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### Vacuum adiabatic body and refrigerator

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#### Abstract

A vacuum adiabatic body includes a first plate defining at least one portion of a wall of a first space; a second plate defining at least one portion of a wall of a second space having a different temperature from the first space; a seal that seals the first plate and the second plate to provide a third space that has a temperature between the temperature of the first space and the temperature of the second space and is in a vacuum state; a support to maintain the third space; an exhaust port through which a gas in the third space is exhausted; a peripheral adiabatic material, as a previously formed separate molded product, fixed to an edge of the third space; and a gasket having at least one portion fixed to the peripheral adiabatic material to provide a boundary between the first space and the second space.

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## References Cited

### U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
1413169	12/1921	Lawton	N/A	N/A
1588707	12/1925	Csiga	N/A	N/A
1845353	12/1931	Snell	N/A	N/A
1898977	12/1932	Comstock	N/A	N/A
2000882	12/1934	Comstock	N/A	N/A
2550040	12/1950	Clar	N/A	N/A
2708774	12/1954	Seelen	N/A	N/A
2715976	12/1954	Whitmore	N/A	N/A
2729863	12/1955	Kurtz	N/A	N/A
2768046	12/1955	Evans	N/A	N/A
2786241	12/1956	Garvey et al.	N/A	N/A
3091946	12/1962	Kesling	N/A	N/A
3161265	12/1963	Matsch et al.	N/A	N/A
3289423	12/1965	Berner	N/A	N/A
3370740	12/1967	Anderson	N/A	N/A
3520581	12/1969	Giovanni	312/236	F25D 23/064
4056211	12/1976	Zumwalt	N/A	N/A
4646934	12/1986	McAllister	N/A	N/A
4822117	12/1988	Boston, Jr.	N/A	N/A
4959111	12/1989	Kruck et al.	N/A	N/A
5011729	12/1990	Mcallister	N/A	N/A

5018328	12/1990	Cur	N/A	N/A
5033803	12/1990	Katsuyoshi et al.	N/A	N/A
5185981	12/1992	Martinez	N/A	N/A
5200015	12/1992	Schilf	N/A	N/A
5361598	12/1993	Roseen	N/A	N/A
5512345	12/1995	Tsutsumi et al.	N/A	N/A
5532034	12/1995	Kirby et al.	N/A	N/A
5694789	12/1996	Do	N/A	N/A
5795639	12/1997	Lin	N/A	N/A
5843353	12/1997	De Vos et al.	N/A	N/A
5947479	12/1998	Ostrowski	N/A	N/A
5966888	12/1998	Richardson	N/A	N/A
6001890	12/1998	Hamilton	N/A	N/A
6029846	12/1999	Hirath et al.	N/A	N/A
6038830	12/1999	Hirath et al.	N/A	N/A
6109712	12/1999	Haworth et al.	N/A	N/A
6168040	12/2000	Sautner et al.	N/A	N/A
6192703	12/2000	Salyer et al.	N/A	N/A
6244458	12/2000	Frysinger et al.	N/A	N/A
6280814	12/2000	Offermann	N/A	N/A
6338536	12/2001	Ueno et al.	N/A	N/A
6427945	12/2001	Bansemir	N/A	N/A
6485122	12/2001	Wolf	N/A	N/A
6485805	12/2001	Smith	N/A	N/A
6739104	12/2003	Tokonabe	N/A	N/A
6860082	12/2004	Yamamoto	N/A	N/A
7001656	12/2005	Maignan	N/A	N/A
7111752	12/2005	Bucher	N/A	N/A
7169459	12/2006	Lichodziejewski	N/A	N/A
7288326	12/2006	Elzey	N/A	N/A
7954301	12/2010	Mills	N/A	N/A
8383225	12/2012	Rotter	N/A	N/A
8857931	12/2013	Jung et al.	N/A	N/A
8881398	12/2013	Hanley et al.	N/A	N/A
8943770	12/2014	Sanders	N/A	N/A
8944541	12/2014	Allard et al.	N/A	N/A
9182158	12/2014	Wu	N/A	N/A
9328951	12/2015	Shin	N/A	N/A
9441779	12/2015	Alshourbagy et al.	N/A	N/A
9463918	12/2015	Reid	N/A	N/A
9752818	12/2016	Naik	N/A	N/A
9791204	12/2016	Kim	N/A	N/A
9945600	12/2017	Kang	N/A	N/A
10082328	12/2017	Jung et al.	N/A	N/A
10274247	12/2018	Jeong et al.	N/A	N/A
2002/0041134	12/2001	Wolf	312/400	F25D 23/085
2002/0100250	12/2001	Hirath et al.	N/A	N/A
2002/0170265	12/2001	Tokonabe et al.	N/A	N/A
2003/0080126	12/2002	Voute et al.	N/A	N/A

2003/0115838	12/2002	Rouanet et al.	N/A	N/A
2003/0207075	12/2002	Maignan et al.	N/A	N/A
2004/0051427	12/2003	Cittadini et al.	N/A	N/A
2004/0091688	12/2003	Gaku	N/A	N/A
2004/0226956	12/2003	Brooks	N/A	N/A
2005/0175809	12/2004	Hirai et al.	N/A	N/A
2005/0235682	12/2004	Hirai et al.	N/A	N/A
2007/0089989	12/2006	Hoagland	N/A	N/A
2007/0152551	12/2006	Kim et al.	N/A	N/A
2007/0204648	12/2006	Smale et al.	N/A	N/A
2007/0243358	12/2006	Gandini	N/A	N/A
2008/0110128	12/2007	Hirath	N/A	N/A
2008/0289898	12/2007	Rickards	N/A	N/A
2009/0031659	12/2008	Kalfon	N/A	N/A
2009/0113899	12/2008	Dain et al.	N/A	N/A
2010/0104923	12/2009	Takeguchi et al.	N/A	N/A
2010/0178439	12/2009	Bettger et al.	N/A	N/A
2010/0283359	12/2009	Hottmann	N/A	N/A
2011/0089802	12/2010	Cording	N/A	N/A
2011/0146333	12/2010	Koo et al.	N/A	N/A
2011/0241513	12/2010	Nomura	N/A	N/A
2011/0296797	12/2010	Stark et al.	N/A	N/A
2012/0103006	12/2011	Jung	N/A	N/A
2012/0104923	12/2011	Jung et al.	N/A	N/A
2012/0118002	12/2011	Kim et al.	N/A	N/A
2012/0125039	12/2011	Hwang	N/A	N/A
2012/0128920	12/2011	Yoon et al.	N/A	N/A
2012/0231204	12/2011	Jeon et al.	N/A	N/A
2012/0269996	12/2011	Jäger	N/A	N/A
2012/0326587	12/2011	Jeong et al.	N/A	N/A
2013/0008309	12/2012	Hashida	N/A	N/A
2013/0026900	12/2012	Oh et al.	N/A	N/A
2013/0099650	12/2012	Lee et al.	N/A	N/A
2013/0105494	12/2012	Jung	N/A	N/A
2013/0105495	12/2012	Jung	N/A	N/A
2013/0105496	12/2012	Jung	N/A	N/A
2013/0195544	12/2012	Sanders et al.	N/A	N/A
2013/0255304	12/2012	Cur et al.	N/A	N/A
2013/0257257	12/2012	Cur	N/A	N/A
2013/0293080	12/2012	Kim	N/A	N/A
2014/0103791	12/2013	Cheon	N/A	N/A
2014/0132142	12/2013	Kim et al.	N/A	N/A
2014/0216100	12/2013	Toshimitsu	N/A	N/A
2014/0272208	12/2013	Song et al.	N/A	N/A
2014/0315011	12/2013	Lee et al.	N/A	N/A
2014/0346942	12/2013	Kim	29/530	F25D 23/064
2015/0030800	12/2014	Jung et al.	N/A	N/A
2015/0068401	12/2014	Hashida	N/A	N/A
2015/0192356	12/2014	Kang et al.	N/A	N/A

2015/0360842	12/2014	Bessho et al.	N/A	N/A
2016/0108659	12/2015	Stark et al.	N/A	N/A
2016/0109172	12/2015	Kim et al.	N/A	N/A
2016/0356542	12/2015	Kim et al.	N/A	N/A
2017/0325634	12/2016	Cai et al.	N/A	N/A
2018/0266620	12/2017	Kawarazaki et al.	N/A	N/A
2018/0299060	12/2017	Song et al.	N/A	N/A
2018/0313492	12/2017	Kitano et al.	N/A	N/A
2019/0101320	12/2018	Dherde et al.	N/A	N/A
2019/0128593	12/2018	Deka et al.	N/A	N/A

## FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
1132346	12/1995	CN	N/A
1191959	12/1997	CN	N/A
1276052	12/1999	CN	N/A
1286386	12/2000	CN	N/A
1515857	12/2003	CN	N/A
1576678	12/2004	CN	N/A
2700790	12/2004	CN	N/A
1666071	12/2004	CN	N/A
2748848	12/2004	CN	N/A
1731053	12/2005	CN	N/A
1820173	12/2005	CN	N/A
1896657	12/2006	CN	N/A
101072968	12/2006	CN	N/A
101171472	12/2007	CN	N/A
101349493	12/2008	CN	N/A
201191121	12/2008	CN	N/A
201428906	12/2009	CN	N/A
201764779	12/2010	CN	N/A
102032736	12/2010	CN	N/A
201811526	12/2010	CN	N/A
102099646	12/2010	CN	N/A
102116402	12/2010	CN	N/A
102261470	12/2010	CN	N/A
102455103	12/2011	CN	N/A
102455104	12/2011	CN	N/A
102455105	12/2011	CN	N/A
102735013	12/2011	CN	N/A
102818421	12/2011	CN	N/A
102840729	12/2011	CN	N/A
102927740	12/2012	CN	N/A
103062981	12/2012	CN	N/A
103090615	12/2012	CN	N/A
103090616	12/2012	CN	N/A
103140640	12/2012	CN	N/A
103154648	12/2012	CN	N/A
103189696	12/2012	CN	N/A

103228851	12/2012	CN	N/A
203095854	12/2012	CN	N/A
103363764	12/2012	CN	N/A
103370587	12/2012	CN	N/A
103542660	12/2013	CN	N/A
103575038	12/2013	CN	N/A
103649658	12/2013	CN	N/A
103968196	12/2013	CN	N/A
104180595	12/2013	CN	N/A
104204646	12/2013	CN	N/A
104254749	12/2013	CN	N/A
104344653	12/2014	CN	N/A
104457117	12/2014	CN	N/A
104482707	12/2014	CN	N/A
104567215	12/2014	CN	N/A
104634047	12/2014	CN	N/A
104696669	12/2014	CN	N/A
104729201	12/2014	CN	N/A
104746690	12/2014	CN	N/A
105546923	12/2015	CN	N/A
108354755	12/2017	CN	N/A
956 899	12/1956	DE	N/A
28 02 910	12/1977	DE	N/A
29 39 878	12/1980	DE	N/A
31 21 351	12/1981	DE	N/A
9204365	12/1991	DE	N/A
197 45 825	12/1998	DE	N/A
1 980 3908	12/1998	DE	N/A
299 12 917	12/1998	DE	N/A
199 07 182	12/1999	DE	N/A
10-2011-050473	12/2010	DE	N/A
10 2011 014 302	12/2011	DE	N/A
10 2011 079 209	12/2012	DE	N/A
10-2012-100490	12/2012	DE	N/A
10-2012-223539	12/2013	DE	N/A
0 071 090	12/1982	EP	N/A
0 658 716	12/1994	EP	N/A
0 658 733	12/1994	EP	N/A
0 892 120	12/1998	EP	N/A
1 477 752	12/2003	EP	N/A
1 484 563	12/2003	EP	N/A
1 614 954	12/2005	EP	N/A
2 333 179	12/2010	EP	N/A
2 447 639	12/2011	EP	N/A
2 806 239	12/2013	EP	N/A
2 824 405	12/2014	EP	N/A
2 829 827	12/2014	EP	N/A
2 936 013	12/2014	EP	N/A
2 952 839	12/2014	EP	N/A
2952838	12/2014	EP	N/A

2 789 951	12/2019	EP	N/A
890372	12/1961	GB	N/A
2 446 053	12/2007	GB	N/A
H04-341694	12/1991	JP	N/A
H05-10494	12/1992	JP	N/A
H07-234067	12/1994	JP	N/A
H09-145241	12/1996	JP	N/A
11-211334	12/1998	JP	N/A
H11335114	12/1998	JP	N/A
2002-243091	12/2001	JP	N/A
2002340280	12/2001	JP	N/A
2003-106760	12/2002	JP	N/A
2003-269688	12/2002	JP	N/A
2004-044980	12/2003	JP	N/A
2004-196411	12/2003	JP	N/A
2005-214372	12/2004	JP	N/A
2007-218509	12/2006	JP	N/A
2008-045580	12/2007	JP	N/A
2008-249003	12/2007	JP	N/A
2009-078261	12/2008	JP	N/A
2010008011	12/2009	JP	N/A
2012-087993	12/2011	JP	N/A
2012-255607	12/2011	JP	N/A
2013-119966	12/2012	JP	N/A
2013-195009	12/2012	JP	N/A
2014-037931	12/2013	JP	N/A
1019920703942	12/1991	KR	N/A
10-2001-0073363	12/2000	KR	N/A
10-0343719	12/2001	KR	N/A
10-0411841	12/2002	KR	N/A
10-2005-0065088	12/2004	KR	N/A
20070052156	12/2006	KR	N/A
10-2009-0111632	12/2008	KR	N/A
10-2010-0097410	12/2009	KR	N/A
10-2010-0099629	12/2009	KR	N/A
10-2010-0119937	12/2009	KR	N/A
10-2010-0136614	12/2009	KR	N/A
10-2011-0015322	12/2010	KR	N/A
10-2011-0015325	12/2010	KR	N/A
10-2011-0015327	12/2010	KR	N/A
10-1041086	12/2010	KR	N/A
10-2011-0100440	12/2010	KR	N/A
10-2012-0044558	12/2011	KR	N/A
10-2012-0139648	12/2011	KR	N/A
10-1227516	12/2012	KR	N/A
10-2013-0048528	12/2012	KR	N/A
10-2013-0048530	12/2012	KR	N/A
10-2013-0054213	12/2012	KR	N/A
10-2014-0129552	12/2013	KR	N/A
10-2015-0012712	12/2014	KR	N/A

10-1506413	12/2014	KR	N/A
1005962	12/1997	NL	N/A
129188	12/2012	RU	N/A
WO 93/25843	12/1992	WO	N/A
WO 2006/003199	12/2005	WO	N/A
WO 2012/084874	12/2011	WO	N/A
WO 2012/176880	12/2011	WO	N/A
WO 2013/007568	12/2012	WO	N/A
WO-2013007568	12/2012	WO	F16L 59/065
WO 2014/049969	12/2013	WO	N/A
WO 2014/175639	12/2013	WO	N/A
WO 2016/208193	12/2015	WO	N/A
WO 2017/023095	12/2016	WO	N/A
WO 2017/192121	12/2016	WO	N/A
WO 2018/044274	12/2017	WO	N/A

## OTHER PUBLICATIONS

WO-2013007568-A2 Translation (Year: 2013). cited by examiner

European Search Report dated Nov. 3, 2022 issued in EP Application No. 22151005.0. cited by applicant

U.S. Office Action dated Apr. 27, 2023 issued in U.S. Appl. No. 17/072,231. cited by applicant

U.S. Notice of Allowance dated Mar. 23, 2023 issued in U.S. Appl. No. 16/953,846. cited by applicant

Korean Notice of Allowance dated Nov. 2, 2022 issued in KR Application No. 10-2015-0109720. cited by applicant

U.S. Office Action dated Mar. 20, 2023 issued in copending U.S. Appl. No. 17/030,806. cited by applicant

Machine translation of EP 2 952 839. cited by applicant

European Office Action dated Nov. 21, 2022 issued in EP Application No. 20168389.3. cited by applicant

United States Office Action dated Nov. 25, 2022 issued in co-pending related U.S. Appl. No. 17/411,659. cited by applicant

United States Office Action dated Oct. 6, 2022 issued in co-pending related U.S. Appl. No. 17/072,231. cited by applicant

International Search Report and Written Opinion dated Oct. 12, 2016 issued in Application No. PCT/KR2016/008465. cited by applicant

International Search Report and Written Opinion dated Oct. 12, 2016 issued in Application No. PCT/KR2016/008507. cited by applicant

International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008466. cited by applicant

International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008468. cited by applicant

International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008469. cited by applicant

International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008470. cited by applicant

International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008501. cited by applicant

International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No.



PCT/KR2016/008502. cited by applicant  
International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008505. cited by applicant  
International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008519. cited by applicant  
International Search Report and Written Opinion dated Nov. 21, 2016 issued in Application No. PCT/KR2016/008523. cited by applicant  
International Search Report and Written Opinion dated Dec. 7, 2016 issued in Application No. PCT/KR2016/008516. cited by applicant  
International Search Report and Written Opinion dated Dec. 23, 2016 issued in Application No. PCT/KR2016/008512. cited by applicant  
International Search Report and Written Opinion dated Dec. 23, 2016 issued in Application No. PCT/KR2016/008514. cited by applicant  
Russian Office Action dated Sep. 25, 2018 issued in RU Application No. 2018107646. cited by applicant  
European Search Report dated Dec. 21, 2018 issued in EP Application No. 16833330.0. cited by applicant  
European Search Report dated Feb. 13, 2019 issued in EP Application No. 16833309.4. cited by applicant  
European Search Report dated Feb. 13, 2019 issued in EP Application No. 16833311.0. cited by applicant  
European Search Report dated Feb. 20, 2019 issued in EP Application No. 16833313.6. cited by applicant  
European Search Report dated Feb. 22, 2019 issued in EP Application No. 16833312.8. cited by applicant  
European Search Report dated Feb. 26, 2019 issued in EP Application No. 16833324.3. cited by applicant  
European Search Report dated Feb. 26, 2019 issued in EP Application No. 16833336.7. cited by applicant  
European Search Report dated Mar. 1, 2019 issued in EP Application No. 16833323.5. cited by applicant  
European Search Report dated Mar. 1, 2019 issued in EP Application No. 16833338.3. cited by applicant  
European Search Report dated Mar. 13, 2019 issued in EP Application No. 16833331.8. cited by applicant  
European Search Report dated Mar. 15, 2019 issued in EP Application No. 16833326.8. cited by applicant  
European Search Report dated Apr. 3, 2019 issued in EP Application No. 16833325.0. cited by applicant  
U.S. Office Action dated Jun. 13, 2019 issued in related U.S. Appl. No. 15/749,139. cited by applicant  
U.S. Office Action dated Jun. 13, 2019 issued in related U.S. Appl. No. 15/749,142. cited by applicant  
U.S. Office Action dated Jun. 13, 2019 issued in related U.S. Appl. No. 15/749,136. cited by applicant  
Chinese Office Action (with English translation) dated Jul. 15, 2019 issued in CN Application No. 201680045949.0. cited by applicant  
Chinese Office Action (with English translation) dated Aug. 5, 2019 issued in CN Application No. 201680045869.5. cited by applicant  
Chinese Office Action (with English translation) dated Aug. 5, 2019 issued in CN Application No.

201680045899.6. cited by applicant  
Chinese Office Action (with English translation) dated Aug. 5, 2019 issued in CN Application No. 201680045908.1. cited by applicant  
Chinese Office Action (with English translation) dated Aug. 5, 2019 issued in CN Application No. 201680045935.9. cited by applicant  
Chinese Office Action (with English translation) dated Aug. 5, 2019 issued in CN Application No. 201680046042.6. cited by applicant  
Chinese Office Action (with English translation) dated Aug. 5, 2019 issued in CN Application No. 201680046048.3. cited by applicant  
Chinese Office Action (with English translation) dated Aug. 13, 2019 issued in CN Application No. 201680045950.3. cited by applicant  
Chinese Office Action (with English translation) dated Sep. 19, 2019 issued in CN Application No. 201680045897. 7. cited by applicant  
Chinese Office Action (with English translation) dated Sep. 19, 2019 issued in CN Application No. 201680045898.1. cited by applicant  
Chinese Office Action (with English translation) dated Sep. 19, 2019 issued in CN Application No. 201680046047.9. cited by applicant  
United States Office Action dated Sep. 20, 2019 issued in U.S. Appl. No. 15/749,149. cited by applicant  
U.S. Office Action dated Oct. 4, 2019 issued in related U.S. Appl. No. 15/749,140. cited by applicant  
U.S. Office Action dated Oct. 17, 2019 issued in U.S. Appl. No. 15/749,147. cited by applicant  
U.S. Office Action dated Oct. 17, 2019 issued in U.S. Appl. No. 15/749,143. cited by applicant  
U.S. Office Action dated Oct. 17, 2019 issued in U.S. Appl. No. 15/749,162. cited by applicant  
United States Office Action dated Dec. 10, 2019 issued in U.S. Appl. No. 15/749,132. cited by applicant  
United States Office Action dated Feb. 18, 2020 issued in U.S. Appl. No. 15/749,146. cited by applicant  
United States Office Action dated Mar. 20, 2020 issued in U.S. Appl. No. 15/749,162. cited by applicant  
United States Office Action dated Mar. 24, 2020 issued in U.S. Appl. No. 15/749,154. cited by applicant  
United States Office Action dated Mar. 25, 2020 issued in U.S. Appl. No. 15/749,156. cited by applicant  
United States Office Action dated Mar. 27, 2020 issued in U.S. Appl. No. 15/749,149. cited by applicant  
United States Office Action dated Apr. 15, 2020 issued in U.S. Appl. No. 15/749,136. cited by applicant  
United States Notice of Allowance dated Apr. 15, 2020 issued in U.S. Appl. No. 15/749,140. cited by applicant  
Korean Office Action dated Jun. 5, 2020 issued in Application 10-2017-0093784. cited by applicant  
Extended European Search Report dated Jul. 10, 2020 issued in Application 20168389.3. cited by applicant  
United States Notice of Allowance dated Aug. 10, 2020 issued in U.S. Appl. No. 15/749,154. cited by applicant  
U.S. Office Action dated Sep. 1, 2020 issued in U.S. Appl. No. 15/749,156. cited by applicant  
United States Notice of Allowance dated Oct. 21, 2020 issued in U.S. Appl. No. 15/749,154. cited by applicant  
European Office Action dated Jan. 11, 2021 issued in Application 16 833 313.6. cited by applicant  
U.S. Office Action dated Mar. 31, 2021 issued in co-pending U.S. Appl. No. 15/749,132. cited by

applicant  
Chinese Office Action dated Apr. 6, 2021 issued in CN Application No. 202010248772.2. cited by applicant  
Chinese Office Action dated Apr. 6, 2021 issued in CN Application No. 202010248789.8. cited by applicant  
Chinese Office Action dated Apr. 6, 2021 issued in CN Application No. 202010248791.5. cited by applicant  
Chinese Office Action dated Apr. 8, 2021 issued in CN Application No. 202010248891.8. cited by applicant  
Chinese Office Action dated Jun. 2, 2021 issued in CN Application No. 202010634146.7. cited by applicant  
Chinese Office Action dated Jun. 23, 2021 issued in CN Application No. 202010669915.7. cited by applicant  
U.S. Office Action dated Jun. 28, 2021 issued in co-pending related U.S. Appl. No. 15/749,156. cited by applicant  
Chinese Office Action and Search Report dated Jul. 20, 2021 issued in Application 20101067100.X. cited by applicant  
Chinese Office Action dated Jun. 24, 2021 issued in CN Application No. 202010669926.5. cited by applicant  
United States Office Action dated Oct. 5, 2021 issued in co-pending related U.S. Appl. No. 16/942,262. cited by applicant  
United States Office Action dated Oct. 19, 2021 issued in co-pending related U.S. Appl. No. 17/021,582. cited by applicant  
United States Office Action dated Oct. 26, 2021 issued in co-pending related U.S. Appl. No. 16/942,213. cited by applicant  
Korean Office Action dated Aug. 1, 2021 issued in KR Application No. 10-2021-0085731. cited by applicant  
Chinese Office Action dated Aug. 2, 2021 issued in CN Application No. 202010972409.5. cited by applicant  
Chinese Office Action dated Aug. 3, 2021 issued in CN Application No. 202010972419.9. cited by applicant  
Chinese Office Action dated Aug. 4, 2021 issued in CN Application No. 202010972442.8. cited by applicant  
European Search Report dated Oct. 11, 2021 issued in EP Application No. 21185349.4. cited by applicant  
European Search Report dated Oct. 11, 2021 issued in EP Application No. 21185362.7. cited by applicant  
Chinese Office Action dated Dec. 3, 2021 issued in CN Application No. 202110032077.7. cited by applicant  
European Search Report dated Feb. 8, 2022 issued in EP Application No. 21203498.7. cited by applicant  
Chinese Office Action dated Feb. 15, 2022 issued in CN Application No. 202010671000.X. cited by applicant  
Chinese Office Action dated Feb. 18, 2022 issued in CN Application No. 202010975466.9. cited by applicant  
U.S. Office Action dated Mar. 31, 2022 issued in co-pending related U.S. Appl. No. 16/929,523. cited by applicant  
U.S. Office Action dated Mar. 2, 2022 issued in co-pending related U.S. Appl. No. 17/170,005. cited by applicant  
Chinese Office Action dated May 18, 2022 issued in CN Application No. 202110718315.X. cited

by applicant  
U.S. Office Action dated Jun. 10, 2022 issued in co-pending related U.S. Appl. No. 16/942,213.  
cited by applicant  
U.S. Office Action dated Jul. 7, 2022 issued in co-pending related U.S. Appl. No. 16/710,720. cited  
by applicant  
U.S. Office Action dated Jul. 13, 2022 issued in co-pending related U.S. Appl. No. 17/134,911.  
cited by applicant  
U.S. Office Action dated Jul. 26, 2022 issued in co-pending related U.S. Appl. No. 17/030,806.  
cited by applicant  
Chinese Notice of Allowance dated Jun. 1, 2022 issued in CN Application No. 202110032072.4.  
cited by applicant  
Korean Office Action dated Aug. 8, 2022 issued in KR Application No. 10-2015-0109622. cited by  
applicant  
Korean Notice of Allowance dated Jun. 1, 2022 issued in KR Application No. 10-2021-0085731.  
cited by applicant  
United States Office Action dated Jan. 18, 2023 issued in co-pending related U.S. Appl. No.  
16/942,213. cited by applicant  
United States Office Action dated Dec. 22, 2022 issued in co-pending related U.S. Appl. No.  
16/953,846. cited by applicant  
Chinese Office Action dated Aug. 30, 2023 issued in Application No. 202110718284.8. cited by  
applicant  
Korean Office Action dated Nov. 13, 2023 issued in Application No. 10-2023-0014241. cited by  
applicant  
U.S. Notice of Allowance dated Oct. 23, 2023, issued in U.S. Appl. No. 17/072,231. cited by  
applicant  
Korean Office Action dated Jul. 31, 2023 issued in Application 10-2023-0020717. cited by  
applicant  
U.S. Appl. No. 18/091,203, filed Dec. 29, 2022. cited by applicant  
U.S. Non-Final Office Action dated Feb. 27, 2024 issued in U.S. Appl. No. 17/980,088. cited by  
applicant  
U.S. Appl. No. 16/710,720, filed Dec. 11, 2019. cited by applicant  
U.S. Appl. No. 16/942,213, filed Jul. 29, 2020. cited by applicant  
U.S. Appl. No. 17/030,806, filed Sep. 24, 2020. cited by applicant  
U.S. Appl. No. 17/072,231, filed Oct. 16, 2020. cited by applicant  
U.S. Appl. No. 17/155,430, filed Jan. 22, 2021. cited by applicant  
U.S. Office Action dated Jan. 24, 2024 issued in U.S. Appl. No. 17/582,596. cited by applicant  
Korean Office Action dated Apr. 4, 2024 issued in Application No. 10-2023-0036738. cited by  
applicant  
U.S. Office Action dated Jul. 3, 2024 issued in U.S. Appl. No. 17/582,596. cited by applicant  
U.S. Office Action dated Mar. 18, 2024, issued in U.S. Appl. No. 18/237,531. cited by applicant  
U.S. Office Action dated Nov. 29, 2024 issued in U.S. Appl. No. 17/411,659. cited by applicant  
U.S. Appl. No. 17/411,659, filed Aug. 25, 2021. cited by applicant  
U.S. Appl. No. 18/640,367, filed Apr. 19, 2024. cited by applicant  
U.S. Appl. No. 17/170,005, filed Feb. 8, 2021. cited by applicant  
U.S. Appl. No. 17/749,679, filed May 20, 2022. cited by applicant  
U.S. Appl. No. 17/582,596, filed Jan. 24, 2022. cited by applicant  
U.S. Appl. No. 18/508,279, filed Nov. 14, 2023. cited by applicant  
U.S. Appl. No. 18/095,658, filed Jan. 11, 2023. cited by applicant  
U.S. Appl. No. 18/237,531, filed Aug. 24, 2023. cited by applicant  
U.S. Appl. No. 17/980,088, filed Nov. 3, 2022. cited by applicant

U.S. Appl. No. 18/416,453, filed Jan. 18, 2024. cited by applicant  
U.S. Appl. No. 18/091,040, filed Dec. 29, 2022. cited by applicant  
European Search Report dated Jul. 12, 2024 issued in Application No. 20193768.7. cited by applicant  
Chinese Office Action dated Jun. 14, 2024 issued in Application No. 202010974212.5. cited by applicant  
U.S. Office Action dated Nov. 18, 2024 issued in U.S. Appl. No. 18/095,658. cited by applicant  
Korean Office Action dated Oct. 22, 2024 issued in Application No. 10-2024-0110720. cited by applicant  
U.S. Appl. No. 18/915,472, filed Oct. 15, 2024. cited by applicant  
Korean Office Action dated Nov. 1, 2023 issued in Application No. 10-2023-0015566. cited by applicant

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## **Background/Summary**

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a Continuation Applications of U.S. patent application Ser. No. 17/170,005 filed Feb. 8, 2021, which is a Continuation Applications of U.S. application Ser. No. 15/749,136, filed Jan. 31, 2018 (now U.S. Pat. No. 10,941,974), which is a U.S. National Stage Application under 35 U.S.C. § 371 of PCT Application No. PCT/KR2016/008501, filed Aug. 2, 2016, which claims priority to Korean Patent Application No. 10-2015-0109722, filed Aug. 3, 2015, whose entire disclosures are hereby incorporated by reference.

### **BACKGROUND**

#### **1. Field**

(1) The present disclosure relates to a vacuum adiabatic body and a refrigerator.

#### **2. Background**

(2) A vacuum adiabatic body is a product for suppressing heat transfer by vacuumizing the interior of a body thereof. The vacuum adiabatic body can reduce heat transfer by convection and conduction, and hence is applied to heating apparatuses and refrigerating apparatuses. In a typical adiabatic method applied to a refrigerator, although it is differently applied in refrigeration and freezing, a foam urethane adiabatic wall having a thickness of about 30 cm or more is generally provided. However, the internal volume of the refrigerator is therefore reduced. In order to increase the internal volume of a refrigerator, there is an attempt to apply a vacuum adiabatic body to the refrigerator.

(3) First, Korean Patent No. 10-0343719 (Reference Document 1) of the present applicant has been disclosed. According to Reference Document 1, there is disclosed a method in which a vacuum adiabatic panel is prepared and then built in walls of a refrigerator, and the exterior of the vacuum adiabatic panel is finished with a separate molding such as Styrofoam (polystyrene). According to the method, additional foaming is not required, and the adiabatic performance of the refrigerator is improved. However, manufacturing cost is increased, and a manufacturing method is complicated.

(4) As another example, a technique of providing walls using a vacuum adiabatic material and additionally providing adiabatic walls using a foam filling material has been disclosed in Korean Patent Publication No. 10-2015-0012712 (Reference Document 2). According to Reference Document 2, manufacturing cost is increased, and a manufacturing method is complicated.

(5) As another example, there is an attempt to manufacture all walls of a refrigerator using a vacuum adiabatic body that is a single product. For example, a technique of providing an adiabatic structure of a refrigerator to be in a vacuum state has been disclosed in U.S. Patent Laid-Open Publication No. US 2004/0026956 A1 (Reference Document 3).

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

(1) The embodiments will be described in detail with reference to the following drawings in which like reference numerals refer to like elements wherein:

(2) FIG. 1 is a perspective view of a refrigerator according to an embodiment.

(3) FIG. 2 is a view schematically showing a vacuum adiabatic body used in a main body and a door of the refrigerator.

(4) FIG. 3 is a view showing various embodiments of an internal configuration of a vacuum space part.

(5) FIG. 4 is a view showing various embodiments of conductive resistance sheets and peripheral parts thereof.

(6) FIG. 5 is a view illustrating in detail a vacuum adiabatic body according to an embodiment.

(7) FIG. 6 is an exploded perspective view of the vacuum adiabatic body according to the embodiment.

(8) FIG. 7 is a sectional view of any one edge portion of the vacuum adiabatic body.

(9) FIG. 8 is a view illustrating a state in which a gasket is fixed to a peripheral adiabatic material.

(10) FIG. 9 is a view showing a process of fastening the peripheral adiabatic material.

(11) FIG. 10 is a sectional view of an edge portion of a vacuum adiabatic body according to an embodiment.

(12) FIG. 11 illustrates graphs showing changes in adiabatic performance and changes in gas conductivity with respect to vacuum pressures by applying a simulation.

(13) FIG. 12 illustrates graphs obtained by observing, over time and pressure, a process of exhausting the interior of the vacuum adiabatic body when a supporting unit is used.

(14) FIG. 13 illustrates graphs obtained by comparing vacuum pressures and gas conductivities.

(15) FIG. 14 is a schematic sectional view illustrating a case where a vacuum adiabatic body is applied to a door-in-door refrigerator according to an embodiment, in which FIG. 14(a) illustrates a case where typical foaming urethane is applied and FIG. 14(b) illustrates a case where the vacuum adiabatic body is applied.

### DETAILED DESCRIPTION

(16) Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings.

(17) In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific preferred embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure, and it is understood that other embodiments may be utilized and that logical structural, mechanical, electrical, and chemical changes may be made without departing from the spirit or scope of the disclosure. To avoid detail not necessary to enable those skilled in the art to practice the disclosure, the description may omit certain information known to those skilled in the art. The following detailed description is, therefore, not to be taken in a limiting sense.

(18) In the following description, the term 'vacuum pressure' means a certain pressure state lower than atmospheric pressure. In addition, the expression that a vacuum degree of A is higher than that of B means that a vacuum pressure of A is lower than that of B.

(19) FIG. 1 is a perspective view of a refrigerator according to an embodiment. Referring to FIG. 1, the refrigerator **1** includes a main body **2** provided with a cavity **9** capable of storing storage goods and a door **3** provided to open/close the main body **2**. The door **3** may be rotatably or movably disposed to open/close the cavity **9**. The cavity **9** may provide at least one of a refrigerating chamber and a freezing chamber.

(20) Parts constituting a freezing cycle in which cold air is supplied into the cavity **9** may be included. Specifically, the parts include a compressor **4** for compressing a refrigerant, a condenser **5** for condensing the compressed refrigerant, an expander **6** for expanding the condensed refrigerant, and an evaporator **7** for evaporating the expanded refrigerant to take heat. As a typical structure, a fan may be installed at a position adjacent to the evaporator **7**, and a fluid blown from the fan may pass through the evaporator **7** and then be blown into the cavity **9**. A freezing load is controlled by adjusting the blowing amount and blowing direction by the fan, adjusting the amount of a circulated refrigerant, or adjusting the compression rate of the compressor, so that it is possible to control a refrigerating space or a freezing space.

(21) FIG. 2 is a view schematically showing a vacuum adiabatic body used in the main body and the door of the refrigerator. In FIG. 2, a main body-side vacuum adiabatic body is illustrated in a state in which top and side walls are removed, and a door-side vacuum adiabatic body is illustrated in a state in which a portion of a front wall is removed. In addition, sections of portions at conductive resistance sheets are provided are schematically illustrated for convenience of understanding.

(22) Referring to FIG. 2, the vacuum adiabatic body includes a first plate member (or first plate **10** for providing a wall of a low-temperature space, a second plate member (or second plate) **20** for providing a wall of a high-temperature space, and a vacuum space part (or vacuum space) **50** defined as a gap part between the first and second plate members **10** and **20**. Also, the vacuum adiabatic body includes the conductive resistance sheets **60** and **63** for preventing heat conduction between the first and second plate members **10** and **20**.

(23) A sealing part (or seal) **61** for sealing the first and second plate members **10** and **20** is provided such that the vacuum space part **50** is in a sealing state. When the vacuum adiabatic body is applied to a refrigerating or heating cabinet, the first plate member **10** may be referred to as an inner case, and the second plate member **20** may be referred to as an outer case. A machine chamber **8** in which parts providing a freezing cycle are accommodated is placed at a lower rear side of the main body-side vacuum adiabatic body, and an exhaust port **40** for forming a vacuum state by exhausting air in the vacuum space part **50** is provided at any one side of the vacuum adiabatic body. In addition, a pipeline **64** passing through the vacuum space part **50** may be further installed so as to install a defrosting water line and electric lines.

(24) The first plate member **10** may define at least one portion of a wall for a first space provided thereto. The second plate member **20** may define at least one portion of a wall for a second space provided thereto. The first space and the second space may be defined as spaces having different temperatures. Here, the wall for each space may serve as not only a wall directly contacting the space but also a wall not contacting the space. For example, the vacuum adiabatic body of the embodiment may also be applied to a product further having a separate wall contacting each space.

(25) Factors of heat transfer, which cause loss of the adiabatic effect of the vacuum adiabatic body, are heat conduction between the first and second plate members **10** and **20**, heat radiation between the first and second plate members **10** and **20**, and gas conduction of the vacuum space part **50**.

(26) Hereinafter, a heat resistance unit provided to reduce adiabatic loss related to the factors of the heat transfer will be provided. Meanwhile, the vacuum adiabatic body and the refrigerator of the embodiment do not exclude that another adiabatic means is further provided to at least one side of the vacuum adiabatic body. Therefore, an adiabatic means using foaming or the like may be further provided to another side of the vacuum adiabatic body.

(27) FIG. 3 is a view showing various embodiments of an internal configuration of the vacuum

space part. First, referring to FIG. 3a, the vacuum space part **50** is provided in a third space having a different pressure from the first and second spaces, preferably, a vacuum state, thereby reducing adiabatic loss. The third space may be provided at a temperature between the temperature of the first space and the temperature of the second space. Since the third space is provided as a space in the vacuum state, the first and second plate members **10** and **20** receive a force contracting in a direction in which they approach each other due to a force corresponding to a pressure difference between the first and second spaces. Therefore, the vacuum space part **50** may be deformed in a direction in which it is reduced. In this case, adiabatic loss may be caused due to an increase in amount of heat radiation, caused by the contraction of the vacuum space part **50**, and an increase in amount of heat conduction, caused by contact between the plate members **10** and **20**.

(28) A supporting unit (or support) **30** may be provided to reduce the deformation of the vacuum space part **50**. The supporting unit **30** includes bars **31**. The bars **31** may extend in a direction substantially vertical to the first and second plate members **10** and **20** so as to support a distance between the first and second plate members **10** and **20**. A support plate **35** may be additionally provided to at least one end of the bar **31**. The support plate **35** connects at least two bars **31** to each other, and may extend in a direction horizontal to the first and second plate members **10** and **20**.

(29) The support plate **35** may be provided in a plate shape, or may be provided in a lattice shape such that its area contacting the first or second plate member **10** or **20** is decreased, thereby reducing heat transfer. The bars **31** and the support plate **35** are fixed to each other at at least one portion, to be inserted together between the first and second plate members **10** and **20**. The support plate **35** contacts at least one of the first and second plate members **10** and **20**, thereby preventing deformation of the first and second plate members **10** and **20**.

(30) In addition, based on the extending direction of the bars **31**, a total sectional area of the support plate **35** is provided to be greater than that of the bars **31**, so that heat transferred through the bars **31** can be diffused through the support plate **35**. A material of the supporting unit **30** may include a resin selected from the group consisting of PC, glass fiber PC, low outgassing PC, PPS, and LCP so as to obtain high compressive strength, low outgassing and water absorptance, low thermal conductivity, high compressive strength at high temperature, and excellent machinability.

(31) A radiation resistance sheet **32** for reducing heat radiation between the first and second plate members **10** and **20** through the vacuum space part **50** will be described. The first and second plate members **10** and **20** may be made of a stainless material capable of preventing corrosion and providing a sufficient strength. The stainless material has a relatively high emissivity of 0.16, and hence a large amount of radiation heat may be transferred.

(32) In addition, the supporting unit **30** made of the resin has a lower emissivity than the plate members, and is not entirely provided to inner surfaces of the first and second plate members **10** and **20**. Hence, the supporting unit **30** does not have great influence on radiation heat. Therefore, the radiation resistance sheet **32** may be provided in a plate shape over a majority of the area of the vacuum space part **50** so as to concentrate on reduction of radiation heat transferred between the first and second plate members **10** and **20**.

(33) A product having a low emissivity may be preferably used as the material of the radiation resistance sheet **32**. In an embodiment, an aluminum foil having an emissivity of 0.02 may be used as the radiation resistance sheet **32**. Since the transfer of radiation heat cannot be sufficiently blocked using one radiation resistance sheet, at least two radiation resistance sheets **32** may be provided at a certain distance so as not to contact each other. In addition, at least one radiation resistance sheet may be provided in a state in which it contacts the inner surface of the first or second plate member **10** or **20**.

(34) Referring to FIG. 3b, the distance between the plate members is maintained by the supporting unit **30**, and a porous material **33** may be filled in the vacuum space part **50**. The porous material **33** may have a higher emissivity than the stainless material of the first and second plate members **10** and **20**. However, since the porous material **33** is filled in the vacuum space part **50**, the porous



material **33** has a high efficiency for resisting the radiation heat transfer. In this embodiment, the vacuum adiabatic body can be manufactured without using the radiation resistance sheet **32**.

(35) Referring to FIG. **3c**, the supporting unit **30** maintaining the vacuum space part **50** is not provided. Instead of the supporting unit **30**, the porous material **33** is provided in a state in which it is surrounded by a film **34**. In this case, the porous material **33** may be provided in a state in which it is compressed so as to maintain the gap of the vacuum space part **50**. The film **34** is made of, for example, a PE material, and may be provided in a state in which holes are formed therein.

(36) In this embodiment, the vacuum adiabatic body can be manufactured without using the supporting unit **30**. In other words, the porous material **33** can serve together as the radiation resistance sheet **32** and the supporting unit **30**.

(37) FIG. **4** is a view showing various embodiments of the conductive resistance sheets and peripheral parts thereof. Structures of the conductive resistance sheets are briefly illustrated in FIG. **2**, but will be understood in detail with reference to FIG. **4**.

(38) First, a conductive resistance sheet proposed in FIG. **4a** may be preferably applied to the main body-side vacuum adiabatic body. Specifically, the first and second plate members **10** and **20** are to be sealed so as to vacuumize the interior of the vacuum adiabatic body. In this case, since the two plate members have different temperatures from each other, heat transfer may occur between the two plate members. A conductive resistance sheet **60** is provided to prevent heat conduction between two different kinds of plate members.

(39) The conductive resistance sheet **60** may be provided with sealing parts **61** at which both ends of the conductive resistance sheet **60** are sealed to define at least one portion of the wall for the third space and maintain the vacuum state. The conductive resistance sheet **60** may be provided as a thin foil in units of micrometers so as to reduce the amount of heat conducted along the wall for the third space. The sealing parts may be provided as welding parts. That is, the conductive resistance sheet **60** and the plate members **10** and **20** may be fused to each other.

(40) In order to cause a fusing action between the conductive resistance sheet **60** and the plate members **10** and **20**, the conductive resistance sheet **60** and the plate members **10** and **20** may be made of the same material, and a stainless material may be used as the material. The sealing parts **61** are not limited to the welding parts, and may be provided through a process such as cocking. The conductive resistance sheet **60** may be provided in a curved shape. Thus, a heat conduction distance of the conductive resistance sheet **60** is provided longer than the linear distance of each plate member, so that the amount of heat conduction can be further reduced.

(41) A change in temperature occurs along the conductive resistance sheet **60**. Therefore, in order to block heat transfer to the exterior of the conductive resistance sheet **60**, a shielding part (or shield) **62** may be provided at the exterior of the conductive resistance sheet **60** such that an adiabatic action occurs. In other words, in the refrigerator, the second plate member **20** has a high temperature and the first plate member **10** has a low temperature. In addition, heat conduction from high temperature to low temperature occurs in the conductive resistance sheet **60**, and hence the temperature of the conductive resistance sheet **60** is suddenly changed. Therefore, when the conductive resistance sheet **60** is opened to the exterior thereof, heat transfer through the opened place may seriously occur.

(42) In order to reduce heat loss, the shielding part **62** is provided at the exterior of the conductive resistance sheet **60**. For example, when the conductive resistance sheet **60** is exposed to any one of the low-temperature space and the high-temperature space, the conductive resistance sheet **60** does not serve as a conductive resistor as well as the exposed portion thereof, which is not preferable.

(43) The shielding part **62** may be provided as a porous material contacting an outer surface of the conductive resistance sheet **60**. The shielding part **62** may be provided as an adiabatic structure, e.g., a separate gasket, which is placed at the exterior of the conductive resistance sheet **60**. The shielding part **62** may be provided as a portion of the vacuum adiabatic body, which is provided at a position facing a corresponding conductive resistance sheet **60** when the main body-side vacuum

adiabatic body is closed with respect to the door-side vacuum adiabatic body. In order to reduce heat loss even when the main body and the door are opened, the shielding part **62** may be preferably provided as a porous material or a separate adiabatic structure.

(44) A conductive resistance sheet proposed in FIG. **4b** may be preferably applied to the door-side vacuum adiabatic body. In FIG. **4b**, portions different from those of FIG. **4a** are described in detail, and the same description is applied to portions identical to those of FIG. **4a**. A side frame **70** is further provided at an outside of the conductive resistance sheet **60**. A part for sealing between the door and the main body, an exhaust port necessary for an exhaust process, a getter port for vacuum maintenance, and the like may be placed on the side frame **70**. This is because the mounting of parts is convenient in the main body-side vacuum adiabatic body, but the mounting positions of parts are limited in the door-side vacuum adiabatic body.

(45) In the door-side vacuum adiabatic body, it is difficult to place the conductive resistance sheet **60** at a front end portion of the vacuum space part, i.e., a corner side portion of the vacuum space part. This is because, unlike the main body, a corner edge portion of the door is exposed to the exterior. More specifically, if the conductive resistance sheet **60** is placed at the front end portion of the vacuum space part, the corner edge portion of the door is exposed to the exterior, and hence there is a disadvantage in that a separate adiabatic part should be configured so as to heat-insulate the conductive resistance sheet **60**.

(46) A conductive resistance sheet proposed in FIG. **4c** may be preferably installed in the pipeline passing through the vacuum space part. In FIG. **4c**, portions different from those of FIGS. **4a** and **4b** are described in detail, and the same description is applied to portions identical to those of FIGS. **4a** and **4b**. A conductive resistance sheet having the same shape as that of FIG. **4a**, preferably, a wrinkled conductive resistance sheet **63** may be provided at a peripheral portion of the pipeline **64**. Accordingly, a heat transfer path can be lengthened, and deformation caused by a pressure difference can be prevented. In addition, a separate shielding part may be provided to improve the adiabatic performance of the conductive resistance sheet.

(47) A heat transfer path between the first and second plate members **10** and **20** will be described with reference back to FIG. **4a**. Heat passing through the vacuum adiabatic body may be divided into surface conduction heat {circle around (1)} conducted along a surface of the vacuum adiabatic body, more specifically, the conductive resistance sheet **60**, supporter conduction heat {circle around (2)} conducted along the supporting unit **30** provided inside the vacuum adiabatic body, gas conduction heat (or convection) {circle around (3)} conducted through an internal gas in the vacuum space part, and radiation transfer heat {circle around (4)} transferred through the vacuum space part.

(48) The transfer heat may be changed depending on various design dimensions. For example, the supporting unit may be changed such that the first and second plate members **10** and **20** can endure a vacuum pressure without being deformed, the vacuum pressure may be changed, the distance between the plate members may be changed, and the length of the conductive resistance sheet may be changed. The transfer heat may be changed depending on a difference in temperature between the spaces (the first and second spaces) respectively provided by the plate members. In the embodiment, a preferred configuration of the vacuum adiabatic body has been found by considering that its total heat transfer amount is smaller than that of a typical adiabatic structure formed by foaming polyurethane. In a typical refrigerator including the adiabatic structure formed by foaming the polyurethane, an effective heat transfer coefficient may be proposed as 19.6 mW/mK.

(49) By performing a relative analysis on heat transfer amounts of the vacuum adiabatic body of the embodiment, a heat transfer amount by the gas conduction heat {circle around (3)} can become smallest. For example, the heat transfer amount by the gas conduction heat {circle around (3)} may be controlled to be equal to or smaller than 4% of the total heat transfer amount. A heat transfer amount by solid conduction heat defined as a sum of the surface conduction heat {circle around

(1)} and the supporter conduction heat {circle around (2)} is largest. For example, the heat transfer amount by the solid conduction heat may reach 75% of the total heat transfer amount. A heat transfer amount by the radiation transfer heat {circle around (4)} is smaller than the heat transfer amount by the solid conduction heat but larger than the heat transfer amount of the gas conduction heat {circle around (3)}. For example, the heat transfer amount by the radiation transfer heat {circle around (4)} may occupy about 20% of the total heat transfer amount.

(50) According to such a heat transfer distribution, effective heat transfer coefficients (eK: effective K) (W/mK) of the surface conduction heat {circle around (1)}, the supporter conduction heat {circle around (2)}, the gas conduction heat {circle around (3)}, and the radiation transfer heat {circle around (4)} may have an order of Math Figure 1.

$eK_{\text{sub.solid conduction heat}} > eK_{\text{sub.radiation transfer heat}} > eK_{\text{sub.gas conduction heat}}$  Math Figure 1

(51) Here, the effective heat transfer coefficient (eK) is a value that can be measured using a shape and temperature differences of a target product. The effective heat transfer coefficient (eK) is a value that can be obtained by measuring a total heat transfer amount and a temperature of at least one portion at which heat is transferred. For example, a calorific value (W) is measured using a heating source that can be quantitatively measured in the refrigerator, a temperature distribution (K) of the door is measured using heats respectively transferred through a main body and an edge of the door of the refrigerator, and a path through which heat is transferred is calculated as a conversion value (m), thereby evaluating an effective heat transfer coefficient.

(52) The effective heat transfer coefficient (eK) of the entire vacuum adiabatic body is a value given by  $k = QL / A_{\text{sub}} \Delta T$ . Here, Q denotes a calorific value (W) and may be obtained using a calorific value of a heater. A denotes a sectional area ( $m^2$ ) of the vacuum adiabatic body, L denotes a thickness (m) of the vacuum adiabatic body, and  $\Delta T$  denotes a temperature difference.

(53) For the surface conduction heat, a conductive calorific value may be obtained through a temperature difference ( $\Delta T$ ) between an entrance and an exit of the conductive resistance sheet **60** or **63**, a sectional area (A) of the conductive resistance sheet, a length (L) of the conductive resistance sheet, and a thermal conductivity (k) of the conductive resistance sheet (the thermal conductivity of the conductive resistance sheet is a material property of a material and can be obtained in advance). For the supporter conduction heat, a conductive calorific value may be obtained through a temperature difference ( $\Delta T$ ) between an entrance and an exit of the supporting unit **30**, a sectional area (A) of the supporting unit, a length (L) of the supporting unit, and a thermal conductivity (k) of the supporting unit.

(54) Here, the thermal conductivity of the supporting unit is a material property of a material and can be obtained in advance. The sum of the gas conduction heat {circle around (3)}, and the radiation transfer heat {circle around (4)} may be obtained by subtracting the surface conduction heat and the supporter conduction heat from the heat transfer amount of the entire vacuum adiabatic body. A ratio of the gas conduction heat {circle around (3)}, and the radiation transfer heat {circle around (4)} may be obtained by evaluating radiation transfer heat when no gas conduction heat exists by remarkably lowering a vacuum degree of the vacuum space part **50**.

(55) When a porous material is provided inside the vacuum space part **50**, porous material conduction heat {circle around (5)} may be a sum of the supporter conduction heat {circle around (2)} and the radiation transfer heat {circle around (4)}. The porous material conduction heat {circle around (5)} may be changed depending on various variables including a kind, an amount, and the like of the porous material.

(56) According to an embodiment, a temperature difference  $\Delta T_{\text{sub.1}}$  between a geometric center formed by adjacent bars **31** and a point at which each of the bars **31** is located may be preferably provided to be less than  $0.5^\circ \text{C}$ . Also, a temperature difference  $\Delta T_{\text{sub.2}}$  between the geometric center formed by the adjacent bars **31** and an edge portion of the vacuum adiabatic

body may be preferably provided to be less than  $0.5^{\circ}\text{C}$ . In the second plate member **20**, a temperature difference between an average temperature of the second plate and a temperature at a point at which a heat transfer path passing through the conductive resistance sheet **60** or **63** meets the second plate may be largest.

(57) For example, when the second space is a region hotter than the first space, the temperature at the point at which the heat transfer path passing through the conductive resistance sheet meets the second plate member becomes lowest. Similarly, when the second space is a region colder than the first space, the temperature at the point at which the heat transfer path passing through the conductive resistance sheet meets the second plate member becomes highest.

(58) This means that the amount of heat transferred through other points except the surface conduction heat passing through the conductive resistance sheet should be controlled, and the entire heat transfer amount satisfying the vacuum adiabatic body can be achieved only when the surface conduction heat occupies the largest heat transfer amount. To this end, a temperature variation of the conductive resistance sheet may be controlled to be larger than that of the plate member.

(59) Physical characteristics of the parts constituting the vacuum adiabatic body will be described. In the vacuum adiabatic body, a force by vacuum pressure is applied to all of the parts. Therefore, a material having a strength ( $\text{N/m}^2$ ) of a certain level may be preferably used.

(60) Under such circumstances, the plate members **10** and **20** and the side frame **70** may be preferably made of a material having a sufficient strength with which they are not damaged by even vacuum pressure. For example, when the number of bars **31** is decreased so as to limit the support conduction heat, deformation of the plate member occurs due to the vacuum pressure, which may be a bad influence on the external appearance of refrigerator. The radiation resistance sheet **32** may be preferably made of a material that has a low emissivity and can be easily subjected to thin film processing. Also, the radiation resistance sheet **32** is to ensure a strength high enough not to be deformed by an external impact. The supporting unit **30** is provided with a strength high enough to support the force by the vacuum pressure and endure an external impact, and is to have machinability. The conductive resistance sheet **60** may be preferably made of a material that has a thin plate shape and can endure the vacuum pressure.

(61) In an embodiment, the plate member, the side frame, and the conductive resistance sheet may be made of stainless materials having the same strength. The radiation resistance sheet may be made of aluminum having a weaker strength than the stainless materials. The supporting unit may be made of resin having a weaker strength than the aluminum.

(62) Unlike the strength from the point of view of materials, analysis from the point of view of stiffness is required. The stiffness ( $\text{N/m}$ ) is a property that would not be easily deformed. Although the same material is used, its stiffness may be changed depending on its shape. The conductive resistance sheets **60** or **63** may be made of a material having a predetermined strength, but the stiffness of the material is preferably low so as to increase heat resistance and minimize radiation heat as the conductive resistance sheet is uniformly spread without any roughness when the vacuum pressure is applied. The radiation resistance sheet **32** requires a stiffness of a certain level so as not to contact another part due to deformation. Particularly, an edge portion of the radiation resistance sheet may generate conduction heat due to drooping caused by the self-load of the radiation resistance sheet. Therefore, a stiffness of a certain level is required. The supporting unit **30** requires a stiffness high enough to endure a compressive stress from the plate member and an external impact.

(63) In an embodiment, the plate member and the side frame may preferably have the highest stiffness so as to prevent deformation caused by the vacuum pressure. The supporting unit, particularly, the bar may preferably have the second highest stiffness. The radiation resistance sheet may preferably have a stiffness that is lower than that of the supporting unit but higher than that of the conductive resistance sheet.

(64) The conductive resistance sheet may be preferably made of a material that is easily deformed

by the vacuum pressure and has the lowest stiffness. Even when the porous material **33** is filled in the vacuum space part **50**, the conductive resistance sheet may preferably have the lowest stiffness, and the plate member and the side frame may preferably have the highest stiffness.

(65) FIG. 5 is a view illustrating in detail a vacuum adiabatic body according to an embodiment. The embodiment proposed in FIG. 5 may be preferably applied to the door-side vacuum adiabatic body, and the description of the vacuum adiabatic body shown in FIG. 4b among the vacuum adiabatic bodies shown in FIG. 4 may be applied to portions to which specific descriptions are not provided.

(66) Referring to FIG. 5, an inside, i.e., a middle portion of the vacuum adiabatic body may be heat-insulated in a vacuum state, and an edge portion of the vacuum adiabatic body is heat-insulated by a separately molded peripheral adiabatic material or mold **90**. The peripheral adiabatic material **90** may be manufactured by fixing a molded product previously formed using an adiabatic material, e.g., EPS (Styrofoam) or EPDM, which has a thermal conductivity of 1 W/mk or less.

(67) A thickness of the peripheral adiabatic material **90** may be provided at a level equal to that of the middle portion of the vacuum adiabatic body. As the middle portion and edge portion of the vacuum adiabatic body are provided to have the same thickness, a slim door can be manufactured. Further, it is possible to maximize the internal volume of a device such as a refrigerator, to which the vacuum adiabatic body is applied. Particularly, an unnecessary space at the edge portion can be removed.

(68) When a space corresponding to the size of the peripheral adiabatic material **90** is formed using foaming urethane, a sufficient adiabatic effect may not be obtained due to a thin thickness of the formed space. Therefore, a separately molded peripheral adiabatic material is preferably provided.

(69) The vacuum adiabatic body of this embodiment includes a first plate member (or first plate) **10** providing a wall for a low-temperature space, a second plate member (or second plate) **20** providing a wall for a high-temperature space, and a vacuum space part (or vacuum space) **50** defined as a space part between the first plate member **10** and the second plate member **20**. Also, the vacuum adiabatic body includes a conductive resistance sheet **60** for blocking heat conduction between the first and second plate members **10** and **20**.

(70) Also, the vacuum adiabatic body includes a side frame **70** fastened to the conductive resistance sheet **60** and the second plate member **20** to provide a wall for a portion of the vacuum space part **50**. Fastening parts of the side frame **70** may be formed through welding. A supporting unit (or support) **30** capable of maintaining a gap of the vacuum space part **50** may be provided inside the vacuum space part **50**.

(71) A gasket **80** may be fixed to the peripheral adiabatic material **90**. The gasket **80** is preferably provided into a structure in which it at least covers the outside of the conductive resistance sheet **60**. Accordingly, the peripheral adiabatic material **90** can provide an adiabatic effect to a region including at least an outer surface of the conductive resistance sheet **60**. An inner surface of the conductive resistance sheet **60** may be heat-insulated by the vacuum space part **50**, and the outer surface of the conductive resistance sheet **60** may be heat-insulated by the peripheral adiabatic material **90**.

(72) As already described above, a sudden change in temperature occurs in the conductive resistance sheet **60**, and hence the loss of heat through the outer surface of the conductive resistance sheet **60** may be further increased. Therefore, the conductive resistance sheet **60** is preferably heat-insulated by the gasket **80**. It can be easily considered that the gasket **80** can shield first and second spaces from each other.

(73) As already described above, the peripheral adiabatic material **90** is provided the edge portion of the vacuum adiabatic body. The thickness of the peripheral adiabatic material **90** is provided at a level equal to that of the middle portion of the vacuum adiabatic body so as to implement a slim door. When the improvement of adiabatic performance is further required, the peripheral adiabatic material **90** may be provided to have a thickness about two times greater than that of the middle

portion of the vacuum adiabatic body.

(74) If the thickness of the peripheral adiabatic material **90** is decreased, the peripheral adiabatic material **90** cannot provide a thickness where a hinge shaft is installed at the peripheral adiabatic material. Since parts such as a torsion spring are inserted into the hinge shaft, the peripheral adiabatic material **90** requires a predetermined thickness or more. Therefore, when a door is provided using the vacuum adiabatic material, a hinge shaft **96** constituting a hinge **95** (see FIG. **6**) may be provided to the main body. When two doors are provided, the hinge shaft **96** may be installed at an inner door capable of ensuring a constant thickness. Therefore, as the other end of the hinge, instead of the hinge shaft, is fastened by a fastening tool such as a screw, the vacuum adiabatic body may be fastened.

(75) In this case, the hinge shaft **96** serving as a rotating shaft may become more distant from the gasket **80**. When the distance between the hinge shaft **96** and the gasket **80** is increased, the gasket **80** can be less pushed when the vacuum adiabatic body as the door is opened or closed. For example, when the door is closed, one side of the gasket **80** contacts the main body, and the other side of the gasket **80** then contacts the main body. After the one side of the gasket **80** contacts the main body, the one side of the gasket **80** is not slipped with respect to the main body by its friction with the main body. Therefore, the gasket **80** may be deformed.

(76) As the distance between the rotating shaft and the gasket **80** is increased, a deformation of the gasket **80** may be decreased, and thus the operational reliability of the gasket **80** can be improved. For example, the gasket **80** itself or a distance between parts adjacent to the gasket **80** can be maintained to have an originally designed numerical value. In this case, the degradation of adiabatic performance of the conductive resistance sheet **60** can be accurately prevented. Particularly, it is possible to prevent the degradation of adiabatic performance of the conductive resistance sheet **60** due to deterioration of the gasket **80**, which may occur when the gasket **80** is used for a long period of time.

(77) FIG. **6** is an exploded perspective view of the vacuum adiabatic body according to the embodiment. Referring to FIG. **6**, the first plate member **10** and the second plate member **20** are provided to form the vacuum space part **50**. The first plate member **10** may be provided at one portion of an inner surface of the second plate member **20**, and an edge region of the vacuum adiabatic body, in which the first plate member **10** is not provided, may be heat-insulated by the peripheral adiabatic material **90**.

(78) The peripheral adiabatic material **90** may be provided in a shape in which it is divided into a first peripheral adiabatic material **901** and a second peripheral adiabatic material **902**. The peripheral adiabatic material **90** is provided for convenience of fastening, and may be provided in another shape. The fastening between the first and second peripheral adiabatic materials **901** and **902** will be described later.

(79) An exhaust port **40** and a getter port **41** may be provided at predetermined positions of the first plate member **10**. The conductive resistance sheet **60** is provided at the outer circumference of the first plate member **10**, and the side frame **70** is fastened to the conductive resistance sheet **60** and the second plate member **20** to provide the vacuum space part **50** as a sealing space. Here, the position at which the side frame **70** and the second plate member **20** are fastened to each other may be provided as an edge portion of the second plate member **20**. Thus, it is possible to prevent formation of dews due to cold air transferred along the side frame **70**. Further, it is possible to a user not to view, with the naked eye, deformation of the second plate member **20**, caused by heat generated when the side frame **70** and the second plate member **20** are fastened to each other.

(80) The supporting unit **30** for maintaining the gap of the vacuum space part **50** is provided inside the vacuum space part **50**, and a radiation resistance sheet **32** may be provided to obtain a radiation adiabatic effect.

(81) The edge portion of the vacuum adiabatic body is heat-insulated by the peripheral adiabatic material **90**. More specifically, the first and second peripheral adiabatic materials **901** and **902** are

provided in a shape in which they are bent twice to be respectively inserted from upper and lower sides of the vacuum adiabatic body. The first and second peripheral adiabatic materials **901** and **902** may be fixed by being held to at least one part of the side frame **70** and the first plate member **10**. This will be described in detail later. In addition, the gasket **80** may be fastened to the peripheral adiabatic body **90**.

(82) The hinges **95** may be fastened to upper and lower ends of the vacuum adiabatic body, respectively. The hinge shaft **96** of the hinge **95** may be placed at the outside of the vacuum adiabatic body. The hinge shaft **96** may be fixed to the main body in the refrigerator.

(83) FIG. **7** is a sectional view of any one edge portion of the vacuum adiabatic body. Referring to FIG. **7**, the first plate member **10** and the second plate member **20** form the vacuum space part **50**, and the second plate member **20** is bent to further extend from the vacuum space part **50**.

Specifically, an end portion of the second plate member **20** is bent in a pocket shape to provide a first adiabatic material holding end (or first bracket) **91**. The first adiabatic material holding end **91** may be provided at only a left/right edge portion of the vacuum adiabatic body to support the peripheral adiabatic material **90**. If the peripheral adiabatic material **90** is inserted at a left/right side, the first adiabatic material holding end **91** may be provided at only an upper/lower edge portion of the vacuum adiabatic body.

(84) A second adiabatic material holding end (or second bracket) **92** may be provided at an end portion of the first plate member **10**. As both end portions of the peripheral adiabatic material **90** are held to the first and second adiabatic material holding ends **91** and **92**, respectively, the peripheral adiabatic material **90** can be fixed. According to the above-described structure, the position of the peripheral adiabatic material **90** can be fixed in such a manner that the peripheral adiabatic material **90** is held to the first and second adiabatic material holding ends **91** and **92** and then slid more deeply.

(85) Although it is illustrated that the peripheral adiabatic material **90** does not contact a curve-shaped outer surface of the conductive resistance sheet **60**, the present disclosure is not limited thereto, and the peripheral adiabatic material **90** may be provided in a shape in which it covers the outer surface of the conductive resistance sheet **60**. The peripheral adiabatic material **90** may be fixed by the action in which the first adiabatic material holding end **91** and the side frame **70** push each other between the first adiabatic material holding end **91** and a vertical bending portion provided to the side frame **70**. An end portion of the side frame **70** may be fastened as, for example, a welding part, at the edge portion of the second plate member **20**.

(86) A groove **82** may be provided in an inner surface of the peripheral adiabatic material **90**, and a gasket holding end or tab **81** may be provided at another side of the peripheral adiabatic material **90**. According to the above-described structure, when an outer appearance of the gasket **80** is formed, a pocket through which the gasket holding end **81** can be held may be provided, and a member that can be forcibly inserted into the groove **82** may be provided. According to the above-described configuration, when the gasket **80** is fixed, the gasket holding end **81** is inserted and fixed into the pocket, and then the member is forcibly inserted into the groove **82**, thereby fixing the gasket **80**. The gasket **80** may be provided as a member having elasticity, and hence the above-described forcible insertion can be easily derived as the gasket **80** is deformed while the gasket **80** is being inserted.

(87) FIG. **8** is a view illustrating a state in which the gasket is fixed to the peripheral adiabatic material. Referring to FIG. **8**, it can be seen that the gasket is stably fixed by the groove and the gasket holding end. Meanwhile, the gasket **80** may perform heat insulation by covering the outside of the conductive resistance sheet **60**. Thus, the reliability of heat insulation can be further improved with respect to a portion at which a sudden change in temperature occurs.

(88) FIG. **9** is a view showing a process of fastening the peripheral adiabatic material. Referring to FIG. **9**, any one entry portion of the peripheral adiabatic material **90** is inserted into the adiabatic material holding ends **91** and **92**, and the peripheral adiabatic material **90** is further inserted up to

the end in the length direction of the adiabatic material holding ends **91** and **92**, thereby fastening the peripheral adiabatic material **90**.

(89) Meanwhile, the peripheral adiabatic material **90** is a separate molded product made of resin, and hence a contact force of the peripheral adiabatic material **90** with another part may be lowered. When the contact force is decreased, adiabatic loss may occur due to a gap between the peripheral adiabatic material **90** and the other part. When an assembly tolerance is decreased so as to increase the contact force, friction is increased in the insertion of the peripheral adiabatic material **90**, and therefore, it may be difficult to insert the peripheral adiabatic material **90**. An embodiment capable of solving this problem will be proposed.

(90) FIG. **10** is a sectional view of an edge portion of a vacuum adiabatic body according to an embodiment. Referring to FIG. **10**, one portion of the internal space of a peripheral adiabatic material **90** is provided as an empty space. A separate adiabatic material may be additionally inserted into the empty space. The separate adiabatic material may be named as a side frame adiabatic material or mold **100**.

(91) If the side frame adiabatic material **100** is inserted into the internal space of the peripheral adiabatic material **90**, the outer portion of the peripheral adiabatic material **90** can be further adhered closely to a side frame **70**. It will be apparent that the side frame adiabatic material **100** is further adhered closely to the side frame **70**. In addition, the peripheral adiabatic material **90** that may have difficulty in insertion can be more easily inserted into adiabatic material holding ends **91** and **92** by deformation of the empty space, which occurs during the insertion. After the peripheral adiabatic material **90** is inserted, the side frame adiabatic material **100** is further inserted into the empty space, so that the peripheral adiabatic material **90** and the side frame **70** can more accurately contact each other. The same material as the peripheral adiabatic material **90** may be used as a material of the side frame adiabatic material **100**.

(92) Hereinafter, a vacuum pressure preferably determined depending on an internal state of the vacuum adiabatic body will be described. As already described above, a vacuum pressure is to be maintained inside the vacuum adiabatic body so as to reduce heat transfer. At this time, it will be easily expected that the vacuum pressure is preferably maintained as low as possible so as to reduce the heat transfer.

(93) The vacuum space part **50** may resist the heat transfer by applying only the supporting unit **30**. Alternatively, the porous material **33** may be filled together with the supporting unit in the vacuum space part **50** to resist the heat transfer. Alternatively, the vacuum space part may resist the heat transfer not by applying the supporting unit but by applying the porous material **33**.

(94) The case where only the supporting unit is applied will be described. FIG. **11** illustrates graphs showing changes in adiabatic performance and changes in gas conductivity with respect to vacuum pressures by applying a simulation. Referring to FIG. **11**, it can be seen that, as the vacuum pressure is decreased, i.e., as the vacuum degree is increased, a heat load in the case of only the main body (Graph **1**) or in the case where the main body and the door are joined together (Graph **2**) is decreased as compared with that in the case of the typical product formed by foaming polyurethane, thereby improving the adiabatic performance. However, it can be seen that the degree of improvement of the adiabatic performance is gradually lowered. Also, it can be seen that, as the vacuum pressure is decreased, the gas conductivity (Graph **3**) is decreased.

(95) However, it can be seen that, although the vacuum pressure is decreased, the ratio at which the adiabatic performance and the gas conductivity are improved is gradually lowered. Therefore, it is preferable that the vacuum pressure is decreased as low as possible. However, it takes long time to obtain excessive vacuum pressure, and much cost is consumed due to excessive use of a getter. In the embodiment, an optimal vacuum pressure is proposed from the above-described point of view.

(96) FIG. **12** illustrates graphs obtained by observing, over time and pressure, a process of exhausting the interior of the vacuum adiabatic body when the supporting unit is used. Referring to FIG. **12**, in order to create the vacuum space part **50** to be in the vacuum state, a gas in the vacuum



space part **50** is exhausted by a vacuum pump while evaporating a latent gas remaining in the parts of the vacuum space part **50** through baking. However, if the vacuum pressure reaches a certain level or more, there exists a point at which the level of the vacuum pressure is not increased any more (.sub. $\Delta t1$ ).

(97) After that, the getter is activated by disconnecting the vacuum space part **50** from the vacuum pump and applying heat to the vacuum space part **50** (.sub. $\Delta t2$ ). If the getter is activated, the pressure in the vacuum space part **50** is decreased for a certain period of time, but then normalized to maintain a vacuum pressure of a certain level. The vacuum pressure that maintains the certain level after the activation of the getter is approximately  $1.8 \times 10^{-6}$  Torr. In the embodiment, a point at which the vacuum pressure is not substantially decreased any more even though the gas is exhausted by operating the vacuum pump is set to the lowest limit of the vacuum pressure used in the vacuum adiabatic body, thereby setting the minimum internal pressure of the vacuum space part **50** to  $1.8 \times 10^{-6}$  Torr.

(98) FIG. **13** illustrates graphs obtained by comparing vacuum pressures and gas conductivities. Referring to FIG. **13**, gas conductivities with respect to vacuum pressures depending on sizes of a gap in the vacuum space part **50** are represented as graphs of effective heat transfer coefficients (eK). Effective heat transfer coefficients (eK) were measured when the gap in the vacuum space part **50** has three sizes of 2.76 mm, 6.5 mm, and 12.5 mm.

(99) The gap in the vacuum space part **50** is defined as follows. When the radiation resistance sheet **32** exists inside vacuum space part **50**, the gap is a distance between the radiation resistance sheet **32** and the plate member adjacent thereto. When the radiation resistance sheet **32** does not exist inside vacuum space part **50**, the gap is a distance between the first and second plate members.

(100) It can be seen that, since the size of the gap is small at a point corresponding to a typical effective heat transfer coefficient of 0.0196 W/mK, which is provided to an adiabatic material formed by foaming polyurethane, the vacuum pressure is  $2.65 \times 10^{-1}$  Torr even when the size of the gap is 2.76 mm. Meanwhile, it can be seen that the point at which reduction in adiabatic effect caused by gas conduction heat is saturated even though the vacuum pressure is decreased is a point at which the vacuum pressure is approximately  $4.5 \times 10^{-3}$  Torr. The vacuum pressure of  $4.5 \times 10^{-3}$  Torr can be defined as the point at which the reduction in adiabatic effect caused by gas conduction heat is saturated. Also, when the effective heat transfer coefficient is 0.1 W/mK, the vacuum pressure is  $1.2 \times 10^{-2}$  Torr.

(101) When the vacuum space part **50** is not provided with the supporting unit but provided with the porous material, the size of the gap ranges from a few micrometers to a few hundredths of micrometers. In this case, the amount of radiation heat transfer is small due to the porous material even when the vacuum pressure is relatively high, i.e., when the vacuum degree is low. Therefore, an appropriate vacuum pump is used to adjust the vacuum pressure. The vacuum pressure appropriate to the corresponding vacuum pump is approximately  $2.0 \times 10^{-4}$  Torr.

(102) Also, the vacuum pressure at the point at which the reduction in adiabatic effect caused by gas conduction heat is saturated is approximately  $4.7 \times 10^{-2}$  Torr. Also, the pressure where the reduction in adiabatic effect caused by gas conduction heat reaches the typical effective heat transfer coefficient of 0.0196 W/mK is 730 Torr. When the supporting unit and the porous material are provided together in the vacuum space part, a vacuum pressure may be created and used, which is middle between the vacuum pressure when only the supporting unit is used and the vacuum pressure when only the porous material is used.

(103) FIG. **14** is a schematic sectional view illustrating a case where a vacuum adiabatic body is applied to a door-in-door refrigerator according to an embodiment. FIG. **14(a)** illustrates a case where typical foaming urethane is applied, and FIG. **14(b)** illustrates a case where the vacuum adiabatic body is applied.

(104) Referring to FIG. **14**, the door-in-door refrigerator includes a first door **300** or **301** placed at the outside thereof and a second door **200** or **201** placed at the inside thereof. The typical foaming

urethane is applied to the first door **301**, and hence the width in the front-rear direction, where a basket is placed, may be narrowed. On the other hand, the first door **300** of the embodiment can be manufactured as a slim door, and hence it can be expected that the width in the front-rear direction, where a basket is placed, will be widened.

(105) In order to maximize such an advantage of the slim door, it is preferably considered that the width of the second door **200** in the front-rear direction is provided to be long. For example, a door expanding part (or door spacer) **250** may be provided to compensate the second door **200** for a thickness corresponding to a width decreased as the door using the typical foaming urethane is replaced with the slim door of the embodiment. The door expanding part **250** may be equipped with parts necessary for an operation thereof. Alternatively, an additional adiabatic material may be provided in the door expanding part **250** so as to obtain an adiabatic effect.

(106) In the description of the present disclosure, a part for performing the same action in each embodiment of the vacuum adiabatic body may be applied to another embodiment by properly changing the shape or dimension of the other embodiment. Accordingly, still another embodiment can be easily proposed. For example, in the detailed description, in the case of a vacuum adiabatic body suitable as a door-side vacuum adiabatic body, the vacuum adiabatic body may be applied as a main body-side vacuum adiabatic body by properly changing the shape and configuration of a vacuum adiabatic body.

(107) Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

(108) The vacuum adiabatic body proposed in the present disclosure may be preferably applied to refrigerators. However, the application of the vacuum adiabatic body is not limited to the refrigerators, and may be applied in various apparatuses such as cryogenic refrigerating apparatuses, heating apparatuses, and ventilation apparatuses.

(109) According to the present disclosure, the vacuum adiabatic body can be industrially applied to various adiabatic apparatuses. The adiabatic effect can be enhanced, so that it is possible to improve energy use efficiency and to increase the effective volume of an apparatus.

(110) However, it is difficult to obtain an adiabatic effect of a practical level by providing the walls of the refrigerator to be in a sufficient vacuum state. Specifically, it is difficult to prevent heat transfer at a contact portion between external and internal cases having different temperatures. Further, it is difficult to maintain a stable vacuum state. Furthermore, it is difficult to prevent deformation of the cases due to a sound pressure in the vacuum state. Due to these problems, the technique of Reference Document 3 is limited to cryogenic refrigerating apparatuses, and is not applied to refrigerating apparatuses used in general households.

(111) Embodiments provide a vacuum adiabatic body and a refrigerator, which can obtain a sufficient adiabatic effect in a vacuum state and be applied commercially. In one embodiment, a vacuum adiabatic body includes: a first plate member defining at least one portion of a wall for a first space; a second plate member defining at least one portion of a wall for a second space having a different temperature from the first space; a sealing part sealing the first plate member and the second plate member to provide a third space that has a temperature between the temperature of the first space and the temperature of the second space and is in a vacuum state; a supporting unit maintaining the third space; a heat resistance unit for decreasing a heat transfer amount between the first plate member and the second plate member; an exhaust port through which a gas in the third space is exhausted; a peripheral adiabatic material, as a previously formed separate molded

product, fixed to an edge of the third space; and a gasket having at least one portion fixed to the peripheral adiabatic material to provide a boundary between the first space and the second space. (112) The vacuum adiabatic body may include: a conductive resistance sheet capable of resisting thermal conduction flowing along a wall for the third space; and a side frame providing at least one outer wall for the third space, the side frame being fastened to the second plate member and the conductive resistance sheet. The peripheral adiabatic material may be held to at least one of the first plate member, the second plate member, and the side frame, so that a position of the peripheral adiabatic material is fixed.

(113) The vacuum adiabatic body may include a side frame adiabatic material inserted into an empty space of the peripheral adiabatic material, to increase a contact force of the peripheral adiabatic material with an external part of the peripheral adiabatic material. The peripheral adiabatic material may be made of EPS or EPDM. A thickness of the peripheral adiabatic material may be equal to or greater than a height of the third space, and may be provided equal to or smaller than twice of the height of the third space.

(114) The vacuum adiabatic body may further include a conductive resistance sheet capable of resisting heat conduction flowing along the wall for the third space. The peripheral adiabatic material may perform heat insulation by covering the conductive resistance sheet. The gasket may perform heat insulation by covering the conductive resistance sheet at an outside of the peripheral adiabatic material.

(115) The peripheral adiabatic material may include a first peripheral adiabatic material and a second peripheral adiabatic material as two different members separated from each other. The first peripheral adiabatic material and the second peripheral adiabatic material may contact each other at two different spots. The vacuum adiabatic body may include an adiabatic material holding end formed by bending an edge portion of the second plate member to fix the peripheral adiabatic material.

(116) In another embodiment, a vacuum adiabatic body includes: a first plate member defining at least one portion of a wall for a first space; a second plate member defining at least one portion of a wall for a second space having a different temperature from the first space; a sealing part sealing the first plate member and the second plate member to provide a third space that has a temperature between the temperature of the first space and the temperature of the second space and is in a vacuum state; a supporting unit maintaining the third space; a heat resistance unit for decreasing a heat transfer amount between the first plate member and the second plate member; an exhaust port through which a gas in the third space is exhausted; and a peripheral adiabatic material, as a previously formed separate molded product, fixed to an edge of the third space.

(117) The heat resistance unit may include at least one conductive resistance sheet provided as a curved surface thinner than each of the first and second plate members to resist heat conduction flowing along a wall for the third space. The peripheral adiabatic material may be provided to cover the conductive resistance sheet.

(118) A vacuum degree of the third space may be equal to or greater than  $1.8 \times 10^{-6}$  Torr and equal to or smaller than  $4.5 \times 10^{-3}$  Torr. The heat resistance unit may include at least one radiation resistance sheet provided in a plate shape inside the third space or may include a porous material to resist radiation heat transfer between the second plate member and the first plate member inside the third space. The sealing part may include a welding part.

(119) In still another embodiment, a refrigerator includes: a main body provided with an internal space in which storage goods are stored; and a door provided to open/close the main body from an external space, wherein, in order to supply a refrigerant into the main body, the refrigerator includes: a compressor for compressing the refrigerant; a condenser for condensing the compressed refrigerant; an expander for expanding the condensed refrigerant; and an evaporator for evaporating the expanded refrigerant to take heat, wherein the door includes a vacuum adiabatic body, wherein the vacuum adiabatic body includes: a first plate member defining at least one portion of a wall for

the internal space; a second plate member defining at least one portion of a wall for the external space; a sealing part sealing the first plate member and the second plate member to provide a vacuum space part that has a temperature between a temperature of the internal space and a temperature of the external space and is in a vacuum state; a supporting unit maintaining the vacuum space part; a heat resistance unit at least including a conductive resistance sheet capable of resisting heat conduction flowing along a wall for the third space to decrease a heat transfer amount between the first plate member and the second plate member; an exhaust port through which a gas in the vacuum space part is exhausted; and a peripheral adiabatic material, as a previously formed separate molded product, fixed to an edge of the third space, wherein the refrigerator further includes a hinge rotatably supporting the main body and the door, wherein a hinge shaft of the hinge is fastened to the main body, and at least one portion of the hinge is fastened to the peripheral adiabatic material.

(120) The peripheral adiabatic material may include a first peripheral adiabatic material and a second peripheral adiabatic material as two different members separated from each other. The first peripheral adiabatic material and the second peripheral adiabatic material may contact each other at two different spots.

(121) The refrigerator may include a gasket fixed to the peripheral adiabatic material to provide a boundary between the first space and the second space, the gasket covering the conductive resistance sheet. The refrigerator may include a side frame adiabatic material inserted into an empty space of the peripheral adiabatic material, to increase a contact force of the peripheral adiabatic material with an external part of the peripheral adiabatic material.

(122) According to the present disclosure, it is possible to obtain a sufficient vacuum adiabatic effect. According to the present disclosure, it is possible to implement a slim door. According to the present disclosure, it is possible to implement a slim door that can be industrially applied to products such as refrigerators.

(123) The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

(124) Any reference in this specification to “one embodiment,” “an embodiment,” “example embodiment,” etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

(125) Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

## Claims

1. A vacuum adiabatic body, comprising: a first plate; a second plate; a vacuum space to be provided between the first plate and the second plate; a peripheral adiabatic body configured as a portion of the vacuum adiabatic body, wherein an end portion of the second plate is bent to provide

a first adiabatic material holding end, and an end portion of the first plate is bent to provide a second adiabatic material holding end; and wherein a first end portion of the peripheral adiabatic body is held by the first adiabatic material holding end, and a second end portion of the peripheral adiabatic body is held by the second adiabatic material holding end, wherein the peripheral adiabatic body is a previously formed separate molded product, and the peripheral adiabatic body is configured to be held to the first and second adiabatic material holding ends and then slid more deeply such that the peripheral adiabatic body is fixed, wherein the first plate comprises a first surface facing outside of the vacuum space and a second surface facing the vacuum space, and the second plate comprises a first surface facing outside of the vacuum space and a second surface facing the vacuum space, wherein the peripheral adiabatic body contacts at least one side of the first plate and one side of the second plate, and wherein the first adiabatic material holding end is bent in a pocket shape, and the peripheral adiabatic body is accommodated inside the first adiabatic material holding end such that the peripheral adiabatic body is not exposed to the outside of the vacuum adiabatic body.

2. The vacuum adiabatic body according to claim 1, further comprising a conductive resistance sheet that connects the first plate to the second plate and is configured to reduce heat transfer between the second plate and the first plate, wherein a portion of the peripheral adiabatic body is to contact the conductive resistance sheet to provide heat insulation.

3. The vacuum adiabatic body according to claim 2, further comprising a side frame fastened to the second plate and to the conductive resistance sheet and configured to form at least one outer wall of the vacuum space, wherein the peripheral adiabatic body is held to at least one of the first plate, the second plate, and the side frame, so as to maintain a position of the peripheral adiabatic body.

4. The vacuum adiabatic body according to claim 1, comprising: a conductive resistance sheet that connects the first plate to the second plate, and a side frame fastened to a side portion of the vacuum adiabatic body and configured to form at least one outer wall of the vacuum space, wherein the peripheral adiabatic body is held to at least one of the first plate, the second plate, and the side frame, so as to maintain a position of the peripheral adiabatic body.

5. The vacuum adiabatic body according to claim 1, comprising a side frame adiabatic body disposed in an empty space provided at an internal space of the peripheral adiabatic body.

6. A vacuum adiabatic body, comprising: a first plate; a second plate; a vacuum space to be provided between the first plate and the second plate; a peripheral adiabatic body configured as a portion of the vacuum adiabatic body; a conductive resistance sheet that connects the first plate to the second plate, and has a curved surface thinner than each of the first and second plates to resist heat conduction flowing from the second plate to the first plate, and the conductive resistance sheet is configured to reduce heat transfer between the second plate and the first plate, to form a portion of a wall of the vacuum space, and to have a first surface and a second surface; and a side frame fastened to the second plate and to the conductive resistance sheet and configured to form at least one outer wall of the vacuum space, wherein the peripheral adiabatic body is to cover the portion of the wall of the vacuum space formed by the conductive resistance sheet, wherein the peripheral adiabatic body does not contact an outside of the curved surface of the conductive resistance sheet, wherein the conduction resistance sheet is disposed in a longitudinal direction of the vacuum space, wherein the first surface of the conductive resistance sheet is to be heat-insulated by the peripheral adiabatic body provided adjacent to the conductive resistance sheet, and the second surface of the conductive resistance sheet is to be heat-insulated by the vacuum space, and wherein the peripheral adiabatic body is held to at least one of the first plate, the second plate, or the side frame, so as to maintain a position of the peripheral adiabatic body.

7. The vacuum adiabatic body according to claim 6, further comprising a gasket having a portion fixed to the peripheral adiabatic body and having a portion adjacent to the first plate.

8. The vacuum adiabatic body according to claim 7, wherein the gasket is to cover the portion of the wall of the vacuum space formed by the conductive resistance sheet and a portion of the

peripheral adiabatic body covering the wall such that the portion of the peripheral adiabatic body is between the wall of the vacuum space and the gasket.

9. The vacuum adiabatic body according to claim 6, further comprising a shielding part configured to provide an adiabatic effect, and the shielding part is disposed outside the vacuum space.

10. The vacuum adiabatic body according to claim 9, wherein the shielding part is disposed to cover the conductive resistance sheet.

11. The vacuum adiabatic body according to claim 6, wherein the peripheral adiabatic body is a previously formed separate molded product, and the peripheral adiabatic body is configured to be held to first and second adiabatic material holding ends and then slid more deeply such that the peripheral adiabatic body is fixed.

12. The vacuum adiabatic body according to claim 6, comprising a side frame adiabatic body disposed in an empty space provided at an internal space of the peripheral adiabatic body.

13. The vacuum adiabatic body according to claim 6, comprising a side frame fastened to a side portion of the vacuum adiabatic body and configured to form at least one outer wall of the vacuum space, wherein the peripheral adiabatic body is held to at least one of the first plate, the second plate, and the side frame, so as to maintain a position of the peripheral adiabatic body.

14. The vacuum adiabatic body according to claim 6, comprising a side frame fastened to the second plate and to the conductive resistance sheet and configured to form at least one outer wall of the vacuum space, wherein the peripheral adiabatic body is held to at least one of the first plate, the second plate, and the side frame, so as to maintain a position of the peripheral adiabatic body.

15. The vacuum adiabatic body according to claim 6, wherein a first peripheral adiabatic body and a second peripheral adiabatic body are arranged side by side in a longitudinal direction of the vacuum space.

16. A vacuum adiabatic body, comprising: a first plate; a second plate; a vacuum space to be provided between the first plate and the second plate; a peripheral adiabatic body configured as a portion of the vacuum adiabatic body; a side frame fastened to a side portion of the vacuum adiabatic body and configured to form at least one outer wall of the vacuum space, wherein the first plate comprises a first surface facing outside of the vacuum space and a second surface facing the vacuum space, wherein the first surface faces the peripheral adiabatic body; and a side frame adiabatic body disposed in an empty space provided at an internal space of the peripheral adiabatic body, wherein the peripheral adiabatic body is held to at least one of the first plate, the second plate, and the side frame, so as to maintain a position of the peripheral adiabatic body, wherein the peripheral adiabatic body includes a first peripheral adiabatic body and a second peripheral adiabatic body as two different molds separated from each other, and wherein the first peripheral adiabatic body and the second peripheral adiabatic body contact each other at two different spots.

17. The vacuum adiabatic body according to claim 16, further comprising: a support that supports the first and second plates and is provided in the vacuum space; and an exhaust port configured to exhaust a gas from the vacuum space.

18. The vacuum adiabatic body according to claim 16, further comprising a conductive resistance sheet that connects the first plate to the second plate and is configured to reduce heat transfer between the second plate and the first plate, wherein a portion of the peripheral adiabatic body is to cover the conductive resistance sheet to provide heat insulation, wherein the conduction resistance sheet is disposed in a longitudinal direction of the vacuum space.

19. The vacuum adiabatic body according to claim 18, further comprising a gasket having a portion fixed to the peripheral adiabatic body and having a portion adjacent to the first plate.

20. The vacuum adiabatic body according to claim 19, wherein the gasket is to cover the peripheral adiabatic body on top of the conductive resistance sheet such that a portion the peripheral adiabatic body is between the gasket and the conductive resistance sheet.

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