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(54) **REFRIGERANT SERVICE HOSE CHECK VALVE DEVICE AND METHOD**

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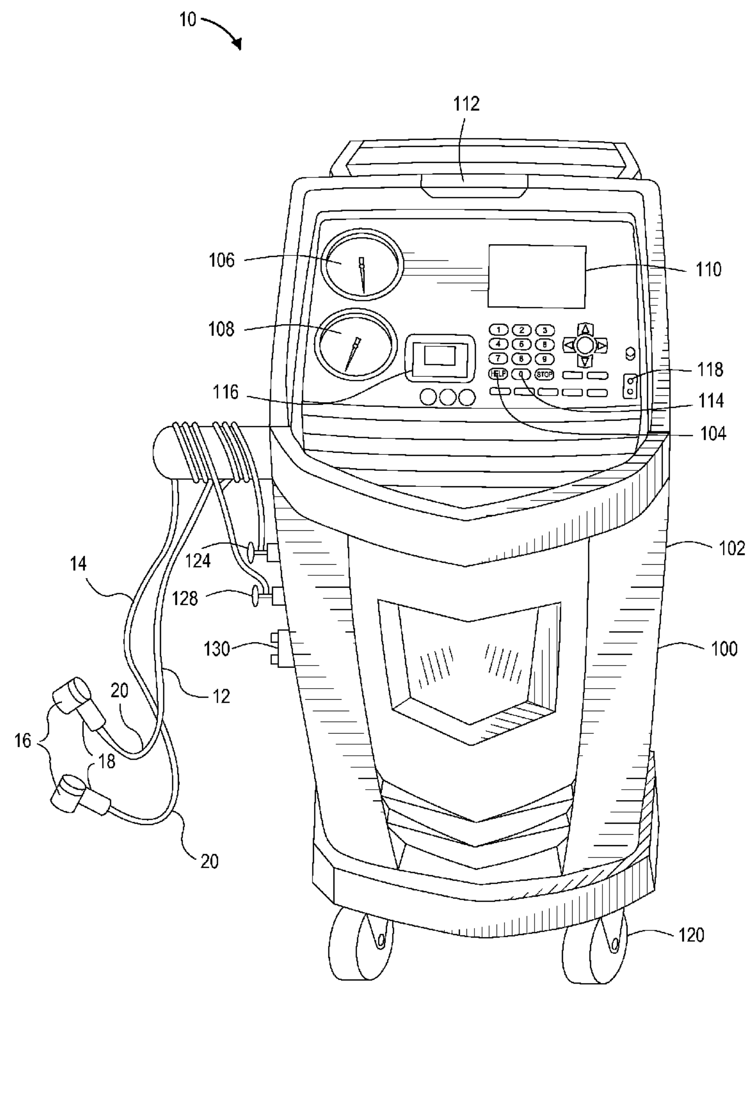
(57) **ABSTRACT**

A service hose includes a service coupler and a check valve assembly. The service coupler is configured to fluidly connect the service hose to a refrigeration system. The check valve assembly is disposed proximal to the service coupler and includes a recovery and a recharge flow path. The recovery flow path is defined by a flow of a refrigerant from the refrigeration system and flows along a first bore disposed in a body having a recovery poppet. The recharge flow path is defined by a flow of the refrigerant to the refrigeration system and flows along a second bore disposed in the body, a recharge poppet, and a biasing member. The check valve assembly is configured to provide a substantially free flow of refrigerant along the recovery flow path and also configured to provide a predetermined cracking pressure in response to the refrigerant being urged to flow along the recharge flow path.



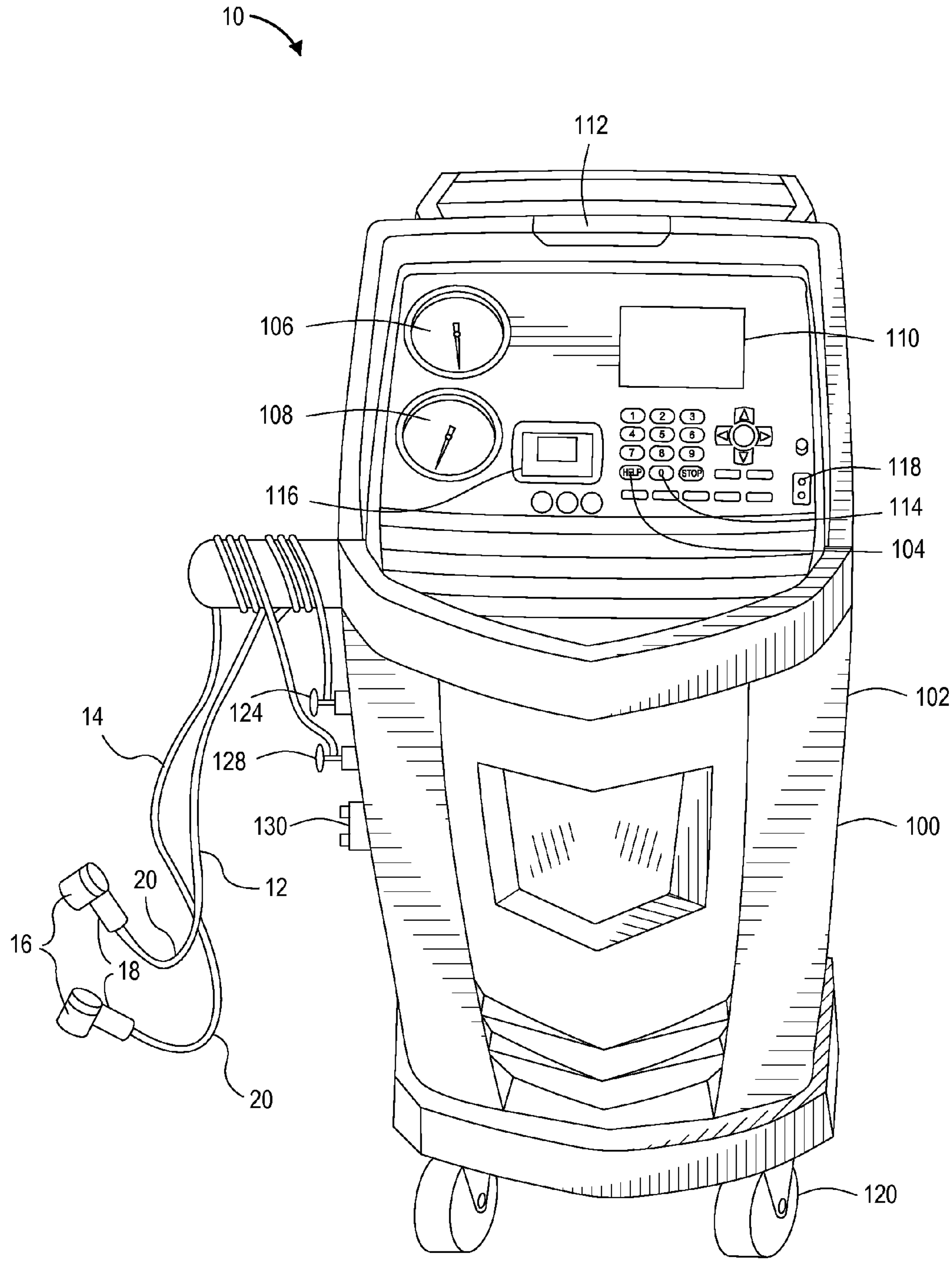

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FIG. 1

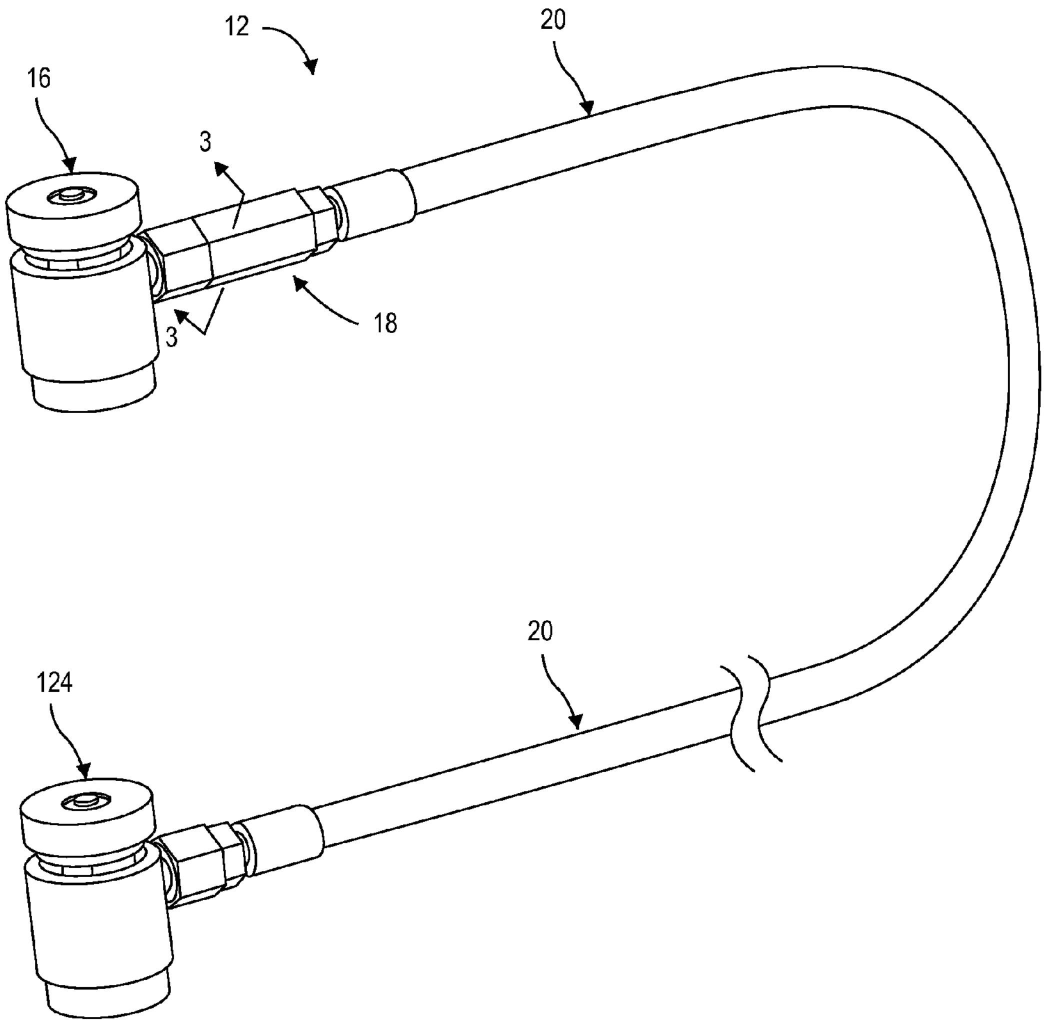


FIG. 2

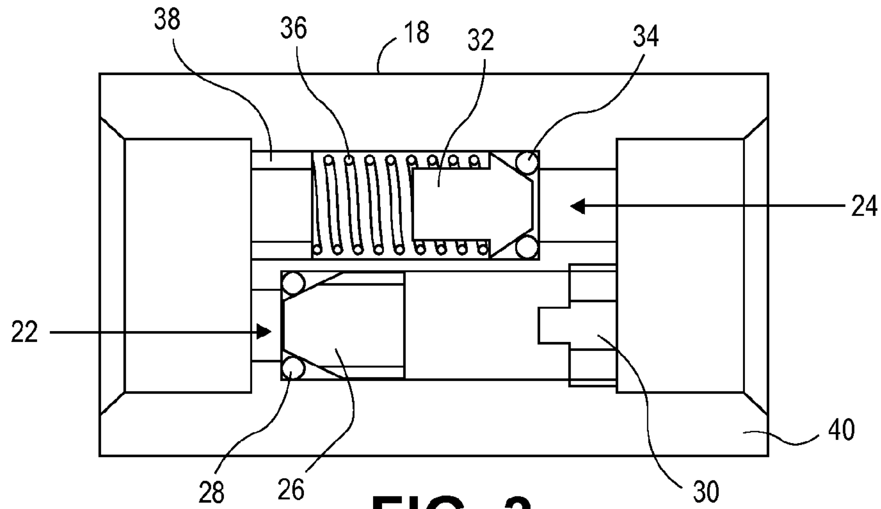


FIG. 3

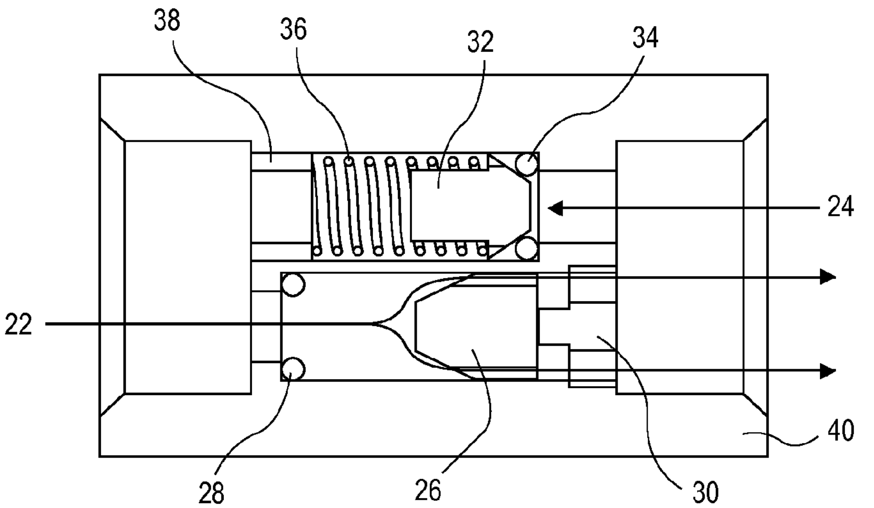


FIG. 4

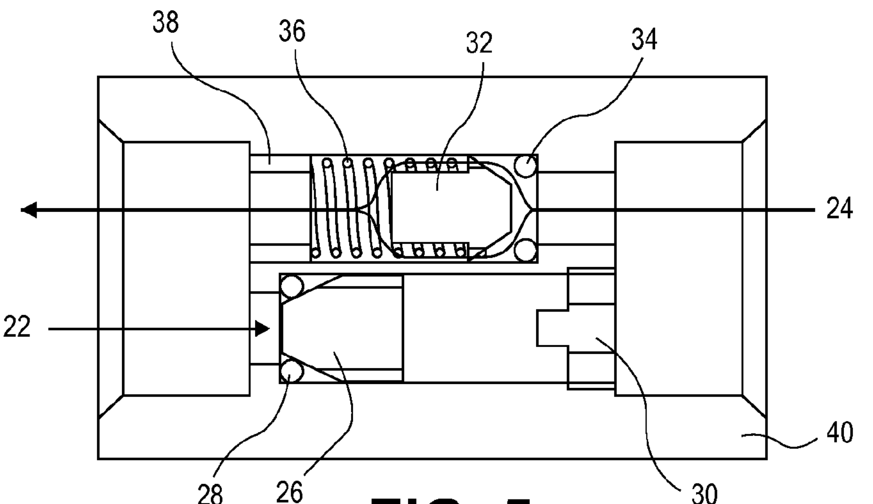


FIG. 5

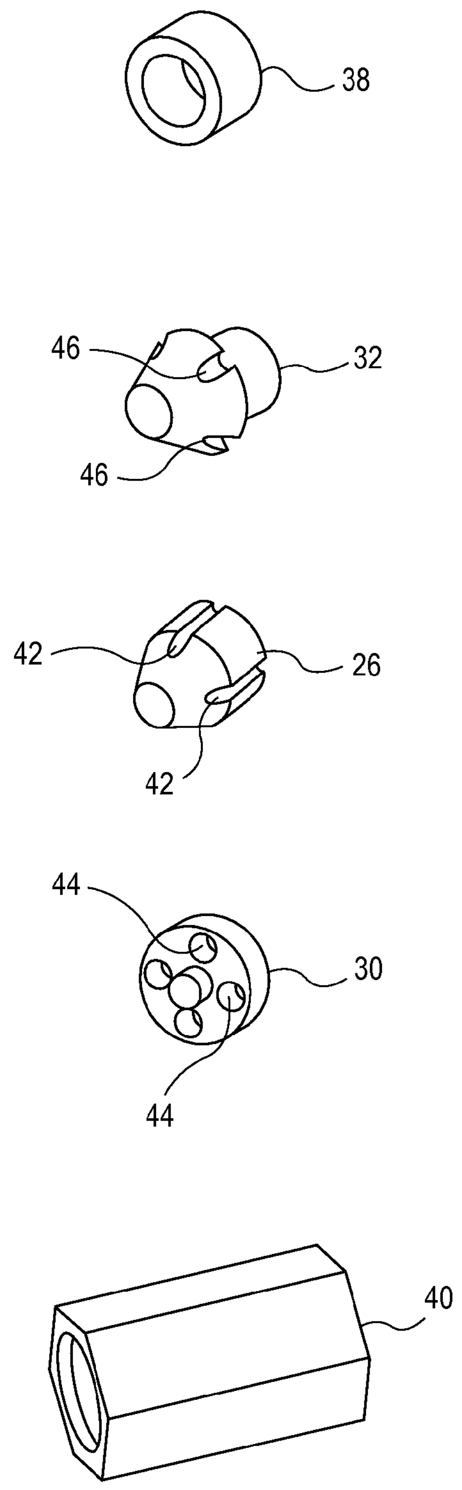
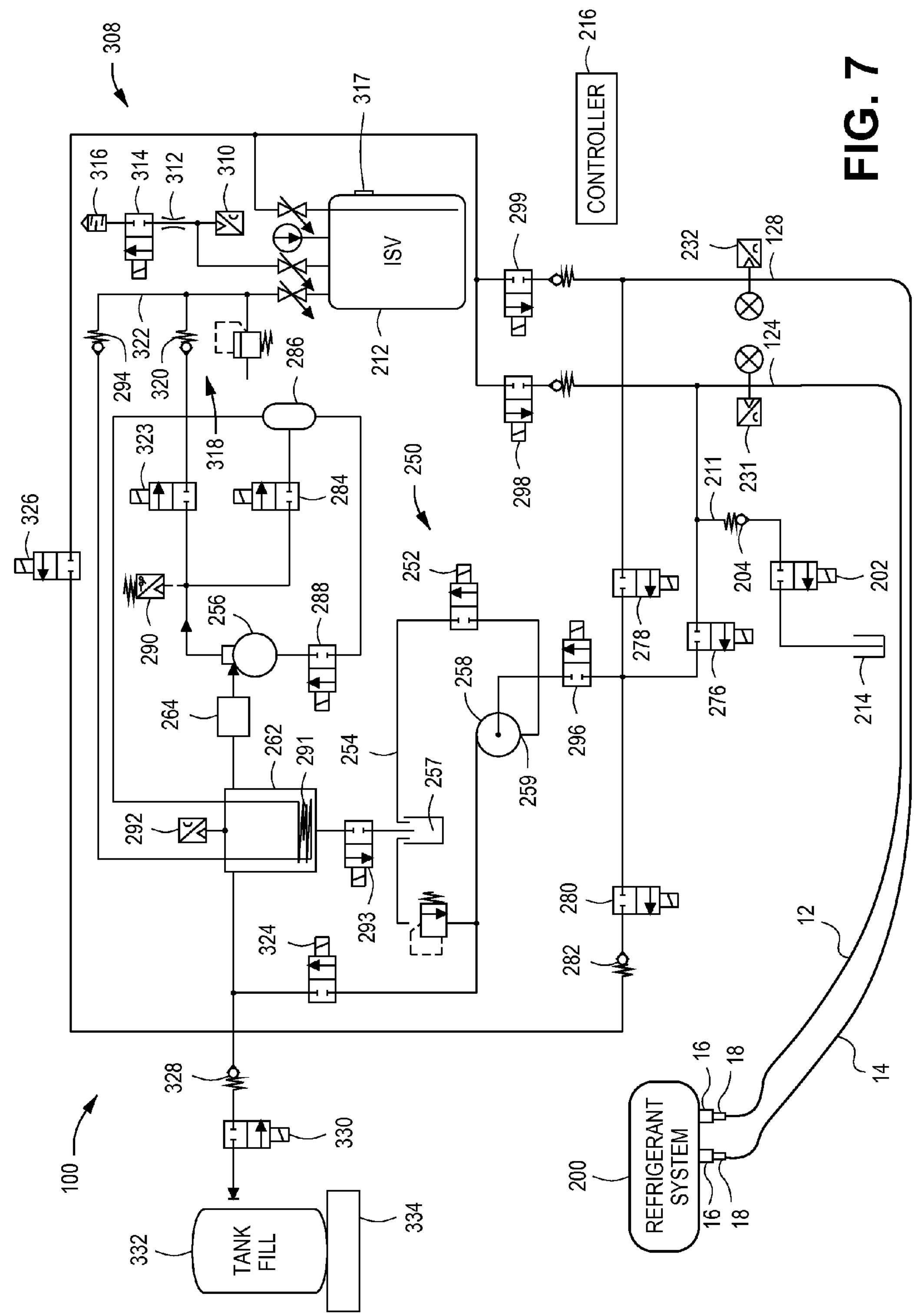


FIG. 6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CONTROLLER
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256
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278
276
214
258
296
264
262
291
254
257
259
292
293
324
280
282
12
328
330
100
332
TANK FILL
334
200
REFRIGERANT SYSTEM
16
18
14

FIG. 7

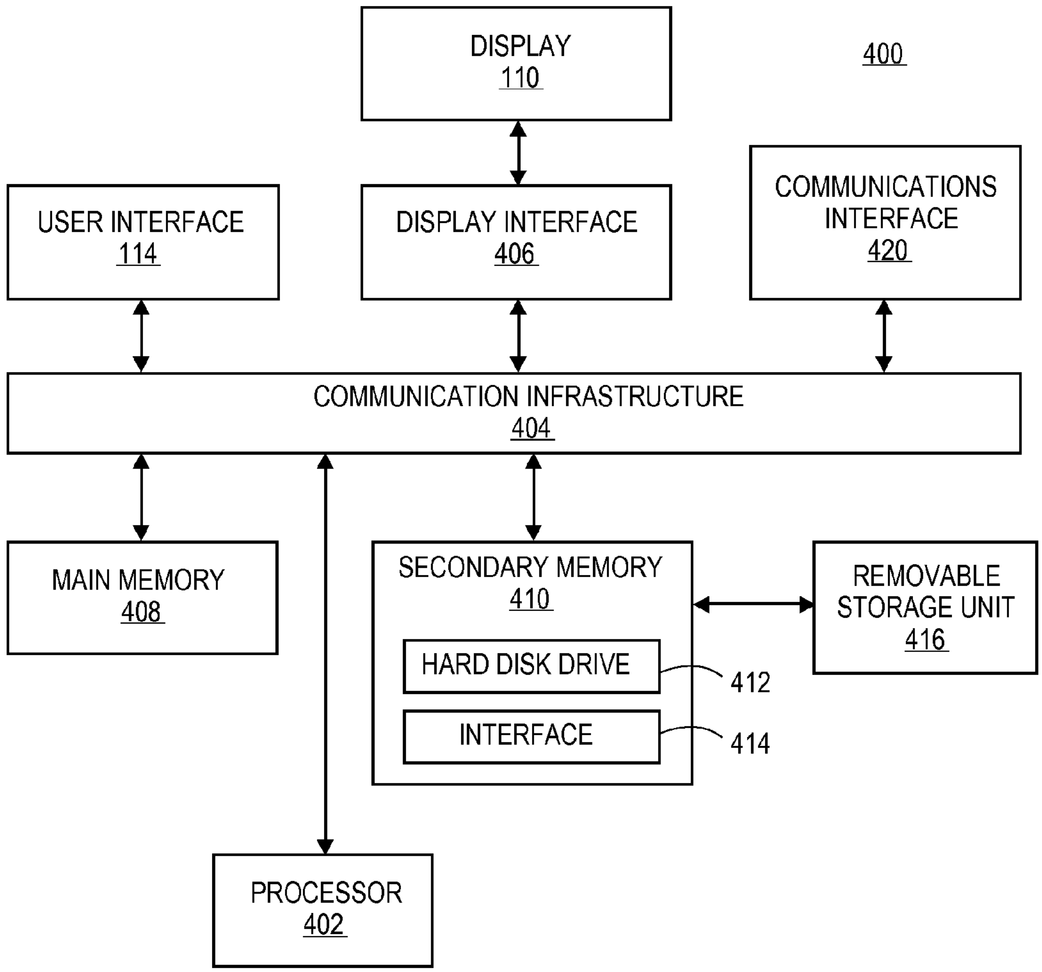
DISPLAY
110
400
USER INTERFACE
114
DISPLAY INTERFACE
406
COMMUNICATIONS
INTERFACE
420
COMMUNICATION INFRASTRUCTURE
404
MAIN MEMORY
408
SECONDARY MEMORY
410
REMOVABLE
STORAGE UNIT
416
HARD DISK DRIVE
412
INTERFACE
414
PROCESSOR
402

FIG. 8

REFRIGERANT SERVICE HOSE CHECK VALVE DEVICE AND METHOD

FIELD OF THE INVENTION

[0001] The disclosure generally relates to servicing a refrigeration system. More particularly, the disclosure relates to an improved check valve assembly for servicing the refrigeration systems and a method of utilizing the improved check valve assembly with a refrigerant recovery unit.

BACKGROUND OF THE INVENTION

[0002] Portable refrigerant recovery units or carts are used in connection with the service and maintenance of refrigeration systems, such as a vehicle's air conditioning system. The refrigerant recovery unit connects to the air conditioning system of the vehicle to recover refrigerant out of the system, separate out oil and contaminants from the refrigerant in order to recycle the refrigerant, and recharge the system with additional refrigerant.

[0003] Overcharging or undercharging a refrigeration system, such as an air conditioning system, may cause damage to the system and/or decrease the efficiency of the system. Vehicle air conditioning systems are typically small systems with relatively small amounts of refrigerant as compared to residential and commercial air conditioning systems. As such, it is relatively more important that the vehicle air conditioning systems be recharged with refrigerant accurately. However, due to many environmental variables and extremes in temperature experienced within the engine compartment of the vehicle, the state of the refrigerant (e.g., liquid or vapor) in the service hoses is often difficult to know. This, in turn, may lead to significant over or under charging.

[0004] Accordingly, it is desirable to provide an improved refrigerant recovery device and method.

SUMMARY OF THE INVENTION

[0005] The foregoing needs are met, to a great extent, by some embodiments of the present invention, wherein in one respect an improved check valve assembly for servicing a refrigeration system is provided.

[0006] An embodiment of the present invention pertains to a refrigerant recovery system. The refrigerant recovery system includes a service hose and a refrigerant recovery unit. The service hose includes a service coupler, a check valve assembly, and a hose. The service coupler is configured to fluidly connect the service hose to a refrigeration system. The hose is to convey a refrigerant. The check valve assembly is disposed proximal to the service coupler. The check valve assembly includes a recovery flow path and a recharge flow path. The recovery flow path is defined by a flow of the refrigerant from the refrigeration system and flows along a first bore disposed in a body, a recovery poppet, a first O-ring, and a stand-off. The recharge flow path is defined by a flow of the refrigerant to the refrigeration system and flows along a second bore disposed in the body, a recharge poppet, a second O-ring, a biasing member, and a shim. The check valve assembly is configured to provide a substantially free flow of refrigerant along the recovery flow path and the check valve assembly is configured to provide a predetermined cracking pressure in response to the refrigerant being urged to flow along the recharge flow path. The refrigerant recovery unit includes a refrigerant storage unit, a refrigerant circuit, a processor, and a memory. The refrigerant storage unit is configured to store the refrigerant. The refrigerant circuit is in fluid connection with the refrigeration system. The refrigerant circuit is configured to recover refrigerant from the refrigeration system and recharge the refrigeration system with the refrigerant. The processor is configured to control the refrigerant recovery unit. The memory is to store diagnostic software and operating software to operate the refrigerant recovery unit.

[0007] Another embodiment of the present invention relates to a service hose. The service hose includes a service coupler, a check valve assembly, and a hose. The service coupler is configured to fluidly connect the service hose to a refrigeration system. The hose is to convey a refrigerant. The check valve assembly is disposed proximal to the service coupler. The check valve assembly includes a recovery flow path and a recharge flow path. The recovery flow path is defined by a flow of the refrigerant from the refrigeration system and flows along a first bore disposed in a body, a recovery poppet, a first O-ring, and a stand-off. The recharge flow path is defined by a flow of the refrigerant to the refrigeration system and flows along a second bore disposed in the body, a recharge poppet, a second O-ring, a biasing member, and a shim. The check valve assembly is configured to provide a substantially free flow of refrigerant along the recovery flow path and the check valve assembly is configured to provide a predetermined cracking pressure in response to the refrigerant being urged to flow along the recharge flow path.

[0008] Yet another embodiment of the present invention pertains to a method of servicing a refrigeration system. In this method, a refrigerant is recovered from the refrigeration system and the refrigeration system is recharged with the refrigerant. The refrigerant is recovered from the refrigeration system with a refrigeration recovery unit. The refrigeration recovery unit is in fluid communication with the refrigeration system via a service hose. The service hose includes a service coupler, a check valve assembly, and a hose. The service coupler is configured to fluidly connect the service hose to a refrigeration system. The hose is to convey a refrigerant. The check valve assembly is disposed proximal to the service coupler. The check valve assembly includes a recovery flow path and a recharge flow path. The recovery flow path is defined by a flow of the refrigerant from the refrigeration system and flows along a first bore disposed in a body, a recovery poppet, a first O-ring, and a stand-off. The recharge flow path is defined by a flow of the refrigerant to the refrigeration system and flows along a second bore disposed in the body, a recharge poppet, a second O-ring, a biasing member, and a shim. The check valve assembly is configured to provide a substantially free flow of refrigerant along the recovery flow path and the check valve assembly is configured to provide a predetermined cracking pressure in response to the refrigerant being urged to flow along the recharge flow path. The refrigeration system is recharged with the refrigerant by urging the refrigerant to flow from the refrigeration recovery unit at a pressure greater than the predetermined cracking pressure of the check valve assembly.

[0009] There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional embodiments of the invention that will be described below and which will form the subject matter of the claims appended hereto.

[0010] In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

[0011] As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a perspective view of a refrigerant recovery system in accordance with an embodiment of the invention.

[0013] FIG. **2** is a perspective view of a service hose in accordance with the embodiment of FIG. **1**.

[0014] FIG. **3** is cut away view of a parallel flow check valve assembly in an idle conformation in accordance with the embodiment of FIG. **1**.

[0015] FIG. **4** is cut away view of the parallel flow check valve assembly in a recovery conformation in accordance with the embodiment of FIG. **1**.

[0016] FIG. **5** is cut away view of a parallel flow check valve assembly in a charging conformation in accordance with the embodiment of FIG. **1**.

[0017] FIG. **6** is a perspective view of components suitable for use in the parallel flow check valve assembly according to FIGS. **3-5**.

[0018] FIG. **7** is a schematic diagram illustrating components of the refrigerant recovery unit shown in FIG. **1** in accordance with an embodiment of invention.

[0019] FIG. **8** is a block diagram illustrating aspects of a control system, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0020] According to various embodiments described herein, a refrigerant recovery system is provided that facilitates the servicing of a refrigeration system. As used herein, the term, "servicing" refers to any suitable procedure performed on a refrigeration system such as, for example, recovering refrigerant, testing refrigerant, leak testing the refrigeration system, recharging refrigerant into the refrigeration system, purifying the refrigerant to remove contaminants, recovering the lubricant, replacing the lubricant, and the like. In an embodiment, the refrigerant recovery system disclosed herein includes improved servicing hoses. In this or other embodiments, the servicing hoses include a check valve assembly that allows free flow of refrigerant during recovery operations and provides sufficient cracking pressure during recharging operations to maintain the refrigerant in a liquid state. For the purposes of this disclosure, the term, "cracking pressure" refers to a pressure at which flow through a valve starts. In this regard, one potential inaccuracy in determining an amount of refrigerant delivered to a refrigeration system is knowing the state of the refrigerant in the servicing hoses. For example, if the servicing hoses are cold enough, the refrigerant may be liquid even at relatively low pressure. Alternatively, at higher temperatures, the refrigerant may be gaseous. Depending upon the length and bore diameter of the servicing hoses, the volume may be great enough that the difference in weight between liquid and gaseous refrigerant represents a significant inaccuracy. By providing a cracking pressure configured to maintain the refrigerant in a liquid state throughout expected temperatures, the accuracy of the recharge can be improved. However, during recovery, it is preferable to have little or no cracking pressure so as to improve efficiency of the recovery. It is an advantage of one or more embodiments that the valve disclosed herein is configured to provide sufficient cracking pressure during recharging operations to maintain the refrigerant in a liquid state while allowing substantially unrestricted flow of refrigerant during recovery operations.

[0021] As shown in FIG. **1**, a refrigerant recovery system **10** includes a pair of hoses **12** and **14**. One or both of the pair of service hoses **12** and **14** includes a service coupler **16**, check valve assembly **18**, and hose **20**. The service coupler **16** is configured to mate with a port or coupler of a refrigeration system such as the refrigeration system **200** shown in FIG. **7**. In various embodiments, the refrigeration system may include any suitable device, unit, or system having a supply of refrigerant therein. Examples of suitable refrigeration systems include a standalone air conditioning or de-humidifying unit and/or a unit disposed within a vehicle, device, appliance, structure, or the like. A vehicle can be any suitable vehicle, such as an automobile, train, airplane, boat, ship and the like. Suitable devices or appliances may include, for example, an air conditioning unit, dehumidifier, ice maker, refrigerator/freezer, beverage dispenser, ice cream maker, and the like.

[0022] The check valve assembly **18** is configured to provide substantially unrestricted unidirectional flow of refrigerant during recovery operations and to provide a predetermined cracking pressure during recharging operations. The predetermined cracking pressure is determined based upon a variety of factors. These factors include: refrigerant type and/or chemistry; refrigerant manufacturer's recommendations; expected operating conditions including ambient temperature and pressure; empirical data; and the like.

[0023] The hose **20** is configured to convey refrigerant through the service hose **12**/**14**. As is generally known, the hose **20** has a nominal inside diameter and a length. Given the nominal inside diameter and a length, an interior volume of the hose **20** is readily determinable. For example, given a nominal inside diameter of 5 millimeters (mm) and a length of 2 meters (m), the interior volume of the hose **20** is 100 milliliters (ml). A common automotive refrigerant is R-134a (1,1,1,2-Tetrafluorethane) which has a liquid density of 1206 of kilograms/m^3 or 1.206 grams (g)/ml and gas density of 4.25 kg/m^3 or 4.25 milligrams (mg)/ml at 1.013 bar and 15° C. As such, the hose **20** may retain about 120.6 g of liquid refrigerant vs. 0.425 g of gaseous refrigerant at standard atmospheric conditions. Unfortunately, the conditions within the hose **20** may be difficult to determine given the potential variability in ambient conditions and rapid increases and decreases in pressure during recovery and recharging operations. As such, the weight of gaseous refrigerant in the hose **20** may vary from nearly 120 g to essentially 0 g (given a partial vacuum and temperatures of 40° C. or more). However, the weight of liquid refrigerant will always be substantially 120.6

g for the hose **20** having an interior volume of 100 ml and given the refrigerant is R-134a. For the purposes of this disclosure, the term "substantially" and "essentially" refers to a generally understood variance of about 1%-5%. Factors that may cause this variance include wear on the hose **20**, excessive pressure within the hose **20**, contaminants within the refrigerant that have different densities or other properties, and the like.

[0024] The refrigerant recovery unit **100** can be the AC1234™ from ROBINAIR® based in Owatonna, Minn. (Service Solutions U.S., LLC). The refrigerant recovery unit **100** includes a cabinet **102** to house components of the system (See FIG. **7**). The cabinet **102** may be made of any suitable material such as thermoplastic, steel and the like.

[0025] The cabinet **102** includes a control panel **104** that allows the user to operate the refrigerant recovery unit **100**. The control panel **104** may be part of the cabinet as shown in FIG. **1** or separated. The control panel **104** includes high and low gauges **106**, **108**, respectively. For the purposes of this disclosure, the terms, "high" and "low" generally refer to the high and low pressure sides of a refrigeration system, respectively. The gauges may be analog or digital. The control panel **104** has a display **110** to provide information to a user. The information may include, for example, operating status of the refrigerant recovery unit **100** or provide messages or menus to the user. The control panel **104** may include indicators **112** to indicate to the user the operational status of the refrigerant recovery unit **100**. If included, the indicators **112** may include light emitting diodes (LEDs) or the like, that when activated, may indicate that the refrigerant recovery unit **100** is in the recovery, recycling or recharging mode or indicate that the filter needs to be changed or that there is a malfunction.

[0026] According to an embodiment, the control panel **104** includes a user interface **114** to provide the user with an interface to interact and operate the refrigerant recovery unit **100**. The user interface **114** may include any suitable interface such as, for example, an alphanumeric keypad, directional arrows, function keys, pressure or touch sensitive display, and the like. Optionally, a printer **116** is provided to print out information, such as test results.

[0027] The cabinet **102** further includes a plurality attachment points **124**, **128** for the service hoses **12**, **14** that connect the refrigerant recovery unit **100** to a refrigerant containing device, such as a refrigeration system (shown in FIG. **7**). Also shown in FIG. **1**, a vehicle connector interface **130** is provided so that a communication cable can be connected from the vehicle connector interface to a data link connector in a vehicle (not shown in FIG. **1**). This allows the refrigerant recovery unit **100** to communicate with the vehicle and diagnose any issues with it. In order for the refrigerant recovery unit **100** to be mobile, one or more wheels **120** are provided at a bottom portion of the cabinet **102**.

[0028] During servicing of a refrigeration system (shown in FIG. **7**), if it is determined that the refrigerant therein should be recovered and then recharged, the refrigerant recovery unit **100** may be connected to the refrigeration system via the service hoses **12** and **14**. More particularly, the respective service coupler **16** of each of the service hoses **12** and **14** is used to fluidly connect the refrigeration system to the refrigerant recovery unit **100**. For example, the refrigerant may be conveyed through the service hoses **12** and **14** in response to the refrigeration system being connected to the refrigerant recovery unit **100**.

[0029] FIG. **2** is a perspective view of the service hose **12** in accordance with the embodiment of FIG. **1**. Of note, while particular reference is made of the service hose **12**, the service hose **14** and the components of the service hose **14** are similar to the description of the service hose **12**. As shown in FIG. **2**, the service hose **12** includes the service coupler **16**, the check valve assembly **18**, the hose **20**, and the attachment point **124**. As described herein, the service coupler **16** is configured to mate with a refrigeration system. The check valve assembly **18** is disposed proximal to the service coupler **16** to minimize volume in the service hose **12** that is not subject to the cracking pressure supplied by the check valve assembly **18**. The hose **20** is configured to convey the refrigerant therethrough and to have a known internal volume. The attachment point **124** is configured to fluidly connect the service hose **12** to the refrigerant recovery unit **100**. Like the service coupler **16**, the attachment point **124** is configured to seal the service hose **12** when not connected. In this manner, refrigerant leakage into the environment may be minimized or reduced.

[0030] FIG. **3** is cut away view of the parallel flow check valve assembly **18** in an idle conformation in accordance with the embodiment of FIG. **1**. As shown in FIG. **3**, the check valve assembly **18** includes a recovery flow path **22** and a recharge flow path **24**. The recovery flow path **22** includes a recovery poppet **26**, an O-ring **28**, and a stand-off **30**. The recharge flow path **24** includes a recharge poppet **32**, an O-ring **34**, a spring **36**, and a shim **38**. The various components of the check valve assembly **18** are disposed in a body **40**. The recovery flow path **22** is defined by a first bore disposed in the body **40**, the recovery poppet **26**, the O-ring **28**, and the stand-off **30**. The recharge flow path **24** is defined by a second bore disposed in the body **40**, the recharge poppet **32**, the O-ring **34**, the spring **36**, and the shim **38**. As shown in FIG. **3**, both flow paths **22** and **24** are sealed. That is, the recovery poppet **26** is sealed against the O-ring **28** and the recharge poppet **32** is sealed against the O-ring **34**. However, as discussed herein, the recovery poppet **26** is not biased toward an open or closed position and thus, without backpressure on the recovery poppet **26**, flow in the direction of the recovery flow path **22** is configured to open the seal between the recovery poppet **26** and the O-ring **28**. In contrast, the spring **36** is configured to bias the recharge poppet **32** against the O-ring **34** sufficiently to provide the predetermined cracking pressure. While the spring **36** is shown in FIG. **3**, any suitable biasing member may be utilized to bias the recharge poppet **32** against the O-ring **34**. Examples of suitable biasing members include other springs, Belleville washers, pneumatic cylinders and actuators, electronic actuators, and the like.

[0031] FIG. **4** is cut away view of the parallel flow check valve assembly **18** in a recovery conformation in accordance with the embodiment of FIG. **1**. As shown in FIG. **4**, flow along the recovery flow path **22** is open to the flow of refrigerant. More particularly, the flow of refrigerant along the recovery flow path **22**, has broken the seal between the recovery poppet **26** and the O-ring **28** and driven the recovery poppet **26** against the stand-off **30**. The stand-off **30** includes a central post to prevent the recovery poppet **26** from blocking the outflow of refrigerant. As described herein, the recovery conformation facilitates efficient recovery of refrigerant from a refrigeration system such as the refrigeration system **200** shown in FIG. **7**.

[0032] FIG. **5** is cut away view of the parallel flow check valve assembly **18** in a charging conformation in accordance with the embodiment of FIG. **1**. As shown in FIG. **5**, flow along the recharge flow path **24** is open to the flow of refrigerant. More particularly, the flow of refrigerant along the recharge flow path **24** is of sufficient force to overcome the predetermined cracking pressure provided by the spring **36**. As a result, the seal between the recharge poppet **32** and the O-ring **34** is broken and is configured to remain open to the flow of refrigerant as long as the force of the flow exceeds the predetermined cracking pressure. By maintaining the pressure of the refrigerant upstream of the recharge poppet **32** above the predetermined cracking pressure, the refrigerant upstream of the recharge poppet **32** is maintained in the liquid state. As described herein, calculating the weight of refrigerant is easier and more accurate if the refrigerant is known to be in the liquid state. In this manner, the recharge conformation facilitates improved accuracy of recharging a refrigeration system such as the refrigeration system **200** shown in FIG. **7**.

[0033] FIG. **6** is a perspective view of components suitable for use in the parallel flow check valve assembly **18** according to FIGS. **3-5**. As shown in FIG. **6**, the recovery poppet **26** includes one or more channels **42** to facilitate the flow of refrigerant. The stand-off **30** also includes one or more channels **44** to facilitate the flow of refrigerant. Similarly, the recharge poppet **32** includes one or more channels **46** to facilitate the flow of refrigerant.

[0034] FIG. **7** illustrates components of the refrigerant recovery system **10** of FIG. **1** according to an embodiment of the present disclosure. In general, the refrigerant recovery unit **100** is configured to facilitate testing, removing, and recharging refrigerant and/or lubricant in a refrigeration system **200**. More particularly, the refrigerant recovery system **10** is configured to recover the refrigerant quickly and efficiently and the refrigerant recovery system **10** is configured to recharge the refrigeration system **200** accurately. These two processes benefit from different flow characteristics. The service hoses **12** and **14** are configured to provide a first flow characteristic that is conducive to recovery and the service hoses **12** and **14** are configured to provide a second flow characteristic that is conducive to recharging. The first flow characteristic provides minimal inhibition to flow. The second flow characteristic provides a predetermined cracking pressure to maintain the refrigerant in a liquid state.

[0035] In the particular example shown, the refrigerant recovery unit **100** is coupled to the refrigeration system **200** via the service hose **12** (high side) and the service hose **14** (low side). In general, the various hoses and couplers are configured to be closed until they are coupled to the refrigerant recovery unit **100** and/or the refrigeration system **200**. In this manner, refrigerant leakage may be minimized or prevented.

[0036] The recovery cycle is initiated by the opening of high pressure and low-pressure solenoids **276**, **278**, respectively. This allows the refrigerant within the vehicle's refrigeration system **200** to flow through the service hoses **12** and **14** and then through a recovery valve **280** and a check valve **282**. The service hoses **12** and **14** provide minimal restriction to the flow of refrigerant during recovery which allows the refrigerant to boil off and be efficiently drawn from the refrigeration system **200**. To continue, the refrigerant flows from the check valve **282** into a system oil separator **262**, where it travels through a filter/dryer **264**, to an input of a compressor **256**. Refrigerant is drawn through the compressor **256** through a normal discharge valve **284** and through a compressor oil separator **286**, which circulates oil back to the compressor **256** through an oil return valve **288**. The refrigerant recovery unit **100** may include a high-pressure switch **290** in communication with a controller **216**, which is programmed to determine an upper pressure limit, for example, 435 psi, to optionally shut down the compressor **256** to protect the compressor **256** from excessive pressure. The controller **216** can also be, for example, a microprocessor, a field programmable gate array (FPGA) or application-specific integrated circuit (ASIC). The controller **216** via a wired or wireless connection (not shown) controls the various valves and other components (e.g. vacuum, compressor) of the refrigerant recovery unit **100**. In some embodiments of the present disclosure, any or all of the electronic solenoid or electrically activated valves may be connected and controlled by the controller **216**.

[0037] A high-side clear valve **323** may optionally be coupled to the output of the compressor **256** to release the recovered refrigerant transferred from compressor **256** directly into a storage tank **212**, instead of through a path through the normal discharge valve **284**.

[0038] The heated compressed refrigerant exits the oil separator **286** and then travels through a loop of conduit or heat exchanger **291** for cooling or condensing. As the heated refrigerant flows through the heat exchanger **291**, the heated refrigerant gives off heat to the cold refrigerant in the system oil separator **262**, and assists in maintaining the temperature in the system oil separator **262** within a working range. Coupled to the system oil separator **262** is a switch or transducer **292**, such as a low pressure switch or pressure transducer, for example, that senses pressure information, and provides an output signal to the controller **216** through a suitable interface circuit programmed to detect when the pressure of the recovered refrigerant is down to 13 inches of mercury, for example. An oil separator drain valve **293** drains the recovered oil into a container **257**. Finally, the recovered refrigerant flows through a normal discharge check valve **294** and into the storage tank **212**.

[0039] The evacuation cycle begins by the opening of high pressure and low-pressure solenoids **276** and **278** and valve **296**, leading to the input of a vacuum pump **258**. Prior to opening valve **296**, an air intake valve (not shown) is opened, allowing the vacuum pump **258** to start exhausting air. The vehicle's refrigeration system **200** is then evacuated by the closing of the air intake valve and opening the valve **296**, allowing the vacuum pump **258** to exhaust any trace gases remaining until the pressure is approximately 29 inches of mercury, for example. When this occurs, as detected by pressure transducers **231** and **232**, optionally, coupled to the high side **226** and low side **230** of the vehicle's refrigeration system **200** and to the controller **216**, the controller **216** turns off valve **296** and this begins the recharging cycle. Here again, the minimal restriction to flow from the refrigeration system **200** provided by the service hoses **12** and **14** facilitate efficient evacuation of the refrigeration system **200**.

[0040] The recharging cycle begins by opening charge valve **298** to allow the refrigerant in storage tank **212**, which is at a pressure of approximately 70 psi or above, to flow into the service hose **12**. Once sufficient refrigerant pressure has developed within the service hose **12** to overcome the cracking pressure, the refrigerant is allowed to flow through the respective check valve assembly **18** and then through the high side of the vehicle's refrigeration system **200**. The flow is through charge valve **298** for a period of time programmed to provide a full charge of refrigerant to the vehicle. The full charge of the refrigerant is based on the manufacturer's refrigerant amount recommendation plus the weight of refrigerant remaining in the service hose **12**. Because the service hose **12** is configured to maintain the refrigerant in the liquid state and the internal volume of the service hose **12** is known, the weight of refrigerant remaining in the service hose **12** is readily determinable. Optionally, charge valve **299** may be opened to charge the low side. The charge valve **299** may be opened alone or in conjunction with charge valve **298** to supply a flow of refrigerant to the service hose **14**. In a manner similar to the service hose **12**, the service hose **14** is configured to retain the refrigerant until the predetermined cracking pressure is reached before allowing the refrigerant to pass through the respective check valve assembly **18** and then charge the vehicle's refrigeration system **200**. The storage tank **212** may be disposed on a scale (not shown) that measures the weight of the refrigerant in the storage tank.

[0041] Following recharging, any refrigerant remaining in the service hoses **12** and/or **14** may be recovered. For example, the user may be instructed to remove the service couplers **16** from the refrigeration system **200** so that refrigerant is not drawn out of the refrigeration system **200**. Once the service couplers **16** have been removed, a recovery cycle as described herein may be performed to remove any remaining refrigerant in the service hoses **12** and/or **14**.

[0042] Other components shown in FIG. **7** include an oil inject circuit having an oil inject valve **202** and an oil inject hose or line **211**. The oil inject hose **211** is one example of a fluid transportation means for transmitting oil for the refrigerant recovery unit **100**. The oil inject hose **211** may be one length of hose or multiple lengths of hose or tubing or any other suitable means for transporting fluid. The oil inject hose **211** connects on one end to an oil inject bottle **214** and on the other end couples to the refrigerant circuit in the refrigerant recovery unit **100**. Disposed along the length of the oil inject hose **211** are the oil inject valve **202** and an oil check valve **204**. The oil inject path follows from the oil inject bottle **214**, through the oil inject valve **202**, to the junction with the high side charge line, and to the vehicle's refrigeration system **200**.

[0043] FIG. **7** also illustrates a vacuum pump oil drain circuitry **250** that includes a vacuum pump oil drain valve **252** that is located along a vacuum pump oil drain conduit **254** connecting a vacuum pump oil drain outlet **259** to the container **257** for containing the drained vacuum pump oil. The vacuum pump oil drain valve **252** may be an electronically activated solenoid valve controlled by controller **216**. The connection may be a wireless or wired connection. In other embodiments the valve **252** may be a manually activated valve and manually actuated by a user. The conduit **254** may be a flexible hose or any other suitable conduit for provided fluid communication between the outlet **259** and the container **257**.

[0044] FIG. **7** also illustrates an air purging apparatus **308**. The air purging apparatus **308** allows the refrigerant recovery unit **100** to be purged of non-condensable, such as air. Air purged from the refrigerant recovery unit **100** may exit the storage tank **212**, through an orifice **312**, through a purging valve **314** and through an air diffuser **316**. In some embodiments, the orifice may be 0.028 of an inch. A pressure transducer **310** may measure the pressure contained within the storage tank **212** and purge apparatus **308**. The pressure transducer **310** may send the pressure information to the controller **216**. Based upon the pressure information, the controller **216** may initiate purging if it is determined the pressure is too high, as calculated by the controller. The valve **314** may be selectively actuated to permit or not permit the purging apparatus **308** to be open to the ambient conditions. A temperature sensor **317** may be coupled to the main tank to measure the refrigerant temperature therein. The placement of the temperature sensor **317** may be anywhere on the tank or alternatively, the temperature sensor may be placed within a refrigerant line **322**. The measured temperature and pressure may be used to calculate the ideal vapor pressure for the type of refrigerant used in the refrigerant recovery unit. The ideal vapor pressure can be used to determine when the non-condensable gases need to be purged and how much purging will be done in order for the refrigerant recovery unit to function properly.

[0045] High side clearing valves **318** may be used to clear out part of the high-pressure side of the system. The high side clearing valves **318** may include valve **323** and check valve **320**. Valve **323** may be a solenoid valve. When it is desired to clear part of the high side, valve **323** is opened. Operation of the compressor **256** will force refrigerant out of the high pressure side through valves **323** and **320** and into the storage tank **212**. During this procedure the normal discharge valve **284** may be closed.

[0046] A deep recovery valve **324** is provided to assist in the deep recovery of refrigerant. When the refrigerant from the refrigeration system **200** has, for the most part, entered into the refrigerant recovery unit **100**, the remaining refrigerant may be extracted from the refrigeration system **200** by opening the deep recovery valve **324** and turning on the vacuum pump **258**.

[0047] In another embodiment, in order to charge the refrigeration system **200**, the power charge valve **326** may be opened and a tank fill structure **332** may be used. Alternatively or in addition to, the tank fill structure **332** may also be used to fill the storage tank **212**. In order to obtain refrigerant from a refrigerant source, the refrigerant recovery unit **100** may include the tank fill structure **332**, and valves **328** and **330**. The tank fill structure **332** may be configured to attach to a refrigerant source. The valve **330** may be a solenoid valve and the valve **328** may be a check valve. In other embodiments, valve **330** may be a manually operated valve.

[0048] When it is desired to allow refrigerant from a refrigerant source to enter the refrigerant recovery unit **100**, the tank fill structure **332** is attached to the refrigerant source and the tank fill valve **330** is opened. The check valve **328** prevents refrigerant from the refrigerant recovery unit **100** from flowing out of the refrigerant recovery unit **100** through the tank fill structure **332**. When the tank fill structure **332** is not connected to a refrigerant source, the tank fill valve **330** is kept closed. The tank fill valve **330** may be connected to and controlled by the controller **216**.

[0049] The tank fill structure **332** may be configured to be seated on the scale **334** configured to weigh the tank fill structure **332** in order to determine an amount of refrigerant stored in the tank fill structure **332**. The scale **334** may be operatively coupled to the controller **216** and provide a measurement of a weight of the tank fill structure **332** to the controller **216**. The controller **216** may cause a display of the weight of the tank fill structure **332** on the display **110**.

[0050] Aspects of the refrigerant recovery unit **100** may be implemented via control system **400** using software or a combination of software and hardware. In one variation, aspects of the present invention may be directed toward a control system **400** capable of carrying out the functionality described herein. An example of such a control system **400** is shown in FIG. **8**.

[0051] Control system **400** may be integrated with the controller **216** to permit, for example, automation of the recovery, evacuation, and recharging processes and/or manual control over one or more of each of the processes individually. In one embodiment, the control system **400** allows the refrigerant recovery unit to direct communicate and diagnose the vehicle under service. In another embodiment, the control system **400** allows for communication with a diagnostic tool, such as a vehicle communication interface (VCI), that is coupled to the vehicle under service. It should be understood that the VCI does not have to be coupled to a vehicle in order to communicate with the refrigerant recovery unit **100**. This allows the refrigerant recovery unit **100** to receive information from the vehicle such as VIN (vehicle identification number), manufacturer, make, model, and odometer information, and vehicle sensor data that pertains to the heating, ventilation, and air conditioning sensors and systems on the vehicle. Data could include A/C and heating, ventilation, and air conditioning (HVAC) system sensor readings, A/C and HVAC related diagnostic trouble codes, system pressures, and interactive tests, like actuating of various components, such as a fan control. All of this data and information would be displayed on the display **110** of the refrigerant recovery unit **100**. Menu selections, diagnostic trouble codes, and interactive tests may be displayed and certain diagnostic may be performed using the refrigerant recovery unit.

[0052] The control system **400** may also provide access to a configurable database of vehicle information so the specifications pertaining to a particular vehicle, for example, may be used to provide exacting control and maintenance of the functions described herein. The control system **400** may include a processor **402** connected to a communication infrastructure **404** (e.g., a communications bus, cross-over bar, or network). The various software and hardware features described herein are described in terms of an exemplary control system. A person skilled in the relevant art(s) will realize that other computer related systems and/or architectures may be used to implement the aspects of the disclosed invention.

[0053] The control system **400** may include a display interface **406** that forwards graphics, text, and other data from memory and/or the user interface **114**, for example, via the communication infrastructure **404** for display on the display **110**. The communication infrastructure **404** may include, for example, wires for the transfer of electrical, acoustic and/or optical signals between various components of the control system and/or other well-known means for providing communication between the various components of the control system, including wireless means. The control system **400** may include a main memory **408**, preferably random access memory (RAM), and may also include a secondary memory **410**. The secondary memory **410** may include a hard drive **412** or other devices for allowing computer programs including diagnostic database (DTC information and repair and diagnostic information) or other instructions and/or data to be loaded into and/or transferred from the control system **400**. Such other devices may include an interface **414** and a removable storage unit **416**, including, for example, a Universal Serial Bus (USB) port and USB storage device, a program cartridge and cartridge interface (such as that found in video game devices), a removable memory chip (such as an erasable programmable read only memory (EPROM), or programmable read only memory (PROM)) and associated socket, and other removable storage units **416** and interfaces **414**.

[0054] The control system **400** may also include a communications interface **420** for allowing software and data to be transferred between the control system **400** and external devices. Examples of a communication interfaces include a modem, a network interface (such as an Ethernet card), a communications port, wireless transmitter and receiver, Bluetooth, Wi-Fi, infra-red, cellular, satellite, a Personal Computer Memory Card International Association (PCMCIA) slot and card, etc.

[0055] The control system **400** also includes transceivers and signal translators necessary to communicate with the vehicle electronic control units in various communication protocols, such as J1850 (VPM and PWM), international standards organization (ISO) 9141-2 signal, communication collision detection (CCD) (e.g., Chrysler collision detection), data communication links (DCL), serial communication interface (SCI), Controller Area Network (CAN), Keyword 2000 (ISO 14230-4), on-board diagnostics (OBD) II or other communication protocols that are implemented in a vehicle. This allows the refrigerant recovery unit to communicate directly with the vehicle without the VCI (e.g., directly connected to the vehicle) or while the VCI is simply acting as a pass through.

[0056] A software program (also referred to as computer control logic) may be stored in main memory **408** and/or secondary memory **410**. Software programs may also be received through communications interface **420**. Such software programs, when executed, enable the control system **400** to perform the features of the present invention, as discussed herein. In particular, the software programs, when executed, enable the processor **402** to perform the features of the present invention. Accordingly, such software programs may represent controllers of the control system **400**.

[0057] In variations where the invention is implemented using software, the software may be stored in a computer program product and loaded into control system **400** using hard drive **412**, removable storage unit **416**, and/or the communications interface **420**. The control logic (software), when executed by the processor **402**, causes the controller **216**, for example, to perform the functions of the invention as described herein. In another variation, aspects of the present invention can be implemented primarily in hardware using, for example, hardware components, such as application specific integrated circuits (ASICs), field programmable gate array (FPGA). Implementation of the hardware state machine so as to perform the functions described herein will be apparent to persons skilled in the relevant art(s).

[0058] The many features and advantages of the invention are apparent from the detailed specification, and thus, it is intended by the appended claims to cover all such features and advantages of the invention which fall within the true spirit and scope of the invention. Further, since numerous modifications and variations will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation illustrated and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed is:

1. A refrigerant recovery system, comprising:

a service hose, including:

a service coupler configured to fluidly connect the service hose to a refrigeration system;

a check valve assembly disposed proximal to the service coupler, the check valve assembly including:

a recovery flow path defined by a flow of a refrigerant from the refrigeration system and flowing along a first bore disposed in a body, a recovery poppet, a first O-ring, and a stand-off; and

a recharge flow path defined by a flow of the refrigerant to the refrigeration system and flowing along a second bore disposed in the body, a recharge poppet, a second O-ring, a biasing member, and a shim;

a hose to convey refrigerant, wherein the check valve assembly is configured to provide a substantially free flow of refrigerant along the recovery flow path and the check valve assembly is configured to provide a predetermined cracking pressure in response to the refrigerant being urged to flow along the recharge flow path; and

a refrigerant recovery unit, including:

a refrigerant storage unit configured to store the refrigerant;

a refrigerant circuit in fluid connection with the refrigeration system, the refrigerant circuit configured to recover refrigerant from the refrigeration system and recharge the refrigeration system with the refrigerant;

a processor configured to control the refrigerant recovery unit; and

a memory to store diagnostic software and operating software to operate the refrigerant recovery unit.

2. The refrigerant recovery system according to claim **1**, further comprising:

a second service coupler configured to fluidly connect the service hose to the refrigeration system.

3. The refrigerant recovery system according to claim **1**, wherein the biasing member is a spring.

4. The refrigerant recovery system according to claim **1**, wherein the refrigerant recovery unit further comprises:

an input interface configured to receive an input from a user; and

a display configured to display information to the user.

5. The refrigerant recovery system according to claim **1**, wherein the predetermined cracking pressure is selected to maintain the refrigerant disposed in the hose being recharged into the refrigeration system in a liquid state.

6. The refrigerant recovery system according to claim **1**, wherein the refrigerant recovery unit further includes a compressor to urge the refrigerant to flow through the refrigerant circuit and the compressor is configured to supply the refrigerant to the service hose at or greater than the predetermined cracking pressure.

7. The refrigerant recovery system according to claim **1**, wherein the recovery poppet is configured to seal upon the first O-ring in response to a supply of the refrigerant flowing into the service hose from the refrigerant recovery unit.

8. The refrigerant recovery system according to claim **1**, wherein the refrigerant recovery unit is further configured to recover and recharge the refrigerant in the refrigeration system.

9. The refrigerant recovery system according to claim **1**, wherein the refrigerant recovery unit further includes an oil separator to remove oil from the refrigerant.

10. The refrigerant recovery system according to claim **1**, further comprising:

a second service hose to fluidly connect the refrigeration recovery unit to the refrigeration system.

11. A service hose, comprising:

a service coupler configured to fluidly connect the service hose to a refrigeration system; and

a check valve assembly disposed proximal to the service coupler, the check valve assembly including:

a recovery flow path defined by a flow of a refrigerant from the refrigeration system and flowing along a first bore disposed in a body, a recovery poppet, a first O-ring, and a stand-off; and

a recharge flow path defined by a flow of the refrigerant to the refrigeration system and flowing along a second bore disposed in the body, a recharge poppet, a second O-ring, a biasing member, and a shim, wherein the check valve assembly is configured to provide a substantially free flow of refrigerant along the recovery flow path and the check valve assembly is configured to provide a predetermined cracking pressure in response to the refrigerant being urged to flow along the recharge flow path.

12. The service hose according to claim **11**, wherein the biasing member is a spring.

13. The service hose according to claim **11**, further comprising:

a hose to convey the refrigerant between the refrigeration system and a refrigerant recovery unit.

14. The service hose according to claim **13**, wherein the recovery poppet is configured to seal upon the first O-ring in response to a supply of the refrigerant flowing into the service hose from the refrigerant recovery unit.

15. The service hose according to claim **12**, wherein the biasing member is configured to urge the recharge poppet to seal upon the second O-ring to provide the predetermined cracking pressure.

16. A method of servicing a refrigeration system, the method comprising the steps of:

recovering a refrigerant from the refrigeration system with a refrigeration recovery unit, the refrigeration recovery unit being in fluid communication with the refrigeration system via a service hose, the service hose including:

a service coupler configured to fluidly connect the service hose to the refrigeration system;

a check valve assembly disposed proximal to the service coupler, the check valve assembly including:

a recovery flow path defined by a flow of the refrigerant from the refrigeration system and flowing along a first bore disposed in a body, a recovery poppet, a first O-ring, and a stand-off; and

a recharge flow path defined by a flow of the refrigerant to the refrigeration system and flowing along a second bore disposed in the body, a recharge poppet, a second O-ring, a biasing member, and a shim; and

a hose to convey refrigerant, wherein the check valve assembly is configured to provide a substantially free flow of refrigerant along the recovery flow path and the check valve assembly is configured to provide a predetermined cracking pressure in response to the refrigerant being urged to flow along the recharge flow path; and

recharging the refrigeration system with the refrigerant by urging the refrigerant to flow from the refrigeration recovery unit at a pressure greater than the predetermined cracking pressure of the check valve assembly.

17. The method according to claim **16**, further comprising the step of:

determining a recharge weight of refrigerant in response to a recommended weight of refrigerant for the refrigeration system and a weight of refrigerant remaining in the service hose.

18. The method according to claim **16**, further comprising the step of:

determining the predetermined cracking pressure in response to a pressure the refrigerant is in liquid state at ambient temperature.

19. The method according to claim **18**, further comprising the step of:

determining a tension for the biasing member based on the determined predetermined cracking pressure.

20. The method according to claim **16**, further comprising the step of:

recovering the refrigerant from the service hose in response to the service coupler being fluidly disconnected from the refrigeration system.

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