US012385494B2

(12) **United States Patent**
Herrera et al.

(10) **Patent No.: US 12,385,494 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **FAN FOR HANDHELD BLOWER**

(71) Applicant: **MILWAUKEE ELECTRIC TOOL CORPORATION**, Brookfield, WI (US)

(72) Inventors: **Nathaniel A. Herrera**, Oak Creek, WI (US); **Beth E. Cholst**, Wauwatosa, WI (US); **Shannon C. Bartlett**, Cedarburg, WI (US); **John L. Whealon**, West Bend, WI (US)

(73) Assignee: **Milwaukee Electric Tool Corporation**, Brookfield, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/572,095**

(22) PCT Filed: **Oct. 10, 2022**

(86) PCT No.: **PCT/US2022/046176**
§ 371 (c)(1),
(2) Date: **Dec. 19, 2023**

(87) PCT Pub. No.: **WO2023/064213**
PCT Pub. Date: **Apr. 20, 2023**

(65) **Prior Publication Data**

US 2024/0280110 A1 Aug. 22, 2024

Related U.S. Application Data

(60) Provisional application No. 63/254,296, filed on Oct. 11, 2021.

(51) **Int. Cl.**
F04D 25/08 (2006.01)
A01G 20/43 (2018.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F04D 25/08*** (2013.01); ***F04D 29/32*** (2013.01); ***F04D 29/34*** (2013.01); ***F04D 29/38*** (2013.01)

(58) **Field of Classification Search**
CPC A01G 20/47; A01G 20/43; A47L 5/14; A47L 5/24; A47L 5/22; A47L 5/28;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,898,410 A 2/1933 Wales
2,284,586 A 5/1942 McDermott
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2825035 A1 8/2012
CN 2053083 U 2/1990
(Continued)

OTHER PUBLICATIONS

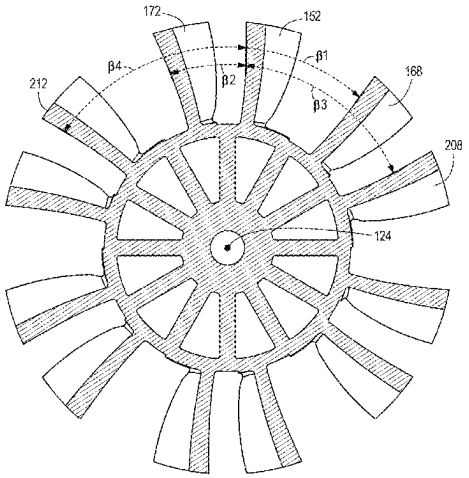
Machine Translation of CN 2628767 [retrieved on Sep. 4, 2024]. Retrieved from: Espacenet. (Year: 2024).*
(Continued)

Primary Examiner — Eric J Zamora Alvarez
(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57) **ABSTRACT**

A fan includes a hub and a plurality of blades extending radially outwardly from the hub and spaced circumferentially about the hub. The plurality of blades includes a reference blade, a first blade, and a second blade. The reference blade is disposed after the first blade in a circumferential direction about the hub. The second blade is disposed after the reference blade in the circumferential direction. The first blade is circumferentially spaced a first distance from the reference blade. The second blade is circumferentially spaced a second distance from the reference blade. The first distance is greater than the second distance.

19 Claims, 9 Drawing Sheets



(51) **Int. Cl.**

F04D 25/06	(2006.01)
F04D 29/32	(2006.01)
F04D 29/34	(2006.01)
F04D 29/38	(2006.01)
F04D 29/66	(2006.01)

(58) **Field of Classification Search**

CPC A47L 9/02; F04D 19/002; F04D 25/08; F04D 29/545; F04D 29/32; F04D 29/34; F04D 25/084; F04D 29/281; F04D 29/327; F04D 29/329; F04D 29/38; F04D 29/388; F04D 25/0673; F04D 29/666; F05B 2240/301

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,768,782	A	10/1956	Tateishi	
2,938,527	A	5/1960	Nichols	
3,346,174	A	10/1967	Lievens et al.	
3,407,431	A	10/1968	Melnik	
3,540,547	A	11/1970	Coward, Jr.	
4,185,688	A	1/1980	Wiater et al.	
4,222,318	A	9/1980	Patton et al.	
4,413,371	A	11/1983	Tuggle et al.	
4,597,203	A	7/1986	Middleton	
4,615,069	A	10/1986	Henning	
4,692,091	A	9/1987	Ritenour	
4,696,450	A	9/1987	Huang	
4,734,017	A	3/1988	Levin	
4,773,119	A	9/1988	Duthie et al.	
4,792,286	A	12/1988	Gassen	
4,794,225	A	12/1988	Maese	
4,821,366	A	4/1989	Levine	
4,838,151	A	6/1989	Shin-Chin	
4,884,314	A	12/1989	Miner et al.	
4,945,604	A	8/1990	Miner et al.	
4,981,414	A	1/1991	Sheets	
5,035,586	A	7/1991	Sadler et al.	
5,195,208	A	3/1993	Yamami et al.	
5,267,371	A	12/1993	Soler et al.	
5,269,665	A	12/1993	Sadler et al.	
5,383,427	A	1/1995	Tuggle et al.	
5,511,281	A	4/1996	Webster	
5,560,076	A	10/1996	Leung	
5,701,631	A	12/1997	Lindquist	
5,768,749	A	6/1998	Ohi et al.	
5,821,473	A	10/1998	Takahashi	
5,839,397	A	11/1998	Funabashi et al.	
5,938,527	A	8/1999	Oshima et al.	
5,975,862	A	11/1999	Arahata et al.	
5,979,013	A	11/1999	Beckey et al.	
6,006,400	A	12/1999	Presenza	
6,105,206	A	8/2000	Tokumaru et al.	
6,158,082	A	12/2000	Beckey et al.	
6,244,823	B1	6/2001	Marino et al.	
6,305,048	B1	10/2001	Salisian	
6,324,720	B1	12/2001	Beckey et al.	
6,324,721	B2	12/2001	Doragrip	
6,370,729	B2	4/2002	Miyamoto	
6,442,790	B1	9/2002	Svoboda et al.	
6,464,459	B2	10/2002	Illingworth	
6,468,053	B2	10/2002	Wölpert	
6,497,553	B2	12/2002	Illingworth et al.	
6,514,036	B2	2/2003	Marshall et al.	
6,520,449	B2	2/2003	Illingworth	
6,543,726	B2	4/2003	Illingworth	
6,565,321	B1	5/2003	Illingworth et al.	
6,575,695	B1	6/2003	Miyamoto	
6,595,753	B1	7/2003	Illingworth et al.	
6,616,094	B2	9/2003	Illingworth	
6,619,922	B2	9/2003	Illingworth et al.	
6,623,352	B2	9/2003	Illingworth	
6,687,951	B2	2/2004	Illingworth et al.	
6,689,225	B2	2/2004	Illingworth	
6,719,830	B2	4/2004	Illingworth et al.	
6,729,839	B1	5/2004	Illingworth et al.	
6,796,858	B2 *	9/2004	Dusablon	B63H 11/08 440/38
6,802,693	B2	10/2004	Reinfeld et al.	
6,802,881	B2	10/2004	Illingworth et al.	
6,811,687	B2	11/2004	Illingworth	
6,857,163	B2	2/2005	Iida et al.	
6,881,025	B2	4/2005	Illingworth et al.	
6,957,472	B2	10/2005	Illingworth et al.	
6,960,063	B2	11/2005	Reinfeld et al.	
7,055,213	B2	6/2006	Iida et al.	
7,143,468	B2	12/2006	Illingworth et al.	
7,300,484	B2	11/2007	Scully et al.	
7,600,290	B1	10/2009	Peters	
7,607,244	B2	10/2009	Hishida	
7,735,188	B2	6/2010	Shaffer	
7,774,896	B2	8/2010	Andresen et al.	
7,845,048	B1	12/2010	Bailey et al.	
7,850,513	B1	12/2010	Parker et al.	
7,922,470	B2	4/2011	Joseph	
7,941,894	B1	5/2011	Skorput	
8,266,762	B2	9/2012	Hsu	
8,449,589	B1	5/2013	Harsy	
8,510,910	B1	8/2013	Ramsey	
8,745,815	B2	6/2014	Takano et al.	
8,894,382	B2	11/2014	Binder	
8,918,956	B2	12/2014	Pellenc	
8,967,949	B2	3/2015	Gamissans Bou	
9,004,854	B2	4/2015	Nakazawa	
9,057,166	B2	6/2015	Prager	
9,062,681	B2 *	6/2015	Lee	F04D 19/007
9,167,751	B2	10/2015	Thackery et al.	
9,277,844	B1	3/2016	Millan	
9,364,125	B2	6/2016	Takahashi	
9,439,548	B2	9/2016	Jenson	
9,456,722	B2	10/2016	Tomasiak et al.	
9,538,711	B2	1/2017	Mutoh et al.	
9,603,497	B2	3/2017	Yamaoka et al.	
9,737,182	B2	8/2017	Gindele et al.	
9,861,242	B2	1/2018	Tomasiak et al.	
9,869,327	B2	1/2018	Kodato et al.	
D812,825	S	3/2018	Smith et al.	
9,970,445	B2	5/2018	Kodato et al.	
9,974,241	B2	5/2018	Yamaoka et al.	
10,000,900	B2	6/2018	Yamaoka et al.	
10,065,219	B2	9/2018	Suzuki et al.	
10,091,954	B1	10/2018	Yamaoka et al.	
10,227,988	B2	3/2019	Gao et al.	
10,232,502	B2	3/2019	Bylund et al.	
10,264,739	B2	4/2019	Yamaoka et al.	
10,267,323	B2	4/2019	Patrick	
10,306,843	B2	6/2019	Thackery et al.	
10,337,526	B2	7/2019	Shao et al.	
10,375,901	B2	8/2019	Bermudez et al.	
10,398,095	B2	9/2019	Gao et al.	
10,405,707	B2 *	9/2019	Zhu	F04D 29/545
10,487,850	B2	11/2019	Shao et al.	
10,670,048	B2	6/2020	Landén et al.	
10,674,681	B2	6/2020	Bermudez et al.	
10,722,085	B2	7/2020	Gao et al.	
10,774,487	B2	9/2020	Yamaoka et al.	
10,897,858	B2	1/2021	Hoffman et al.	
10,947,983	B2	3/2021	Hoffman	
2001/0054212	A1	12/2001	Walker	
2002/0060107	A1	5/2002	Kamoshita et al.	
2002/0148069	A1	10/2002	Illingworth	
2002/0155002	A1	10/2002	Reinfeld et al.	
2002/0176777	A1	11/2002	Reinfeld et al.	
2002/0176778	A1	11/2002	Reinfeld et al.	
2002/0182077	A1	12/2002	Reinfeld et al.	
2002/0182078	A1	12/2002	Reinfeld et al.	
2003/0033689	A1	2/2003	Marshall et al.	
2003/0136094	A1	7/2003	Illingworth et al.	
2003/0150198	A1	8/2003	Illingworth et al.	
2003/0167741	A1	9/2003	Illingworth et al.	
2003/0221399	A1	12/2003	Hall	
2004/0018089	A1	1/2004	Illingworth et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0091357	A1	5/2004	Reinfeld et al.	
2004/0139709	A1	7/2004	Illingworth et al.	
2004/0139710	A1	7/2004	Illingworth et al.	
2004/0159109	A1	8/2004	Harvie	
2006/0182502	A1	8/2006	Schliemann et al.	
2007/0209346	A1	9/2007	Bovo et al.	
2007/0217914	A1*	9/2007	Fujimura	F01D 5/3015 416/219 R
2007/0280829	A1*	12/2007	Stevens	F04D 29/164 416/189
2007/0294855	A1	12/2007	Iida et al.	
2008/0089785	A1	4/2008	Schliemann et al.	
2008/0098703	A1	5/2008	Lucas et al.	
2008/0141541	A1	6/2008	Hurley	
2009/0038108	A1	2/2009	Shaanan et al.	
2009/0078485	A1	3/2009	Gutsch et al.	
2009/0241285	A1	10/2009	Hinklin et al.	
2009/0282642	A1	11/2009	Batchelder et al.	
2010/0003149	A1	1/2010	Nelson	
2010/0192314	A1	8/2010	Otsuka et al.	
2010/0247316	A1	9/2010	Aynsley et al.	
2011/0146023	A1	6/2011	Wada et al.	
2012/0093490	A1	4/2012	Steinberg	
2012/0096672	A1	4/2012	Hatano et al.	
2012/0099996	A1*	4/2012	Delvaux	F04D 29/544 416/204 A
2012/0138058	A1	6/2012	Fu et al.	
2013/0017079	A1	1/2013	Armstrong et al.	
2013/0180495	A1	7/2013	Veerathappa et al.	
2013/0183141	A1	7/2013	Tan	
2013/0206172	A1	8/2013	Bjar et al.	
2014/0021203	A1	1/2014	Walker et al.	
2014/0056738	A1	2/2014	Takahashi	
2014/0086728	A1	3/2014	Engert et al.	
2014/0105749	A1	4/2014	Pellenc et al.	
2014/0140861	A1	5/2014	Pellenc	
2014/0230181	A1*	8/2014	Yamaoka	A01G 20/47 15/344
2014/0356159	A1*	12/2014	Heikurinen	F01D 5/34 29/888.025
2015/0152879	A1*	6/2015	Tzeng	F04D 19/002 416/223 R
2015/0282356	A1	10/2015	Takahashi et al.	
2015/0377253	A1	12/2015	Shibata et al.	
2016/0108924	A1	4/2016	Conrad et al.	
2016/0120131	A1	5/2016	Conrad et al.	
2016/0169249	A1	6/2016	Takahashi et al.	
2016/0198636	A1	7/2016	Poole et al.	
2016/0216249	A1	7/2016	Sass	
2016/0265540	A1	9/2016	Tirone et al.	
2016/0298635	A1	10/2016	Su et al.	
2016/0305438	A1	10/2016	Yamamoto et al.	
2016/0324380	A1	11/2016	Sergyeyenko et al.	
2017/0042096	A1	2/2017	Bylund et al.	
2017/0045058	A1	2/2017	Bylund et al.	
2017/0045246	A1	2/2017	Kaleta et al.	
2017/0208748	A1	7/2017	Yamaoka et al.	
2017/0241423	A1	8/2017	Han et al.	
2017/0273251	A1	9/2017	Haramoto et al.	
2017/0273252	A1	9/2017	Haramoto et al.	
2018/0000014	A1	1/2018	Yamaoka et al.	
2018/0087513	A1	3/2018	Hoffman	
2018/0094393	A1	4/2018	Takahashi et al.	
2018/0146628	A1	5/2018	Huo et al.	
2018/0146682	A1	5/2018	Beau et al.	
2018/0209429	A1	7/2018	Ishida	
2018/0320705	A1*	11/2018	Van Houten	F01P 5/02
2019/0021243	A1	1/2019	Naka et al.	
2019/0098844	A1	4/2019	Yang et al.	
2019/0162192	A1	5/2019	Gao et al.	
2019/0191638	A1	6/2019	Yamaoka et al.	
2019/0211830	A1	7/2019	Liu et al.	
2019/0320598	A1	10/2019	Bermudez et al.	
2020/0096001	A1	3/2020	Chung	
2020/0096006	A1	3/2020	Shao et al.	
2021/0227758	A1	7/2021	Bylund et al.	
2022/0136526	A1	5/2022	Shao et al.	

FOREIGN PATENT DOCUMENTS

CN	2580819	Y	10/2003
CN	2628767	Y	7/2004
CN	101135139	A	3/2008
CN	101260833	A	9/2008
CN	201968600	U	9/2011
CN	202015678	U	10/2011
CN	102296555	A	12/2011
CN	202157288	U	3/2012
CN	203270492	U	11/2013
CN	103671175	A	3/2014
CN	203498784	U	3/2014
CN	104074155	A	10/2014
CN	204126922	U	1/2015
CN	104564839	A	4/2015
CN	204722966	U	10/2015
CN	204811640	U	12/2015
CN	105248156	A	1/2016
CN	205276194	U	6/2016
CN	106284148	A	1/2017
CN	106284149	A	1/2017
CN	106284153	A	1/2017
CN	205999837	U	3/2017
CN	206090426	U	4/2017
CN	206289575	U	6/2017
CN	107201734	A	9/2017
CN	206480689	U	9/2017
CN	107269550	A	10/2017
CN	206815252	U	12/2017
CN	107532604	A	1/2018
CN	207498881	U	6/2018
CN	207582389	U	7/2018
CN	108476871	A	9/2018
CN	212508973	U	2/2021
DE	3812105	A1	9/1988
DE	8815616	U1	2/1989
DE	19523339	A1	1/1996
DE	29921751	U1	2/2000
DE	102007037011	A1	2/2008
DE	102010054841	A1	6/2012
DE	202017106572	U1	1/2018
EP	0821872	A2	2/1998
EP	2617281	A1	7/2013
FR	2224713	A1	10/1974
FR	2840172	A1	12/2003
GB	958481	A	5/1964
GB	2156962	A	10/1985
GB	2390118	A	12/2003
GB	2513230	A	10/2014
JP	H0214790	A	1/1990
JP	2749885	B2	5/1998
JP	2000018720	A	1/2000
JP	2009264300	A	11/2009
JP	2014037818	A	2/2014
KR	101048421	B1	7/2011
KR	20110009355	U	10/2011
KR	200458939	Y1	3/2012
KR	102042387	B1	11/2019
WO	WO0073662	A1	12/2000
WO	WO2011097157	A1	8/2011
WO	WO2012140825	A1	10/2012
WO	WO2014119175	A1	8/2014
WO	WO2017101666	A1	6/2017
WO	WO2017118276	A1	7/2017
WO	WO2018164145	A1	9/2018
WO	WO2019062279	A1	4/2019

OTHER PUBLICATIONS

Black & Decker, "20V Max* Lithium Sweeper" Instruction Manual, Model No. LSW20, Nov. 2011 (32 pages).

Black & Decker, "36V Lithium Hard Surface Sweeper Vac Instruction Manual," Model No. LSWV36, Jun. 2012 (44 pages).

(56) **References Cited**

OTHER PUBLICATIONS

Black & Decker, "Cordless Broom Instruction Manual," Catalog Nos. NS118, NS118L, Jun. 2011 (6 pages).
Black & Decker, "Heat Gun Instruction Manual," Catalog No. HG1300, Nov. 2010 (32 pages).
Black & Decker, "Instruction Manual," Catalog No. BV2500, BV9000, May 2004 (4 pages).
Black & Decker, "Straight Tube Blower / Sweeper," Instruction Manual, Catalog No. BL950, Aug. 2003 (3 pages).
Black & Decker, "Sweeper," Instruction Manual, Catalog No. CS100, © 2003 (4 pages).
Charles & Hudson, "Stihl BGA 85 Electric Leaf Blower," <https://www.youtube.com/watch?v=JMK4zdlUbbY> YouTube video publicly available at least as early as Feb. 25, 2012.
DeWalt, "D26950, D26960 Heavy-Duty Heat Gun," Instruction Manual © 2009 (7 pages).
E Magazine, "Blow, Leaves, Blow," Sep./Oct. 2012, p. 36.
Greenworks, "24V Lithium-Ion Cordless Blower 24352," Owner's Manual, Apr. 24, 2014 (18 pages).
Greenworks, "40V Brushless Blower/Vac 24322," Owner's Manual, Jul. 25, 2013 (13 pages).
Greenworks, "40V Lithium-ion Cordless Blower 24212," Owner's Manual, Dec. 24, 2012 (20 pages).
Greenworks, "40V Lithium-Ion Cordless Blower 24252," Owner's Manual, Jan. 15, 2013 (20 pages).
Kobalt Tools, "Kobalt 40-Volt Max* Blower," <https://web.archive.org/web/20150509211919/http://kobalttools.com:80/ . . . > web page publicly available at least as early as May 2015.
Leister, "Hot Air Blower, Hotwind Premium Hotwind System," Brochure, May 2011 (4 pages).
Machine Design, "Leaf Removal is a Breeze," Feb. 24, 2000, pp. 60, 62.
Milwaukee Tool, "M18™ Fuel™ Blower," service parts list bulletin No. 54-05-2705 dated Aug. 2019 (2 pages).
Outdoor Power Equipment, "DR Power introduces lithium-ion battery-powered hand tools," Jul. 2012, p. 60.
Popular Mechanics, "Leaf Mover and Shaker," Oct. 2009, p. 28.
Pro Tool Reviews, "Kobalt 40V Max Lithium-Ion Mower, Blower, and Chainsaw," <https://web.archive.org/web/20140630170346/http://www.protoolreviews.com/tools/outdoor-eq . . . > web page publicly available at least as early as Jun. 2014.
Remington, "18 Volt Cordless Blower RM170B," Operator's Manual, Apr. 2011 (12 pages).
Ryobi, "18 Volt Blower, P2100, P2100A, P2100B," Operator's Manual, Rev. 04, Feb. 25, 2008 (14 pages).
Shop Vac, "Wet/Dry Vacuum," Manual © 2013 (15 pages).
Steinel, "Electronic Heat Guns," <https://web.archive.org/web/20121022121431/http://www.steinel.net/pro . . . > webpage available at least as early as Oct. 2012 (3 pages).
Steinel, "Heat Gun Handbook," © 2007 (28 pages).
Stihl, "Saving Green and Going Green by Choosing Orange," Article dated Feb. 2012 (2 pages).
Stihl, "Stihl BGA 85," Nov. 2010 Manual, © 2011 (30 pages).
Stihl, "Stihl BGA 85," Instruction Manual, © 2011 (56 pages).
Stihl, "Stihl BGA 85," Instruction Manual, © 2013 (60 pages).
Toolmonger, "This Shop-Vac Blows (But in a Good Way)," <https://toolmonger.com/2007/05/10/this-shop-vac-blows-but-in-a-good-way/> Article dated May 10, 2007 (3 pages).
Toro, "Rake and Vac™, Super, and Ultra Blower/Vacuum," Operator's Manual, © 2012 (6 pages).
Troy-Bilt "TB4300 / TB4300B Cordless Blower," Operator's Manual, Mar. 2016 (32 pages).
Worx, "18V Cordless Li-ion Blower/Sweeper, WG540," Manual ©2009 (10 pages).
Worx, "Cordless Li-ion Blower/Sweeper, WG545," Manual ©2015 (28 pages).
International Search Report and Written Opinion for Application No. PCT/US2022/046176 dated Feb. 3, 2023 (10 pages).

* cited by examiner

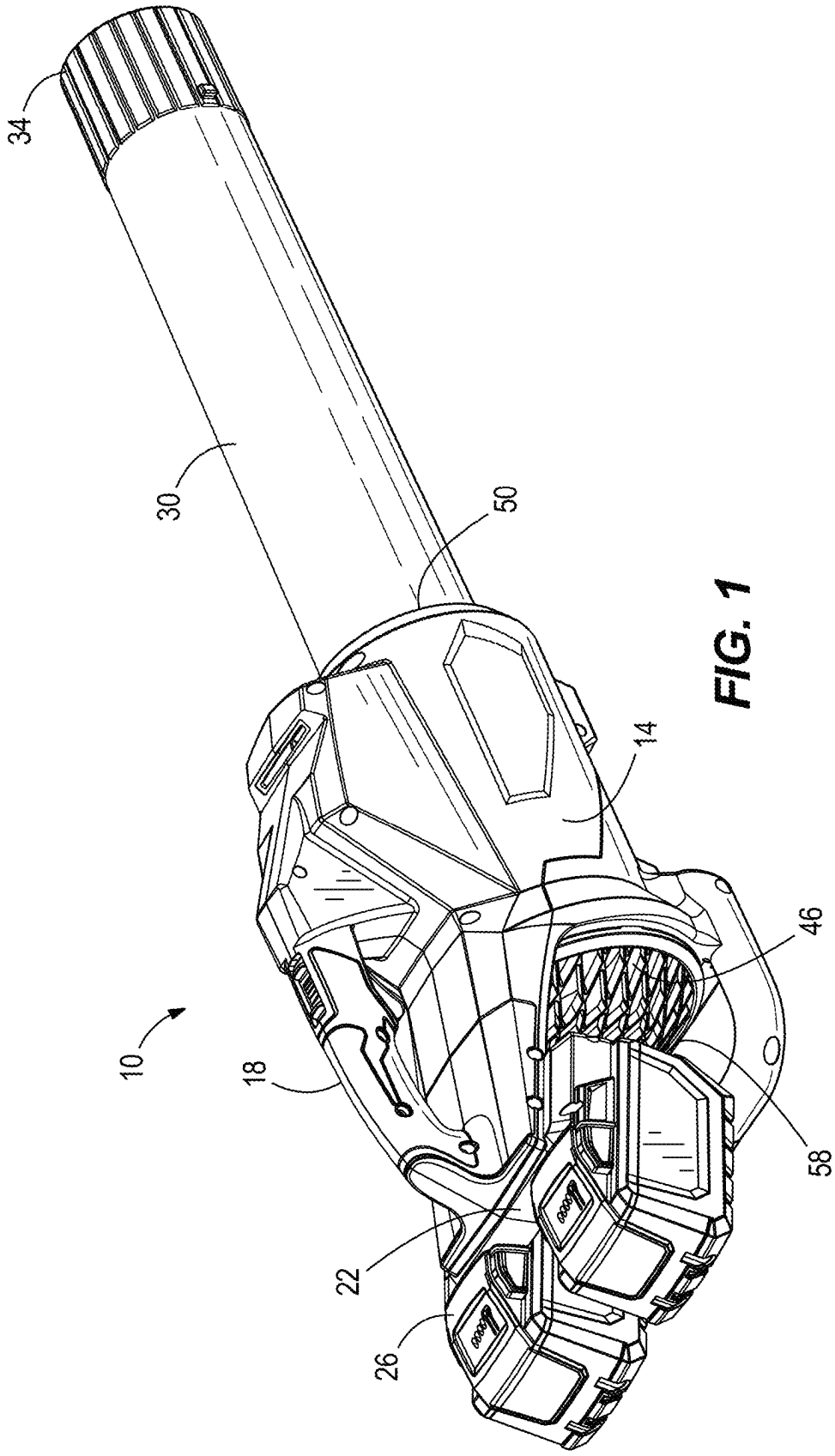


FIG. 1

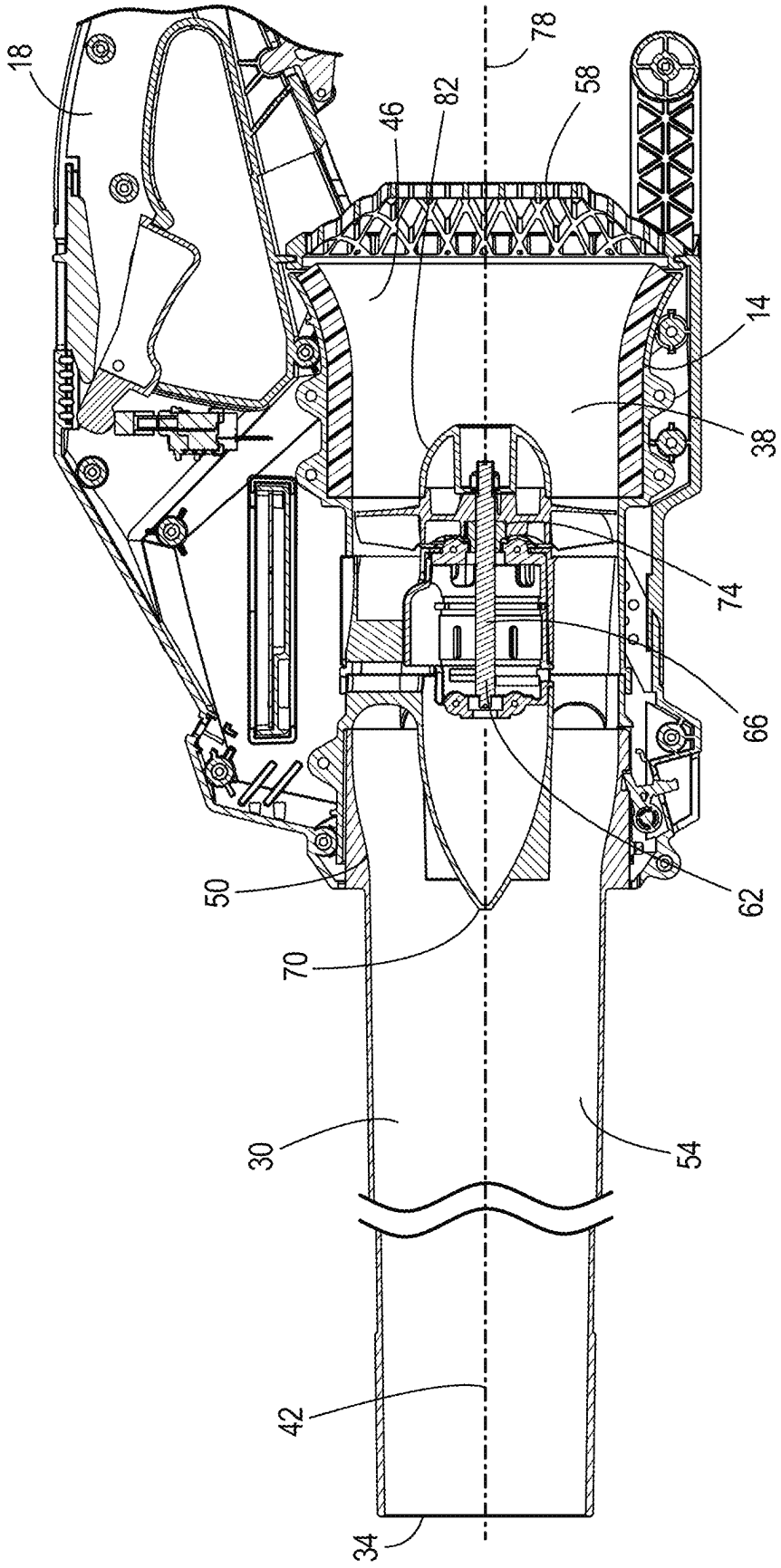


FIG. 2

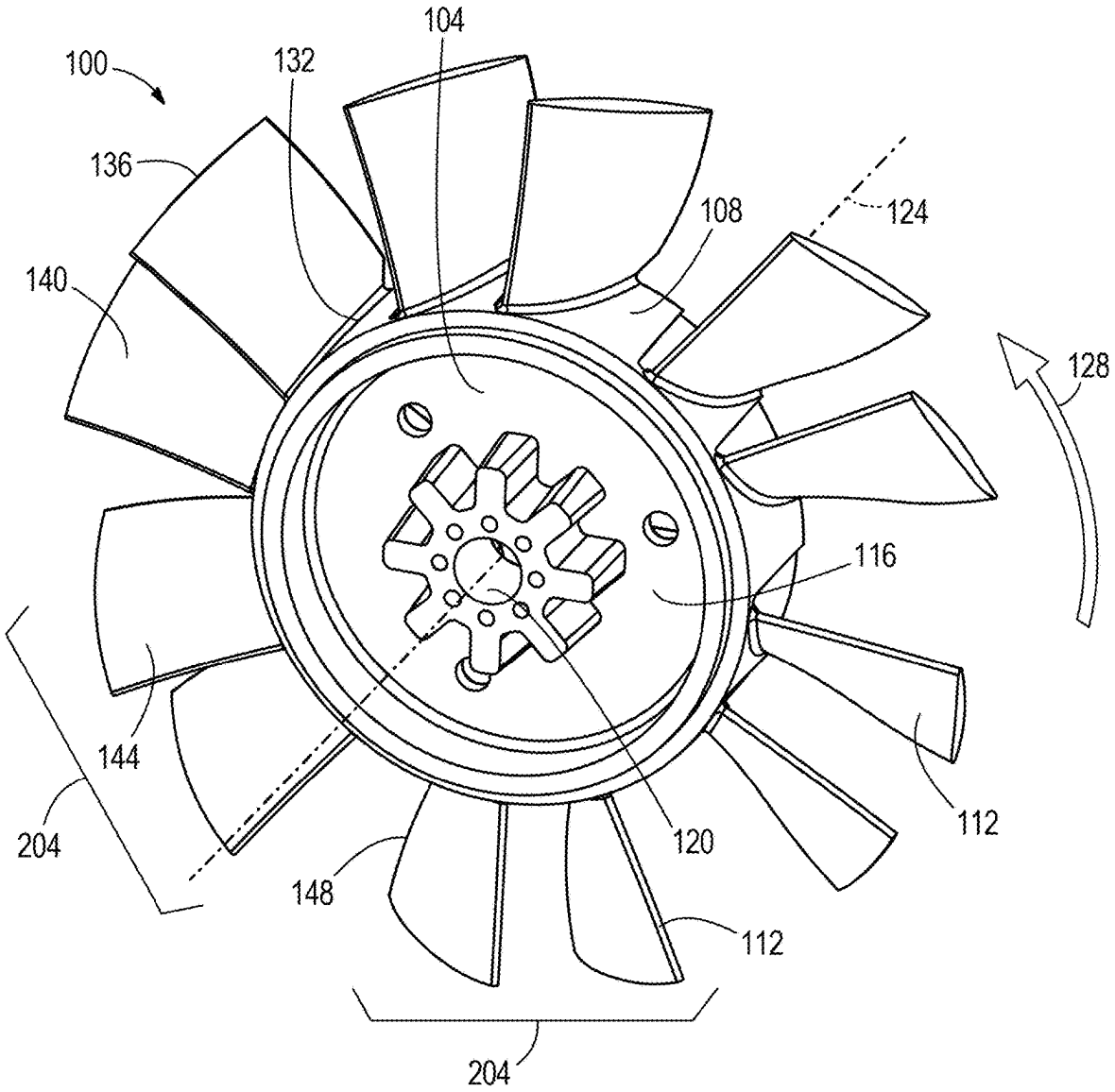


FIG. 3

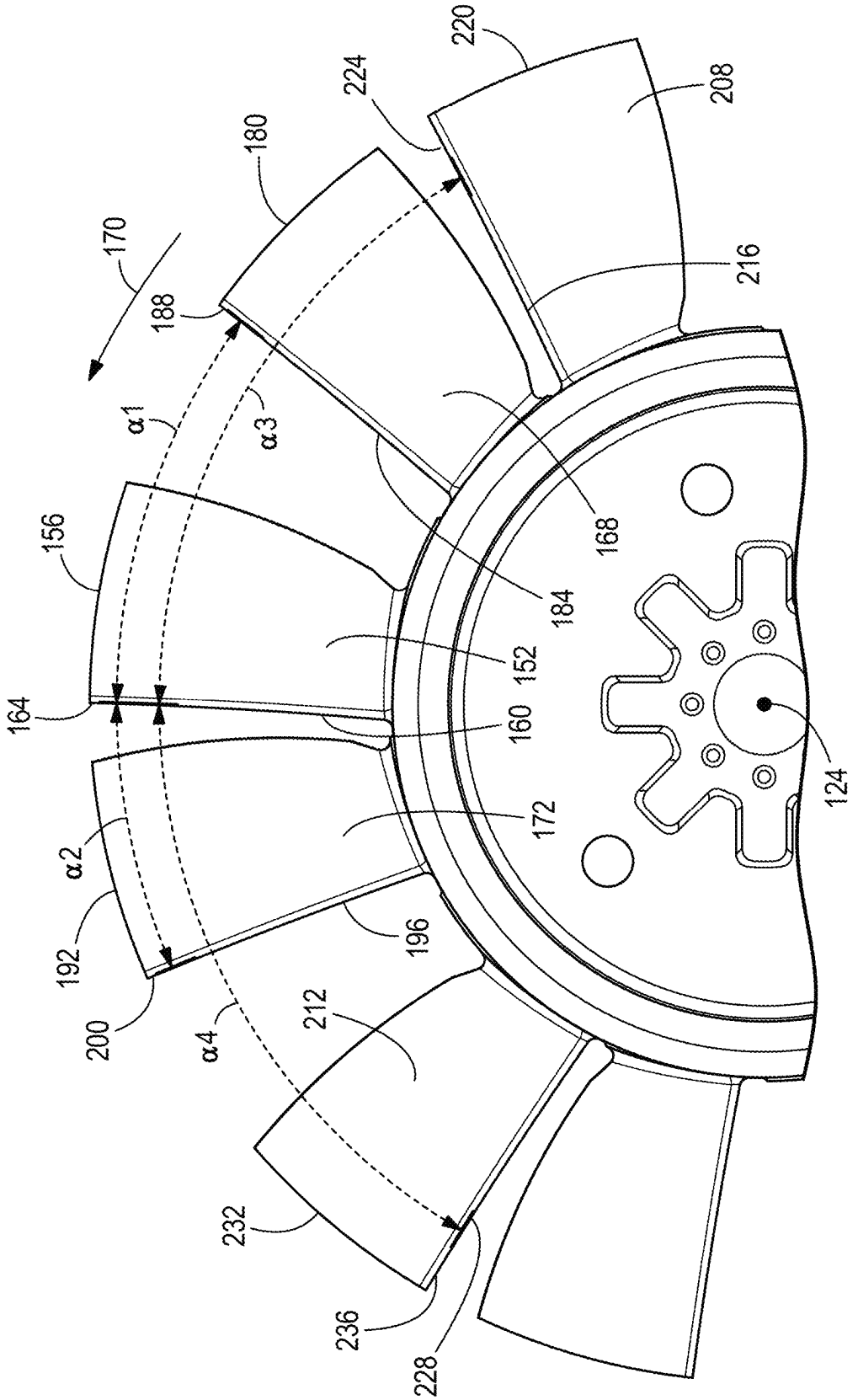

220
224
208
180
170
216
188
α1
α3
156
168
184
152
164
160
172
124
α2
192
196
200
α4
212
232
236
228

FIG. 4

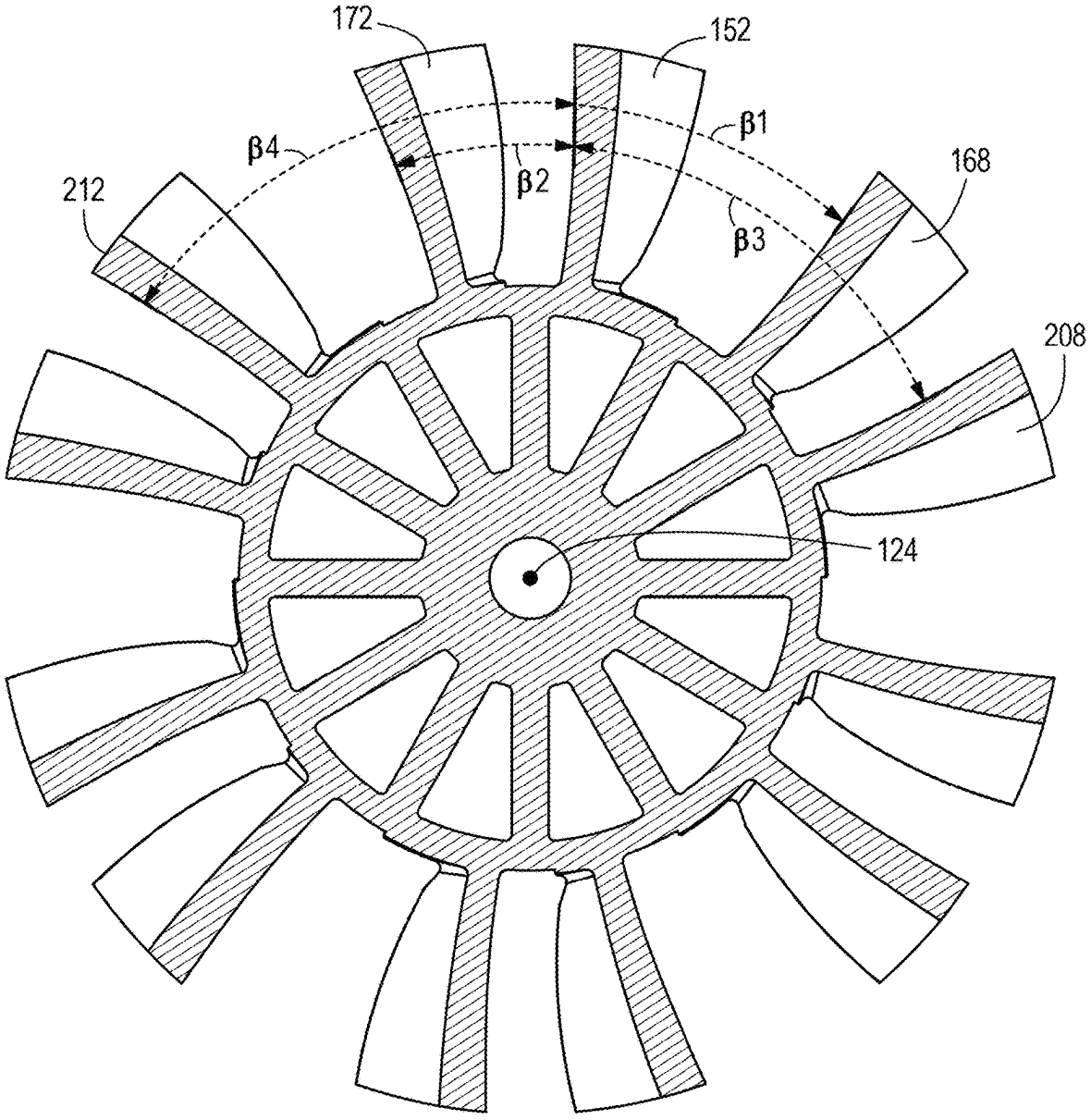


FIG. 5

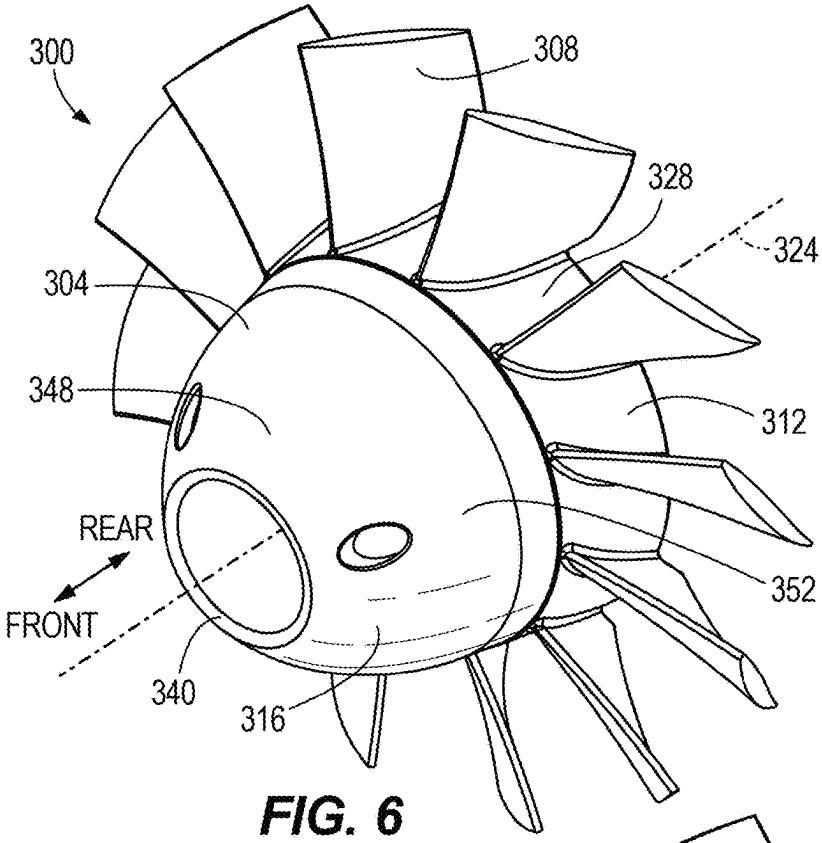

300
308
328
324
304
348
312
REAR
FRONT
352
340
316

FIG. 6

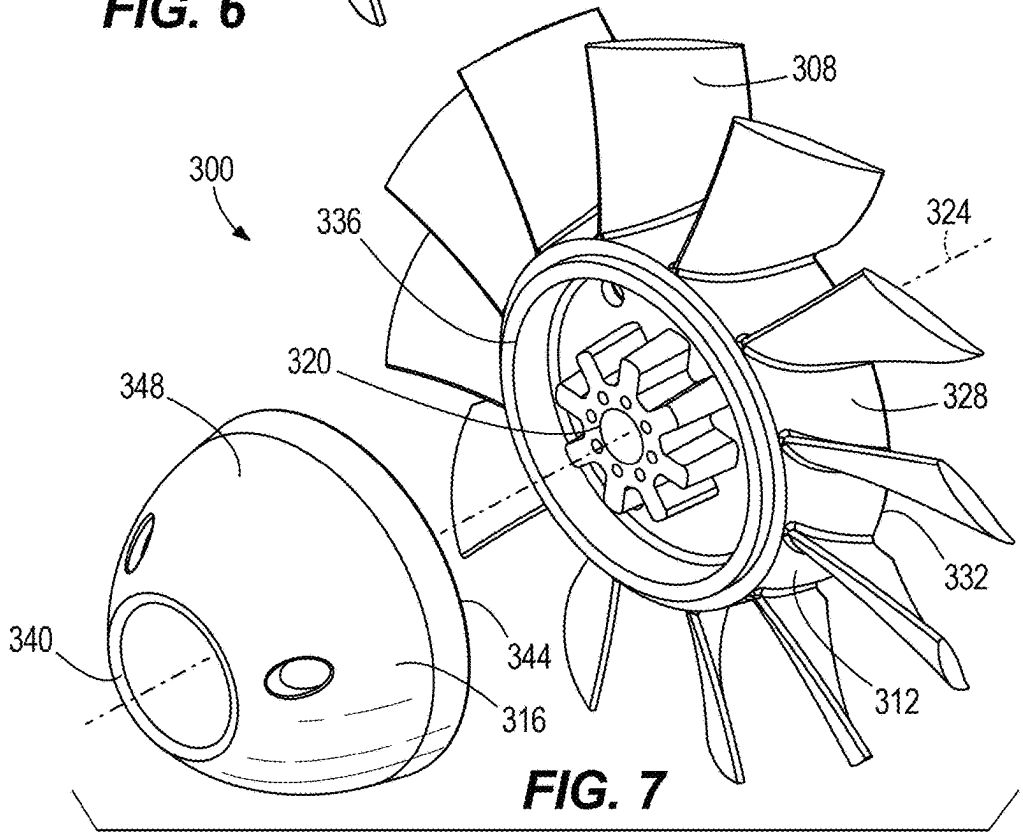

308
300
336
324
320
348
328
332
340
344
316
312

FIG. 7

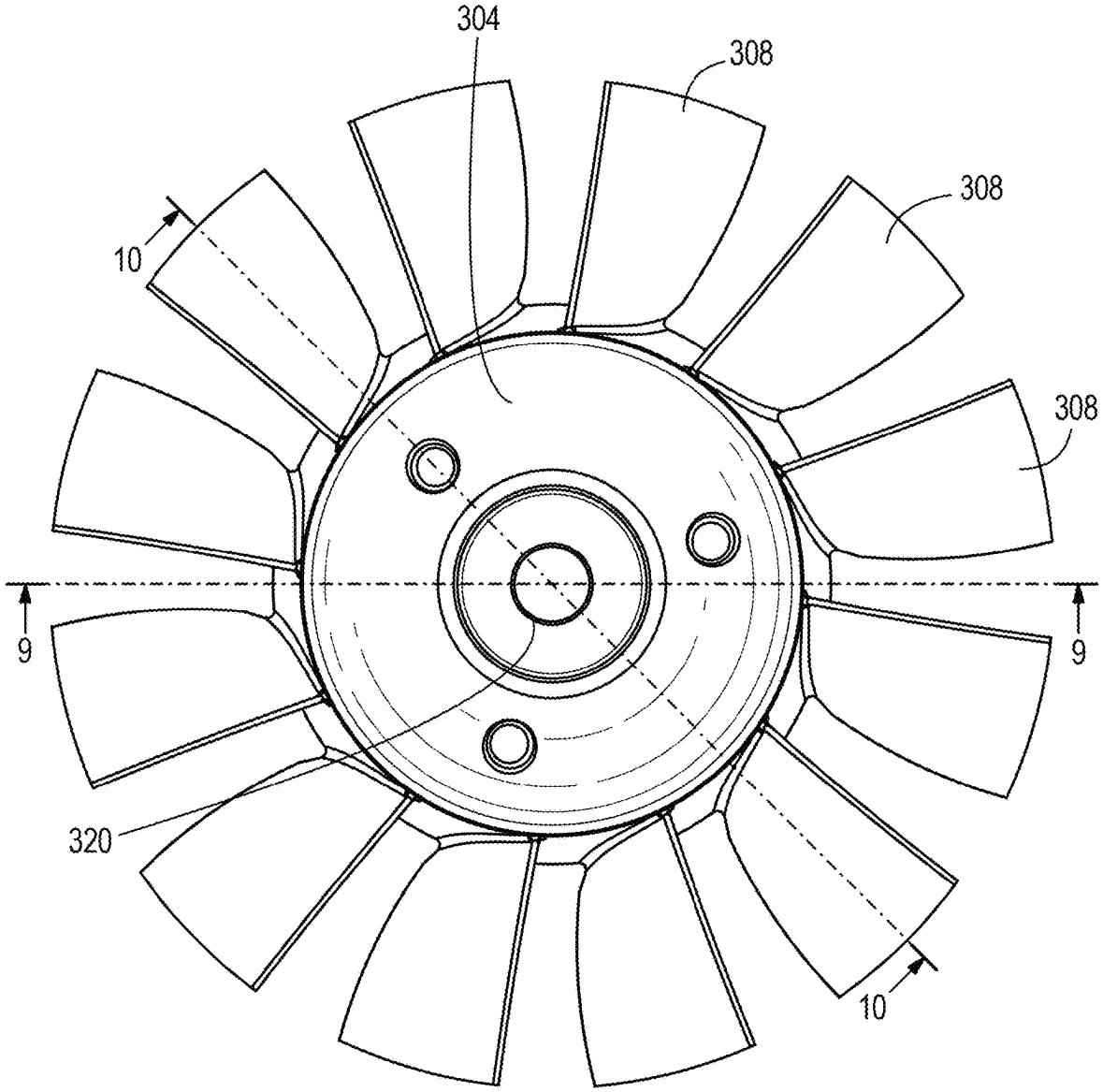


FIG. 8

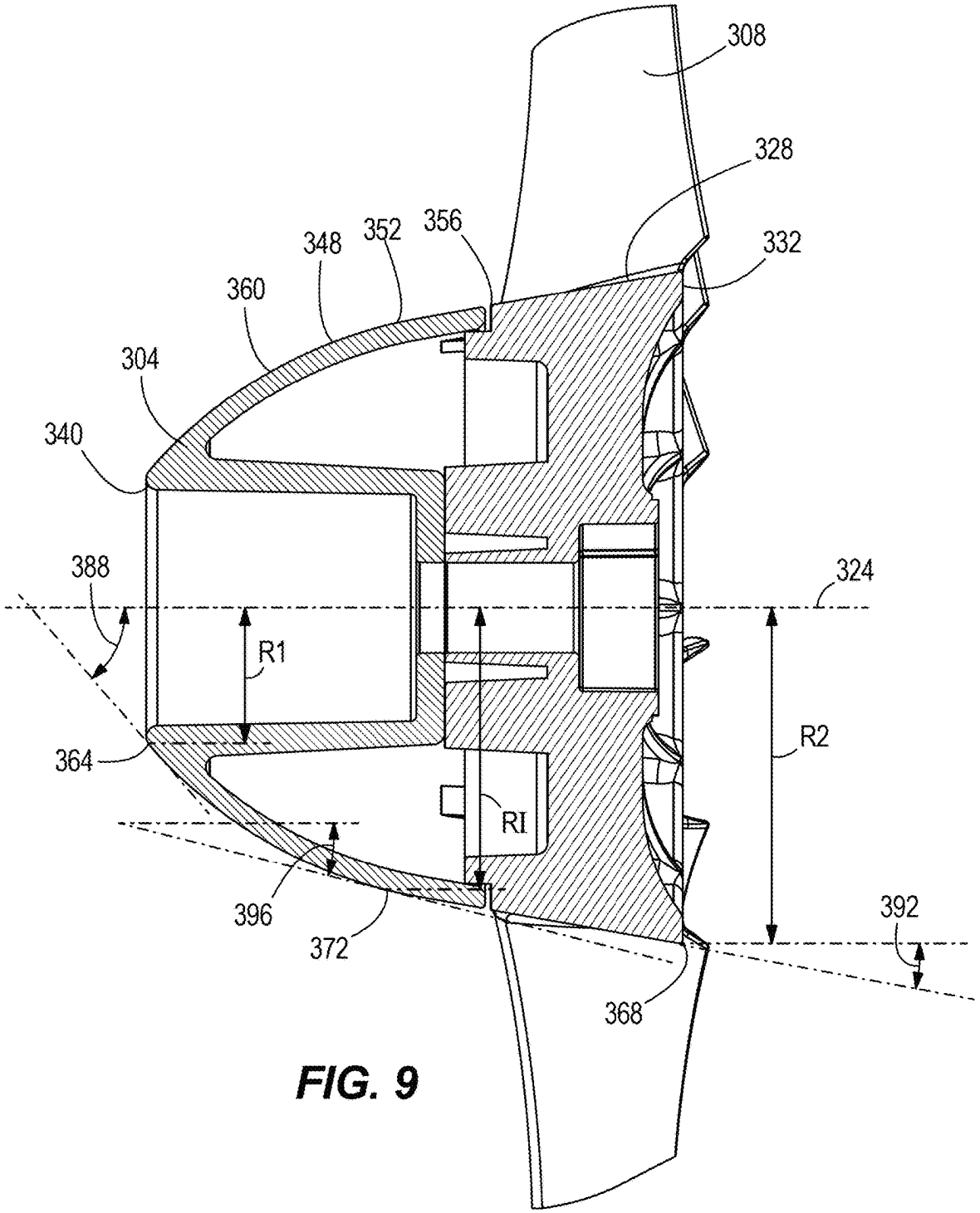

308
328
332
356
352
348
360
304
340
388
324
R1
R2
364
RI
396
372
392
368

FIG. 9

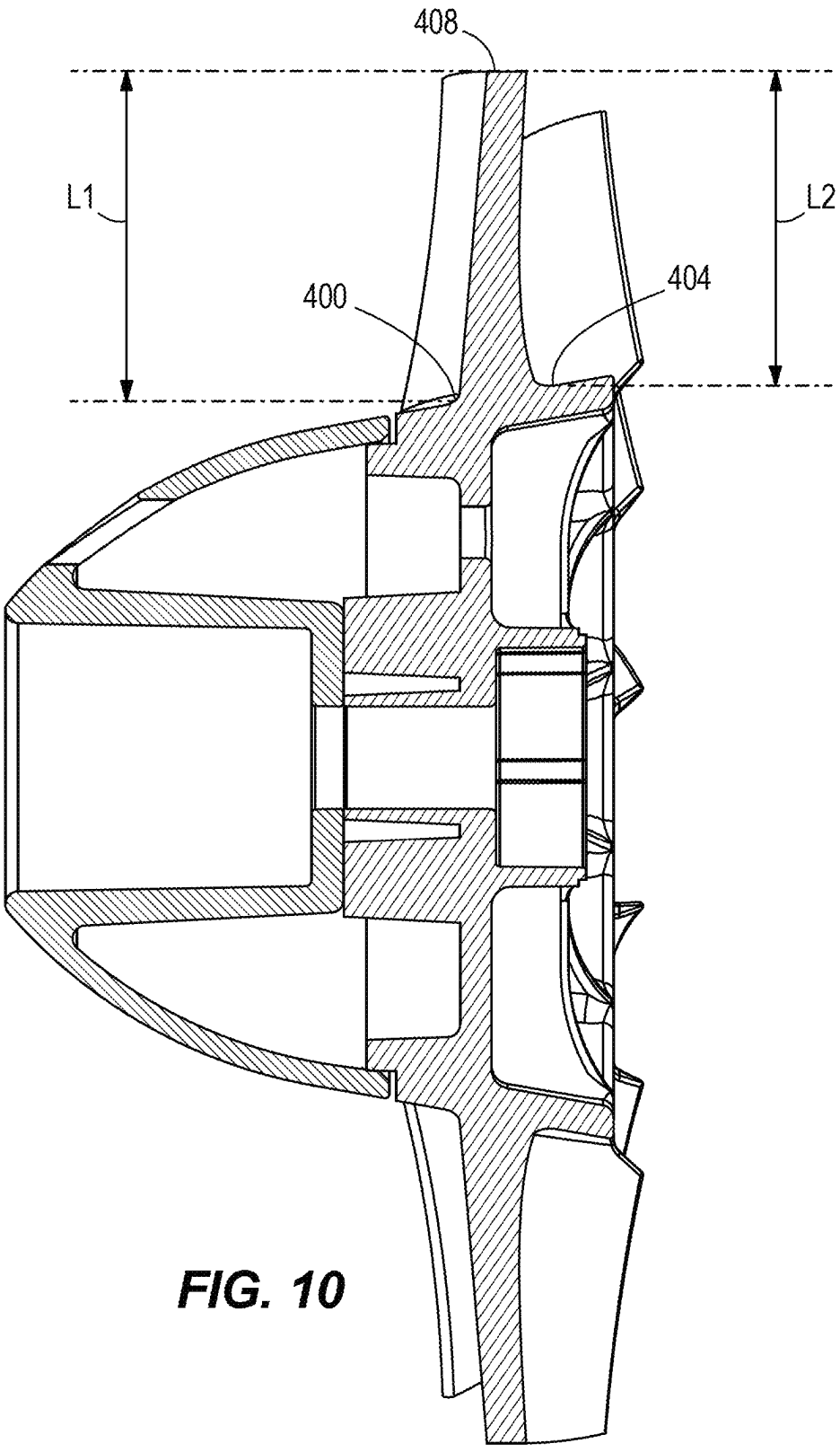


FIG. 10

FAN FOR HANDHELD BLOWER

RELATED APPLICATIONS

This application is a national phase filing under 35 U.S.C. § 371 of International Application No. PCT/US2022/046176, filed Oct. 10, 2022, which claims the benefit of U.S. Provisional Patent Application No. 63/254,296, filed Oct. 11, 2021, the entire contents of each of which are hereby incorporated by reference.

BACKGROUND

The present disclosure relates to handheld blowers, and more particularly to fans used in handheld blowers.

SUMMARY

In one independent aspect, the disclosure provides a fan including a hub and a plurality of blades extending radially outwardly from the hub and spaced circumferentially about the hub. The plurality of blades includes a reference blade, a first blade, and a second blade. The reference blade is disposed after the first blade in a circumferential direction about the hub. The second blade is disposed after the reference blade in the circumferential direction. The first blade is circumferentially spaced a first distance from the reference blade. The second blade is circumferentially spaced a second distance from the reference blade. The first distance is greater than the second distance.

In another independent aspect, the disclosure provides a fan including a hub having an air guide cone and a blade connection portion, and a plurality of blades extending radially outwardly from the blade connection portion and spaced circumferentially about the hub. The blade connection portion tapers radially inwardly and tangentially meets the air guide cone.

In another independent aspect, the disclosure provides a handheld blower including an air duct extending along an axis, the air duct including an air inlet and an air outlet opposite the air inlet, and a fan disposed in the air duct between the air inlet and the air outlet. The fan rotates about the axis. The fan includes a fan hub extending from an upstream end to a downstream end, the fan hub defining an outer surface with a radius that continuously increases from the upstream end to the downstream end, and a plurality of fan blades extending radially outward from the outer surface between the upstream end and the downstream end. The plurality of fan blades is separated into pairs of blades. The pairs of blades are evenly spaced circumferentially about the fan hub to each other.

Other features and aspects of the disclosure will become apparent by consideration of the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a perspective view of a handheld blower, according to embodiments disclosed herein.

FIG. **2** is a cross-sectional elevation view of a portion of the handheld blower of FIG. **1**.

FIG. **3** is a perspective view of a fan, according to embodiments disclosed herein.

FIG. **4** is a front elevation view of a portion of the fan of FIG. **3**.

FIG. **5** is a cross-sectional front elevation view of the fan of FIG. **3**.

FIG. **6** is a perspective view of a fan, according to embodiments disclosed herein.

FIG. **7** is a perspective exploded view of the fan of FIG. **6**.

FIG. **8** is a front elevation view of the fan of FIG. **6**.

FIG. **9** is a cross-sectional side elevation view of the fan of FIG. **8** taken along line **9-9**.

FIG. **10** is a cross-sectional side elevation view of the fan of FIG. **8** taken along line **10-10**.

Before any embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The disclosure is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION

FIGS. **1** and **2** generally illustrate a handheld blower **10** including a housing **14**. The housing **14** includes a handle **18** and a battery receiving area **22** for receiving one or more battery packs **26**. A blower tube **30** connects to the housing **14** and includes an outlet **34**. With reference to FIG. **2**, the housing **14** defines an air duct **38** extending along a duct axis **42** between a duct inlet **46** and a duct outlet **50**, opposite and downstream of the duct inlet **46**. The blower tube **30** is positioned adjacent the duct outlet **50** to create an air flow path **54** extending between the duct inlet **46** and the outlet **34**. A grate **58** is positioned adjacent the duct inlet **46**. A motor assembly **62** is positioned in the air duct **38** and includes a motor **66** and a fan **74**. The motor **66** and the fan **74** are positioned in the air duct **38** for rotation about a rotation axis **78**. In the illustrated embodiment, the rotation axis **78** is coaxial with the duct axis **42**. In the illustrated embodiment, the motor assembly **62** is assembled such that the fan **74** is upstream from the motor **66**. In other embodiments, however, the motor assembly **62** may be assembled in other configurations.

FIGS. **3-5** illustrate a fan **100** for use with, for example, the handheld blower **10** of FIGS. **1-2**. The fan **100** includes a fan hub **104** defining an outer surface **108**. A plurality of blades **112** extends radially outwardly from the outer surface **108** of the fan hub **104**. The fan hub **104** may include a body **116** and a hub cap or air guiding cone (not shown but discussed with regard to other embodiments below). In some embodiments, the hub cap is formed as a separate piece and is removed from the body **116**. However, in other embodiments, the hub cap may be formed integrally with the body **116**. The fan **100** may include a passage **120** extending through the fan hub **104** that defines a central rotational axis **124** or rotation axis **124** of the fan **100**. The fan **100** may be supported in a handheld blower or other air moving machine for rotation about the central rotational axis **124** in a rotation direction **128**.

Each blade **112** extends between a blade base **132** and a blade tip **136**, with the blade tip **136** located at a cantilevered end **140** of the blade **112**. The blade **112** defines a leading edge **144** and a trailing edge **148** extending between the blade base **132** and the blade tip **136**. In the illustrated embodiment, the leading edge **144** may be generally straight while the trailing edge **148** may be curved. However, in other embodiments, other shapes of the fan blade may be used. In the illustrated embodiment, each of the plurality of

blades **112** is identical to the others such that a pitch, shape, width, and length of the blades are the same.

With specific reference to FIGS. **4** and **5**, the plurality of blades **112** may be unevenly spaced about the fan hub **104**. For purposes of discussion, one of the plurality of blades **112** has been identified as a reference blade **152**. While a specific blade has been identified, and the relationships between the blades are discussed with this respect to the reference blade **152**, the relationships apply equally no matter which blade **112** is selected as the reference blade **152**, except where otherwise noted.

As shown in FIG. **4**, the reference blade **152** has a reference tip **156** and a reference leading edge **160**. The reference tip **156** and reference leading edge **160** meet at a reference corner **164**. A first neighbor blade **168** (or first blade **168**) is located next in order from the reference blade **152** in a direction opposite a circumferential direction **170** (or first direction). In other words, the reference blade **152** is disposed after the first blade **168** in the circumferential direction **170**. In the illustrated embodiment, the circumferential direction **170** is the same as the rotation direction **128** of the fan **100**, however, in other embodiments, the circumferential direction **170** may be opposite the rotation direction **128**. A second neighbor blade **172** (or second blade **172**) is located next in order from the reference blade **152** in the circumferential direction **170** (or second direction). The first neighbor blade **168** includes a first tip **180** and a first leading edge **184** which intersect in a first corner **188**. The second neighbor blade **172** includes a second tip **192** and a second leading edge **196** which intersect in a second corner **200**.

The reference blade **152** is circumferentially spaced a first distance from the first blade **168**, and the reference blade **152** is circumferentially spaced a second distance from the second blade **172**. Specifically, the first distance may be measured as a first angle $\alpha 1$ measured about the rotation axis **124** between the first corner **188** and the reference corner **164**. The second distance may similarly be measured as a second angle $\alpha 2$ measured about the rotation axis **124** between the reference corner **164** and the second corner **200**. The first angle $\alpha 1$ and the second angle $\alpha 2$ are different. In the case of the exemplary reference blade **152**, the first angle $\alpha 1$ is larger than the second angle $\alpha 2$. This relationship may be inverted if another blade is selected as the reference blade. While the first distance and second distance may be described using angles, it is also possible to use the linear distances or arcuate distances between the blades. The relationships between the spacings would remain the same such that a first length would be larger than a second length.

In the illustrated embodiment, the plurality of blades **112** includes twelve blades **112** separated into pairs of blades **204** evenly spaced around the fan hub **104**. Therefore, each blade **112** has a corresponding diametrically opposed blade **112**. Additionally, a third neighbor blade **208** (or third blade **208**) is located next in order from the first neighbor blade **168** in the first direction. Or in other words, the third blade **208** is positioned before the first blade **168** in the circumferential direction **170**. A fourth neighbor blade **212** is located next in order from the second neighbor blade **172** in the second direction. In other words, the fourth blade **212** is positioned after the second blade **172** in the circumferential direction **170**. The third neighbor blade **208** includes a third leading edge **216** and a third tip **220** intersecting in a third corner **224**, and the fourth neighbor blade **212** includes a fourth leading edge **228** and a fourth tip **232** intersecting in a fourth corner **236**. The third blade **208** is circumferentially spaced by a third distance from the reference blade **152**. The third distance may be measured as a third angle $\alpha 3$ measured about the rotation axis **124** between the third corner **224** and the reference corner **164**. The fourth blade **212** is circumferentially spaced by a fourth distance from the reference blade **152**. The fourth distance may be represented as a fourth angle $\alpha 4$ measured about the rotation axis **124** between the fourth corner **236** and the reference corner **164**. The third angle $\alpha 3$ is the equal to the fourth angle $\alpha 4$. Again, linear distances may be used instead of angles with the same result, such that a third length would be equal to a fourth length.

The fan **100** is rotationally symmetrical about the rotation axis **124**. In other words, the spacing between each of the plurality of blades **112** alternates between the first distance (e.g. the first angle $\alpha 1$) and the second distance (e.g. the second angle $\alpha 2$) in the circumferential direction **170**. The rotational symmetry means that the plurality of blades **112** are rotationally balanced about the fan hub **104**.

With reference to FIG. **5**, while the distances were described as angles measured between respective corners, the relationships between the blades remain the same if like points on each blade are used. For example, FIG. **5** illustrates alternate angles (ß**1**-ß**4**) measured between center points on each blade. The first angle ß**1** is still different from, and larger than, the second angle ß**2**. The third angle ß**3** is still equal to the fourth angle ß**4**.

In operation, the uneven spacing allows air to flow through the fan **100** at a high speed while reducing frequencies that are typically perceived by users as being unpleasant compared to fans with evenly spaced blades. For example, embodiments of the fan **100** may primarily generate an output frequency of approximately 1500 Hertz. For comparison, a fan with evenly spaced blades may primarily generate an output frequency of approximately 3200 Hertz.

FIGS. **6-10** illustrate another embodiment of a fan **300** for use with, for example, the handheld blower **10** of FIGS. **1** and **2**. The fan **300** includes a fan hub **304** and a plurality of blades **308** extending radially outwardly from the fan hub **304**. The plurality of blades **308** are shown as evenly spaced around the hub **304**, however, the plurality of blades **308** may be unevenly spaced as described with respect to FIGS. **3-5** in some embodiments. The fan hub **304** includes a body **312** and an air guiding cone **316**. As shown in FIG. **7**, the air guiding cone **316** may be removably coupled to the body **312**. However, in some embodiments, the air guiding cone **316** may be integrally formed with the body **312**. The fan **300** includes a passageway **320** extending through the body **312**. The passageway **320** defines a central rotational axis **324** (or rotation axis **324**). The passageway **320** may receive a shaft or other support to rotatably support the fan **300** in the handheld blower **10**. In the illustrated embodiment of FIG. **6**, the forward direction may be generally upstream while a rearward direction may be generally downstream. While the terms forward, front, upstream, rearward, rear, and downstream may be used to describe the fan, these directions do not necessarily correspond to the directions of the motor assembly, the handheld blower, or the environment. The directional language is used for description purposes only and is not meant to limit the embodiment to a certain orientation.

With reference to FIGS. **6-8**, as described above, the fan hub **304** includes the body **312** and the air guiding cone **316**. The plurality of blades **308** may extend from and be unitarily formed with the body **312**. In other embodiments, the plurality of blades **308** may be otherwise secured to the body **312**. The body **312** may also be referred to herein as the blade connection portion **312**. The body **312** may be tapered radially inward. The body **312** may include a circumferential

surface **328**. The circumferential surface **328** may be the radial outermost surface of the body **312**. The plurality of blades **308** may extend from the circumferential surface **328**. The body **312** may extend between a rear end **332** and a body connection end **336** configured to couple to the air guiding cone **316**.

The air guiding cone **316** may extend between a truncated tip **340** and a cone connection end **344**. The cone connection end **344** may couple to the body connection end **336** of the body **312**. The air guiding cone **316** may further include a cone surface **348**. The cone surface **348** may be the radially outermost surface of the air guiding cone **316**. The cone surface **348** may be curved with respect to the central rotational axis **324**.

Turning now to FIGS. **9** and **10**, the circumferential surface **328** and the cone surface **348** may combine to form an outer hub surface **352**. The shape of the air guiding cone **316** and body **312** may be such that the circumferential surface **328** and the cone surface **348** meet tangentially at a connection point **356**. The outer hub surface **352** may taper radially inwardly continuously between the rear end **332** and the truncated tip **340**.

Specifically, as shown in FIG. **9**, in a vertical cross section taken through the fan **300** parallel to the rotation axis **324**, the outer hub surface **352** may form a curved profile **360**. The curved profile **360** may include a first point **364** located at the truncated tip **340**, a second point **368** located at the rear end **332**, and an intermediate point **372** located between the first point **364** and second point **368**. In some embodiments, the intermediate point **372** is co-located with the connection point **356** between the cone surface **348** and the circumferential surface **328**. However, the intermediate point **372** may be any point on the curved profile **360** between the first point **364** and the second point **368**. The first point **364** may be radially located at a first distance R**1** with respect to the rotation axis **324**. The second point **368** may be located at a second distance R**2** with respect to the rotation axis **324**, and the intermediate point **372** may be radially located at an intermediate distance R**1** from the rotation axis **324**.

As shown in FIG. **9**, a tangent is taken at each of the points **364**, **368**, **372**. A tangent line taken at the first point **364** forms a first angle **388** with respect to the rotation axis **324**. A tangent line taken at the second point **368** forms a second angle **392** with respect to the rotation axis **324**. Finally, a tangent line taken at the intermediate point **372** forms an intermediate angle **396** with respect to the rotation axis **324**. The hub **304** tapers inwardly such that a slope of the outer hub surface **352** is more aggressive at the truncated tip **340** than at the rear end **332**. In other words, the first angle **388** is larger than the second angle **392**. Additionally, the hub **304** is shaped such that the outer hub surface **352** is never parallel to the rotation axis **324**. Finally, the hub **304** is shaped such that the angle of the tangent to the curved profile **360** decreases constantly between the truncated tip **340** and the rear end **332**. Thus, the first angle **388** is larger than the intermediate angle **396**, which is larger than the second angle **392**.

In operation, the shape of the air guiding cone **316** is such that the fan hub **304** has an increased draft angle as compared a standard fan hub. As shown in FIG. **10**, each blade **308** is connected to the fan hub **304** at an upstream connection point **400** and a downstream connection point **404**. A first length L**1** is measured between the upstream connection point **400** and a tip **408** of the blade **308**. A second length L**2** is measured between the downstream connection point **404** and a tip **408** of the blade **308**. Because of the taper of the blade connection portion **312**, the first length L**1** is larger than the second length L**2**, meaning that the available blade surface of the plurality of fan blades **308** is maximized, or at least greater than is the case for standard fans, for contacting the operational medium (e.g., air). Thus, the fan **300** has an increased fan efficiency compared to a standard fan.

Although the disclosure has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the disclosure as described.

What is claimed is:

1. A fan comprising:

a hub;

a plurality of blades, each blade of the plurality of blades including a blade base coupled to the hub, each blade extending radially outwardly from the hub to a cantilevered end, the plurality of blades spaced circumferentially about the hub at a common axial location of the hub, the plurality of blades including a reference blade, a first blade, and a second blade; and

wherein

the reference blade is disposed after the first blade in a circumferential direction about the hub and the second blade is disposed after the reference blade in the circumferential direction,

the first blade is circumferentially spaced a first distance from the reference blade,

the second blade is circumferentially spaced a second distance from the reference blade, and

the first distance is greater than the second distance; and

wherein the fan is rotationally symmetrical.

2. The fan of claim **1**, wherein the plurality of blades includes twelve blades.

3. The fan of claim **1**, wherein

the hub includes an outer surface, and

the plurality of blades extends from the outer surface.

4. The fan of claim **1**, wherein the blades are grouped in pairs circumferentially about the hub.

5. The fan of claim **1**, wherein the blades are identical.

6. The fan of claim **1**, wherein the hub includes a passage for receiving a shaft, the passage defining a central rotational axis of the fan.

7. The fan of claim **1**, wherein each blade of the plurality of blades has a corresponding diametrically opposed blade.

8. The fan of claim **1**, wherein any blade of the plurality of blades can be the reference blade.

9. The fan of claim **8**, wherein the circumferential spacing between respective blades alternates between the first distance and the second distance in the circumferential direction.

10. A fan comprising:

a hub including an air guide cone and a blade connection portion, the blade connection portion tapering radially inwardly and tangentially meeting the air guide cone; and

a plurality of blades, each blade of the plurality of blades including a blade base coupled to the hub at a common axial location of the hub, each blade extending radially outwardly from the blade connection portion to a cantilevered end,

wherein at least a portion of the plurality of blades are unevenly spaced about the hub,

wherein the plurality of fan blades separated into pairs of blades, the pairs of blades evenly spaced circumferentially about the hub with each other,

wherein the fan is rotationally symmetrical.

11. The fan of claim **10**, wherein the blade connection portion tapers radially inwardly along an entire axial length of the blade connection portion.

12. The fan of claim **10**, wherein the air guide cone is removably coupled to the blade connection portion.

13. The fan of claim **10**, wherein each blade is formed as a single unitary part with the blade connection portion.

14. The fan of claim **10**, wherein

the air guide cone and the blade connection portion form an outer surface of the hub, and

the outer surface of the hub tapers inwardly along an entire axial length of the hub.

15. The fan of claim **10**, wherein each blade of the plurality of blades is longer radially through an upstream connection point than through a downstream connection point.

16. The fan of claim **10**, wherein the air guide cone has a truncated tip.

17. The fan of claim **10**, wherein the blade connection portion includes a passage defined therein for receiving a shaft, the passage defining a central rotational axis of the fan.

18. The fan of claim **17**, wherein the blade connection portion tapers radially inwardly along the central rotational axis in an upstream direction.

19. A handheld blower comprising:

an air duct extending along an axis, the air duct including an air inlet and an air outlet opposite the air inlet; and

a fan disposed in the air duct between the air inlet and the air outlet, the fan configured to rotate about the axis, the fan including

a fan hub extending from an upstream end to a downstream end, the fan hub defining an outer surface with a radius that continuously increases from the upstream end to the downstream end, the fan hub including an air guide cone and a blade connection portion, and

a plurality of fan blades extending radially outwardly from the outer surface of the blade connection portion between the upstream end and the downstream end, each blade of the plurality of blades including a blade base coupled to the blade connection portion of the hub, each blade of the plurality of blades extending to a cantilevered end, the plurality of fan blades separated into pairs of blades, the pairs of blades evenly spaced circumferentially about the fan hub with each other,

wherein at least a portion of the plurality of blades are unevenly spaced about the hub,

further wherein the fan is rotationally symmetrical.

* * * * *