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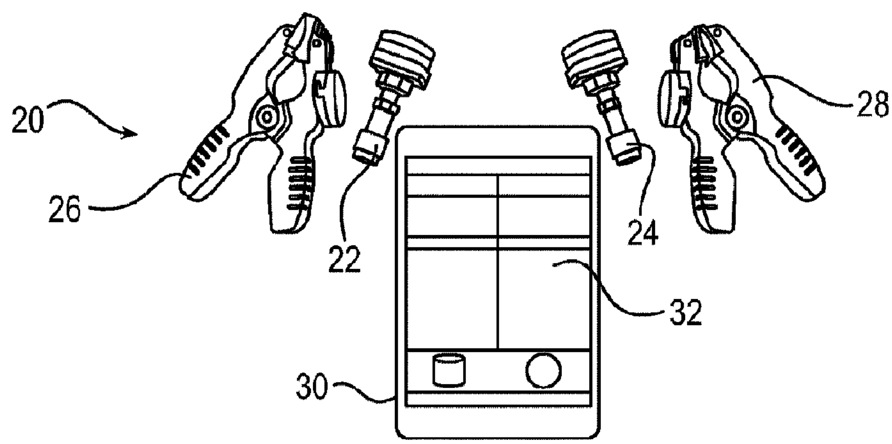

(57) Abrégé/Abstract:
A hoseless sensor system for a refrigerant unit includes a plurality of hoseless sensors for sensing system parameters of the refrigerant unit, and a portable electronic device configured to receive the system parameters from the hoseless sensors and to calculate system conditions for the refrigerant based on the system parameters. The plurality of hoseless sensors includes a hoseless first pressure sensor and a hoseless second pressure sensor, and a hoseless first temperature sensor and a hoseless second temperature sensor. The temperature sensors may be temperature sensor clamps. Each temperature sensor clamp includes a clamping portion configured to clamp on a tube of the refrigerant unit, the clamping portion including a sensor element to measure temperature about the tube. The clamping portion further includes a plurality of clamping teeth, and adjacent clamping teeth interlock in an overlapping configuration when the clamp closes inward beyond a threshold point.

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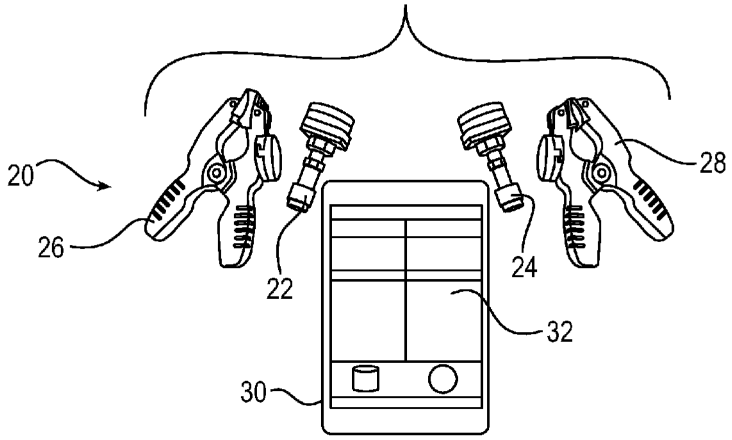
FIG. 4



(57) Abstract: A hoseless sensor system for a refrigerant unit includes a plurality of hoseless sensors for sensing system parameters of the refrigerant unit, and a portable electronic device configured to receive the system parameters from the hoseless sensors and to calculate system conditions for the refrigerant based on the system parameters. The plurality of hoseless sensors includes a hoseless first pressure sensor and a hoseless second pressure sensor, and a hoseless first temperature sensor and a hoseless second temperature sensor. The temperature sensors may be temperature sensor clamps. Each temperature sensor clamp includes a clamping portion configured to clamp on a tube of the refrigerant unit, the clamping portion including a sensor element to measure temperature about the tube. The clamping portion further includes a plurality of clamping teeth, and adjacent clamping teeth interlock in an overlapping configuration when the clamp closes inward beyond a threshold point.

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TITLE: HOSE FREE SENSOR SYSTEM FOR REFRIGERANT UNIT

FIELD OF THE INVENTION

The present invention is directed to enhanced sensor systems for refrigeration units for monitoring and collecting system conditions, such as superheat and subcooling.

BACKGROUND OF THE INVENTION

As used herein, the term "refrigerant unit" or "refrigeration unit" is employed as a generalized term that encompasses equipment broadly used in heating, ventilation, air conditioning and refrigeration (HVACR) systems. The HVACR markets have been served by manual, analog gauge sets for many decades. Fig. 1 depicts a conventional gauge set used for monitoring and collecting system conditions of a refrigerant unit such as pressure, which may then be used to calculate system parameters such as superheat and subcooling. The gauge set permits a service technician to see inside the system to help diagnose and repair faulty systems and components.

As seen in Fig. 1, a conventional gauge set 10 is an analog gauge set that uses a set of hoses 11 connected to a manifold with valves 12. There is a set of analog pressure gauges 14, typically a high side pressure gauge (often identified with a red color) and a low side pressure gauge (often identified with a blue color). The hoses are attached to the system via a flare quick connection (commonly referred to as an SAE connection) for both the low side and high side of the refrigeration unit or air conditioning system. The refrigerant pressure is transmitted via the hoses, through the manifold and up to the analog gauges, and the gauges display the pressure to the technician.

For the service technician to calculate superheat or subcooling, a temperature sensor is attached to the refrigeration unit to measure temperature of the refrigeration. This temperature sensor operates as a temperature meter that is manually attached to the outside of a refrigerant tube near the pressure port where the gauge set hoses are attached. Figs. 2 and 3 (Fig. 3 being a more close-up view) depict the installation of the conventional gauge set 10 and temperature sensors 16 within an air conditioning unit 18. The temperature and pressure are then used by the technician to manually calculate superheat and subcooling. In particular, as is known in the art, there are established calculations by which superheat and subcooling are calculated based on the measured temperature and pressure parameters.

The conventional hose gauge system has significant deficiencies. The refrigerant travels through the length of the hoses to the analog or digital gauges at the manifold to display pressure. The refrigerant can be in the form of vapor or liquid, with common hose sizes being 5' or 6' in length. Under current environmental regulations, refrigerant in the hoses must be collected and reclaimed, and not just released into the environment. A quick connect coupling is available on the market to eliminate refrigerant "blow off" (emptying the refrigeration hoses after system inspection). The coupling is attached to the end of the hoses and essentially traps the refrigerant in the hoses after removing them from the system. The disadvantage of using this form of coupling is that the analog gauge set can only be used for one type of system, i.e., the system refrigerant must be the same type as the trapped refrigerant inside of the hoses or refrigerant and oil contamination will occur.

Relatedly, cross contamination between refrigerant systems must be avoided. Common practice today is that a service technician needs to have several analog gauge sets for particular refrigerants. For example, a technician may have a first gauge set for R-134a, a second gauge set for R-410, and a third gauge set for R-404a refrigerants. By having multiple analog gauge sets, a technician must be careful to avoid cross contamination among the gauge sets. Cross contamination can cause damage to the gauge set hoses and also reduce system performance, particularly on small systems due to incompatibilities among different refrigerant and oils.

The hoses also are bulky and therefore must be carried and transported. The efforts and inconvenience of transport are increased by the need for multiple gauge sets. Weight and flexibility further are significant for service technicians due to the fact that they are often climbing on ladders and carrying tools to roofs to service roof-top condensing units for refrigeration or air conditioners. Conventional analog gauge sets also require the technician to stand next to the gauge set to read pressure, or two technicians with two-way radios or equivalent mobile devices may need to report measurements to each other. The close distance requirements of conventional analog gauge sets provides yet another deficiency of such systems.

SUMMARY OF THE INVENTION

There is a need in the art for an improved sensor system for refrigeration units for monitoring and collecting system conditions such as superheat and subcooling. The described invention is a hoseless system of individual hose-free sensors that are installed on a refrigeration or air conditioning system. Sensor information may be transmitted wirelessly to a remote device, such as a portable electronic device (e.g., tablet computer, laptop computer, smartphone, or the like). The portable electronic device may have installed a software or program application that receives the sensor information and calculates automatically system conditions, such as for example superheat and subcooling.

The sensors may include high side and low side pressure and temperature, which permit installation into the refrigeration unit without hoses to collect system parameters, such as temperature and pressure. The system parameter measurements are transmitted from the sensors to a mobile portable electronic device via a wireless communication. The measurements are used by the mobile device via executing the program application to calculate system conditions, such as for example superheat and subcooling. The invention thus permits service technicians to diagnose and repair systems or components, without the drawbacks of conventional analog hose gauge sets.

In accordance with the above, an aspect of the invention is a sensor system for a refrigerant unit. In exemplary embodiments, the sensor system includes a plurality of hoseless sensors for sensing system parameters of the refrigerant unit, and a portable electronic device configured to receive the system parameters from the hoseless sensors and to calculate system conditions for the refrigerant based on the system parameters. The plurality of hoseless sensors may include a hoseless first pressure sensor and a hoseless second pressure sensor, and a hoseless and wireless first temperature sensor and a hoseless and wireless second temperature sensor. The first pressure sensor and first temperature sensor may be sensors for a high side of the refrigerant system, and the second pressure sensor and the second temperature sensor may be sensors for a low side of the refrigerant system. The system conditions calculated by the portable electronic device may include superheat and subcooling for the refrigerant system.

Another aspect of the invention is an enhanced temperature sensor clamp for use as the temperature sensors in the described sensor system for sensing temperature in the refrigerant unit. In exemplary embodiments, the temperature sensor clamp includes a clamping portion configured to clamp on a tube of the refrigerant unit, the clamping portion including a sensor element to measure temperature about the tube. The clamping portion further includes a plurality of clamping teeth, and adjacent clamping teeth interlock in an overlapping configuration when the clamp closes inward beyond a threshold point. The clamping portion further includes a perforated gripping portion for gripping the tube of the refrigerant unit, the gripping portion including a grating. When the clamping portion clamps the tube, the grating scores the tube to clean and grip the tube. The temperature sensor clamp further includes a handle and integrated electronics incorporated into the handle. The integrated electronics, for example, may include a battery housing for a battery, a light emitting status indicator, wireless transmitter and/or a wireless interface pair button.

These and further features of the present invention will be apparent with reference to the following description and attached drawings. In the description and drawings, particular embodiments of the invention have been disclosed in detail as being indicative of some of the ways in which the principles of the invention may be employed, but it is understood that the invention is not limited correspondingly in scope. Rather, the invention includes all changes, modifications and equivalents coming within the spirit and terms of the claims appended hereto. Features that are described and/or illustrated with respect to one embodiment may be used in the same way or in a similar way in one or more other embodiments and/or in combination with or instead of the features of the other embodiments.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 depicts a conventional gauge set used for monitoring and collecting system parameters of a refrigerant unit.

Figs. 2 depicts the installation of the conventional gauge set of Fig. 1 and a temperature sensor within an air conditioning unit.

Fig. 3 depicts a close-up view of the installation of Fig. 2.

Fig. 4 depicts an exemplary hoseless sensor system for use in sensing parameters and determining system conditions in a refrigerant unit.

Figs. 5 depicts the installation of the hoseless sensor system of Fig. 4 within an air conditioning unit.

Fig. 6 depicts a close-up view of the installation of Fig. 5.

Fig. 7 is a schematic block diagram depicting operative portions of an exemplary portable electronic device for use in the sensor system.

Figs. 8A-B are schematic diagrams depicting side views of an exemplary temperature sensor clamp with the clamp open.

Figs. 9A-B are schematic diagram depicting side views of the exemplary temperature sensor clamp of Fig. 8 with the clamp closed.

Fig. 10 is a schematic diagram depicting an isometric bottom view of the exemplary temperature sensor clamp of Fig. 9.

Fig. 11 is a schematic diagram depicting an isometric top view of the exemplary temperature sensor clamp of Fig. 9.

Fig. 12 is a schematic diagram depicting an isometric close-up view of a clamping portion of the temperature sensor clamp, including clamping teeth in the closed position.

Fig. 13 is a schematic diagram depicting the operation of the clamping portion of the temperature sensor clamp to grip a relatively large diameter tube.

Fig. 14 is a schematic diagram depicting the operation of the clamping portion of the temperature sensor clamp to grip a relatively small diameter tube.

Fig. 15A is a schematic diagram depicting an isometric close-up view of a lower clamp tip, including a perforated gripping pad.

Fig. 15B is a schematic diagram depicting an isometric close-up view of an upper clamp tip, including a gripping surface and incorporated sensing element.

Fig. 16 is a schematic diagram depicting an isometric close-up view of an upper handle portion of the temperature sensor clamp, including integrated electronics.

Figs. 17 is a schematic diagram depicting a side cross-sectional view of an exemplary hoseless pressure sensor.

DETAILED DESCRIPTION

Embodiments of the present invention will now be described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. It will be understood that the figures are not necessarily to scale.

As referenced above, as used herein the term "refrigerant unit" or "refrigeration unit" is employed as a generalized term that encompasses equipment broadly used in heating, ventilation, air conditioning and refrigeration (HVACR) systems. Accordingly, it is understood that the present invention is not limited to usage in any particular type of device, and the term refrigerant unit or refrigeration unit is a generic term that encompasses all HVACR related and like devices in which the present invention may be employed.

Fig. 4 depicts an exemplary hoseless sensor system 20 for use in sensing parameters and determining system conditions in a refrigerant unit. In exemplary embodiments, the sensor system includes a plurality of hoseless sensors for sensing system parameters of the refrigerant unit, and a portable electronic device configured to receive the system parameters from the hoseless sensors and to calculate system conditions for the refrigerant unit based on the system parameters.

Referring to Fig. 4, in the sensor system 20 the plurality of hoseless sensors may include a hoseless first pressure sensor 22 and a hoseless second pressure sensor 24. The plurality of hoseless sensors further may include a hoseless first temperature sensor 26 and a hoseless second temperature sensor 28. The first pressure sensor 22 and first temperature sensor 26 may be sensors for a high side of the refrigerant system, and the second pressure sensor 24 and the second temperature sensor 28 may be sensors for the low side of the refrigerant system. The high side and low side sensors respectively may be color coded red and blue as is conventional. A portable electronic device 30 may calculate system conditions based on sensor parameters measured by the plurality of hoseless sensors. The portable electronic device may execute a software program application 32 to calculate system conditions, including superheat and subcooling for the refrigerant system. The portable electronic device 30 may be any suitable mobile device, such as, for example, a tablet computer, laptop computer, smartphone, or the like. The program application 32 may be a mobile application suitable for execution by such portable electronic devices.

The use of high side and low side pressure and temperature sensors permits a variety of system calculations to be performed by the portable electronic device 30 executing the program application 32. The measurements may be used to calculate system conditions, such as for example superheat and subcooling. The program application further may be executed to calculate a temperature differential (ΔT) and pressure differential (ΔP) based on measurements of the high side sensors relative to the low side sensors. ΔT and ΔP are useful indications of system performance. For example, ΔT may be employed as a measure of air coil performance and system capacity. As another example, a high ΔP may be indicative of clog in the system, such as for example at a filter or coil. ΔT and ΔP parameters are useful in a variety of trouble shooting determinations in evaluating system performance.

Figs. 5 depicts the installation of the hoseless sensor system of Fig. 4 within an air conditioning unit 34. Fig. 6 depicts a close-up view of the installation of Fig. 5. The sensor system of the present invention eliminates the need for hoses to measure system parameters. The pressure sensors 22 and 24 are installed by hand onto the system tube via a flare quick connection, such as for example a ¼" SAE connector or other suitable structure. The temperature sensors 26 and 28 may be configured as temperature sensor clamps also installed by hand. The temperature sensor clamps are installed by clamping on the outside of the refrigerant system tubes next to the pressure sensors to sense temperature of the refrigerant inside the tubes. The pressure and temperature sensors may be visually identified with color for low side (blue) and high side (red) of the refrigerant system as is conventional.

Fig. 7 is a schematic block diagram depicting operative portions of an exemplary portable electronic device 30. The portable electronic device 30 may include a communications interface 36 for wirelessly receiving the system parameters from the hoseless sensors. The communications interface may also include a wireless transmitting capability that can transmit information to the sensors, such as for example firmware updates or the like, or otherwise transmit data externally from the electronic device. The wireless communication may be performed over any suitable wireless interface, such as Bluetooth, Wi-Fi, cellular networks, or other suitable wireless technologies that are known in the art. As part of such wireless communication and interfacing, the communications interface 36 may include an auto-connect feature that automatically establishes a wireless connection for communication with the sensors based on specified criteria, such as for example range, readiness status or state, and/or other suitable criteria.

A memory 38, which may be any suitable non-transitory computer readable medium known in the art, stores the program application 32. The programming of such applications are known to those skilled in the programming art, so the precise program code is omitted here for convenience. A processor device 40 is configured to receive the sensor parameters via the communications interface 36, and to execute the program application 32 to calculate the system conditions based on the system parameters. The portable electronic device 30 further may include a display 42 for displaying pertinent sensor and system condition information to the technician.

The pressure and temperature sensors transmit pressure and temperature data to the portable electronic device preferably by a wireless communication. The executed program application performs a calculation to display real time system conditions, such as superheat and subcooling. The portable electronic device and related program application can support multiple wireless sensors and sensor types, including for example pressure and temperature sensors as described above, and additionally sensor types such as, for example, sensors for humidity, weight, current, vibration, and other parameters. The program application also allows the user to record and store the data in the device memory, and may include a graphing feature to aid in diagnosing the system. It will be appreciated that a variety of communications technologies may be employed to execute the program application and cooperate with the sensors. For example, the system may operate via a cellular network, WiFi network, or other external network. In certain locations, however, access to such networks may be limited (e.g., in basements, cellars, subway systems, and other enclosed, underground and remote areas). Accordingly, in exemplary embodiments the application may run solely over a localized interface with all requisite data being stored and processed locally on the portable electronic device 30.

The program application also may include a GPS feature and a “send” feature to allow the technician to pin where the job is, and to send the system data back to a service shop for analysis. The program application also may offer a refrigerant type selection to allow service technicians to use the sensor system across multiple different refrigerant systems, along with a calibration feature to offset the temperature and pressure display readings. The program application also permits the technician to save and send system data for further analysis. The program application also may use location services to inform a technician of the closest wholesaler and/or customer service contact information to order replacement parts for system repair. In this manner, enhanced product support can be provided.

The hoseless configuration of the present invention has significant advantages over conventional gauge sets. Because there are no hoses, the present invention minimizes refrigerant loss and difficulties associated with processing and reclaiming refrigerant trapped in hoses. The quick connect coupling of the pressure sensors eliminates the need for the refrigerant blow off to empty refrigeration hoses after system inspection. Also, without the need to reclaim trapped refrigerant, the hoseless system of the present invention can be used for multiple types of refrigerant systems. Relatedly, the invention eliminates cross contamination between systems by replacing multiple gauge sets with a sensor system that is useable across different refrigerant systems with otherwise incompatible refrigerants and oils. The program application permits the technician to select the proper refrigerant per system for current usage, and to change the selection for a different type of system.

In addition, because the present invention has a hoseless configuration, the present invention can be easily carried in a small case or separately. The overall weight of the hoseless configuration is approximately one fifth as light as conventional hose-containing gauge sets. The hoseless configuration, therefore, is more readily usable by service technicians when there is a need, for example, to climb on ladders and carry tools to service roof-top condensing units for refrigeration or air conditioners.

The wireless nature of the transmission of the sensor data to the portable electronic device permits the service technician the flexibility of walking around the different parts of the system while reading system conditions displayed on the portable electronic device with the program application. There is no need for the technician to stand next to the gauge set to read pressure, or to utilize two technicians with a two-way mobile radio system, as referenced above with respect to conventional hose gauge sets. The present invention also allows flexibility for adjusting system components while reading the real time data through the portable electronic device via the program application. The increased permissible distance also allows the technician to remove himself of herself from noise where the measurements are taken, such as for example a mechanical room in supermarkets where refrigeration compressors are located. In exemplary embodiments, a repeater or other suitable device may be employed to extend the range of communication.

In exemplary embodiments, the hoseless sensor system has enhanced temperature sensors. Each enhanced temperature sensor is configured as a temperature sensor clamp. In exemplary embodiments, the temperature sensor clamp includes a clamping portion configured to clamp on a tube of the refrigerant unit, the clamping portion including a sensor element to measure temperature about the tube. The clamping portion further includes a plurality of clamping teeth, and adjacent clamping teeth interlock in an overlapping configuration when the clamp closes inward beyond a threshold point. The clamping portion further includes a perforated gripping portion for gripping the tube of the refrigerant unit, the gripping portion including a grating. When the clamping portion clamps the tube, the grating scores the tube to clean and grip the tube. The temperature sensor clamp further includes a handle and integrated electronics incorporated into the handle. The integrated electronics, for example, may include a battery housing for a battery, a light emitting status indicator, and/or a wireless interface pair button.

Figs. 8-11 are schematic diagrams depicting various views of an exemplary temperature sensor clamp 50, including side views with the clamp open (Figs. 8A-B), side views with the clamp closed (Figs. 9A-B), an isometric bottom view (Fig. 10), and an isometric top view (Fig. 11.) The temperature sensor clamp 50 includes a clamping portion 52 constituting the tip of the temperature sensor clamp, and a handle portion 54. The clamping portion 52 includes an upper clamp tip 56 and a lower clamp tip 58, which respectively include an upper gripping portion 60 and a lower gripping portion 62. The upper gripping portion 62 includes an embedded temperature sensing element 68 for sensing temperature of a tube in a refrigerant unit. As best seen in Fig. 11 of this group of figures, the clamping portion further includes a plurality of clamping teeth 64, whose operation is described in more detail below. The upper and lower clamp tips 56 and 58 each may be rotatable about a clamp tip shaft 66, one each provided in the upper and lower portions of the clamping portion 52.

The handle portion 54 includes an upper handle portion 70 and a lower handle portion 72. The upper handle portion 70/upper clamp tip 56 are rotatable about the lower handle portion 72/lower clamp tip 58 via a center shaft 76. As further described below, the upper handle portion 70 includes integrated electronics 78 that are in electrical connection with the temperature sensing element 68.

As referenced above, Fig. 11 depicts the plurality of clamping teeth 64. Fig. 12 is a schematic diagram depicting an isometric close-up view of the clamping portion 52 of the temperature sensor clamp 50, including the clamping teeth 64 in the closed position. As seen in Figs. 11 and 12, adjacent clamping teeth interlock in an overlapping configuration when the clamps closes inward. The interlocking and overlapping nature of the clamp teeth permits an increased range of tube size for which the temperature sensor clamp 50 may be employed.

Figs. 13 and 14 are schematic diagrams depicting the operation of the clamping portion of the temperature sensor clamp for different sized tubes. In particular, Fig. 13 first depicts the operation of the clamping portion to grip a relatively large diameter tube 80. As seen in Fig. 13, the clamping portion is opened to fit the tube diameter, and a relatively wider gripping range may be achieved by outward rotation of the upper and lower clamping tips 56 and 58 about the clamp tip shafts 66.

As the tube size is reduced, the clamping teeth begin to come together until the clamp teeth reach a threshold point at which edges of the clamp teeth essentially meet. As the clamping teeth close further, adjacent clamping teeth interlock in an overlapping configuration when the clamps closes inward beyond the threshold point. Such configuration, for example, is seen in Figs. 11 and 12 in which the clamping portion is fully closed without gripping any tube. In addition, Fig. 14 depicts the operation of the clamping portion to grip a relatively small diameter tube 82. The tube 82 is of a sufficiently small diameter that the clamping teeth 64 are closed beyond the threshold point, and thus interlock in an overlapping configuration to grip the small-sized tube 82. An enhanced grip further may be achieved by inward rotation of the upper and lower clamping tips 56 and 58 about the clamp tip shafts 66.

The enhanced tip configuration of the present invention provides for gripping an increased range of tube diameters, for example approximately 3/16” to 1-1/2” diameter tubes, although the tip configuration may be made to accommodate any suitable diameter tube. Conventional temperature sensor clamps utilize a flat style jaw that lacks the described interlocking teeth. The conventional flat jaw limits the size of tube diameters, for example to approximately 3/8” to 1-1/8”. As a result, the configuration of the clamping portion of the present invention permits the technician to service white goods (i.e., small appliances) with small diameter tubes up to large refrigeration or air conditioning chillers with large diameter tubes, a range of usage that is not available with conventional configurations.

The clamping portion of the present invention further includes an integrated perforated gripping portion for gripping the tube of the refrigerant unit. The integrated perforated gripping portion may be configured as a perforated gripping pad to increase the grip of the clamp on the tube. The perforated gripping portion is seen slightly in the various views. Fig. 15A is a schematic diagram depicting an isometric close-up view of the lower clamp tip 58, including a perforated gripping pad 84. Oppositely to the perforated gripping pad 84, a smooth gripping pad 85 is positioned oppositely on the upper clamp tip 56, as seen in Fig. 15B. As also seen in Fig. 15B, the sensing element 68 is incorporated into the upper clamp tip within or under the gripping pad 85. The gripping portion 85 is made smooth (instead of perforated as the gripping pad 84) to provide a better transfer of heat to the sensing element.

The pad material for either of the perforated gripping pad 84 or smooth gripping pad 85 may be, for example, metal, plastic or other similar materials to provide a requisite abrasion against a gripped refrigerant tube. Conventional temperature clamps have smooth or sometimes slightly dimpled pads for contacting the tube. Conventional smooth or dimpled pads often do not adequately hold the temperature sensor clamp to the pipe, and the temperature sensor clamp can slide around or down the tube due to gravity. Such deficiencies are avoided by the configuration of the described integrated perforated gripping portion. The gripping portion has a grating configuration formed by the perforations. When the clamping portion clamps the tube, the grating scores the tube to pre-clean and better grip the tube.

It is known in the art that an optimal position of the clamping portion is to grip the refrigerant tube at approximately 4:00/8:00 opposite clock positions relative to the cross-sectional diameter of the tube. The perforated gripping portion aids in maintaining this optimal grip position. The clamping portion also may include an external marking to aid in aligning at the optimal position, or the program application may indicate a proper orientation when installed for measurement. The proper installation improves the temperature reading by placing the clamp sensing element in the region where vapor exists inside the tube. If the clamp is installed at an improper position or allowed to slide down, the temperature measurement may be skewed due to oil and/or liquid refrigerant in that location of the tube.

A common practice is to pre-clean the tube with a piece of sandpaper or similar material, but this adds time to the measurement operation. The present invention avoids this deficiency. As referenced above, the perforated grating can score the tube to pre-clean the outside of the tube prior to taking a measurement. In typical cases, the tube will be copper; but non-copper tubes also can be pre-cleaned in this manner. Due to environmental effects, the copper tubes develop a protective coating naturally called copper oxide. The tube may also pick up oil and other debris such as dust or dirt, or adhesives that will reduce the thermal conductivity, and hence accuracy, of the temperature sensor clamp. By installing the temperature sensor clamp of the present invention as described, the technician may spin and rotate the clamp around the tube to remove the copper oxide layer and any other contaminants for better heat transfer prior to taking a measurement. This technique will improve temperature reading accuracy.

In exemplary embodiments, as referenced above the temperature sensor clamp further includes integrated electronics, and the integrated electronics are incorporated into the handle and are in electrical connection with the sensor element 68 and a power source. The configuration of the electronics is shown, for example, in Fig. 10. In addition, Fig. 16 is a schematic diagram depicting an isometric close-up view of the upper handle portion of the temperature sensor clamp, including integrated electronics. In particular, the upper handle portion 70 includes integrated electronics 78 that are in electrical connection with the temperature sensing element 68. The integrated electronics may include a power source housing or cover 90 (see also Fig. 11) housing a power source such as, for example, a battery or other power supply, a light emitting indicator 92, and a wireless interface pair button 94. The light emitting indicator may provide status indications for the temperature sensor clamp, such as for example power on/off, ready status, error states, or the like. The wireless interface pair button 94 may aid in pairing the temperature sensor clamp for wireless connection with the portable electronic device 30. The integrated electronics and the sensors may be sealed from environmental elements using any suitable sealing elements. Such sealing may be configured to satisfy any applicable environmental standards for outdoor use or other specified use conditions.

Fig. 17 is a schematic diagram depicting a side cross-sectional view of an exemplary hoseless pressure sensor that may be employed as the first pressure sensor 22 and/or second pressure sensor 24. As seen in Fig. 17, each pressure sensor includes a pressure sensing element 96 that is threaded into a pressure sensor housing 98. The threaded engagement, for example, may be provided by a 1/8" threading. The pressure sensor further may include a flare quick connection 100, such as for example a ¼” SAE connector or other suitable structure, for connection to the refrigerant unit. The pressure sensor further may include an integrated charging port 102, which also may be configured as a ¼” SAE connector or other suitable structure. The integrated charging port allows the technician to add or remove refrigerant, or pull a vacuum on the system without removing the pressure sensor. Such configuration permits the technician to monitor real time conditions as the refrigerant is added or removed.

In accordance with the above description, an aspect of the invention is a sensor system for a refrigerant. In exemplary embodiments, the sensor system includes a plurality of hoseless sensors for sensing system parameters of the refrigerant unit, and a portable electronic device configured to receive the system parameters from the hoseless sensors and to calculate system conditions for the refrigerant based on the system parameters.

In an exemplary embodiment of the sensor system, the plurality of hoseless sensors comprises a hoseless first pressure sensor and a hoseless second pressure sensor, and a hoseless first temperature sensor and a hoseless second temperature sensor.

In an exemplary embodiment of the sensor system, the first pressure sensor and first temperature sensor are sensors for a high side of the refrigerant system, the second pressure sensor and the second temperature sensor are sensors for the low side of the refrigerant system, and the system conditions calculated by the portable electronic device comprise superheat and subcooling for the refrigerant system.

In an exemplary embodiment of the sensor system, the first and second temperature sensors each comprises a temperature sensor clamp having a clamping portion configured to clamp on a tube of the refrigerant unit, the clamping portion including a sensor element to measure temperature about the tube.

In an exemplary embodiment of the sensor system, the clamping portion of each temperature sensor clamp includes a plurality of clamping teeth, and adjacent clamping teeth interlock in an overlapping configuration when the clamps closes inward beyond a threshold point.

In an exemplary embodiment of the sensor system, the clamping portion of each temperature sensor clamp includes a perforated gripping portion for gripping the tube of the refrigerant unit.

In an exemplary embodiment of the sensor system, the gripping portion comprises a grating, wherein when the clamping portion clamps the tube, the grating scores the tube to clean and grip the tube.

In an exemplary embodiment of the sensor system, each temperature sensor clamp further comprises a handle and integrated electronics, and the integrated electronics are incorporated into the handle and in electrical connection with the sensor element.

In an exemplary embodiment of the sensor system, the integrated electronics include at least one of a power source, a light emitting indicator, and a wireless interface pair button.

In an exemplary embodiment of the sensor system, the integrated electronics and the sensors are sealed from environmental elements.

In an exemplary embodiment of the sensor system, each of the first and second pressure sensors comprises a hoseless flare quick connection for connecting the pressure sensors to the refrigerant unit.

In an exemplary embodiment of the sensor system, the first and second pressure sensors further comprise an integrated charging port.

In an exemplary embodiment of the sensor system, the portable electronic device is configured to receive the system parameters from the hoseless sensors over a wireless interface.

In an exemplary embodiment of the sensor system, the portable electronic device includes a communications interface for wirelessly receiving the system parameters from the hoseless sensors, a memory storing a program application for calculating system conditions, and a processor device configured to receive the sensor parameters via the communications interface, and to execute the program application to calculate the system conditions based on the system parameters.

Another aspect of the invention is a temperature sensor clamp for sensing temperature in a refrigerant unit. In exemplary embodiments, the temperature sensor clamp includes a clamping portion configured to clamp on a tube of the refrigerant unit, the clamping portion including a sensor element to measure temperature about the tube, and the clamping portion includes a plurality of clamping teeth, and adjacent clamping teeth interlock in an overlapping configuration when the clamp closes inward beyond a threshold point.

In an exemplary embodiment of the temperature sensor clamp, the clamping portion includes a perforated gripping portion for gripping the tube of the refrigerant unit.

In an exemplary embodiment of the temperature sensor clamp, the gripping portion comprises a grating, wherein when the clamping portion clamps the tube, the grating scores the tube to clean and grip the tube.

In an exemplary embodiment of the temperature sensor clamp, the temperature sensor clamp further comprises a handle and integrated electronics, and the integrated electronics are incorporated into the handle and in electrical connection with the sensor element.

In an exemplary embodiment of the temperature sensor clamp, the integrated electronics include at least one of a battery, a light emitting indicator, and a wireless interface pair button.

Although the invention has been shown and described with respect to certain preferred embodiments, it is understood that equivalents and modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalents and modifications, and is limited only by the scope of the following claims.

Claims

1. A sensor system for a refrigerant unit, the sensor system comprising:

a plurality of hoseless sensors for sensing system parameters of the refrigerant unit; and

a portable electronic device configured to receive the system parameters from the hoseless sensors and to calculate system conditions for the refrigerant based on the system parameters;

wherein:

the plurality of hoseless sensors comprises a hoseless first pressure sensor and a hoseless second pressure sensor, and a hoseless first temperature sensor and a hoseless second temperature sensor;

the first and second temperature sensors each comprises a temperature sensor clamp having a clamping portion configured to clamp on a tube of the refrigerant unit, the clamping portion including a sensor element to measure temperature about the tube; wherein:

the portable electronic device comprises:

a communications interface for wirelessly receiving the system parameters from the hoseless sensors;

a memory storing a program application for calculating system conditions; and

a processor device configured to receive the sensor parameters via the communications interface, and to execute the program application to calculate the system conditions based on the system parameters; and

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each temperature sensor clamp further comprises a handle and integrated electronics, and the integrated electronics are incorporated into the handle and in electrical connection with the sensor element.

2. The sensor system of claim 1, wherein:

the first pressure sensor and first temperature sensor are sensors for a high side of the refrigerant system;

the second pressure sensor and the second temperature sensor are sensors for the low side of the refrigerant system; and

the system conditions calculated by the portable electronic device comprise superheat and subcooling for the refrigerant system.

3. The sensor system of any one of claims 1-2, wherein the clamping portion of each temperature sensor clamp includes a plurality of clamping teeth, and adjacent clamping teeth interlock in an overlapping configuration when the clamps closes inward beyond a threshold point.

4. The sensor system of any one of claims 1-3, wherein the clamping portion of each temperature sensor clamp includes a perforated gripping portion for gripping the tube of the refrigerant unit.

5. The sensor system of claim 4, wherein the gripping portion comprises a grating, wherein when the clamping portion clamps the tube, the grating scores the tube to clean and grip the tube.

6. The sensor system of any one of claims 1-5, wherein the integrated electronics include at least one of a power source, a light emitting indicator, and a wireless interface pair button.

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7. The sensor system of any one of claims 1-6, wherein the integrated electronics and the sensors are sealed from environmental elements.

8. The sensor system of any one of claims 1-7, wherein each of the first and second pressure sensors comprises a hoseless flare quick connection for connecting the pressure sensors to the refrigerant unit.

9. The sensor system of any one of claims 1-8, wherein the first and second pressure sensors further comprise an integrated charging port.

10. The sensor system of any one of claims 1-9, wherein the portable electronic device is configured to receive the system parameters from the hoseless sensors over a wireless interface.

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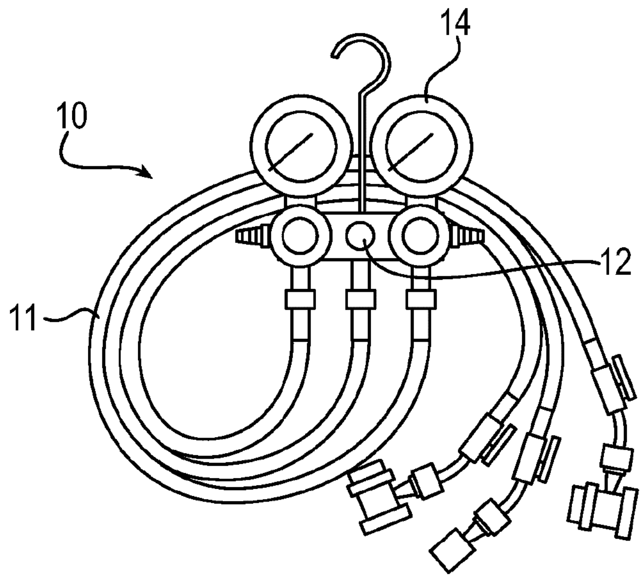


FIG. 1

PRIOR ART

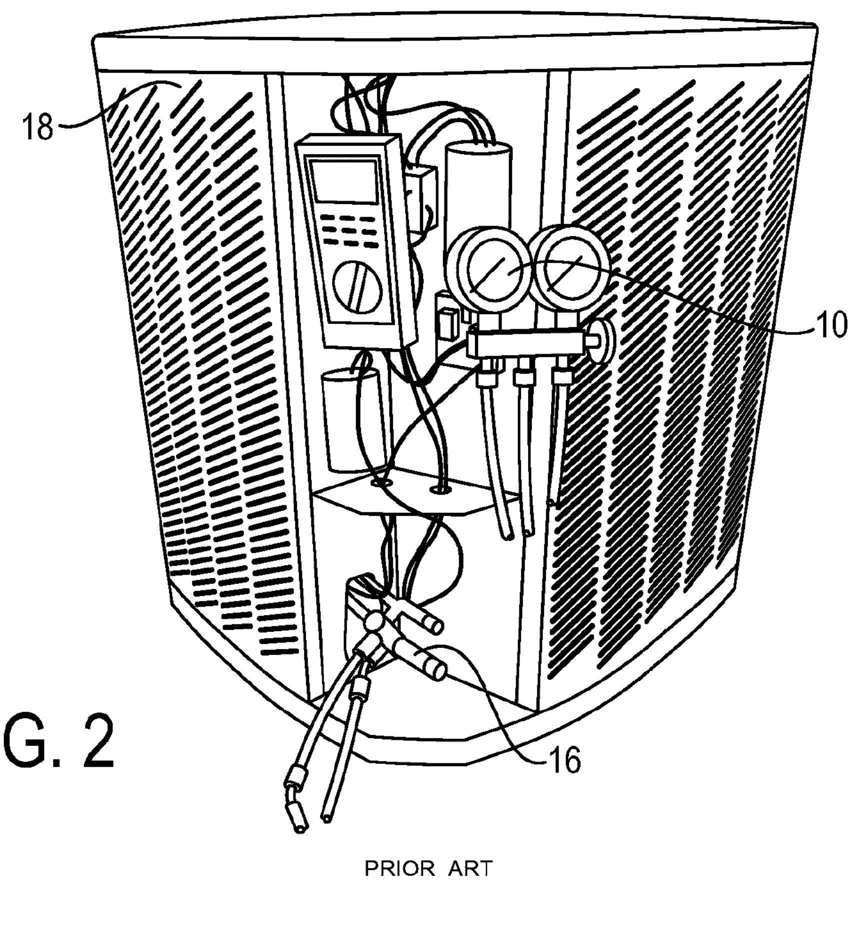


FIG. 2

PRIOR ART

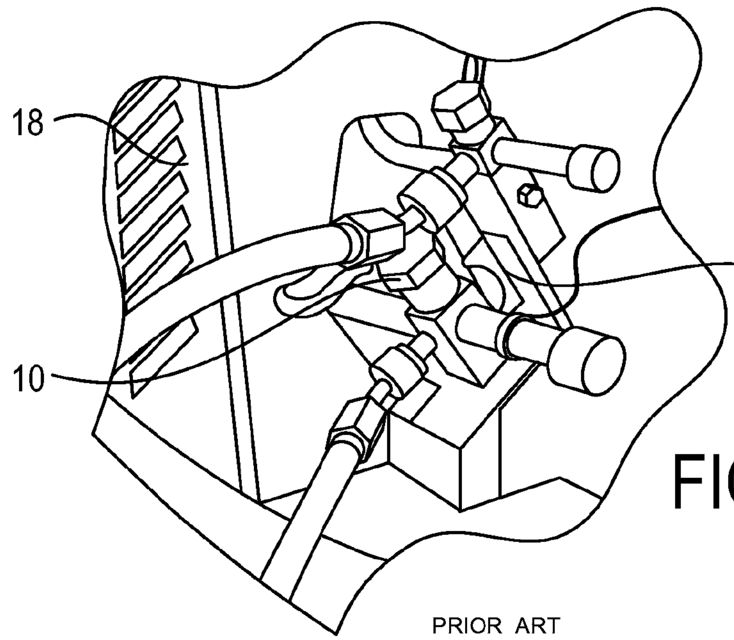


FIG. 3

PRIOR ART

FIG. 4

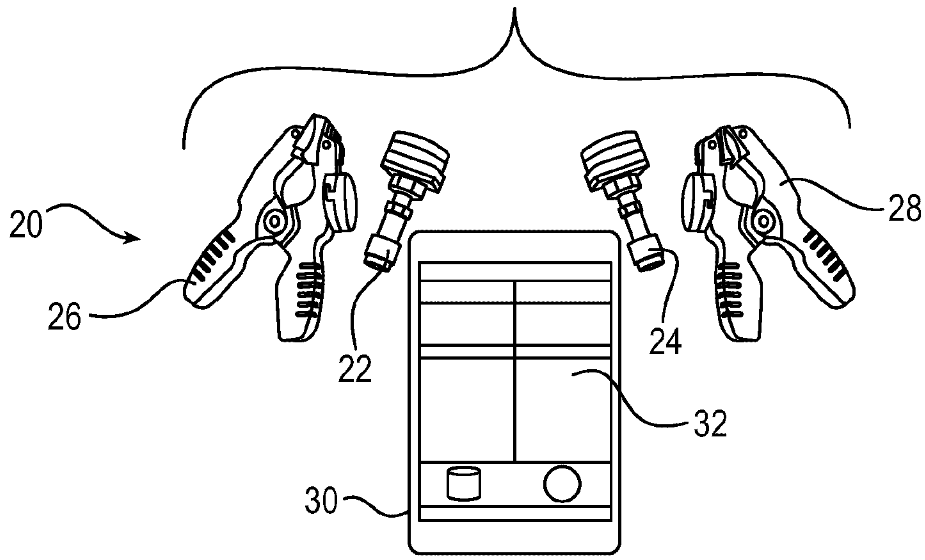
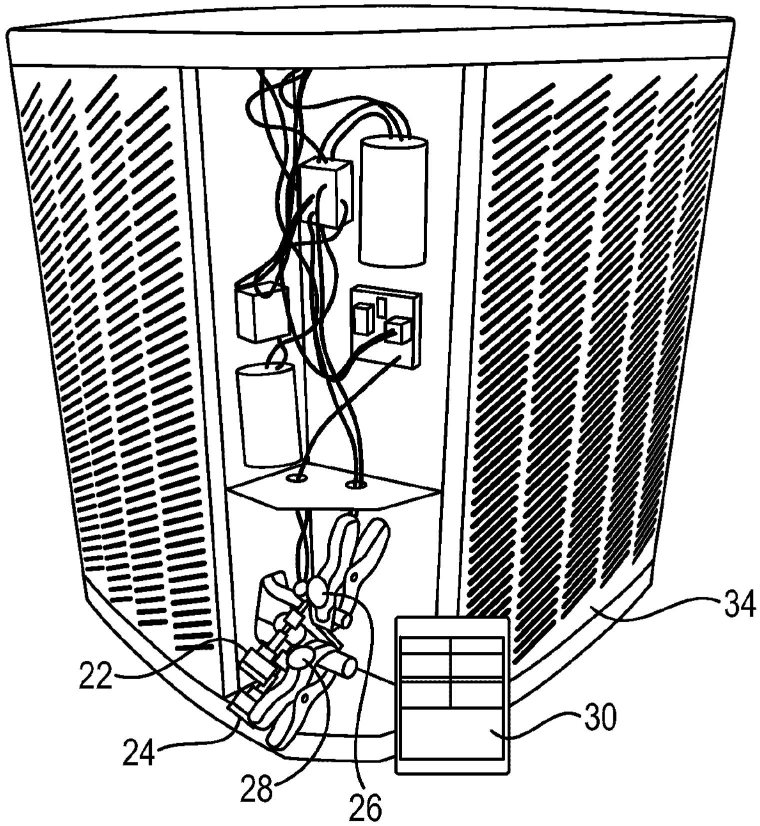


FIG. 5



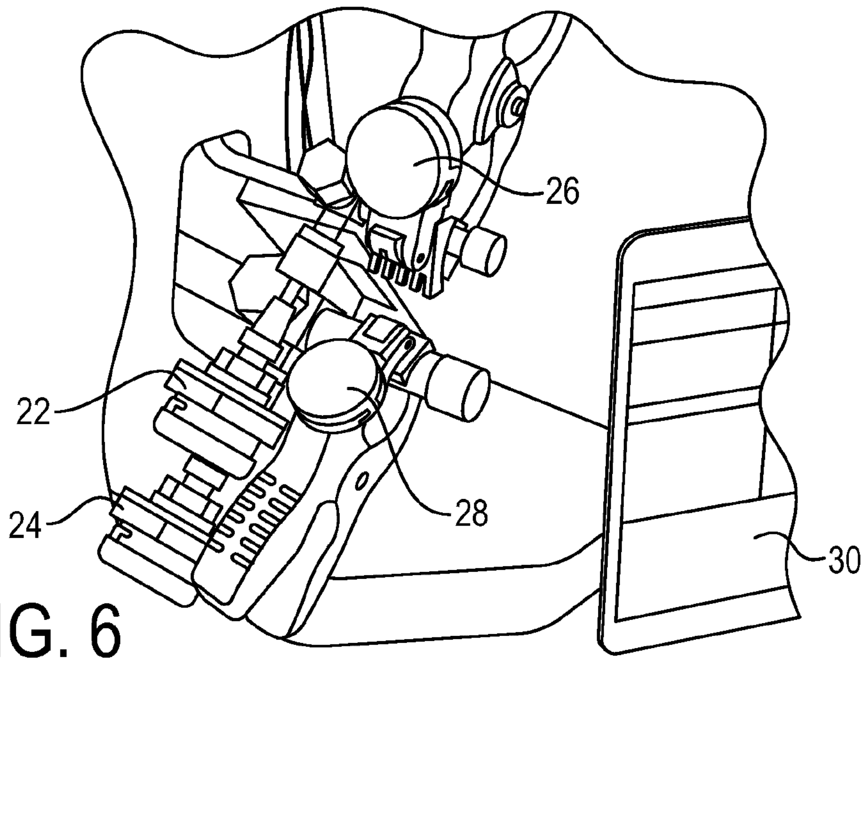
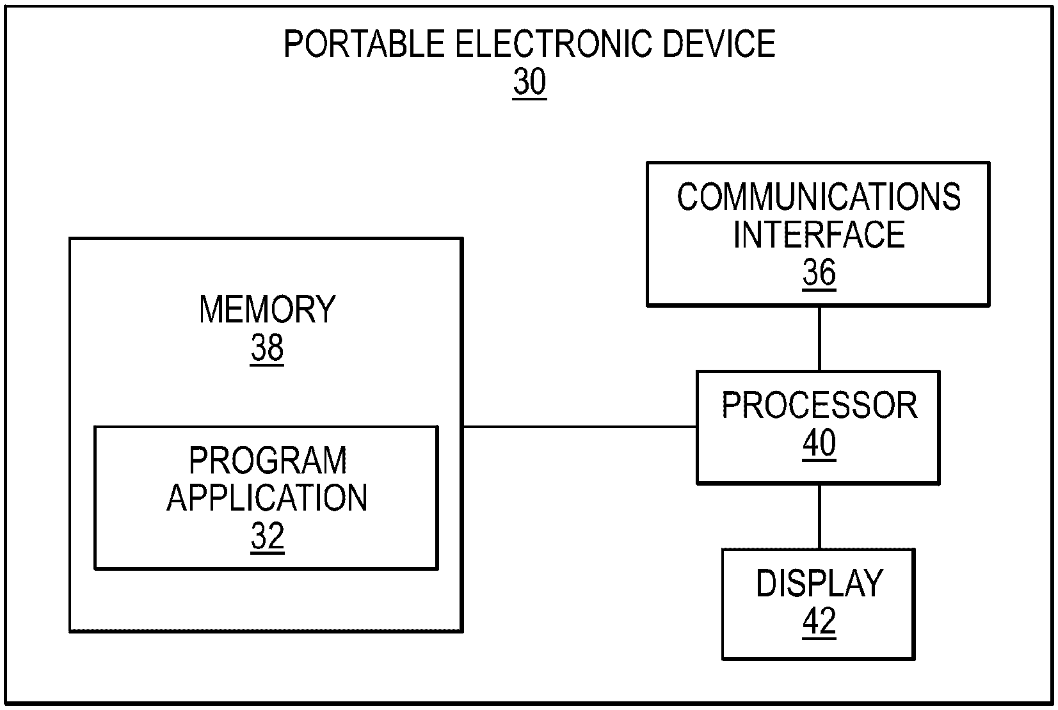


FIG. 6


PORTABLE ELECTRONIC DEVICE
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COMMUNICATIONS INTERFACE
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MEMORY
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PROCESSOR
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PROGRAM APPLICATION
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DISPLAY
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FIG. 7

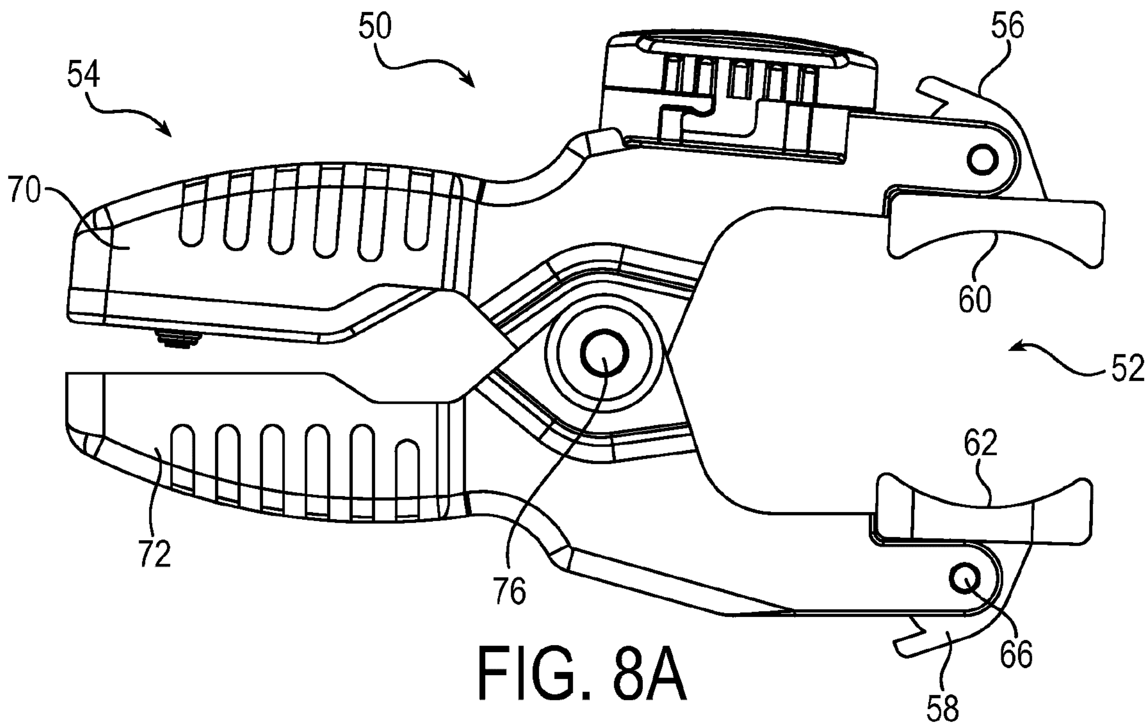

FIG. 8A

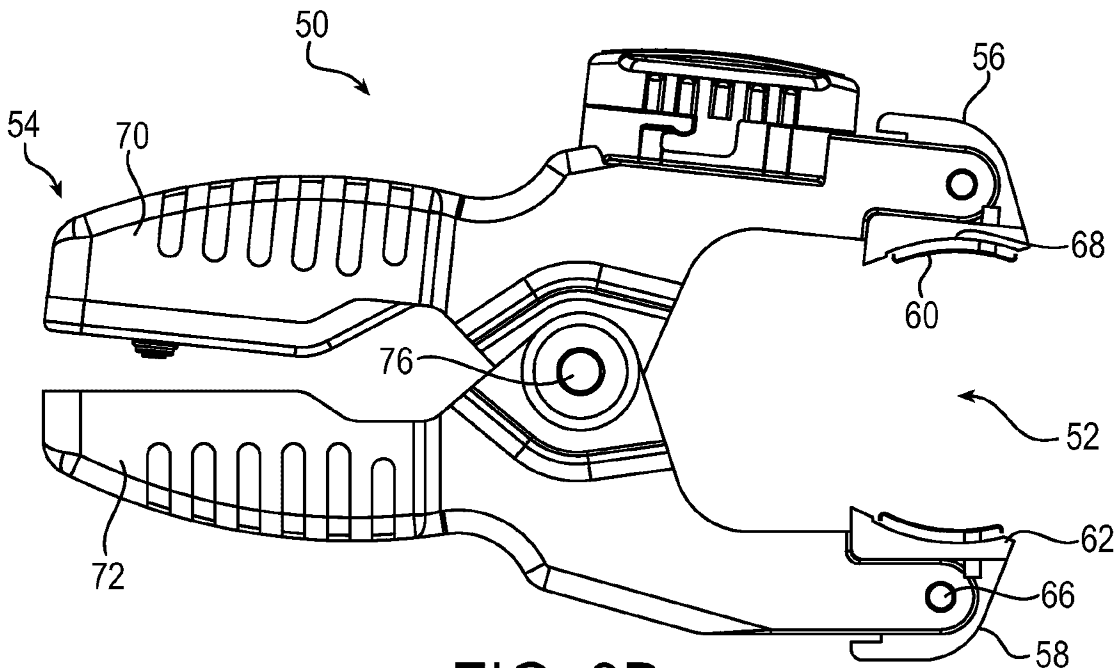

FIG. 8B

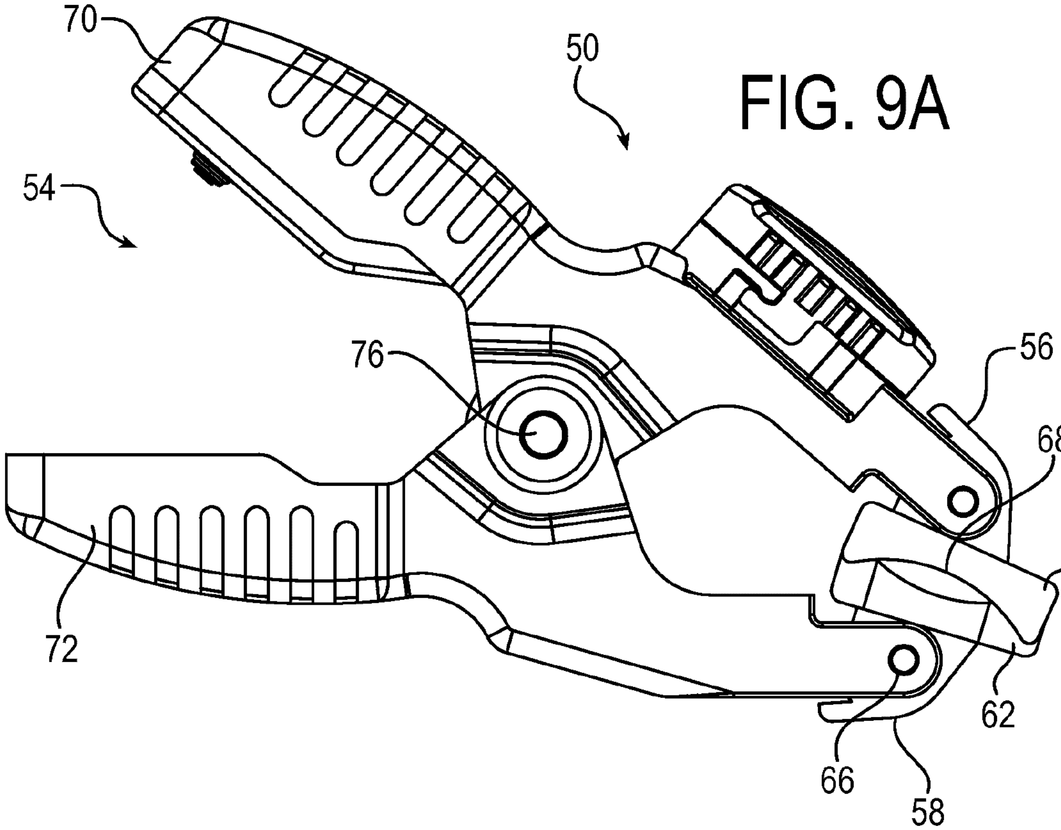

FIG. 9A

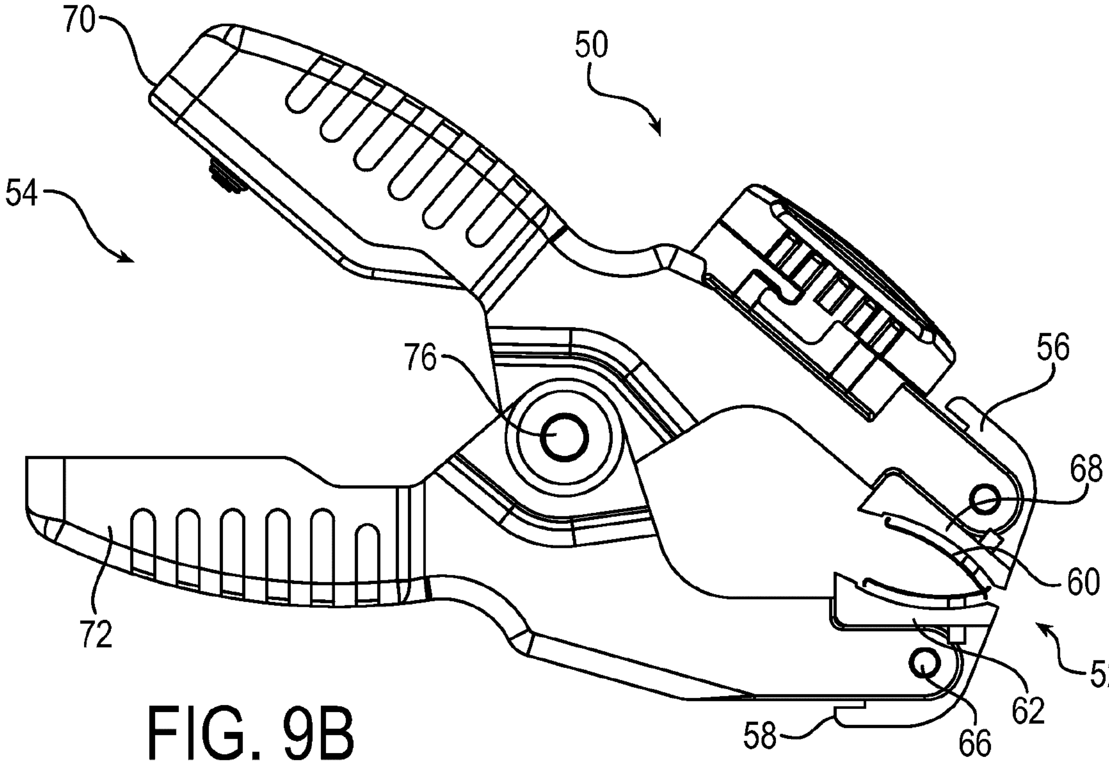

FIG. 9B

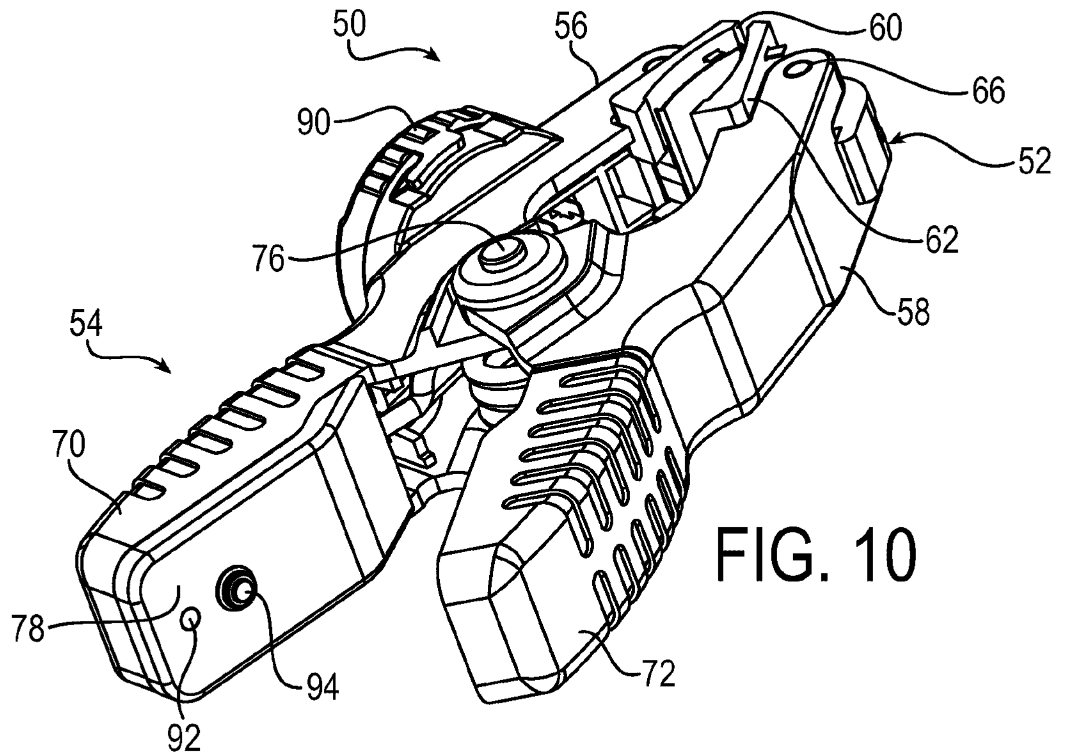
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FIG. 10

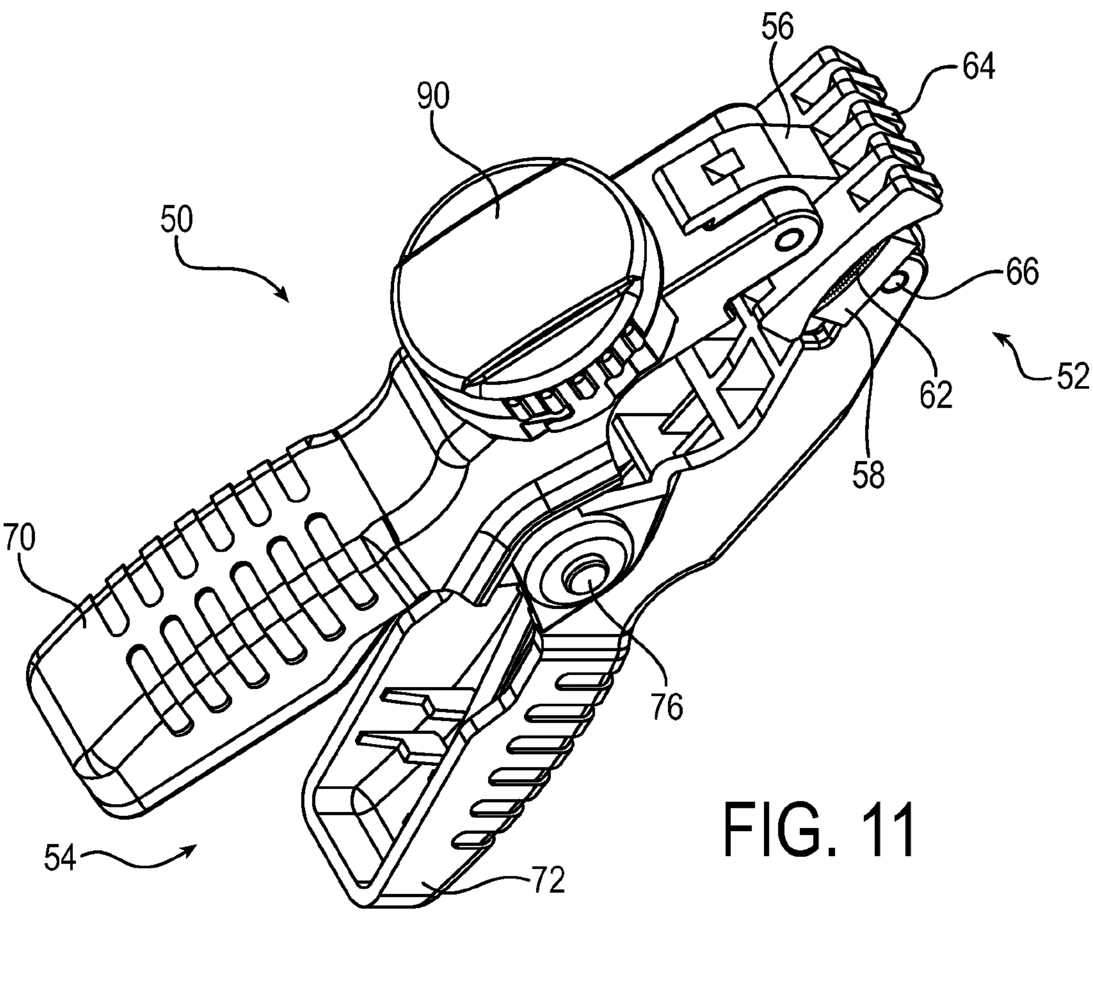
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FIG. 11

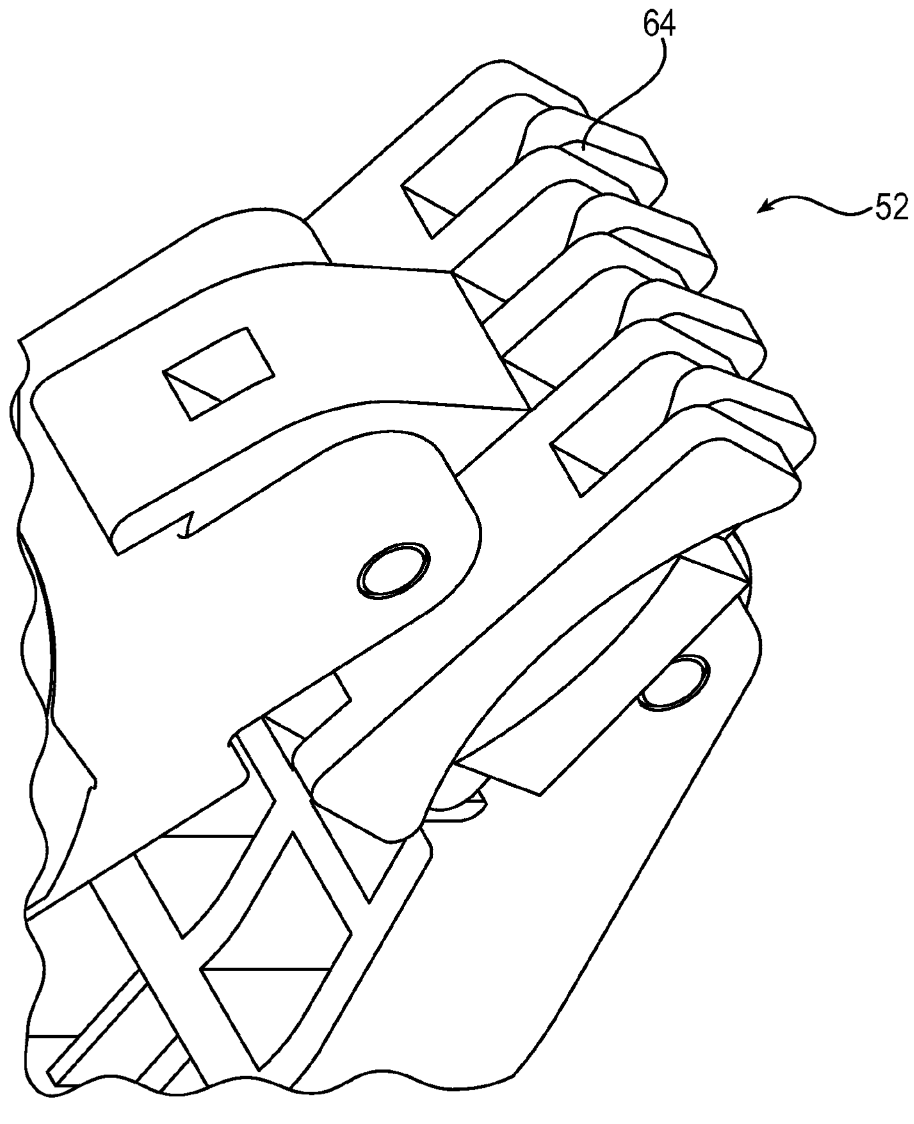


FIG. 12

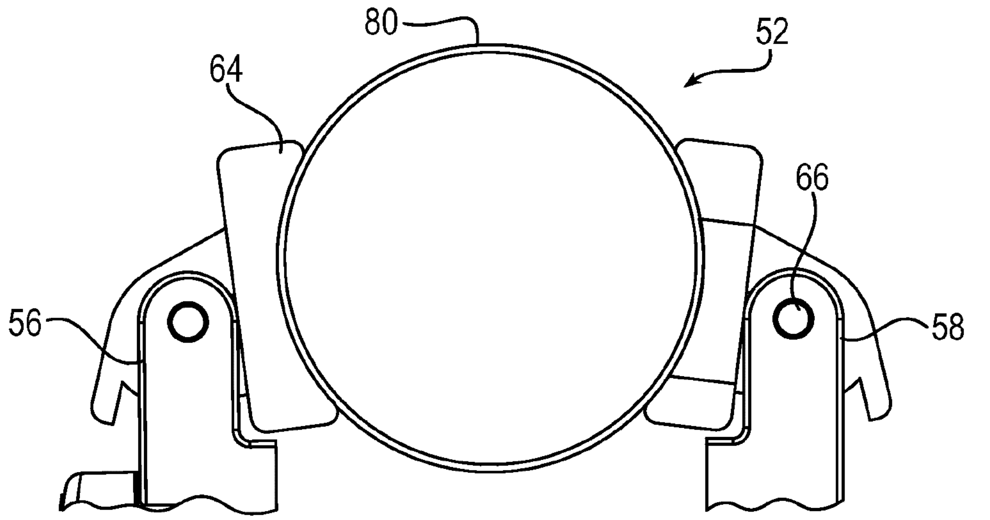


FIG. 13

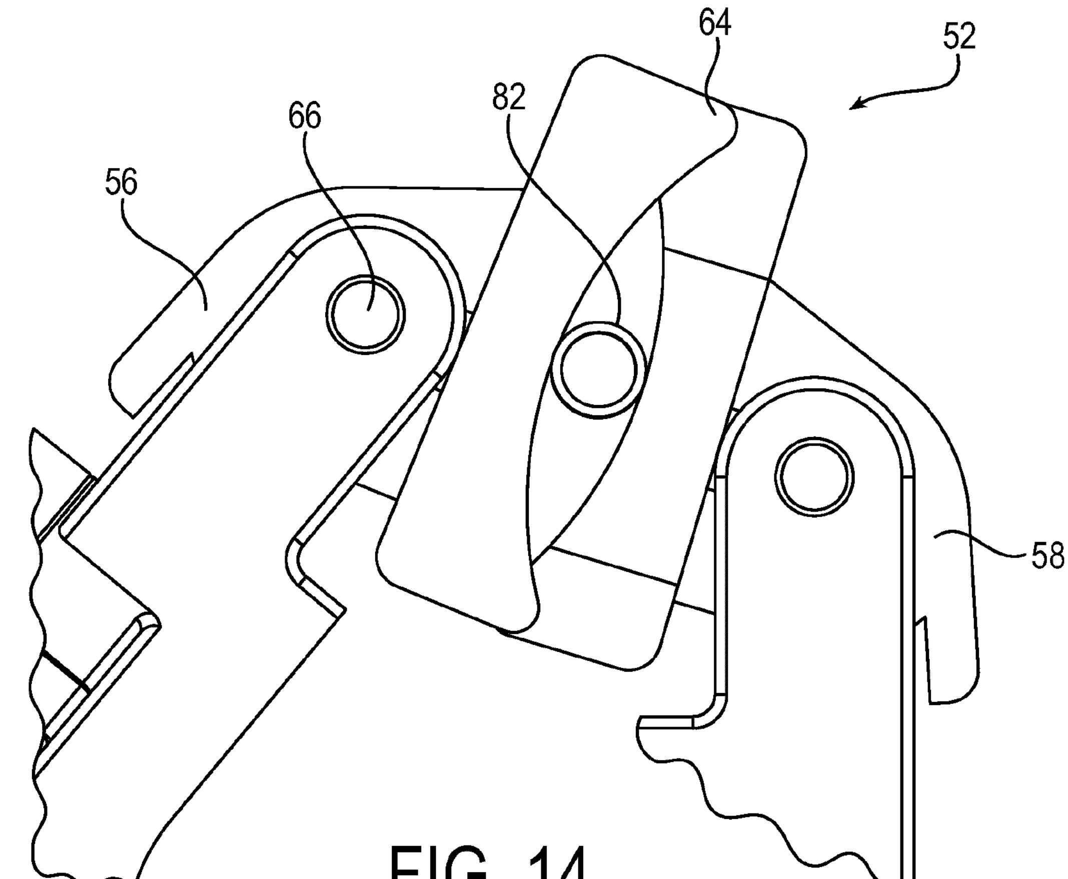


FIG. 14

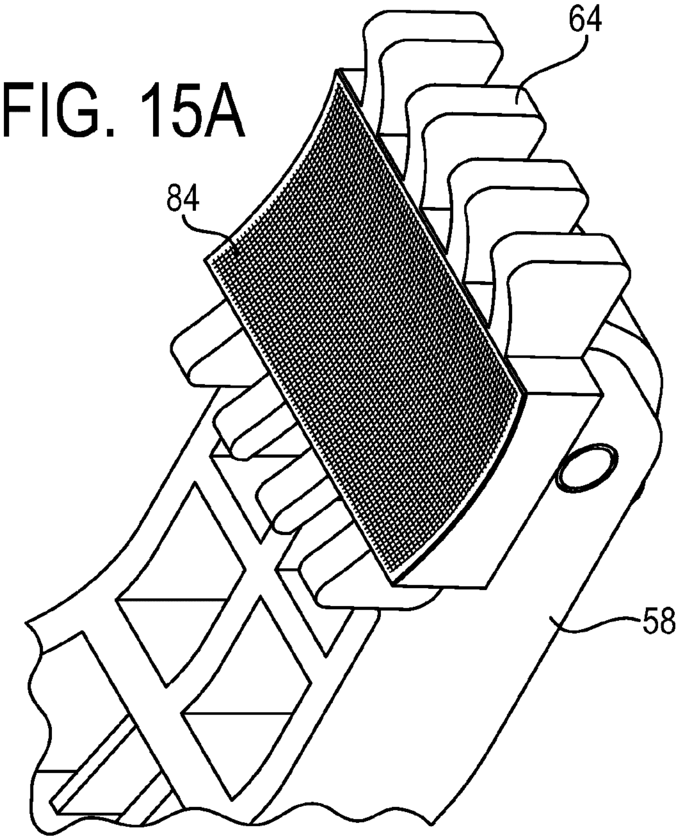


FIG. 15A

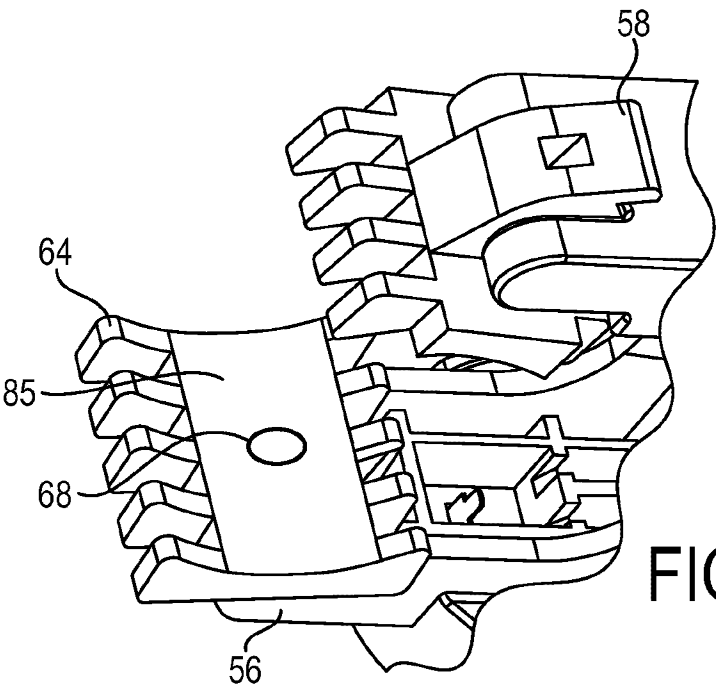
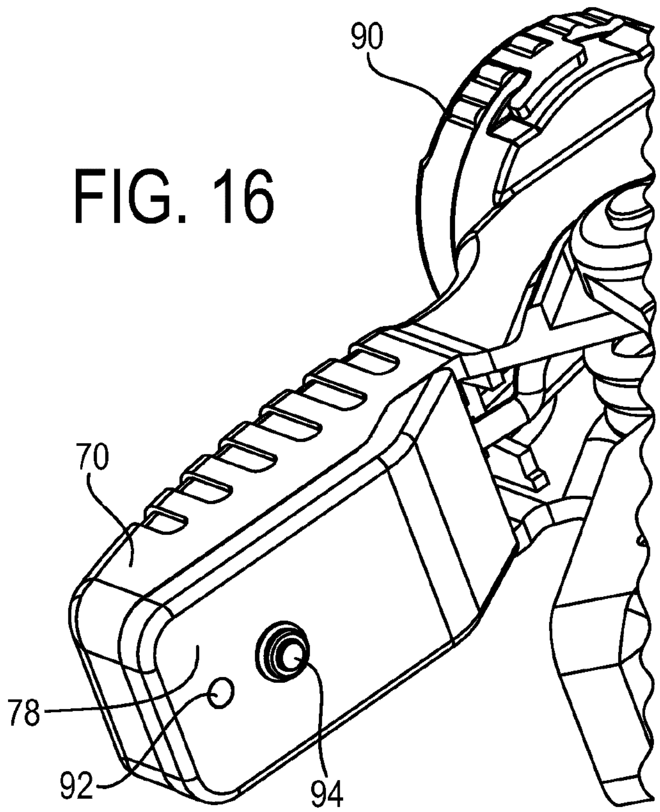


FIG. 15B

FIG. 16



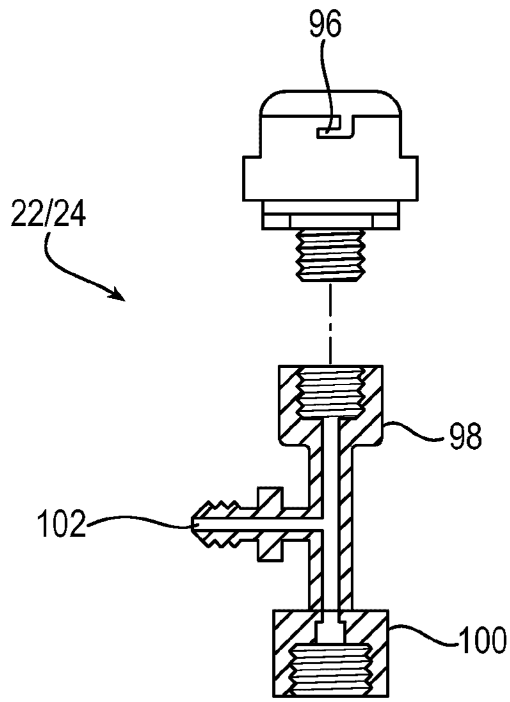
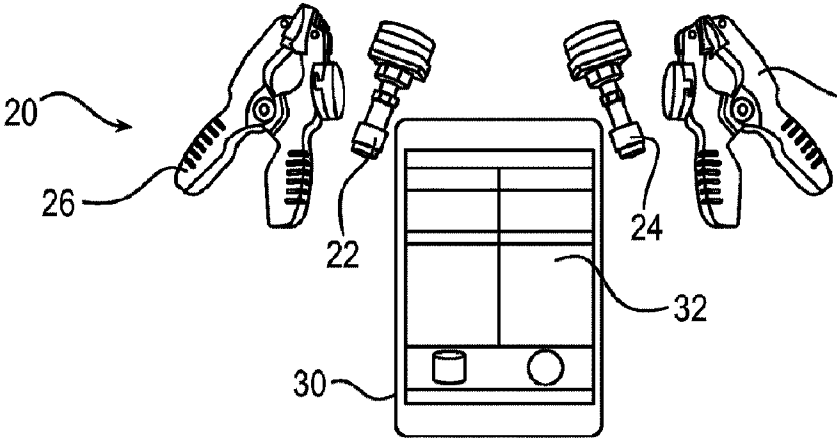


FIG. 17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