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**CANADIAN PATENT APPLICATION**

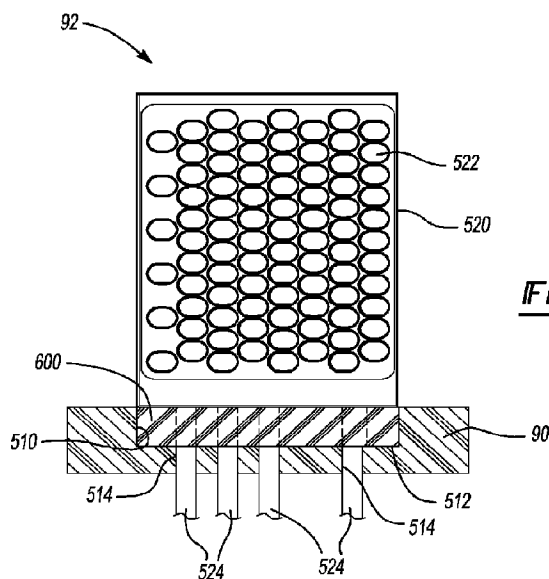
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(54) **Titre : ONDULEUR AYANT UN ELEMENT D'ETANCHEITE ENTRE UN SEMI-CONDUCTEUR DE PUISSANCE ET UN SUPPORT D'ONDULEUR**

(54) **Title: INVERTER HAVING SEAL MEMBER BETWEEN POWER SEMI-CONDUCTOR AND INVERTER MOUNT**



**Fig-7**

(57) **Abrégé/Abstract:**

An electric drive unit having a motor assembly with a stator, a rotor, which is rotatably received in the stator, and an inverter that includes an inverter mount, a plurality of heat-sinked power semiconductors, and a plurality of seal members. The inverter mount has a base that defines a plurality of terminal apertures. Each heat-sinked power semiconductor includes a power semiconductor, which has a body and a plurality of terminals that extend from the body, and a heat sink that is fixedly and thermally coupled to the body of the power semiconductor. The terminals of each of the power semiconductors are received through a corresponding one of the seal members and through a set of the terminal apertures. Each seal member forms a seal between the power semiconductor and the inverter mount that inhibits fluid flow through the terminal apertures.



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**Abstract:**

An electric drive unit having a motor assembly with a stator, a rotor, which is rotatably received in the stator, and an inverter that includes an inverter mount, a plurality of heat-sinked power semiconductors, and a plurality of seal members. The inverter mount has a base that defines a plurality of terminal apertures. Each heat-sinked power semiconductor includes a power semiconductor, which has a body and a plurality of terminals that extend from the body, and a heat sink that is fixedly and thermally coupled to the body of the power semiconductor. The terminals of each of the power semiconductors are received through a corresponding one of the seal members and through a set of the terminal apertures. Each seal member forms a seal between the power semiconductor and the inverter mount that inhibits fluid flow through the terminal apertures.

## INVERTER HAVING SEAL MEMBER BETWEEN POWER SEMI-CONDUCTOR AND INVERTER MOUNT

### CROSS-REFERENCE TO RELATED APPLICATIONS

- 5   **[0001]**        This application claims the benefit of U.S. Provisional Patent Application No. 63/264,201,588 filed November 17, 2021, the disclosure of which is incorporated by reference as if fully set forth in detail herein.

### FIELD

- 10   **[0002]**        The present disclosure relates to an inverter having a seal member between a power semi-conductor and an inverter mount.

### BACKGROUND

- 15   **[0003]**        This section provides background information related to the present disclosure which is not necessarily prior art.

- 20   **[0004]**        International Patent Application PCT/US2020/029925 entitled "Electric Drive Unit" discloses an electric drive unit with an inverter that is mounted to the stator of an electric motor. The inverter includes a plurality of power semiconductor devices, which are employed to switch power to various phases of the windings of the electric motor, a plurality of heat sinks that are each mounted to a corresponding one of the power semiconductor devices, and an inverter mount that is employed to position and retain the power semiconductor devices. A coolant fluid is circulated through the heat sinks and into the stator of the electric motor to cool the inverter and the electric motor.

- 25   **[0005]**        While the above inverter configuration is suited for its intended purpose, it is nevertheless susceptible to improvement.

### SUMMARY

- 30   **[0006]**        This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

- [0007]**        In one form, the present disclosure provides an electric drive unit having a motor assembly with a stator, a rotor, which is rotatably received in the stator, and an inverter. The inverter includes an inverter mount, a plurality of heat-sinked power semiconductors, and a plurality of seal members. The

inverter mount has a base that defines a plurality of semiconductor terminal apertures. Each heat-sinked power semiconductor includes a power semiconductor, which has a body and a plurality of terminals that extend from the body, and a heat sink that is fixedly and thermally coupled to the body of the power semiconductor. The terminals of each of the power semiconductors are received through a corresponding one of the seal members and through a corresponding set of the semiconductor terminal apertures. The seal members form seals between the power semiconductor and the inverter mount that inhibit fluid flow through the semiconductor terminal apertures.

[0008] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

## DRAWINGS

[0009] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0010] Figure 1 is a perspective view of an exemplary electric drive unit constructed in accordance with the teachings of the present disclosure;

[0011] Figure 2 is a longitudinal cross-section view of the electric drive unit of Figure 1;

[0012] Figure 3 is sectional view of a portion of the electric drive unit of Figure 1, the view illustrating an inverter of a motor assembly in greater detail;

[0013] Figure 4 is a perspective view of a portion of the inverter;

[0014] Figure 5 is a perspective view of a portion of the inverter, the view illustrating an inverter mount in more detail;

[0015] Figure 6 is a perspective view of a portion of the inverter, the view illustrating a heat-sinked power semiconductor in more detail;

[0016] Figure 7 is a sectional view of a portion of the inverter, the view illustrating a seal member disposed between the inverter mount and a body of a power semiconductor of the heat-sinked power semiconductor;

**[0017]** Figure 8 is a sectional view of a portion of an inverter of another electric drive unit constructed in accordance with the teachings of the present disclosure; and

**[0018]** Figure 9 is a sectional view of a portion of the inverter of Figure 8 illustrating the seal member in an alternate location.

**[0019]** Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

#### DETAILED DESCRIPTION

**[0020]** In Figures 1 and 2, an exemplary electric drive unit constructed in accordance with the teachings of the present disclosure is generally indicated by reference numeral 10. Components, aspects, features and functions of the electric drive unit 10 that are not expressly described herein or shown (partly or fully) in the accompanying drawings, could be configured or function in a manner that is similar to the components, aspects, features and/or functions of electric drive units that is described in co-pending U.S. Provisional Patent Application No. 63/161164 filed March 15, 2021, the disclosure of which is incorporated by reference as if fully set forth in detail herein. In brief, the electric drive unit 10 includes a housing assembly 12, a motor assembly 14, a transmission 16, a differential assembly 18, a pair of output shafts 20, which are rotatable about an output axis 22, and a lubrication and cooling system 24. Rotary power provided by the motor assembly 14 is transmitted through the transmission 16 to the differential assembly 18 to drive the output shafts 20. The lubrication and cooling system 24 is configured to circulate a fluid through the housing assembly 12, the motor assembly 14, the transmission 16 and the differential assembly 18 to cool and/or lubricate various components of the motor assembly 14, the transmission 16 and the differential assembly 18.

**[0021]** With specific reference to Figure 2, the motor assembly 14 comprises an electric motor 40, and a motor control unit that includes an inverter 44. The electric motor 40 includes a stator 46 and a rotor 48 that is rotatable about a motor output axis 50. The rotor 48 includes a motor output shaft 52.

**[0022]** In Figures 3 and 4, the inverter 44 is shown to include an inverter mount 90, a plurality of heat-sinked power semiconductors 92, a plurality of

busbars 94 and an inverter circuit board 96. The inverter mount 90 is employed to couple the inverter 44 to the housing assembly 12 and to the stator 46 of the motor 40. The busbars 94, which are schematically shown, include a positive busbar, which is electrically coupled to a source of electrical power, ground  
5 busbar, which is coupled to an electric ground, and a plurality of phase busbars. The inverter 44 is configured to control the amplitude and frequency of the power supplied to the electric motor 40. More specifically, the inverter 44 employs the heat-sinked power semiconductors 92 to control the switching of DC electricity to create three AC electric outputs, where each AC electric output  
10 is associated with a given phase of the windings 100 of the stator 46. Each phase of the windings 100 is fixedly and electrically coupled an associated one of the (phase) busbars 94 in the inverter 44 and as such, each of the three AC electrical outputs is transmitted through an associated one of the phase busbars.

15 **[0023]** With reference to Figures 3 and 5, the inverter mount 90 is illustrated in more detail. The inverter mount 90 can include a base 500, a plurality of terminal receptacles 502, a first side wall 506 and a second side wall 508. The base 500 can have a generally annular configuration. A first axial side or face of the base 500 can have a central portion that is somewhat thicker  
20 than an outer portion that is disposed radially outwardly of the central portion. A second, opposite side or face of the base 500 can be flat. The base 500 can define a plurality of semiconductor mounts 510 that can be formed into the central portion on the first face of the base 500. Each of the semiconductor mounts 510 can define a semiconductor recess 512 and a plurality of  
25 semiconductor terminal apertures 514. The semiconductor mounts 510 can be disposed in any desired arrangement, but in the particular example provided, the semiconductor mounts 510 are disposed in a ring-shaped arrangement. The semiconductor terminal apertures 514 are disposed in each the semiconductor recess 512 and are formed through the base 500. Each of the  
30 terminal receptacles 502 can have a first portion, which is located on the portion of the base 500 that is disposed radially outwardly of the central portion and which extend axially away from the first face of the base 500, and a second portion that extends axially away from the second face of the base 500. In the example shown, each of the terminal receptacles 502 is a generally tubular

structure that is disposed through the outer portion of the base 500. The terminal receptacles 502 can be spaced circumferentially apart from one another. Each of the sensor receptacles 504 can extend from the second face of the base 500 and can intersect an associated one of the terminal receptacles 502. The first and second sidewalls 506 and 508 can be fixedly coupled to the base 500 and can encircle the outer perimeter and the inner perimeter, respectively, of the base 500. The first side wall 506 can extend from the first face of the base 500 by a relatively large distance and from the second face of the base 500 by a relatively short distance. The second side wall 508 can extend from the second face of the base 500 by a relatively large distance and from the first face of the base by a relatively small distance. A seal groove 516 is formed about the first side wall 506 and is configured to receive a seal 518 therein that sealingly engages the first side wall 506 and the housing assembly 12.

**[0024]** In Figures 4 and 6, each of the heat-sinked power semiconductors 92 includes a power semiconductor 520 and a heat sink 522. The power semiconductor 520 can be any appropriate device, such as a MOSFET or an IGBT, and can include a plurality of pins or terminals 524. The heat sink 520 can be formed of a suitable thermally conductive material and can be electrically coupled to an associated one of the terminals 524. As a non-limiting example, the heat sink 522 could be formed of a metal material, such as aluminum, brass, bronze or copper. The heat sink 522 can define a plurality of fins 526 that can be employed to discharge heat into a flow of fluid passing through the fins 526. The fins 526 are depicted as rods that project orthogonally from a base of the heat sink 522. The distal ends of the fins 526 are tapered so that the fins 526 of one heat-sinked power semiconductor 92 do not touch an adjacent heat-sinked power semiconductor, but it will be appreciated that the configuration of the fins 526 could be different from that which is depicted in the drawings to balance considerations for heat transfer and flow restriction to desired degrees.

**[0025]** With reference to Figures 3 through 5 and 7, each of the heat-sinked semiconductor assemblies 92 can be mounted in a respective one of the semiconductor mounts 510 on the inverter mount 90 such that each of the heat-sinked power semiconductors 92 is received into a corresponding one of

the semiconductor recesses 512 and the terminals 524 on each of the heat-sinked power semiconductors 92 are received through the semiconductor terminal apertures 514. A seal member 600 can be disposed between a body 520a (Fig. 6) of the power semiconductor 520 and the inverter mount 90. The seal member 600 is configured to form a seal between the power semiconductor 520 and the inverter mount 90. In the example provided, individual seal members 600 are disposed in each of the semiconductor recesses 512 and sealingly engage the terminals 524 of the power semiconductor 520 and the inverter mount 90 to inhibit the flow of fluid through the semiconductor terminal apertures 514. The seal member 600 could have pre-formed holes therethrough that are configured to receive corresponding terminals 524 of the power semiconductor 520. Alternatively, the terminals 524 of a power semiconductor 520 could pierce the seal member 600 when the heat-sinked power semiconductor 92 is assembled to the inverter mount 90. While the seal members 600 have been illustrated and described herein as each being a discrete component that is assembled to the inverter mount 90, it will be appreciated that the seal members 600 could be unitarily and integrally formed (e.g., in an annular ring), and that the seal members 600 could optionally be overmolded onto the inverter mount 90.

**[0026]** With reference to Figure 3, a coolant fluid enters the inverter 44 through a gallery 610 in the housing assembly 12 and is directed through the fins 526 (Fig. 6) in the heat-sinked power semiconductors 92 before the coolant is routed into the stator 46 of the motor 40. The seal member 600 inhibits the flow of coolant through the base 500 of the inverter mount 90 so that the coolant does not come into contact with the inverter circuit board 96 or the bus bars 94.

**[0027]** While the seal members 600 have been illustrated and described as abutting both the base 500 of the inverter mount 90 and the body 520a (Fig. 6) of the power semiconductor 520, it will be appreciated that the seal members 600 could be configured somewhat differently. For example, the seal members 600 need not abut or engage the bodies 520a (Fig. 6) of the power semiconductors 520, but rather could be configured to sealingly engage the inverter mount 90 and the terminals 524 to inhibit the flow of fluid through the terminal apertures 514. The example of Figures 8 and 9 is similar to the example that is discussed in detail, above, except that the seal members 600'

are disposed on a side of the base 500' of the inverter mount 90' that is opposite the body of the power semiconductor 520. In this example, each seal member 600' is sealingly engaged to the base 500' of the inverter mount 90' and to the terminals 524 of a corresponding one of the power semiconductors 520. Like  
5 the above-described example, the seal members 600' can be discrete components, or could be unitarily and integrally formed (e.g., as an annular ring), and/or could be molded onto the inverter mount 90'. Advantageously, the seal members 600' in this example help to retain the heat-sinked power semiconductors 92 to the base 500' of the inverter mount 90' prior to the  
10 assembly of the bus bars 94 to the terminals 524 of the power semiconductors 520.

**[0028]** The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular  
15 embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the  
20 scope of the disclosure.

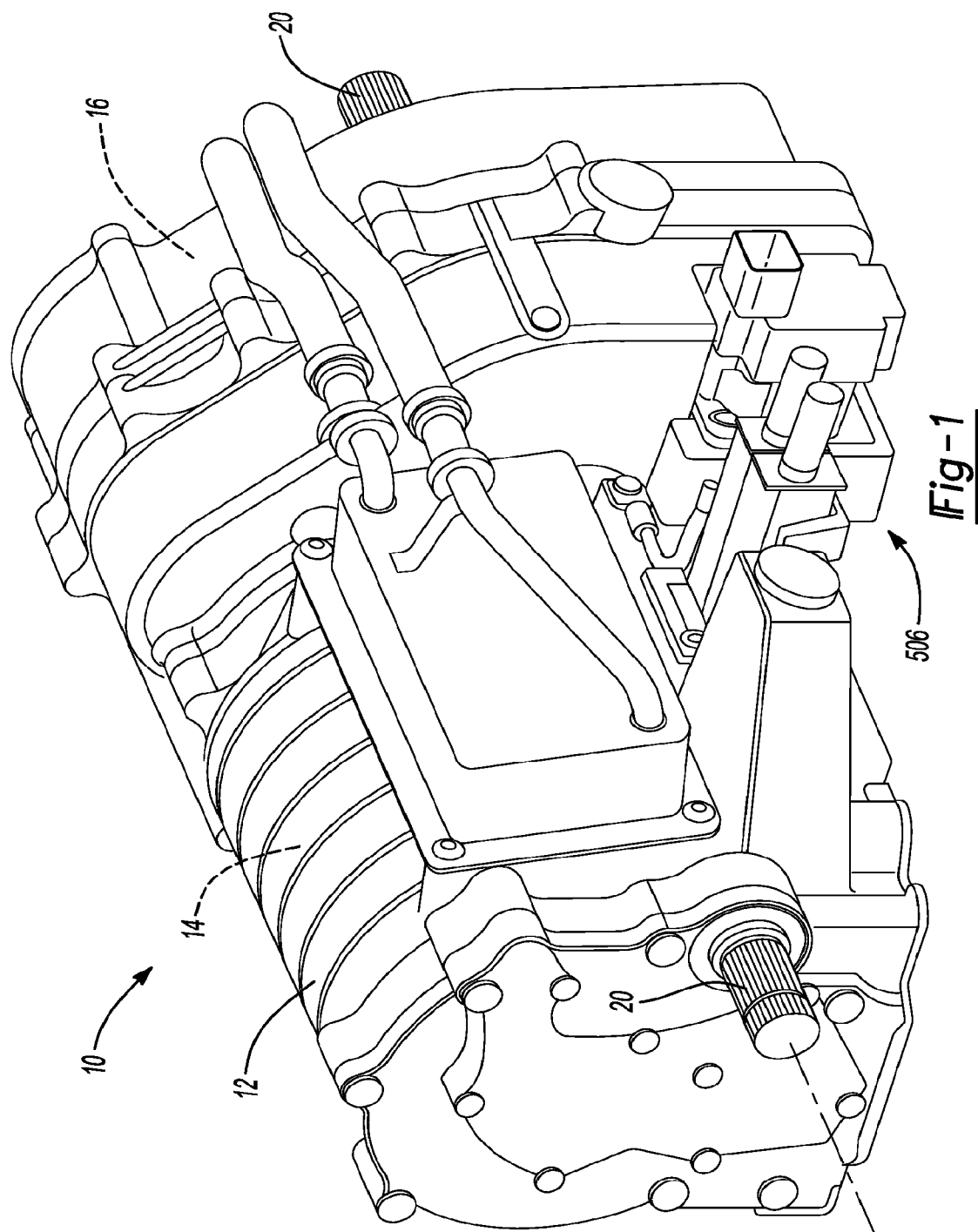
## CLAIMS

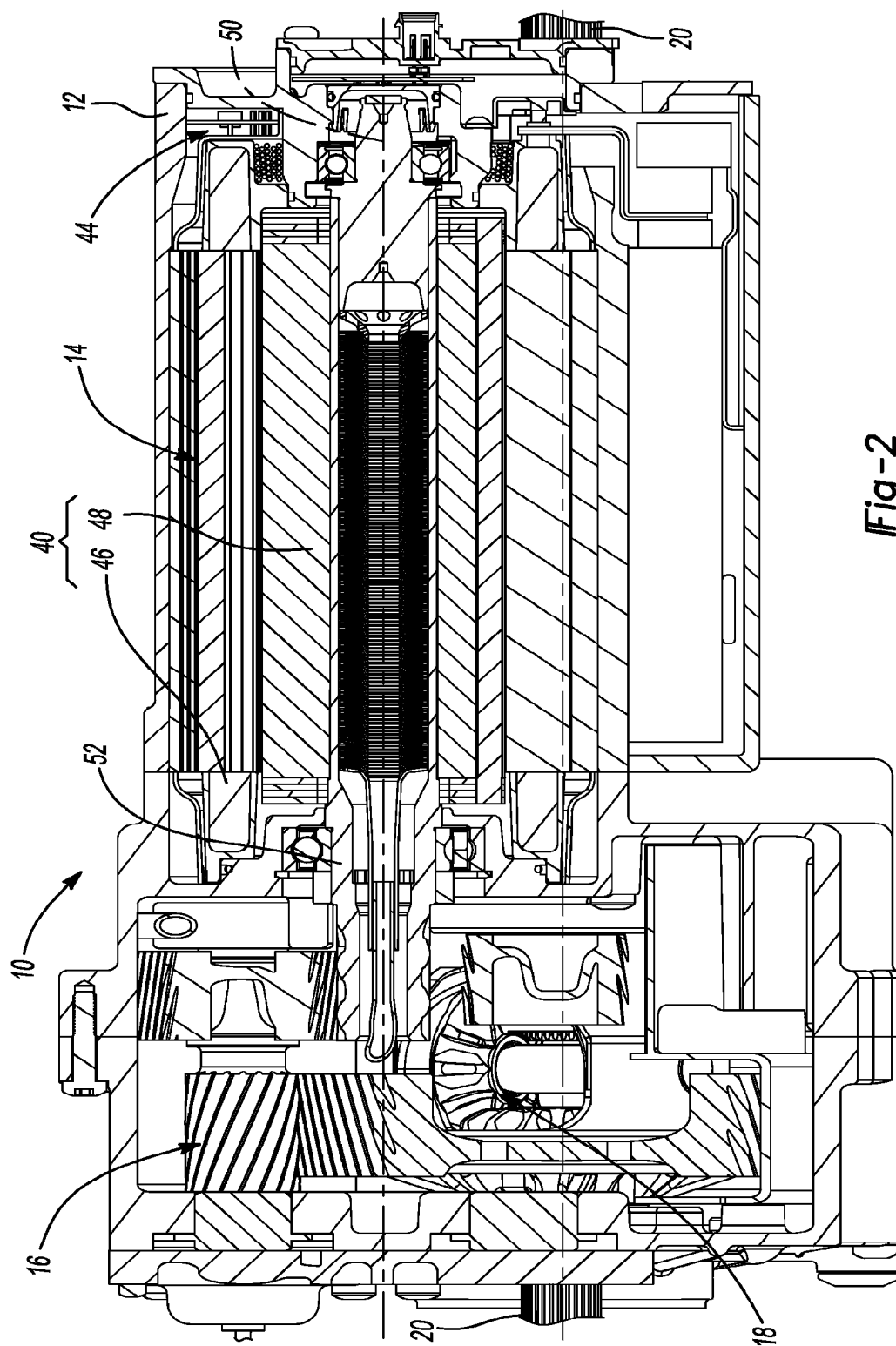
What is claimed is:

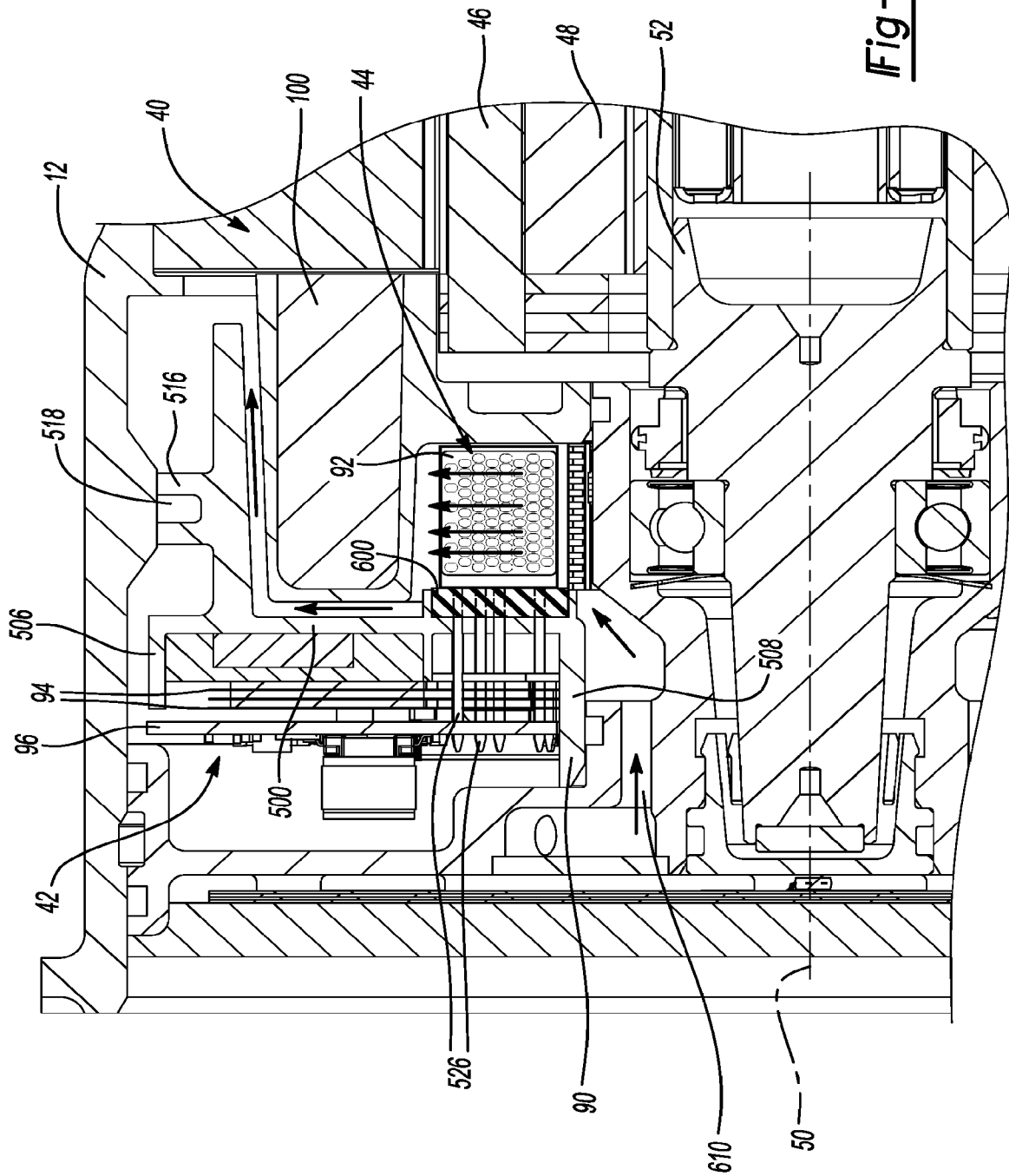
1. An electric drive unit comprising:  
a motor assembly having a stator, a rotor and an inverter, the stator  
5 having a plurality of windings, the rotor being rotatably disposed within the  
stator, the inverter having an inverter mount, a plurality of heat-sinked power  
semiconductors, and a plurality of seal members, the inverter mount having a  
base that defines a plurality of semiconductor terminal apertures, each of the  
heat-sinked power semiconductors having a power semiconductor and a heat  
10 sink, the power semiconductor having a body and a plurality of terminals that  
extend from the body, the heat sink being fixedly and thermally coupled to the  
body of the power semiconductor, wherein the terminals of each of the power  
semiconductors are received through a corresponding one of the seal members  
and through an associated set of the semiconductor terminal apertures, the seal  
15 members forming seals between the power semiconductor and the inverter  
mount that inhibits fluid flow through the semiconductor terminal apertures.
2. The electric drive unit of Claim 1, wherein each of the seal  
members is a discrete component.  
20
3. The electric drive unit of Claim 1, wherein a plurality of the seal  
members are fixedly coupled to one another.
4. The electric drive unit of Claim 3, wherein all of the seal members  
25 are fixedly coupled to one another.
5. The electric drive unit of Claim 1, wherein the seal members are  
overmolded onto the inverter mount.
- 30 6. The electric drive unit of Claim 1, wherein each of the seal  
members is disposed between the inverter mount and the body of an  
associated one of the power semiconductors.

7. The electric drive unit of Claim 6, wherein the inverter mount defines a plurality of semiconductor recesses, wherein each set of terminal apertures intersects an associated one of the semiconductor recesses, and wherein each seal member is received in a corresponding one of the  
5 semiconductor recesses.

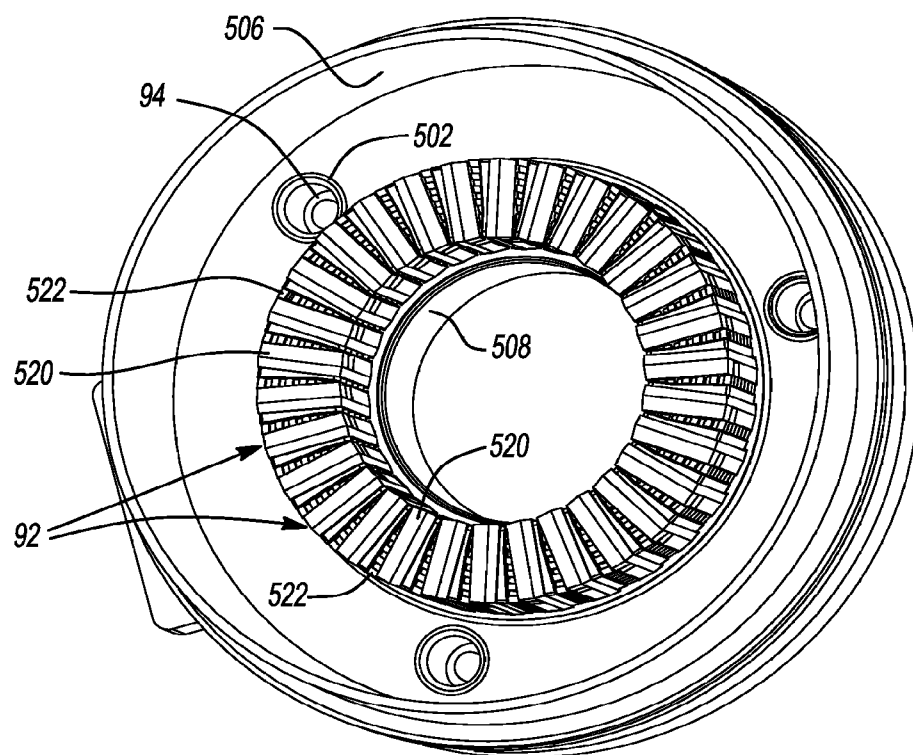
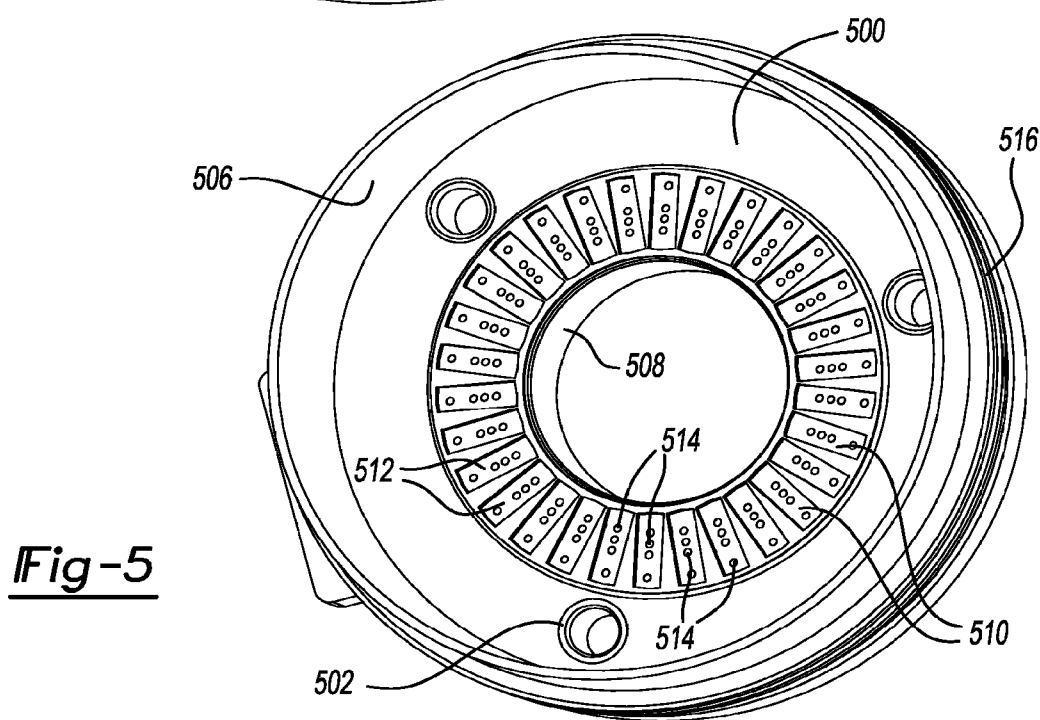
8. The electric drive unit of Claim 1, wherein each of the seal members is disposed on side of the inverter mount that is opposite the bodies of the power semiconductors.  
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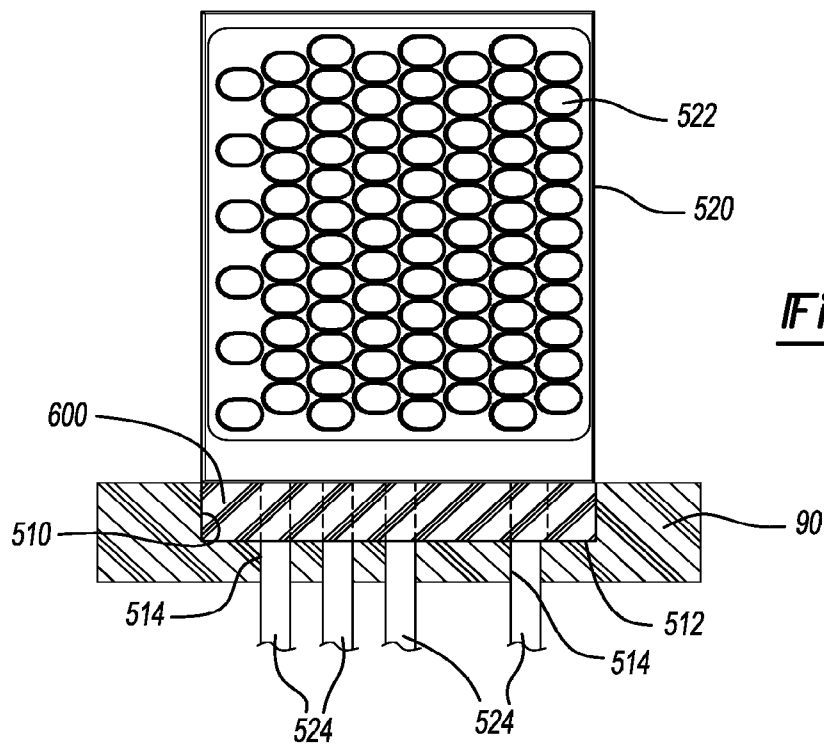
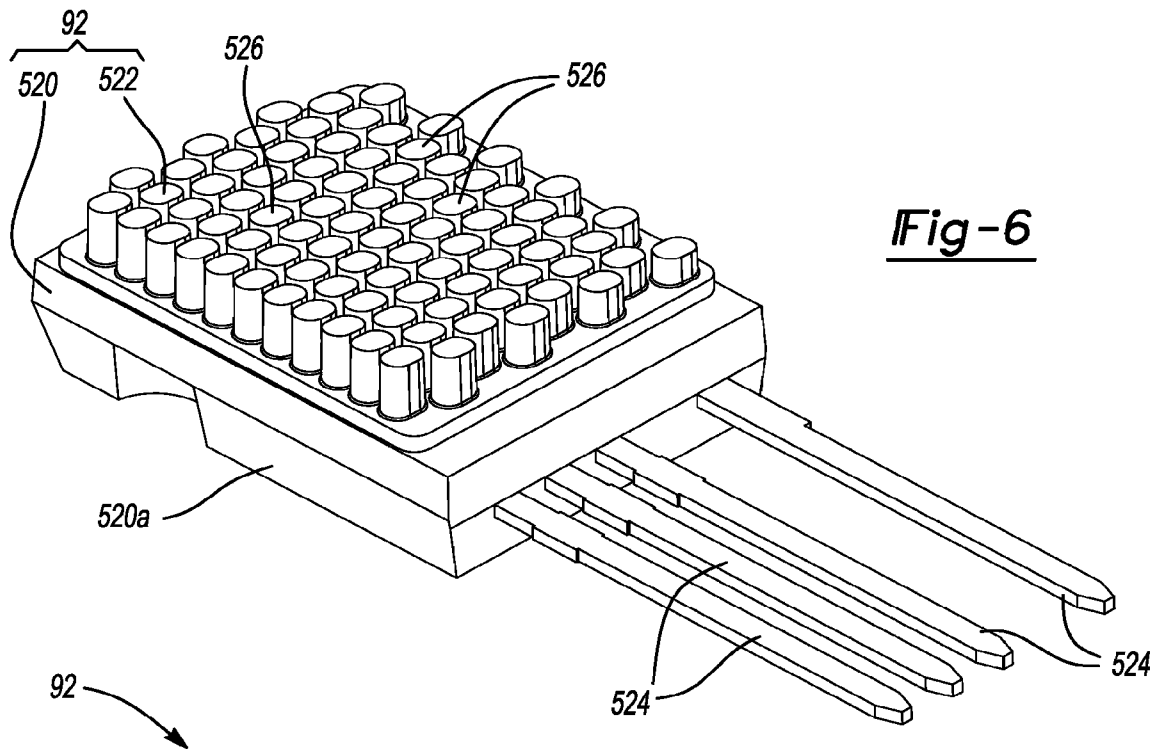
**Fig-2**

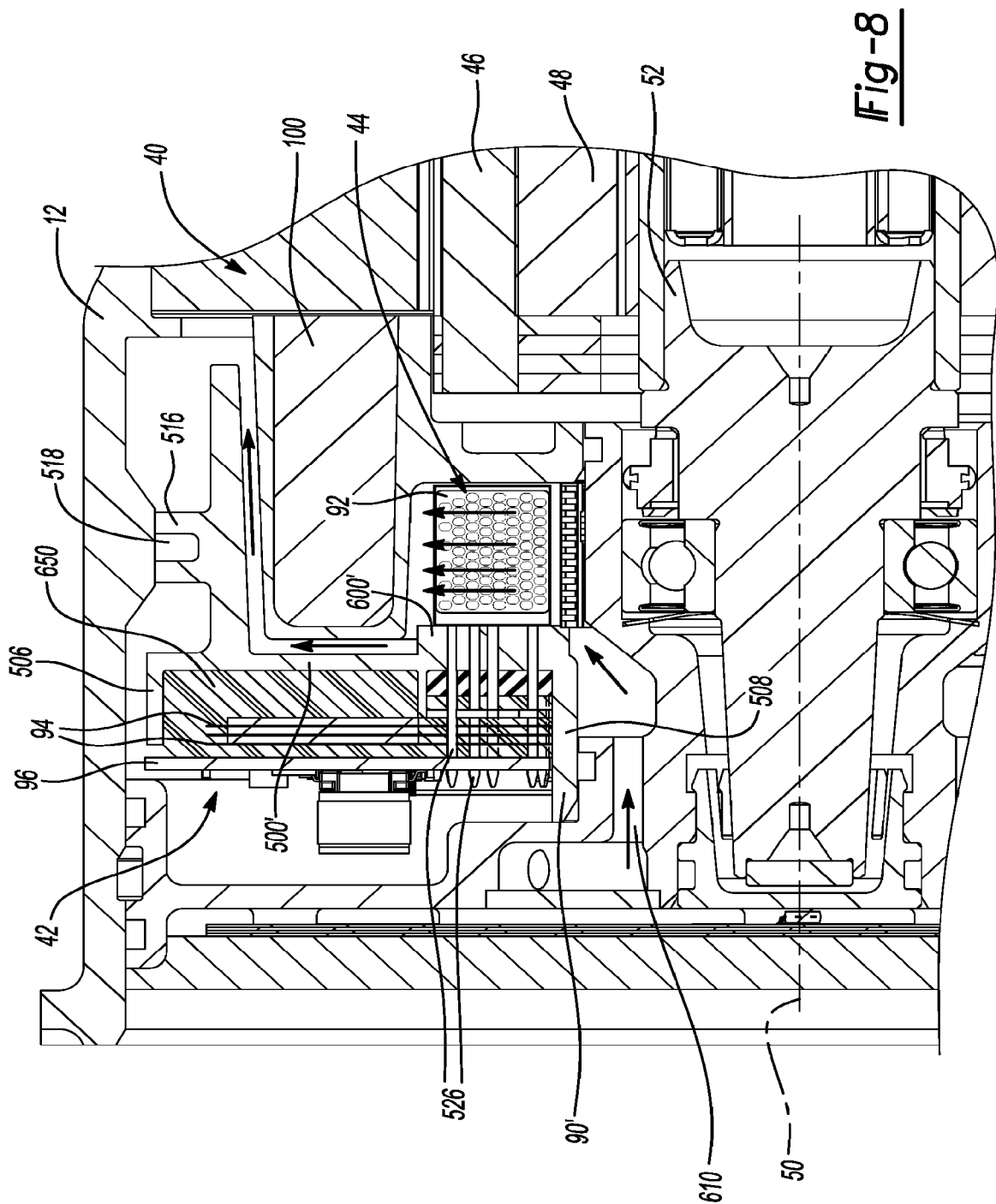


**Fig -3**

Fig-4Fig-5

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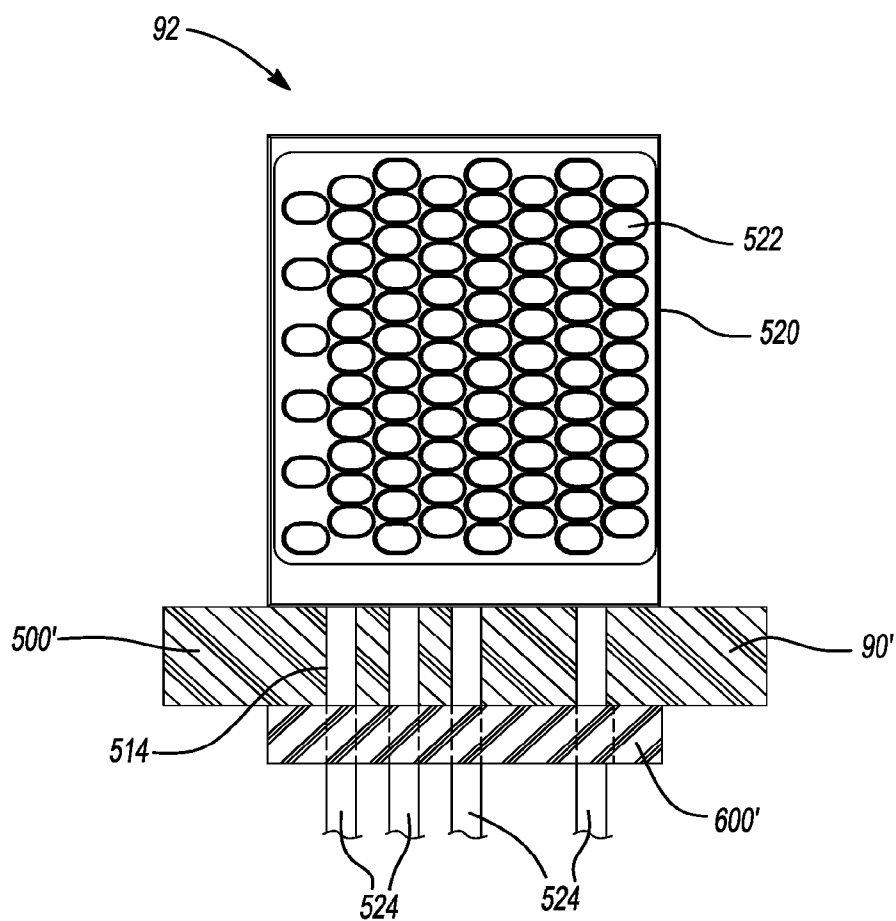


Fig-9

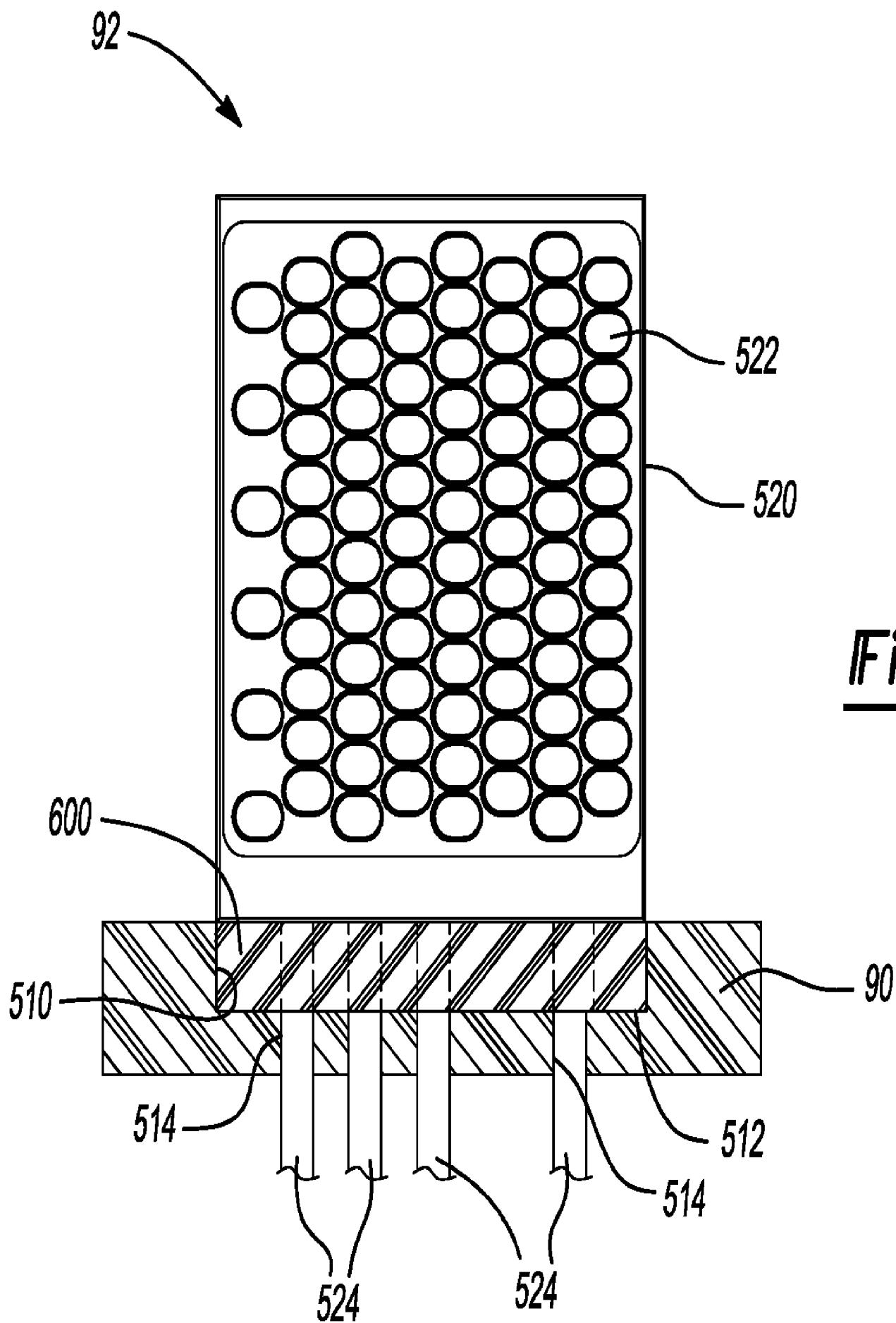


Fig-7