US00D944776S

(12) **United States Design Patent**
Miller et al.

(10) **Patent No.: US D944,776 S**
(45) **Date of Patent: ** Mar. 1, 2022**

(54) **AUDIO DEVICE**

(71) Applicant: **Shure Acquisition Holdings, Inc.**, Niles, IL (US)

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(**) Term: **15 Years**

(21) Appl. No.: **29/733,652**

(22) Filed: **May 5, 2020**

(51) **LOC (13) Cl.** **14-01**

(52) **U.S. Cl.**
USPC **D14/222**

(58) **Field of Classification Search**
USPC D14/159, 218, 217, 219, 220, 221, 222, D14/223, 224, 224.1, 225, 227, 228, 229, D14/299, 204, 209, 185
CPC . H04R 1/00; H04R 1/02; H04R 1/323; H04R 1/326; H04R 1/403; H04R 1/406; H04R 1/222; H04R 1/023; H04R 7/00; H04R 7/20; H04R 27/00; H04R 2201/00; H04R 2400/00; H04R 17/02; H04R 29/004;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,535,408 A 4/1925 Fricke
1,540,788 A 6/1925 McClure
1,965,830 A 7/1934 Hammer
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2505496 10/2006
CA 2838856 A1 12/2012
(Continued)

OTHER PUBLICATIONS

MXA310, announced © 2009-2021 [online], retrieved Nov. 30, 2021, retrieved from internet, https://www.shure.com/en-US/products/microphones/mxa310.*
(Continued)

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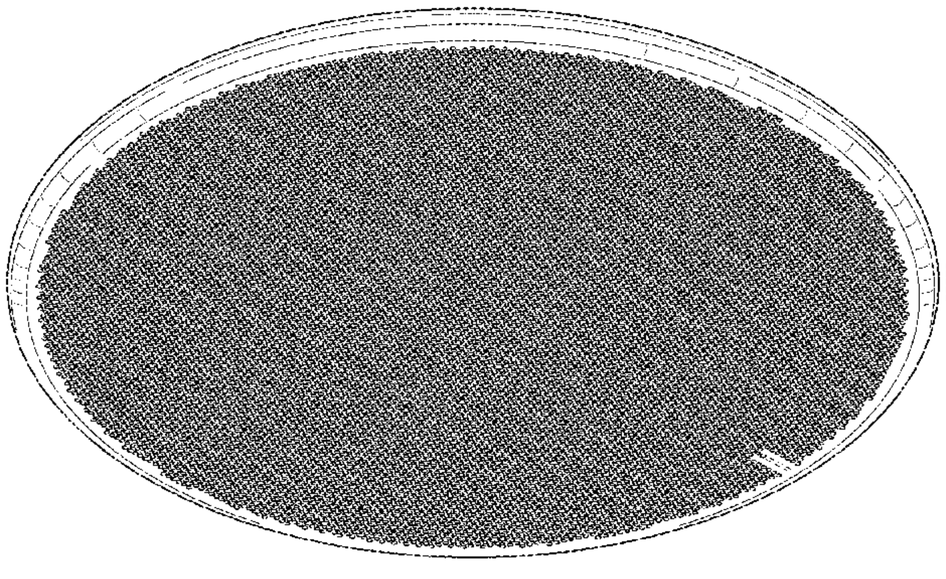
(57) **CLAIM**

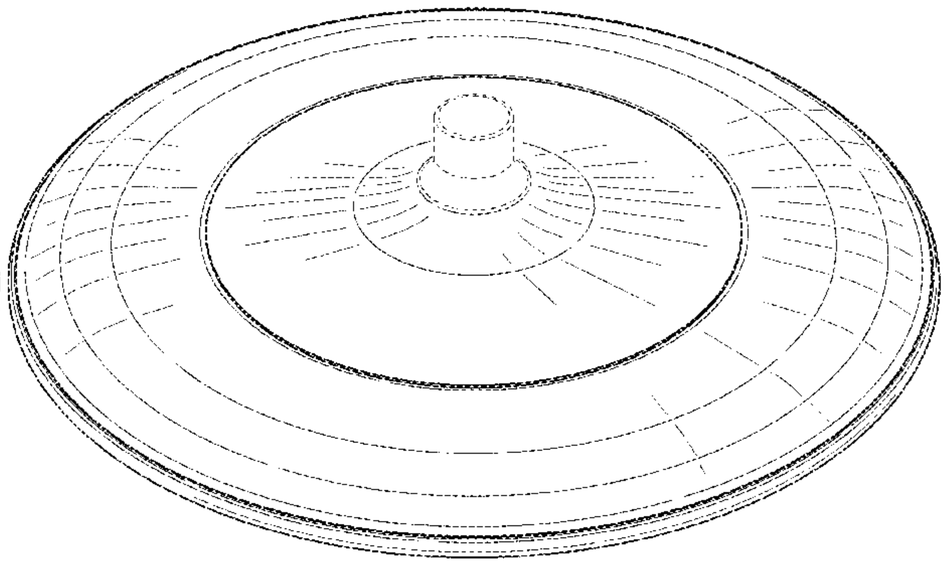
The ornamental design for an audio device, as shown and described.

DESCRIPTION

FIG. **1** is a front perspective view of an audio device showing the new design in a first embodiment.
FIG. **2** is a rear perspective view thereof.
FIG. **3** is a side elevation view thereof, the other side elevation views and two end elevation views being identical thereto.
FIG. **4** is a rear plan view thereof.
FIG. **5** is a front plan view thereof.
FIG. **6** is a front perspective view of the audio device according to a second embodiment.
FIG. **7** is a rear perspective view thereof.
FIG. **8** is a side elevation view thereof, the other side elevation views and two end elevation views being identical thereto.
FIG. **9** is a rear plan view thereof; and,
FIG. **10** is a front plan view thereof.
The dot-dash broken lines represent the bounds of the claim and form no part of the claimed design. All other broken lines depict portions of the audio device that form no part of the claimed design.

1 Claim, 10 Drawing Sheets





(58) **Field of Classification Search**
CPC . H04R 29/005; H04R 19/00; H04R 2420/07; H04R 2410/00
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,164,655	A		7/1939	Kleerup
D122,771	S		10/1940	Doner
2,233,412	A		3/1941	Hill
2,343,037	A		2/1944	Adelman
2,377,449	A		6/1945	Prevette
2,481,250	A		9/1949	Schneider
2,521,603	A		9/1950	Prew
2,533,565	A		12/1950	Eichelman
2,840,181	A		6/1958	Wildman
2,912,605	A		11/1959	Tibbetts
2,938,113	A		5/1960	Schnell
2,950,556	A		8/1960	Larios
3,019,854	A		2/1962	OBryant
3,143,182	A		8/1964	Sears
3,160,225	A		12/1964	Sechrist
3,161,975	A		12/1964	McMillan
3,205,601	A		9/1965	Gawne
3,509,290	A		4/1970	Mochida
3,696,885	A		10/1972	Grieg
3,755,625	A		8/1973	Maston
3,857,191	A		12/1974	Sadorus
3,906,431	A		9/1975	Clearwaters
D237,103	S		10/1975	Fisher
3,938,617	A		2/1976	Forbes
3,941,638	A		3/1976	Horky
4,008,408	A		2/1977	Kodama
4,029,170	A		6/1977	Phillips
4,032,725	A		6/1977	McGee
4,070,547	A		1/1978	Dellar
4,072,821	A		2/1978	Bauer
4,096,353	A		6/1978	Bauer
4,127,156	A		11/1978	Brandt
4,131,760	A		12/1978	Christensen
4,184,048	A		1/1980	Alcaide
4,198,705	A		4/1980	Massa
D255,234	S		6/1980	Wellward
D256,015	S		7/1980	Doherty
4,212,133	A		7/1980	Lufkin
4,237,339	A		12/1980	Bunting
4,244,096	A		1/1981	Kashichi
4,254,417	A		3/1981	Speiser
4,305,141	A		12/1981	Massa
4,308,425	A		12/1981	Momose
4,311,874	A		1/1982	Wallace, Jr.
4,330,691	A		5/1982	Gordon
4,334,740	A		6/1982	Wray
4,365,449	A		12/1982	Liautaud
4,414,433	A		11/1983	Horie
4,429,850	A		2/1984	Weber
4,436,966	A		3/1984	Botros
4,449,238	A		5/1984	Lee
4,466,117	A		8/1984	Goerike
4,485,484	A		11/1984	Flanagan
4,489,442	A		12/1984	Anderson
4,518,826	A		5/1985	Caudill
4,521,908	A		6/1985	Miyaji
4,566,557	A		1/1986	Lemaitre
4,593,404	A		6/1986	Bolin
D285,067	S		8/1986	Delbuck
4,653,102	A		3/1987	Hansen
4,658,425	A		4/1987	Julstrom
4,669,108	A		5/1987	Deinzer
4,696,043	A		9/1987	Iwahara
4,712,231	A		12/1987	Julstrom
4,741,038	A		4/1988	Elko
4,752,961	A		6/1988	Kahn
4,815,132	A		3/1989	Minami
4,860,366	A		8/1989	Fukushi
4,866,868	A		9/1989	Kass
4,881,135	A		11/1989	Heilweil
4,903,247	A		2/1990	Van Gerwen
4,923,032	A		5/1990	Nuernberger
4,928,312	A		5/1990	Hill
4,969,197	A		11/1990	Takaya
5,038,935	A		8/1991	Wenkman
5,121,426	A		6/1992	Baumhauer
D328,900	S	*	8/1992	Harle D14/216
D329,239	S		9/1992	Hahn
5,214,709	A		5/1993	Ribic
D340,718	S		10/1993	Leger
D345,346	S		3/1994	Alfonso
D345,379	S		3/1994	Chan
5,297,210	A		3/1994	Julstrom
5,322,979	A		6/1994	Cassity
5,323,459	A		6/1994	Hirano
5,335,011	A		8/1994	Addeo
5,359,374	A		10/1994	Schwartz
5,371,789	A		12/1994	Hirano
5,383,293	A		1/1995	Royal
5,384,843	A		1/1995	Masuda
5,396,554	A		3/1995	Hirano
5,400,413	A		3/1995	Kindel
D363,045	S		10/1995	Phillips
5,473,701	A		12/1995	Cezanne
5,509,634	A		4/1996	Gebka
5,513,265	A		4/1996	Hirano
5,525,765	A		6/1996	Freiheit
5,550,924	A		8/1996	Helf
5,574,793	A		11/1996	Hirschhorn
5,602,962	A		2/1997	Kellermann
5,633,936	A		5/1997	Oh
5,645,257	A		7/1997	Ward
5,661,813	A		8/1997	Shimauchi
5,673,327	A		9/1997	Julstrom
5,687,229	A		11/1997	Sih
5,706,344	A		1/1998	Finn
5,717,171	A		2/1998	Miller
D392,977	S		3/1998	Kim
D394,061	S		5/1998	Fink
5,761,318	A		6/1998	Shimauchi
5,787,183	A		7/1998	Chu
5,796,819	A		8/1998	Romesburg
5,848,146	A		12/1998	Slattery
5,870,482	A		2/1999	Loeppert
5,888,412	A		3/1999	Sooriakumar
5,888,439	A		3/1999	Miller
6,035,962	A		3/2000	Lin
6,039,457	A		3/2000	O'Neal
6,041,127	A		3/2000	Elko
6,049,607	A		4/2000	Marash
D424,538	S		5/2000	Hayashi
6,069,961	A		5/2000	Nakazawa
6,125,179	A		9/2000	Wu
D432,518	S		10/2000	Muto
6,137,887	A		10/2000	Anderson
6,144,746	A		11/2000	Azima
6,157,724	A		12/2000	Kawakami
6,173,059	B1		1/2001	Huang
6,198,831	B1		3/2001	Azima
6,205,224	B1		3/2001	Underbrink
6,215,881	B1		4/2001	Azima
6,266,427	B1		7/2001	Mathur
6,285,770	B1		9/2001	Azima
6,329,908	B1		12/2001	Frecska
6,332,029	B1		12/2001	Azima
D453,016	S		1/2002	Nevill
6,393,129	B1		5/2002	Conrad
6,442,272	B1		8/2002	Osovets
6,449,593	B1		9/2002	Valve
6,488,367	B1		12/2002	Debesis
6,505,057	B1		1/2003	Finn
6,556,682	B1		4/2003	Gilloire
D474,173	S	*	5/2003	Right D14/209
D480,923	S		10/2003	Neubourg
6,665,971	B2		12/2003	Lowry
6,704,422	B1		3/2004	Jensen
D489,707	S		5/2004	Kobayashi
6,731,334	B1		5/2004	Maeng

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,741,720	B1	5/2004	Myatt	
6,757,393	B1	6/2004	Spitzer	
6,768,795	B2	7/2004	Feltstroem	
6,885,750	B2	4/2005	Egelmeers	
D504,889	S	5/2005	Andre	
6,895,093	B1	5/2005	Ali	
6,931,123	B1	8/2005	Hughes	
6,944,312	B2	9/2005	Mason	
6,968,064	B1	11/2005	Ning	
6,990,193	B2	1/2006	Beaucoup	
6,993,126	B1	1/2006	Kyrylenko	
6,993,145	B2	1/2006	Combest	
7,003,099	B1	2/2006	Zhang	
7,031,269	B2	4/2006	Lee	
7,035,415	B2	4/2006	Belt	
7,054,451	B2	5/2006	Janse	
D526,643	S	8/2006	Ishizaki	
D527,372	S	8/2006	Allen	
7,092,516	B2	8/2006	Furuta	
7,092,882	B2	8/2006	Arrowood	
7,098,865	B2	8/2006	Christensen	
7,120,269	B2	10/2006	Lowell	
D542,543	S	5/2007	Bruce	
D545,297	S *	6/2007	Lee	D14/168
D546,318	S	7/2007	Ki-Hyun	
D547,748	S	7/2007	Tsuge	
D549,673	S	8/2007	Niitsu	
7,269,263	B2	9/2007	Dedieu	
D552,570	S	10/2007	Niitsu	
D559,553	S	1/2008	James	
D566,685	S	4/2008	Koller	
7,359,504	B1	4/2008	Reuss	
7,387,151	B1	6/2008	Payne	
D587,709	S	3/2009	Niitsu	
D589,605	S	3/2009	Reedy	
7,503,616	B2	3/2009	Linhard	
7,536,769	B2	5/2009	Pedersen	
D595,736	S	7/2009	Son	
7,565,949	B2	7/2009	Tojo	
D599,553	S	9/2009	Shapiro	
7,660,428	B2	2/2010	Rodman	
D613,338	S	4/2010	Marukos	
7,701,110	B2	4/2010	Fukuda	
D614,871	S	5/2010	Tang	
7,724,891	B2	5/2010	Beaucoup	
7,747,001	B2	6/2010	Kellermann	
7,756,278	B2	7/2010	Moorer	
D623,265	S *	9/2010	Reynoso	D23/213
7,831,035	B2	11/2010	Stokes	
7,831,036	B2	11/2010	Beaucoup	
7,852,369	B2	12/2010	Cutler	
D636,188	S	4/2011	Kim	
D636,760	S *	4/2011	Cheng	D14/216
7,925,006	B2	4/2011	Hirai	
7,925,007	B2	4/2011	Stokes	
D639,385	S *	6/2011	Flowers	D23/213
7,970,123	B2	6/2011	Beaucoup	
7,970,151	B2	6/2011	Oxford	
D642,385	S	8/2011	Lee	
7,991,167	B2	8/2011	Oxford	
7,995,768	B2	8/2011	Miki	
8,005,238	B2	8/2011	Tashev	
8,019,091	B2	9/2011	Burnett	
8,064,629	B2	11/2011	Jiang	
8,085,947	B2	12/2011	Haulick	
D652,823	S *	1/2012	Chen	H04R 1/1016 D14/223
8,098,842	B2	1/2012	Florencio	
8,098,844	B2	1/2012	Elko	
8,103,030	B2	1/2012	Barthel	
D656,473	S	3/2012	Laube	
8,130,969	B2	3/2012	Buck	
8,130,977	B2	3/2012	Chu	
8,135,143	B2	3/2012	Ishibashi	
8,144,886	B2	3/2012	Ishibashi	
8,175,291	B2	5/2012	Chan	
8,184,801	B1	5/2012	Hamalainen	
8,189,765	B2	5/2012	Nishikawa	
8,189,810	B2	5/2012	Wolff	
8,199,927	B1	6/2012	Raftery	
8,204,198	B2	6/2012	Adeney	
8,213,596	B2	7/2012	Beaucoup	
8,213,634	B1	7/2012	Daniel	
8,219,387	B2	7/2012	Cutler	
8,229,134	B2	7/2012	Duraiswami	
8,233,352	B2	7/2012	Beaucoup	
8,249,273	B2	8/2012	Inoda	
8,275,120	B2	9/2012	Stokes, III	
8,284,949	B2	10/2012	Farhang	
8,286,749	B2	10/2012	Stewart	
8,290,142	B1	10/2012	Lambert	
8,297,402	B2	10/2012	Stewart	
8,331,582	B2	12/2012	Steele	
8,385,557	B2	2/2013	Tashev	
8,395,653	B2	3/2013	Feng	
8,403,107	B2	3/2013	Stewart	
8,433,061	B2	4/2013	Cutler	
8,437,490	B2	5/2013	Marton	
8,443,930	B2	5/2013	Stewart, Jr.	
8,447,590	B2	5/2013	Ishibashi	
D685,346	S	7/2013	Szymanski	
8,479,871	B2	7/2013	Stewart	
8,483,398	B2	7/2013	Fozunbal	
8,498,423	B2	7/2013	Thaden	
8,503,653	B2	8/2013	Ahuja	
8,515,089	B2	8/2013	Nicholson	
8,553,904	B2	10/2013	Said	
8,583,481	B2	11/2013	Viveiros	
8,600,443	B2	12/2013	Kawaguchi	
8,605,890	B2	12/2013	Zhang	
8,631,897	B2	1/2014	Stewart	
8,634,547	B2	1/2014	Takahashi	
8,638,951	B2	1/2014	Zurek	
D699,712	S	2/2014	Bourne	
8,644,477	B2	2/2014	Gilbert	
8,654,990	B2	2/2014	Faller	
8,660,274	B2	2/2014	Wolff	
8,660,275	B2	2/2014	Buck	
8,670,581	B2	3/2014	Harman	
8,672,087	B2	3/2014	Stewart	
8,676,728	B1	3/2014	Velusamy	
8,744,069	B2	6/2014	Cutler	
8,761,385	B2	6/2014	Sugiyama	
8,811,601	B2	8/2014	Mohammad	
8,818,002	B2	8/2014	Tashev	
8,842,851	B2	9/2014	Beaucoup	
8,855,326	B2	10/2014	Derkx	
8,855,327	B2	10/2014	Tanaka	
8,873,789	B2	10/2014	Bigeh	
D717,272	S	11/2014	Kim	
8,886,343	B2	11/2014	Ishibashi	
8,893,849	B2	11/2014	Hudson	
D718,731	S	12/2014	Lee	
8,903,106	B2	12/2014	Meyer	
8,942,382	B2	1/2015	Elko	
D725,059	S	3/2015	Kim	
D725,631	S	3/2015	McNamara	
D726,144	S	4/2015	Kang	
9,002,028	B2	4/2015	Haulick	
D729,767	S	5/2015	Lee	
9,094,496	B2	7/2015	Teutsch	
D737,245	S	8/2015	Fan	
9,113,247	B2	8/2015	Chatlani	
9,113,264	B2	8/2015	Frater	
9,126,827	B2	9/2015	Hsieh	
9,129,223	B1	9/2015	Velusamy	
9,172,345	B2	10/2015	Kok	
D743,376	S	11/2015	Kim	
D743,939	S	11/2015	Seong	
9,215,327	B2	12/2015	Bathurst	
9,215,543	B2	12/2015	Sun	
9,226,088	B2	12/2015	Pandey	
9,237,391	B2	1/2016	Benesty	
9,247,367	B2	1/2016	Nobile	

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,253,567	B2		2/2016	Morcelli
9,264,553	B2		2/2016	Pandey
D752,014	S	*	3/2016	Bolmstrand D14/204
D752,199	S	*	3/2016	Berkman D23/370
9,294,839	B2		3/2016	Lambert
9,301,049	B2		3/2016	Elko
D754,103	S		4/2016	Fischer
9,319,532	B2		4/2016	Bao
9,319,799	B2		4/2016	Salmon
9,326,060	B2		4/2016	Nicholson
9,338,549	B2		5/2016	Haulick
9,357,080	B2		5/2016	Beaucoup
9,403,670	B2		8/2016	Schelling
9,462,378	B2		10/2016	Kuech
9,479,627	B1		10/2016	Rung
9,479,885	B1		10/2016	Ivanov
9,489,948	B1		11/2016	Chu
9,510,090	B2		11/2016	Lissek
9,516,412	B2		12/2016	Shigenaga
9,560,451	B2		1/2017	Eichfeld
9,565,493	B2		2/2017	Abraham
9,578,413	B2		2/2017	Sawa
9,591,404	B1		3/2017	Chhetri
D784,299	S		4/2017	Cho
9,615,173	B2		4/2017	Sako
9,635,186	B2		4/2017	Pandey
D787,481	S		5/2017	Tyss
9,641,688	B2		5/2017	Pandey
9,641,929	B2		5/2017	Li
9,641,935	B1		5/2017	Ivanov
9,761,243	B2		9/2017	Taenzer
9,813,806	B2		11/2017	Graham
9,826,211	B2		11/2017	Sawa
9,854,101	B2		12/2017	Pandey
9,866,952	B2		1/2018	Pandey
9,877,580	B2		1/2018	Stewart, Jr.
D811,393	S		2/2018	Ahn
9,894,434	B2		2/2018	Rollow, IV
9,930,448	B1		3/2018	Chen
9,936,291	B2		4/2018	Christoph
D819,607	S		6/2018	Chui
10,244,219	B2		3/2019	Sawa
D860,319	S		9/2019	Beruto
D864,136	S		10/2019	Kim
D864,923	S	*	10/2019	Yang D14/230
10,453,471	B2		10/2019	Sugiyama
D865,723	S		11/2019	Cho
D877,122	S	*	3/2020	Klosowski D14/216
D878,325	S	*	3/2020	Paterson D14/203.1
D879,737	S	*	3/2020	Suzuki D14/149
D883,256	S	*	5/2020	Zeng D14/219
D888,687	S	*	6/2020	Xu D14/216
D900,070	S		10/2020	Lantz
D900,071	S		10/2020	Lantz
D900,072	S		10/2020	Lantz
D900,073	S		10/2020	Lantz
D900,074	S		10/2020	Lantz
D901,427	S	*	11/2020	Zhang D14/149
D901,431	S	*	11/2020	Paterson D14/203.1
D920,276	S	*	5/2021	Law D14/149
D920,944	S	*	6/2021	Paterson D14/203.1
D921,605	S	*	6/2021	Feng D14/204
D924,189	S		7/2021	Park
D924,196	S	*	7/2021	Wang D14/149
D927,448	S	*	8/2021	Zhang D14/204
D929,366	S	*	8/2021	Mihara D14/215
D932,463	S	*	10/2021	Wu D14/204
D934,191	S	*	10/2021	Lv D14/149
2002/0015500	A1		2/2002	Belt
2002/0041679	A1		4/2002	Beaucoup
2002/0131580	A1		9/2002	Smith
2002/0146282	A1		10/2002	Wilkes
2002/0149070	A1		10/2002	Sheplak
2003/0026437	A1		2/2003	Janse
2003/0053639	A1		3/2003	Beaucoup
2003/0059061	A1		3/2003	Tsuji
2003/0063762	A1		4/2003	Tajima
2003/0107478	A1		6/2003	Hendricks
2003/0118200	A1		6/2003	Beaucoup
2003/0138119	A1		7/2003	Pocino
2003/0161485	A1		8/2003	Smith
2003/0185404	A1		10/2003	Milsap
2004/0013038	A1		1/2004	Kajala
2004/0013252	A1		1/2004	Craner
2004/0105557	A1		6/2004	Matsuo
2004/0125942	A1		7/2004	Beaucoup
2004/0240664	A1		12/2004	Freed
2005/0094580	A1		5/2005	Kumar
2005/0094795	A1		5/2005	Rambo
2005/0149320	A1		7/2005	Kajala
2005/0175189	A1		8/2005	Lee
2005/0213747	A1		9/2005	Popovich
2005/0271221	A1		12/2005	Cerwin
2005/0286698	A1		12/2005	Bathurst
2005/0286729	A1		12/2005	Harwood
2006/0088173	A1		4/2006	Rodman
2006/0104458	A1		5/2006	Kenoyer
2006/0151256	A1		7/2006	Lee
2006/0159293	A1		7/2006	Azima
2006/0165242	A1		7/2006	Miki
2006/0192976	A1		8/2006	Hall
2006/0198541	A1		9/2006	Henry
2006/0215866	A1		9/2006	Francisco
2006/0233353	A1		10/2006	Beaucoup
2006/0239471	A1		10/2006	Mao
2006/0262942	A1		11/2006	Oxford
2006/0269080	A1		11/2006	Oxford
2007/0053524	A1		3/2007	Haulick
2007/0093714	A1		4/2007	Beaucoup
2007/0116255	A1		5/2007	Derkx
2007/0120029	A1		5/2007	Keung
2007/0165871	A1		7/2007	Roovers
2007/0230712	A1		10/2007	Belt
2008/0044053	A1	*	2/2008	Belanger H04R 1/023 381/391
2008/0056517	A1		3/2008	Algazi
2008/0101622	A1		5/2008	Sugiyama
2008/0130907	A1		6/2008	Sudo
2008/0144848	A1		6/2008	Buck
2008/0232607	A1		9/2008	Tashev
2008/0247567	A1		10/2008	Kjolerbakken
2008/0259731	A1		10/2008	Happonen
2008/0260175	A1		10/2008	Elko
2008/0285772	A1		11/2008	Haulick
2009/0003586	A1		1/2009	Lai
2009/0030536	A1		1/2009	Gur
2009/0052684	A1		2/2009	Ishibashi
2009/0087000	A1		4/2009	Ko
2009/0087001	A1		4/2009	Jiang
2009/0129609	A1		5/2009	Oh
2009/0147967	A1		6/2009	Ishibashi
2009/0150149	A1		6/2009	Cutter
2009/0169027	A1		7/2009	Ura
2009/0274318	A1		11/2009	Ishibashi
2009/0310794	A1		12/2009	Ishibashi
2010/0011644	A1		1/2010	Kramer
2010/0034397	A1		2/2010	Nakadai
2010/0074433	A1		3/2010	Zhang
2010/0111324	A1		5/2010	Yeldener
2010/0119097	A1		5/2010	Ohtsuka
2010/0128892	A1		5/2010	Chen
2010/0131749	A1		5/2010	Kim
2010/0150364	A1		6/2010	Buck
2010/0189275	A1		7/2010	Christoph
2010/0202628	A1		8/2010	Meyer
2010/0215184	A1		8/2010	Buck
2010/0217590	A1		8/2010	Nemer
2010/0314513	A1		12/2010	Evans
2011/0007921	A1		1/2011	Stewart
2011/0038229	A1		2/2011	Beaucoup
2011/0096915	A1		4/2011	Nemer
2011/0164761	A1		7/2011	McCowan
2011/0194719	A1		8/2011	Frater
2011/0211706	A1		9/2011	Tanaka

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0311064	A1	12/2011	Teutsch	
2011/0311085	A1	12/2011	Stewart	
2011/0317861	A1*	12/2011	Haase	F21S 8/026 381/333
2011/0317862	A1	12/2011	Hosoe	
2012/0002835	A1	1/2012	Stewart	
2012/0027227	A1	2/2012	Kok	
2012/0076316	A1	3/2012	Zhu	
2012/0080260	A1	4/2012	Stewart	
2012/0093344	A1	4/2012	Sun	
2012/0128160	A1	5/2012	Kim	
2012/0128175	A1	5/2012	Visser	
2012/0155688	A1	6/2012	Wilson	
2012/0169826	A1	7/2012	Jeong	
2012/0177219	A1	7/2012	Mullen	
2012/0182429	A1	7/2012	Forutanpour	
2012/0224709	A1	9/2012	Keddem	
2012/0243698	A1	9/2012	Elko	
2012/0262536	A1	10/2012	Chen	
2012/0288079	A1	11/2012	Burnett	
2012/0288114	A1	11/2012	Duraiswami	
2012/0294472	A1	11/2012	Hudson	
2012/0327115	A1	12/2012	Chhetri	
2013/0004013	A1	1/2013	Stewart	
2013/0015014	A1	1/2013	Stewart	
2013/0016847	A1	1/2013	Steiner	
2013/0029684	A1	1/2013	Kawaguchi	
2013/0034241	A1	2/2013	Pandey	
2013/0039504	A1	2/2013	Pandey	
2013/0083911	A1	4/2013	Bathurst	
2013/0094689	A1	4/2013	Tanaka	
2013/0101141	A1	4/2013	McElveen	
2013/0136274	A1	5/2013	Aehgren	
2013/0206501	A1	8/2013	Yu	
2013/0251181	A1	9/2013	Stewart	
2013/0264144	A1	10/2013	Hudson	
2013/0271559	A1	10/2013	Feng	
2013/0336516	A1	12/2013	Stewart	
2013/0343549	A1	12/2013	Vemireddy	
2014/0016794	A1	1/2014	Lu	
2014/0072151	A1	3/2014	Ochs	
2014/0098964	A1	4/2014	Rosca	
2014/0233777	A1	8/2014	Tseng	
2014/0264654	A1	9/2014	Salmon	
2014/0265774	A1	9/2014	Stewart	
2014/0270271	A1	9/2014	Dehe	
2014/0286518	A1	9/2014	Stewart	
2014/0301586	A1	10/2014	Stewart	
2014/0307882	A1	10/2014	Leblanc	
2014/0341392	A1	11/2014	Lambert	
2014/0357177	A1	12/2014	Stewart	
2015/0030172	A1	1/2015	Gaensler	
2015/0055796	A1	2/2015	Nugent	
2015/0055797	A1	2/2015	Nguyen	
2015/0070188	A1	3/2015	Aramburu	
2015/0078581	A1	3/2015	Etter	
2015/0078582	A1	3/2015	Graham	
2015/0117672	A1	4/2015	Christoph	
2015/0118960	A1	4/2015	Petit	
2015/0126255	A1	5/2015	Yang	
2015/0281832	A1	10/2015	Kishimoto	
2015/0281833	A1	10/2015	Shigenaga	
2015/0350621	A1	12/2015	Sawa	
2016/0029120	A1	1/2016	Nesta	
2016/0031700	A1	2/2016	Sparks	
2016/0080867	A1	3/2016	Nugent	
2016/0111109	A1	4/2016	Tsujikawa	
2016/0142548	A1	5/2016	Pandey	
2016/0142815	A1	5/2016	Norris	
2016/0148057	A1	5/2016	Oh	
2016/0150316	A1	5/2016	Kubota	
2016/0234593	A1	8/2016	Matsumoto	
2016/0295279	A1	10/2016	Srinivasan	
2016/0300584	A1	10/2016	Pandey	
2016/0302002	A1	10/2016	Lambert	
2016/0302006	A1	10/2016	Pandey	
2016/0323668	A1	11/2016	Abraham	
2016/0330545	A1	11/2016	McElveen	
2016/0353200	A1	12/2016	Bigeh	
2017/0019744	A1	1/2017	Matsumoto	
2017/0105066	A1	4/2017	McLaughlin	
2017/0134849	A1	5/2017	Pandey	
2017/0134850	A1	5/2017	Graham	
2017/0164101	A1	6/2017	Rollow, IV	
2017/0180861	A1	6/2017	Chen	
2017/0264999	A1	9/2017	Fukuda	
2017/0374454	A1	12/2017	Bernardini	
2018/0160224	A1	6/2018	Graham	
2018/0338205	A1	11/2018	Abraham	
2019/0075381	A1*	3/2019	Katz	H04R 1/026
2019/0090047	A1*	3/2019	Ivey	H04R 1/227
2019/0208297	A1*	7/2019	Bech	H04R 1/023
2020/0186902	A1*	6/2020	Brousseau	H04R 1/025
2020/0288237	A1	9/2020	Abraham	
2021/0044881	A1	2/2021	Lantz	

FOREIGN PATENT DOCUMENTS

CA	2846323	A1	9/2014
CN	102646418		8/2012
CN	102821336		12/2012
CN	102833664	A	12/2012
CN	102860039		1/2013
CN	104080289	A	10/2014
CN	104581463		4/2015
CN	306391029		3/2021
CN	306550450	*	5/2021
CN	306620375	*	6/2021
CN	306839641	*	9/2021
CN	306941684	*	11/2021
DE	2941485		4/1981
EM	0077546430001		3/2020
EP	0594098		4/1994
EP	0869697		10/1998
EP	1184676		3/2002
EP	0944228		6/2003
EP	1439526		7/2004
EP	1651001		4/2006
EP	1727344		11/2006
EP	1906707		4/2008
EP	1962547		8/2008
EP	2197219		6/2010
EP	2721837	A1	4/2014
EP	277831		9/2014
EP	3131311		2/2017
JP	H01260967		10/1989
JP	H07336790		12/1995
JP	3175622		6/2001
JP	2003087890		3/2003
JP	2004349806		12/2004
JP	2004537232		12/2004
JP	2005323084		11/2005
JP	2006094389		4/2006
JP	2006101499		4/2006
JP	4120646		8/2006
JP	4258472		8/2006
JP	4196956		9/2006
JP	2006340151		12/2006
JP	4760160		1/2007
JP	4752403		3/2007
JP	4867579		6/2007
JP	2007208503		8/2007
JP	2007228069		9/2007
JP	2007228070		9/2007
JP	2007274131		10/2007
JP	2007274463		10/2007
JP	2008005347		1/2008
JP	2008042754		2/2008
JP	2008154056		7/2008
JP	2008259022		10/2008
JP	2008312002		12/2008
JP	2009206671		9/2009
JP	2010114554		5/2010
JP	2010268129		11/2010

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

JP	2011015018		1/2011
KR	100960781		6/2010
KR	300856915		5/2016
KR	300888582		12/2016
WO	2006049260		5/2006
WO	2006071119		7/2006
WO	2010001508		1/2010
WO	2010140084		12/2010
WO	2010144148	A2	12/2010
WO	2011104501		9/2011
WO	2012160459		11/2012
WO	2012174159	A1	12/2012
WO	2016176429		11/2016
WO	D211684-001	*	11/2020
WO	D211684-002	*	11/2020

OTHER PUBLICATIONS

MXA910, announced © 2009-2021 [online], retrieved Nov. 30, 2021, retrieved from internet, https://www.shure.com/en-US/products/microphones/mxa910.*

JBL White & Black Apart Ceiling Speakers, announced © 1996-2021 [online], retrieved Nov. 30, 2021, retrieved from internet, https://www.indiamart.com/proddetail/apart-ceiling-speakers-15163710088.html.*

Best Conference Call Speaker in 2021—Top Models Review, announced Jan. 16, 2021 [online], retrieved Nov. 30, 2021, retrieved from internet, https://www.leantravellerguide.com/2021/01/best-conference-call-speaker-in-2021/.*

Ring in the holidays with these Bluetooth speakers on sale at Black Friday prices, announced Nov. 28, 2021 [online], retrieved Nov. 30, 2021, retrieved from internet, https://mashable.com/deals/nov-28-bluetooth-speakers-on-sale.*

Jabra Speak 410 Corded Speakerphon, announced Apr. 1, 2012 [online], retrieved Nov. 30, 2021, retrieved from internet, https://www.amazon.com/Jabra-PHS001U-Speakerphone-Retail-Packaging/dp/B007SHJIO2.*

Yealink Bluetooth Speakerphone Conference Microphone, announced Jan. 1, 2021 [online], retrieved Nov. 30, 2021, retrieved from internet, https://www.amazon.com/Yealink-Speakerphone-Conference-Microphone-Microsoft-Teams-Certified/dp/B08RRP8PZ7.*

Arnold, et al., "A directional acoustic array using silicon micromachined piezoresistive microphones," Journal of Acoustical Society of America, 113 (1), pp. 289-298, Jan. 2003 (10 pp.).

Chou, "Frequency-Independent Beamformer with Low Response Error," 1995 International Conference on Acoustics, Speech, and Signal Processing, pp. 2995-2998, May 9, 1995, 4 pp.

International Search Report and Written Opinion for PCT/US2016/029751 dated Nov. 28, 2016, 21 pp.

Office Action issued for Japanese Patent Application No. 2015-023781 dated Jun. 20, 2016.

Myllyla et al., Adaptive Beamforming Methods for Dynamically Steered Microphone Array Systems, 2008 IEEE International Conference on Acoustics, Speech and Signal Processing, Mar.-Apr. 2008, pp. 305-308.

Nguyen-Ky et al., An Improved Error Estimation Algorithm for Sterephonic Acoustic Echo Cancellation Systems, 1st International Conference on Signal Processing and Communication Systems, Dec. 2007, 5 pgs.

Oh et al., Hands-Free Voice Communication in an Automobile With a Microphone Array, 1992 IEEE International Conference on Acoustics, Speech, and Signal Processing, Mar. 1992, pp. I-281-I-284.

Omologo, Multi-Microphone Signal Processing for Distant-Speech Interaction, Human Activity and Vision Summer School (HAVSS), INRIA Sophia Antipolis, Oct. 3, 2012, 79 pgs.

Pados et al., An Iterative Algorithm for the Computation of the MVDR Filter, IEEE Trans. On Signal Processing, vol. 49, No. 2, Feb. 2001, pp. 290-300.

Pettersen, Broadcast Applications for Voice-Activated Microphones, db, Jul./Aug. 1985, 6 pgs.

Plascore, PCGA-XR1 3003 Aluminum Honeycomb Data Sheet, 2008, 2 pgs.

Polycom Inc., Vortex EF2211/EF2210 Reference Manual, 2003, 66 pgs.

Polycom, Inc., Polycom SoundStructure C16, C12, C8, and SR12 Design Guide, Nov. 2013, 743 pgs.

Polycom, Inc., Setting Up the Polycom HDX Ceiling Microphone Array Series, https://support.polycom.com/content/dam/polycom-support/products/Telepresence-and-Video/HDX%20Series/setup-maintenance/en/hdx_ceiling_microphone_array_setting_up.pdf, 2010, 16 pgs.

Polycom, Inc., Vortex EF2241 Reference Manual, 2002, 68 pgs.

Powers, Proving Adaptive Directional Technology Works: A Review of Studies, The Hearing Review, http://www.hearingreview.com/2004/04/proving-adaptive-directional-technology-works-a-review-of-studies/, Apr. 2004, 8 pgs.

Rabinkin et al., Estimation of Wavefront Arrival Delay Using the Cross-Power Spectrum Phase Technique, 132nd Meeting of the Acoustical Society of America, Dec. 1996, pp. 1-10.

Rane Corp., Halogen Acoustic Echo Cancellation Guide, AEC Guide Version 2, Nov. 2013, 16 pgs.

Rao et al., Fast LMS/Newton Algorithms for Sterophonic Acoustic Echo Cancellation, IEEE Transactions on Signal Processing, vol. 57, No. 8, Aug. 2009, pp. 2919-2930.

Reuven et al., Joint Acoustic Echo Cancellation and Transfer Function GSC in the Frequency Domain, 23rd IEEE Convention of Electrical and Electronics Engineers in Israel, Sep. 2004, pp. 412-415.

Reuven et al., Joint Noise Reduction and Acoustic Echo Cancellation Using the Transfer-Function Generalized Sidelobe Canceller, Speech Communication, vol. 49, 2007, pp. 623-635.

Reuven, et al., "Multichannel Acoustic Echo Cancellation and Noise Reduction in Reverberant Environments Using the Transfer-Function GSC," IEEE 1-4244-0728, 2007.

Ristimaki, Distributed Microphone Array System for Two-Way Audio Communication, Helsinki Univ. of Technology, Master's Thesis, Jun. 15, 2009, 73 pgs.

Rombouts et al., An Integrated Approach to Acoustic Noise and Echo Cancellation, Signal Processing 85, 2005, pp. 849-871.

Sasaki et al., A Predefined Command Recognition System Using a Ceiling Microphone Array in Noisy Housing Environments, 2008 IEEE/RSJ International Conference on Intelligent Robots and Systems, Sep. 2008, pp. 2178-2184.

Sennheiser, New microphone solutions for ceiling and desk installation, https://en-us.sennheiser.com/news-new-microphone-solutions-for-ceiling-and-desk-installation, Feb. 2011, 2 pgs.

Sennheiser, TeamConnect Ceiling, https://en-us.sennheiser.com/conference-meeting-rooms-teamconnect-ceiling, 7 pgs.

Shure AMS Update, vol. 1, No. 1, 1983, 2 pgs.

Shure AMS Update, vol. 1, No. 2, 1983, 2 pgs.

Shure AMS Update, vol. 4, No. 4, 1997, 8 pgs.

Shure Inc., Microflex Advance, http://www.shure.com/americas/microflex-advance, 12 pgs.

Shure Inc., MX395 Low Profile Boundary Microphones, 2007, 2 pgs.

Shure Inc., MXA910 Ceiling Array Microphone, http://www.shure.com/americas/products/microphones/microflex-advance/mxa910-ceiling-array-microphone, 7 pgs.

Silverman et al., Performance of Real-Time Source-Location Estimators for a Large-Aperture Microphone Array, IEEE Transactions on Speech and Audio Processing, vol. 13, No. 4, Jul. 2005, pp. 593-606.

Sinha, Ch. 9: Noise and Echo Cancellation, in Speech Processing in Embedded Systems, Springer, 2010, pp. 127-142.

Soda et al., Introducing Multiple Microphone Arrays for Enhancing Smart Home Voice Control, The Institute of Electronics, Information and Communication Engineers, Technical Report of IEICE, Jan. 2013, 6 pgs.

Symetrix, Inc., SymNet Network Audio Solutions Brochure, 2008, 32 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

Tandon et al., An Efficient, Low-Complexity, Normalized LMS Algorithm for Echo Cancellation, 2nd Annual IEEE Northeast Workshop on Circuits and Systems, Jun. 2004, pp. 161-164.
Tetelbaum et al., Design and Implementation of a Conference Phone Based on Microphone Array Technology, Proc. Global Signal Processing Conference and Expo (GSPx), Sep. 2004, 6 pgs.
Tiete et al., SoundCompass: A Distributed MEMS Microphone Array-Based Sensor for Sound Source Localization, Sensors, Jan. 23, 2014, pp. 1918-1949.
TOA Corp., Ceiling Mount Microphone AN-9001 Operating Instructions, http://www.toaelectronics.com/media/an9001_mt1e.pdf, 1 pg.
Van Compernolle, Switching Adaptive Filters for Enhancing Noisy and Reverberant Speech from Microphone Array Recordings, Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing, Apr. 1990, pp. 833-836.
Van Trees, Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, 2002, 54 pgs., pp. i-xxv, 90-95, 201-230.
Van Veen et al., Beamforming: A Versatile Approach to Spatial Filtering, IEEE ASSP Magazine, vol. 5, issue 2, Apr. 1988, pp. 4-24.
Wang et al., Combining Superdirective Beamforming and Frequency-Domain Blind Source Separation for Highly Reverberant Signals, EURASIP Journal on Audio, Speech, and Music Processing, vol. 2010, pp. 1-13.
Weinstein et al., LOUD: A 1020-Node Microphone Array and Acoustic Beamformer, 14th International Congress on Sound & Vibration, Jul. 2007, 8 pgs.
Wung, A System Approach to Multi-Channel Acoustic Echo Cancellation and Residual Echo Suppression for Robust Hands-Free Teleconferencing, Georgia Institute of Technology, May 2015, 167 pgs.
Yamaha Corp., MRX7-D Signal Processor Product Specifications, 2016, 12 pgs.
Yamaha Corp., PJP-100H IP Audio Conference System Owner's Manual, Sep. 2006, 59 pgs.
Yamaha Corp., PJP-EC200 Conference Echo Canceller, Oct. 2009, 2 pgs.
Yan et al., Convex Optimization Based Time-Domain Broadband Beamforming with Sidelobe Control, Journal of the Acoustical Society of America, vol. 121, No. 1, Jan. 2007, pp. 46-49.
Yensen et al., Synthetic Stereo Acoustic Echo Cancellation Structure with Microphone Array Beamforming for VOIP Conferences, 2000 IEEE International Conference on Acoustics, Speech, and Signal Processing, Jun. 2000, pp. 817-820.
Zhang et al., Selective Frequency Invariant Uniform Circular Broadband Beamformer, EURASIP Journal on Advances in Signal Processing, vol. 2010, pp. 1-11.
Zhang, et al., "Multichannel Acoustic Echo Cancelation in Multiparty Spatial Audio Conferencing with Constrained Kalman Filtering," 11 h International Workshop on Acoustic Echo and Noise Control, Sep. 14, 2008.
Do et al., A Real-Time SRP-PHAT Source Location Implementation using Stochastic Region Contraction (SRC) on a Large-Aperture Microphone Array, 2007 IEEE International Conference on Acoustics, Speech and Signal Processing—ICASSP '07, , Apr. 2007, pp. I-121-I-124.
Fan, et al., "Localization Estimation of Sound Source by Microphones Array," Procedia Engineering 7, 2010, pp. 312-317.
Flanagan et al., Autodirective Microphone Systems, Acustica, vol. 73, 1991, pp. 58-71.
Flanagan, et al., "Computer-Steered Microphone Arrays for Sound Transduction in Large Rooms," J. Acoust. Soc. Am. 78 (5), Nov. 1985, pp. 1508-1518.
Frost, III, An Algorithm for Linearly Constrained Adaptive Array Processing, Proc. IEEE, vol. 60, No. 8, Aug. 1972, pp. 926-935.
Gannot el al., Signal Enhancement using Beamforming and Nonstationarity with Applications to Speech, IEEE Trans. On Signal Processing, vol. 49, No. 8, Aug. 2001, pp. 1614-1626.
Gansler et al., A Double-Talk Detector Based on Coherence, IEEE Transactions on Communications, vol. 44, No. 11, Nov. 1996, pp. 1421-1427.
Gazor et al., Robust Adaptive Beamforming via Target Tracking, IEEE Transactions on Signal Processing, vol. 44, No. 6, Jun. 1996, pp. 1589-1593.
Gazor et al., Wideband Multi-Source Beamforming with Adaptive Array Location Calibration and Direction Finding, 1995 International Conference on Acoustics, Speech, and Signal Processing, May 1995, pp. 1904-1907.
Gentner Communications Corp., AP400 Audio Perfect 400 Audioconferencing System Installation & Operation Manual, Nov. 1998, 80 pgs.
Gentner Communications Corp., XAP 800 Audio Conferencing System Installation & Operation Manual, Oct. 2001, 152 pgs.
Gil-Cacho et al., Multi-Microphone Acoustic Echo Cancellation Using Multi-Channel Warped Linear Prediction of Common Acoustical Poles, 18th European Signal Processing Conference, Aug. 2010, pp. 2121-2125.
Gritton, et al., "Echo Cancellation Algorithms," IEEE ASSP Magazine, vol. 1, issue 2, Apr. 1984, pp. 30-38.
Hamalainen, et al., "Acoustic Echo Cancellation for Dynamically Steered Microphone Array Systems," 2007 IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, Oct. 2007, pp. 58-61.
Herbordt, "Combination of Robust Adaptive Beamforming with Acoustic Echo Cancellation for Acoustic Human/Machine Interfaces," Friedrich-Alexander University, 2003, 293 pgs.
Herbordt, et al., "A Real-time Acoustic Human-Machine Front-End for Multimedia Applications Integrating Robust Adaptive Beamforming and Stereophonic Acoustic Echo Cancellation," 7th International Conference on Spoken Language Processing, Sep. 2002, 4 pgs.
Herbordt, et al., "GSAEC—Acoustic Echo Cancellation embedded into the Generalized Sidelobe Canceller," 10th European Signal Processing Conference, Sep. 2000, 5 pgs.
Herbordt, et al., "Multichannel Bin-Wise Robust Frequency-Domain Adaptive Filtering and Its Application to Adaptive Beamforming," IEEE Transactions on Audio, Speech, and Language Processing, vol. 15, No. 4, May 2007, pp. 1340-1351.
Herbordt, et al., Joint Optimization of LCMV Beamforming and Acoustic Echo Cancellation for Automatic Speech Recognition, IEEE International Conference on Acoustics, Speech, and Signal Processing, Mar. 2005, pp. III-77-III-80.
Huang et al., Immersive Audio Schemes: The Evolution of Multiparty Teleconferencing, IEEE Signal Processing Magazine, Jan. 2011, pp. 20-32.
InvenSense Inc., Microphone Array Beamforming, Dec. 31, 2013, 12 pgs.
Ishii et al., Investigation on Sound Localization using Multiple Microphone Arrays, Reflection and Spatial Information, Japanese Society for Artificial Intelligence, JSAI Technical Report, SIG-Challenge-B202-11, 2012, pp. 64-69.
Ito et al., Aerodynamic/Aeroacoustic Testing in Anechoic Closed Test Sections of Low-speed Wind Tunnels, 16th AIAA/CEAS Aeroacoustics Conference, 2010, 11 pgs.
Johansson et al., Robust Acoustic Direction of Arrival Estimation using Root-SRP-PHAT, a Realtime Implementation, IEEE International Conference on Acoustics, Speech, and Signal Processing, Mar. 2005, 4 pgs.
Johansson, et al., Speaker Localisation using the Far-Field SRP-PHAT in Conference Telephony, 2002 International Symposium on Intelligent Signal Processing and Communication Systems, 5 pgs.
Julstrom et al., Direction-Sensitive Gating: A New Approach to Automatic Mixing, J. Audio Eng. Soc., vol. 32, No. 7/8, Jul./Aug. 1984, pp. 490-506.
Kahrs, Ed., The Past, Present, and Future of Audio Signal Processing, IEEE Signal Processing Magazine, Sep. 1997, pp. 30-57.
Kallinger et al., Multi-Microphone Residual Echo Estimation, 2003 IEEE International Conference on Acoustics, Speech, and Signal Processing, Apr. 2003, 4 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

Kammeyer, et al., New Aspects of Combining Echo Cancellers with Beamformers, IEEE International Conference on Acoustics, Speech, and Signal Processing, Mar. 2005, pp. III-137-III-140.
Kellermann, A Self-Steering Digital Microphone Array, 1991 International Conference on Acoustics, Speech, and Signal Processing, Apr. 1991, pp. 3581-3584.
Kellermann, Acoustic Echo Cancellation for Beamforming Microphone Arrays, in Brandstein, ed., Microphone Arrays: Techniques and Applications, 2001, Springer-Verlag Berlin Heidelberg, pp. 281-306.
Kellermann, Integrating Acoustic Echo Cancellation with Adaptive Beamforming Microphone Arrays, Forum Acusticum, Berlin, Mar. 1999, pp. 1-4.
Kellermann, Strategies for Combining Acoustic Echo Cancellation and Adaptive Beamforming Microphone Arrays, 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing, Apr. 1997, 4 pgs.
Knapp, et al., The Generalized Correlation Method for Estimation of Time Delay, IEEE Transactions on Acoustics, Speech, and Signal Processing, vol. ASSP-24, No. 4, Aug. 1976, pp. 320-327.
Kobayashi et al., A Hands-Free Unit with Noise Reduction by Using Adaptive Beamformer, IEEE Transactions on Consumer Electronics, vol. 54, No. 1, Feb. 2008, pp. 116-122.
Kobayashi et al., A Microphone Array System with Echo Canceller, Electronics and Communications in Japan, Part 3, vol. 89, No. 10, Feb. 2, 2006, pp. 23-32.
Lebret, et al., Antenna Array Pattern Synthesis via Convex Optimization, IEEE Trans. on Signal Processing, vol. 45, No. 3, Mar. 1997, pp. 526-532.
Lectrosonics, LecNet2 Sound System Design Guide, Jun. 2006, 28 pgs.
Lee et al., Multichannel Teleconferencing System with Multispatial Region Acoustic Echo Cancellation, International Workshop on Acoustic Echo and Noise Control (IWAENC2003), Sep. 2003, pp. 51-54.
Lindstrom et al., An improvement of the Two-Path Algorithm Transfer Logic for Acoustic Echo Cancellation, IEEE Transactions on Audio, Speech, and Language Processing, vol. 15, No. 4, May 2007, pp. 1320-1326.
Liu et al., Adaptive Beamforming with Sidelobe Control: A Second-Order Cone Programming Approach, IEEE Signal Proc. Letters, vol. 10, No. 11, Nov. 2003, pp. 331-334.
Lobo, et al., Applications of Second-Order Cone Programming, Linear Algebra and its Applications 284, 1998, pp. 193-228.
Luo et al., Wideband Beamforming with Broad Nulls of Nested Array, Third Int'l Conf. on Info. Science and Tech., Mar. 23-25, 2013, pp. 1645-1648.
Marquardt et al., A Natural Acoustic Front-End for Interactive TV in the EU-Project DICIT, IEEE Pacific Rim Conference on Communications, Computers and Signal Processing, Aug. 2009, pp. 894-899.
Martin, Small Microphone Arrays with Postfilters for Noise and Acoustic Echo Reduction, in Brandstein, ed., Microphone Arrays: Techniques and Applications, 2001, Springer-Verlag Berlin Heidelberg, pp. 255-279.
Maruo et al., On the Optimal Solutions of Beamformer Assisted Acoustic Echo Cancellers, IEEE Statistical Signal Processing Workshop, 2011, pp. 641-644.
McCowan, Microphone Arrays: A Tutorial, Apr. 2001, 36 pgs.
Mohammed, A New Adaptive Beamformer for Optimal Acoustic Echo and Noise Cancellation with Less Computational Load, Canadian Conference on Electrical and Computer Engineering, May 2008, pp. 000123-000128.
Mohammed, A New Robust Adaptive Beamformer for Enhancing Speech Corrupted with Colored Noise, AICCSA, Apr. 2008, pp. 508-515.
Mohammed, Real-time Implementation of an efficient RLS Algorithm based on IIR Filter for Acoustic Echo Cancellation, AICCSA, Apr. 2008, pp. 489-494.
Advanced Network Devices, IPSCM Ceiling Tile IP Speaker, Feb. 2011, 2 pgs.
Advanced Network Devices, IPSCM Standard 2' by 2' Ceiling Tile Speaker, 2 pgs.
Affes, et al., "A Signal Subspace Tracking Algorithm for Microphone Array Processing of Speech," IEEE Trans. On Speech and Audio Processing, vol. 5, No. 5, Sep. 1997, pp. 425-437.
Affes, et al., "A Source Subspace Tracking Array of Microphones for Double Talk Situations," 1996 IEEE International Conference on Acoustics, Speech, and Signal Processing Conference Proceedings, May 1996, pp. 909-912.
Affes, et al., "An Algorithm for Multisource Beamforming and Multitarget Tracking," IEEE Trans. On Signal Processing, vol. 44, No. 6, Jun. 1996, pp. 1512-1522.
Affes, et al., "Robust Adaptive Beamforming via LMS-Like Target Tracking," Proceedings of IEEE International Conference on Acoustics, Speech and Signal Processing, Apr. 1994, pp. IV-269-IV-272.
Armstrong World Industries, Inc., I-Ceilings Sound Systems Speaker Panels, 2002, 4 pgs.
Atlas Sound, 1'X2' IP Speaker with Mioophone for Suspended Ceiling Systems, https://www.atlasied.com/i128sym, retrieved Oct. 25, 2107, 5 pgs.
Atlas Sound, I128SYSM IP Compliant Loudspeaker System with Microphone Data Sheet, 2009, 2 pgs.
Audio Technica, ES945 Omnidirectional Condenser Boundary Microphones, https://eu.audio-technica.com/resources/ES945%20Specfications.pdf, 2007, 1 pg.
Audix Microphones, Audix Introduces Innovative Ceiling Mics, http://audixusa.com/docs_12/latest_news/EFplFkAAkIOtSdolke.shtml, Jun. 2011, 6 pgs.
Audix Microphones, M70 Flush Mount Ceiling Mic, May 2016, 2 pgs.
Beh, et al., "Combining Acoustic Echo Cancellation and Adaptive Beamforming for Achieving Robust Speech Interface in Mobile Robot," 2008 IEEE/RSJ International Conference on Intelligent Robots and Systems, Sep. 2008, pp. 1693-1698.
Benesty et al., A New Class of Doubletalk Detectors Based on Cross-Correlation, IEEE Transactions on Speech and Audio Processing, vol. 8, No. 2, Mar. 2000, pp. 168-172.
Benesty, et al., "Adaptive Algorithms for Mimo Acoustic Echo Cancellation," AI2 Allen Institute for Artifical Intelligence, 2003.
Benesty, et al., "Frequency-Domain Adaptive Filtering Revisited, Generalization to the Multi-Channel Case, and Application to Acoustic Echo Cancellation," 2000 IEEE International Conference on Acoustics, Speech, and Signal Processing Proceedings, Jun. 2000, pp. 789-792.
Beyer Dynamic, Classis BM 32-33-34 DE-EN-FR 2016,1 pg.
Beyer Dynamic, Classis-BM-33-PZ A1, 2013, 1 pg.
Boyd, et al., Convex Optimization, Mar. 15, 1999, 216 pgs.
Brandstein et al., Eds., Microphone Arrays: Signal Processing Techniques and Applications, Digital Signal Processing, Springer-Verlag Berlin Heidelberg, 2001, 401 pgs.
Bruel & Kjaer, by J.J. Christensen and J. Hald, Technical Review: Beamforming, No. 1, 2004, 54 pgs.
BSS Audio, Soundweb London Application Guides, 2010, 120 pgs.
Buchner et al., An Acoustic Human-Machine Interface with Multi-Channel Sound Reproduction, IEEE Fourth Workshop on Multimedia Signal Processing, Oct. 2001, pp. 359-364.
Buchner, et al., "An Efficient Combination of Multi-Channel Acoustic Echo Cancellation with a Beamforming Microphone Array," International Workshop on Hands-Free Speech Communication (HSC2001), Apr. 2001, pp. 55-58.
Buchner, et al., "Full-Duplex Communication Systems Using Loudspeaker Arrays and Microphone Arrays," IEEE International Conference on Multimedia and Expo, Aug. 2002, pp. 509-512.
Buchner, et al., "Generalized Multichannel Frequency-Domain Adaptive Filtering: Efficient Realization and Application to Hands-Free Speech Communication," Signal Processing 85, 2005, pp. 549-570.
Buchner, et al., "Multichannel Frequency-Domain Adaptive Filtering with Application to Multichannel Acoustic Echo Cancellation," Adaptive Signal Processing, 2003, pp. 95-128.
Buchner, Multichannel Acoustic Echo Cancellation, http://www.buchner-net.com/mcaec.html, Jun. 2011.

(56) **References Cited**

OTHER PUBLICATIONS

Buck, "Aspects of First-Order Differential Microphone Arrays in the Presence of Sensor Imperfections," Transactions on Emerging Telecommunications Technologies, 13.2, 2002, 8 pp.
Buck, et al., "Self-Calibrating Microphone Arrays for Speech Signal Acquisition: A Systematic Approach," Signal Processing, vol. 86, 2006, pp. 1230-1238.
Burton, et al., "A New Structure for Combining Echo Cancellation and Beamforming in Changing Acoustical Environments," IEEE International Conference on Acoustics, Speech and Signal Processing, 2007, pp. 1-77-1-80.
Campbell, "Adaptive Beamforming Using a Microphone Array for Hands-Free Telephony," Virginia Polytechnic Institute and State University, Feb. 1999, 154 pgs.
Chan, et al., "Uniform Concentric Circular Arrays with Frequency—Invariant Characteristics—Theory, Design, Adaptive Beamforming and DOA Estimation," IEEE Transactions on Signal Processing, vol. 55, No. 1, Jan. 2007, pp. 165-177.
Chen, et al., "Design of Robust Broadband Beamformers with Passband Shaping Characteristics using Tikhonov Regularization," IEEE Transactions on Audio, Speech, and Language Processing, vol. 17, No. 4, May 2009, pp. 565-681.
Chen, et al., A General Approach to the Design and Implementation of Linear Differential Microphone Arrays, Asia-Pacific Signal and Information Processing Association Annual Summit and Conference, 2013, 7 pgs.
Chu, "Desktop Mic Array for Teleconferencing," 1995 International Conference on Acoustics, Speech, and Signal Processing, May 1995, pp. 2999-3002.
ClearOne Communications, XAP Audio Conferencing White Paper, Aug. 2002, 78 pgs.
ClearOne, Beamforming Microphone Array, Mar. 2012, 6 pgs.
ClearOne, Ceiling Microphone Array Installation Manual, Jan. 9, 2012, 20 pgs.
Cook, et al., An Alternative Approach to Interpolated Array Processing for Uniform Circular Arrays, Asia-Pacific Conference on Circuits and Systems, 2002, pp. 411-414.
Cox et al., Robust Adaptive Beamforming, IEEE Trans. Acoust., Speech, and Signal Processing, vol. ASSP-35, No. 10, Oct. 1987, pp. 1365-1376.
CTG Audio, Ceiling Microphone CTG CM-01, Jun. 5, 2008, 2 pgs.
CTG Audio, CM-01 & CM-02 Ceiling Microphones Specifications, 2 pgs.
CTG Audio, CM-01 & CM-02 Ceiling Microphones, 2017, 4 pgs.
CTG Audio, Expand Your IP Teleconferencing to Full Room Audio, Obtained from website htt.)://www ct audio com/exand-, our-i -teleconforencino-to-ful-room-audio-while-conquennc.1-echo-cancelation-issues Mull, 2014.
CTG Audio, Installation Manual, Nov. 21, 2008, 25 pgs.
CTG Audio, White on White—Introducing the CM-02 Ceiling Microphone, https://ctgaudio.com/white-on-white-introducing-the-cm-02-ceiling-microphone/, Feb. 20, 2014, 3 pgs.
Dahl et al., Acoustic Echo Cancelling with Microphone Arrays, Research Report 3/95, Univ. of Karlskrona/Ronneby, Apr. 1995, 64 pgs.
Desiraju et al., Efficient Multi-Channel Acoustic Echo Cancellation Using Constrained Sparse Filter Updates in the Subband Domain, ITG-Fachbericht 252: Speech Communication, Sep. 2014, 4 pgs.
DiBiase et al., Robust Localization in Reverberant Rooms, in Brandstein, ed., Microphone Arrays: Techniques and Applications, 2001, Springer-Verlag Berlin Heidelberg, pp. 157-180.
Zheng et al., Experimental Evaluation of a Nested Microphone Array with Adaptive Noise Cancellers, IEEE Transactions on Instrumentation and Measurement, vol. 53, No. 3, Jun. 2004, p. 777-786.

* cited by examiner

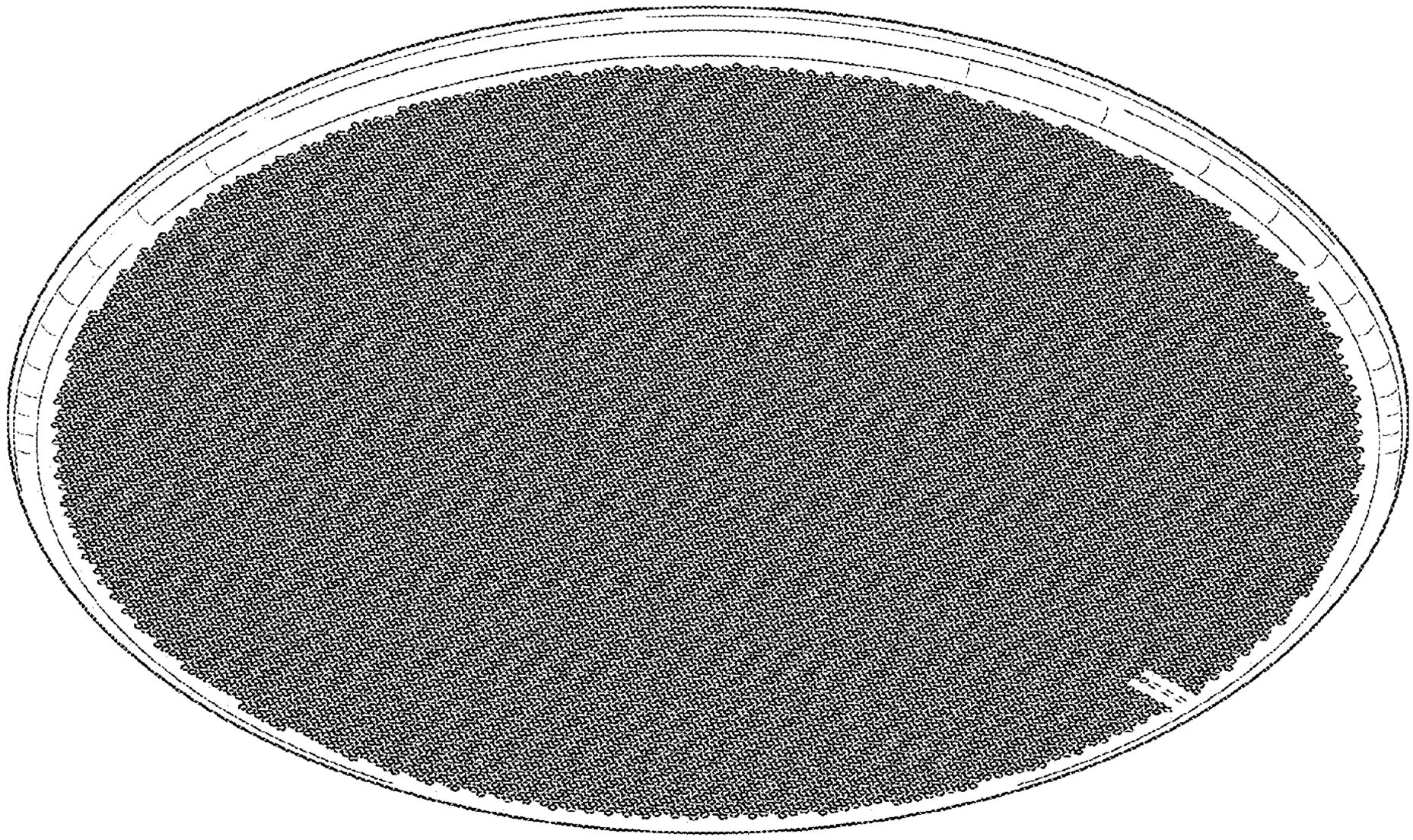


FIG. 1

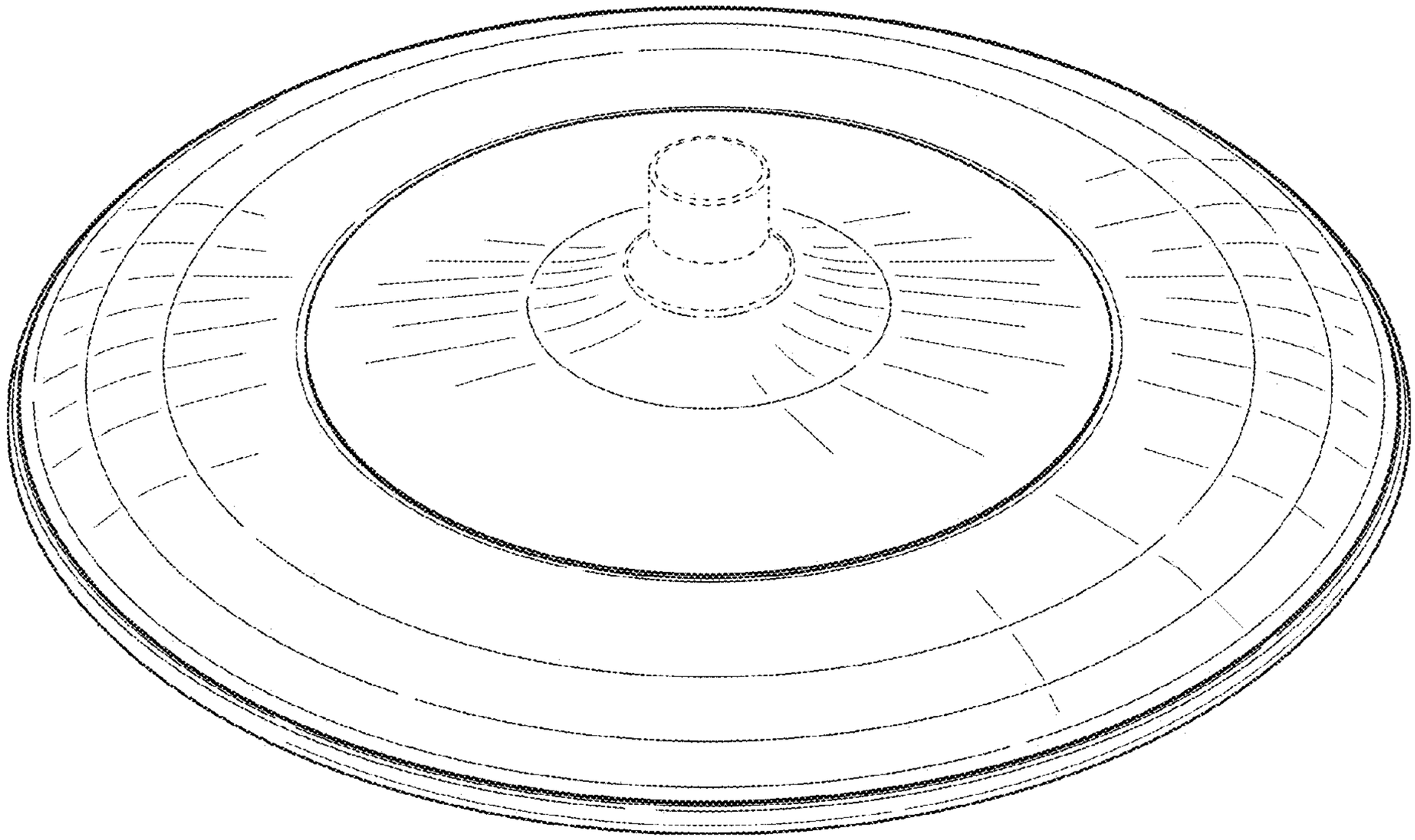


FIG. 2

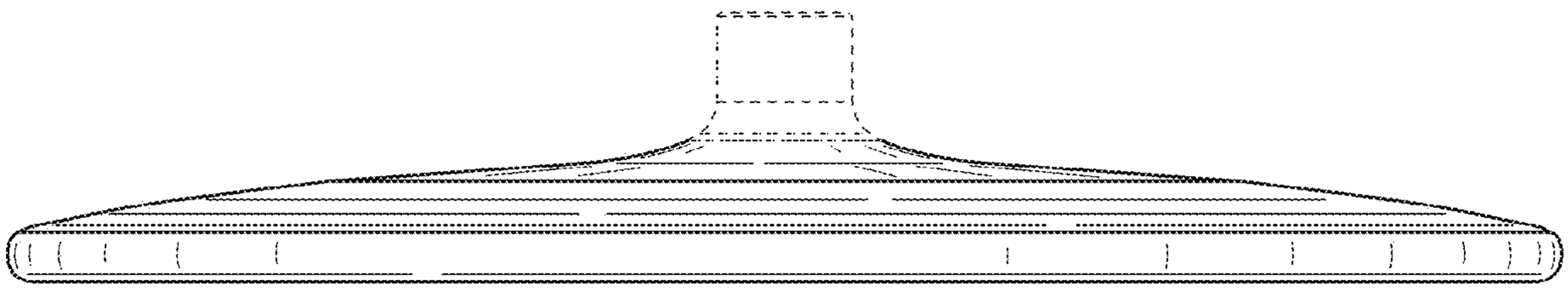


FIG. 3

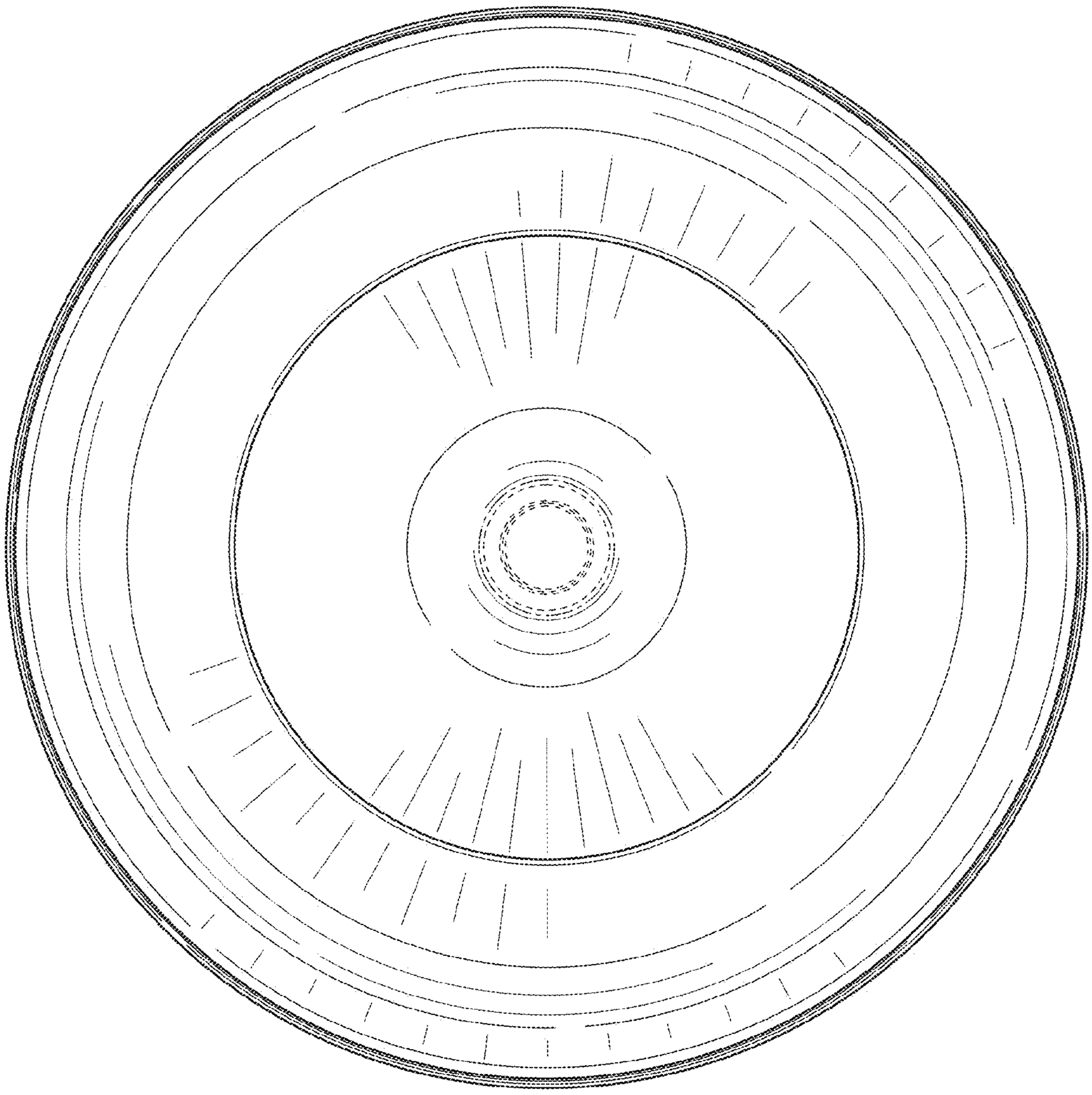


FIG. 4

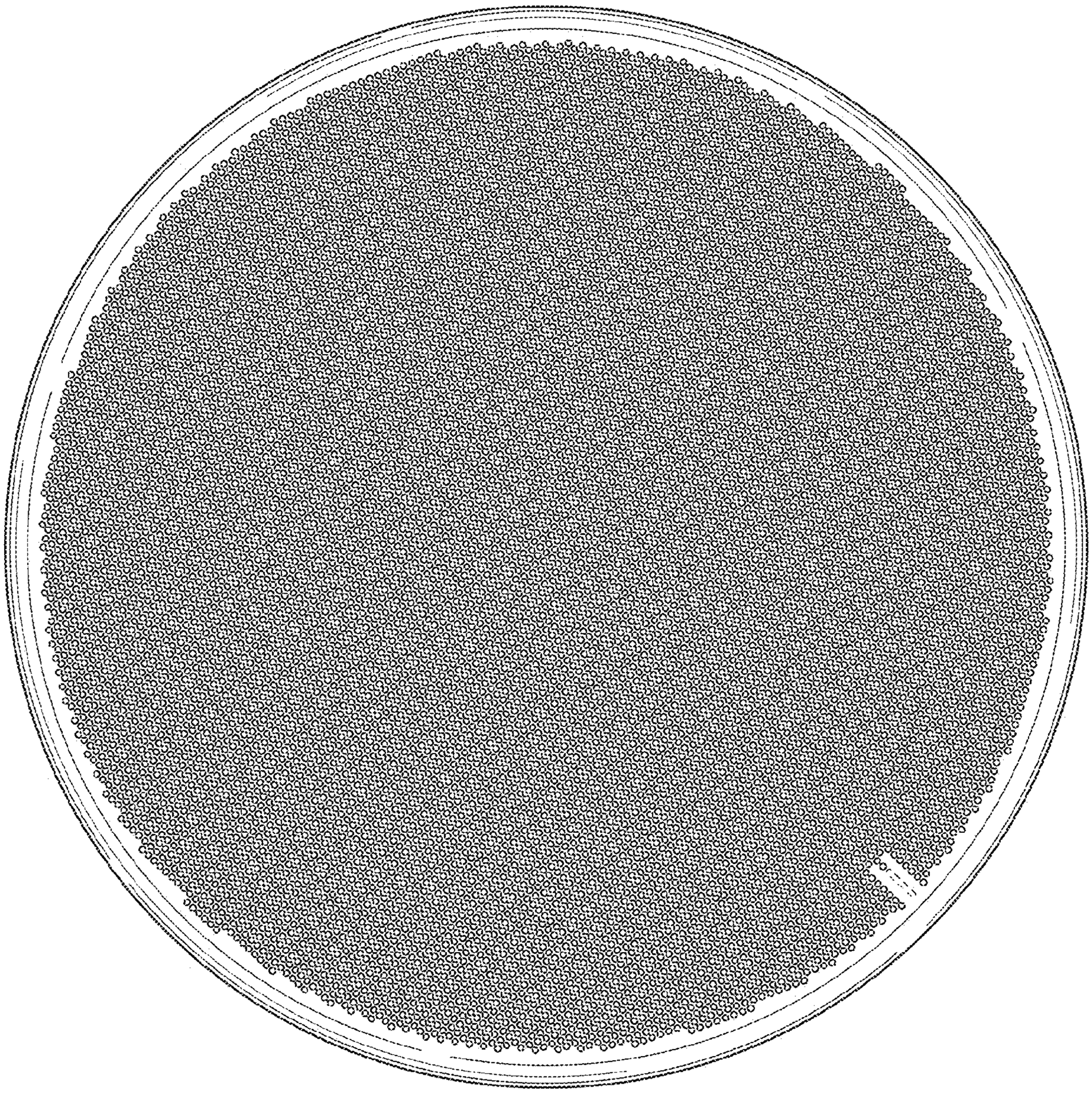


FIG. 5

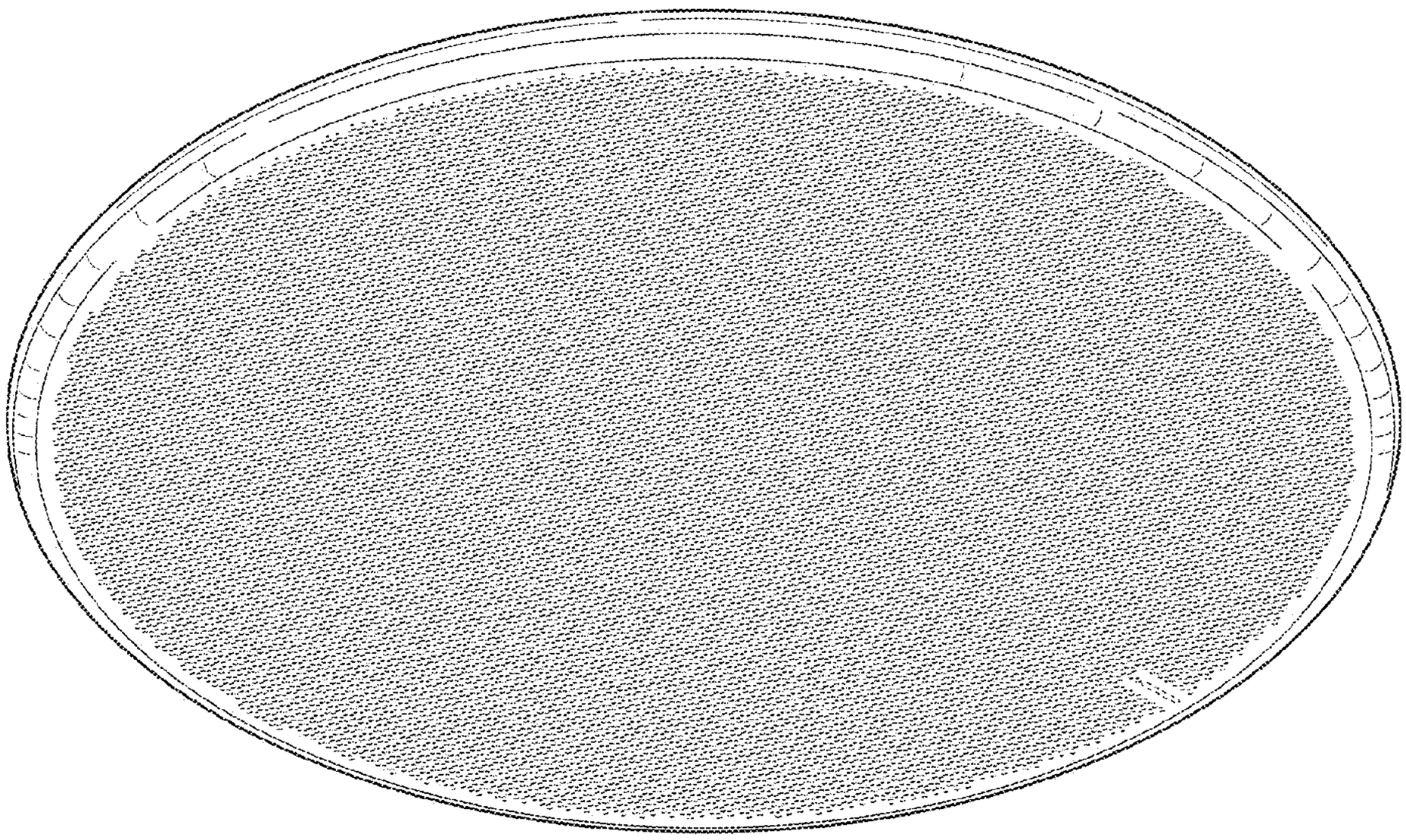


FIG. 6

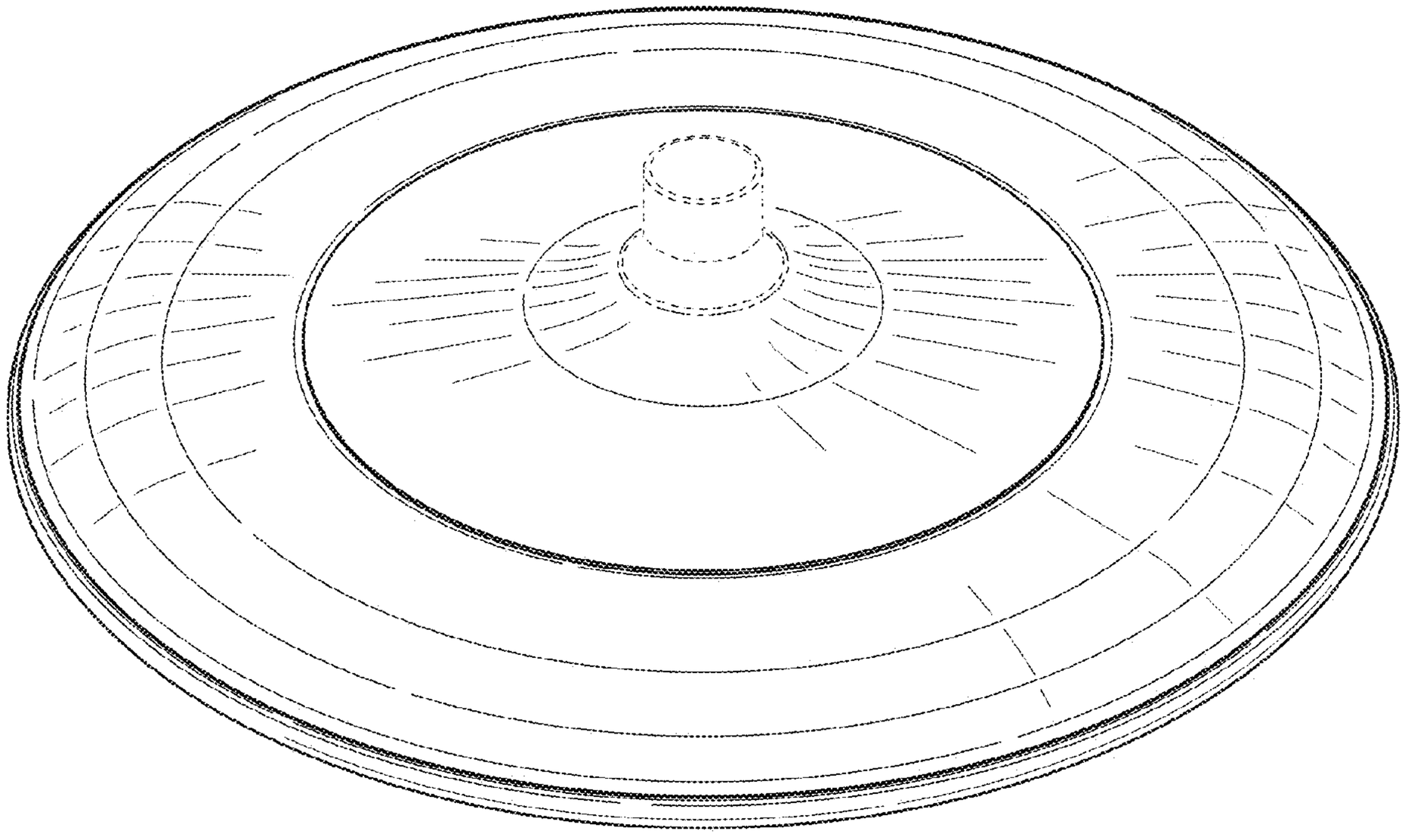


FIG. 7

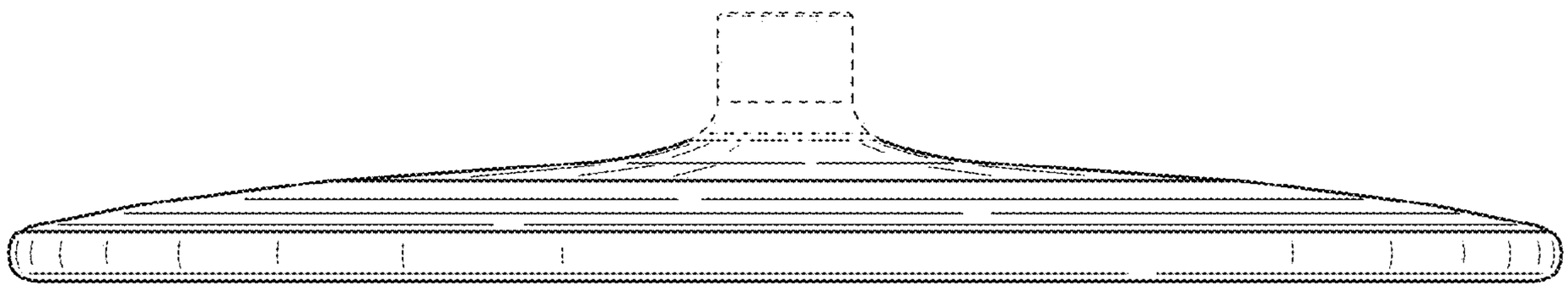


FIG. 8

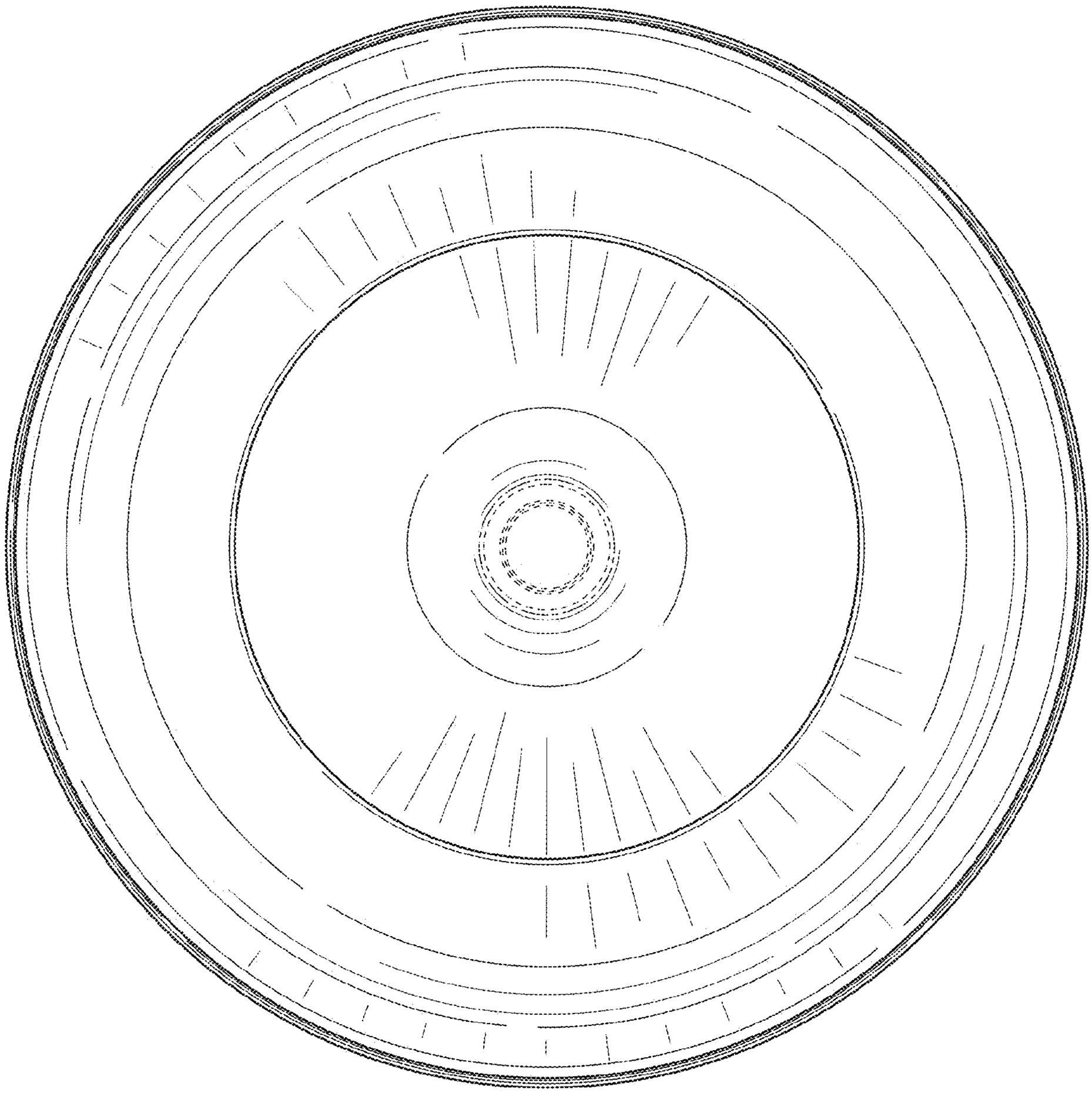


FIG. 9

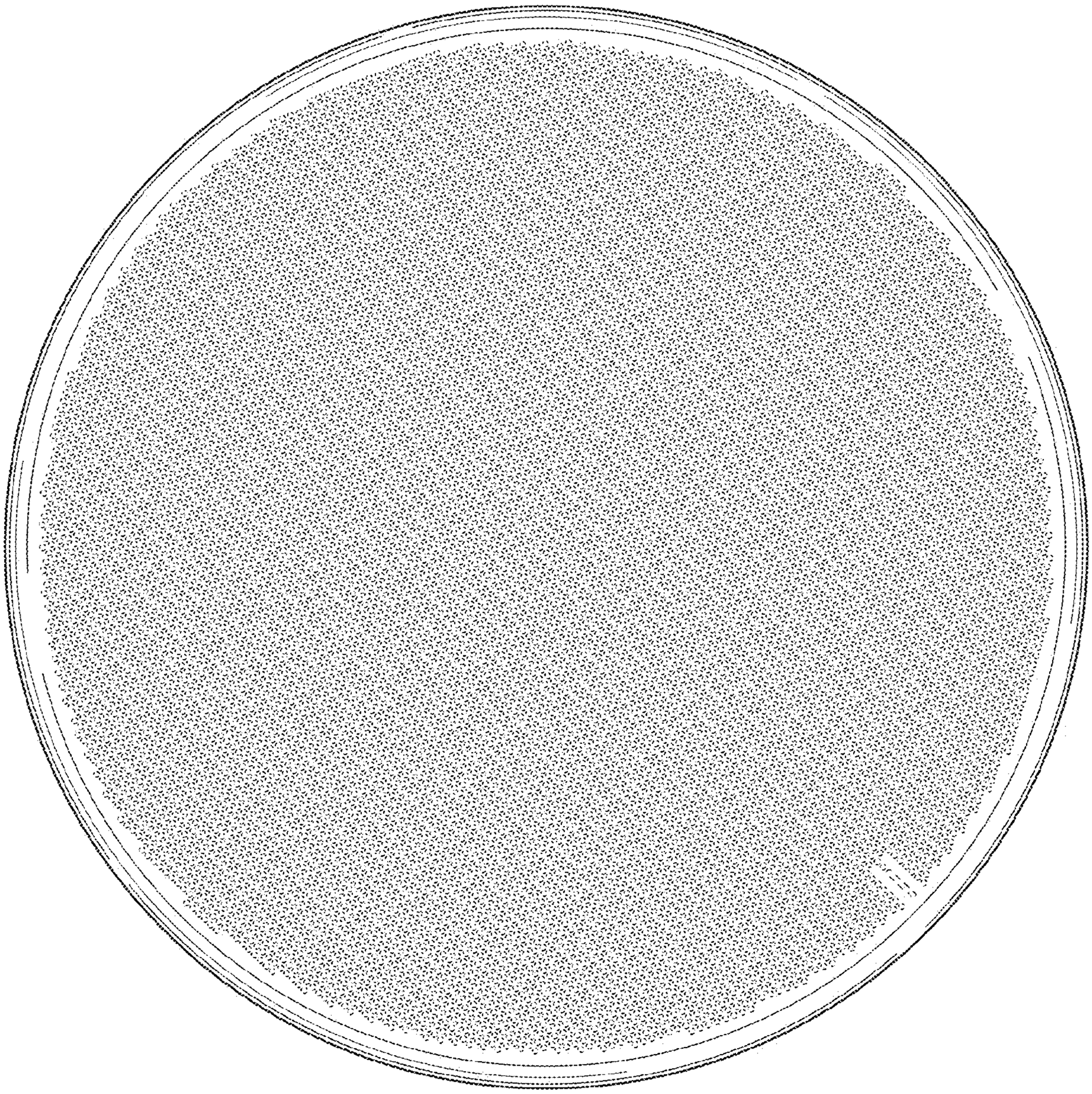


FIG. 10