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(54) QUICK TEMPERATURE RISE AIR INTAKE HEATER

(76) Inventors: **Alan P. Gill**, Batavia, IL (US); **Jan P. Thimmesch**, Eden Prairie, MN (US); **Chadwick P. Anderson**, New Prague, MN (US); **Scott A. Betcher**, Burnsville, MN (US)

Correspondence Address:
HARNESS, DICKEY & PIERCE, P.L.C.
P.O. BOX 828
BLOOMFIELD HILLS, MI 48303 (US)

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(57) ABSTRACT

A quick temperature rise air intake heater is operable to rapidly transfer heat to air as it moves across a heating element and enters the combustion chambers of an internal combustion engine. The air heater may be energized simultaneously when the engine is cranked to provide a solution to starting internal combustion engines exposed to relatively low ambient temperatures.

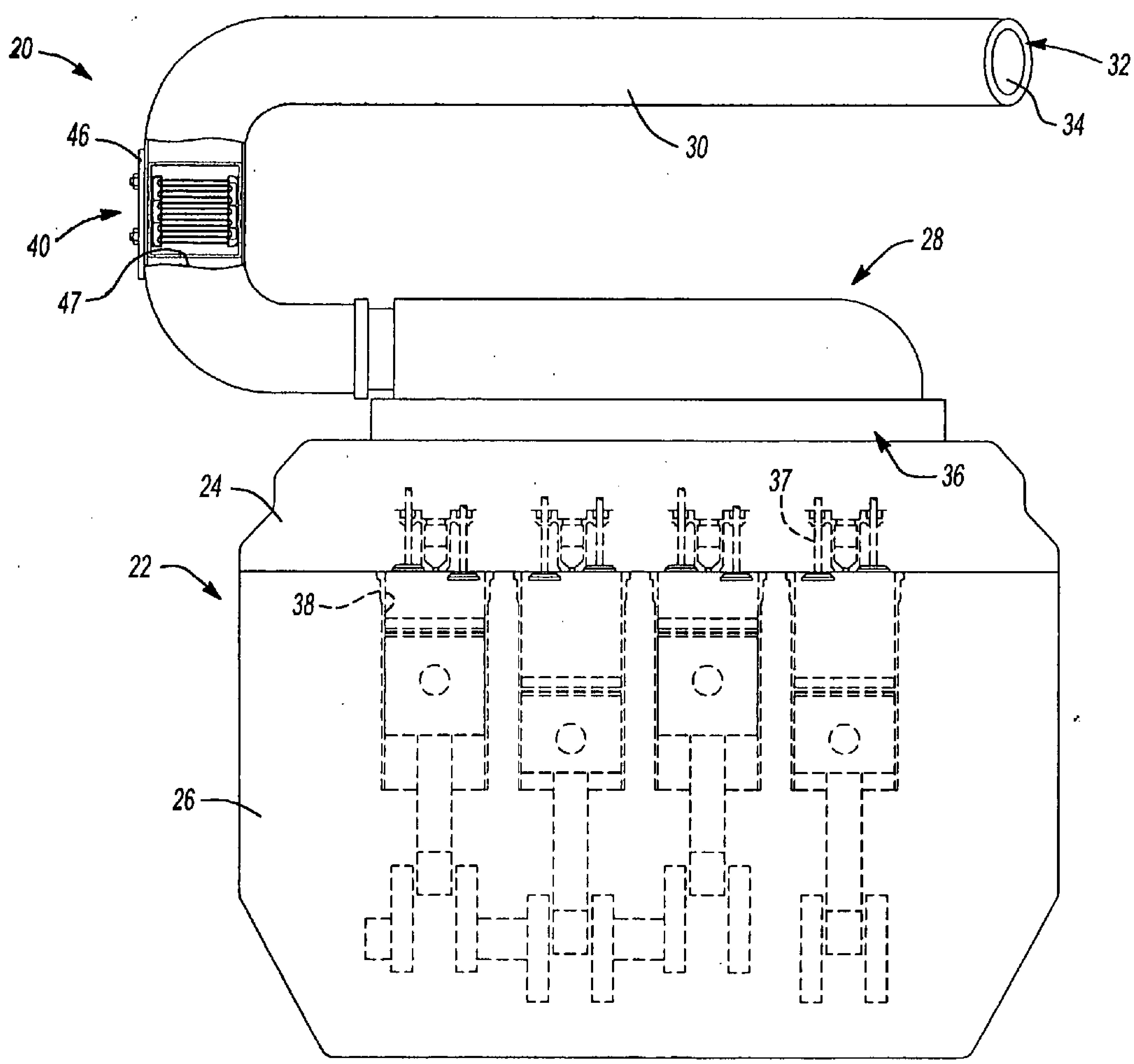
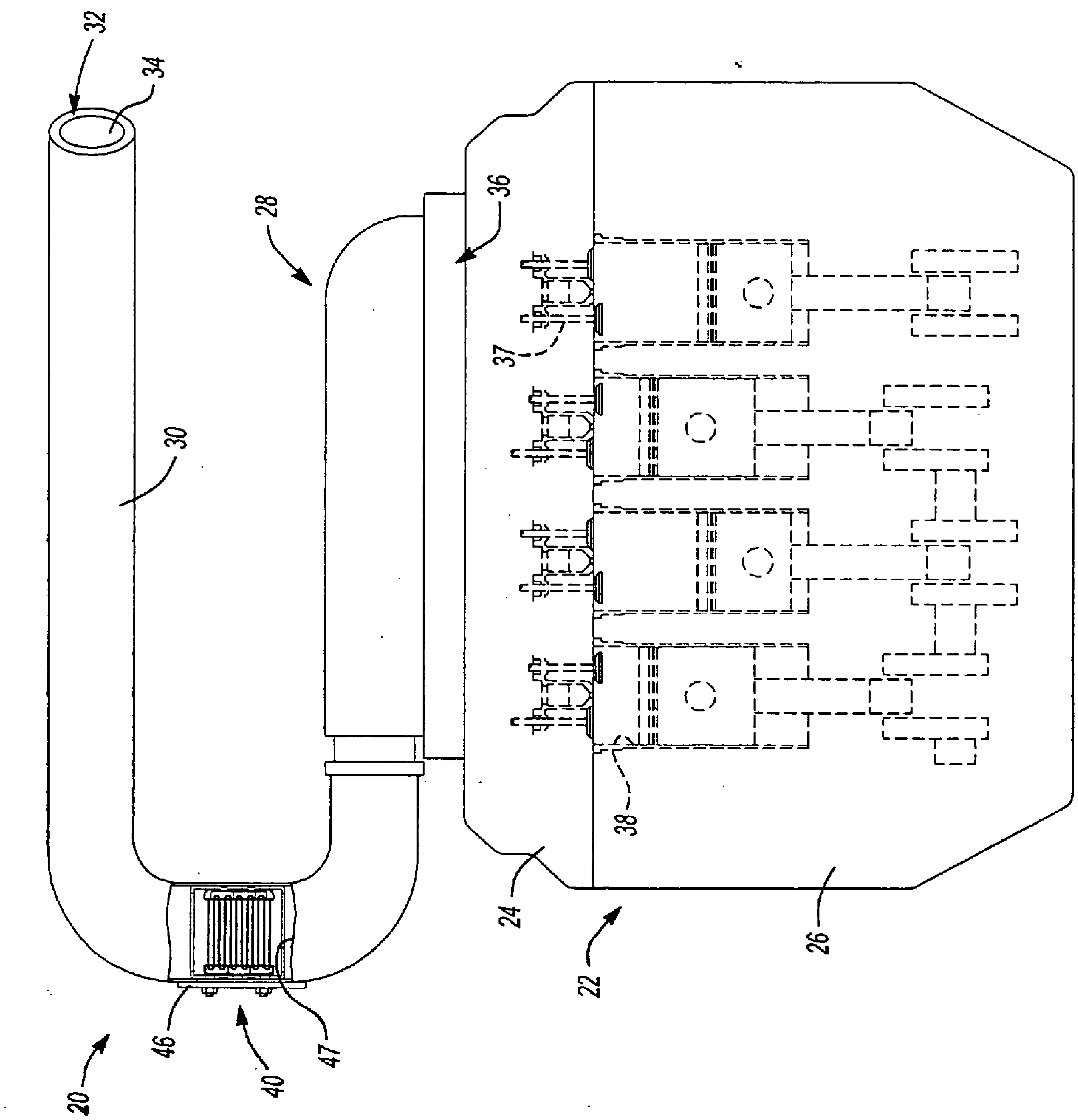


Fig-1



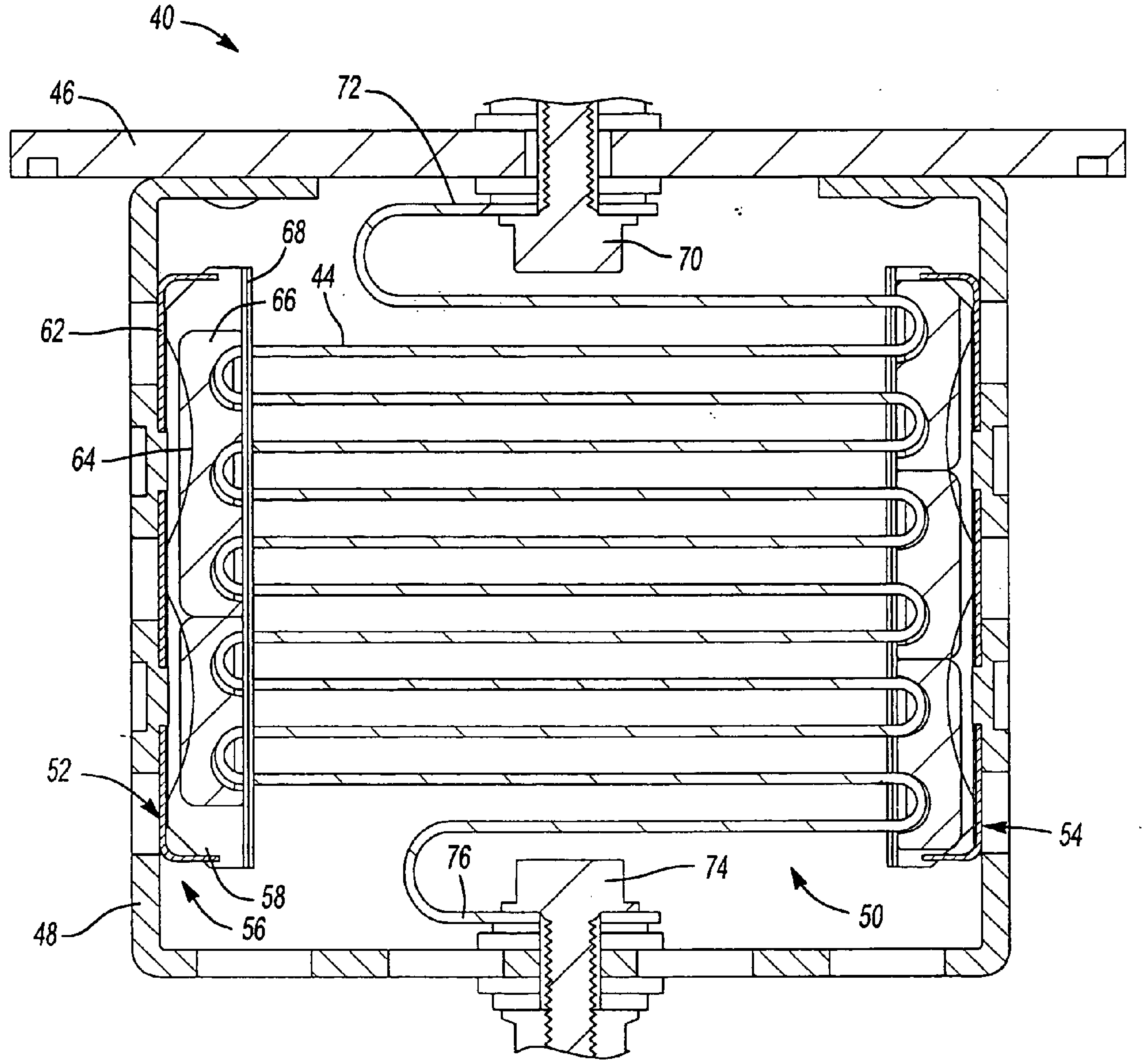


Fig-2

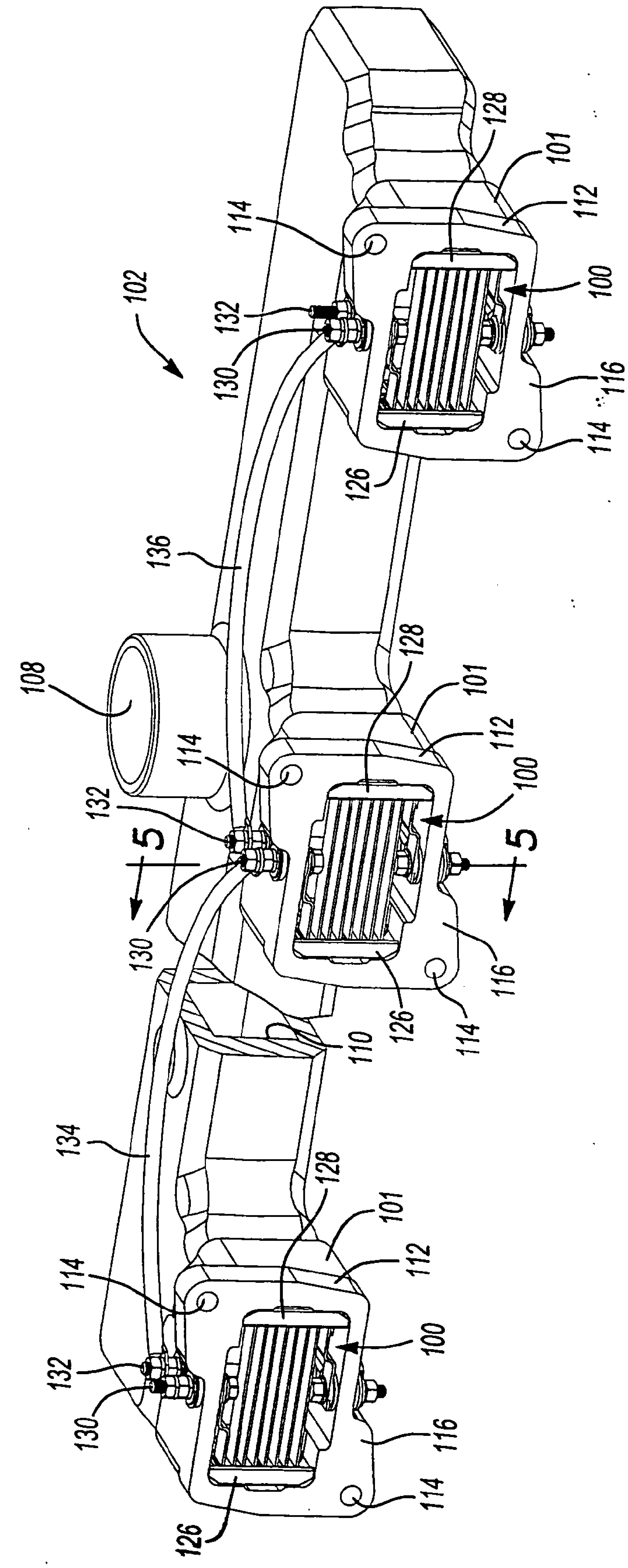


Fig-3

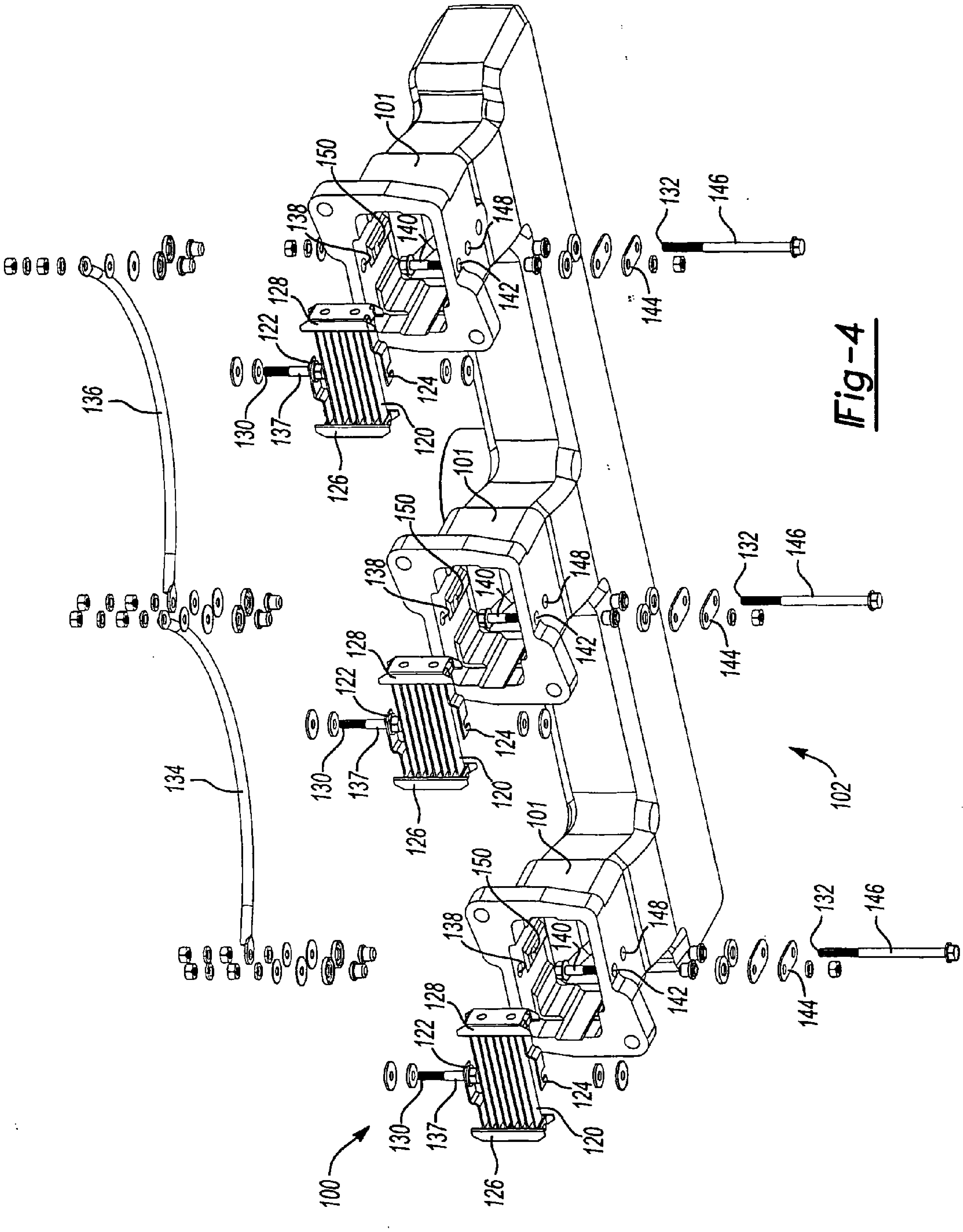

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Fig-4

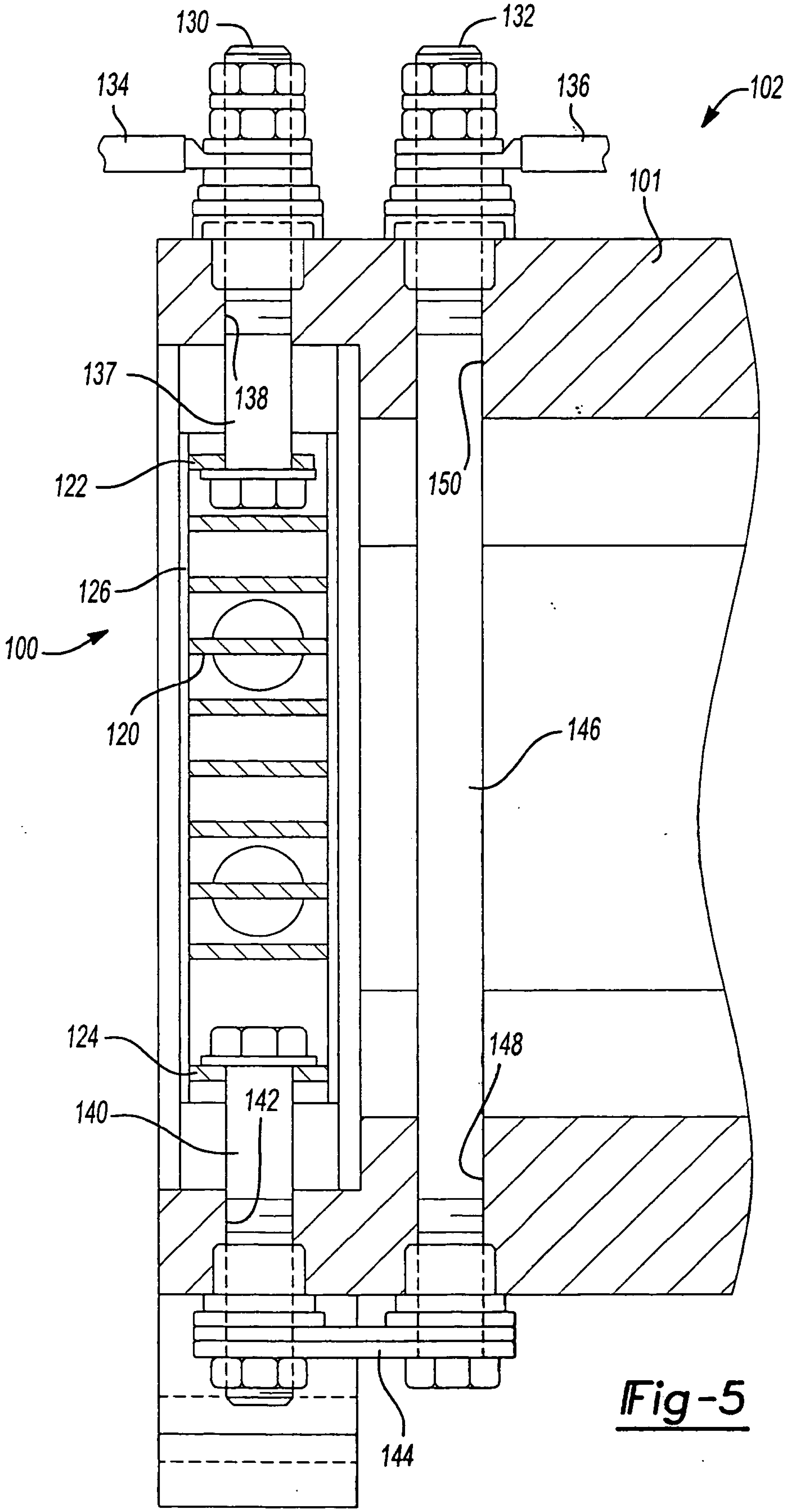
130
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Fig-5

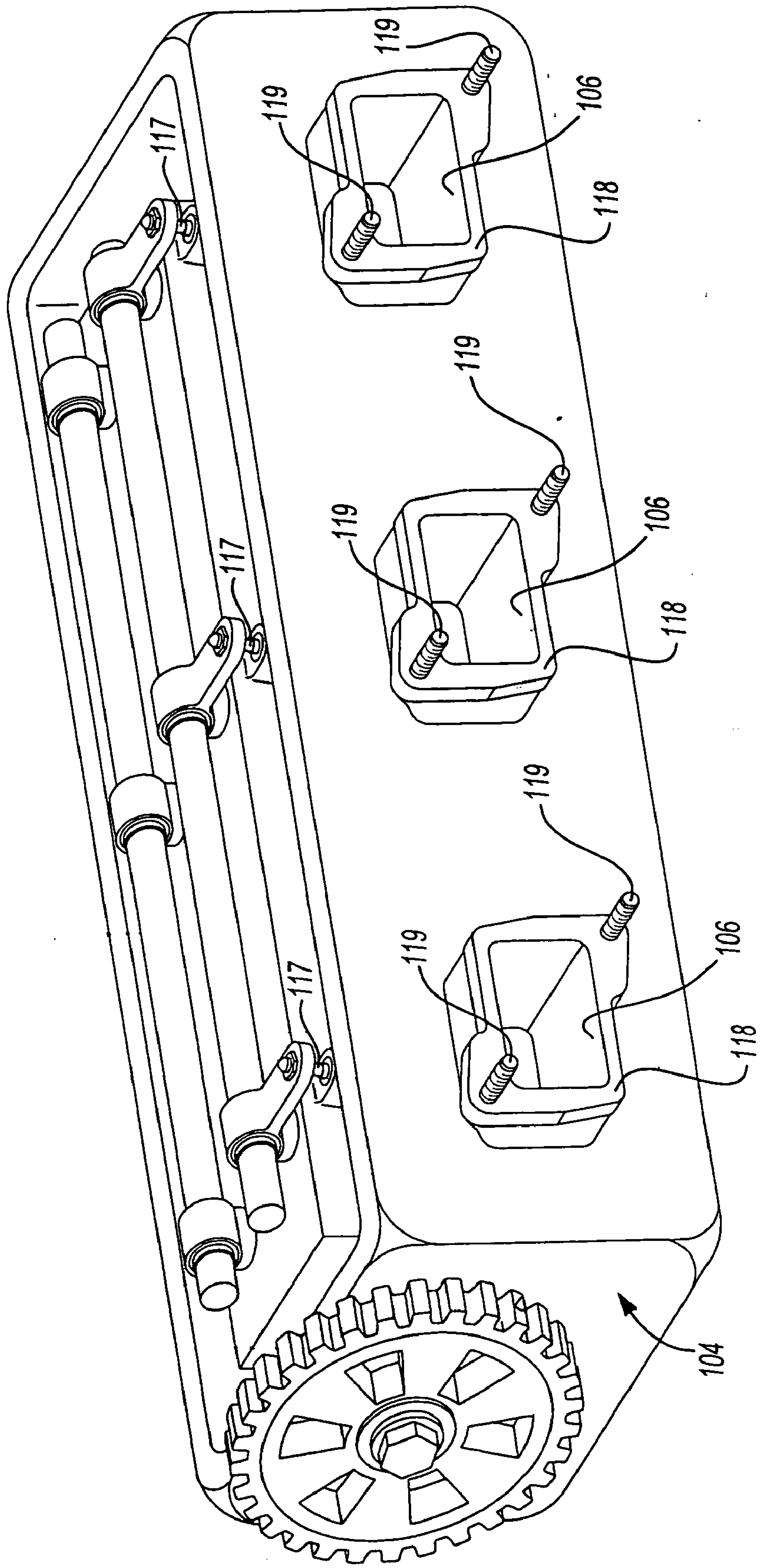

Fig-6

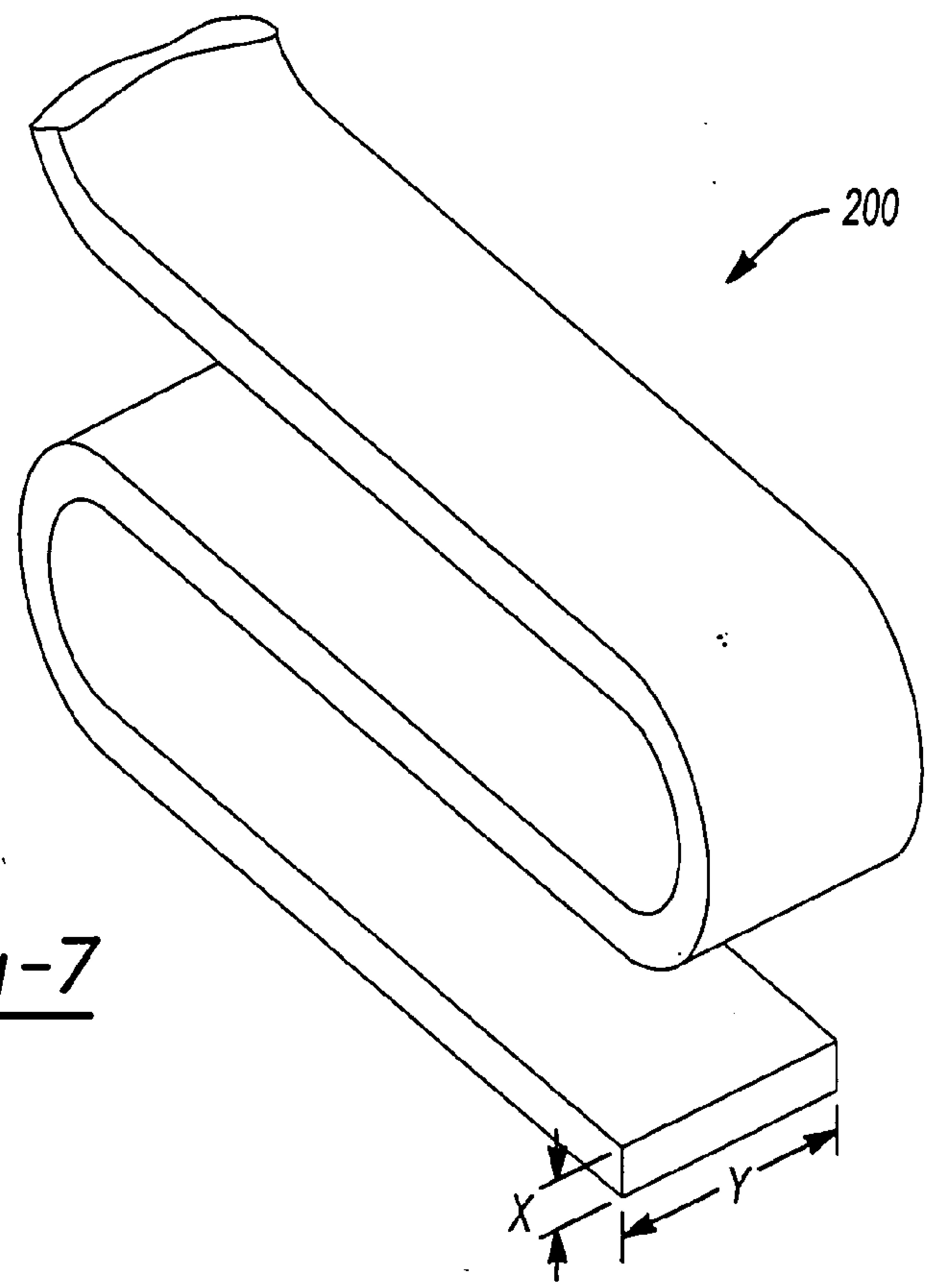

Fig-7

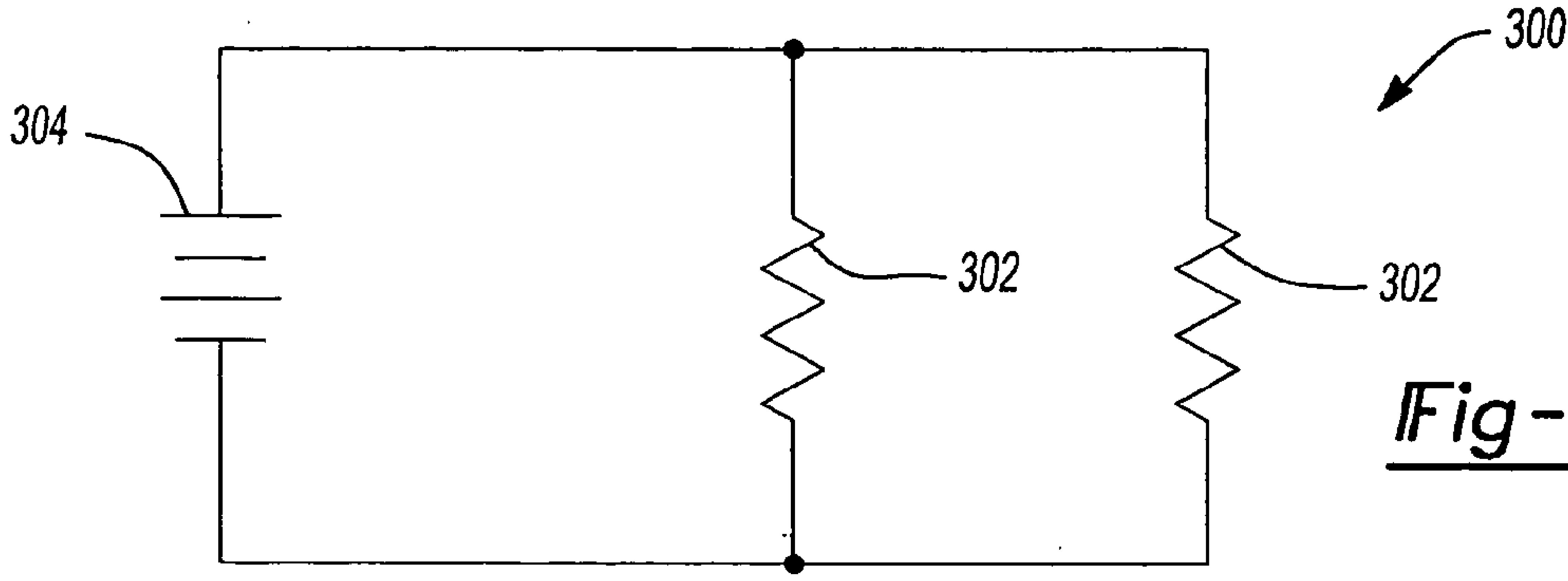

Fig-8

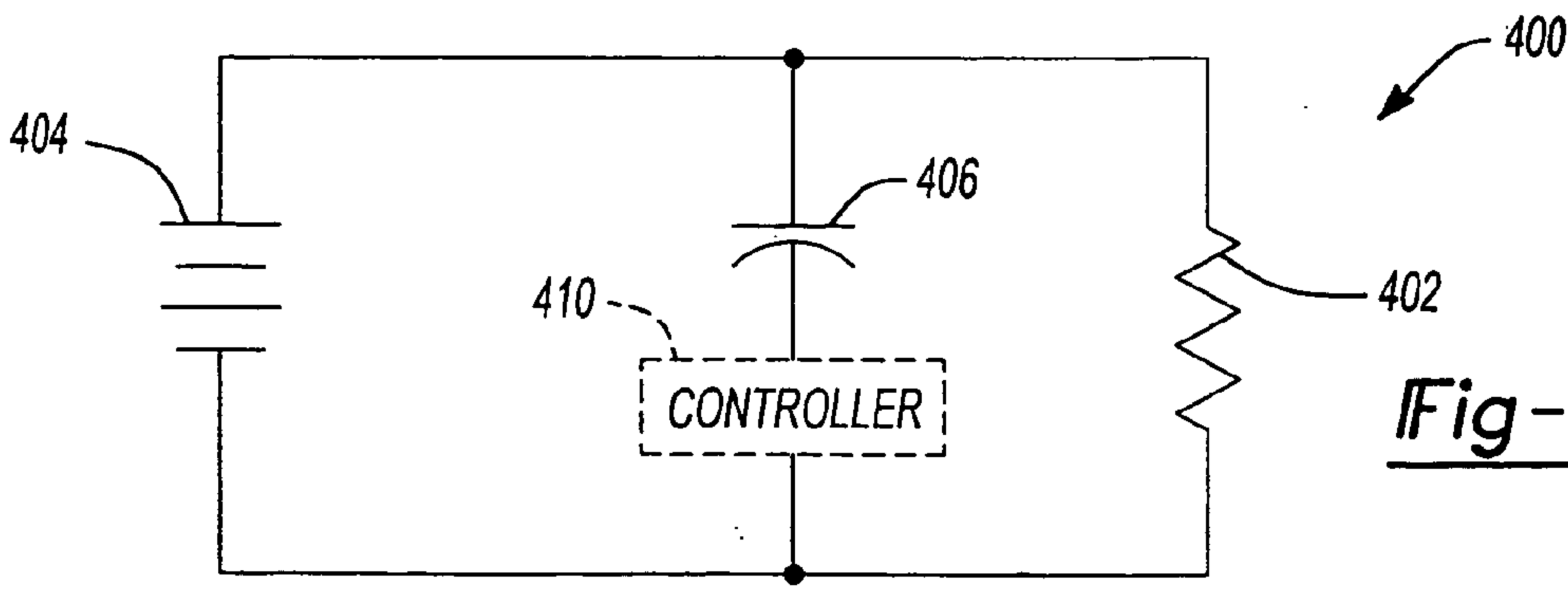

Fig-9

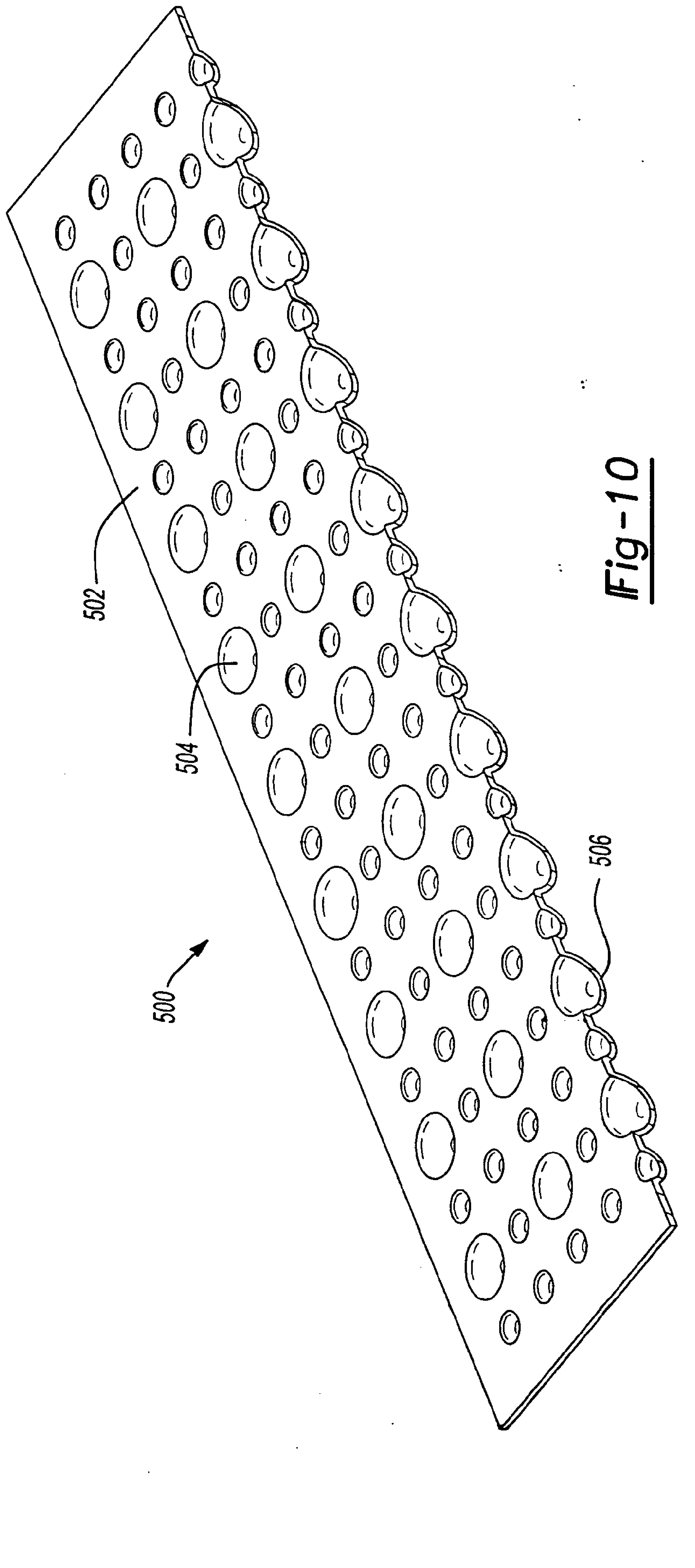

Fig-10

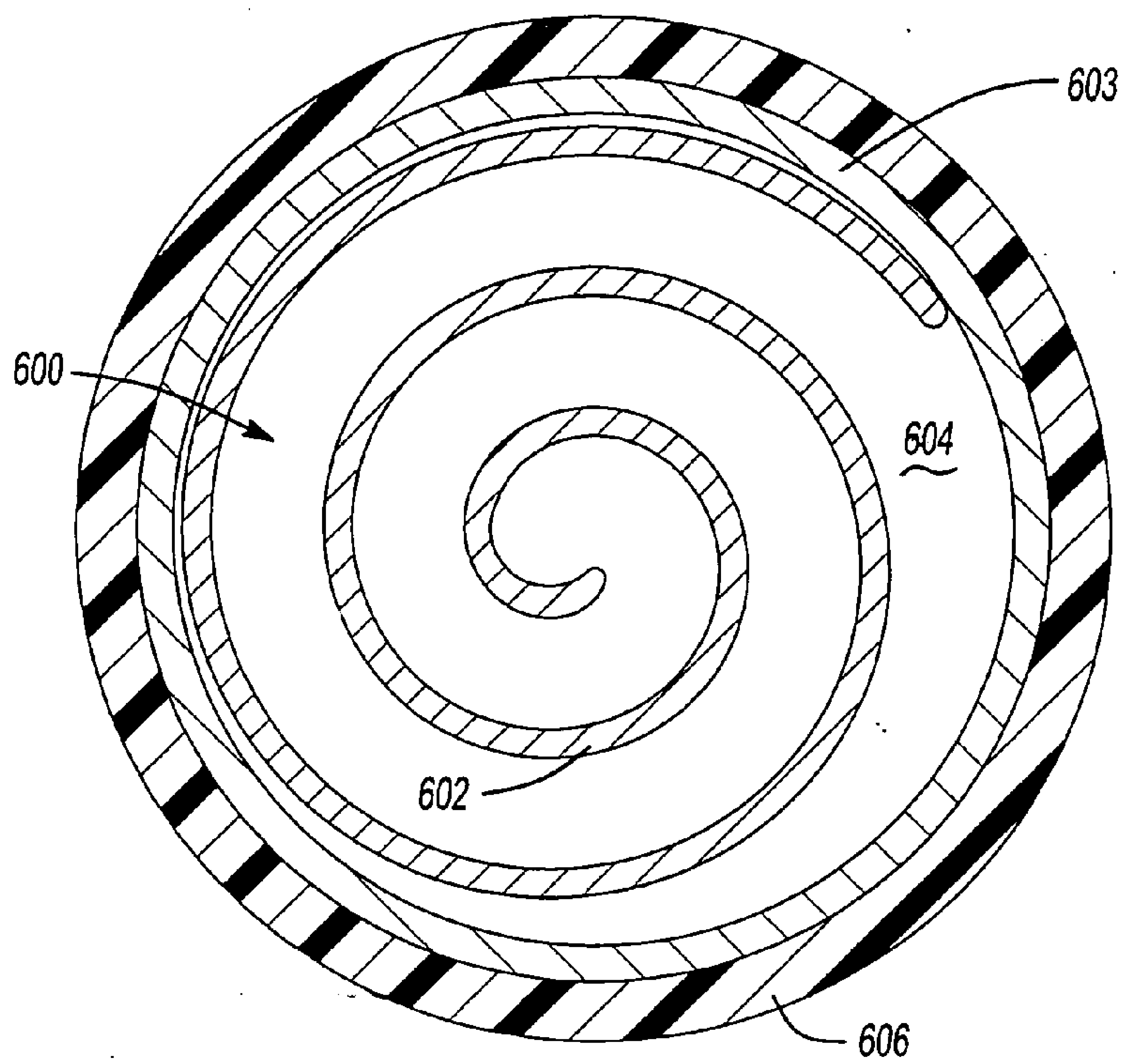

Fig-11

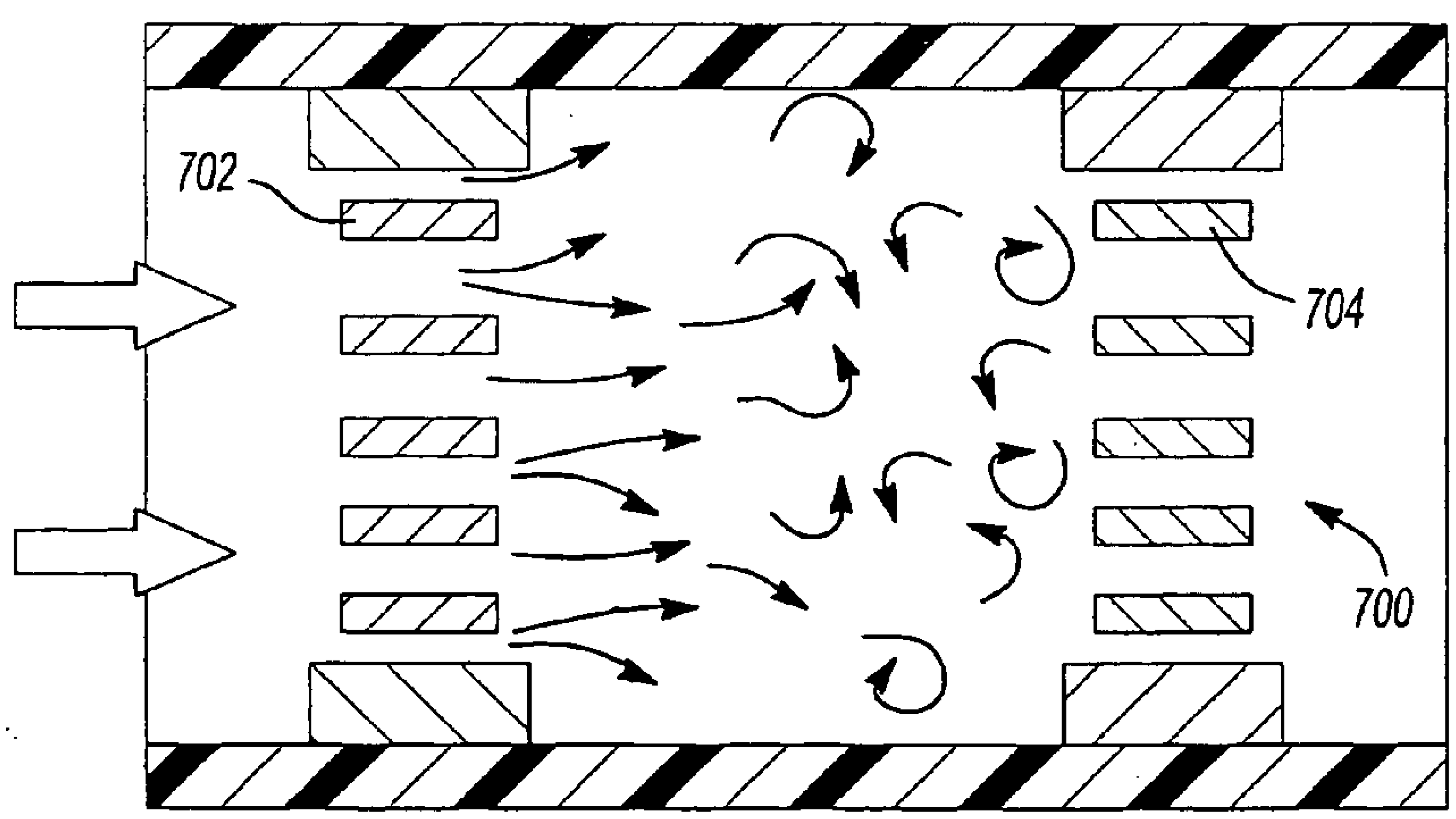

Fig-12

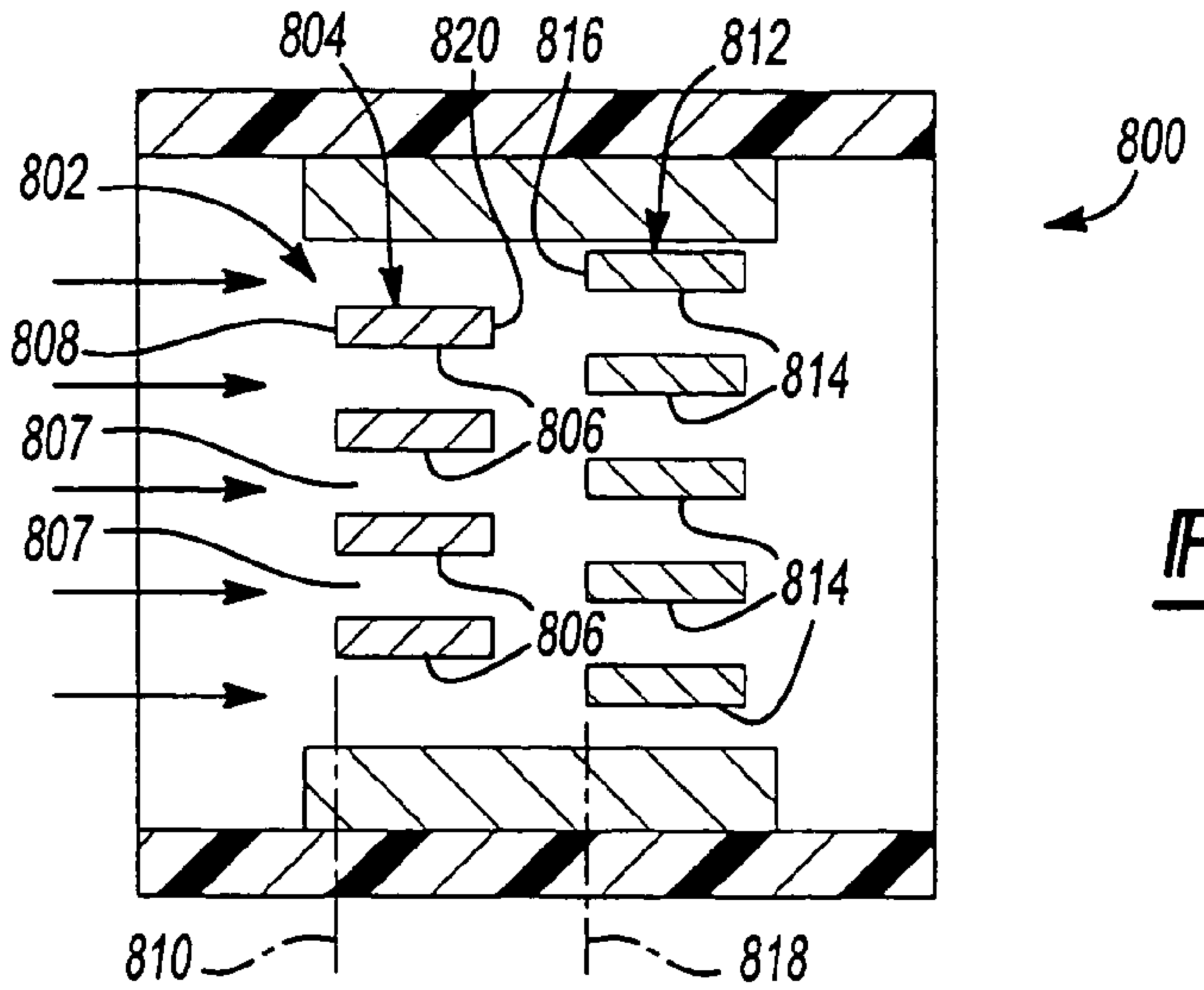

Fig-13

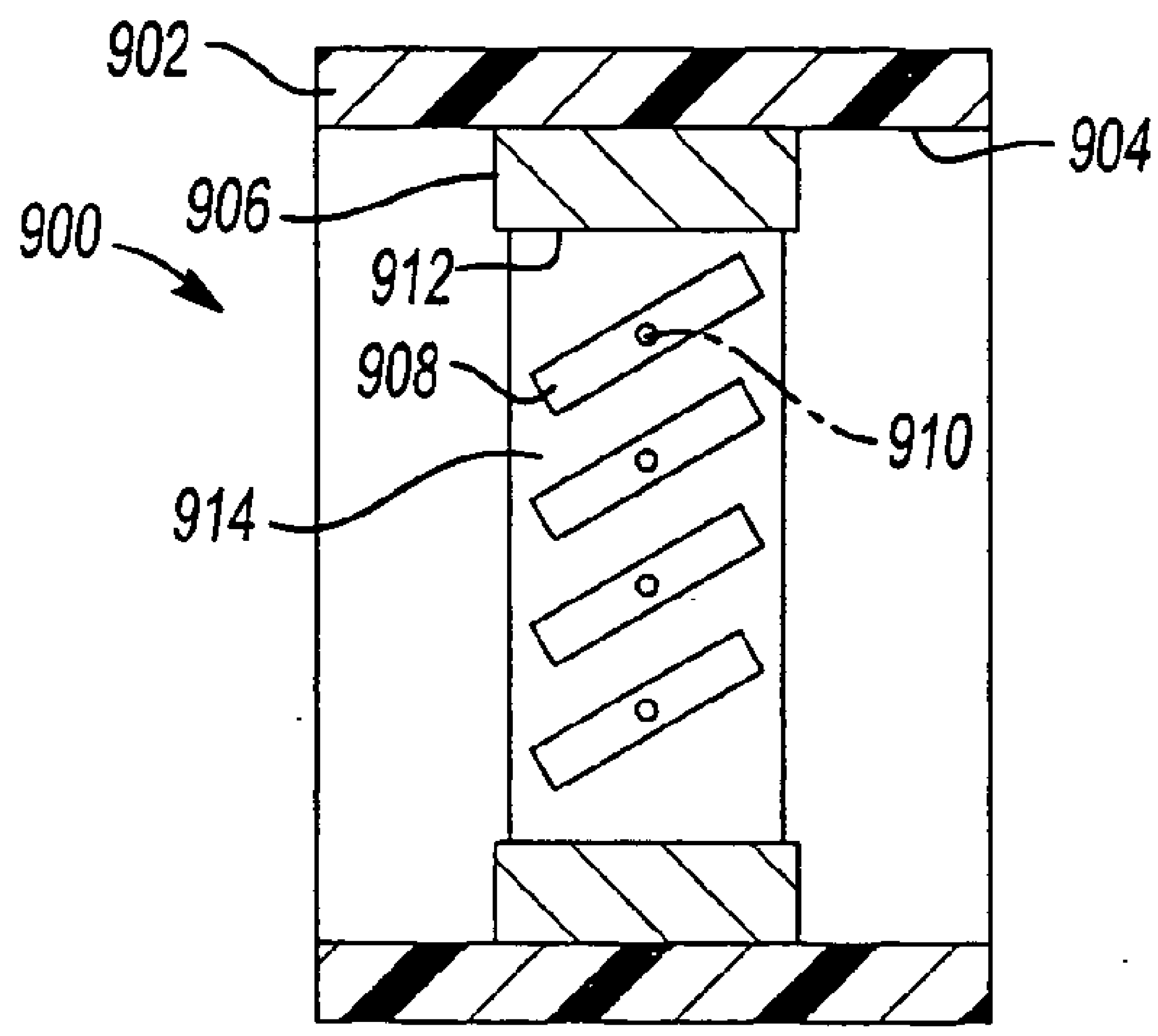

Fig-14

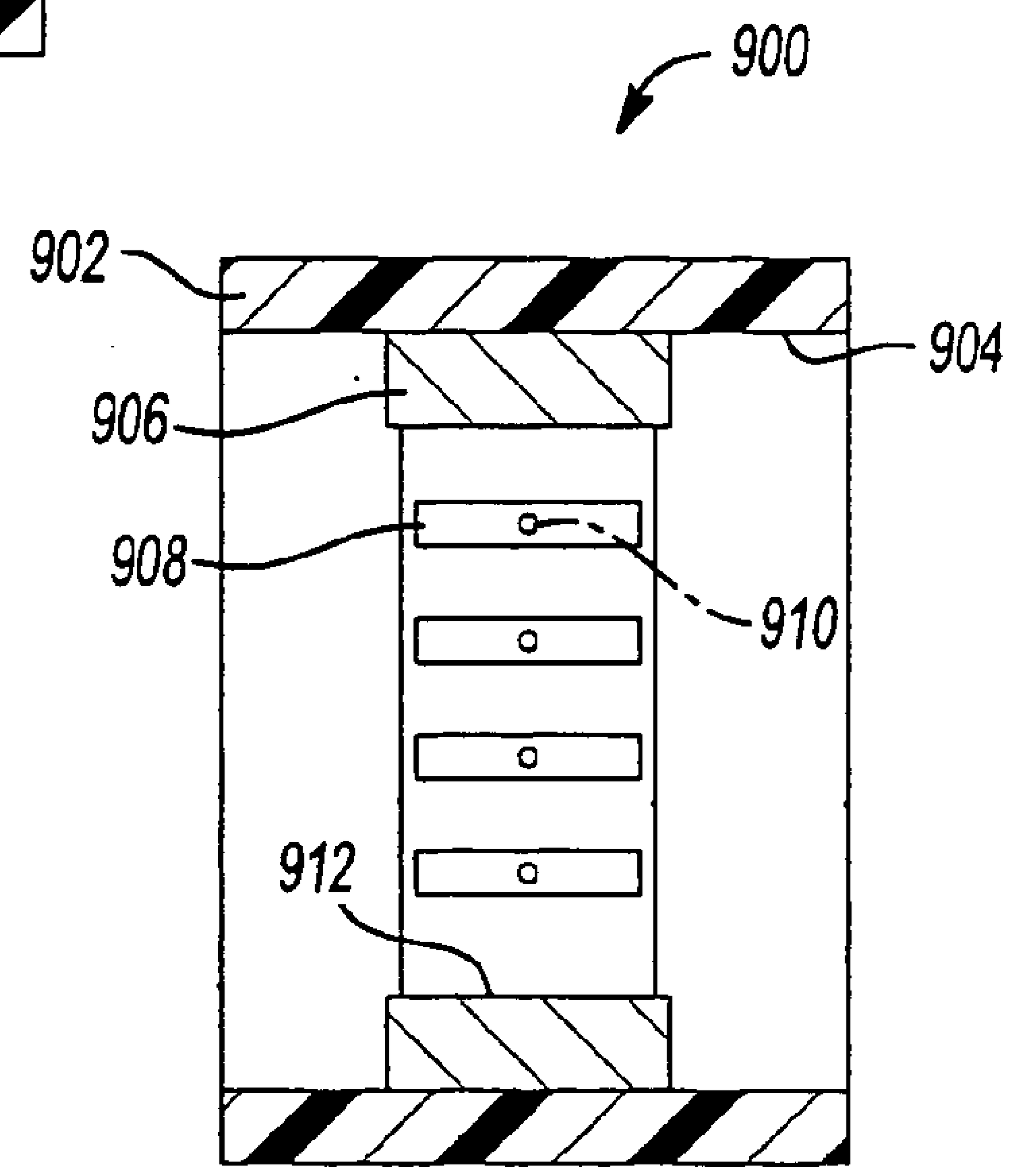

Fig-15

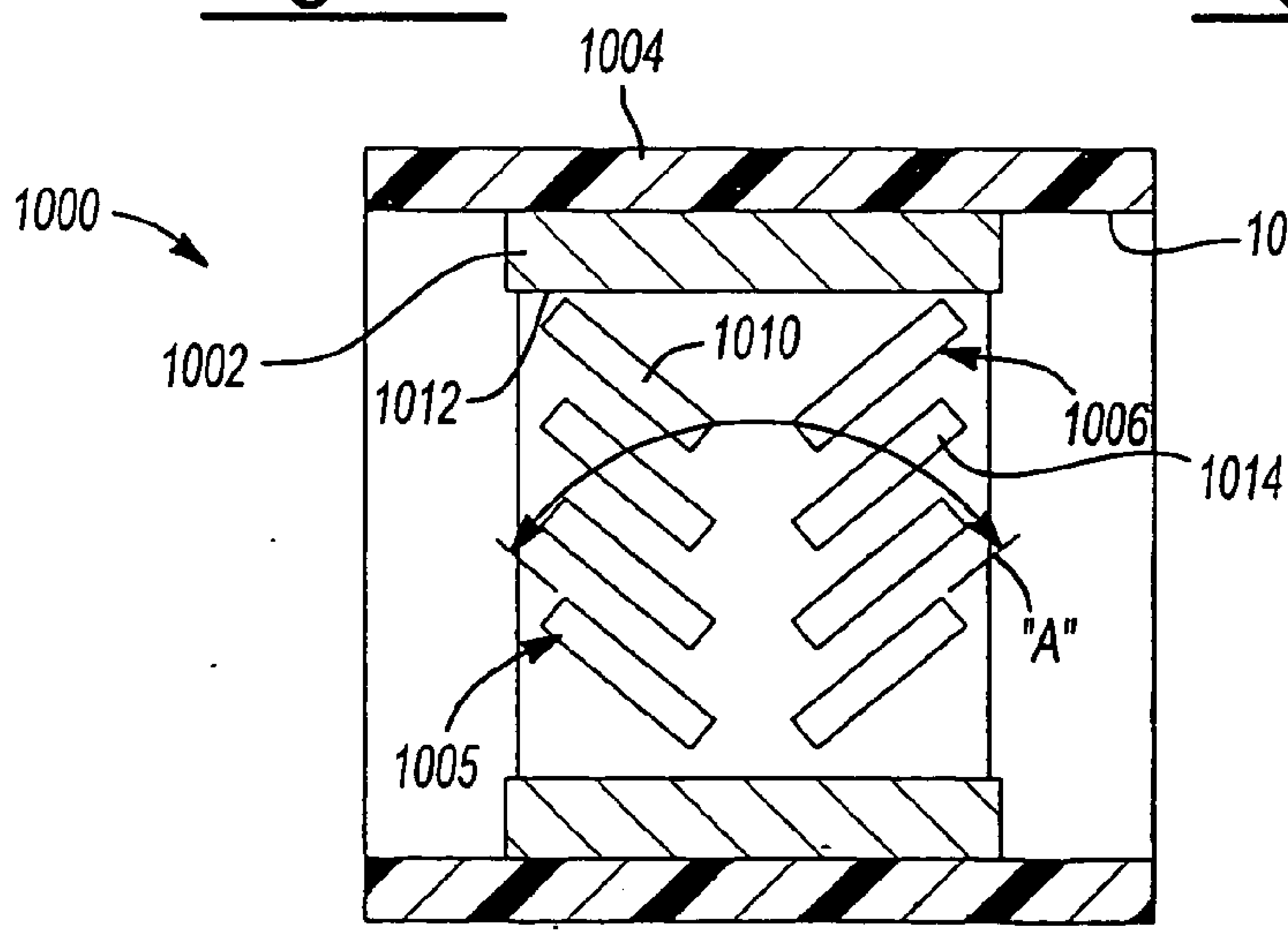

Fig-16

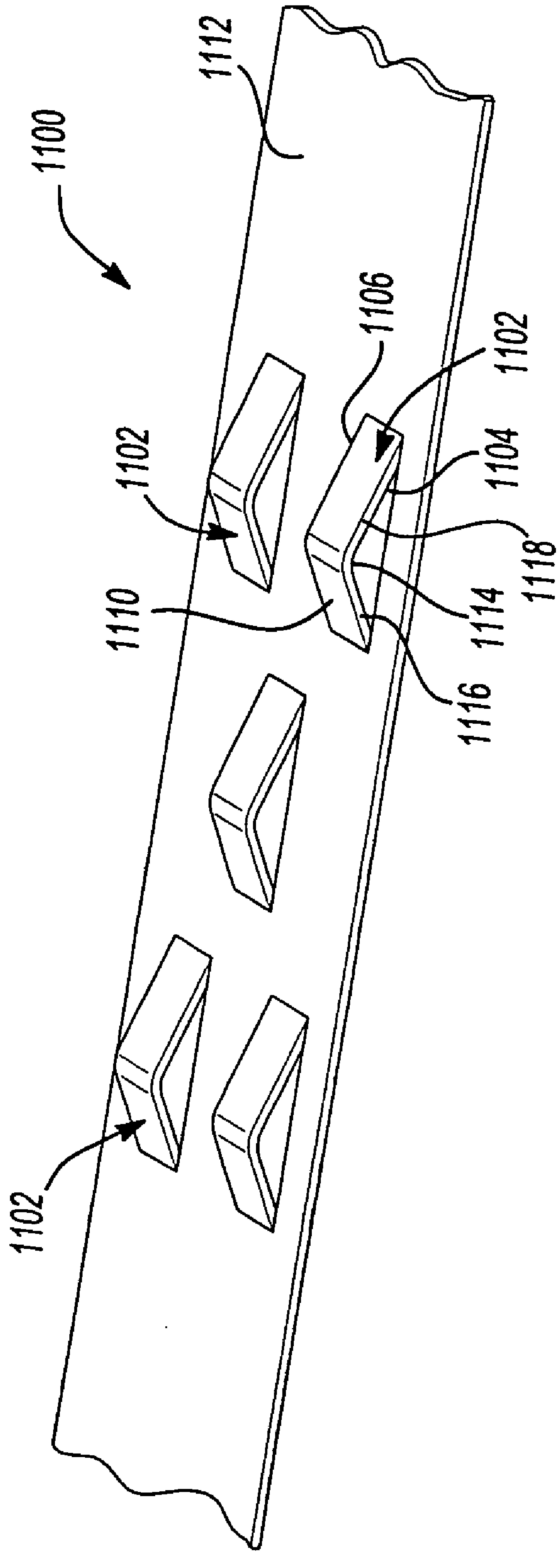

Fig-17

QUICK TEMPERATURE RISE AIR INTAKE HEATER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of International Application No. PCT/US2004/024079, filed on Jul. 27, 2004, which claims the benefit of U.S. Provisional Application No. 60/490,456, filed on Jul. 28, 2003. The disclosures of the above applications are incorporated herein by reference.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] The present invention relates to air heaters for internal combustion engines and, more particularly, to quick temperature rise air intake heaters.

[0003] Automotive vehicles are used throughout the world in a variety of climates. Many of the operating climates experience ambient temperatures significantly below 40° F. during at least some portion of the day for months at a time. Typical diesel powered internal combustion engines are capable of starting using a mixture of fuel and ambient air to temperatures as low as approximately 10° F., depending on engine size and compression ratio.

[0004] Diesel engines produce power using a self-ignition process. During the diesel cycle, intake air is compressed and diesel fuel is injected into the combustion chamber. The injected fuel mixes with the compressed air, evaporates and ignites. This process occurs because the intake air heats up during compression and diesel fuel has a relatively low ignition temperature. An external ignition device such as a spark plug is not needed. However, as ambient temperatures decrease, the temperature within the combustion chamber may not be high enough to ensure proper ignition of the injected diesel fuel. Accordingly, a need to heat the air and/or ignite the fuel/air mixture arises.

[0005] Many manufacturers have addressed this issue by positioning glow plugs in the combustion chambers of the engine. Glow plugs are typically shaped as elongated tubes having external threads that engage an internally threaded port formed in the cylinder head of the engine. Depending on the ambient air temperature, the glow plugs may need to be energized for some period of time prior to attempting to start the engine. Some manufacturers have begun to develop "fast start" glow plugs in an attempt to reduce the time the glow plugs need to be energized prior to starting the engine. While glow plug technology has provided some solutions to the issues involving cold starting a diesel fueled engine, glow plugs are relatively expensive and cumbersome. Specifically, many engines require one or more glow plugs to be positioned within each combustion chamber of the engine. The cylinder head or heads of the engine must be specially machined to receive and properly position the glow plugs within the combustion chambers. Because each glow plug occupies a predetermined amount of space, valve geometry and fuel injector geometry may have to deviate from their optimum positions to accommodate the size and position of each glow plug.

[0006] Additional challenges in diesel engine technology exist due to relatively restrictive emission standards becoming law. These laws limit the content of the exhaust to a certain chemical makeup. As such, vehicle manufacturers must contend with the fact that diesel engines exposed to cold ambient temperatures typically exhibit poor combustion characteristics immediately after starting. The "cold" intake air results in poor HC emissions (sometimes referred to as white smoke) and in fact may not meet certain future standards. In any case, the white smoke is undesirable and not acceptable to many customers. Accordingly, a need in the art exists for an improved method of starting cold diesel engines and reducing the initial cold emissions from the engine.

[0007] Air intake heaters have also been used to start diesel powered engines exposed to relatively cold ambient temperatures. Depending on the ambient temperature, some air intake heaters are energized up to 30 seconds or more prior to attempting to start the engine. The air heater heats a volume of air within the air intake tube located upstream of the combustion chambers. A relatively long preheat time is sometimes required to heat the air to a warm enough temperature such that the air is still above a predetermined value once it enters the combustion chambers some distance downstream from the air intake heater. These devices have been very effective in the field. However, a need exists for a more immediate start.

[0008] A new quick temperature rise air intake heater is disclosed to address some, if not all of the previously outlined concerns relating to glow plugs and air heaters. A quick temperature rise air intake heater is operable to rapidly transfer heat to the intake air as it moves across the air heater and enters the combustion chambers.

[0009] In one embodiment, power is provided to a quick temperature air rise intake heater simultaneously as the engine is cranked. The intake air is heated as it passes over the quick temperature air rise intake heater to allow the engine to start without the use of glow plugs.

[0010] In another embodiment, a quick temperature rise air intake heater is electrically coupled to a capacitor operable to selectively increase the power supply to the heating element. The output of the heater is increased during cranking of the engine.

[0011] Another quick temperature rise air heater includes a heating element having portions movable between first and second positions. The movable portions restrict more air flow when in the first position than in the second position. Very low air flows are typical during cranking or at low engine operating speeds or loads when an air heater may more likely be in use. When the heating elements are in the second position, air flow restriction is minimized. Relatively higher air flows are present when the heater would typically not be in use.

[0012] Other quick temperature rise air intake heaters include a heating element adapted to be positioned in a heat transfer relationship with the passage of an intake housing. The heating elements may include a surface having a plurality of indentations or protrusions. The indentations or protrusions cause an air flow traveling across the heating element to become turbulent to increase heat transfer from the heating element to the air or simply provide a better heat transfer situation due to surface area in contact with the air stream.

[0013] In another embodiment, a quick temperature rise air intake heater for use in an internal combustion engine includes a heating element adapted to be positioned in a heat transfer relationship with a passage formed in an intake. The heating element has first substantially planar spaced apart portions. Each first portion has a leading edge aligned along a first plane. The heating element has second substantially planar spaced apart portions. Each second portion has a leading edge aligned along a second plane spaced apart from and substantially parallel to the first plane. Each portion of the second heating element is aligned with a gap formed between the first portions.

[0014] In another embodiment, the quick temperature rise air intake heater includes a first heating element having substantially planar portions aligned with one another. Each portion is positioned at an angle to the direction of air flow. The air heater also includes a second heating element having substantially planar portions aligned with one another. Each portion of the second heating element is positioned at a second angle to the direction of air flow.

[0015] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0017] **FIG. 1** is a schematic showing a quick temperature rise air intake heater in conjunction with an exemplary engine;

[0018] **FIG. 2** is a cross-sectional side view of an exemplary drop-in style air intake heater;

[0019] **FIG. 3** is a perspective view depicting three alternate embodiment quick temperature rise air intake heaters coupled to an exemplary air intake manifold;

[0020] **FIG. 4** is an exploded perspective view of the intake manifold and air heater assembly of **FIG. 3**;

[0021] **FIG. 5** is a cross-sectional view taken along line **5-5** as shown in **FIG. 3**;

[0022] **FIG. 6** is a perspective view depicting an exemplary engine head;

[0023] **FIG. 7** is a partial perspective view of an alternate embodiment heating element;

[0024] **FIG. 8** is an electrical schematic showing multiple heating elements and/or multiple quick temperature rise air intake heaters electrically coupled in parallel;

[0025] **FIG. 9** is an electrical schematic depicting a quick temperature rise air intake heater electrically coupled with a capacitor;

[0026] **FIG. 10** is a partial fragmentary perspective view of an alternate embodiment heating element having a plurality of indentations formed thereon;

[0027] **FIG. 11** is a cross-sectional view of an alternate embodiment quick temperature rise air intake heater positioned within a passageway formed in an exemplary intake tube; t

[0028] **FIG. 12** is a cross-sectional view showing another embodiment quick temperature rise air intake heater;

[0029] **FIG. 13** is a cross-sectional view depicting another alternate embodiment quick temperature rise air intake heater;

[0030] **FIG. 14** is a cross-sectional view depicting another alternate embodiment quick temperature rise air intake heater showing movable heating elements in a restricted position;

[0031] **FIG. 15** is a cross-sectional view depicting the quick temperature rise air intake heater of **FIG. 14** having the movable heating elements oriented at an open position;

[0032] **FIG. 16** is a cross-sectional view depicting another alternate embodiment quick temperature rise air intake heater; and

[0033] **FIG. 17** is a fragmentary perspective view of an alternate embodiment heating element having a plurality of upset portions.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0035] With reference to **FIG. 1**, an air intake system **20** is shown in communication with an exemplary internal combustion engine **22**. Internal combustion engine **22** includes a cylinder head **24** coupled to an engine block **26**. Intake system **20** includes an intake housing **28** mounted to head **24**. Intake housing **28** includes an inlet tube **30** having a distal end **32** in communication with a source of ambient air. Ambient air is drawn through a passageway **34** extending through intake housing **28**. Intake housing **28** includes an open end **36** in communication with intake valves **37** positioned within head **24**. A quick temperature rise air intake heater **40** is coupled to intake housing **28**. At least a portion of air heater **40** is positioned within passageway **34** in communication with and upstream of air entering combustion chambers **38** formed within engine block **26**. **FIG. 1** depicts air heater **40** as a "drop-in" style heater. Alternatively, air heater **40** may be mounted entirely within intake housing **28**, between intake housing **28** and head **24** or within head **24**.

[0036] **FIG. 2** depicts air heater **40** in greater detail as including a heating element **44** coupled to an access panel **46**. Heating element **44** is positioned within an aperture **47** (**FIG. 1**) formed within inlet tube **30**. In this manner, heating element **44** is placed in communication with air traveling through passageway **34** toward combustion chambers **38** of engine **22**. Access panel **46** sealingly engages inlet tube **30** to restrict undesirable ingress of contaminants.

[0037] Air heater **40** includes a U-shaped frame **48** coupled to access panel **46**. A heater subassembly **50** is coupled to frame **48**. Heater subassembly **50** includes a first holder **52**, a second holder **54** and heating element **44**. First holder **52** includes a housing **56** preferably shaped from a stainless steel sheet. Housing **56** defines a "C"-shaped channel bounded on three sides by a side wall **58**, a side wall not shown in the Figure and an end wall **62**. As is shown in **FIG. 2**, second holder **54** is configured substantially similar to first holder **52**. Therefore, second holder **54** will not be described in greater detail.

[0038] Wave springs **64** are positioned within housing **56** in engagement with end wall **62**. Thermal and electrical insulators **66** are positioned within housing **56** to engage and capture springs **64** between end wall **62** and insulator **66**. Wave springs **64** urge insulators away from end wall **62** and into engagement with stops **68** which extend inwardly from the side walls.

[0039] A first bolt **70** mounts a first end **72** of heating element **44** to access panel **46**. Insulators are positioned between first bolt **70** and access panel **46** such that first end **72** and first bolt **70** are not electrically coupled to access panel **46**. A second bolt **74** physically and electrically couples a second end **76** of heating element **44** to frame **48**. Air heater **40** is operable to emit heat once current is passed through heating element **44** via an electrical path including access panel **46**, frame **48**, second bolt **74**, heating element **44** and first bolt **70**. One skilled in the art will appreciate that air heater **40** may be constructed to include two outwardly protruding terminals similar to first bolt **70** if it is desirable to not pass current through access panel **46** and frame **48**. Further details regarding air intake heaters may be found in U.S. Pat. Nos. 6,073,615 and 6,031,204, which are incorporated by reference herein.

[0040] Quick temperature rise air intake heater **40** is operable to transfer a large quantity of energy per unit time to the air as it passes over heating element **44** during engine cranking. In relative terms, the quick temperature rise air intake heater **40** provides substantially higher wattage output than air heaters previously contemplated. As discussed earlier, previous air heaters were energized a relatively long period of time prior to engine cranking during a "pre-heat" phase to heat the air located in the inlet tube while the air was not flowing into the combustion chambers of the engine. Prior air intake heater operation relied on heating a large enough volume of the air trapped within the inlet tube to a higher temperature such that the heated mass of air would still contain sufficient energy to cause combustion once the air reached the combustion chamber. The quick temperature rise air intake heater **40** operates to output a much higher quantity of energy per unit time and transfer the energy to a flowing air stream. By sizing the air heater in this manner and energizing the air heater just prior to or simultaneously with engine cranking, the "pre-heat" time required before engine start is greatly reduced, if not eliminated entirely. Specifically, at least one embodiment quick temperature rise air intake heater is energized only 5 seconds or less prior to engine cranking. The heater may also be energized shortly after engine cranking begins. Operation of air intake heater **40** as described results in less total power being used per engine start because the "pre-heat" time is very short in comparison to earlier devices. Depending on the ambient air temperature and the characteristics of the specific engine to be started, air intake heater **40** may be energized after the engine has been started to assure the engine remains running.

[0041] **FIGS. 3-5** depict alternate embodiment air heaters **100** positioned within outlet branches **101** of air intake housing **102**. **FIG. 6** depicts an engine head **104** having intake ports **106**. Head **104** is adapted to be coupled to an engine block (not shown). Head **104** includes a plurality of intake valves **107** operable to selectively allow intake air passing through intake ports **106** to enter the combustion chambers of the engine. Each branch **101** of air intake housing **102** is coupled to one of intense ports **106**. Air intake housing **102** includes an inlet **108** in fluid communication with each branch **101** via a passageway **110**. In this manner, passageway **110** provides fresh air to the combustion chambers.

[0042] Each branch **101** of air intake housing **102** includes a flange **112**. Each flange **112** includes a pair of fastener apertures **114** extending therethrough. Each flange **112** includes a substantially planar mounting surface **116** in engagement with corresponding substantially planar mounting surfaces **118** (**FIG. 6**) formed adjacent each intake port **106** of engine head **104**. Threaded fasteners **119** are mounted to head **104** and extend through apertures **114** to couple air intake housing **102** to engine head **104**. Each air heater **100** is positioned within very close proximity to one of mounting surfaces **116**. Therefore, each air heater **100** is positioned within very close proximity of its corresponding intake port **106** formed within engine head **104**. By positioning air heaters **100** in close proximity to intake ports **106**, intake air heated by each heater **100** is required to travel only a minimal distance prior to entering a combustion chamber. Such placement of the air heaters is greatly advantageous when attempting to start an engine exposed to cold ambient temperatures. Within engines equipped with air heaters positioned a greater distance from the head intake port, more energy is transferred to the walls of the air intake housing, other components mounted to the air intake housing and the engine head. This heat transfer path results in less energy being present within the charge of air entering the combustion chambers.

[0043] Each air heater **100** includes a heating element **120** operable to emit heat when current is passed between a first end **122** and a second end **124**. A first holder **126** and a second holder **128** are electrically insulated from heating element **120**. First and second holders **126**, **128** capture heating element **120** therebetween and provide a method of mounting heating element **120** to air intake housing **102**.

[0044] Each heater **100** includes a first electrical terminal **130** and a second electrical terminal **132**. The electrical terminals may be shaped as threaded fasteners partly extending or completely extending through air intake housing **102**. In the embodiment shown in **FIG. 3**, heaters **100** are electrically coupled to one another in series via a first jumper cable **134** and a second jumper cable **136**.

[0045] Each first electrical terminal **130** includes a threaded fastener **137** coupled to first end **122** of heating element **120**. Threaded fastener **137** extends through an aperture **138** formed in intake housing **102**. Another threaded fastener **140** is mechanically and electrically coupled to second end **124** of heating element **120**. Threaded fastener **140** extends through an aperture **142** extending through air intake housing **102**. A jumper plate **144** electrically interconnects threaded fastener **140** and a jumper bolt **146**. Jumper bolt **146** extends through apertures **148** and **150** formed in air intake housing **102** such that the threaded end of bolt **146** forms second terminal **132**.

[0046] A variety of conductive and non-conductive spacers are used to mount heaters **100** to intake housing **102** and define an electrical path through each of heating elements **120**. In particular, one terminal of a power source (not shown) is coupled to terminal **130** located at the left end of **FIG. 3** and another terminal of the power source is coupled to second terminal **132** located at the right side of **FIG. 3**. First jumper cable **134** interconnects second terminal **132** of the leftmost heater **100** to first electrical terminal **130** of the center heater **100**. Second jumper cable **136** interconnects second electrical terminal **132** of the center heater **100** to first electrical terminal **130** of the rightmost heater **100**. Accordingly, a series electrical path is formed.

[0047] **FIG. 7** depicts an alternate embodiment quick temperature rise air intake heating element **200**. Heating element **200** has a modified cross-section for providing a reduced resistance to current passing therethrough. By reducing the resistance of heating element **200**, greater power output from a heater including heating element **200** will be realized from a given power supply. For example, heating element **200** is a generally serpentine shaped ribbon having cross-sectional dimensions X and Y. In one embodiment, a ribbon having a dimension X equal to 0.7 mm and a dimension of Y equal to 10 mm is contemplated. A standard heavy duty truck battery has approximately 12.6 volts available at a maximum 1125 amps. Based on these power supply parameters, it is estimated that heating element **200** will output 5000 watts. It should be noted that the various heater embodiments described not only allow for fast engine starts but the heating elements could run considerably cooler than previous designs. This has a very positive impact on the life of the heating elements as a result of the relatively low operating temperatures. Furthermore, by implementing the heater strategies outlined, alternate embodiment heating elements may be designed to heat up faster than prior art air heaters. In one example, a thinner heating element is implemented as another way of achieving fast engine starts.

[0048] The material composition as well as the geometry of the heating element may also be varied to change the resistance of the heating element to obtain a desired result such as higher wattage and/or faster heater response. In this manner, a particular customer's needs may be met. In some cases, heating elements constructed from more exotic materials are used. In other cases, materials that are known to be inexpensive are chosen. Accordingly, the heating element material may have little or considerable nickel content depending on the specific customer program requirements. Furthermore, it is contemplated that any of the heating elements described may be constructed from a Positive Temperature Coefficient (PTC) type material.

[0049] **FIG. 8** depicts a circuit **300** having multiple heating elements **302** electrically coupled to one another in parallel. A battery **304** provides energy to heating elements **302**. By coupling the heating elements in parallel, the circuit resistance is decreased. Accordingly, the energy output from multiple heating elements **302** is increased compared to a heater having elements connected in series.

[0050] **FIG. 9** depicts a circuit **400** having an air heater **402** electrically coupled to a vehicle battery **404** and a capacitor **406**. Capacitor **406** is operable to selectively supply power to the air intake heater **402**. Capacitor **406** is operable to maintain the voltage supply to the air heater and deliver greater power in a short amount of time. Furthermore, use of capacitor **406** may alleviate an original equipment manufacturer's concerns of using battery power during engine cranking.

[0051] **FIG. 9** also shows an optional controller **410** in communication with capacitor **406**. Controller **410** is operable to optimize the capacitor power flow. Optimization of the capacitor power flow allows optimization of the wattage output from heater **402**. Engine start time is greatly minimized by providing a properly heated volume of air during engine cranking.

[0052] **FIG. 10** depicts a portion of an alternate embodiment heating element **500** having a dimpled external surface **502**. Dimpled surface **502** includes a plurality of substantially hemispherically shaped indentations **504** spaced apart from one another. The indentations **504** and corresponding protrusions **506** cause the flow of air passing over heating element **500** to become turbulent. Turbulent air flow maximizes heat transfer from heating element **500** to the air passing thereby. The surface area is also increased further enhancing the heat transfer to the air. As previously mentioned, the engine is more likely to start if the heat content of the air/fuel mixture is above a predetermined quantity. Maximizing the heat content of the air entering the combustion cylinders increases the likelihood of engine start.

[0053] **FIG. 11** depicts a quick temperature rise air intake heater **600** having a heating element **602** coupled to a frame **603**. Air heater **600** is shaped to fill a substantially cylindrically-shaped space **604** formed in an intake tube **606**. Many air intake tubes have passageways defining circular cross-sections. The cylindrical shapes of heating element **602** and frame **603** facilitate mounting the air heater within a number of air intake tubes. Furthermore, this heater shape may also be more conducive to positioning the heating element closer to the combustion chambers.

[0054] **FIG. 12** depicts another alternate embodiment quick temperature rise air intake heater **700** having a first heating element **702** and a second heating element **704**. Heating element **702** is spaced apart from heating element **704** such that air flow entering the downstream heating element **704** is substantially turbulent in nature. Heat transfer from heating element **704** to the air is more efficient within a turbulent air stream. Accordingly, this embodiment attempts to maximize the heat content of the air entering the combustion chamber.

[0055] **FIG. 13** shows an air intake heater **800** having a heating element **802**. Heating element **802** has a first portion **804** having substantially planar sections **806**. Planar sections **806** are spaced apart from one another to define gaps **807**. Each planar section **806** includes a leading edge **808** aligned along a first plane **810**. A second portion **812** of heating element **802** includes substantially planar sections **814**. Planar sections **814** are also spaced apart from one another. Each planar section **814** includes a leading edge **816** aligned along a second plane **818**.

[0056] Intake air travels along the direction of the arrows depicted in **FIG. 13**. The flow of intake air is impeded by leading edges **808** of first portion **804**. Air continues to travel across the width of first portion **804** where heat is transferred from heating element **802** to the air passing thereby. Leading edges **816** of second portion **812** are positioned to impede the flow of air passing between individual sections **806** of first portion **804**. By positioning sections **814** of second portion **812** in line with the gaps **807** defined by sections **806** of first portion **804**, a greater heat transfer efficiency is realized because the air is required to follow a circuitous path around various sections of heating element **802**. It should be appreciated that while **FIG. 13** depicts only two planes of leading edges, a single heating element or multiple heating elements may be arranged to provide a more convoluted path for the air to follow as it passes through air heater **800**. Furthermore, **FIG. 13** depicts leading edges **816** aligned along second plane **818** as being spaced apart from a plurality of trailing edges **820** of first portion **804**. Other embodiments having sections **806** and sections **814** that at least partially overlap one another to form a nested or intergiditated arrangement are contemplated.

[**0057**] **FIGS. 14 and 15** relate to another quick temperature rise air intake heater embodiment identified at reference numeral **900**. Air intake heater **900** is positioned within an air intake tube **902** having a passageway **904**. Air heater **900** includes a frame **906** and a plurality of movable heating elements **908**. Each heating element **908** is rotatable about an axis **910** between a substantially restricted position as shown in **FIG. 14** and a substantially open position as shown in **FIG. 15**. In the substantially restricted position of **FIG. 14**, each heating element **908** is rotated to at least partially close off an aperture **912** extending through air heater **900**. When heating elements **908** are in the substantially restricted position, a greater quantity of air is forced into contact with the surfaces of heating elements **908**. During this mode of operation, heat transfer from heating elements **908** to the air passing through aperture **912** is maximized. Accordingly, heating elements **908** are rotated to the substantially restricted position prior to an attempt to start a diesel fueled engine at relatively cold ambient temperatures. Sufficient gaps **914** exist between elements **908** while in the restricted position to allow air to pass by heating elements **908** at a flow rate required during engine cranking. This heating element position may also be maintained during low load engine operations where the air flow rates are low and very low restriction exists.

[**0058**] During maximum engine load conditions, heating elements **908** are rotated to the position shown in **FIG. 15**. In this position, each heating element **908** is substantially parallel to one another and parallel to the direction of air flow passing through aperture **912**. **FIG. 15** represents a heating element position where the flow through intake tube **902** is least restricted. The movable set of heating elements **908** provides the benefit of transferring a large quantity of heat to the intake air during starting while in the most restrictive position and is also operable to meet engine manufacturers' standards regarding intake air flow under maximum load conditions.

[**0059**] **FIG. 16** depicts another quick temperature air rise intake heater embodiment at reference numeral **1000**. Intake heater **1000** includes a frame **1002** coupled to an intake tube **1004**. Air intake heater **1000** includes a first heating element **1005** and a second heating element **1006** positioned in heat transfer relationship with air passing through a passageway **1008** extending through intake tube **1004**. First heating element **1005** includes a plurality of spaced apart portions **1010** positioned at an angle to the direction of air flow passing through an aperture **1012** extending through air heater **1000**. First heating element **1005** disrupts the flow of air through aperture **1012** and transfers heat to air passing thereby.

[**0060**] Second heating element **1006** includes a plurality of spaced apart portions **1014** fixed to frame **1002**. Portions **1014** are positioned at a different angle than portions **1010** relative to the flow of intake air. Portions **1014** are positioned to maximize the transfer of energy to air passing through aperture **1012**. The combination effect of the positioning of first heating element **1005** and second heating element **1006** is taken into account to assure that a minimum flow rate of air through intake tube **1004** may be met during a maximum engine load condition. In one embodiment, an included angle between like portions of first heating element **1005** and second heating element **1006** form an angle "A" ranging between 30-120 degrees.

[**0061**] **FIG. 17** shows a portion of an alternate embodiment heating element **1100** having a plurality of upset portions **1102** spaced apart from one another. Each upset portion **1102** is defined by a first slit **1104** and a second slit **1106** extending through the thickness of heating element **1100**. Slit **1106** is positioned substantially parallel to slit **1104**. A band of material **1110** positioned between slits **1106** and **1104** is mechanically deformed to protrude above a substantially planar surface **1112** of heating element **1100**. Band **1110** includes an inflection point **1114** defining a first leg **1116** and a second leg **1118** of upset portions **1102**. The geometry of upset portions **1102** and their spacing are configured to create a turbulent air flow conducive to greater heat transfer. Upset portions **1102**, also known as turbulators, significantly increase the effectiveness of the heater to transmit heat to the air. Furthermore, by forming upset portions **1102** from the material of the heating element itself, current passes through the upset bands of material as well as the material surrounding the projections to further improve heat transfer to the air passing by heating element **1100**.

[**0062**] The foregoing discussion discloses and describes merely exemplary embodiments of the present invention. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations may be made therein without department from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A quick temperature rise air intake heater and control system for use in an internal combustion engine having an intake defining a passage, the air intake heater comprising:

a heating element coupled to a frame, the frame being adapted to be coupled to the intake, the heating element being adapted to be positioned in a heat transfer relationship with the passage; and

a capacitor electrically coupled to the heating element, the capacitor being operable to selectively increase the power supplied to the heating element to increase the output of the heater.

2. The air intake heater of claim 1 further including a controller operable to selectively control the supply of power from the capacitor to the heating element.

3. The air intake heater of claim 2 wherein the heating element is positioned within 5-20 cm of an intake port opening of an engine head.

4. The air intake heater of claim 3 wherein the heater is operable to output 2000-5000 watts when the capacitor is electrically discharging into the heating element.

5. A quick temperature rise air intake heater for use in an internal combustion engine having an intake defining a passage, the air intake heater comprising:

a heating element adapted to be positioned in a heat transfer relationship with the passage, the heating element having portions movable between first and second positions, said portions relatively restricting more air flow when in the first position than in the second position.

6. The air intake heater of claim 5 wherein the portions are positioned substantially parallel to the direction of air flow when in the second position.

7. The air intake heater of claim 6 wherein during engine starting the portions are in the first position to transfer a maximum amount of energy to the air passing through the air heater, the portions not restricting the very low air flows experienced during engine cranking.

8. The air intake heater of claim 5 wherein the movable portions of the heating elements may be positioned at positions between the first and second positions to vary the heat transfer to the air and the air flow restriction caused by the movable portions.

9. A quick temperature rise air intake heater for use in an internal combustion engine having an intake defining a passage, the air intake heater comprising:

a heating element adapted to be positioned in a heat transfer relationship with the passage, wherein the heating element includes a surface having a plurality of indentations formed thereon, wherein the indentations cause an air flow traveling across the heating element to become turbulent to increase heat transfer from the heating element to the air.

10. The air intake heater of claim 9 wherein the heating element has a serpentine shape.

11. A quick temperature rise air intake heater for use in an internal combustion engine having an intake defining a passage, the air intake heater comprising:

a heating element adapted to be positioned in a heat transfer relationship with the passage, wherein the heating element includes a surface having a plurality of indentations formed thereon, wherein the indentations cause an air flow traveling across the heating element to contact additional heating element surface area and increase heat transfer from the heating element to the air.

12. The air intake heater of claim 11 wherein the heating element has a serpentine shape.

13. A quick temperature rise air intake heater for use in an internal combustion engine having an intake defining a passage, the air intake heater comprising:

a heating element adapted to be positioned in a heat transfer relationship with the passage, wherein the heating element includes a surface having a plurality of protrusions formed thereon, wherein the protrusions cause an air flow traveling across the heating element to become turbulent to increase heat transfer from the heating element to the air.

14. The air intake heater of claim 13 wherein the protrusions include webs of heating element material partially separated from adjacent heating element material, wherein the webs are deformed to protrude from a surface of the adjacent heating element material.

15. The air intake heater of claim 14 wherein the webs are defined by two substantially parallel slits extending through the heating element.

16. The air intake heater of claim 13 wherein current flows through the protrusions during energization of the heating element.

17. A quick temperature rise air intake heater for use in an internal combustion engine having an intake defining a passage having a direction of air flow, the air intake heater comprising:

first and second heating elements coupled to a frame, the frame being adapted to be coupled to the intake, the heating elements being adapted to be positioned in a heat transfer relationship with the passage, the first heating element having substantially planar portions aligned with one another, at least two of the planar portions being positioned at an angle to the direction of air flow, the second heating element having substantially planar portions aligned with one another, at least two of the planar portions of the second heating element being positioned at a second angle to the direction of air flow.

18. The air intake heater of claim 17 wherein the first heating element portions are positioned at an angle to deflect the flow in a first direction substantially perpendicular to the direction of air flow.

19. The air intake heater of claim 18 wherein the second heating element portions are positioned at an angle to deflect the flow in a direction opposite the first direction.

20. The air intake heater of claim 19 wherein the first and second heating elements are serpentine in shape.

21. The air intake heater of claim 17 wherein at least one planar portion of the first heating element forms an angle with at least one planar portion of the second heating element ranging between thirty and one hundred and twenty degrees.

22. A quick temperature rise air intake heater for use in an internal combustion engine having an intake defining a passage having a direction of air flow, the air intake heater comprising:

a heating element adapted to be positioned in a heat transfer relationship with the passage, the heating element having first substantially planar spaced apart portions, each first portion having a leading edge aligned along a first plane, the heating element having second substantially planar spaced apart portions, each second portion having a leading edge aligned along a second plane spaced apart from and substantially parallel to the first plane, each portion of the heating element being aligned with a gap formed between the first portions.

23. The air intake heater of claim 22 wherein the first and second heating element portions are oriented substantially parallel to one another and parallel to the direction of air flow.

24. The air intake heater of claim 23 wherein the heating element is serpentine in shape.

25. A method of cold starting a diesel fueled internal combustion engine having a quick temperature rise air intake heater, the method comprising:

determining the ambient air temperature;

simultaneously energizing the quick temperature rise air intake heater and cranking the engine if the ambient air temperature is below a predetermined value; and

heating intake air as it passes over the quick temperature rise air intake heater until the engine starts.

26. The method of claim 25 further including electrically connecting a capacitor to the air intake heater to selectively increase the power supplied to the heater during engine cranking.

27. The method of claim 26 further including outputting a signal indicative of the ambient air temperature to a controller and selectively controlling the output of the capacitor during engine cranking.

28. The method of claim 25 further including outputting at least 2000 watts from the heater during engine cranking.

29. The method of claim 25 further including positioning the air intake heater at the entrance to the intake port.

30. The method of claim 25 further including electrically connecting a plurality of heating elements in parallel.

31. The method of claim 25 further including positioning a cylindrically shaped outer surface of the air heater within a cylindrically shaped aperture upstream of the intake valves of the engine.

32. The method of claim 25 wherein the predetermined ambient air temperature is 10° F.

33. The method of claim 25 further including spacing apart a plurality of indentations on a surface of a heating element to cause turbulent air flow and increase the heat transfer from the heating element to the air passing over the heating element.

34. The method of claim 25 further including positioning a first heating element at a first position and a second heating element at a position downstream from said first position, said second heating element being spaced apart from said first heating element a distance great enough to place said second heating element in a substantially turbulent flow.

35. A method of cold starting a diesel fueled internal combustion engine having a quick temperature rise air intake heater, the method comprising:

determining the ambient air temperature;

energizing the quick temperature rise air intake heater if the ambient air temperature is below a predetermined value;

starting the engine within 5 seconds of heater initial energization; and

heating intake air as it passes over the quick temperature rise air intake heater to achieve a start.

36. The method of claim 35 further including outputting at least 2000 watts from the heater during engine cranking.

37. The method of claim 35 continuing to energize the quick temperature rise air intake heater after the engine has started.

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