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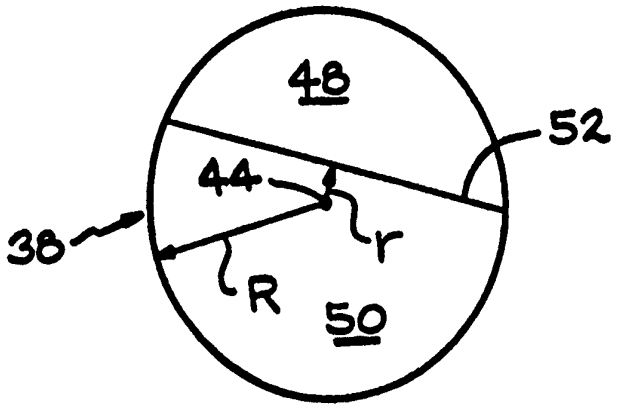
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(54) Title: IRREGULARLY SHAPED GLASS FIBERS AND INSULATION THEREFROM

(57) Abstract

Irregularly shaped glass fibers (38) and insulation (30) therefrom comprising two different glasses having differing coefficients of thermal expansion. The irregularly shaped dual-glass fibers are made from wool glass compositions with the addition of at least one of BaO, SrO, K_2O, Li_2O, ZnO, TiO_2 and Fe_2O_3.



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IRREGULARLY SHAPED GLASS FIBERS AND INSULATION THEREFROM

CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of U.S. Serial No. 08/434,699 filed May 4, 1995.

TECHNICAL FIELD

This invention relates to irregularly shaped glass fibers suitable for insulation. Each glass fiber comprises two distinct glasses.

BACKGROUND ART

Glass fibers, mineral fibers, and other wool materials have been insulating buildings for some time. Insulation easily fits into the spaces in attics, ceilings, walls, floors, and the like.

The common prior art methods for producing glass fiber insulation products involve producing glass fibers from a rotary process. A single molten glass composition is forced through the orifices in the outer wall of a centrifuge or spinner, producing primarily straight glass fibers. The fibers are drawn downward by a blower. The binder required to bond the fibers into a wool product is sprayed onto the fibers as they are drawn downward. The fibers are then collected and formed into a wool pack.

Recent developments include insulation which installs rapidly and effectively between the studs of a building. An exterior layer covers the fibrous batt. Preferably, the exterior layer covering comprises a polyethylene package which receives the fibrous batt. Another focal point of recent developments in insulation is one in which all the binder or essentially all the binder is no longer present in the fibrous batt. Evolution of processes for producing low-density insulation provide satisfactory resiliency without a binder in the batt.

Still other developments are insulations of mineral fibers which are irregular in shape. Fibers that are irregular, rather than straight, kinked, or even curly, provide a more uniform lattice structure. This uniform volume filling allows for higher recovery ratios. More importantly, uniform volume filling also results in significantly lower thermal conductivity. Also, the greater entanglement of irregularly shaped fibers provides better wool pack integrity. By sufficient integrity, it is meant that the fibers of the wool batt will remain entangled and not separate.

DISCLOSURE OF INVENTION

The present invention provides irregularly shaped glass fibers suitable for insulation. Each glass fiber comprises two distinct glasses. Each glass has a different coefficient of thermal expansion (CTE) differing by at least 2.0 ppm/°C. Each glass has a different composition. Each glass composition has a log viscosity of 3 at a temperature ranging from 1600 to 2050°F (982 to 1121°C) and a liquidus temperature at least 50°F (28°C) below the temperature for a log viscosity of 3, and each glass composition consists essentially of SiO_2, Al_2O_3, and Na_2O and including at least one of BaO, SrO, K_2O, Li_2O, ZnO, TiO_2, or Fe_2O_3. Preferably, the glasses also include B_2O_3, MgO, or CaO. Preferably, each glass composition has a liquidus temperature at least 150°F (84°C) below the temperature for a log viscosity of 3 and the CTE's differ by at least 4.0 ppm/°C. Preferably, the glass compositions include at least one of BaO, K_2O, Li_2O, or ZnO.

Each glass composition includes 1.0 to 20.0 mole percent of BaO, SrO, K_2O, Li_2O, ZnO, TiO_2, or Fe_2O_3. Preferably, each glass composition includes 2.0 to 10.0 mole percent of one or more of these ingredients.

Two glasses now are being used in fiber forming from wool glass components and compositions. Adjustments were made in the B_2O_3 and Na_2O content to give a large difference in the coefficient of thermal expansion while maintaining the same fiber forming temperature. This approach gave the desired properties but approached the limits of acceptable compositions. The present invention is directed at increasing the number of components in the glass to expand the compositional region and properties possible for these glasses.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a view of a process by which the insulation of the present invention may be produced.

Figure 2 is a view of a fiberizer by which the fibers of the present invention may be produced.

Figure 3 is a view of insulation showing entangled, irregularly shaped fibers of the invention.

Figure 4 is a cross-sectional view of an irregularly shaped fiber of the invention having a 50:50 A/B glass ratio.

Figure 5 is a view of an irregularly shaped fiber having an A/B glass ratio of less than 50:50.

BEST MODE FOR CARRYING OUT THE INVENTION

In general, insulation products comprising irregularly shaped glass fibers according to this invention can be made using suitable means and methods, such as those described and shown in U.S. Patent No. 5,431,992 to Houpt et al., the disclosure of which is incorporated by reference herein.

Preferably, fibers in accordance with the invention are made by the direct-forming method described in International Publication No. WO 95/30787 and U.S. Serial No. 08/240,428 to Scott et al., filed May 10, 1994 (see especially Figure 1 thereof), the disclosures of which are also incorporated by reference. After the fibers are formed, they may be stored for shipment, e.g., to compositers (before or after chopping), or further processed as appropriate for the desired end use. For example, if the fibers are to be used to prepare insulation, they may be encapsulated, chopped, and then rolled using appropriate means known in the art.

The insulation products of irregularly shaped glass fibers of the present invention can be produced from a rotary fiber-forming process as shown in Figure 1.

Referring to Figure 1, furnaces 10 supply two distinct molten glass compositions via forehearths 12 to fiberizers 14. Veils of irregularly shaped glass fibers 18 produced by the fiberizers are collected on conveyor 16 as wool pack 20 by means of a vacuum positioned beneath the conveyor. As the fibers are blown downward by air or gases to the conveyor by means of blowers 22 in the fiberizers, they are attenuated and assume their irregular shape.

Figure 2 shows that fiberizers 14 include spinners 60. Spinner 60 is comprised of spinner bottom wall 62 and spinner peripheral wall 64. Spindle 66 rotates spinner 60. The rotation of the spinner centrifuges molten glass through the spinner peripheral wall into primary fibers 68. The primary fibers are maintained in soft, attenuable condition by the heat of annular burner 70. In one embodiment of the invention, an internal burner, not shown, provides heat to the interior of the spinner. Annular blower 72, using induced air 74, pulls the primary fibers and further attenuates them into secondary fibers

76, suitable for use in wool insulating materials. The secondary fibers, or bicomponent glass fibers, are then collected for formation into a wool pack.

The interior of the spinner is supplied with two separate streams of molten glass, first stream 78 containing glass A and second stream 80 containing glass B. The glass in stream 78 drops directly onto the spinner bottom wall and flows outwardly with centrifugal force toward the spinner peripheral wall to form a head of glass A. Glass B in molten glass stream 80 is positioned closer to the spinner peripheral wall than stream 78, and the glass in stream 80 is intercepted by horizontal flange 82 before it can reach the spinner bottom wall. Thus, a build-up or head of glass B is formed on the horizontal flange.

Figure 3 shows insulation product 30 comprised of entangled, irregularly shaped glass fibers 38.

Figure 4 is a cross-sectional view of an ideal irregularly shaped glass fiber 38 having a 50:50 A/B glass ratio. Halves 40 and 42 essentially are equal in the ideal with point 44 being the center and line 46 being the diameter.

Figure 5 shows a more typical cross-section where halves 48 and 50 are not equal. Line 52 is no longer a diameter, but just a divider. Lines R and r are shown to locate center point 44.

The deviation ratio is a measure of how far the A/B glass ratio is away from 50:50. The larger the deviation from 50:50, the larger r will be as a percent of R. It has been found that the average deviation ratio of the irregularly shaped glass fibers of the invention is typically greater than about 5%, generally greater than about 15%, and in many cases, greater than about 30%.

The irregularly shaped fibers of the present invention are dual-glass fibers, i.e. each fiber is composed of two different glass compositions, glass A and glass B. If one were to make a cross-section of an ideal irregularly shaped glass fiber of the present invention, one half of the fiber would be glass A, with the other half glass B. In reality, a wide range of proportions of the amounts of glass A and glass B may exist in the various irregularly shaped glass fibers in the wool insulating material (or perhaps even over the length of an individual fibers). The percentage of glass A may vary within the range of from about 15 to about 85% of the total glass in each of the irregularly shaped glass fibers

with the balance of total glass being glass B. In general, insulation products of the irregularly shaped fibers will consist of fibers of all different combinations of the percentages of glass A and glass B, including a small fraction of fibers that are single component.

Cross-section photographs of fibers are obtained by mounting a bundle of fibers in epoxy with the fibers oriented in parallel as much as possible. The epoxy plug is then cross-sectioned using a diamond saw blade, and one of the new surfaces is polished using various grinding media. The polished sample surface is then coated with a thin carbon layer to provide a conductive sample for analysis by scanning electron microscopy (SEM). The sample is then examined on the SEM using a backscattered-electron detector, which displays variations in average atomic number as a variation in the gray scale. This analysis reveals the presence of two glasses by a darker and lighter region on the cross-section of the fiber, and shows the interface of the two glasses.

Due to a continuously changing attenuation environment, each irregularly shaped fiber is twisted in a unique way. No two fibers are exactly alike. The fiber's final shape is one with a baseline curvature due to the dual-glass nature, which is modified by the twisting, irregular rotation of the plane of curvature caused by the continuously changing attenuation environment. The fiber has a baseline curvature that is twisted through three dimensions. It is generally not helical. The fiber's irregular nature allows the irregularly shaped glass fibers to stand apart from one another and achieve a uniform volume-filling nature.

While we do not wish to be limited to these, conventional glass compositions, which are suited for insulations, are the soda (or alkaline metal oxide) calcia (or alkaline earth metal oxide) aluminoborosilicate compositions. The constituents in the glass which are of main interest are: SiO_2, which is typically present in an amount of 50 to 68 percent by weight; Al_2O_3, typically present in amounts up to 9 percent by weight; B_2O_3, typically present in amounts up to 25 percent by weight; Na_2O, typically present in amounts of about 5 to 20 percent by weight; CaO, typically present in amounts of about 3 to 14 percent by weight; and MgO, typically present in amounts up to 10 percent by weight.

We found that substitutions can be made to modify the thermal expansion of glass pairs while minimizing differences in the viscosity and overall composition:

1. The molar substitutions of Li_2O for Na_2O and ZnO for CaO decrease the CTE; and

2. The molar substitutions of K_2O for Na_2O and BaO for CaO+MgO increase the CTE.

These would be in addition to modifications already being used such as the exchange of Na_2O for B_2O_3.

These substitutions were made in a series of glasses based on Na_2O-B_2O_3-MgO-CaO-SiO_2 glasses suitable for producing bicomponent glass fibers Al_2O_3. Examples of the compositions are given in the following table. Several of the compositions have the forming temperature (the temperature where the viscosity of the glass is about 1,000 poise), the liquidus temperature, and the coefficient of thermal expansion listed. Coefficients of thermal expansion were either measured between 0 and 300°C or between room temperature (21°C) and 300°C.

Example I

Irregularly shaped glass fibers of the present invention have the following compositions.

Controls #1 and #2 are known as SiO_2-Al_2O_3-B_2O_3-Na_2O-MgO-CaO glasses which can be used to make bicomponent irregularly shaped glass fibers.

	Control, Mole %	
	#1	#2
SiO_2	52.65	62.54
Al_2O_3	4.56	2.35
B_2O_3	21.85	5.79
Li_2O	-	-
Na_2O	5.35	14.33
K_2O	-	0.64
MgO	1.93	5.53
CaO	13.34	8.48
SrO	0.28	0.10
BaO	-	0.04
ZnO	-	-
TiO_2	0.01	0.10
Fe_2O_3	0.01	0.10
CTE ($x10^{-6}$/°C)	6.04	9.17
Temperature °F (°C) for:		
Log n = 3.0	1895 (1035)	1919 (1048)
Liquidus	1657 (903)	1730 (943)

	Examples, Mole %	
	#1	#2
Modification	BaO	BaO
SiO_2	62.54	65.54
Al_2O_3	2.35	2.35
B_2O_3	5.79	2.79
Li_2O	-	-
Na_2O	14.33	14.33
K_2O	0.64	0.64
MgO	-	-
CaO	7.01	7.01
SrO	0.10	0.10
BaO	7.04	7.04
ZnO	-	-
TiO_2	0.10	0.10
Fe_2O_3	0.10	0.10
CTE ($x10^{-6}$/°C)	9.76	9.90
Temperature °F (°C) for:		
Log n = 3.0	1815 (991)	1926 (1052)
Liquidus	1544 (840)	1520 (827)
Advantages of Additional Component:	Higher CTE; Lower Liquidus; Lower Viscosity	Higher CTE: Lower Liquidus

	#3	#4
Modification	BaO	BaO
SiO_2	64.38	62.54
Al_2O_3	2.35	2.35
B_2O_3	1.95	5.79
Li_2O	-	-
Na_2O	16.33	14.33
K_2O	0.64	0.64
MgO	3.51	-
CaO	3.51	-
SrO	0.10	0.10
BaO	7.02	14.05
ZnO	-	-
TiO_2	0.10	0.10
Fe_2O_3	0.10	0.10
CTE ($x10^{-6}$/°C)	10.12	9.72
Temperature °F (°C) for:		
Log n = 3.0	1920 (1049)	1785 (974)
Liquidus	1427 (775)	1774 (968)
Advantages of Additional Component:	Higher CTE; Lower Liquidus	Higher CTE: Lower Viscosity

	#5	#6
Modification	BaO	K_2O
SiO_2	66.74	62.54
Al_2O_3	2.35	2.35
B_2O_3	1.59	5.79
Li_2O	-	-
Na_2O	14.33	7.48
K_2O	0.64	7.48
MgO	-	5.53
CaO	-	8.48
SrO	0.10	0.10
BaO	14.05	0.04
ZnO	-	-
TiO_2	0.10	0.10
Fe_2O_3	0.10	0.10
CTE ($x10^{-6}$/°C)	10.12	9.57
Temperature °F (°C) for:		
Log n = 3.0	1924 (1051)	1991 (1088)
Liquidus	1857 (1014)	1817 (992)
Advantages of Additional Component:	Higher CTE	Higher CTE: Higher Viscosity

	#7	#8
Modification	ZnO	ZnO
SiO_2	62.54	62.54
Al_2O_3	2.35	2.35
B_2O_3	5.79	5.79
Li_2O	-	-
Na_2O	14.33	14.33
K_2O	0.64	0.64
MgO	3.51	-
CaO	3.51	-
SrO	0.10	0.10
BaO	-	-
ZnO	7.02	14.05
TiO_2	0.10	0.10
Fe_2O_3	0.10	0.10
CTE ($x10^{-6}$/°C)	8.74	8.64
Temperature °F (°C) for:		
Log n = 3.0	1947 (1064)	1966 (1074)
Liquidus	1509 (821)	1509 (821)
Advantages of Additional Component:	Lower Liquidus; Lower CTE	Lower Liquidus; Lower CTE

	#9	#10
Modification	TiO_2	TiO_2
SiO_2	62.54	62.54
Al_2O_3	2.35	2.35
B_2O_3	5.79	5.79
Li_2O	-	-
Na_2O	14.33	14.33
K_2O	0.64	0.64
MgO	3.51	-
CaO	3.51	-
SrO	0.10	0.10
BaO	-	-
ZnO	-	-
TiO_2	7.12	14.15
Fe_2O_3	0.10	0.10
CTE ($x10^{-6}$/°C)	8.33	8.09
Temperature °F (°C) for:		
Log n = 3.0	1918 (1048)	1893 (1034)
Liquidus	1765 (963)	1904 (1040)
Advantages of Additional Component:	Lower CTE	Lower CTE

	#11	#12
Modification	Li_2O	Li_2O+ZnO
SiO_2	62.54	62.54
Al_2O_3	2.35	2.35
B_2O_3	5.79	5.79
Li_2O	7.48	7.48
Na_2O	7.48	7.48
K_2O	-	-
MgO	5.53	3.51
CaO	8.48	3.51
SrO	0.10	0.10
BaO	0.04	-
ZnO	-	7.02
TiO_2	0.10	0.10
Fe_2O_3	0.10	0.10
CTE ($x10^{-6}$/°C)	8.19	7.84
Temperature °F (°C) for:		
Log n = 3.0	1829 (998)	1844 (1007)
Liquidus	1848 (1009)	-
Advantages of Additional Component:	Lower CTE; Lower Viscosity	Lower CTE; Lower Viscosity

	#13	#14
Modification	Li_2O+TiO_2	K_2O+BaO
SiO_2	62.54	55.32
Al_2O_3	2.35	5.50
B_2O_3	5.79	3.05
Li_2O	7.48	-
Na_2O	7.48	11.34
K_2O	-	11.34
MgO	3.51	4.33
CaO	3.51	4.48
SrO	0.10	-
BaO	-	4.55
ZnO	-	-
TiO_2	7.12	0.03
Fe_2O_3	0.10	0.06
CTE ($x10^{-6}$/°C)	7.67	12.16
Temperature °F (°C) for:		
Log n = 3.0	1838 (1003)	1904 (1040)
Liquidus	-	1591 (866)
Advantages of Additional Component:	Lower CTE; Lower Viscosity	High CTE; Lower Viscosity

	#15	#16
Modification	K_2O+BaO	BaO
SiO_2	62.54	61.80
Al_2O_3	2.35	2.60
B_2O_3	5.79	1.73
Li_2O	-	-
Na_2O	7.48	18.49
K_2O	7.48	0.61
MgO	3.51	5.33
CaO	3.51	5.74
SrO	0.10	-
BaO	7.02	3.70
ZnO	-	-
TiO_2	0.10	-
Fe_2O_3	0.10	-
CTE ($x10^{-6}$/°C)	9.92	11.53
Temperature °F (°C) for:		
Log n = 3.0	1927 (1053)	1907 (1042)
Liquidus	1348 (731)	1511 (822)
Advantages of Additional Component:	High CTE; Lower Liquidus	High CTE: Lower Liquidus

	#17	#18
Modification	K_2O+BaO	K_2O+BaO
SiO_2	61.80	58.47
Al_2O_3	2.60	4.40
B_2O_3	1.73	-
Li_2O	-	-
Na_2O	9.55	21.02
K_2O	9.55	2.65
MgO	1.96	4.95
CaO	2.11	5.11
SrO	-	-
BaO	10.70	3.30
ZnO	-	-
TiO_2	-	0.03
Fe_2O_3	-	0.06
CTE ($x10^{-6}$/°C)	12.03	12.16
Temperature °F (°C) for:		
Log n = 3.0	1905 (1041)	1921 (1049)
Liquidus	1564 (851)	1779 (971)
Advantages of Additional Component:		

	#19	#20
Modification	K_2O+BaO	Fe_2O_3
SiO_2	53.64	63.10
Al_2O_3	6.60	2.68
B_2O_3	3.63	-
Li_2O	-	-
Na_2O	11.34	19.73
K_2O	11.34	0.20
MgO	4.33	3.21
CaO	4.48	3.71
SrO	-	-
BaO	4.55	5.30
ZnO	-	0.05
TiO_2	0.03	0.51
Fe_2O_3	0.06	1.45
CTE ($x10^{-6}$/°C)	12.08	-
Temperature °F (°C) for:		
Log n = 3.0	1917 (1047)	1919 (1048)
Liquidus	1741 (949)	1323 (717)
Advantages of Additional Component:	High CTE	Low Liquidus

	#21	#22
Modification	ZnO	K_2O+ZnO
SiO_2	62.00	55.47
Al_2O_3	1.76	4.40
B_2O_3	-	4.00
Li_2O	-	-
Na_2O	22.34	11.34
K_2O	0.44	11.34
MgO	4.01	4.01
CaO	4.68	4.68
SrO	-	-
BaO	-	-
ZnO	4.68	4.68
TiO_2	0.03	0.03
Fe_2O_3	0.06	0.06
CTE ($x10^{-6}$/°C)	11.52	12.22
Temperature °F (°C) for:		
Log n = 3.0	1903 (1039)	1894 (1034)
Liquidus	1572 (856)	1411 (766)
Advantages of Additional Component:	Low Liquidus	High CTE; Lower Liquidus

	#23	#24
Modification	K_2O+ZnO	Li_2O
SiO_2	57.34	58.62
Al_2O_3	4.40	3.17
B_2O_3	-	18.08
Li_2O	-	3.00
Na_2O	23.30	3.302
K_2O	1.50	0.77
MgO	4.01	1.61
CaO	4.68	11.12
SrO	-	0.24
BaO	-	-
ZnO	4.68	-
TiO_2	0.03	0.02
Fe_2O_3	0.06	0.07
CTE ($x10^{-6}$/°C)	12.05	-
Temperature °F (°C) for:		
Log n = 3.0	1916 (1047)	1909 (1043)
Liquidus	1773 (967)	1855 (1013)
Advantages of Additional Component:	High CTE	Low Viscosity

	#25	#26
Modification	ZnO	Li_2O
SiO_2	58.62	61.84
Al_2O_3	3.17	2.72
B_2O_3	18.08	14.08
Li_2O	-	2.85
Na_2O	6.30	6.21
K_2O	0.77	0.06
MgO	1.61	2.20
CaO	7.12	9.81
SrO	0.24	-
BaO	-	-
ZnO	4.00	-
TiO_2	0.02	0.16
Fe_2O_3	0.07	0.07
CTE ($x10^{-6}$/°C)	-	6.88
Temperature °F (°C) for:		
Log n = 3.0	1967 (1075)	1918 (1048)
Liquidus	1627 (886)	1896 (1036)
Advantages of Additional Component:	Low Liquidus	Low CTE

	#27	#28
Modification	Li_2O+ZnO	TiO_2
SiO_2	61.84	61.84
Al_2O_3	2.72	2.72
B_2O_3	14.08	14.08
Li_2O	4.50	-
Na_2O	4.56	9.06
K_2O	0.06	0.06
MgO	2.20	2.20
CaO	5.81	5.81
SrO	-	-
BaO	-	-
ZnO	4.00	-
TiO_2	0.16	4.16
Fe_2O_3	0.07	0.07
CTE ($x10^{-6}$/°C)	5.68	6.37
Temperature °F (°C) for:		
Log n = 3.0	1935 (1057)	1972 (1078)
Liquidus	1863 (1017)	1828 (998)
Advantages of Additional Component:	Low CTE	Low CTE

	#29	#30
Modification	Li_2O+TiO_2	$Li_2O+ZnO+TiO_2$
SiO_2	61.84	61.84
Al_2O_3	2.72	2.72
B_2O_3	14.08	14.08
Li_2O	3.00	4.50
Na_2O	6.06	4.56
K_2O	0.06	0.06
MgO	2.20	3.00
CaO	5.81	3.00
SrO	-	-
BaO	-	-
ZnO	-	3.00
TiO_2	4.16	3.16
Fe_2O_3	0.07	0.07
CTE ($x10^{-6}$/°C)	6.02	5.45
Temperature °F (°C) for:		
Log n = 3.0	1943 (1062)	1963 (1073)
Liquidus	1843 (1006)	1818 (992)
Advantages of Additional Component:	Low CTE	Low CTE

	#31	#32
Modification	BaO	BaO
SiO_2	58.62	61.51
Al_2O_3	3.17	2.50
B_2O_3	18.08	20.00
Li_2O	-	-
Na_2O	6.30	4.90
K_2O	0.77	-
MgO	1.61	-
CaO	6.22	-
SrO	0.24	-
BaO	4.90	11.00
ZnO	-	-
TiO_2	0.02	0.02
Fe_2O_3	0.07	0.07
CTE ($x10^{-6}$/°C)	-	5.70
Temperature °F (°C) for:		
Log n = 3.0	1914 (1046)	1954 (1068)
Liquidus	1634 (890)	1829 (998)
Advantages of Additional Component:	Low Liquidus	Low CTE

Example II

Irregular-shaped glass fibers of the present invention were produced using the low-expansion glass Control #1 and the high-expansion glass Example #14. Fibers were produced at approximately 40 pounds (18.1 kg) per hour in a pilot scale operation. Test squares of the wool batts were then produced from 50 grams of the fibers in an 8 x 8 inch (203 x 203 mm) sample. The recovery of these test squares was measured by comparing the recovered thickness to the compressed thickness. The compression was for 15 minutes at 12 pcf (192 kg/m^3).

A standard bindered insulation product of the prior art showed a recovery ratio of 18:1. Standard binderless wool insulating material of the prior art showed a recovery ratio of 14.4:1. Binderless irregularly shaped wool insulating material of the present invention showed a recovery of from 32:1 to 38:1 for three samples tested.

CLAIMS

1. Irregularly shaped glass fibers (38) suitable for insulation, each glass fiber comprising two distinct glasses, each glass having a different coefficient of thermal expansion (CTE) wherein the CTE's differ by at least 2.0 ppm/°C, each glass having a different glass composition, each glass composition having a temperature for a log viscosity of 3 ranging from 1600 to 2050°F (871 to 1121°C) and a liquidus temperature at least 50°F (28°C) below the log viscosity of 3 temperature, and at least one glass composition consisting essentially of SiO_2, Al_2O_3, and Na_2O, and including at least one of BaO, SrO, K_2O, Li_2O, ZnO, TiO_2, and Fe_2O_3.

2. Irregularly shaped glass fibers (38) according to claim 1 wherein the glass compositions include B_2O_3, MgO, or CaO.

3. Irregularly shaped glass fibers (38) according to claim 1 wherein the liquidus temperature is at least 150°F (84°C) below the temperature for a log viscosity of 3 and the CTE's differ by at least 4.0 ppm/°C.

4. Glass fiber insulation (30) comprising a collection of irregularly shaped glass fibers according to claim 1.

5. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes 1.0 to 20.0 mole percent of BaO, SrO, K_2O, ZnO, TiO_2, or Fe_2O_3.

6. Irregularly shaped glass fibers (38) according to claim 1 wherein each glass composition includes 2.0 to 10.0 mole percent of BaO, SrO, K_2O, Li_2O, ZnO, or TiO_2 or 1.0 to 5 mole percent Fe_2O_3.

7. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes K_2O and BaO.

8. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes BaO.

9. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes Li_2O.

10. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes ZnO.

11. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes K_2O and ZnO.

12. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes TiO_2.

13. Irregularly shaped glass fibers (38) according to claim 1 wherein at least one glass composition includes Fe_2O_3.

14. Glass fiber insulation (30) comprising a collection of irregularly shaped glass fibers according to any one of claims 1 or 3 to 6.

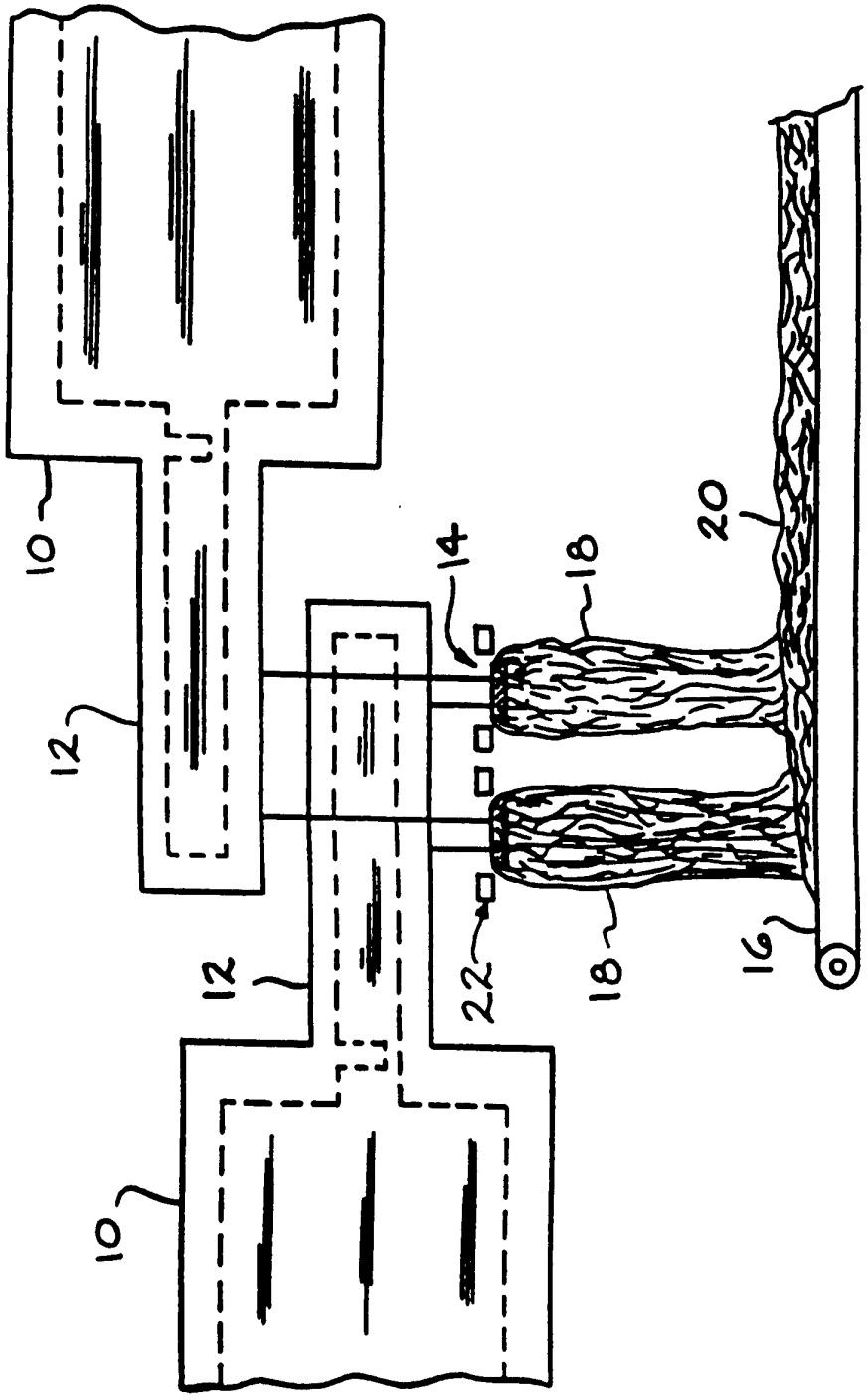


FIG. 1

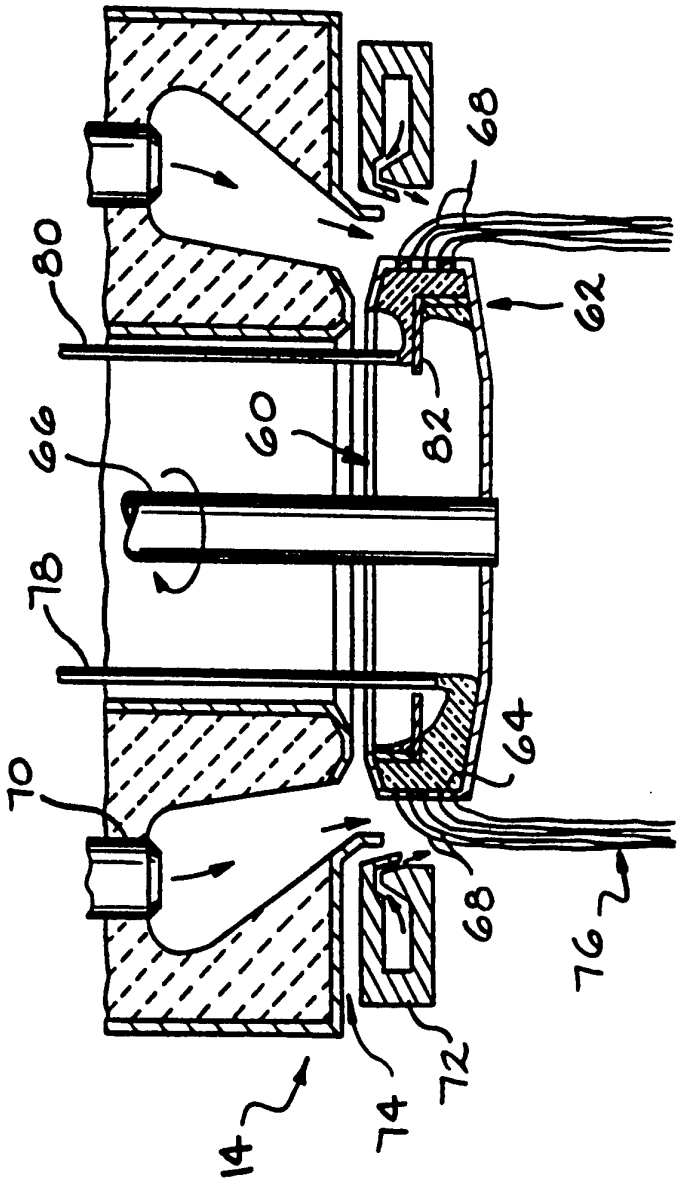


FIG.2

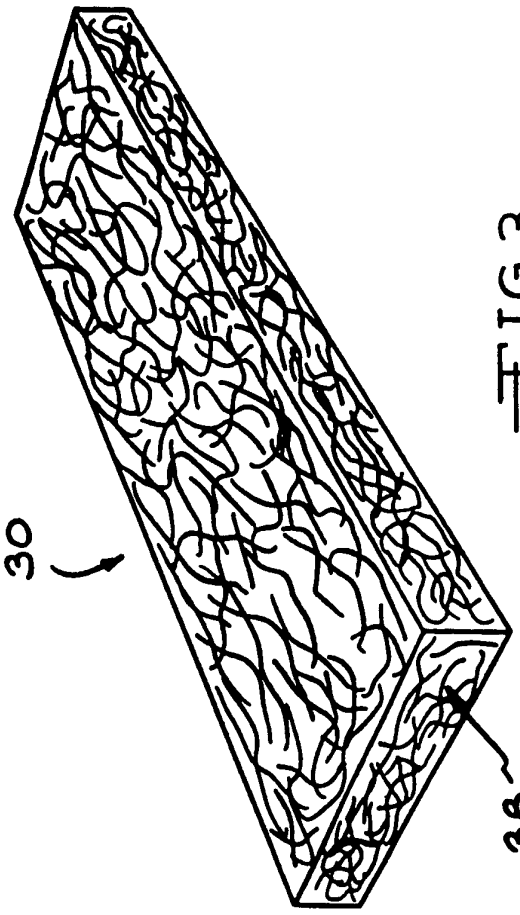


FIG.3

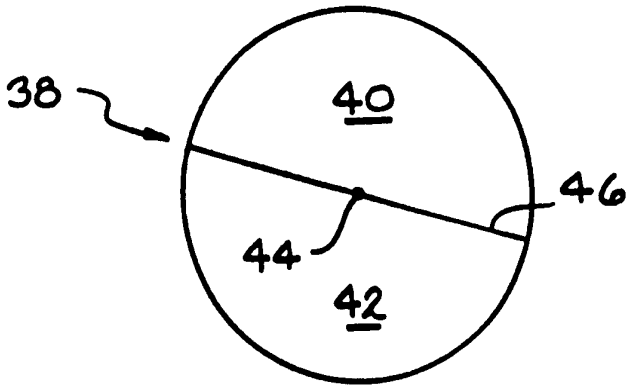


FIG. 4

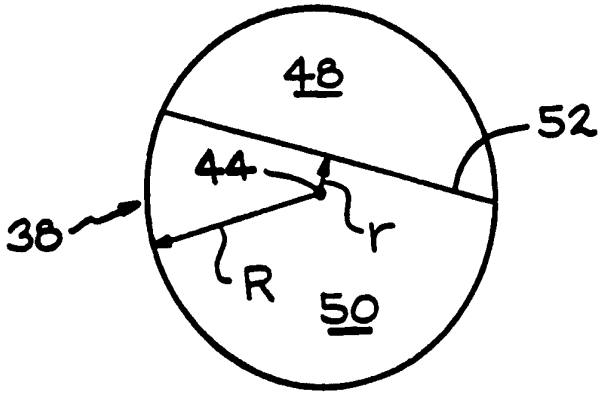


FIG. 5

INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/US 96/06066

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C03C13/00

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)
IPC 6 C03C C03B

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,2 998 620 (STALEGO) 5 September 1961 see column 4, line 73 - column 5, line 19 ---	1,2,4-6, 10,12-14
X	US,A,3 073 005 (TIEDE) 15 January 1963 see column 6, line 45 - line 68 ---	1,2,4-6, 10,12-14
P,X	WO,A,95 12554 (OWENS CORNING FIBERGLASS CORP) 11 May 1995 see page 9, line 36 - page 12, line 2; table 1 --- -/--	1-4, 12-14

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

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

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1

Date of the actual completion of the international search	Date of mailing of the international search report
24 July 1996	19.08.96

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van Bommel, L

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Section Ch, Week 7425 Derwent Publications Ltd., London, GB; Class F01, AN 74-46346V XP002009170 & JP,B,49 020 924 (KANEBO LTD) , 28 May 1974 see abstract -----	1-14

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. ɔnal Application No
PCT/US 96/06066

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US-A-3073005	15-01-63	DE-B-	1217562	
		FR-A-	1217973	06-05-60
		GB-A-	874808	
WO-A-9512554	11-05-95	AU-B-	1044495	23-05-95
		CA-A-	2151490	11-05-95
		JP-T-	8502717	26-03-96
		NO-A-	961774	02-05-96
		ZA-A-	9408681	04-07-95