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(54) **Title**: ROAD SURFACE DRYING APPARATUS

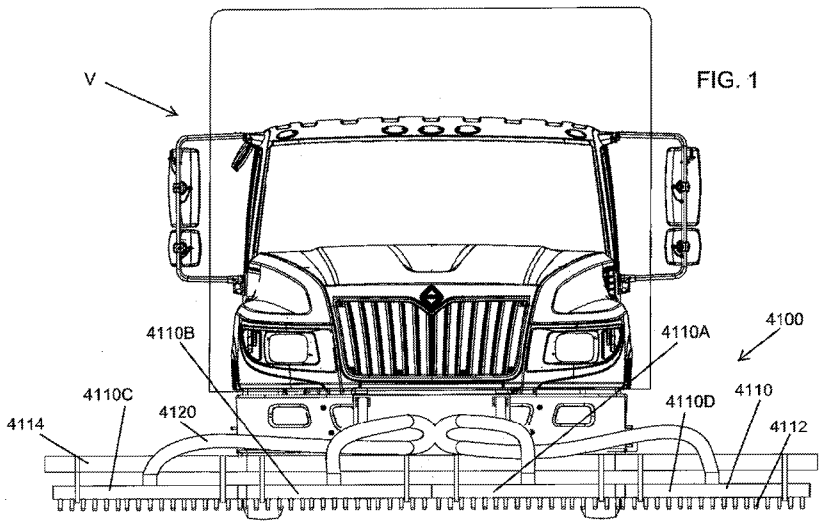

FIG. 1

(57) **Abstract**: Drying apparatus for drying a road surface prior to laying down asphalt includes an air jet for pushing liquid away from a road surface, and a heater for drying the road surface. The air jet removes standing water from the road surface and the dryer evaporates any residual moisture on the surface.

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ROAD SURFACE DRYING APPARATUS

[0001] BACKGROUND INFORMATION

[0002] FIELD OF THE INVENTION

[0003] The invention relates to road paving equipment. More particularly, the invention relates to a method of drying roadway prior to laying asphalt and equipment for practicing the same method.

[0004] DESCRIPTION OF THE PRIOR ART

[0005] When laying asphalt, the road surface must be very dry for the asphalt to bond properly with the substrate. If moisture has accumulated on the road surface, either from rain, dew, or melting snow or ice, or from some other event, the asphalting operation is held up until the road has dried. Most methods of drying a road surface entail blasting massive quantities of heated air onto the surface at a high velocity. Most systems using this method have no control over the temperature of the surface that is being heated, with the result that excessive heat can burn the surface and/or burn the asphalt. Such systems typically include jet engines, such as are used on racetracks, and burn at temperatures well above 1400 degrees Fahrenheit. In order to prevent damage to the surface, the engine has to be continually moving across the surface, so as not to overheat the surface. Efforts to solve this problem include limiting the air temperature to 300 degrees Fahrenheit, but that severely limits the drying capability and makes it very time-consuming to evaporate standing water from the road.

[0006] Drying a road surface with heated air is generally inefficient, especially when the jet engine is required to move at a relatively high velocity across the surface. The jet engines used to dry racetracks, for example, burn 150 – 200 gallons of fuel per hour. The heated air is on the surface for only a short period of

time, before it moves into the surrounding air and is then wasted, with regard to heating the surface.

[0007] Typically, the efficiency of a fuel-burning heater, i.e., a burner, is limited to close to its rated capability. The ability to reduce burner output is very limited. For example, the output may be reduced to 70% of the rated capacity in some fuel-burning heaters, but any further reduction may extinguish the burner. In order to reduce the output to less than the 70%, for example, the burner may have to cycle on and off, which is an inefficient way to operate a burner. Furthermore, when the burner output is reduced, heat may be uneven, resulting in hot and cold spots.

[0008] Fuel-burning heaters are also very susceptible to wind. When using a propane heater, for example, heat is produced by burning gas being forced over a volume of air at low pressure. If there is airflow in a direction opposite the direction of flow of the burning gas, the gas will either not flow out or not burn. This results in spotty heating, with hot and cold spots.

[0009] Other efforts to dry a road surface include vacuuming the water from the surface. US Patent Application 2010/0024242 A1 discloses mobile surface drying apparatus that uses a combination blower/vacuum assembly to dry the road surface. One of the disadvantages of the apparatus is that, when using a vacuum head to suction water off the road surface, the vacuum head must be placed very close to the road surface. Road surfaces are typically uneven, which means that the vacuum head has to be placed high enough above the surface to ensure clearance of the highest points, and that leads to inconsistent results. Some areas are free of water, others not, because the vacuum head is positioned too far away from low points in the surface.

[0010] What is needed, therefore, is a method of and system for drying a road surface. What is further needed is such a method that is energy efficient and effective in removing moisture from the surface and from the surrounding air.

BRIEF SUMMARY OF THE INVENTION

[0011] The invention is a method of drying a road surface and apparatus for implementing the method. A road surface must be completely dry before asphalt can be laid down. It rains frequently in many geographic areas, for example, in New England, so that often a road is too wet to lay down the asphalt. It is often desirable to mechanically dry the surface, so as not to hold up asphalting activities. The drying apparatus according to the invention comprises an air-stream unit and a heater unit that are spaced apart from each other and that are both mounted on a vehicle that travels over the road surface. The air-stream unit is mounted on the front end of the vehicle and has an air knife that provides a continuous wall of air that pushes any water on the roadway in advance of the vehicle and/or off to the side. The heater unit is mounted at the rear end of the vehicle with one or more heaters mounted so as to direct heat downward onto the road surface. The heaters effectively dry any residual moisture on the road surface. Ideally, a paving vehicle follows close behind the drying apparatus to lay down the asphalt.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention is described with reference to the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0013] **FIG. 1** is an illustration of an air knife mounted on a conventional vehicle.

[0014] **FIG. 2** illustrates an air jet for moving liquid away from the road surface.

[0015] **FIG. 2A**

[0016] **FIG. 2B**

[0017] **FIG. 3** illustrates drying heaters mounted on the underside if the backend of the trailer shown in **FIG. 1**, and lowered to a deployed position for heating the road surface.

[0018] **FIG. 4** is a side view of the drying heaters, retracted to a non-deployed position.

DETAILED DESCRIPTION OF THE INVENTION

[0019] The present invention will now be described more fully in detail with reference to the accompanying drawings, in which the preferred embodiments of the invention are shown. This invention should not, however, be construed as limited to the embodiments set forth herein; rather, they are provided so that this disclosure will be complete and will fully convey the scope of the invention to those skilled in the art.

[0020] **FIGS. 1 – 4** illustrate dryer apparatus **4000** for drying a road surface. Asphalt will not properly adhere to a wet or damp surface. For this reason, a drying procedure is carried out before the asphalt is laid down and the seam sealing apparatus **1000** employed to seal an asphalt seam. The drying apparatus **4000** according to the invention is mounted on a vehicle **V** that travels along the roadway. It is shown in the figures as mounted on a conventional vehicle, such as a tractor trailer rig, but it may also be mounted on a vehicle specially constructed for it, for example, a vehicle that is a wide as a conventional lane, or on the seam-sealing roller vehicle **3000** shown above, or on a truck. The vehicle carrying the drying

apparatus will simply be referred to hereinafter as a vehicle **V**, regardless of the type of vehicle that is used.

[0021] The drying apparatus **4000** is mounted on the vehicle **V** and includes apparatus for a two-step process for obtaining a dry road surface. The first step is to push liquid, i.e., water, oil, other liquids, away from the road surface; the second step is to follow up with a dryer, to ensure that the surface is completely dry. Typically, the liquid being removed from the road surface is water, and, although the drying apparatus **4000** may be used to remove other types of liquid from the road surface, the term "water" will be used hereinafter and shall be understood to include other types of liquid.

[0022] The drying apparatus **4000** comprises an air-stream unit **4100** and a heater unit **4200**. The air-stream unit **4100** includes an air jet or air knife **4110** and a power unit (not shown) to force a strong stream of air or other gas through a plurality of jets **4112**, so as to distribute the stream of air across the width of the air knife **4110**. The air stream is powerful enough to push liquid across the surface and the jets **4112** are directed at an angle to the vertical plane, so as to move the liquid in advance of the vehicle. As shown in the figures **9** and **11**, the air knife **4110** is mounted on the front end and the heater unit **4200** on the rear end of the vehicle **V**. As the vehicle **V** travels across the roadway, the air knife **4110** pushes the liquid forward along the road surface, leaving behind a surface that does not have pools or drops of liquid on the surface, but that might still have some moisture on it. The air stream from the jets **4112** effectively provides a continuous wall of air that is projected downward, so that, even if there are irregularities in the road height, such as, for example, shallow hollows in which water can collect, the air stream will reach the hollow and force the water out. The air knife **4110** may be adjustable in width, so that it can be extended out to one or both sides of the vehicle **V**. It may also be tiltably mounted, so that it pushes the water in front of and off to one side of the road

surface, so that the water can flow into the ditches that are typically provided alongside roadways.

[0023] Forward travel of the vehicle **V** now carries the heater unit **4200** over the surface just cleared of water. The heater unit **4200** includes one or more heaters **4210** have and ideally has a width that corresponds approximately to the width of the air knife **4120**. The heaters **4210** are movably mounted under the back end of the vehicle **V** and direct heat downward onto the road surface. **FIG. 3** and **4** show two heaters **4210** mounted on the vehicle **V**, in a lowered position, ready for deployment, and in a raised position.

[0024] As can be seen in **FIG. 1**, the air knife **4110** of the air-stream unit **4100** is height-adjustably mounted on the bumper of the vehicle **V** so that the tips of the air jets **4112** may be lowered to an operational position that is several inches above the road surface or raised to a deployed position that is a distance from the ground that ensures high clearance from the ground. When lowered to the operational position, the jets are brought close enough to the ground to provide sufficient space to avoid interference due to irregularities in the height of the road surface, yet be low enough to provide a stream of air that effectively moves the water along the surface. Details of the air-stream unit **4100**, i.e., the power unit and the hoses and connectors are not shown or described in any detail, because such units are widely known and a person of skill in the art will know how to implement an air-stream unit that has sufficient power to achieve the desired results. **FIG. 1** does show hoses **4120** that are connected directly to the air knife **4110**. In the embodiment shown, the air knife **4110** is constructed in sections **4110A – 4110D**, with a hose **4120** feeding air to each section. The sections **4110A** and **B** extend approximately the width of the vehicle **V**, whereas the sections **4110C** and **D** are wing sections that may be folded out, to one or both sides of the vehicle **V**, as needed, so as to extend across the full width of a road lane, i.e., 14 feet, and folded back in toward the center of the vehicle

when the extra width is not desired. **FIG. 3** shows the air knife **4110** folded in front of the vehicle, recognizable by the double row of air jets **4112**.

[0025] **FIGS. 2**, **2A**, and **2B** illustrate an industrial air knife, such as the one used in this air-stream unit. **FIG. 2** is a front plane view, **FIG. 2A** a side plane view, and **FIG. 2B** a perspective view. Such industrial air knives are typically manufactured to desired specifications. An example of a suitable air knife is one that is manufactured by JetAir Technologies, LLC of Ventura, California.

[0026] **FIGS. 3** and **4** show a partial cut-away side elevation view of the vehicle **V**, fully equipped with the air-stream unit **4100** and the heater unit **4200**. **FIG. 3** shows the air-stream unit **4100** and the heater unit **4200** in their respective deployed positions and **FIG. 4** shows the units retracted to their stowed positions. Depending on the intended application of the dryer apparatus **4000**, the heater unit **4200** is mounted to the rear of the vehicle, behind the air-stream unit **4100**. The heater unit **4200** includes one or more heaters **4210** that are mounted so as to provide heat to the road surface, and are preferably configure to provide heat for the width of the air knife **4110**. The heaters are preferably radiant energy heaters, as described above with the heaters **200**, whereby the term "radiant energy heater" includes infrared heaters, resistive heaters, microwave heaters, and any suitable heater that generates heat by radiation, i.e., by transmitting a stream of photons or particles through air. The heaters **45210** are preferably mounted hydraulically, so as to be movable in the vertical direction. Extra heaters **4210** may be mounted on the sides of the vehicle **V** to accommodate the width of an air knife **4110** that extends out beyond the side boundaries of the vehicle.

[0027] As mentioned above, the heaters are preferably infrared heaters, either electric or fuel powered, and more preferably electric infrared heaters. Infrared heaters have not been hitherto used to dry road surfaces, because it is known that water does not absorb the wavelengths of infrared energy very well. Standing water

is more likely to reflect the energy, rather than absorb it. The combination of the air-stream unit **4100** and the infrared heater **4210**, however, eliminates this difficulty. The air-stream unit pushes standing water away from the surface area over which the infrared heater travels. Removing the standing water reduces the amount of water to be evaporated and, consequently, reduces the amount of energy required. The thin layer of moisture that remains on the surface is not sufficient to reflect the energy and, therefore, does not interfere with the radiant heat from the heater **4210** penetrating into the surface to heat it sufficiently to evaporate the water.

[0028] Electric infrared heaters are preferred, because of the ability to control the output across the full range extending from 0 to 100% output, all the while maintaining even heat across the heater. The intended use of the drying apparatus **4000** is to dry road surfaces prior to laying down a layer of surfacing material. Asphalt has been mentioned previously as the surface layer, but, in reality, other layer materials are also used to pave roads. For example. when paving a bridge, a waterproofing membrane is laid over the concrete bridge and asphalt on top of the waterproofing membrane. Before each layer is put down, the underlying layer needs to be dried, to ensure a good bond between the layers. Thus, the concrete bridge surface is dried, the waterproofing membrane laid over the concrete and dried, and then the asphalt. laid down. Each of these materials can withstand heat to a different degree and wavelength. The waterproofing membrane, for example, is extremely sensitive to heat. The ability to change the output, i.e., to reduce the wavelength and temperature to, for example, 100 degrees Fahrenheit, without losing efficiency, enables each layer to be dried completely at the appropriate temperature and wavelength, thereby avoiding damage to the layer by applying excessive heat.

[0029] The ability to carefully control the output of the radiant energy heater **4210** also allows the drying apparatus **4000** to move at various speeds, or even to come to a halt, during the heating operation, without overheating or underheating the

surface. As the drying apparatus **4000** slows down, the output of the radiant energy heaters **4210** is reduced accordingly, and when the apparatus comes to a stop, the radiant energy heaters **4210** will provide just enough energy to maintain the desired temperature, without cycling the heaters on and off and without losing any efficiency when operating at less than full capacity.

[0030] A temperature control system **4230** is used to continuously monitor and adjust the temperature of the radiant energy heaters**4210**, rather than simply timing the heaters on and off, as must be done with propane heaters, to maintain the desired temperature. The temperature control system **4230** allows digital selection of the desired road surface temperature. An infrared sensor is placed a certain distance above the road surface and measures the surface temperature. Data from the sensor is used by the temperature controller **4230** to send a signal to a power regulator to increase or decrease the heat output of the radiant energy heaters. This method of temperature control avoids an overheating of the surface, something that may happen with other types of heaters.

[0031] A control mechanism **4212** may be used to control the height of the heaters **4210** when they are lowered to a deployed position. In the embodiment shown, the control mechanism **4212** is a wheel **4213** mounted at the end of a hydraulic arm **4214**. The heaters **4210** are offset a predetermined distance from the wheel **4213**. When the wheel **4213** touches the ground, the hydraulic system stops lowering the heaters **4210**, thereby bringing the heaters to a predetermined distance above the road surface.

[0032] The radiant energy heaters **4210** heat the surface directly, thereby raising the temperature of the surface above the dew point, which effectively prevents moisture from forming on the surface. This is important when working under conditions of high humidity and particularly in cool, humid air, when the dew point is high. In night-time paving operations, for example, the dew point is higher than the

temperature of the surrounding surface. Under these conditions, when drying apparatus moves away from the dried surface, the surface is exposed to the cool, moist air at a time when there is no sun to dry or heat up the surface and, as a result, moisture collects on the surface. The heater unit **4200** according to the invention not only dries the surface, but raises the temperature of the surface to a safe, desired temperature that is well above the dew point, effectively preventing the moisture from collecting on the surface for an extended period of time.

[0033] The drying apparatus **4000** may also be used to dry an asphalt tack coat in cool humid conditions. The asphalt tack coat is a water-asphalt emulsion that acts as a glue to bond layers of pavement together. It is heated in a tank and sprayed onto a surface. The water in the emulsion has to evaporate out for the asphalt tack coat to set properly. The drying apparatus **4000** aids in curing this asphalt tack coat by pre-heating the surface, so that the asphalt tack coat is sprayed onto a warm, dry surface. It is also foreseeable, to run the drying apparatus behind the vehicle spraying the asphalt tack coat, to facilitate curing the coat in less than ideal paving conditions. The asphalt tack coat is very sensitive to intense heat, as it readily absorbs heat and may boil away when exposed to excessive heat. The intensity of the air knife **4100** as well as the temperature output of the heater unit **4200** are both adjustable to the specific surface material and paving conditions, making the drying apparatus **4000** particularly well-suited for this operation.

[0034] A diesel engine/generator **4300** is used to power the hydraulic and electrical systems that operate the air-stream unit **4100** and the heater unit **4200**. To aid in the drying process, hot dry air from the diesel engine is captured in a duct **4310** and directed through an opening in the floor of the vehicle down and across the area beneath the heaters **4210**. Using just the heaters alone, in a situation with no air movement, the moisture that evaporated by the heaters remains trapped under the heaters. The air beneath the heaters becomes saturated with this

moisture, to the point where they are not able to hold or remove the moisture. This inhibits the drying process significantly, because there is no place for the moisture to go. The hot dry air sweeping beneath the heaters transports the moist air out from under the heaters and away from the drying site. This synergistic effect of simultaneously heating the surface and sweeping hot dry air between the surface and the heaters effectively removes moisture from the drying area, thereby increasing the drying capability of the drying apparatus **4000**.

[0035] Hydraulic systems, temperature control systems, and diesel-generator sets are well known and it is not necessary to disclose details of these systems.

[0036] The intended configuration of vehicles for an asphalting operation is to have the vehicle **V** dry a road surface with the drying apparatus **4000**. Following closely behind the vehicle **V** with the drying apparatus is the paver **2000** that is laying down the asphalt. Following closely behind the paver is a vehicle carrying the seam sealer **1000**. This intended use is, however, not limiting. Other uses of the apparatus are within the scope of the invention. For example, the apparatus **4000** may be used to keep airport runways clear of ice and snow. In this case, the radiant heaters may be mounted forward of the air knife, so that any snow or ice is first melted and then pushed to the side by the air knife, which is mounted behind the heaters.

[0037] It is understood that the embodiments described herein are merely illustrative of the present invention. Variations in the construction of the seam sealer may be contemplated by one skilled in the art without limiting the intended scope of the invention herein disclosed and as defined by the following claims.

WHAT IS CLAIMED IS:

Claim 1: A method of drying a road surface prior to laying down asphalt, the method comprising the steps of:

a) applying a stream of gas to the road surface to remove liquid from an area of the road surface; and

b) subsequent to removing the liquid, applying radiant heat to remove residual moisture from the road surface.

Claim 2: The method of claim 1, wherein step b) includes the steps of:

b1) using a radiant energy heater for supplying radiant heat;

b2) providing a engine-generator to power the radiant energy heater;

b2) capturing heat from the engine-generator; and

b3) directing the captured heat to an area around the radiant energy heater, so as to remove moisture from ambient air above the road surface.

Claim 3: The method of claim 1, wherein the step of applying the stream of gas includes mounting an air knife on a vehicle and driving the vehicle over the road surface to be dried.

Claim 4: The method of claim 3, wherein the step of applying radiant heat includes mounting infra-red heaters on the vehicle in a location rearward of the air knife.

Claim 5: Apparatus for drying a road surface, the apparatus comprising:

a radiant energy heater;

a power generator for heating the radiant heater;

an air knife that provides a forceful stream of gas; and

a compressor for supplying the gas to the air knife;

wherein the air knife and radiant energy heater are employed to remove liquid from a road surface and to dry the road surface.

Claim 6: The apparatus of claim 5, further comprising:
a hydraulic system for raising and lowering the radiant energy heater.

Claim 7: The apparatus of claim 5, further comprising:
a hydraulic system for raising and lowering the air knife.

Claim 8: The apparatus of claim 5, wherein the gas is compressed air.

Claim 9: The apparatus of claim 5, further comprising a vehicle for traveling across the road surface, wherein the air knife is mounted on a front end of the vehicle and the radiant energy heater is mounted at the rear end of the vehicle.

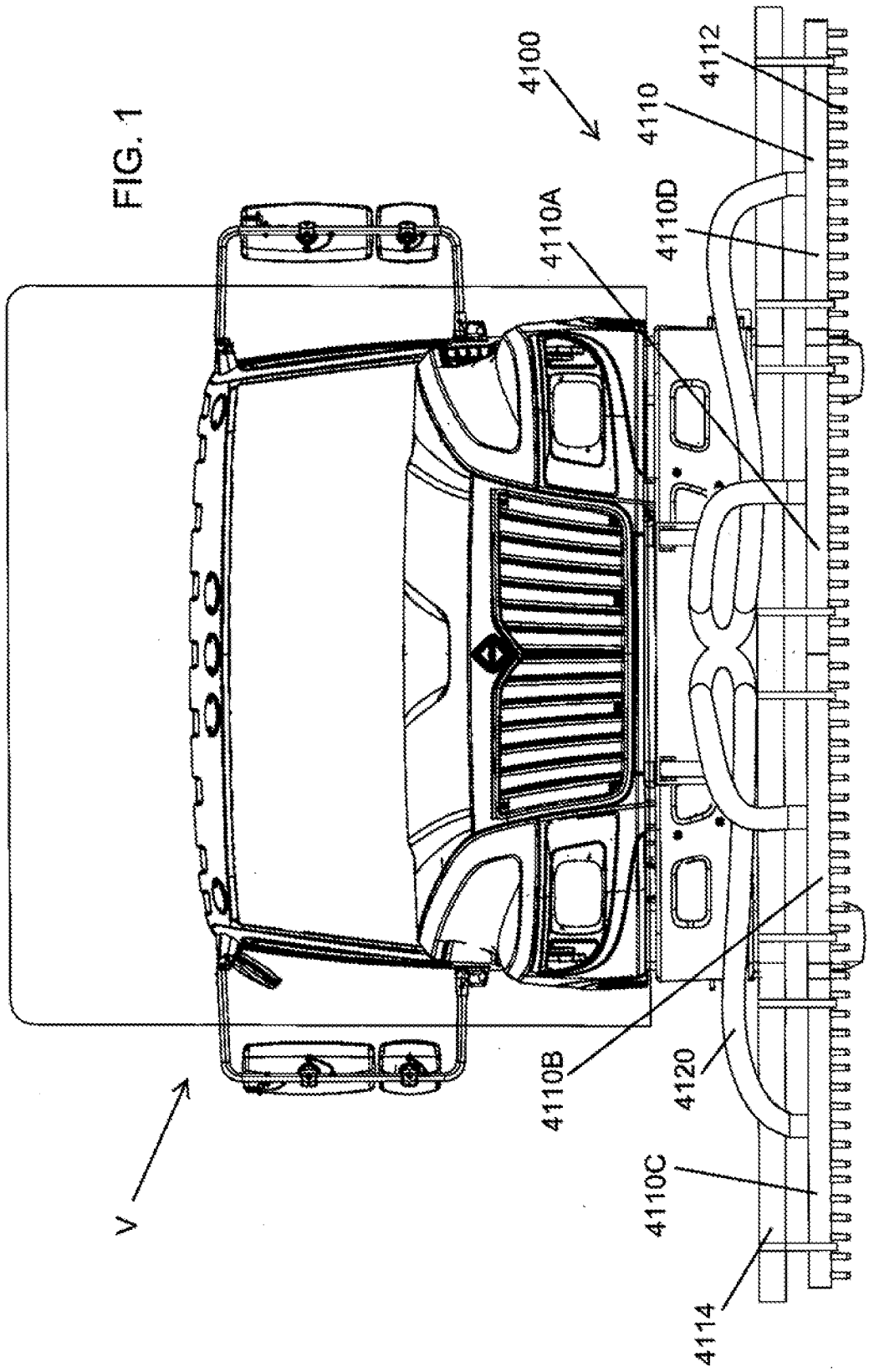
Claim 10: The apparatus of claim 9, wherein the radiant energy heater includes a plurality of radiant energy heaters.

Claim 11: The apparatus of claim 10, wherein each of the radiant energy heaters is individually height adjustable.

Claim 12: The apparatus of claim 5, wherein the air knife is adjustable in width so as to selectively extend beyond a first and a second side of the vehicle.

Claim 13: The apparatus of claim 5, further comprising a temperature control system for regulating a temperature output of the radiant energy heater.

FIG. 1



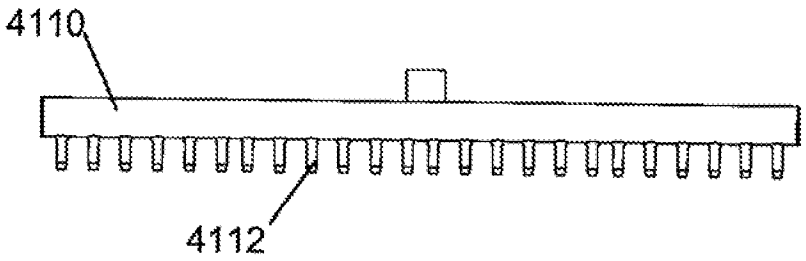


FIG. 2

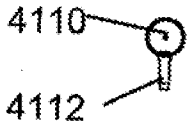


FIG. 2A

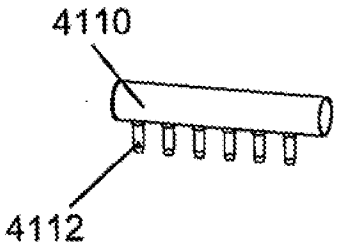


FIG. 2B

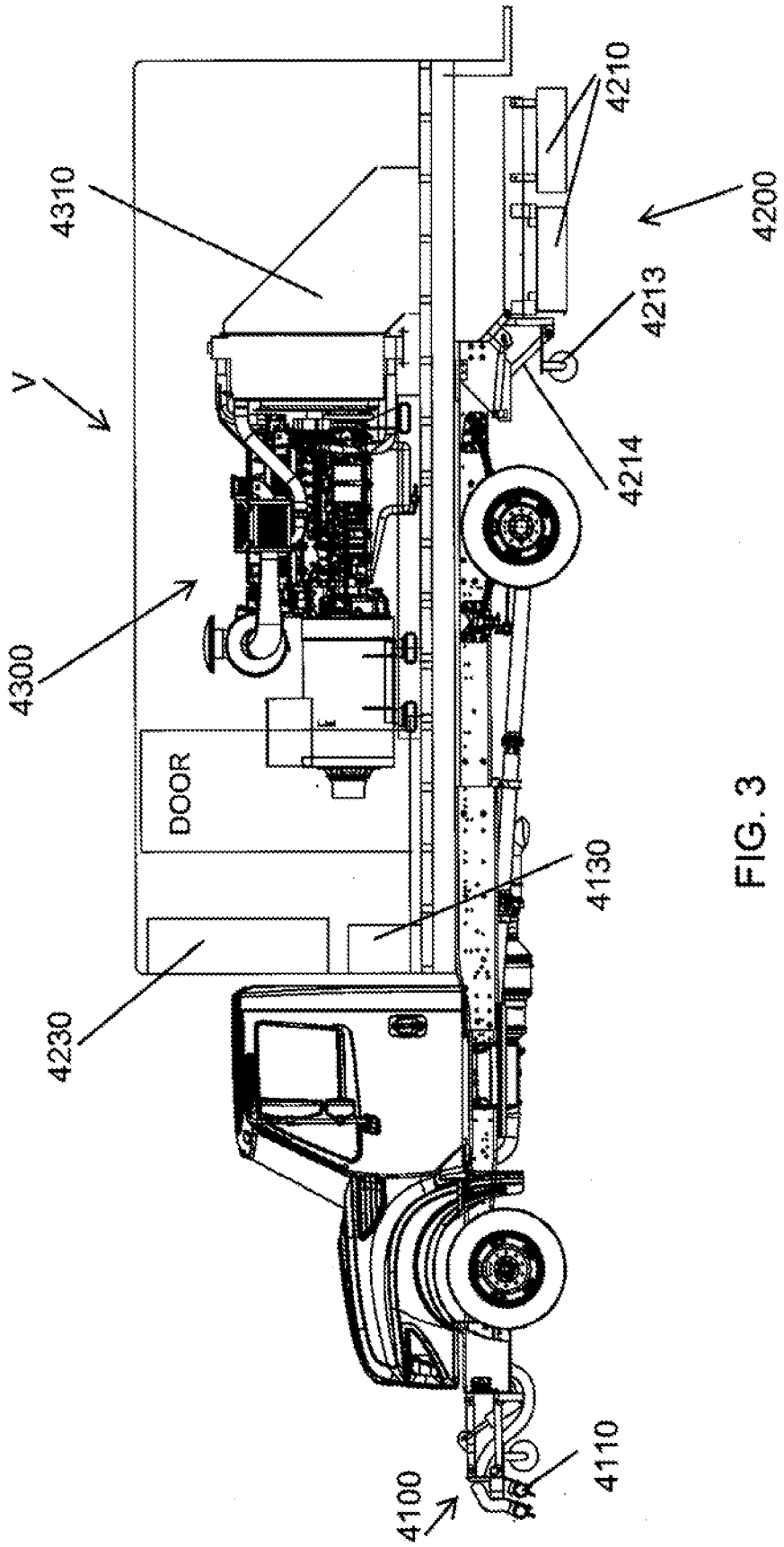


FIG. 3

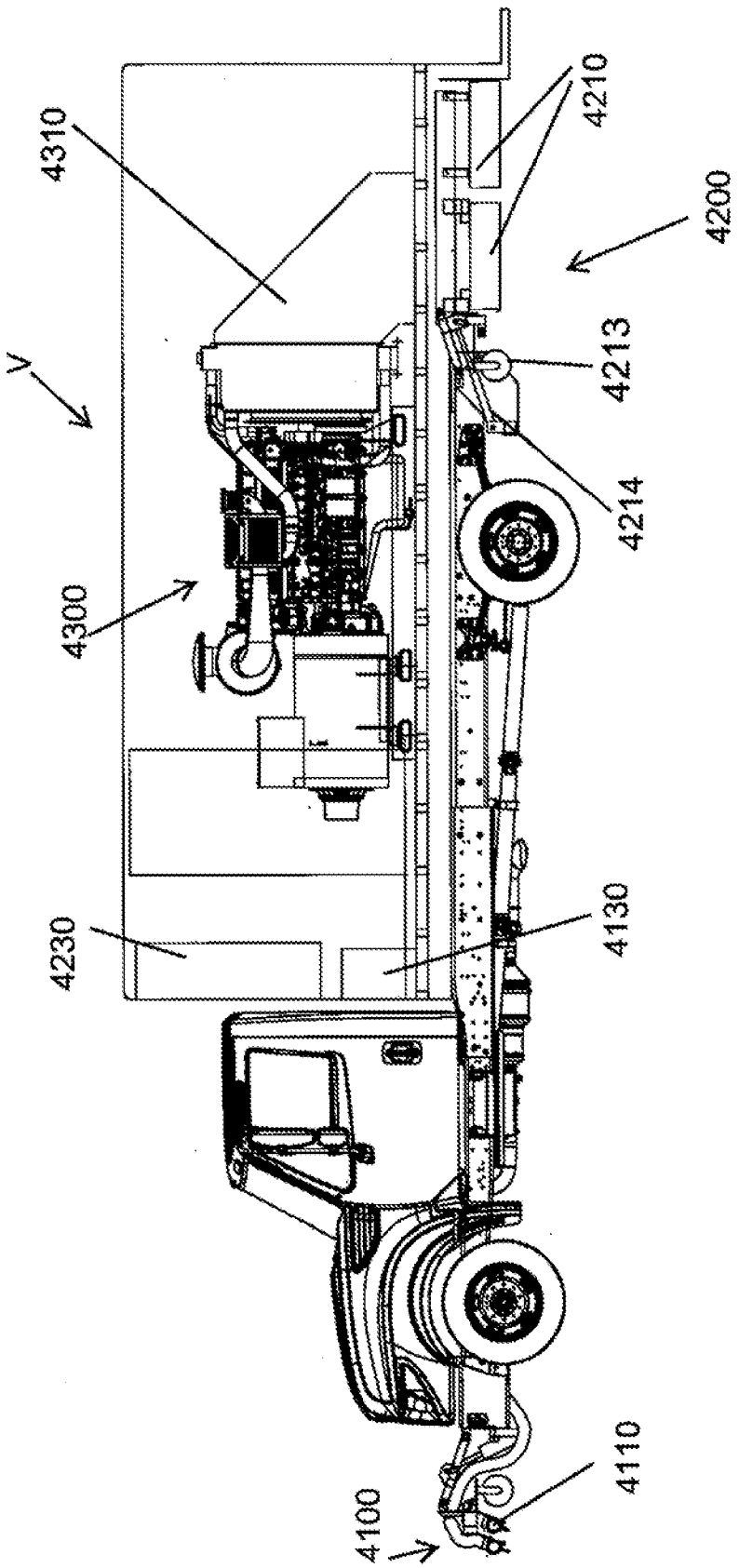


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/054157

A. CLASSIFICATION OF SUBJECT MATTER

E01C 23/14(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E01C 23/14; F26B 5/04; E01C 23/16; E01L 23/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords : drying apparatus, road surface, asphalt, gas, radiant heat, air knife, compressed air, compressor and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5653552 A (WILEY, PATRICK et al.) 5 August 1997	1
Y A	See column 7, line 49 - column 12, line 56 and figures 4A - B.	3,5,8 2,4,6-7,9-13
Y A	EP 0652998 B1 (S & S GMBH) 19 May 1994 See column 1, line 17 - column 3, line 4 and figure 1.	3,5,8 1-2,4,6-7,9-13
A	US 2010-0024242 A1 (FRIESEN, JOHN et al.) 4 February 2010 See paragraphs 0039, 0042, 0043 figures 4A - B, 7A - B.	1-13
A	US 4561800 A (HATAKENAKA, TOSHIKI et al.) 31 December 1985 See abstract, column 2, lines 27 - 56 and figure 1.	1-13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 JANUARY 2013 (28.01.2013)	**30 JANUARY 2013 (30.01.2013)**

Name and mailing address of the ISA/KR

Facsimile No. 82-42-472-7140

Authorized officer

CHOI, Hyun Goo

Telephone No. 82-42-481-8288

INTERNATIONAL SEARCH REPORT

Information on patent family members

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