US00D828294S

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

(10) **Patent No.: US D828,294 S**
(45) **Date of Patent: ** Sep. 11, 2018**

(54) **BATTERY CHARGER**

(71) Applicant: **Delta-Q Technologies Corp.**, Burnaby (CA)

(72) Inventors: **Ngai Eric Lau**, Burnaby (CA); **Jeff Douglas Everett**, Vancouver (CA); **Jonathan Eric Stroud**, Surrey (CA); **James Lennox Fox**, Vancouver (CA); **Alexander John Stone**, Burnaby (CA)

(73) Assignee: **DELTA-Q TECHNOLOGIES CORP.**, Burnaby (CA)

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

(21) Appl. No.: **29/608,436**

(22) Filed: **Jun. 21, 2017**

Related U.S. Application Data

(62) Division of application No. 29/530,060, filed on Jun. 12, 2015, now Pat. No. Des. 796,431.

(51) **LOC (11) Cl.** **13-02**

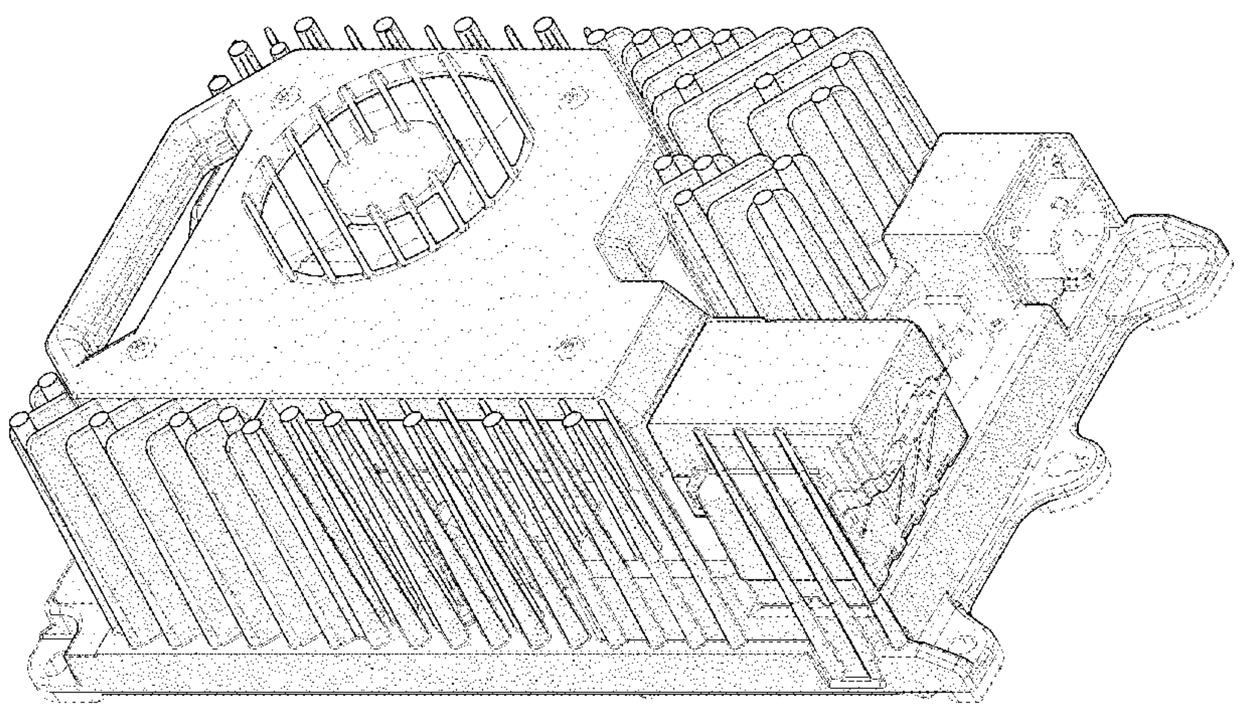
(52) **U.S. Cl.**
USPC **D13/107**

(58) **Field of Classification Search**
USPC D13/107–110, 118–119, 184; D14/251, D14/253, 432, 434
CPC Y02E 60/12; Y02T 90/14; Y02T 90/122; Y02T 90/128; Y02T 90/163; H02J 7/025; H02J 7/0042; H02J 7/0044; H02J 7/0045; H02J 7/0003; H02J 2001/008; H02J 3/32; H02J 3/008; H02J 7/0027; H02J 7/0013; H02J 7/0054; H02J 7/00; H01F 38/14; H01R 13/6675; H01M 2/1022; H01M 2/1055; H01M 10/44; H01M 10/46; H01M 10/425; B60L 11/182; B60L 11/1809; B60L 11/1861; B60R 16/03
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

D203,543	S		1/1966	Coe
3,938,024	A		2/1976	Clarke
4,412,277	A		10/1983	Mitchell
4,559,590	A		12/1985	Davidson
D287,718	S		1/1987	Moeller
D292,914	S		11/1987	Moeller
D305,115	S		12/1989	Kondo et al.
4,885,675	A		12/1989	Henze et al.
5,001,620	A		3/1991	Smith
5,034,871	A		7/1991	Okamoto et al.
5,065,278	A		11/1991	Schultz
5,077,486	A		12/1991	Marson et al.
D328,057	S		7/1992	Prager et al.
D336,074	S		6/1993	Friend et al.
D338,653	S		8/1993	Morgan et al.
D348,869	S	*	7/1994	Egger D13/123
D351,134	S		10/1994	Hunziker
5,355,300	A		10/1994	Zinn
D358,753	S	*	5/1995	Yoshida D13/123
D360,186	S		7/1995	Netz et al.
5,490,057	A		2/1996	Vinciarelli et al.
5,602,462	A		2/1997	Stich et al.
D378,915	S		4/1997	Widmayer et al.
D379,088	S		5/1997	Hopper
D379,799	S		6/1997	Widmayer et al.
D381,011	S		7/1997	Widmayer et al.
D388,399	S		12/1997	Widmayer et al.
D398,589	S		9/1998	Dodson
D401,216	S		11/1998	Person et al.
D409,138	S		5/1999	Gammenthaler
D409,139	S		5/1999	Cornell et al.
D410,652	S		6/1999	Jones et al.
D416,873	S		11/1999	Korsunsky et al.
D427,146	S		6/2000	Wei
D427,147	S		6/2000	Wei
6,076,594	A		6/2000	Kuo
D449,587	S		10/2001	Cronin
D449,817	S		10/2001	Takeuchi et al.
6,320,772	B1		11/2001	Doyama et al.
D458,228	S		6/2002	Jacobson
6,462,966	B1		10/2002	Leung et al.
6,650,559	B1		11/2003	Okamoto et al.
D489,682	S		5/2004	Guillarme
6,736,195	B2		5/2004	Busch et al.
6,809,678	B2		10/2004	Vera et al.
6,841,979	B2		1/2005	Berson et al.
6,847,195	B2		1/2005	Chen
6,862,201	B2		3/2005	Hodge, Jr.
D505,915	S		6/2005	Hussaini et al.



D507,528	S		7/2005	Feldman et al.
D510,320	S		10/2005	Tuomola et al.
7,116,090	B1		10/2006	Yang et al.
7,198,094	B2		4/2007	Barsun et al.
D541,743	S		5/2007	Virolainen et al.
D541,744	S		5/2007	Virolainen et al.
D541,745	S		5/2007	Virolainen et al.
D546,282	S		7/2007	Wardenburg
D551,621	S		9/2007	Iacovelli et al.
D559,778	S		1/2008	Tsuzuki et al.
D562,765	S		2/2008	Tsuzuki et al.
7,365,987	B2		4/2008	Jeong
D568,841	S		5/2008	Fischer et al.
D571,314	S		6/2008	Horng
7,535,716	B2		5/2009	Fischer et al.
D593,512	S		6/2009	Lin
7,616,455	B2		11/2009	Cameron et al.
D606,017	S		12/2009	Charlson et al.
D621,812	S		8/2010	Wayman
D638,376	S		5/2011	Herrmann et al.
D651,200	S		12/2011	Sugime et al.
D652,156	S		1/2012	Li et al.
D661,008	S		5/2012	Yuan
D662,880	S		7/2012	Scott et al.
D664,544	S		7/2012	Yi et al.
D667,789	S	*	9/2012	O'Neil D13/110
D672,730	S		12/2012	Lin
D675,622	S		2/2013	Petrick et al.
D677,621	S		3/2013	Beroukas et al.
D678,852	S		3/2013	Marshall
D682,207	S	*	5/2013	Nakahira D13/110
D684,130	S		6/2013	Vincent et al.
D691,558	S		10/2013	Helosvouri et al.
8,546,974	B2		10/2013	Foxall et al.
8,552,695	B2		10/2013	Stracquadaini
8,598,737	B2		12/2013	Foxall et al.
D698,481	S		1/2014	Wasserman et al.
D702,376	S		4/2014	Su
D703,132	S		4/2014	Pearson et al.
D705,728	S	*	5/2014	Choi D13/110
8,803,489	B2		8/2014	Li et al.
D713,336	S		9/2014	Perin
8,861,238	B2		10/2014	Huang et al.
8,937,469	B2		1/2015	Clark et al.
D722,958	S	*	2/2015	Kotaniemi D13/108
D726,141	S		4/2015	Wilson
D730,333	S		5/2015	Matsumoto
9,028,096	B2		5/2015	Verdes et al.
D734,250	S	*	7/2015	Rennick D13/107
D739,347	S	*	9/2015	Huang D13/110
D751,241	S		3/2016	Aldape
D751,751	S		3/2016	Lockart et al.
D755,740	S		5/2016	Chen et al.
D761,472	S		7/2016	Zhu
D761,729	S	*	7/2016	Leong D13/108
D767,815	S		9/2016	Lee
D768,585	S	*	10/2016	Moore D13/184
D770,975	S	*	11/2016	Nada D13/110
9,490,694	B2		11/2016	Alam
D793,350	S		8/2017	Kenchappa
D796,431	S	*	9/2017	Lau D13/107
D805,473	S		12/2017	Montgomery et al.
D805,486	S		12/2017	Hochman et al.
D806,647	S		1/2018	Lau et al.
2002/0149951	A1		10/2002	Leung et al.
2005/0105311	A1		9/2005	Soldano
2007/0131387	A1		6/2007	Kawabata et al.
2007/0133233	A1		6/2007	Cameron et al.
2008/0002444	A1		1/2008	Shekhawat et al.
2010/0110593	A1		5/2010	Kim et al.
2010/0165683	A1		7/2010	Sugawara
2010/0259240	A1		10/2010	Cuk
2011/0110127	A1		5/2011	Lee
2011/0211377	A1		9/2011	Uno
2011/0292703	A1		12/2011	Cuk
2012/0069615	A1		3/2012	Tomioka
2012/0249102	A1		10/2012	Cuk
2012/0256606	A1		10/2012	van den Broeke
2013/0051102	A1		2/2013	Huang et al.
2013/0235631	A1		9/2013	Pahlevaninezhad et al.
2014/0056045	A1		2/2014	Yan et al.
2014/0097808	A1		4/2014	Clark et al.
2014/0268952	A1		9/2014	Tong
2015/0171734	A1		6/2015	Yu et al.
2015/0263605	A1		9/2015	Alam
2016/0056730	A1		2/2016	Yan et al.
2016/0099660	A1		4/2016	Khaligh et al.

FOREIGN PATENT DOCUMENTS

CA	2 806 870 A1	4/2014
WO	2010/025596 A1	3/2010

OTHER PUBLICATIONS

Chen et al., "Digital Control for Improved Efficiency and Reduced Harmonic Distortion Over Wide Load Range in Boost PFC Rectifiers," *IEEE Transactions on Power Electronics* 25(10):2683-2692, Oct. 2010.

Clark, "Digital Control Techniques for Power Quality Improvements in Power Factor Correction Applications," Master's Thesis, University of British Columbia, Jul. 2012, 114 pages.

De Gussemé et al., "Digitally Controlled Boost Power-Factor-Correction Converts Operating in Both Continuous and Discontinuous Conduction Mode," *IEEE Transactions on Industrial Electronics* 52(1):88-97, Feb. 2005.

De Gussemé et al., "Input-Current Distortion of CCM Boost PFC Converts Operated in DCM," *IEEE Transactions on Industrial Electronics* 54(2):858-865, Apr. 2007.

De Gussemé et al., "Sample Correction for Digitally Controlled Boost PFC Converters Operating in both CCM and DCM," Eighteenth Annual IEEE Applied Power Electronics Conference and Exposition 1:389-395, Feb. 9-13, 2003.

de Souza et al., "A New ZVS-PWM Unity Power Factor Rectifier with Reduced Conduction Losses," *IEEE Transactions on Power Electronics* 10(6):746-752, Nov. 1995.

de Souza et al., "High Power Factor Rectifier with Reduced Conduction and Commutation Losses," 21st International Telecommunication Energy Conference, Copenhagen, Jun. 6-9, 1999, 5 pages.

Delta-Q Technologies Corp., "Delta-Q Technologies Introduces New Lithium-Specific Battery Charger at ProMAT 2017," published Mar. 27, 2017, retrieved from http://www.prnewswire.com/news-releases/delta-q-technologoes-introduces-new-lithium-specific-battery-charger-at-promat-2017-617167523.htm on Jun. 1, 2017, 3 pages.

Dixon, "Average Current Mode Control of Switching Power Supplies," Unitrode Application Note U-140, pp. 3-356-3-369, 1990. (14 pages).

Dixon, "Average Current Mode Control of Switching Power Supplies—Topic 5," Unitrode Corporation, pp. 5-1-5-14, 2001. (16 pages).

Erickson et al., *Fundamentals of Power Electronics*, Second Edition, Kluwer Academic Publishers, Secaucus, NJ, 2001, 12 pages, Table of Contents.

Fairchild Semiconductor, "FAN7930: Critical Conduction Mode PFC Controller," Apr. 2010, 22 pages.

Huber et al., "Performance Evaluation of Bridgeless PFC Boost Rectifiers," *IEEE Transactions on Power Electronics* 23(3):1381-1390, May 2008.

Hwang et al., "Seamless Boost Converter Control in Critical Boundary Condition for Fuel Cell Power Conditioning System," IEEE Energy Conversion Congress and Exposition, Sep. 17-22, 2011, pp. 3641-3648.

Hwang et al., "Seamless Boost Converter Control Under the Critical Boundary Condition for a Fuel Cell Power Conditioning System," *IEEE Transactions on Power Electronics* 27(8):3616-3626, Aug. 2012.

Lau et al., "Battery Charger," U.S. Appl. No. 29/535,892, filed Aug. 11, 2015, 22 pages.

Lau et al., "Battery Charger," U.S. Appl. No. 29/565,135, filed May 18, 2016, 26 pages.

Lau et al., "Battery Charger," U.S. Appl. No. 29/586,567, filed Dec. 5, 2016, 18 pages.

Liou et al., "Design and Implementation of a Boost Power Factor Correction Stage Operated in Mixed-Condition Mode," International Conference of Electric Information and Control Engineering (ICEICE), Apr. 15-17, 2011, pp. 2069-2072.
Maksimović et al., "Impact of Digital Control in Power Electronics," *Proceedings of 2004 International Symposium on Power Semiconductor Devices & ICs*, Kitakyushu, pp. 13-22, 2004.
Martinez et al., "A High-Performance Single-Phase Rectifier with Input Power Factor Correction," *IEEE Transactions on Power Electronics* 11(2):311-317, Mar. 1996.
Marvi et al., "A Fully ZVS Critical Conduction Mode Boost PFC," *IEEE Transactions on Power Electronics* 27(4):1958-1965, Apr. 2012.
Moon et al., "Accurate Mode Boundary Detection in Digitally Controlled Boost Power Factor Correction Rectifiers," IEEE Energy Conversion Congress and Exposition (ECCE), Sep. 12-16, 2010, pp. 1212-1217.
Moon et al., "Autotuning of Digitally Controlled Boost Power Factor Correction Rectifiers," *IEEE Transactions on Power Electronics* 26(10):3006-3018, Oct. 2011.
Musavi et al., "A Phase-Shifted Gating Technique With Simplified Current Sensing for the Semi-Bridgeless AC-DC Converter," *IEEE Transactions on Vehicular Technology* 62(4):1568-1576, May 2013.
Roggia et al., "Digital Control System Applied to a PFC Boost Converter Operating in Mixed Conduction Mode," Brazilian Power Electronics Conference (COBEP), Sep. 2—Oct. 1, 2009, pp. 698-704.
Salmon, "Circuit topologies for pwm boost rectifiers operated from 1-phase and 3-phase ac supplies and using either single or split dc rail voltage outputs," 10th Annual Applied Power Electronics Conference and Exposition, Dallas, TX, Mar. 5-9, 1995, vol. 1, pp. 473-479.
Salmon, "Circuit Topologies for Single-Phase Voltage-Doubler Boost Rectifiers," *IEEE Transactions on Power Electronics* 8(4):521-529, Oct. 1993.
Sebastián et al., "The Determination of the Boundaries Between Continuous and Discontinuous Conduction Modes in PWM DC-to-DC Converters Used as Power Factor Preregulators," *IEEE Transactions on Power Electronics* 10(5):574-582, Sep. 1995.
Su et al., "An Interleaved Totem-Pole Boost Bridgeless Rectifier With Reduced Reverse-Recovery Problems for Power Factor Correction," *IEEE Transactions on Power Electronics* 25(6):1406-1415, Jun. 2010.
Tollik et al., "Comparative Analysis of 1-Phase Active Power Factor Correction Topologies," 14th International Telecommunications Energy Conference, Washington, DC, Oct. 4-8, 1992, pp. 517-523.
Tsai et al., "A Family of Zero-Voltage-Transition Bridgeless Power-Factor-Correction Circuits With a Zero-Current-Switching Auxiliary Switch," *IEEE Transactions on Industrial Electronics* 58(5):1848-1855, May 2011.
Van de Sype et al., "Duty-Ratio Feedforward for Digitally Controlled Boost PFC Converters," *IEEE Transactions on Industrial Electronics* 52(1):108-115, Feb. 2005.
Wang, "A New Single-Phase ZCS-PWM Boost Rectifier With High Power Factor and Low Conduction Losses," *IEEE Transactions on Industrial Electronics* 53(2):500-510, Apr. 2006.

* cited by examiner

Primary Examiner — Rosemary K Tarcza
Assistant Examiner — Nathaniel D. Buckner
(74) *Attorney, Agent, or Firm* — Seed IP Law Group LLP

(57) **CLAIM**

The ornamental design for a battery charger, as shown and described.

DESCRIPTION

FIG. **1** is a top front isometric view of a battery charger showing an embodiment of our new design.
FIG. **2** is a bottom front isometric view thereof.
FIG. **3** is a top rear isometric view thereof.
FIG. **4** is a bottom rear isometric view thereof.
FIG. **5** is a top plan view thereof.
FIG. **6** is a bottom plan view thereof.
FIG. **7** is a front elevational view thereof.
FIG. **8** is a rear elevational view thereof.
FIG. **9** is a left side elevational view thereof; and,
FIG. **10** is a right side elevational view thereof.
The broken lines in the figures represent portions of the article which form no part of the claim.

1 Claim, 8 Drawing Sheets

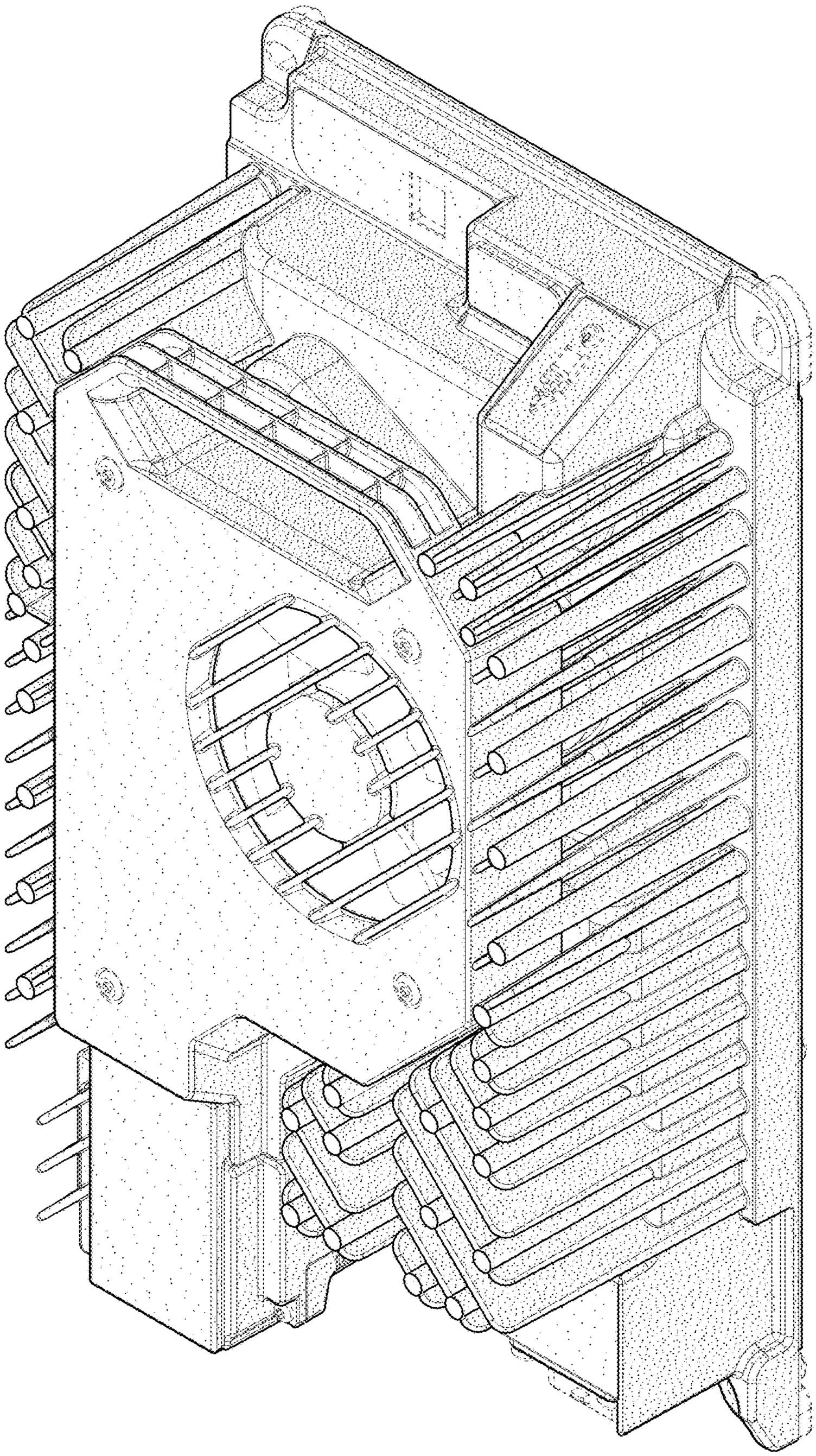


FIG.1

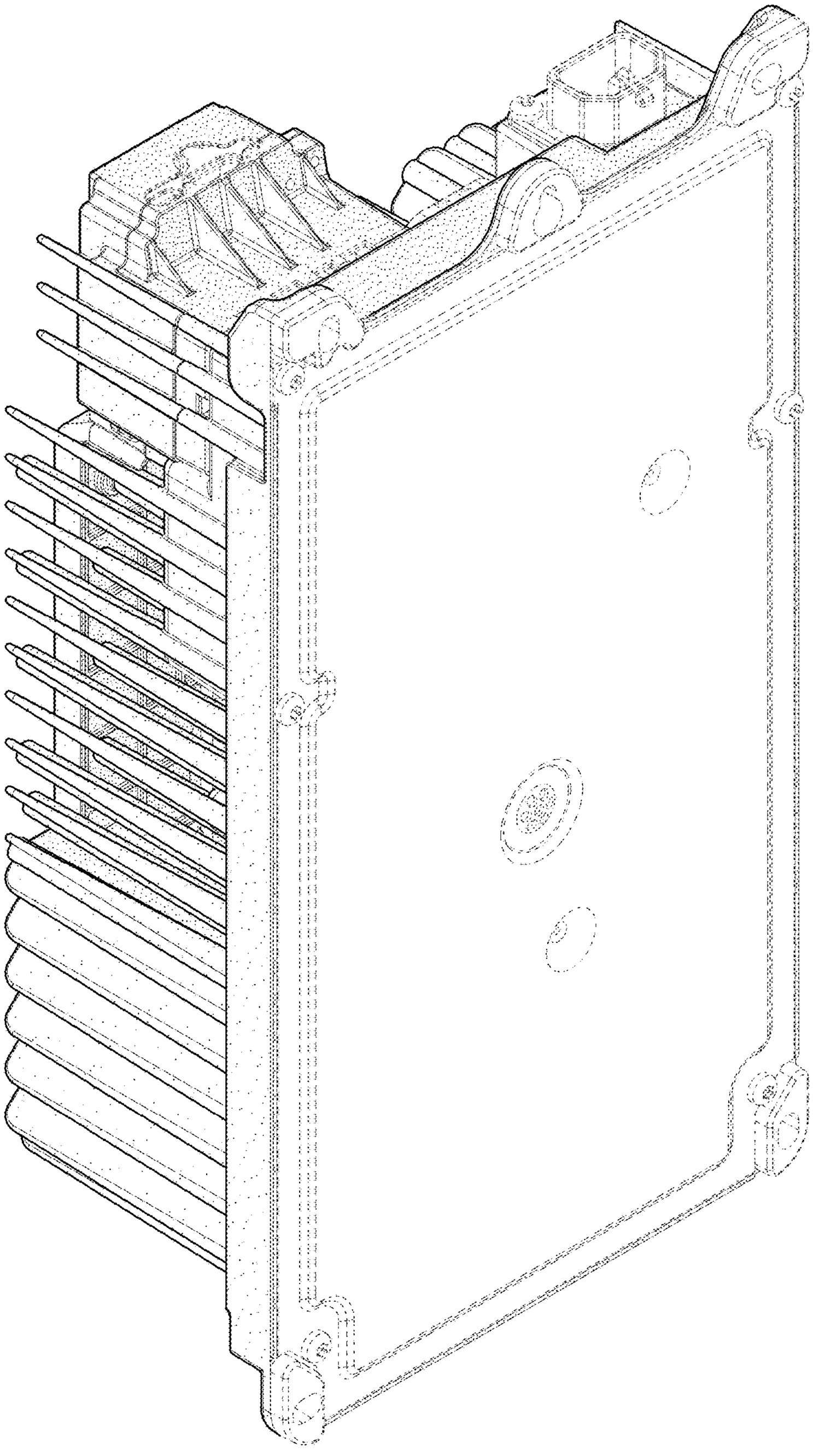


FIG. 2

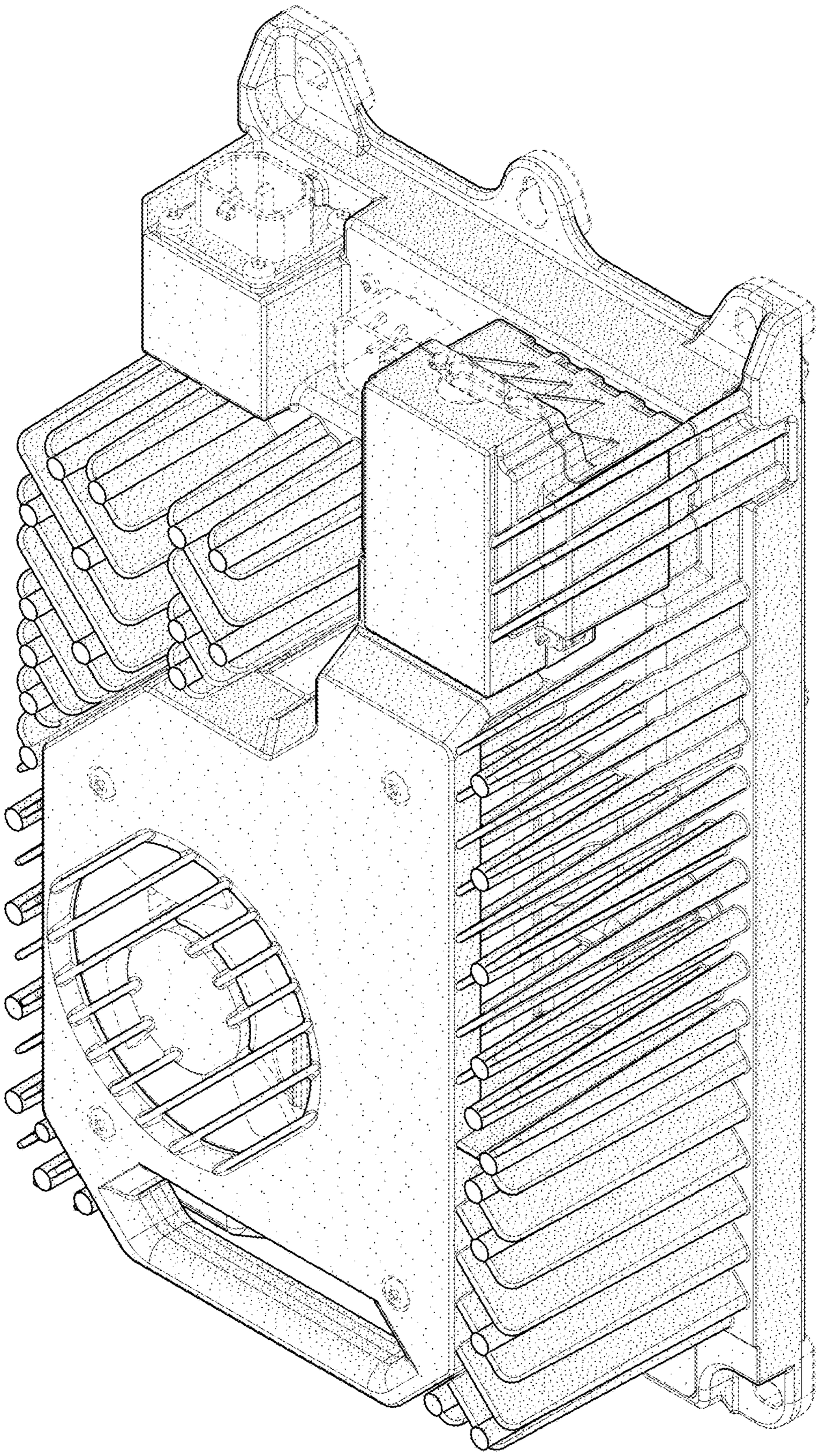


FIG.3

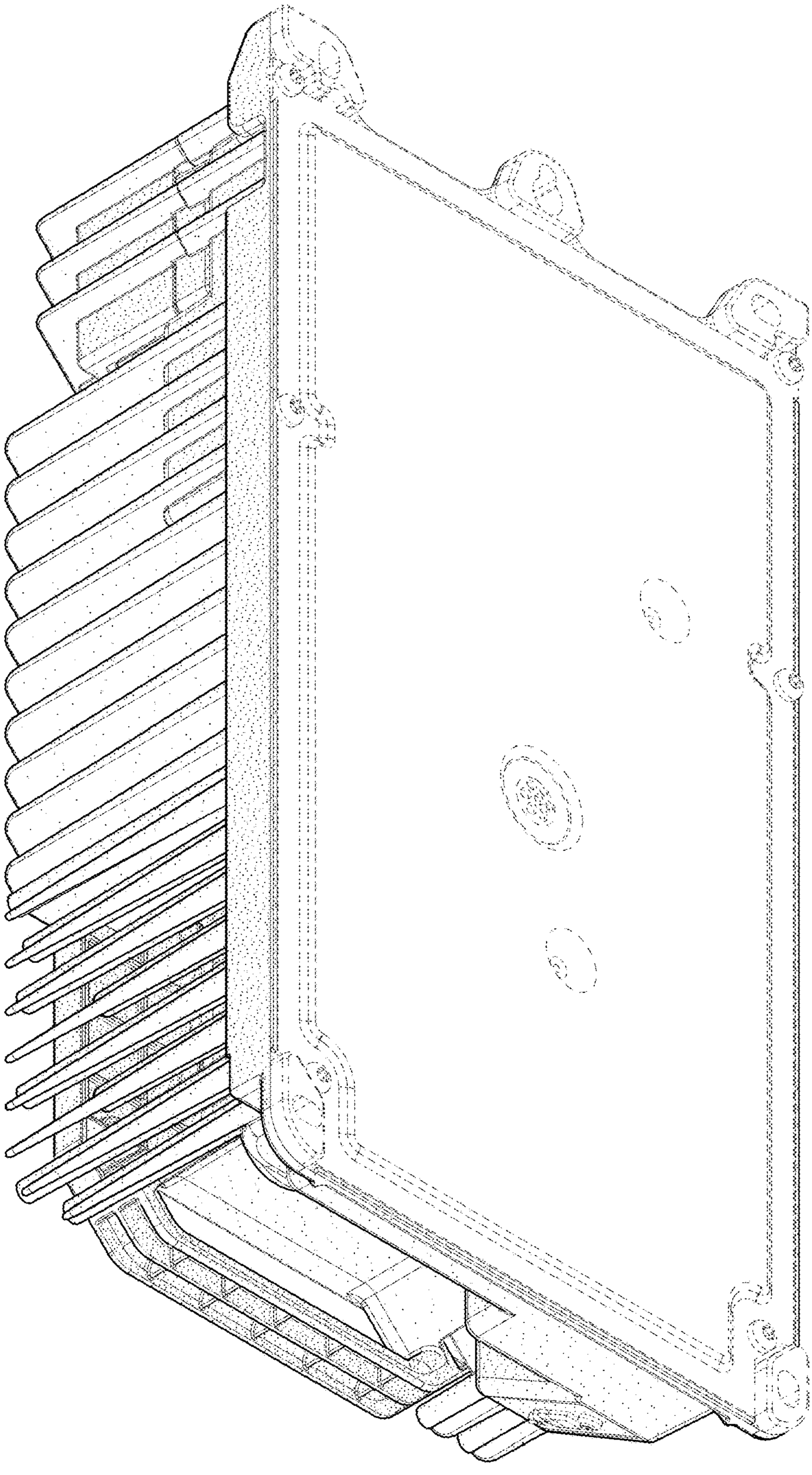


FIG. 4

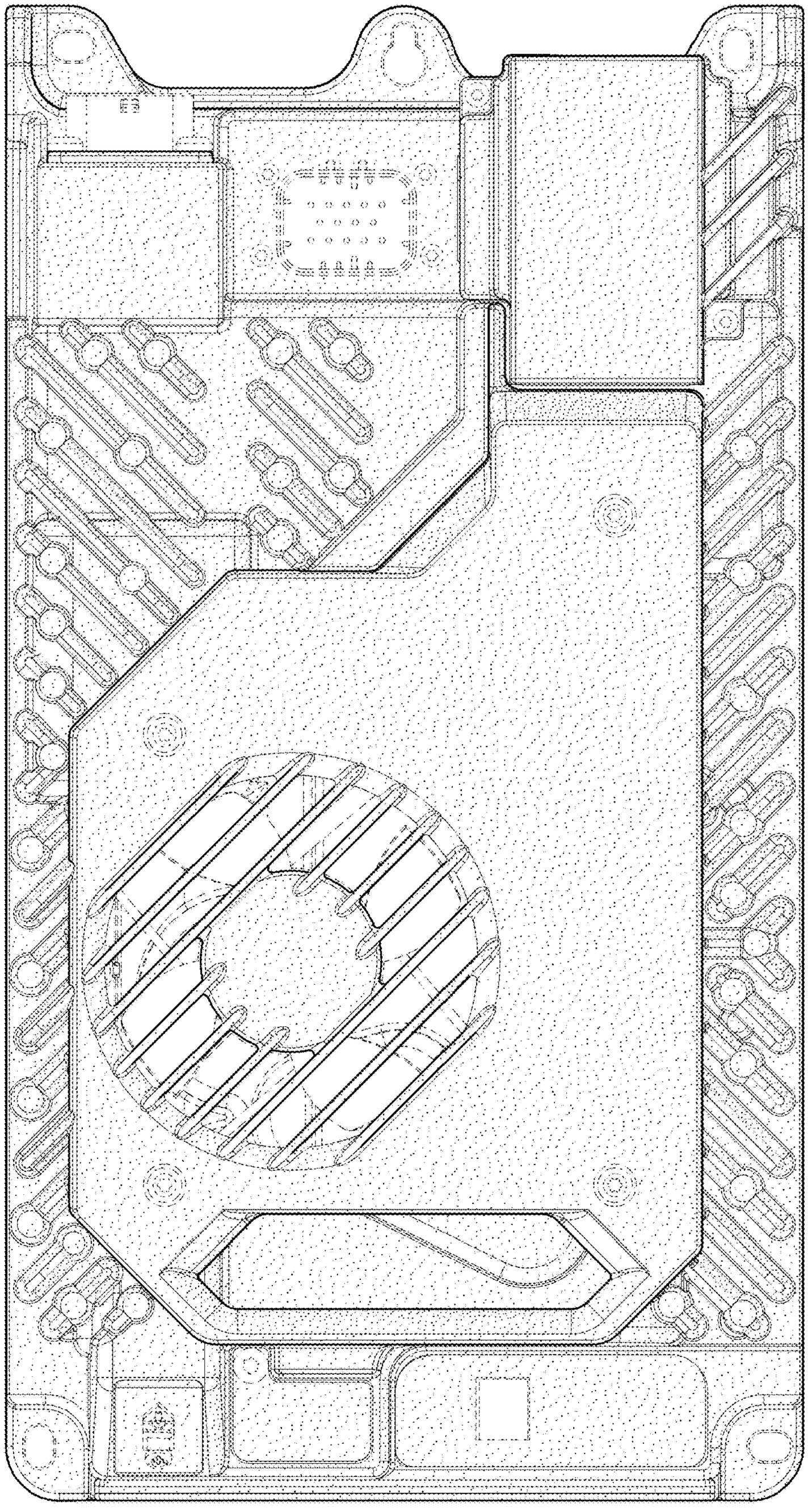


FIG.5

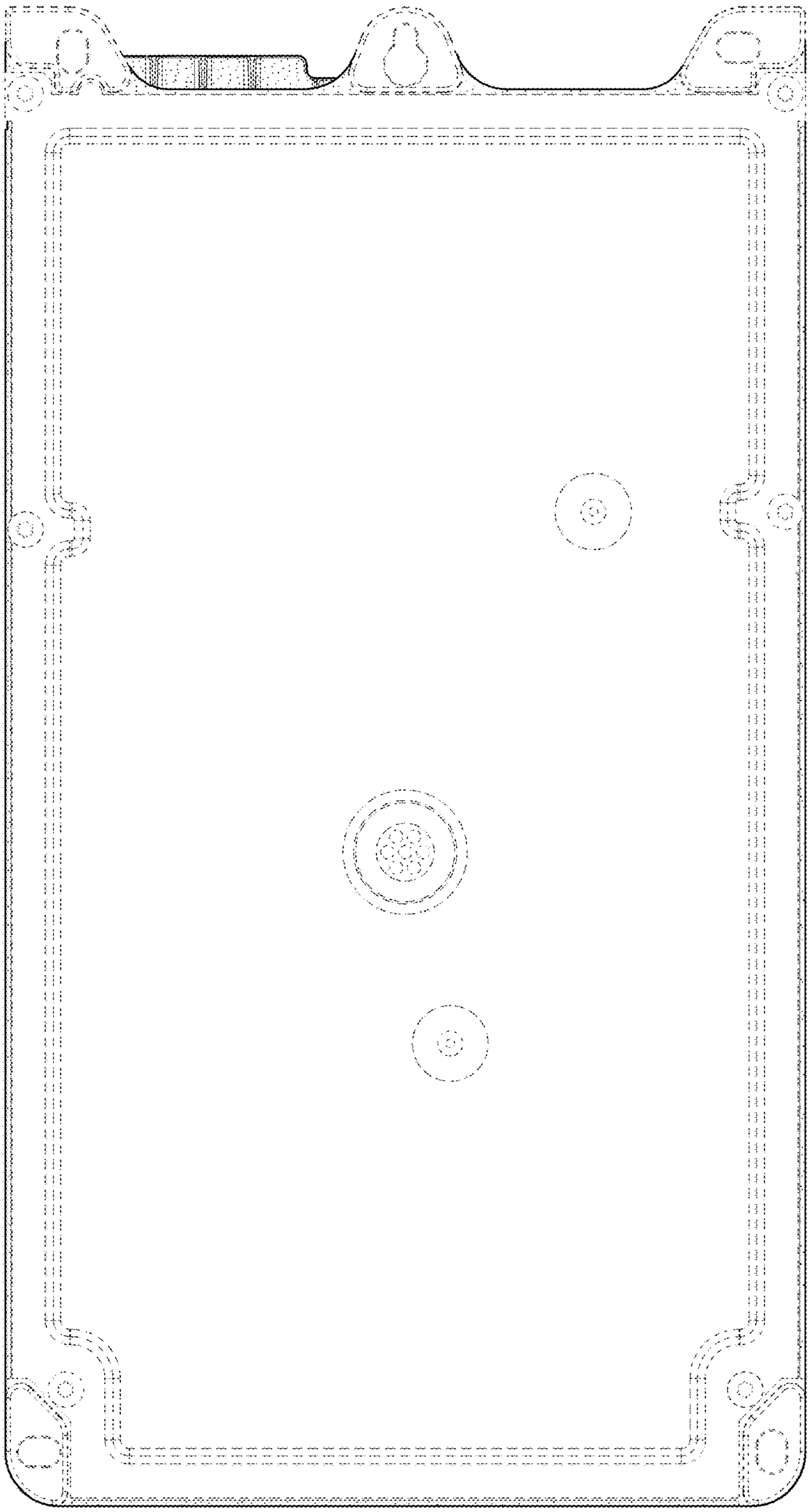


FIG. 6

FIG. 7

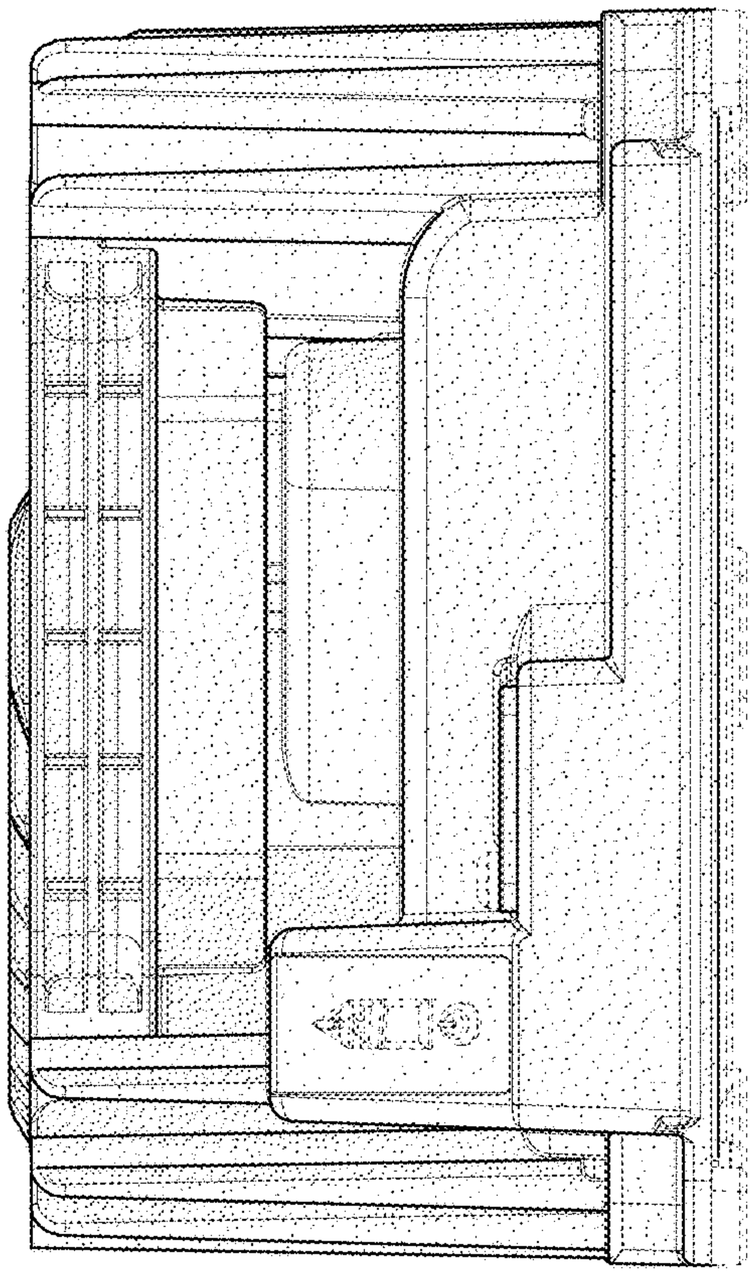


FIG. 8

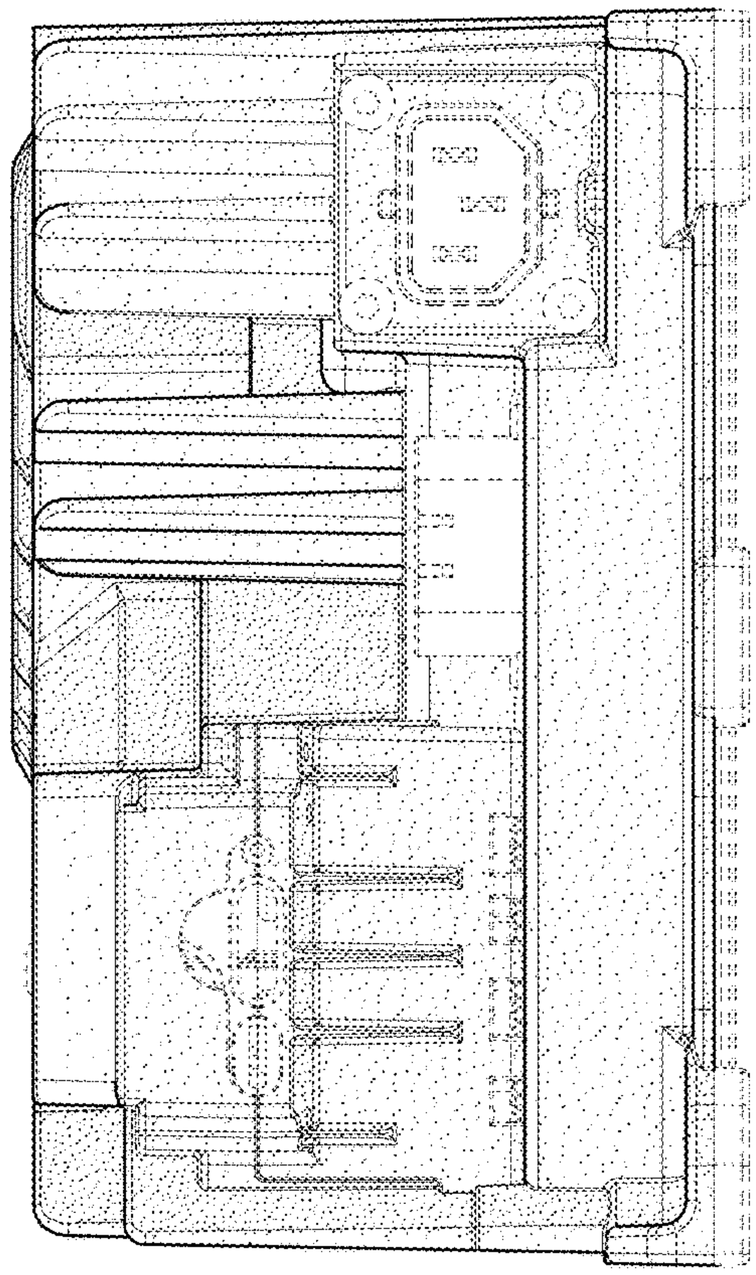
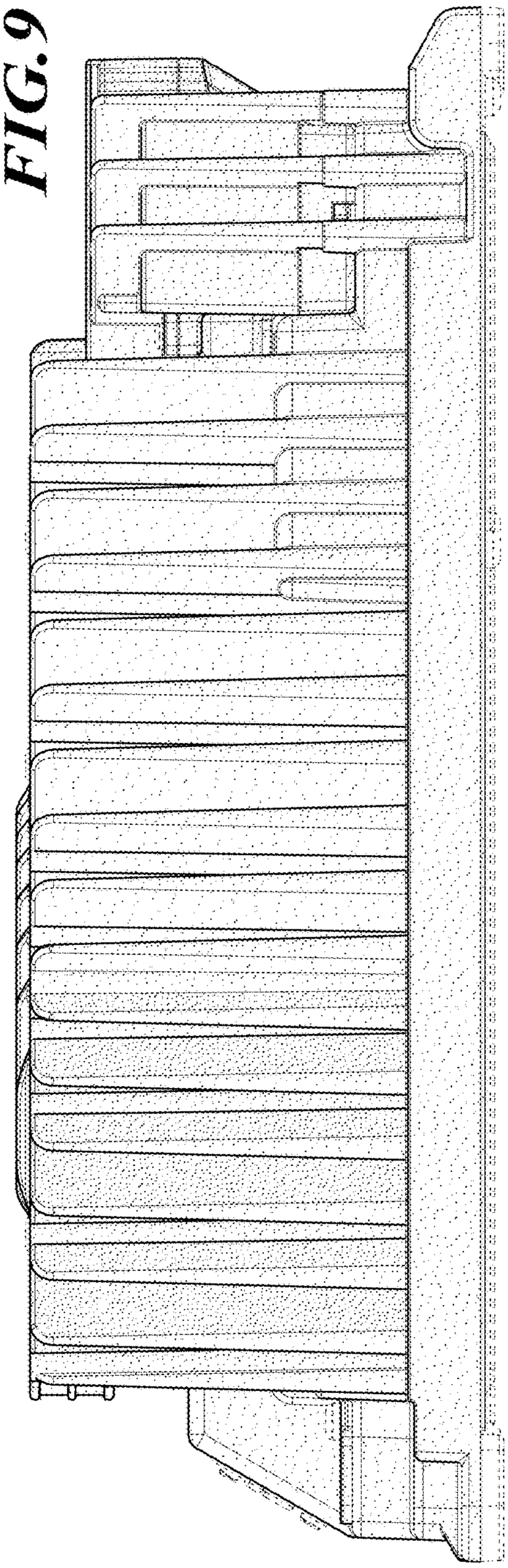


FIG.9



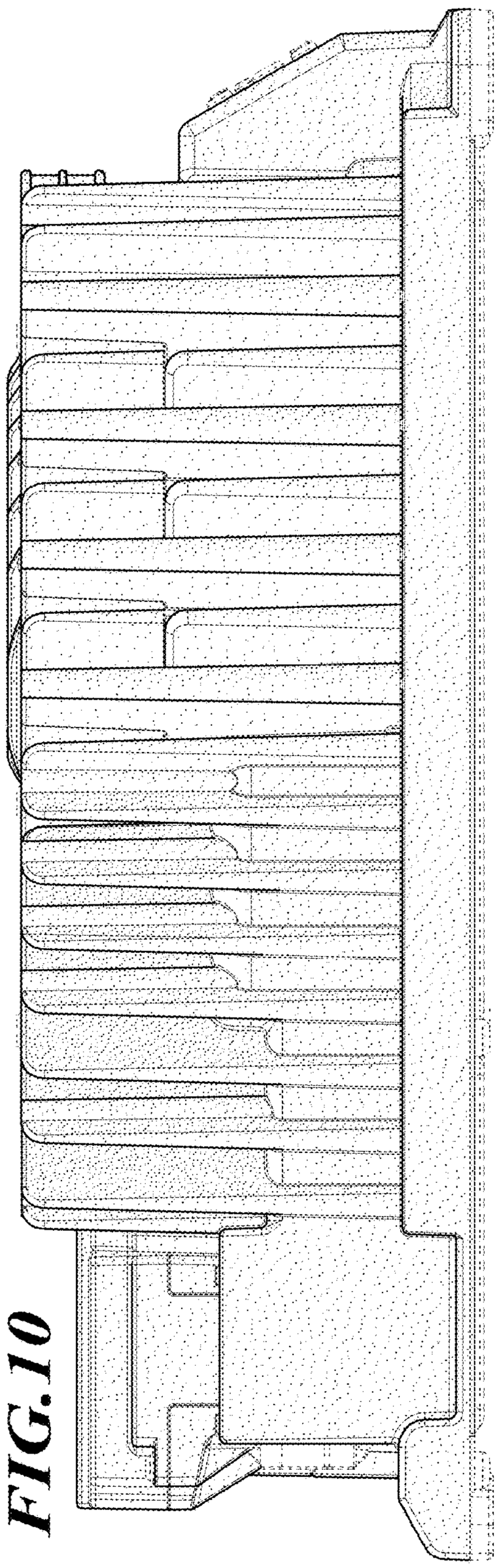


FIG.10