(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 October 2018 (11.10.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/187579 A1

(51) International Patent Classification:
F01N 13/14 (2010.01) *F01N 13/18* (2010.01)
F01N 13/16 (2010.01)

(21) International Application Number:
PCT/US2018/026270

(22) International Filing Date:
05 April 2018 (05.04.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
201731012316 05 April 2017 (05.04.2017) IN

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) Title: THERMAL INSULATOR AND TIE ROPE FOR THERMAL INSULATOR FOR HIGH TEMPERATURE AREAS

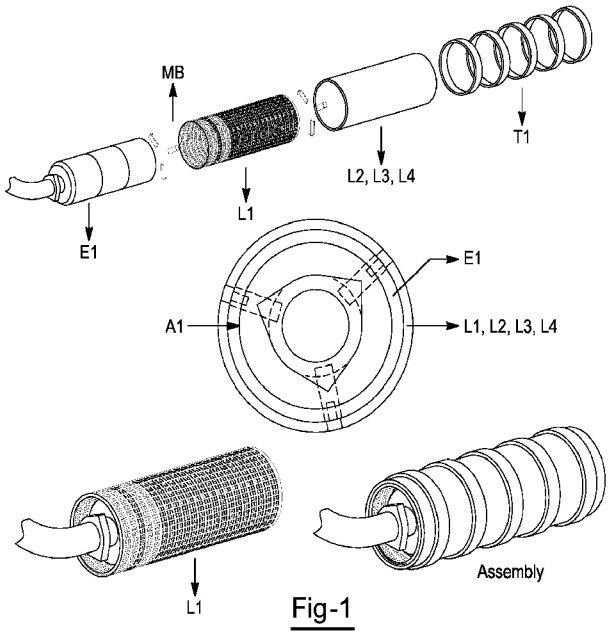

Fig-1

(57) Abstract: A thermal insulator and tie ropes for securing the thermal insulator onto a vehicle exhaust or any other heat source are disclosed. The insulator is non-stretchable, flexible, non¬ flammable and resistant to harsh temperature conditions, mud splashes and water. The thermal insulator comprising of a plurality of layers(L1-L8) ranging from three to eight, depending on area of application. The tie ropes (T1) that are of the type roller ball that may or may not be coated, and may either flat or adjustable type depending on application. These tie ropes (T1) aid in secure the thermal insulator in position and hold the insulator in place when the heat source (E1) is subjected to vibrations.

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EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

THERMAL INSULATOR AND TIE ROPE FOR THERMAL INSULATOR FOR HIGH TEMPERATURE AREAS

FIELD OF THE INVENTION

[001] The subject matter of the present invention, in general, pertains to thermal insulation, and more particularly to a thermal insulator and tie ropes for securing the thermal insulator over a high temperature heat source.

BACKGROUND OF INVENTION

[002] The use of thermal insulation for shielding components influenced by temperature, such as vehicle exhaust or the like (other heat sources), is generally known. In the typically one-piece, rigidly connected heat shields used traditionally, thermally related changes in length of the particular component influenced by temperature may result in failure. Under the influence of temperature, exhaust manifolds in particular may expand thereby causing stress on the heat shield at the region of its attachment that may lead to crack formation as the result of additional vibrations in the exhaust gas system.

[003] Reference is made to JP2001/347323 A, wherein a stationary heat shield is disclosed. It has a sandwich structure and a plurality of uniform or non-uniform patterns having a hill-and-valley shape. It is securely connected via screws to the component to be shielded. The heat shield has a one-piece design, and is essentially adapted to the shape of the component to be shielded. The disadvantage being that depending on the complexity of the component to be shielded, it is not always possible to provide a one-piece heat shield.

[004] Reference is also made to US 2016/0215676, wherein an exhaust system component of a motor vehicle that includes a gas-carrying housing, a heat shield seated on an outside of the housing, and at least one wire mesh provided at least partly between the heat shield and the housing are disclosed. The wire mesh includes a first attachment point and a second attachment point. The heat shield is attached to the housing via the wire mesh, and the wire mesh is attached to both the heat shield, via the first attachment

point, and to the housing via the second attachment point. The first attachment point is separate from the second attachment point.

[005] Reference is also made to WO 2000/022285 A1, wherein a heat shield for an exhaust system of a vehicle includes a resinified spaced layer fabric having at least one inner layer, at least one outer layer, and at least one spacer between the inner layer or layers and the outer layer or layers to form one or more insulation spaces is disclosed. The heat shield includes an emissivity reducing material. The insulation space is between about one and about eight millimetres thick, to reduce convective heat transfer.

[006] Reference is also made to US 2015/0267344, wherein a flexible heat shield with silicone elastomer and a topcoat for inflatable safety devices is disclosed. The heat shield, which is located within the fluid compartment, comprises a fabric layer and a thermal barrier layer located adjacent to the fabric layer. The thermal barrier layer includes at least one layer of silicone elastomer and one or more silicone topcoats.

[007] Reference is also made to KR 1020130043336, wherein an insulator using a multi-layered thin film which can increase a greenhouse heat protecting effect in the winter season, and can reduce an internal temperature by blocking solar radiation in the summer season, and which is formed by alternately laminating plastic films having low thermal conductivity and plastic meshes for forming internal air layers, and laminating a nonwoven fabric on the uppermost part facing sunlight to be light, increase the insulation effect, be convenient during work, blocking solar radiation and preventing internal heat from being discharged to the outside to increase the heat protecting effect of a greenhouse to have an advantage of reducing fuel costs and personnel expenses.

[008] Reference is also made to WO 2014/160665, wherein a thermally insulated component comprising a structure having a heated interior and an exterior, and a thermal insulating structure for thermally insulating at least a portion of the exterior of the component structure is disclosed. The thermal insulating structure comprises an aqueous mixture comprising an inorganic binder and inorganic filler particles, and a fabric comprising inorganic fibers. The fabric is impregnated with the aqueous mixture so as to form a pliable binder structure. The pliable binder structure is disposed completely

around at least a portion of the component structure. It can be desirable for the component to further comprise at least one thermal insulator comprising inorganic fibers, where the thermal insulator is disposed between the pliable binder structure and the exterior of the component structure.

[009] Reference is also made to WO 2014/194873, wherein an external contact thermal insulation system is disclosed. The insulator comes in the form of rigid polyurethane sheets glued to the wall by means of a diffusion-permeable adhesive cement with an admixture of polyurethane fraction. From the outside, the layers are providing a diffusion- permeable levelling cement with an admixture of polyurethane fractions, applied through a mesh of glass fabric. The layer of levelling cement is applied a bonding primer and a layer of visible silicone or silicone-silicate or silicate plaster.

[0010] While the above mentioned prior art documents describe thermal insulators or heat shields that address one of the concerns by using either expandable/stretchable/metallic type heat-shields. The conventional thermal insulators and ties are found to have inherent problems that are multi-fold in nature owing to the harsh conditions they are subjected to. They tend to disintegrate faster requiring frequent replacements that tend to add to the overall maintenance costs. Further, the state of art heat-shields are normally used as barriers to avoid the direct heat from the source to the parts in proximity, *e.g.* heat-shields made out of Aluminium sheets. Others are used for specific target based applications, such as in the engine compartments or over the cat-con to diffuse or reflect the heat from the source.

[0011] Therefore, there is a need for a thermal insulator with tie ropes that are made up of flexible materials, bonded together by stitching, so as to get the inherent properties of a layered material together to perform either absorption or retention of the excessive heat from the source.

[0012] To overcome the said drawbacks, the subject invention discloses a thermal insulation product with superior heat resistance properties and depending upon the functional requirements, can be used to either absorb or retain the excessive heat from high temperature sources. It is non-stretchable, comprising of three to eight layers and tie ropes of roller ball type for use in vehicle exhausts, engine manifold, AC coaches,

genset and other high temperature zones. The tie ropes not only secure the thermal insulator in the position but also aids in holding the product in place while experiencing vibrations in the exhaust systems.

SUMMARY OF THE INVENTION

[0013] The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the present invention. It is not intended to identify the key/critical elements of the invention or to delineate the scope of the invention. Its sole purpose is to present some concept of the invention in a simplified form as a prelude to a more detailed description of the invention presented later.

[0014] An object of the present invention is to provide a thermal insulation and a tie rope for securing the insulation over a high temperature heat source.

[0015] Another object of the present invention is to provide a thermal insulation that can be used in medium to high temperature areas for optimal thermal management. The effective temperature ranges from 300 ºC to 1000 ºC. It is also possible to consider for below 300 ºC temperature depending upon functional requirements.

[0016] Another object of the present invention is to retain the temperature of the exhaust to control particulate emission norms.

[0017] Another object of the present invention is to protect the parts in proximity of the exhaust/high temperature systems.

[0018] Another object of the present invention is to provide consistent temperature drop over the layers from high temperature resistant layer to aesthetic layer.

[0019] Another object of the present invention is to have a layered structure with low thermal conductivity to achieve high thermal performance.

[0020] Another object of the present invention is to provide better flex properties, in addition to anti-friction and air-pockets for superior circulation/retention of heat and vibration resistance.

[0021] Yet another object of the present invention is to provide a thermal insulator that is non-toxic with excellent hot strength, doesn't burn and very low shrinkage capabilities.

[0022] Accordingly, in one aspect of the present invention, a thermal insulator exhibiting superior heat resistance properties and based on functional requirements can be used to absorb or retain excessive heat from high temperature sources thereby finding effective application in medium to high temperature ranges for optimal thermal management, *i.e.* to retain the temperature of a vehicle exhaust thereby controlling particulate emission norms while also protecting the parts in proximity of the vehicle exhaust or other heat sources is disclosed. It is non-stretchable and may comprise of three to eight layers based on area on application that ranges from vehicle exhausts, to engine manifolds, to AC coaches, to genset and other high temperature zones.

[0023] In another aspect, tie ropes for secure the thermal insulator in the position and holding the insulator in place while experiencing vibrations in the exhaust systems is disclosed. These ties are of roller ball type, with or without coating and may be flat or adjustable type for use in vehicle exhausts, engine manifold, AC coaches, genset and other high temperature zones.

[0024] Briefly, a thermal insulator and tie ropes for securing the thermal insulator onto a vehicle exhaust or any other heat source are disclosed. The insulator is non-stretchable, comprising of a plurality of layers, depending on area of application and tie ropes that are of the type roller ball, with or without coating, and may either flat or adjustable type. These tie ropes aid insecure the thermal insulator in position and hold the insulator in place when subjected to vibrations.

[0025] Other aspects, advantages, and salient features of the invention will become apparent to those skilled in the art from the following detailed description, which,

taken in conjunction with the annexed drawings, discloses exemplary embodiments of the invention.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The above and other aspects, features, and advantages of certain exemplary embodiments of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings in which:

[0026] Figure 1 illustrates a typical application wherein the thermal insulator is secured around an exhaust according to one implementation of the present invention.

[0027] Figure 2 illustrates the four- and 6-layer structure according to one implementation of the present invention.

[0028] Figure 3 illustrates the eight-layer structure according to another implementation of the present invention.

[0029] Figure 4 illustrates the tie ropes for securing the thermal insulator according to another implementation of the present invention.

[0030] Persons skilled in the art will appreciate that elements in the figures are illustrated for simplicity and clarity and may have not been drawn to scale. *For example*, the dimensions of some of the elements in the figure may be exaggerated relative to other elements to help to improve understanding of various exemplary embodiments of the present disclosure. Throughout the drawings, it should be noted that like reference numbers are used to depict the same or similar elements, features, and structures.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0031] The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments of the invention. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary.

[0032] Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope of the invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

[0033] The terms and words used in the following description and claims are not limited to the bibliographical meanings, but, are merely used by the inventor to enable a clear and consistent understanding of the invention. Accordingly, it should be apparent to those skilled in the art that the following description of exemplary embodiments of the present invention are provided for illustration purpose only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

[0034] It is to be understood that the singular forms "a", "an", and "the" include plural referents unless the context clearly dictates otherwise.

[0035] By the term "substantially" it is meant that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations, including *for example*, tolerances, measurement error, measurement accuracy limitations and other factors known to those of skill in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide.

[0036] Features that are described and/or illustrated with respect to one embodiment may be used in the same way or in a similar way in one or more other embodiments and/or in combination with or instead of the features of the other embodiments.

[0037] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or component but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

[0038] The subject invention lies in providing a thermal insulator and a tie rope for securing the thermal insulator over vehicle exhausts or high temperature sources.

[0039] In the present invention, a thermal insulator and tie ropes wherein the thermal insulator is non-stretchable, comprising three to eight layers, depending on area of application. The tie ropes are roller ball type, with or without coating, and either flat or adjustable type. The tie ropes aid in secure the thermal insulator in position and hold the product in place while it experiences vibrations.

[0040] In one implementation, a thermal insulator exhibiting superior heat resistance properties is provided for.

[0041] In one implementation, a thermal insulator that based on functional requirements may be used to either absorb or retain excessive heat from high temperature sources is provided for.

[0042] In one implementation, a thermal insulator for effective application in medium to high temperature ranges for optimal thermal management is provided for. In particular, the effective temperature ranges from 300 ºC to 1000 ºC. It is also possible to consider for below 300 ºC temperature depending upon functional requirements.

[0043] In one implementation, a thermal insulator to retain the temperature of a vehicle exhaust for controlling particulate emission norms is provided for.

[0044] In one implementation, a thermal insulator for protecting the parts in proximity of the vehicle exhaust or other heat sources is provided for.

[0045] In one implementation, the thermal insulator is non-stretchable and flexible is provided for.

[0046] In one implementation, tie ropes for secure the thermal insulator in the position and holding the insulator in position when subjected to vibrations is provided for.

[0047] In one implementation, the ties ropes are of roller ball type that may or may not be coated is provided for.

[0048] In one implementation, the tie ropes may be flat or adjustable type is provided for.

[0049] The thermal insulator exhibits superior heat resistance properties and based on functional requirements may be used to either absorb the excessive heat from the high temperature source or retain the excessive heat from the high temperature source. The thermal insulator provides optimal thermal management in medium to high temperature range applications. It aids in retaining the temperature of a vehicle exhaust to acceptable limits thereby controlling the particulate emission norms while also protecting the parts in proximity of the vehicle exhaust or other heat sources. This thermal insulator is non-stretchable, flexible and may comprise of three to eight layers based on its area of application.

[0050] The tie ropes for secure the thermal insulator in the position and holding the insulator in place is of roller ball type, may be with or without coating and may be flat or adjustable type depending on area of application.

[0051] Figure 1 illustrates a typical application of the thermal insulator and tie ropes for the insulator, wherein the thermal insulator is secured around a vehicle exhaust with an air-gap that provides high temperature sustainability. In a similar manner the thermal insulator may be mounted on vehicle exhausts, or engine manifolds, or AC coaches, or genset and any other similar other high temperature zones and held in position with the aid the tie ropes. L1, L2, L3 and L4 are the various layers of the thermal insulator, E1 is the heat source unit, T1 are the SS tie ropes and A1 indicates the air gap.

[0052] Figure 2 illustrates the four and six layered structure wherein the first layer is in contact with heat-source and the last layer is the aesthetic layer. The essential layers of the thermal insulator are a stainless steel wire-mesh (L1), a high temperature resistant layer which could be of coated or high silica cloth or ceramic flex (L2), a substrate (L3) comprising a plurality of ceramic fibers, and an aesthetic layer (L4). The thermal insulator may also contain other intermediate layers depending on area of application. A six-layer structure comprises of are a stainless steel wire-mesh (L1), a coated or high silica cloth

or ceramic flex (L2), a substrate (L3), an intermediate layer (L4), another substrate layer (L5) and an aesthetic layer (L6).

[0053] Figure 3 illustrates the eight six layered structure wherein the first layer (L1) is in contact with heat-source and the last layer is the aesthetic layer (L8). The wire mesh (L1) is followed by a high temperature resistant layer (L2), followed by multiple layers of substrate-intermediate layers (L3-L7), and topped off with the aesthetic layer (L8). Notably, its composition is similar to the six layered structure and contains two extra intermediate layers. The number of intermediate layers depends on the area of application of the thermal insulator.

[0054] The first layer is a stainless steel wire-mesh layer that provides protection for the overlying layers and substrate materials. It provides anti-friction properties, creates air pockets and assists in circulation of the heated air. Notably, a coated glass cloth or an aluminium coated or a graphite coated glass cloth may also be used as a first layer.

[0055] The second layer is a high temperature silica cloth or ceramic flex is a high temperature resistant fabric that can resist temperatures ranging up to 1100 ºC when subjected to continuous exposure. It absorbs a proportion of the directed source temperature. It acts as facing layer to the heat-source and has good sustainability from -30 ºC to 1100 ºC. It is non-flammable, non-toxic, has excellent hot strength and low shrinkage properties.

[0056] The substrate comprises of a plurality of ceramic fibers that may be available in the form of paper/blankets depending upon usage. This is a high temperature resistance blanket/paper that resists temperatures of up to 1250 ºC when subjected to continuous exposure. It absorbs major proposition of the directed temperature and if not supported from either side makes it susceptible to damage or distortion. These blankets are compressible, *i.e., a* 6 mm sheet may be compressed to about 3 ~ 4.5 mm while a 13mm sheet may be compressed to about 8 ~10 mm. This layer is also non-flammable.

[0057] The aesthetic layer is dependent upon its surrounding environmental conditions and temperatures. Based on these parameters, the layer may comprise of a

double side silicon coated glass cloth or a black glass cloth when the outer layer is exposed directly to environment.

[0058] If the thermal insulator is to be used to shield the application area from a heat source, then aluminium or graphite coated glass cloth may be used as the said materials provide additional drop in temperature over a period of time. This layer also provides protection from water and mud splashes.

[0059] The intermediate layers' aid in creating the air gap or spaces between the substrate layers to achieve high thermal performance over higher temperature ranges and improve the product life cycle. It is non-permeable in nature to an extent with minute pores, that prevent sudden escape of heat between the substrate layers.

[0060] A polymeric material is used to seal the edges of the thermal insulator. This the polymeric material is a thread coated with a synthetic fluoropolymer such as Polytetrafluoroethylene (PTFE) to make the sealing non-stick, non-reactive and waterproof. The PTFE reduces friction, wear and energy consumption of machinery.

[0061] The stainless steel tie ropes for securing the thermal insulator aids in wrapping the insulator over the vehicle exhausts or other high temperature sources. It can be tightened to required torque without damaging the tie ropes and once fixed in place, they cannot be loosened or opened without damage.

[0062] The table 1 indicated *hereinbelow* illustrates the flame retardant properties of the thermal insulator. The sandwich material was exposed upto 1100 ºC, and yet the thermal insulator does not deteriorate, *i.e.* does not burn. ASTM C-209 is the standard as followed for carrying out the test.

PROPERTIES	THERMAL INSULATOR
Flammability	Non Flammable (UL-94, V0 compliant)

Table 1: Tabulates Flammability Of The Thermal Insulator

[0063] The table 2 indicated *hereinbelow* illustrates the thermal insulators resistance against water. Delta T indicates Difference in temperature between the 1st and the last layer. Delta T "Resistance against Water" is carried out pickling (immersing) the sample in water for 100 hours and then carrying out the Test to capture the temperature difference between the 1st and the last layer of the sandwich. Bench level Delta T measurement following IS 3144:1992, after completion of Hours.

PROPERTIES	THERMAL INSULATOR
Delta T	60 ~ 83% of Input Temperature (depending upon construction & no's of layers)
Delta T "Resistance against Water" 500-950 Deg C	Delta T = 76.5%

Table 2: Tabulates Resistance Against Water Of The Thermal Insulator

[0064] The table 3 indicated *hereinbelow* illustrates the thermal insulators resistance against grease. Delta T indicates Difference in temperature between the 1stand the last layer. Delta T "Resistance against Grease", is carried out by applying the grease on sample for 25 hours and then carrying out the Test to capture the temperature difference between the 1st and last layer of the sandwich. Bench level Delta T measurement following IS 3144:1992, after completion of Hours.

PROPERTIES	THERMAL INSULATOR
Delta T	60 ~ 83% of Input Temperature (depending upon construction & no's of layers)
Delta T "Resistance against Grease" 500-950 Deg C	Delta T = 75%

Table 3: Tabulates Resistant Against Grease Of The Thermal Insulator

[0065] The table 4 indicated *hereinbelow* illustrates the thermal insulators resistance against mud. Resistance against Mud Delta T indicates Difference in temperature between the 1st and the last layer. Delta T "Resistance against Mud", is carried out by applying the mud on the sample for 100 hours and then carrying out the

Test to capture the temperature difference between the 1st and last layer of sandwich. Bench level Delta T measurement following IS 3144:1992, after completion of Hours.

PROPERTIES	THERMAL INSULATOR
Operating Temperature Range of Product	-30°C to +1000°C
Delta T	60 ~ 83% of Input Temperature (depending upon construction & no's of layers)
Delta T "Resistance against Mud" 500-950 Deg C	Delta T = 79.5%

Table 4: Tabulates Resistant Against Mud Of The Thermal Insulator

[0066] The table 5 indicated *hereinbelow* illustrates the high thermal durability and shock absorption capabilities of the thermal insulator. The resistance against a temperature of 750 ºC for about 400 hrs, after every 60 minutes of water quenching for 20 seconds was tested. Bench level Delta T measured after completing the cycles using IS 3144:1992.

PROPERTIES	THERMAL INSULATOR
High Thermal Durability & Thermal Shock (750 Deg C for 400 Hrs)	Delta T = 72.4%

Table 5: Tabulates Thermal Durability And Shock Properties Of The Thermal Insulator

[0067] The table 6 indicated *hereinbelow* illustrates the low temperature thermal shock property of the thermal insulator. 1 Cycle = At 750 ºC for 15 minutes & 5 minutes at -40 ºC, followed by keeping in hot chamber at 200 ºC for 5 minutes. Total 200 cycles. Bench level Delta T measured after completing the cycles using IS 3144:1992.

PROPERTIES	THERMAL INSULATOR
Low Thermal Shock 750 Deg C for 15 mins & 5mins at -40 Deg C, then in Hot Chamber at 200 Deg C for 5 mins (200 cycles)	Delta T = 71.5% Avg

Table 6: Tabulates Low Temperature Thermal Shock Properties Of The Thermal Insulator

[0068] From the comparative data indicated hereinabove, it may be inferred that the thermal insulator and tie ropes for securing the thermal insulation, as disclosed herein offers superior heat, shock, water, flame and mud resistance properties together with long term durability. The thermal insulator displays thermal conductivity of at least about 0.030~0.038 W/MK and less than about 0.050 W/MK.

[0069] Thus, the thermal insulator of the present invention exhibits superior heat resistance properties and based on functional requirements may be used to either absorb the excessive heat from the high temperature source or retain the excessive heat from the high temperature source. The thermal insulator provides optimal thermal management in medium to high temperature range applications. It aids in retaining the temperature of a vehicle exhaust to acceptable limits thereby controlling the particulate emission norms while also protecting the parts in proximity of the vehicle exhaust or other heat sources. This thermal insulator is non-stretchable, flexible and may comprise of three to eight layers based on its area of application.

[0070] Although a simple, economic, cost effective and durable thermal insulator for wrapping over a heat source and tie ropes for securing the thermal insulator over the vibrating heat source has been described in language specific to structural features, it is to be understood that the embodiments disclosed in the above section are not necessarily limited to the specific features described therein. Rather, the specific features are disclosed as examples of implementations of the thermal insulator and tie ropes.

WE CLAIM:

Claim 1 (Original): A thermal insulator for wrapping around a heat source, the insulator comprising:

a first layer;

a second layer;

at least one substrate;

wherein the first layer is in contact with the heat source;

wherein the second layer is a high temperature resistant layer;

wherein the substrate comprises of a plurality of compressed fibre paper; and

wherein the aesthetic layer is the outermost layer.

Claim 2 (Original): The thermal insulator of claim 1, wherein the insulator optionally comprises an aesthetic layer which is the outermost layer of the insulator.

Claim 3 (Original): The thermal insulator of claim 1 or claim 2, wherein the first layer is a stainless steel wire mesh or a coated glass cloth or an aluminium coated or a graphite coated glass cloth.

Claim 4 (Original): The thermal insulator of any of the preceding claims, wherein the high temperature resistant layer is a vermiculite or calcium silicate coated cloth or a high temperature silica cloth or ceramic flex.

Claim 5 (Original): The thermal insulator of any of the preceding claims, wherein the substrate comprises of a plurality of intermediate layers.

Claim 6 (Original): The thermal insulator of any of the preceding claims, wherein the aesthetic layer is a graphite sheet or an aluminium coated ora silicon coated or black glass cloth, or plain silica sheet or coated glass cloth.

Claim 7 (Original): The thermal insulator as claimed in claim 5, wherein the silicon coated cloth is single sided or double side coated.

Claim 8 (Original): The thermal insulator of any of the preceding claims, wherein the substrate comprises of a plurality of ceramic fibre papers or blankets.

Claim 9 (Original): The thermal insulator of any of the preceding claims, wherein the plurality of intermediate layers are aluminium sheets or graphite sheets or fibre mesh or single side silicon coated sheets or coated glass cloth.

Claim 10 (Original): The thermal insulator as claimed in claim 8, wherein the aluminium coating is single or double sided.

Claim 11 (Original): The thermal insulator as claimed in claim 7, wherein the ceramic fibers is woven blanket or paper.

Claim 12 (Original): The thermal insulator of any of the preceding claims, wherein a polymeric material seals the edges of the thermal insulator.

Claim 13 (Original): The thermal insulator as claimed in claim 12, wherein the polymeric material is a thread coated with a synthetic fluoropolymer.

Claim 14 (Original): The thermal insulator as claimed in claim 13, wherein the synthetic fluoropolymer is Polytetrafluoroethylene (PTFE) thread.

Claim 15 (Original): The thermal insulator of any of the preceding claims, wherein the first layer provides protection to the overlying layers.

Claim 16 (Original): The thermal insulator of any of the preceding claims, wherein the first layer provides anti-friction properties and/or creates air pockets and/or circulates heated air.

Claim 17 (Original): The thermal insulator of any of the preceding claims, wherein the high temperature resistant layer resists temperatures ranging up to 1100 ºC when in contact with the heat source.

Claim 18 (Original): The thermal insulator of any of the preceding claims, wherein the high temperature resistant layer absorbs a proportion of the heat source temperature.

Claim 19 (Original): The thermal insulator of any of the preceding claims, wherein the high temperature resistant layer exhibits sustainability of about -30 ºC to about 1100 ºC.

Claim 20 (Original): The thermal insulator of any of the preceding claims, wherein the high temperature resistant layer is non-flammable, non-toxic, excellent heat strength and low shrinkage properties.

21. The thermal insulator of any of the preceding claims, wherein the substrate is a high temperature resistance blanket or paper resisting temperatures of up to 1250 ºC when in contact with the heat source.

22. The thermal insulator of any of the preceding claims, wherein the substrate absorbs major proposition of the source temperature

23. The thermal insulator of any of the preceding claims, wherein the substrate layers are compressible and non-flammable.

24. The thermal insulator of any of the preceding claims, wherein the aesthetic layer is coated or un-coated.

25. The thermal insulator of any of the preceding claims, wherein the aesthetic layer is exposed directly or indirectly to the surrounding environmental conditions and temperatures.

26. The thermal insulator of any of the preceding claims, wherein the insulator has a thermal conductivity of at least about 0.030 to about 0.038 W/MK.

27. The thermal insulator of any of the preceding claims, wherein the insulator has a thermal conductivity of less than about 0.050 W/MK.

28. The thermal insulator of any of the preceding claims, wherein the insulator exhibits no damage or visual deterioration at temperatures of at least about 500 ºC to about 1000ºC (depending upon the functional and selection of 1st layer).

29. The thermal insulator of any of the preceding claims, wherein the aluminium or graphite coated glass cloth provides additional drop in temperature over a period of time.

30. The thermal insulator of any of the preceding claims, wherein the aesthetic layer provides protection from water and mud splashes and resistance against petrochemical like substances.

31. The thermal insulator as claimed in claim 5, wherein the plurality of intermediate layers creates air gap or spaces between the plurality of substrate layers to achieve high thermal performance over higher temperature ranges and improve the product life cycle.

32. The thermal insulator as claimed in claim 5, wherein the plurality of intermediate layers is non-permeable with minute pores that prevent sudden escape of heat between a plurality of substrate layers.

33. The thermal insulator of any of the preceding claims, wherein the maximum number of substrate layers is 5.

34. A tie rope for securing the thermal insulator of any of the preceding claims, wherein the tie rope is roller ball type.

35. The tie rope of claim 34, wherein the tie rope is of stainless steel.

36. The tie rope of claim 34 or 35, wherein the tie rope is flat or adjustable type depending on area of application.

37. The tie rope of any of claims 34 through 36, wherein the tie rope is tightened to any required torque without damage.

38. The tie rope of any of claims 34 through 37, wherein the tie rope once fixed, cannot be loosened or opened.

39. The tie rope of any of claims 34 through 38, wherein a plurality of tie ropes is employed to secure the thermal insulator over the heat source.

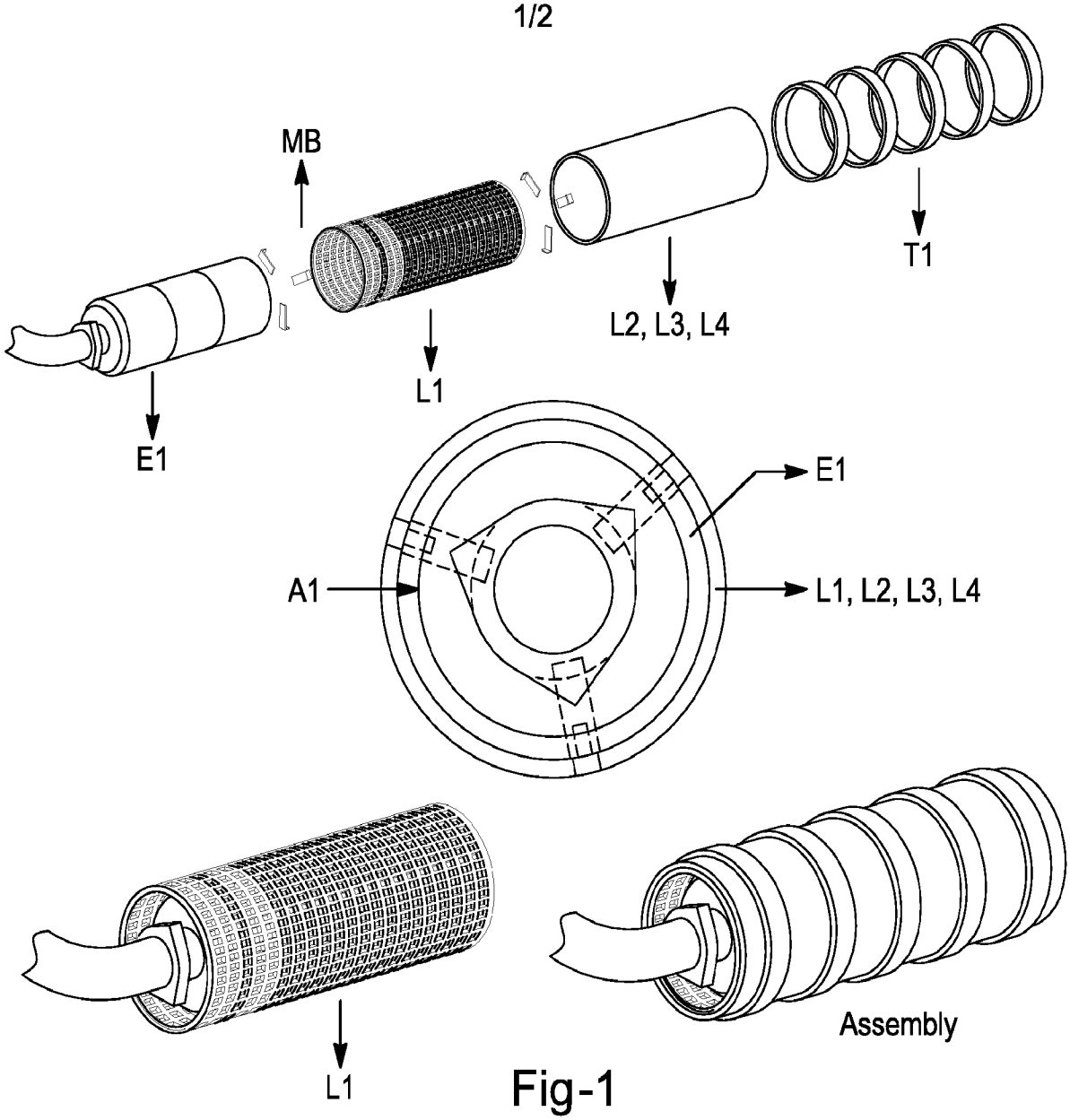
MB
T1
L2, L3, L4
L1
E1
E1
A1
L1, L2, L3, L4
L1
Assembly

Fig-1

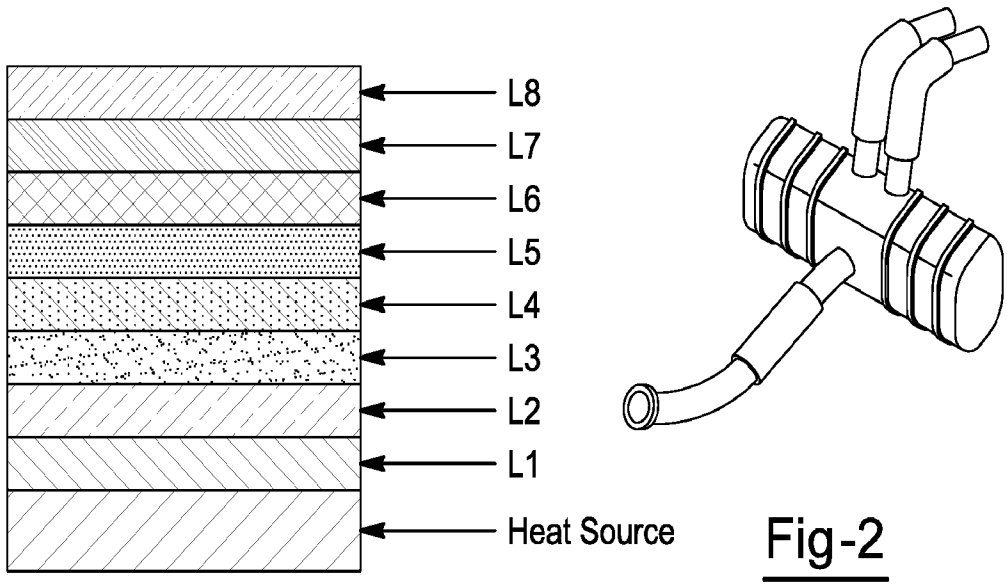
L8
L7
L6
L5
L4
L3
L2
L1
Heat Source

Fig-2

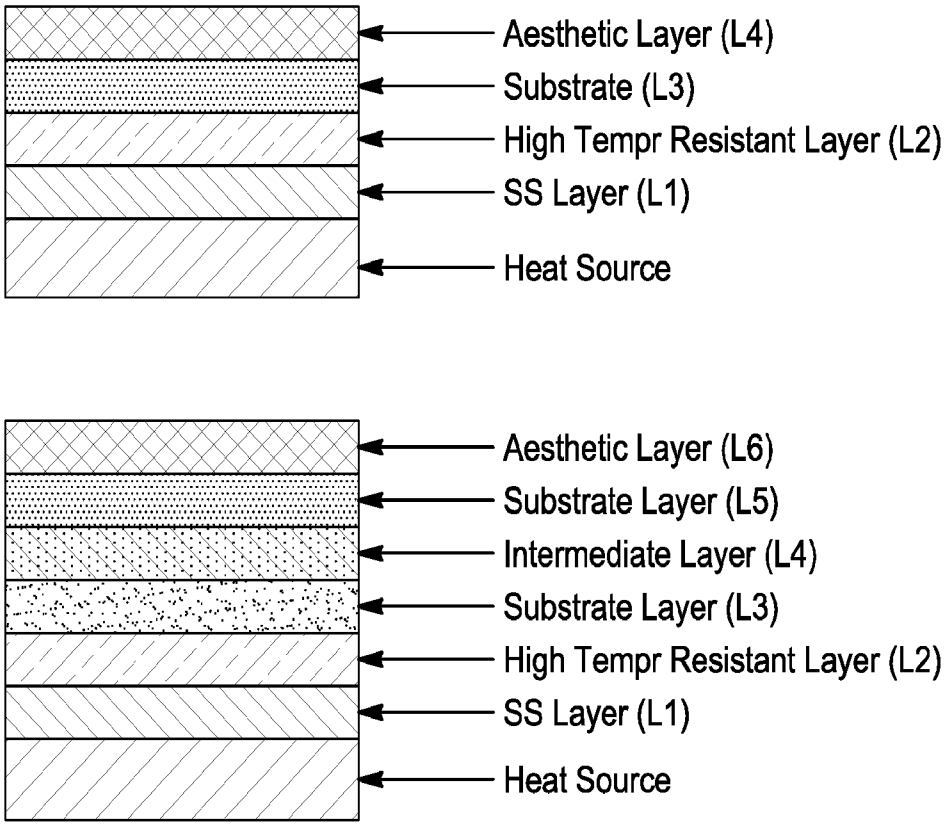
Aesthetic Layer (L4)
Substrate (L3)
High Tempr Resistant Layer (L2)
SS Layer (L1)
Heat Source
Aesthetic Layer (L6)
Substrate Layer (L5)
Intermediate Layer (L4)
Substrate Layer (L3)
High Tempr Resistant Layer (L2)
SS Layer (L1)
Heat Source

Fig-3

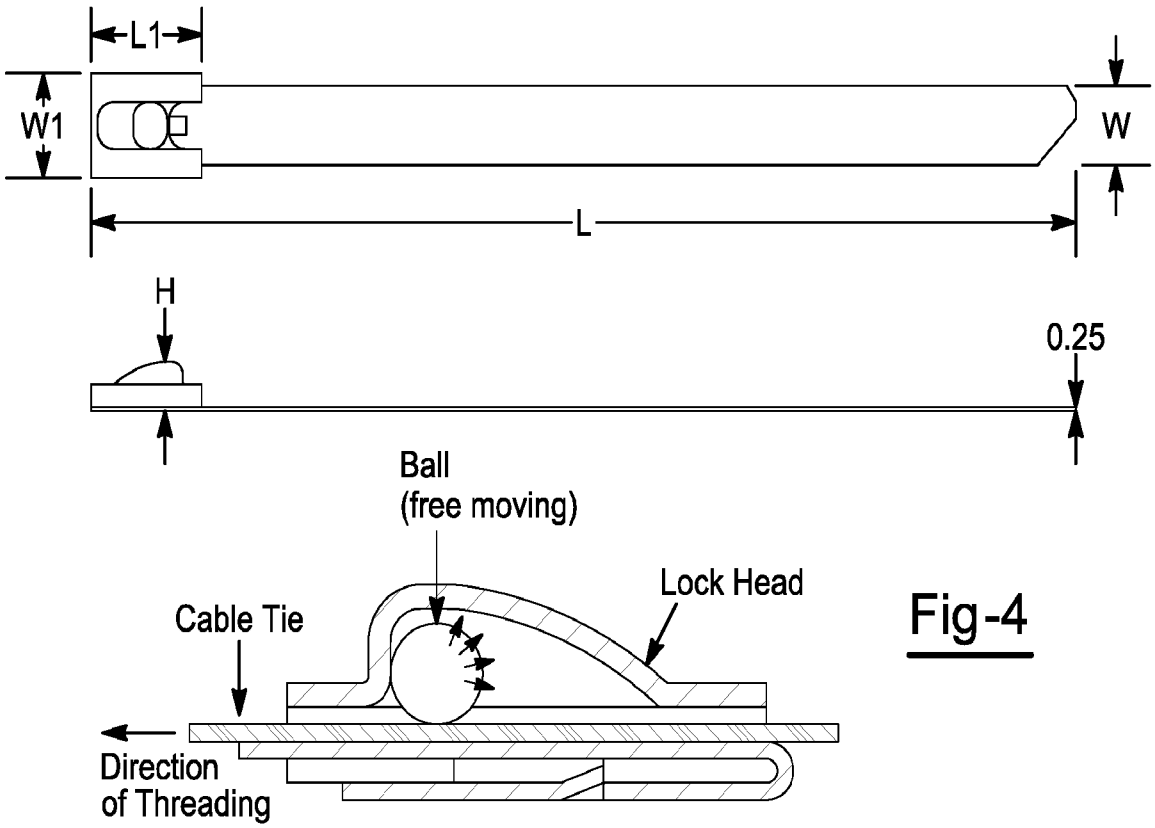
L1
W1
W
L
H
0.25
Ball
(free moving)
Lock Head
Cable Tie
Direction
of Threading

Fig-4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/026270

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N13/14 F01N13/16 F01N13/18
ADD.

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)
F01N F16L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2015/056881 A1 (ZHANG ZHONG HUAI [US] ET AL) 26 February 2015 (2015-02-26) paragraphs [0014], [0015], [0018] - [0020]; figures 1,2	1-39
X	US 5 134 846 A (WHITE JAMES E [US]) 4 August 1992 (1992-08-04) column 1; figures 1,2	1-39
X	US 6 510 833 B1 (ANTHON ANTHONY [US]) 28 January 2003 (2003-01-28) column 4, lines 51-64; figures 5,8,9	1-33

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 2018	06/06/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Blanc, Sébastien

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/026270

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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