



US 20170137925A1

(19) **United States**

(12) **Patent Application Publication**

Leach, JR. et al.

(10) **Pub. No.: US 2017/0137925 A1**

(43) **Pub. Date:** **May 18, 2017**

(54) **METHOD, APPARATUS, AND
COMPUTER-READABLE MEDIUM FOR
CARBURIZATION**

(52) U.S. Cl.

CPC **C23C 8/04** (2013.01); **C23C 8/22**
(2013.01); **C21C 5/5241** (2013.01)

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ABSTRACT

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Presented is a method, apparatus, and computer-readable medium for carburization. A method includes creating a vacuum within an interior of a chamber, the interior of the chamber including an item, the item having a first portion and a second portion, and providing an inert gas and a carbon product to the interior of the chamber. The method further including heating by induction the first portion of the item to induce carburization of the first portion of the item, and in response to the heating, cooling a second portion of the item such that the second portion of the item maintains its structural integrity.

(21) Appl. No.: 14/943,660

(22) Filed: **Nov. 17, 2015**

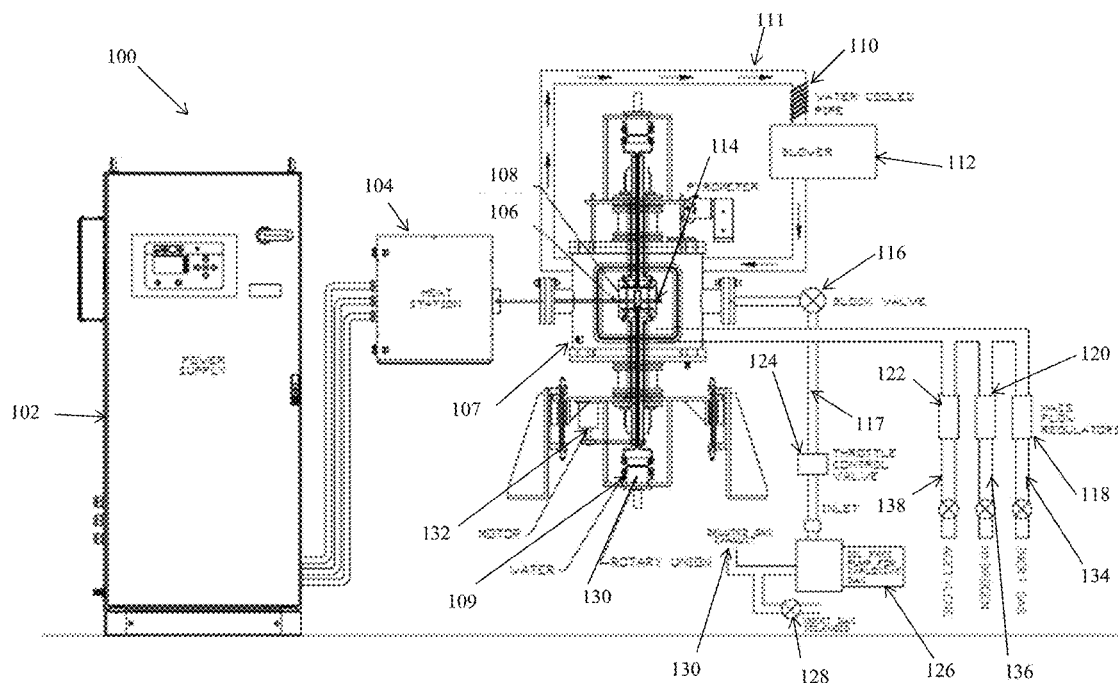
Publication Classification

(51) **Int. Cl.**

C23C 8/04 (2006.01)

C21C 5/52 (2006.01)

C23C 8/22 (2006.01)



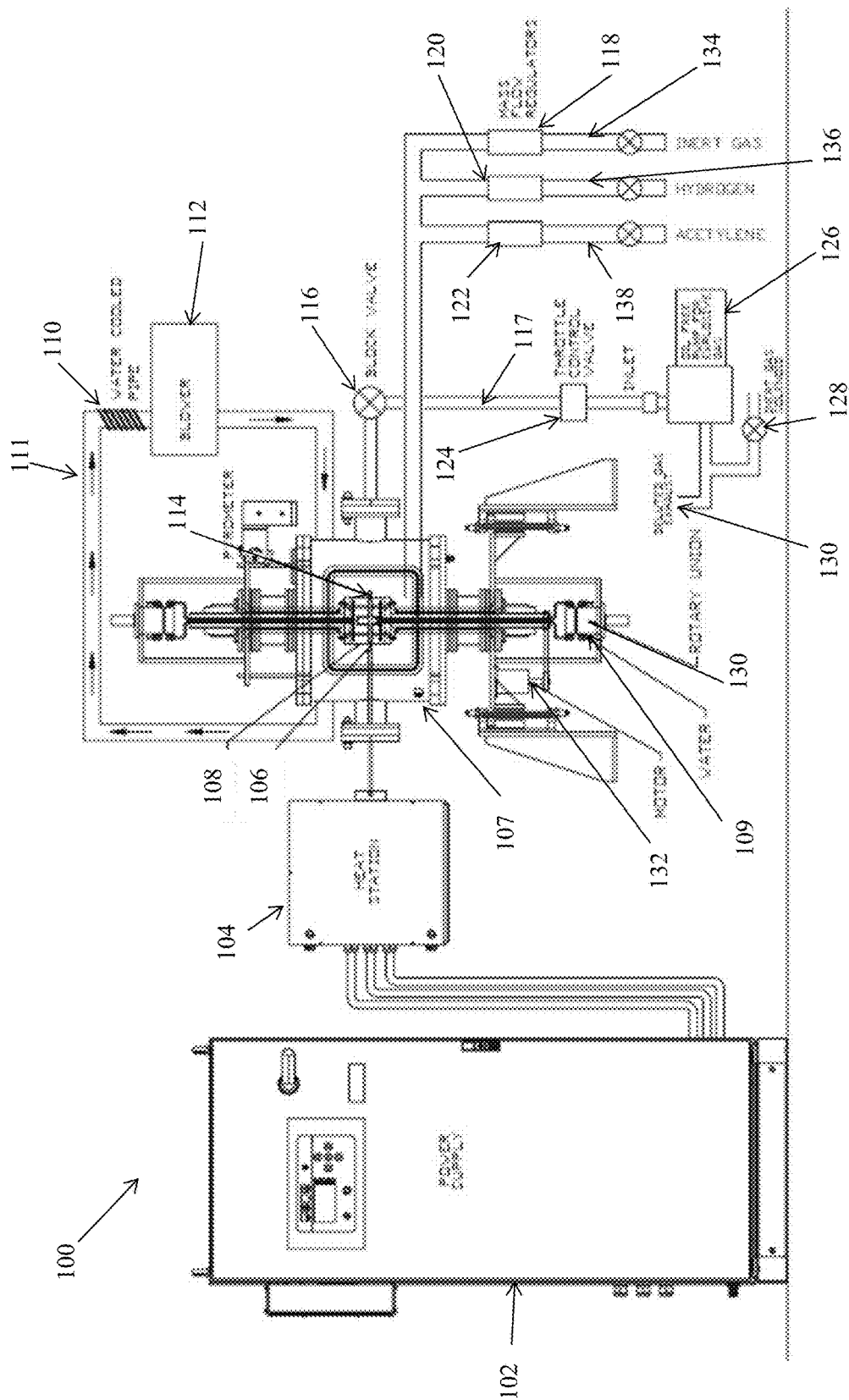
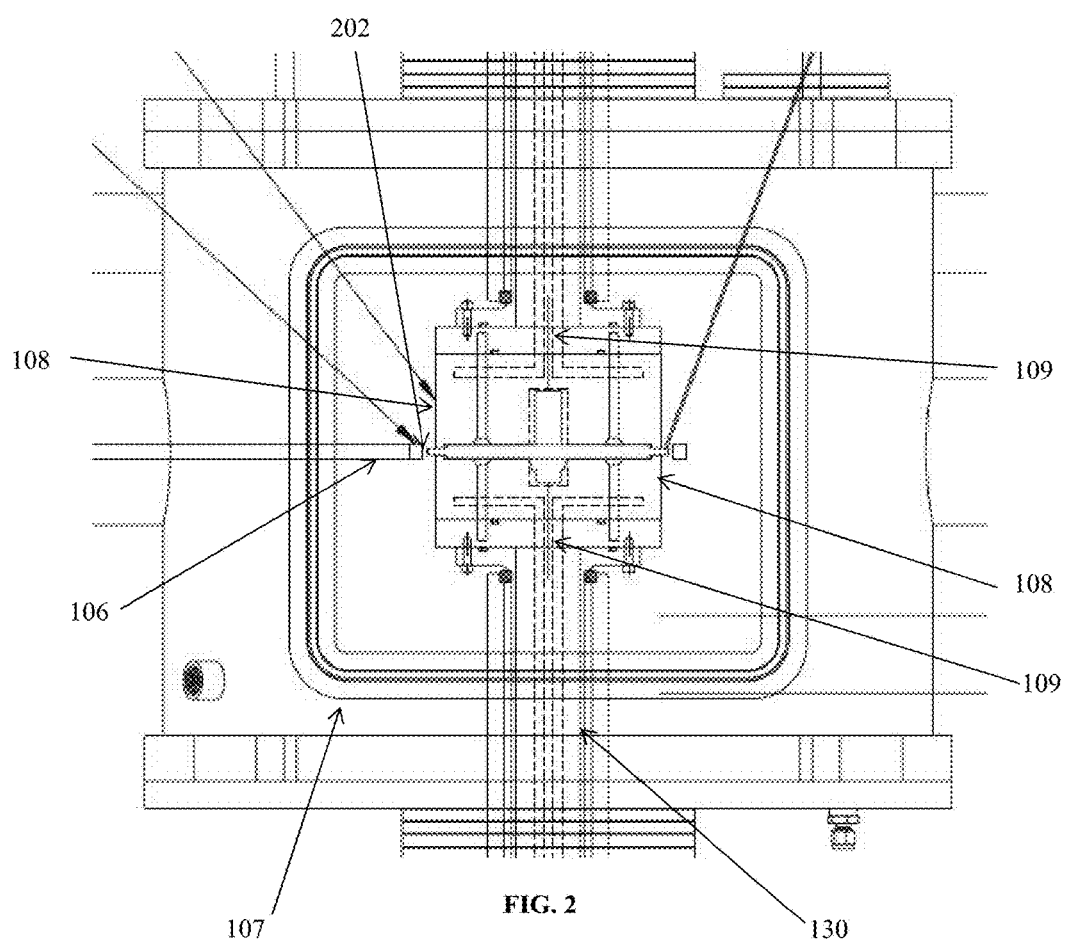


FIG. 1



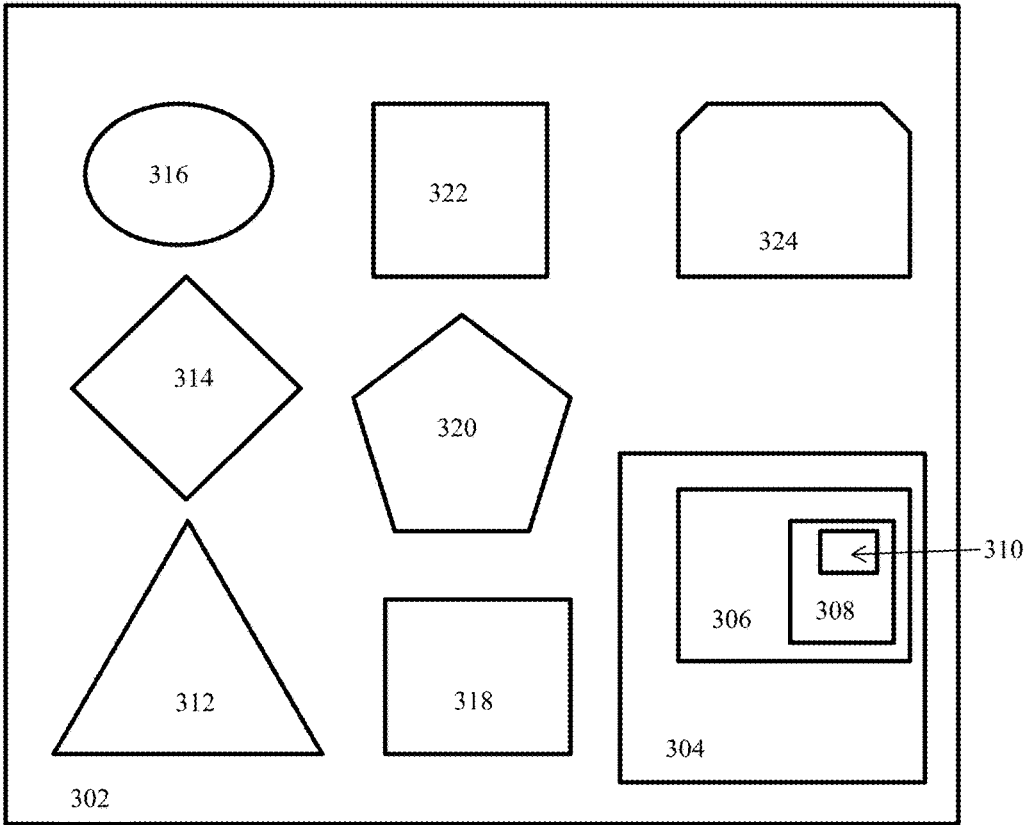


FIG. 3

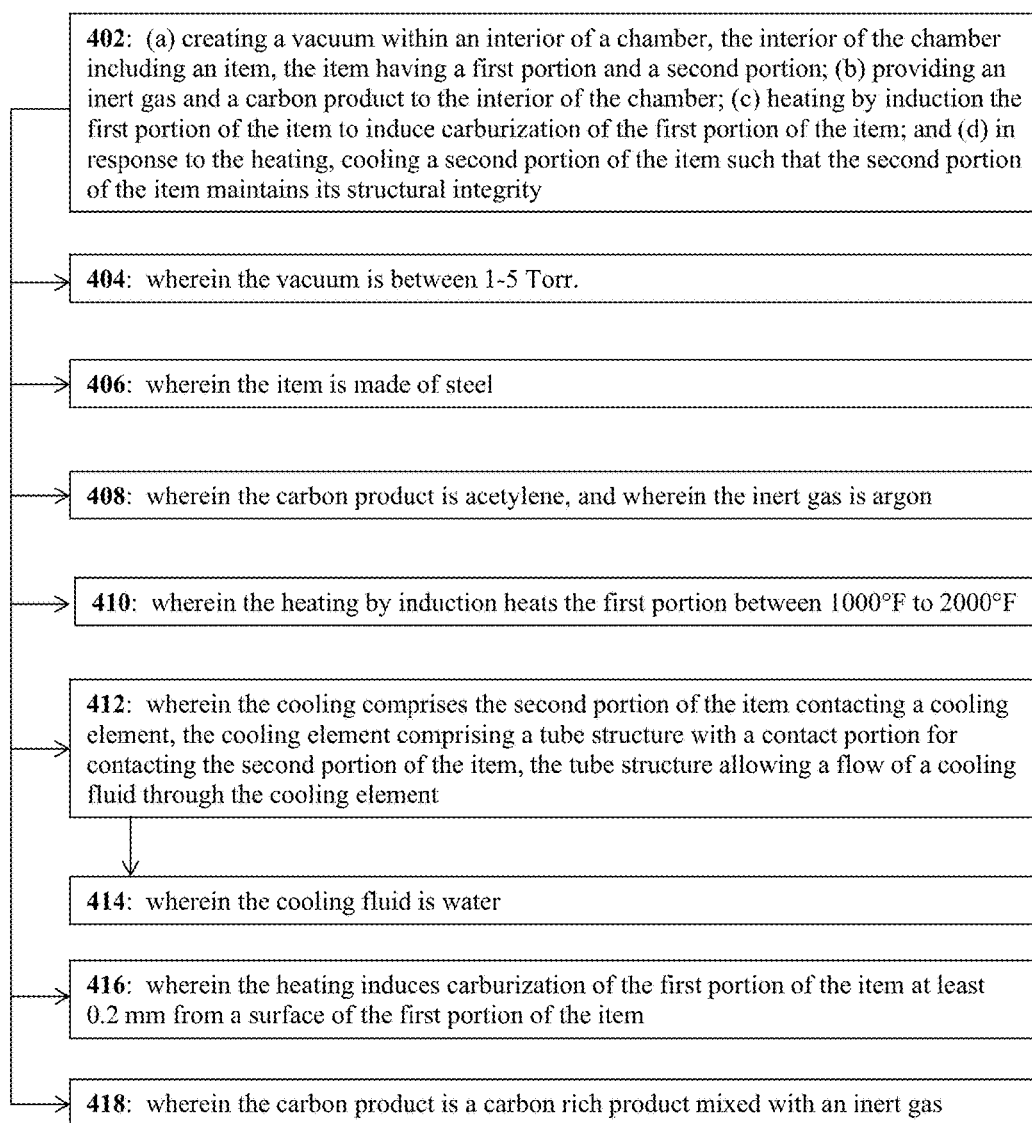


FIG. 4

METHOD, APPARATUS, AND COMPUTER-READABLE MEDIUM FOR CARBURIZATION

BACKGROUND OF THE DISCLOSURE

[0001] Field of the Disclosure

[0002] The present disclosure relates to a method, apparatus, and computer-readable medium for carburization. The present disclosure relates more specifically to a method, apparatus, and computer-readable medium for selective carburization.

[0003] Description of Related Art

[0004] Carburizing or carburization is a heat treatment process in which iron or steel absorbs carbon when the metal is heated in the presence of a carbon emitting material, such as charcoal or carbon monoxide, with the intent of making the metal harder. When the iron or steel is cooled rapidly by quenching, the higher carbon content on the outer surface becomes hard via the transformation from austenite to martensite, while the core remains soft and tough as a ferritic and/or pearlite microstructure.

[0005] The process of carburization works via the implantation of carbon atoms into the surface layers of a metal. As metals are made up of atoms bound tightly into a metallic crystalline lattice, the implanted carbon atoms force their way into the crystal structure of the metal and either remain in solution or react with the host metal to form ceramic carbides. Both of these mechanisms strengthen the surface of the metal, the former by causing lattice strains by virtue of the atoms being forced between those of the host metal and the latter via the formation of very hard particles that resist abrasion.

SUMMARY OF THE DISCLOSURE

[0006] In view of the foregoing, it is an object of the present disclosure to provide a method, apparatus, and computer-readable medium for carburization.

[0007] A first exemplary embodiment of the present disclosure provides a method for carburization. The method includes creating a vacuum within an interior of a chamber, the interior of the chamber including an item, and providing an inert gas and a carbon product to the interior of the chamber. The method further includes heating by induction a first portion of the item to induce carburization of the first portion of the item, and in response to the heating, cooling a second portion of the item such that the second portion of the item maintains its structural integrity.

[0008] A second exemplary embodiment of the present disclosure provides an apparatus for carburization. The apparatus includes a chamber, the chamber operable to create and maintain a vacuum within an interior of the chamber, the chamber sized to hold an item for carburization, and a provider, the provider operably coupled to the chamber and able to provide at least an inert gas and a carbon product to the interior of the chamber. The apparatus further includes a heater, the heater operably coupled to the chamber and able to heat by induction a first portion of the item to induce carburization of the first portion of the item, and a cooler, the cooler operably coupled to the chamber and able to cool a second portion of the item in response to heating by induction the first portion.

[0009] A third exemplary embodiment of the present disclosure provides a non-transitory computer-readable

medium including computer program instructions which when executed on a processor of an apparatus causes the apparatus to at least create a vacuum within an interior of a chamber, the interior of the chamber including an item, the item having a first portion and a second portion. The computer program instructions which when executed on the processor further cause the apparatus to provide an inert gas and a carbon product to the interior of the chamber, and heat by induction the first portion of the item to induce carburization of the first portion of the item. The computer program instructions which when executed on the processor further cause the apparatus to in response to the heating, cooling a second portion of the item such that the second portion of the item maintains its structural integrity.

[0010] The following will describe embodiments of the present disclosure, but it should be appreciated that the present disclosure is not limited to the described embodiments and various modifications of the invention are possible without departing from the basic principle. The scope of the present disclosure is therefore to be determined solely by the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0011] FIG. 1 presents an exemplary apparatus suitable for use in practicing exemplary embodiments of this disclosure.

[0012] FIG. 2 presents a close-up diagram of an exemplary apparatus suitable for use in practicing exemplary embodiments of this disclosure

[0013] FIG. 3 presents a block diagram of an apparatus suitable for use in practicing exemplary embodiments of this disclosure.

[0014] FIG. 4 presents a logic flow diagram of an exemplary method, apparatus, or computer-readable medium in accordance with practicing exemplary embodiments of this disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0015] In various industries, such as the manufacturing industry, iron and/or steel parts are used in the construction of many different devices. Iron or steel is often the material of choice due to their natural characteristics of being stable, hard, and robust. However, sometimes there is a need for iron or steel parts that are structurally more stable or simply harder than the standard iron or steel.

[0016] One way of producing harder iron or steel products or parts can be found in the process of carburization. Carburization generally includes infusing iron or steel with carbon atoms from carbon rich matter. However, conventional means of carburization requires that the entire iron or steel part will be heated to high temperatures and thus the entire surface area of the iron or steel part will be infused with carbon. Since the entire part will be heated to extreme temperatures during the carburization process, the size, shape and overall structure of the part can be effected and/or changed. This is particularly troublesome when elements of an iron or steel part are built to meet certain sizes or specifications and then the carburization process changes those specifications. This is also troublesome in the instance that only a portion of the part or product actually needs to be

carburized. In these cases, the carburized part or product must be reshaped, sized or adjusted to then again meet required specifications.

[0017] Accordingly, there is a need for selective or localized carburization of portions of a part or product. Exemplary embodiments of the present disclosure provide a method, apparatus, and computer-readable medium for selective carburization.

[0018] Referring to FIG. 1, presented is an exemplary apparatus suitable for use in performing exemplary embodiments of the present disclosure. Shown in FIG. 1 is carburization unit 100 for selective or localized carburization of an item, preferably an item comprised of iron and/or steel. Carburization unit 100 includes a power supply 102, heating station 104, coils 106, chamber 107, cooling plates 108, water cooled pipe 110, blower 112, pyrometer 114, block valve 116, a plurality of mass flow regulators 118, 120, and 122, throttle control valve 124, pump 126, inert gas solenoid 128, gas exhaust port 130, rotary union 132, and motor 134.

[0019] Power supply 102 is operably coupled to heat station 104 and the remainder of carburization unit 100 for providing power to heat station 104 and the remainder of carburization unit 100. Embodiments of power supply 102 are able to provide heat station 104 and the remainder of carburization unit 100 with enough power to perform the functions described herein including selective or localized carburization of an item. For instance, power supply 102 may be able to provide at least 20 kilowatts. Embodiments of power supply 102 include generators that are able to produce its own power, such as gasoline generators, but can also include power supplies that are connected or plugged into existing power lines or connections.

[0020] Heat station 104 is operably coupled to coils 106 to heat an item in contact with coils 106 by induction. Embodiments of heat station 104 are able to provide coils 106 with a high-frequency alternating current that is able to cause induction heating in the item that comes into contact with coils 106. Embodiments of heat station 104 includes an electromagnet, and an electronic oscillator able to pass high-frequency alternating current through the electromagnet. Other embodiments of heat station 104 in conjunction with coils 106 are able to heat an item in contact with coils 106 through the creation of eddy currents flowing through the resistance of the item heated or through magnetic hysteresis losses.

[0021] Coils 106 are enclosed in vacuum chamber 107. Coils 106 are operable to heat by induction an item that comes into contact with coils 106. Embodiments of coils 106 are able to heat an iron or steel item to sufficient temperature to cause carburization on the surface of the item. Embodiments of coils 106 are able to heat an item near the point of contact with coils 106 to 1000° F.-2000° F. Coils 106 are operable to cause carburization on the surface of the item and carburization beneath the surface of the item penetrating between 1 mm-5 mm below the surface of the item. Embodiments of coils 106 are shaped and sized to contact a portion of an item enclosed within chamber 107 to allow coils 106 to selectively cause carburization on the portion of the item around the area of contact with coils 106.

[0022] Cooling plates 108 are maintained within chamber 107 and are coupled to water line 109 for cooling a portion of an item enclosed within chamber 107. Cooling plates 108 include a plurality of metal plates that can come into contact with a portion of an item in chamber 107. Cooling plates 108

prevent or substantially prevent the heating and/or carburization of the portion of the item that is in contact or at least partially in contact with cooling plates 108. It should be appreciated that embodiments of cooling plates 108 can be made of any material that can transfer or draw heat away from an item heated by induction in chamber 107 and is also able to maintain its structure and integrity during a carburization cycle. That is, cooling plates 108 can maintain a sufficiently low temperature of a portion of the item during induction heating to substantially preclude carburization of the portion of the item. Cooling plates 108 are coupled to water line 109 such that a side of cooling plates 108 can contact a portion of an item enclosed in chamber 107 while the other side of cooling plates 108 is in contact with water from water line 109.

[0023] Water line 109 circulates water over the portion of cooling plates 108 that is not in contact with an item being carburized, thereby dissipating heat from cooling plates 108 and heat from the item enclosed in chamber 107.

[0024] Pyrometer 114 is operably coupled to chamber 107 to sense or measure the temperature of a surface of an item within chamber 107. Pyrometer 114 may be able to sense from a distance (i.e., without physical contact) the temperature of a surface of an item within chamber 107 from the spectrum of the thermal radiation the item emits. Embodiments of pyrometer 114 are able to monitor the surface temperature of an item within chamber 107 and to communicate the data to a display, computer, and/or controller to inform a user of the temperature.

[0025] Air tube 111 is coupled to chamber 107 and provides a means for circulating air in and out of chamber 107 to cool chamber 107 and its contents after a carburization cycle. Embodiments of air tube 111 can be opened and sealed to allow the flow of air into and out of chamber 107. The movement of air through air tube 111 is controlled by blower 112. Blower 112 includes at least one fan or fan like element for blowing air through air tube 111. Blower 112 is operably coupled to air tube 111. Embodiments of blower 112 include at least one fan or similar device for blowing air through air tube 111.

[0026] The air within air tube 111 can be cooled by water cooled pipe 110. Water cooled pipe 110 is operably coupled to air tube 111 for cooling air tube 111. Embodiments of water cooled pipe 110 contain a hollow tube filled with circulating water able to dissipate heat from air tube 111 and thus the air within air tube 111.

[0027] Mass flow regulators 118, 120, and 122 are operably coupled to tubes 134, 136, and 138, respectively, for measuring and controlling a flow of a liquid or gas through tubes 134, 136, and 138 to the interior of chamber 107. In one embodiment, tube 134 and mass flow regulator 118 are able to provide a predetermined amount of an inert gas to the interior of chamber 107. An exemplary inert gas includes Argon or Nitrogen. Other embodiments of inert gases include the noble gases. Mass flow regulator 120 and tube 136 are able to provide a predetermined amount of hydrogen gas to the interior of chamber 107. Mass flow regulator 122 and tube 138 are able to provide a predetermined amount of a carbon product to the interior of chamber 107. A carbon product is any composition, liquid, gas, or compound that allows carbon atoms to be emitted for carburization. It should be appreciated that carbon product includes carbon rich products and hydrocarbons such as, but not limited to, acetylene, propane, and liquid naphthene. Embodiments of

acetylene contain 99.9% pure acetylene. Embodiments of mass flow regulators **118**, **120** and **122** include any type of provider that is able to start, stop, and measure a flow of liquid or gas at a specified rate and at specified times into container **107**.

[0028] Throttle control valve **124** is operably connected to block valve **116** and chamber **107** through tube **117** for pulling, controlling, and setting a vacuum in the interior of chamber **107**. A vacuum will include a low vacuum and a medium vacuum with a pressure of between 1-5 Torr. Embodiments of the vacuum will include vacuums that are maintained and those that may fluctuate such that some air leaks into the system raising the pressure in the system. Throttle control valve **124** is operably connected to tube **117** set and control gases in chamber **107** and thereby control the vacuum level in chamber **107**. Block valve **116** is able to operably open and seal tube **117**. Embodiments of block valve **116** include a mechanical pump able to repeatedly open and seal tube **117**.

[0029] Pump **126** is operably connected to tube **117** to pump out gases from chamber **107**. During a carburization cycle in chamber **107**, carbon atoms are added to the surface of an item being carburized inside chamber **107**. The carbon product or carbon rich product typically includes carbon atoms and other atoms, such as hydrogen atoms. When the carbon atoms are bonded to the item being carburized, the other atoms, such as hydrogen atoms are released into chamber **107** and create an exhaust. Pump **126** pumps out exhaust from chamber **107** in order to help maintain a given pressure and air composition within chamber **107** ideal for continued carburization.

[0030] Exhaust from chamber **107**, pumped by pump **126** is then diluted with an inert gas by inert gas solenoid **128**. Diluting The diluted gas then exits the system through diluted gas exhaust port **130**.

[0031] Embodiments of carburization unit **100** may also include a rotary unit **130** and motor **132**. Rotary unit **130** has a portion outside of chamber **107** and a portion within the interior of chamber **107**. The portion of rotary unit **130** located within the interior of chamber **107** is operable for attaching or affixing to an item to be carburized. Motor **132** is operable connected to rotary unit **130** to rotate the item to be carburized within chamber **107** such that portions of the item are evenly carburized.

[0032] For instance, a user may have a round or somewhat round shaped item. The user may also desire to carburize round surface of the item. Embodiments of coils **106** provide one or multiple contact points to induce carburization, but do not generally encompass the entire surface of the item the user desires to carburize. Accordingly, the user can attach the item to rotary unit **130**. Rotary unit **130** will rotate the item during the carburization process at a constant rate such that the item will carburize evenly on its surface bringing the different portions of the surface of the item in contact with coils **106**.

[0033] In practice, an item to be carburized will be placed and sealed within the interior of chamber **107** such that it is in contact with coils **106** and cooling plates **108**. Block valve **116** will be placed in the open position and then throttle control valve **124** will remove the air from within the interior of chamber **107** creating a medium vacuum within the range of 0.1-0.01 Torr. Once the desired vacuum is created with in the interior of chamber **107**, throttle control valve **124** will stop removing air from the interior of chamber **107** and

block valve **116** will be sealed. At this point, the system can be checked for leaks by monitoring whether chamber **107** maintains the pressure or if the pressure increases. If the pressure increases then it is known that there is a leak in the system.

[0034] Next, hydrogen gas will be added to the interior of chamber **107** through mass flow regulator **120** and tube **136**. During the addition of hydrogen gas, the pressure in the chamber **107** will be between 1-5 Torr. Next, power supply **102** will supply power to heat station **104** activating coils **106** to cause a current to pass through the item in the chamber **107** and thereby heating the item. Next, the flow of hydrogen gas will be stopped, and a carbon product including a carbon rich product, or other hydrocarbon will be added to the interior of chamber **107** through mass flow regulator **122** and tube **138**. For example, the carbon product acetylene can be added at this stage in the process. During the addition of acetylene, the pressure within the interior of chamber **107** will remain between 1-5 Torr. After a predetermined amount of time, mass flow regulator **122** will stop the flow of the carbon product, carbon rich product, or other hydrocarbon, and mass flow regulator **118** with tube **134** will provide an inert gas into the interior of chamber **107**. In response to the heating of the item by coils **106**, cooling plates **108** will cool and thereby substantially prevent carburization on the portions of the item the user desires to not have carburized. It should be appreciated that embodiments of cooling plates **108** are operable to cool in response to the heating of the item by coils **106** simultaneously with the heating, prior to the heating, after the heating, or a combination of these times. After a predetermined amount of time, the heat from coil **106** will be turned off. Mass flow regulator **118** through tube **134** will then add an inert gas returning the pressure in chamber **107** to approximately 600 Torr. Next, blower **112** will blow cooling air through chamber **107** to cool the entirety of the item and the pressure in the interior of chamber **107** will return to atmospheric pressure.

[0035] The predetermined amount of time will be dependent on how much carburization a user desires to create on the item, and the depth of carburization the user desires to create on the item. In other words, the longer the predetermined amount of time, the deeper the carburization of the item from its surface.

[0036] Therefore, embodiments of the present disclosure provide a method, apparatus, and computer-readable medium for selectively carburizing an item or a workpiece. Embodiments of the present disclosure include a process of providing a workpiece, wherein the workpiece includes a first portion and a second portion. Next, the first portion of the workpiece is heated to induce carburization of the first portion of the workpiece. Then, in response to the heating, the second portion of the workpiece is cooled to substantially prevent carburization of the second portion of the workpiece, thereby selectively carburizing the first portion of the workpiece without carburizing the second portion of the workpiece.

[0037] Reference is now made to FIG. 2, which depicts a close-up view of carburization unit **100** and the interior of chamber **107**. Shown in FIG. 2 is chamber **107**, coils **106**, cooling plates **108**, rotary unit **130**, water line **109**, and item.

[0038] As can be seen in FIG. 2, coils **106** are located on the left side of chamber **107** and will contact an item for carburization within the interior of chamber **107** at point **202**. In the embodiment shown in FIG. 2, coils **106** are

arranged for carburization of the outside surface of a circular plate shaped item. However, it should be appreciated that embodiments of the present disclosure are applicable to an item regardless of its shape. In practice, the circular item will be placed in the center of chamber 107 on rotary unit 130 such that the circular edge of the circular item is in contact coils 106. Cooling plates 108 will be in contact the front and back faces of the circular plate shaped item to prevent carburization of the front and back faces. During carburization, rotary unit 130 will rotate circular plate shaped item such that the circular edge is in constant contact coils 106 and the circular edge obtains an evenly spread layer of carburization on the circular edge surface.

[0039] Referring to FIG. 3, presented is a simplified block diagram of the various elements of an apparatus suitable for use in practicing exemplary embodiment of the present disclosure. Shown in FIG. 3 is carburization unit 302 for selectively carburizing a portion or portions of an item. An exemplary item includes any device or article of manufacture made of iron or steel.

[0040] Carburization unit 302 includes processing means such as a controller 304, which includes at least one data processor 306 storing means such as a computer-readable memory 308 storing a computer program 310 including computer program instructions. Controller 304, data processor 306, and computer-readable memory 308 with computer program 310 provide a mechanism for selectively carburizing a portion or portions of an item.

[0041] Carburization unit 302 also includes a chamber 312 for maintaining an item for carburization. Chamber 312 is able to create and hold a vacuum within an interior of chamber 312. Chamber 312 is also able to allow the addition of other gases and/or fluids while maintaining a relative pressure in chamber 312. Carburization unit 302 includes power supply 314 for providing power to carburization unit 302. Power supply 314 can be operably connected to controller 304 for determining a distribution of power such as when to supply power to heating station 316.

[0042] Carburization unit 302 includes heating station 316 operable to heat by induction an item maintained within chamber 312 to cause carburization. Heating station 316 is operably connected to power supply 314 and controller 304. Gas regulators 318 are able to provide and regulate a flow of gases or fluids to chamber 312. Gas regulators 318 are operably connected to controller 304 for controlling the flow of gases or fluids and chamber 312. Exemplary gases or fluids include carbon products, inert gases (e.g., argon, nitrogen, and noble gases), and carbon rich products (e.g., acetylene, propane, naphthene hydrocarbon, and other hydrocarbons).

[0043] Carburization unit 302 further includes cooling plates 320 for selectively cooling a portion or portions of an item being carburized within chamber 312. Cooling plates 320 are operably maintained within chamber 312 and are operably connected to controller 304. Controller 304 is able to activate and deactivate cooling plates 320.

[0044] Carburization unit 302 includes a vacuum controller 322 for pulling and maintaining a vacuum or a given pressure within chamber 312. Vacuum controller 322 is operable connected to chamber 312 and is controlled by controller 304. Vacuum controller 322 receives power from power supply 314.

[0045] Carburization unit 302 also includes a cooler 324 for cooling the interior of chamber 312 after a carburization

cycle has completed. Cooler 324 is operably connected to chamber 312 to provide cooling air to the interior of chamber 312. Cooler 324 is operably connected to controller 304 for controlling operation of cooler 324, and power supply 314.

[0046] The computer program 310 in carburization unit 302 in exemplary embodiments is a set of program instructions that, when executed by data processor 306, enable carburization unit 302 to operate in accordance with the exemplary embodiments of this disclosure as detailed herein. In these regards, the exemplary embodiments of this disclosure may be implemented at least in part by a computer software stored in computer readable memory 308, which is executable by data processor 306. Devices implementing these aspects of the disclosure need not be the entire device as depicted in FIG. 3 or may be one or more components of same such as the above described tangibly stored software, hardware, and data processor.

[0047] Reference is now made to FIG. 4, which presents a logic flow diagram in accordance with a method, apparatus, and computer-readable medium for performing exemplary embodiments of this disclosure. Block 402 presents (a) creating a vacuum within an interior of a container, the interior of the container including an item; (b) providing an inert gas and a carbon product to the interior of the container; (c) heating by induction a first portion of the item to induce carburization of the first portion of the item; and (d) in response to the heating, cooling a second portion of the item such that the second portion of the item maintains its structural integrity. Then block 404 specifies wherein the vacuum is between 1-5 Torr.

[0048] Some of the non-limiting implementations detailed above are also summarized at FIG. 4 following block 404. Block 406 presents wherein the item is made of steel. Block 408 then specifies wherein the carbon product is acetylene, and wherein the inert gas is argon. Block 410 further specifies wherein the heating by induction heats the first portion between 1000° F. to 2000° F. Block 412 then states wherein the cooling comprises the second portion of the item contacting a cooling element, the cooling element comprising a tube structure with a contact portion for contacting the second portion of the item, the tube structure allowing a flow of a cooling fluid through the cooling element. Block 414 relates to wherein the cooling fluid is water. Block 416 specifies wherein the heating induces carburization of the first portion of the item at least 0.2 mm from a surface of the first portion of the item. Finally block 418 states wherein the carbon product is a carbon rich product mixed with an inert gas.

[0049] The logic diagram of FIG. 4 may be considered to illustrate the operation of a method, a result of execution of computer program instructions stored in a computer-readable medium. The logic diagram of FIG. 4 may also be considered a specific manner in which components of the device are configured to cause that device to operate, whether such a device is an electronic device, laptop, tablet, desktop, mobile phone, smartphone or other device, or one or more components thereof. The various blocks shown in FIG. 4 may also be considered as a plurality of coupled logic circuit elements constructed to carry out the associated function(s), or specific result of strings of computer program instructions or code stored in memory.

[0050] Various embodiments of the computer-readable medium include any data storage technology type which is

suitable to the local technical environment, including but not limited to semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory, removable memory, disc memory, flash memory, dynamic random-access memory (DRAM), static random-access memory (SRAM), electronically erasable programmable read-only memory (EEPROM) and the like. Various embodiments of the processor include but are not limited to general purpose computers, microprocessors, digital signal processors and multi-core processors.

[0051] This disclosure has been described in detail with particular reference to a present embodiment, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. The presently disclosed embodiments are therefore considered in all respects to be illustrative and non-restrictive. The scope of the invention is indicated by the appended claims, and all changes that come within the meaning and range of equivalents thereof are intended to be embraced therein.

1. A method of carburization, the method comprising:
 - (a) creating a vacuum within an interior of a chamber, the interior of the chamber including an item;
 - (b) providing an inert gas and a carbon product to the interior of the chamber;
 - (c) heating by induction a first portion of the item to induce carburization of the first portion of the item; and
 - (d) in response to the heating, cooling a second portion of the item such that the second portion of the item maintains its structural integrity.
2. The method according to claim 1, wherein the vacuum is between 1-5 Torr.
3. The method according to claim 1, wherein the item is made of steel.
4. The method according to claim 1, wherein the carbon product is acetylene, and wherein the inert gas is argon.
5. The method according to claim 1, wherein the heating by induction heats the first portion between 1000° F. to 2000° F.
6. The method according to claim 1, wherein the cooling comprises the second portion of the item contacting a cooling element, the cooling element comprising a tube structure with a contact portion for contacting the second portion of the item, the tube structure allowing a flow of a cooling fluid through the cooling element.
7. The method according to claim 6, wherein the cooling fluid is water.
8. The method according to claim 1, wherein the heating induces carburization of the first portion of the item at least 0.2 mm from a surface of the first portion of the item.
9. The method according to claim 1, wherein the carbon product is a carbon rich product mixed with an inert gas.
10. An apparatus for carburization, the apparatus comprising:
 - (a) a chamber, the chamber operable to create and maintain a vacuum within an interior of the chamber, the chamber sized to hold an item for carburization;
 - (b) a provider, the provider operably coupled to the chamber and able to provide at least an inert gas and a carbon product to the interior of the chamber;
 - (c) a heater, the heater operably coupled to the chamber and able to heat by induction a first portion of the item to induce carburization of the first portion of the item; and

(d) a cooler, the cooler operably coupled to the chamber and able to cool a second portion of the item in response to heating by induction the first portion.

11. The apparatus according to claim 10, wherein the chamber is operably to create and maintain a vacuum within the interior between 1-5 Torr.

12. The apparatus according to claim 10, wherein the item is made of steel.

13. The apparatus according to claim 10, wherein the carbon product is acetylene, and wherein the inert gas is argon.

14. The apparatus according to claim 10, wherein the heater is operable to heat the first portion of the item between 1000° F. to 2000° F.

15. The apparatus according to claim 10, wherein the cooler comprises a tube structure with a contact portion for contacting and cooling the second portion of the item, the tube structure allowing a flow of cooling fluid through the cooler.

16. The apparatus according to claim 14, wherein the cooling fluid is water.

17. The apparatus according to claim 10, wherein the heater induces carburization of the first portion of the item at least 0.2 mm from a surface of the first portion of the item.

18. The apparatus according to claim 10, wherein the carbon product is a carbon rich product mixed with an inert gas.

19. A non-transitory computer-readable medium including computer program instructions which when executed on a processor of an apparatus causes the apparatus to at least:

- (a) creating a vacuum within an interior of a chamber, the interior of the chamber including an item;
- (b) providing an inert gas and a carbon product to the interior of the chamber;
- (c) heating by induction a first portion of the item to induce carburization of the first portion of the item; and
- (d) in response to the heating, cooling a second portion of the item such that the second portion of the item maintains its structural integrity.

20. The non-transitory computer-readable medium according to claim 19, wherein the vacuum is between 1-5 Torr.

21. The non-transitory computer-readable medium according to claim 19, wherein the item is made of steel.

22. The non-transitory computer-readable medium according to claim 19, wherein the carbon product is acetylene, and wherein the inert gas is argon.

23. The non-transitory computer-readable medium according to claim 19, wherein the heating by induction heats the first portion between 1000° F. to 2000° F.

24. The non-transitory computer-readable medium according to claim 19, wherein the cooling comprises the second portion of the item contacting a cooling element, the cooling element comprising a tube structure with a contact portion for contacting the second portion of the item, the tube structure allowing a flow of a cooling fluid through the cooling element.

25. The non-transitory computer-readable medium according to claim 19, wherein the cooling fluid is water.

26. The non-transitory computer-readable medium according to claim 19, wherein the heating induces carburization of the first portion of the item at least 0.2 mm from a surface of the first portion of the item.

27. The non-transitory computer-readable medium according to claim 19, wherein the carbon product is a carbon rich product mixed with an inert gas.

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