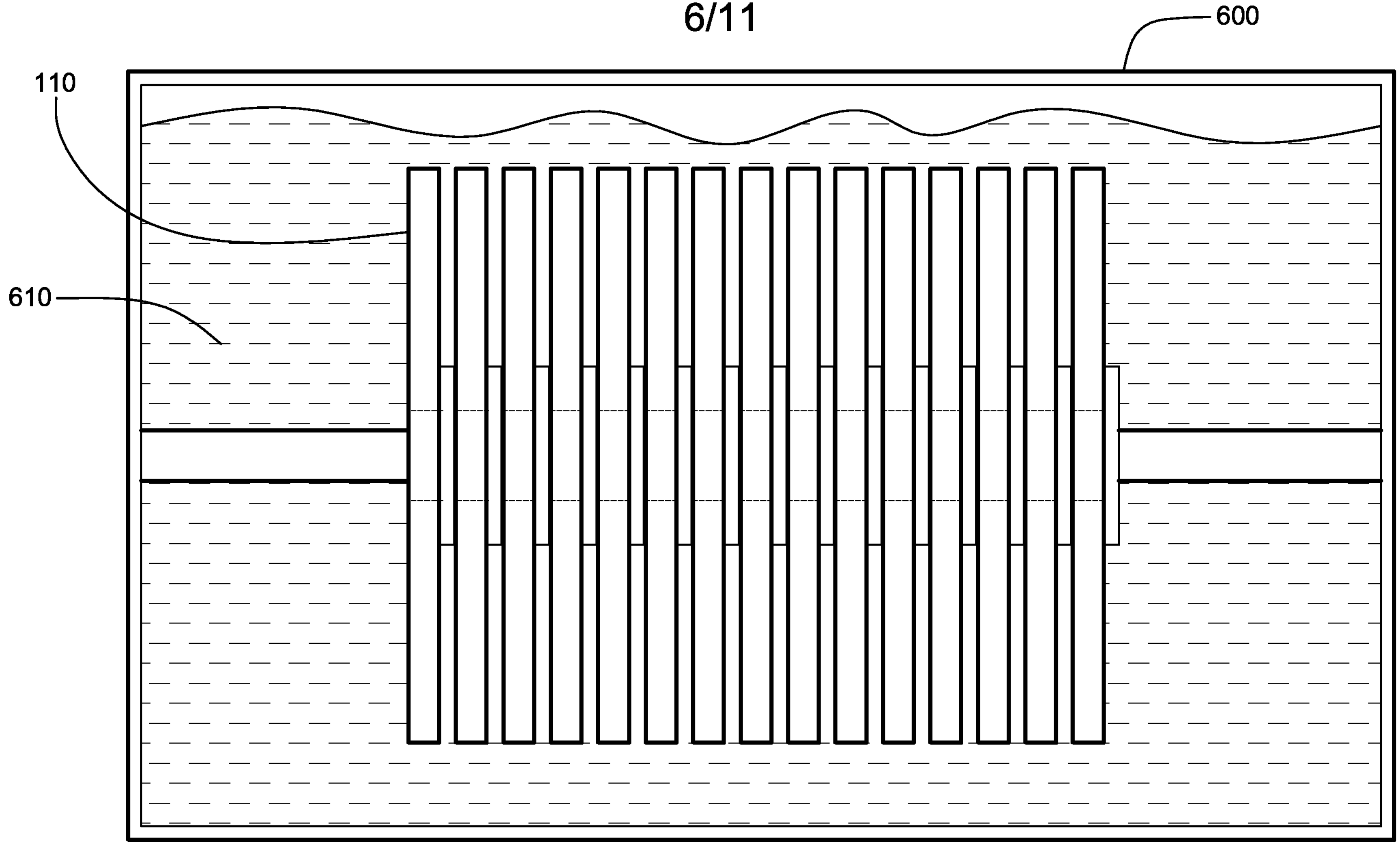

FIG. 6

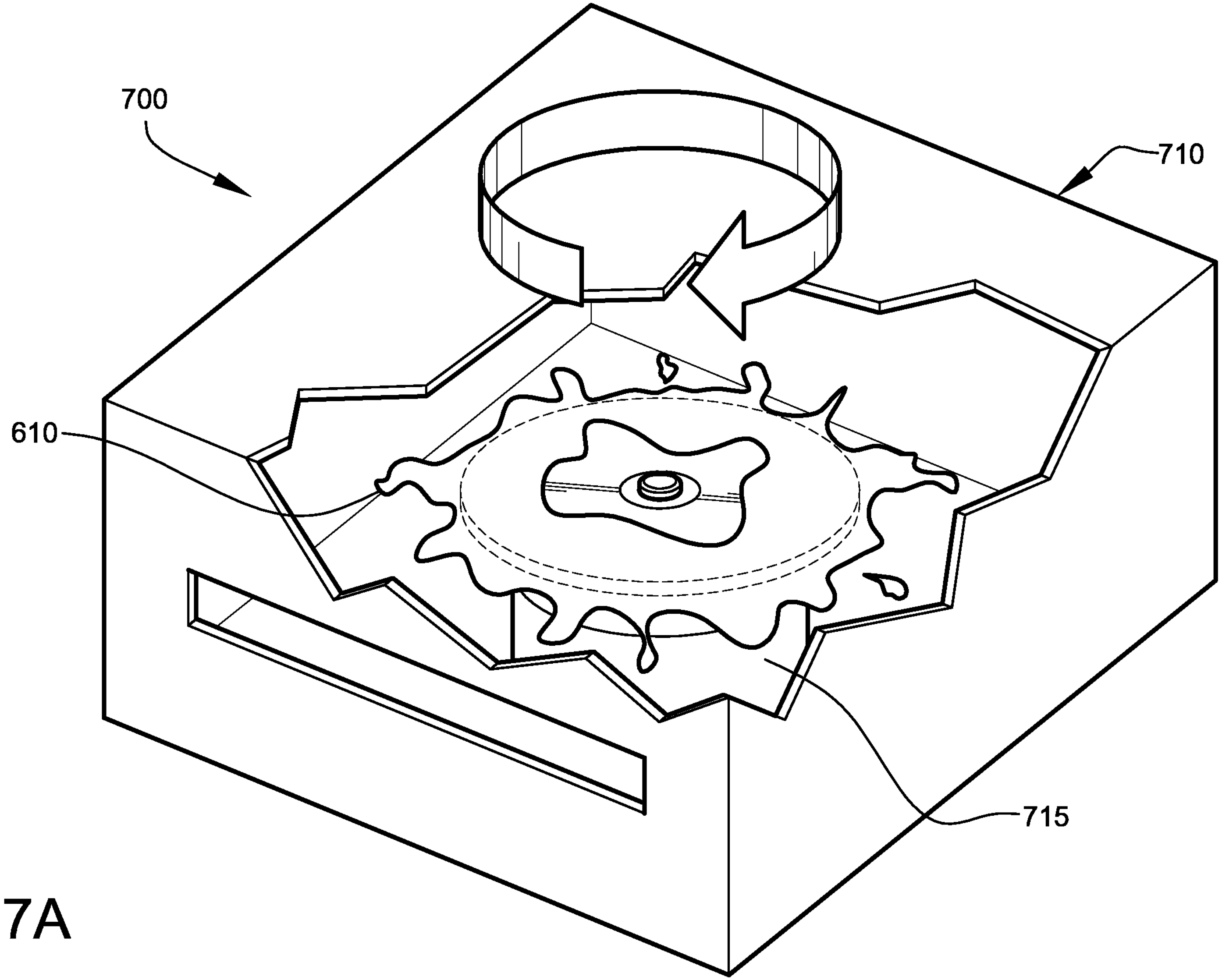

FIG. 7A

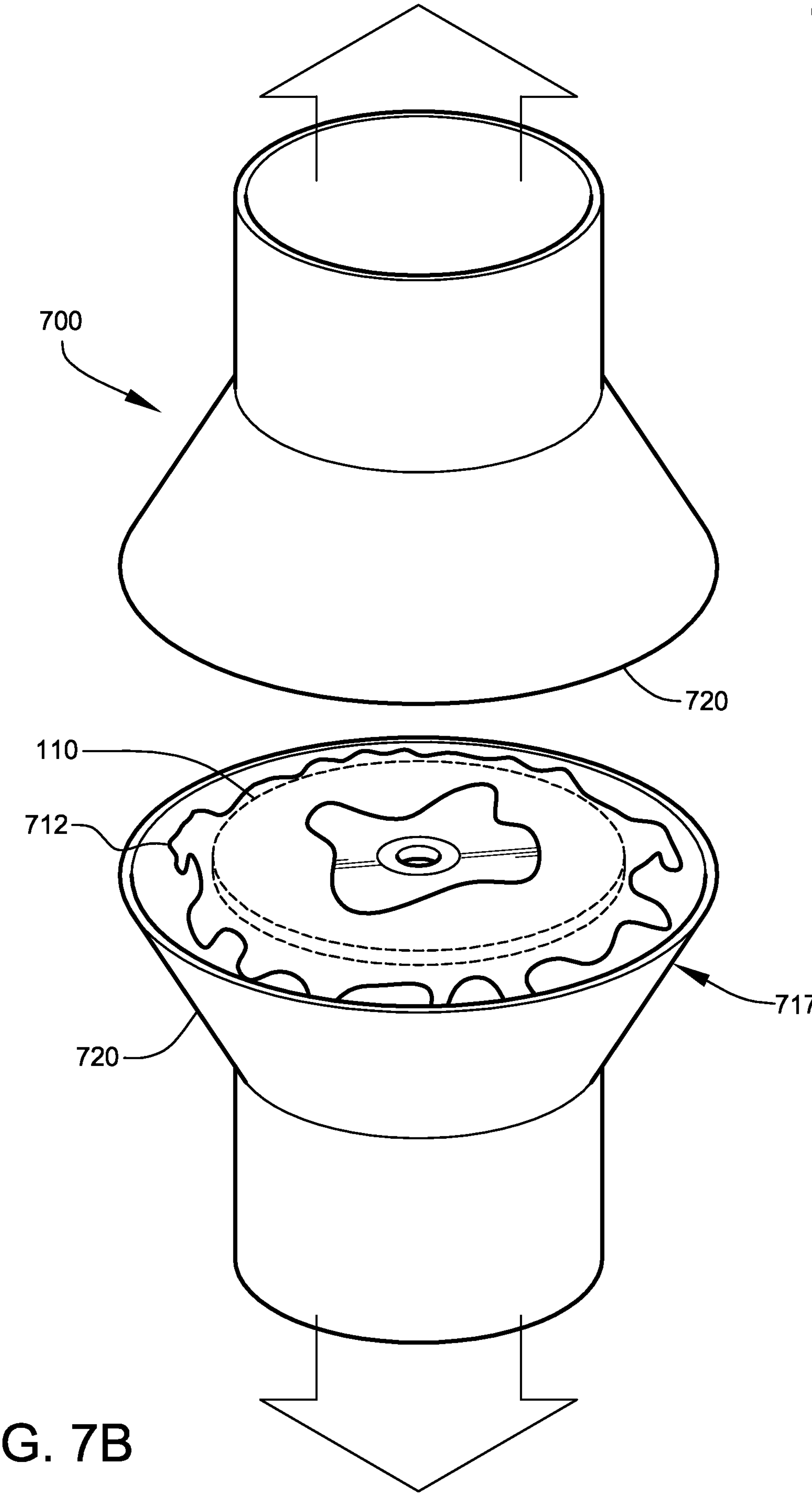

FIG. 7B

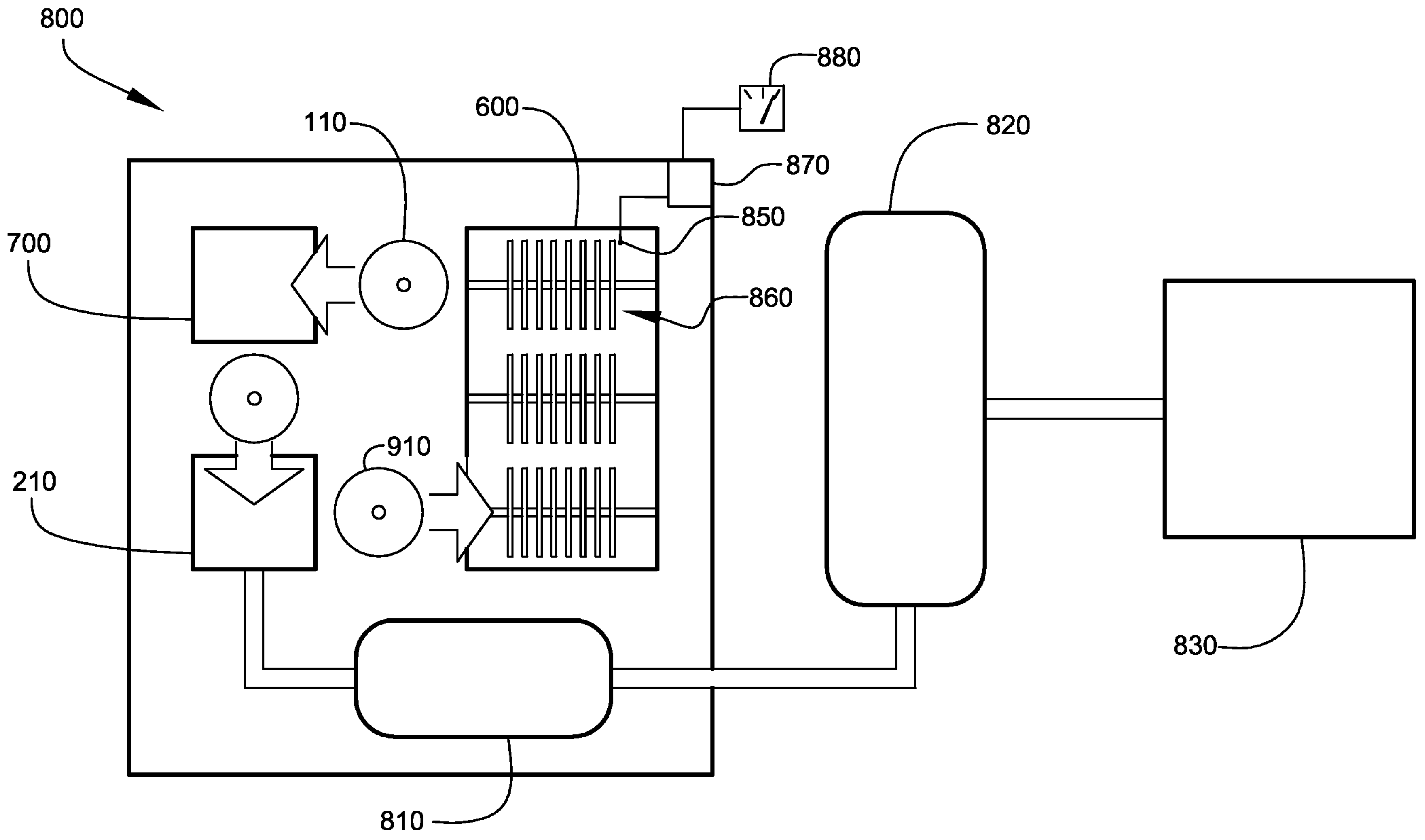

FIG. 8

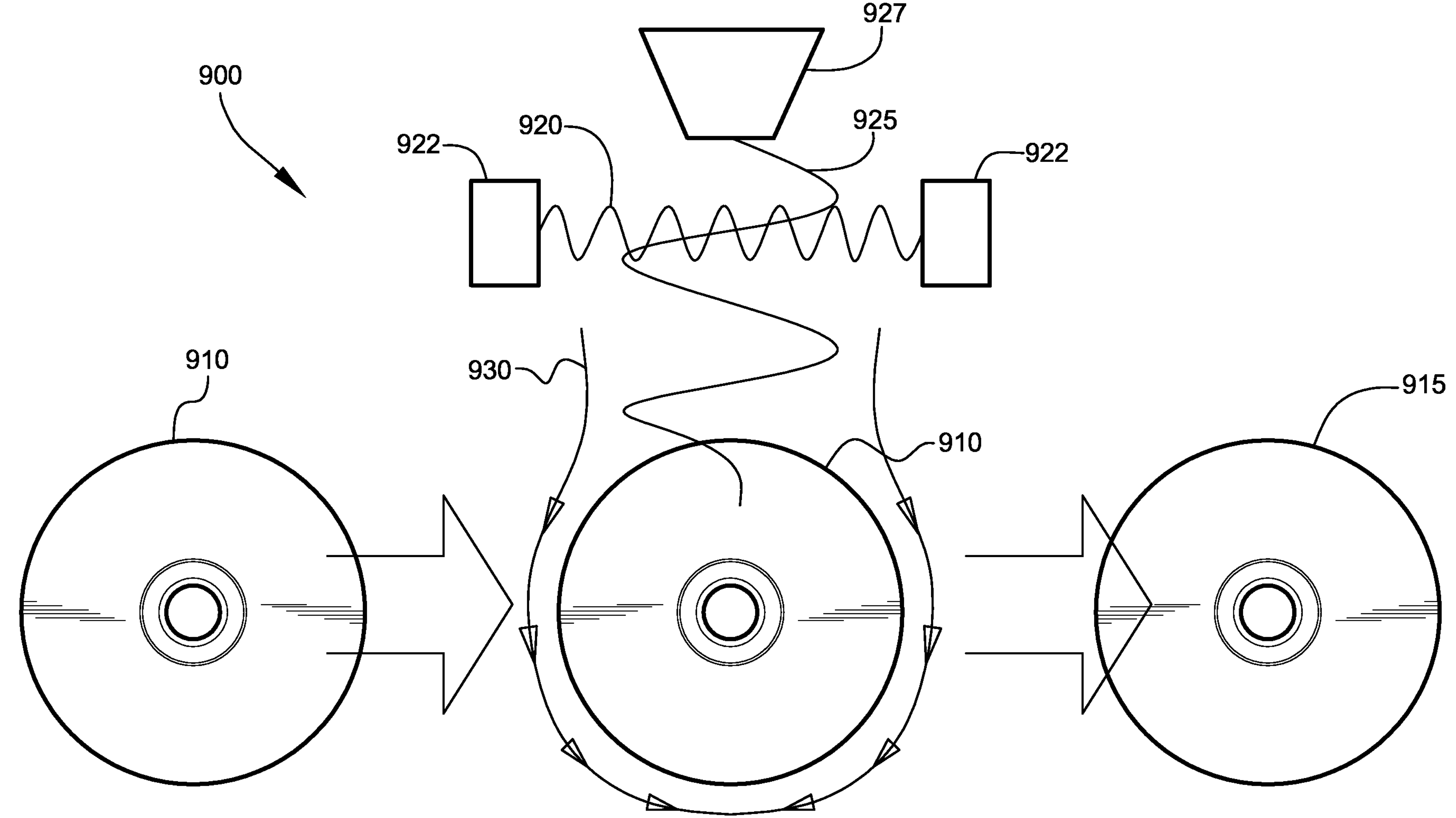

FIG. 9

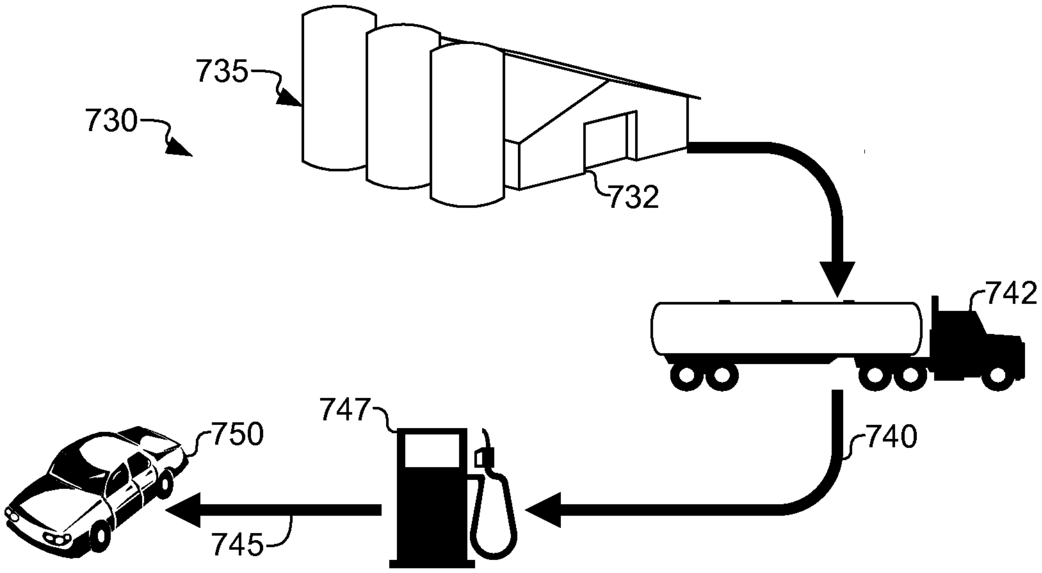
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FIG. 10

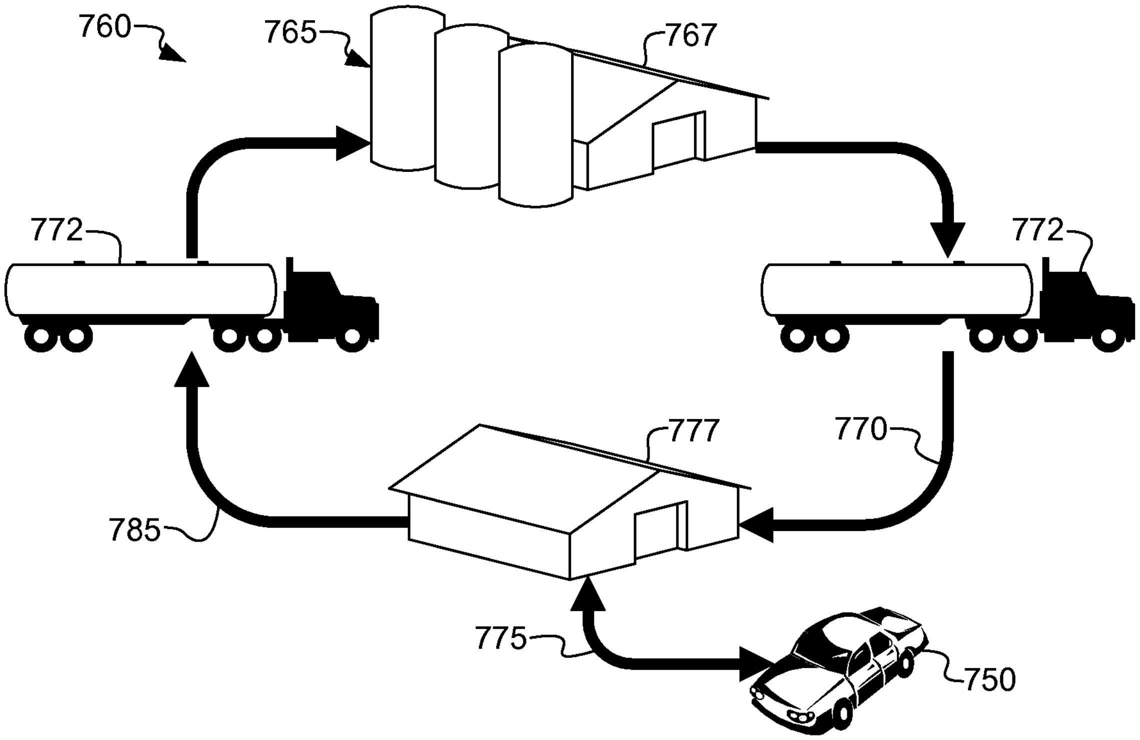
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FIG. 11