



US00D853956S

(12) **United States Design Patent** (10) **Patent No.:** **US D853,956 S**  
**Lau et al.** (45) **Date of Patent:** **\*\* Jul. 16, 2019**

(54) **BATTERY CHARGER**  
 (71) Applicant: **Delta-Q Technologies Corp.**, Burnaby (CA)  
 (72) Inventors: **Ngai Eric Lau**, Burnaby (CA);  
**Jonathan Eric Stroud**, Surrey (CA);  
**James Lennox Fox**, Vancouver (CA)  
 (73) Assignee: **DELTA-Q TECHNOLOGIES CORP.**, Burnaby (CA)

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

(21) Appl. No.: **29/640,834**

(22) Filed: **Mar. 16, 2018**

**Related U.S. Application Data**

(62) Division of application No. 29/565,135, filed on May 18, 2016, now Pat. No. Des. 815,592.

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

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

(58) **Field of Classification Search**  
 USPC ..... D13/102–106, 107, 108, 110, 118–119,  
 D13/184, 199; D14/251, 253, 432, 434  
 CPC ..... Y02E 60/12; Y02E 60/122; Y02E 60/124;  
 Y02E 60/50; H01M 2/02; H01M 2/022;  
 H01M 2/0202; H01M 2/0207; H01M  
 2/0212; H01M 2/1061; H01M 2/1022;  
 H01M 2/1055; H01M 2/1066; H01M  
 2/105; H01M 2/204; H01M 10/4257;  
 H01M 10/0436; H01M 10/48; H02J  
 2001/008; H02J 3/32; H02J 3/008; H02J  
 7/0027; H02J 7/0013; H02J 7/0054; H02J  
 7/00; B60R 16/03; B60L 11/1809; B60L  
 11/1861

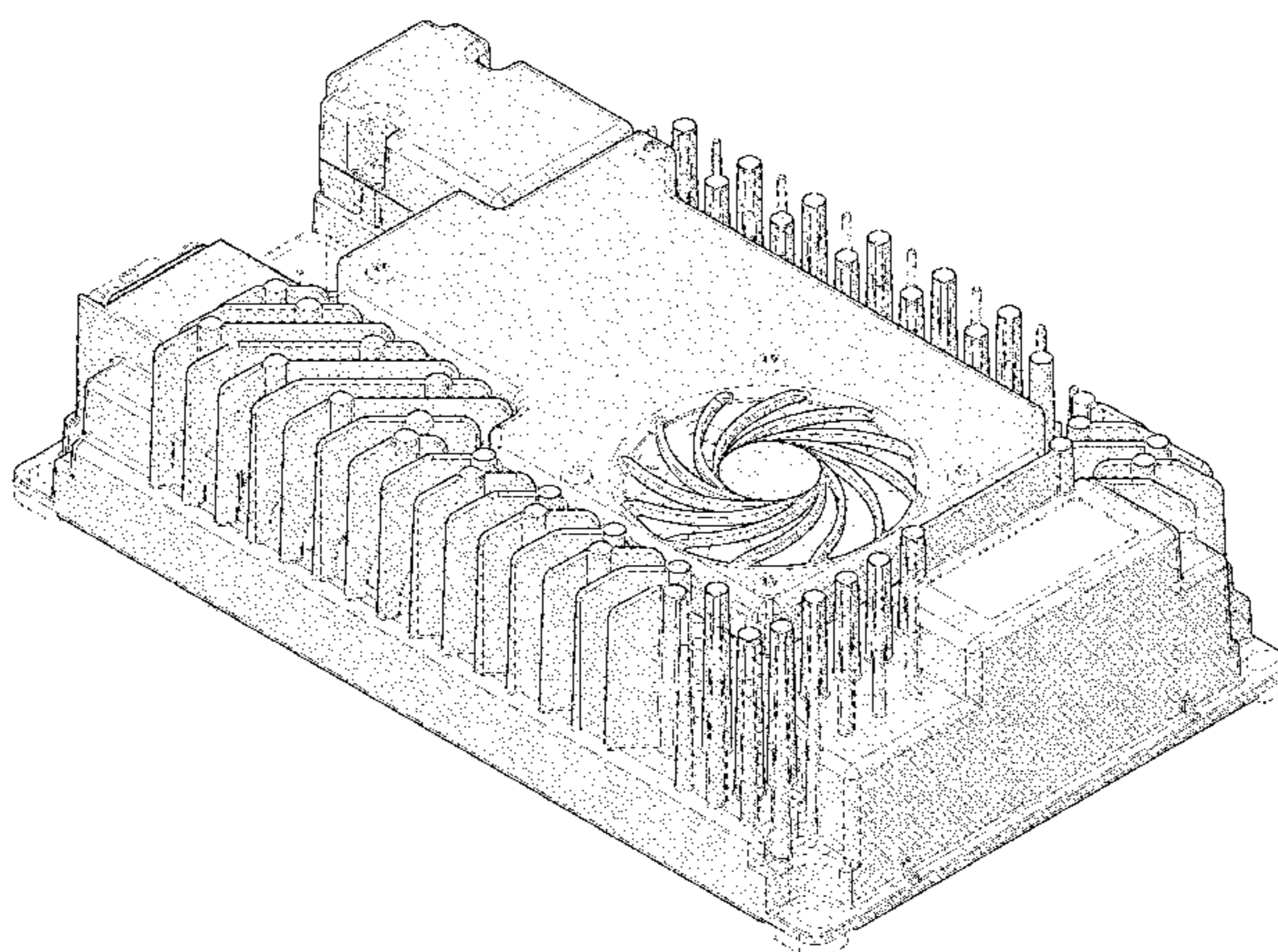
See application file for complete search history.

(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 Dacidson  
 D287,718 S 1/1987 Moeller  
 D292,914 S 11/1987 Moeller  
 D305,115 S 12/1989 Kondo  
 4,885,590 A 12/1989 Henze et al.  
 5,001,620 A 3/1991 Smit  
 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 et al.  
 D351,134 S 10/1994 Hunziker  
 5,355,300 A 10/1994 Zinn  
 D358,753 S 5/1995 Yoshida et al.  
 D360,186 S 7/1995 Netz et al.  
 5,490,057 A 2/1996 Vinciarelli et al.  
 5,602,492 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.  
 6,307,747 B1\* 10/2001 Farnsworth ..... H01L 23/4093  
 165/185  
 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.  
 6,671,172 B2\* 12/2003 Carter ..... H01L 23/3672  
 165/121  
 D489,682 S 5/2004 Guillarme  
 6,736,195 B2 5/2004 Busch et al.  
 6,809,678 B2 10/2004 Very 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.	2008/0295993 A1*	12/2008	Chen .....	H01L 23/427
7,198,094 B2	4/2007	Barsun et al.				165/80.3
D541,743 S	5/2007	Virolainen et al.	2010/0110593 A1	5/2010	Kim et al.	
D541,744 S	5/2007	Virolainen et al.	2010/0165683 A1	7/2010	Sugawara	
D541,745 S	5/2007	Virolainen et al.	2010/0259240 A1	10/2010	Cuk	
D546,282 S	7/2007	Wardenburg	2011/0110127 A1	5/2011	Lee	
D551,621 S	9/2007	Iacovelli et al.	2011/0211377 A1	9/2011	Uno	
D559,778 S	1/2008	Tsuzuki et al.	2011/0286216 A1*	11/2011	Araman .....	F21V 29/004
D562,765 S	2/2008	Tsuzuki et al.				362/249.02
7,365,987 B2	4/2008	Jeong	2011/0292703 A1	12/2011	Cuk	
D568,841 S	5/2008	Fischer et al.	2012/0069615 A1	3/2012	Tomioaka	
D571,314 S	6/2008	Hornig	2012/0249102 A1	10/2012	Cuk	
7,535,716 B2	5/2009	Fischer et al.	2012/0256606 A1	10/2012	Van Den Brioke	
D593,512 S	6/2009	Lin	2013/0235631 A1	9/2013	Pahlevaninezhad et al.	
7,616,455 B2	11/2009	Cameron et al.	2014/0056045 A1	2/2014	Yan et al.	
D606,017 S	12/2009	Charlson et al.	2014/0268952 A1	9/2014	Tong	
D621,812 S	8/2010	Wayman	2015/0171734 A1	6/2015	Tu et al.	
D638,376 S	5/2011	Herrmann et al.	2016/0056730 A1	2/2016	Yan et al.	
7,983,043 B2*	7/2011	Xu .....	2016/0099660 A1	4/2016	Khaligh et al.	
		F28D 15/0233				
		165/185				
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				
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 et al.				
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	Stacquadaini				
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				
D706,216 S *	6/2014	Perin .....	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 et al.				
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				
D739,347 S	9/2015	Huang et al.				
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				
D767,815 S	9/2016	Lee				
D768,585 S	10/2016	Moore et al.				
D770,975 S	11/2016	Nada et al.				
9,490,694 B2	11/2016	Alam				
D793,350 S	8/2017	Kenchappa				
D796,431 S	9/2017	Lau et al.				
D804,434 S *	12/2017	Lu .....	D13/179			
D805,473 S	12/2017	Montgomery et al.				
D805,486 S	12/2017	Hochman et al.				
D806,647 S	1/2018	Lau et al.				
D815,592 S *	4/2018	Lau .....	D13/107			
D828,294 S *	9/2018	Lau .....	D13/107			
D829,649 S *	10/2018	Lau .....	D13/107			
2004/0240182 A1*	12/2004	Shah .....	H01L 23/467			
			361/704			
2005/0061480 A1*	3/2005	Carter .....	B21C 23/10			
			165/80.3			
2005/0105311 A1	5/2005	Soldano				
2007/0014089 A1*	1/2007	Huang .....	H01L 23/467			
			361/695			
2007/0131387 A1	6/2007	Kawabata et al.				
2008/0002444 A1	1/2008	Shekhawat 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," 21<sup>st</sup> 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-technologies-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. 29/530,060, filed Jun. 12, 2015, 18 pages.

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," 10<sup>th</sup> 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," 14<sup>th</sup> 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 — Jennifer Rivard  
 Assistant Examiner — Alison M Ofstun  
 (74) Attorney, Agent, or Firm — Seed IP Law Group LLP

(57)

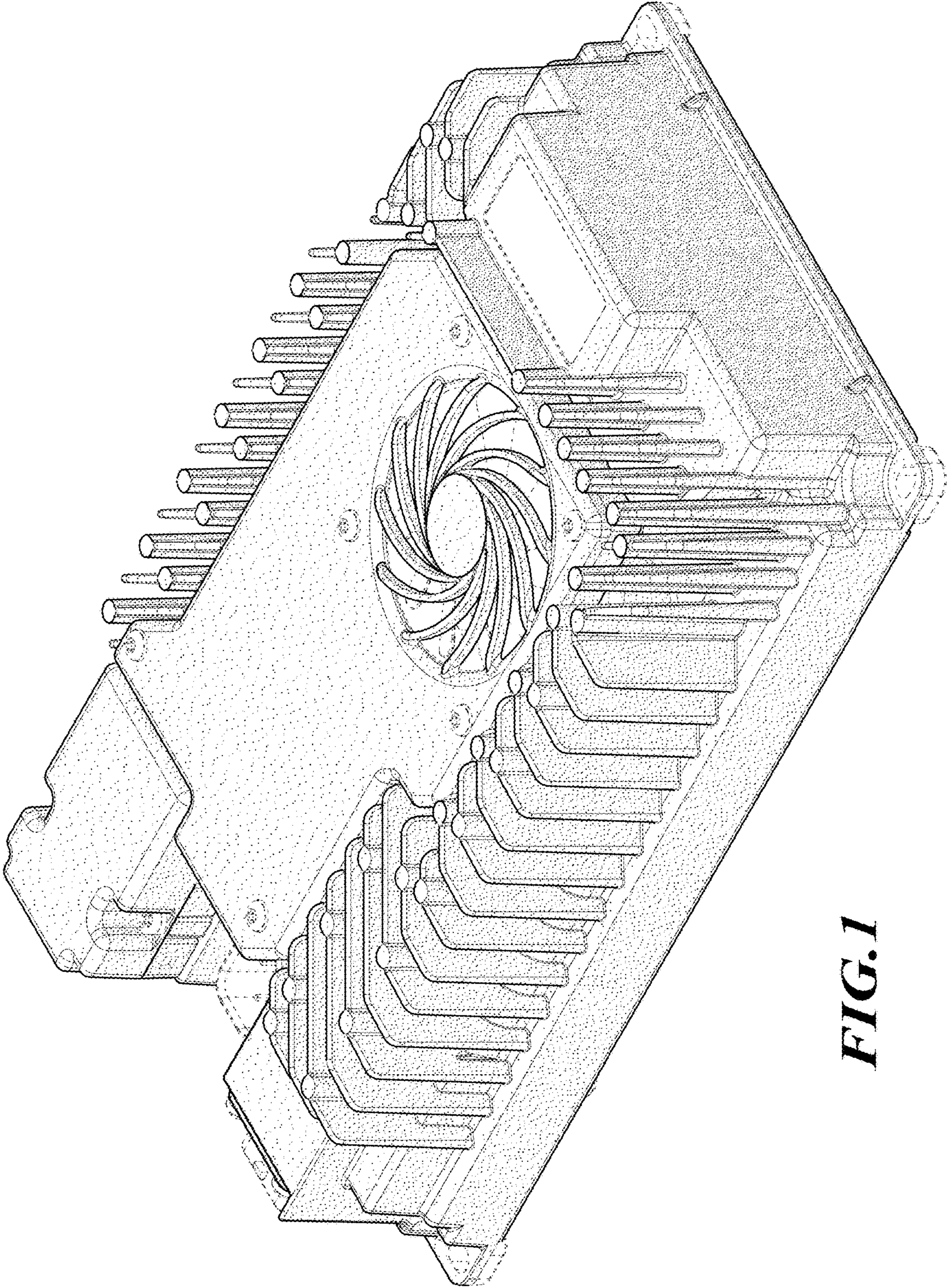
#### CLAIM

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

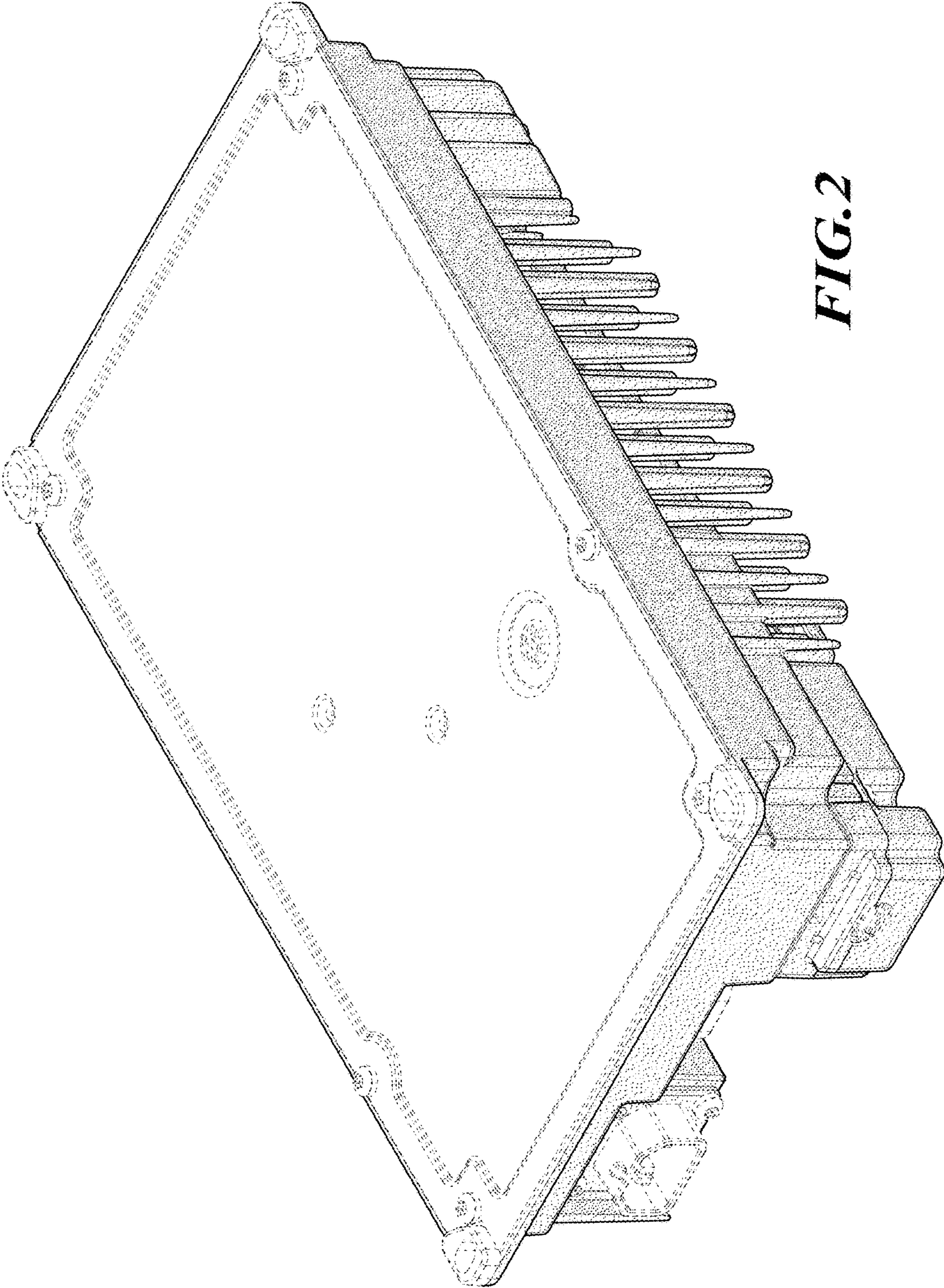
#### DESCRIPTION

FIG. 1 is a top right-front perspective view of a battery charger, showing our new design;  
 FIG. 2 is a bottom left-rear isometric view thereof.  
 FIG. 3 is a top left-rear isometric view thereof.  
 FIG. 4 is a bottom right-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 claimed design.

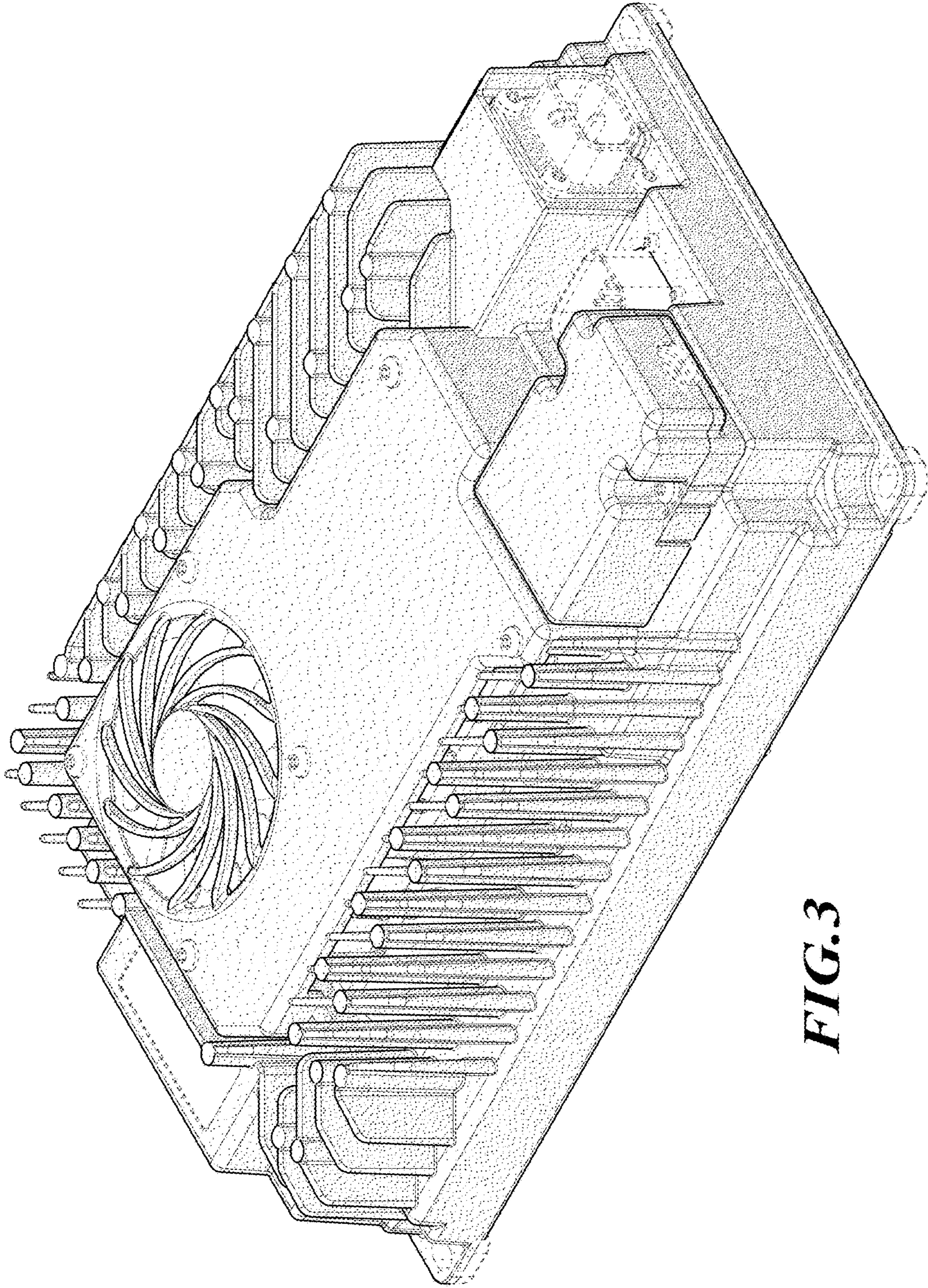
**1 Claim, 8 Drawing Sheets**



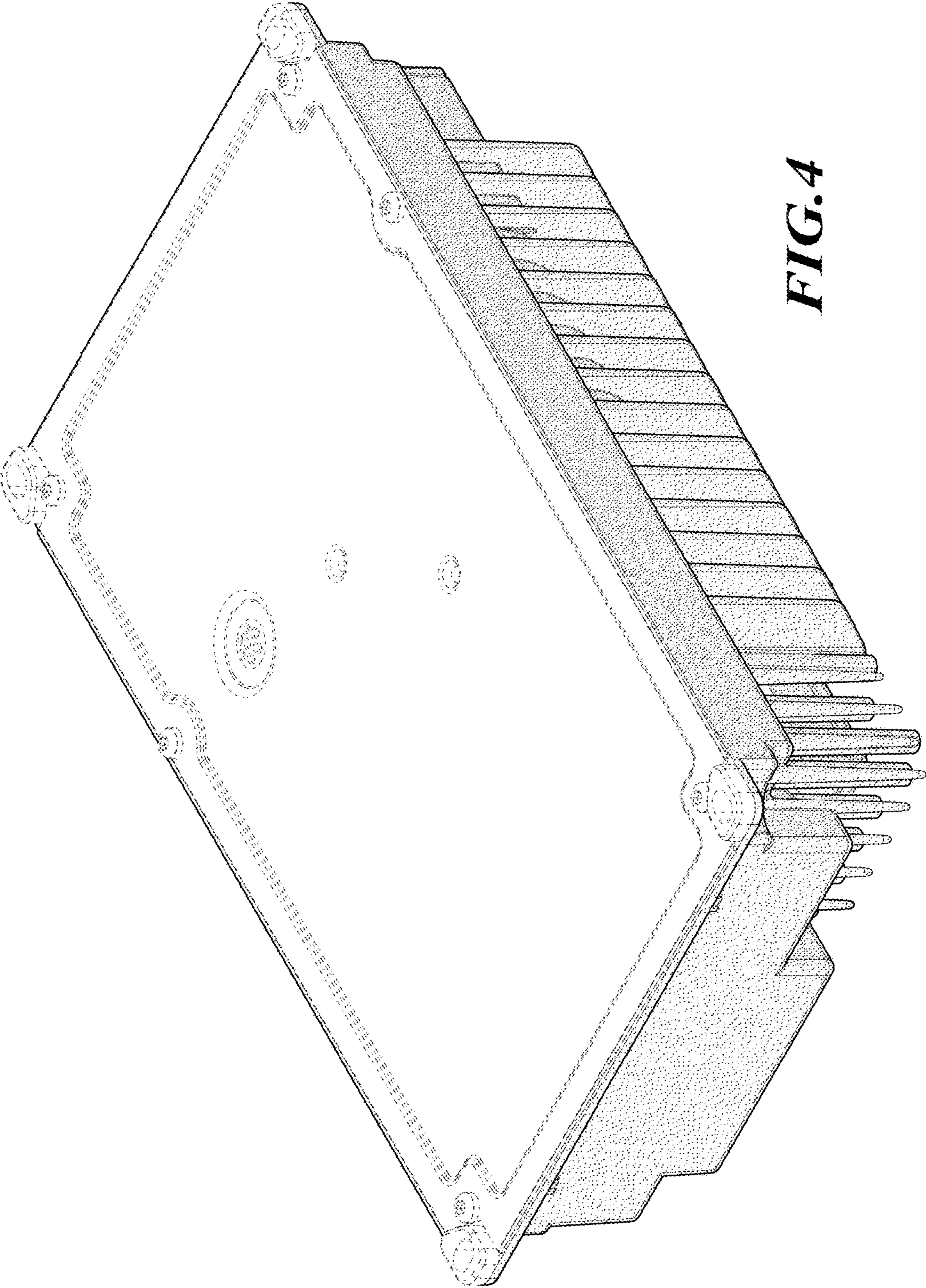
**FIG. 1**



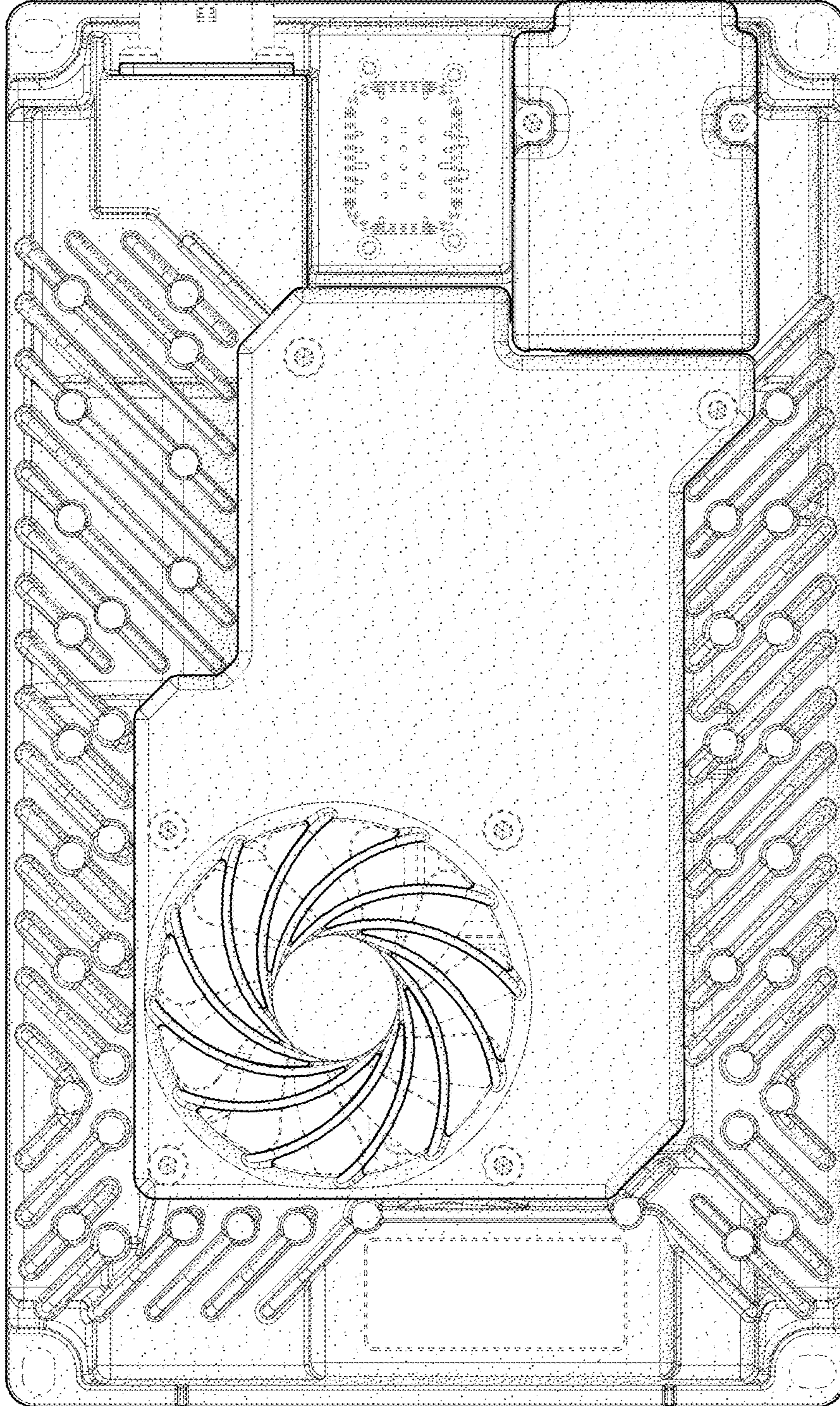
**FIG. 2**



**FIG. 3**

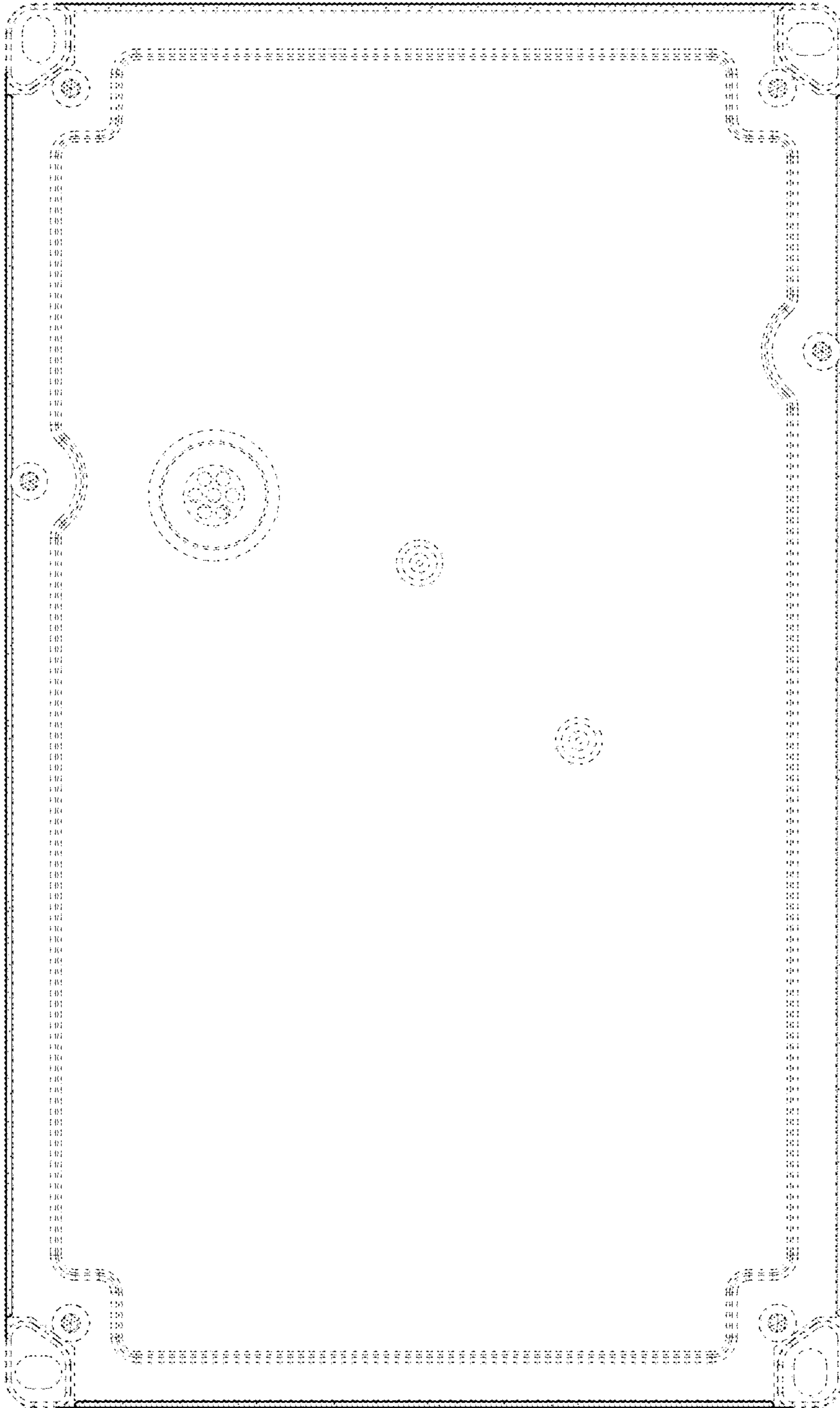


**FIG. 4**

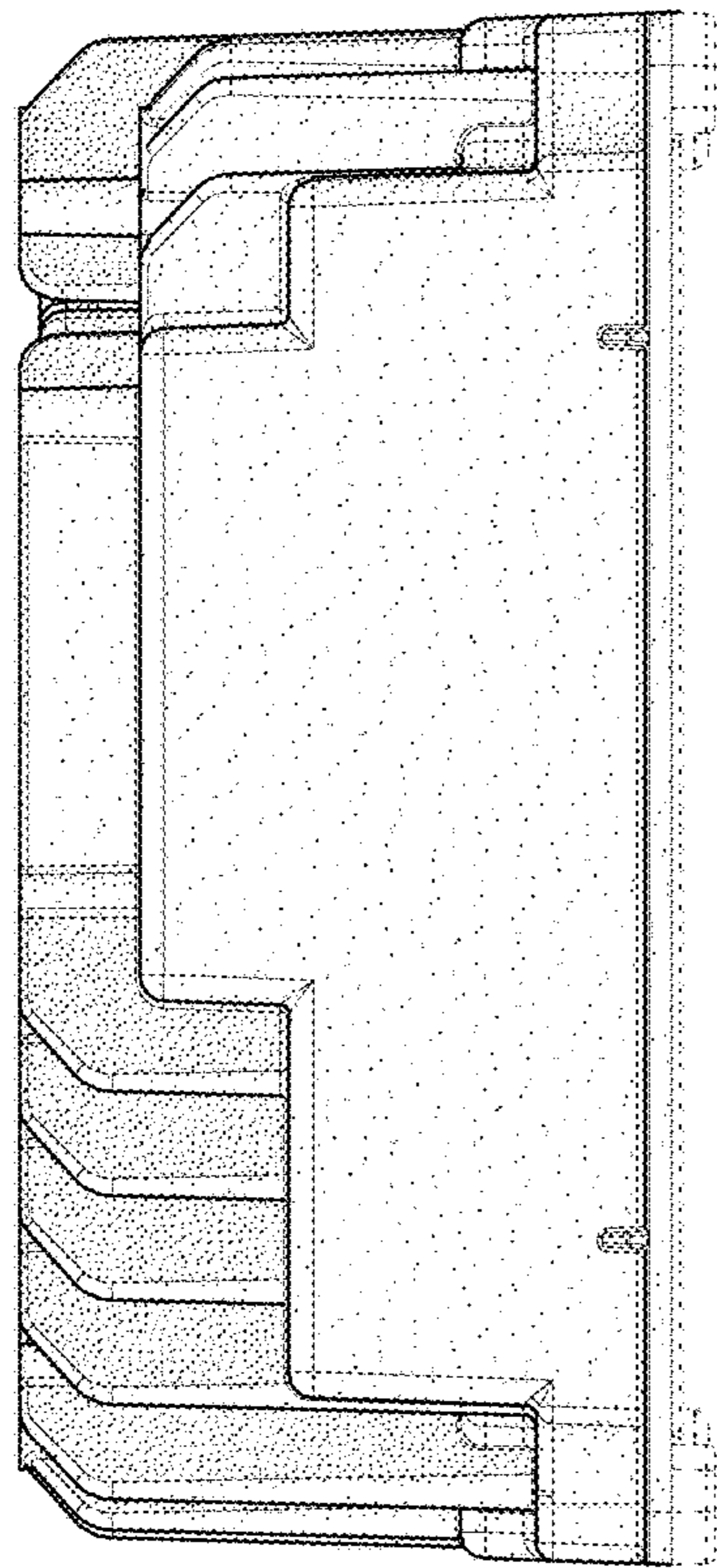


**FIG. 5**

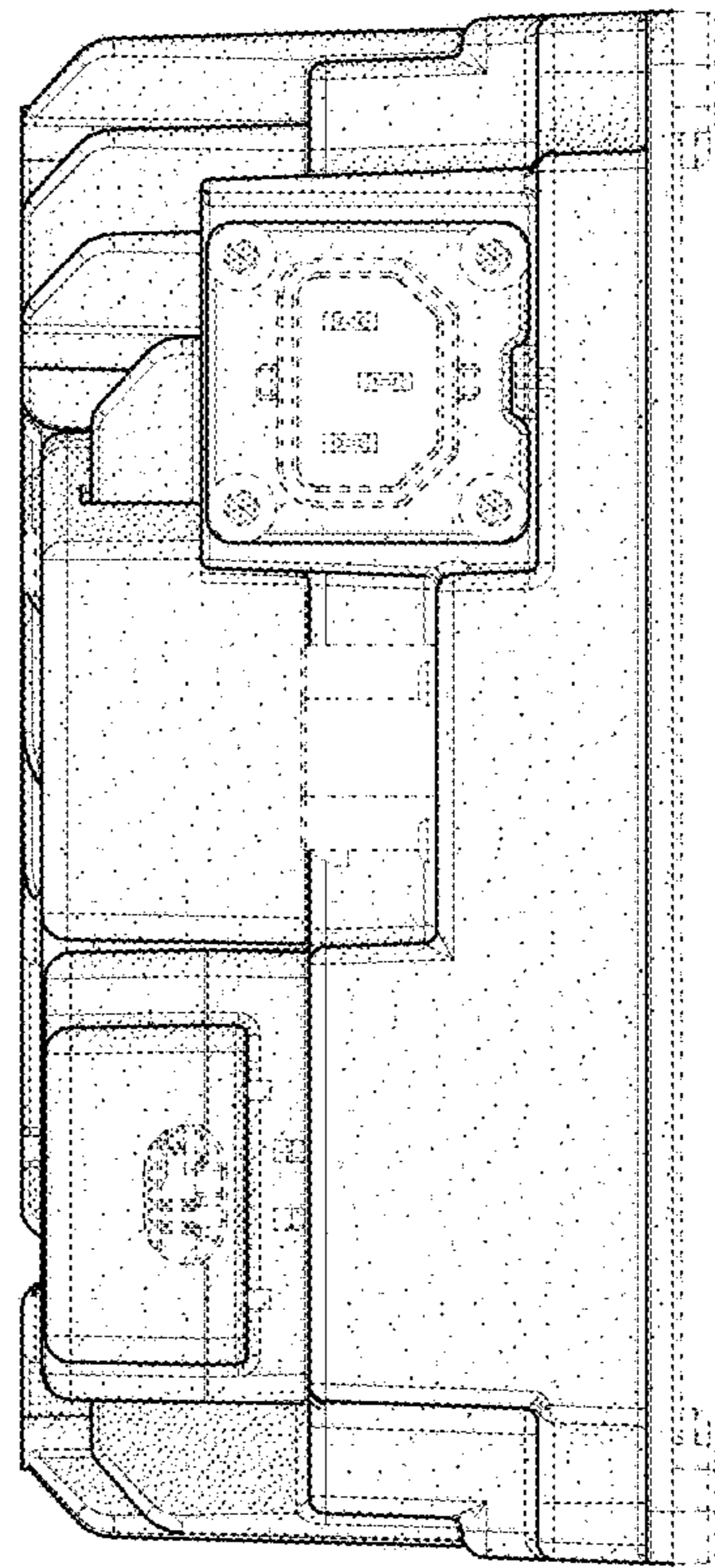




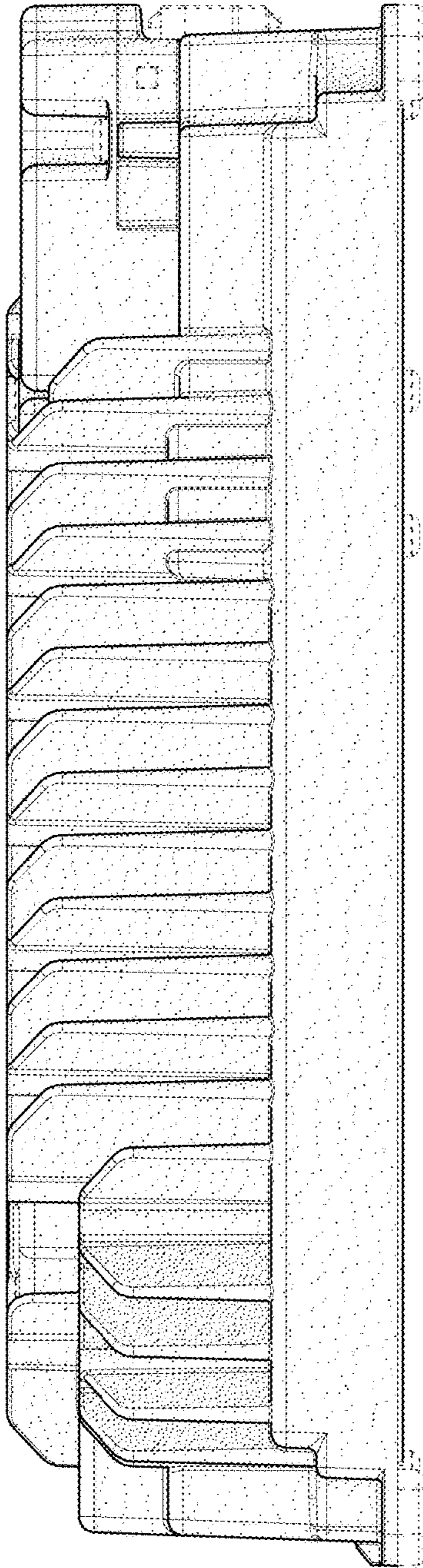
**FIG. 6**



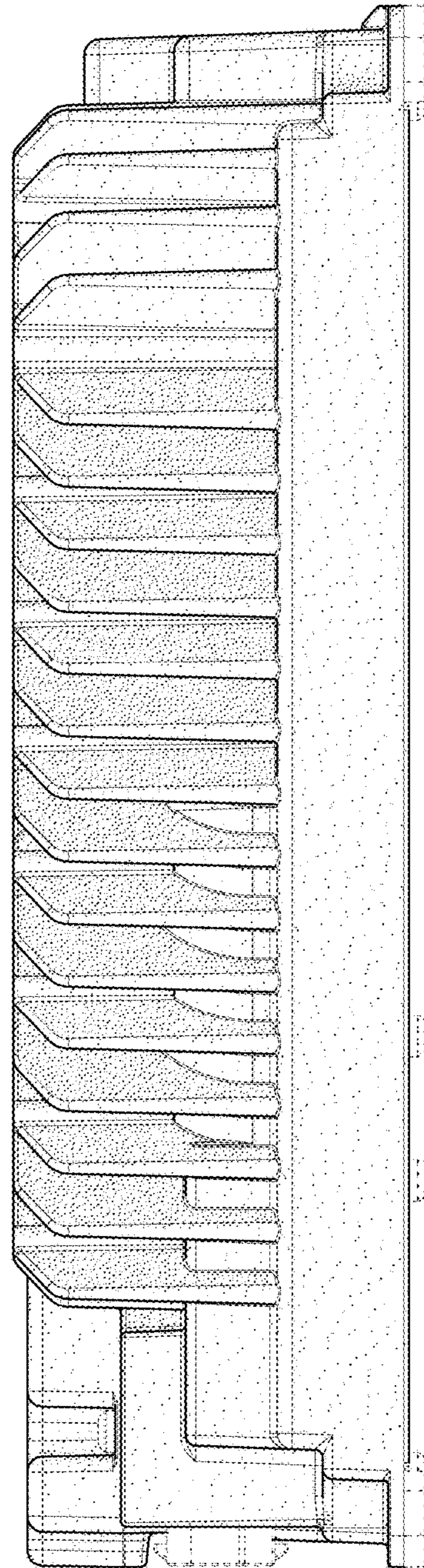
**FIG. 7**



**FIG. 8**



**FIG. 9**



**FIG. 10**