



US00D906269S

(12) **United States Design Patent** (10) **Patent No.:** **US D906,269 S**
Cola et al. (45) **Date of Patent:** **** *Dec. 29, 2020**

(54) **FLEXIBLE HEAT SINK**

FOREIGN PATENT DOCUMENTS

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CN 303114809 2/2015
CN 303114811 * 2/2015

(Continued)

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OTHER PUBLICATIONS

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2013 IEEE International Conference on 3D System Integration, "Contact Testing of Copper Micro-pillars with Very Low Damage for 3D IC Assembly", Onnik Yaglioglu, Ben Eldridge. 2013 (Year: 2013).*

(*) Notice: This patent is subject to a terminal disclaimer.

(Continued)

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

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(21) Appl. No.: **29/703,508**

(57)

CLAIM

We claim the ornamental design for a flexible heat sink, as shown and described.

(22) Filed: **Aug. 28, 2019**

(51) **LOC (12) Cl.** **13-03**

(52) **U.S. Cl.**
USPC **D13/179**

(58) **Field of Classification Search**
USPC D13/179
CPC . H05K 7/20254; H05K 7/20418; F28F 3/022;
F28F 3/04; F28F 21/065; H01L 23/367;
H01L 23/3672; H01L 23/3677; H01L
23/36; G02B 1/111; A61B 17/50; A61M
37/0015

DESCRIPTION

See application file for complete search history.

FIG. 1 is a top isometric view of a flexible heat sink showing our new design;

FIG. 2 is a front elevation view thereof, each of the right elevation, left elevation, and rear elevation views being a mirror image thereof;

FIG. 3 is a top view thereof;

FIG. 4 is a bottom view thereof;

FIG. 5 is a top isometric view of the flexible heat sink illustrated in FIGS. 1 to 4 on a curved surface;

FIG. 6 is a front elevation view thereof, the rear elevation view being a mirror image thereof;

FIG. 7 is a top view thereof; and,

FIG. 8 is a bottom view thereof.

The shade lines in the Figures show contour and not surface ornamentation.

The broken dash-dot-dot lines in the views define boundary lines are not part of the claimed design. The evenly broken lines are used to depict environmental features for illustrative purposes only and form no part of the claimed design.

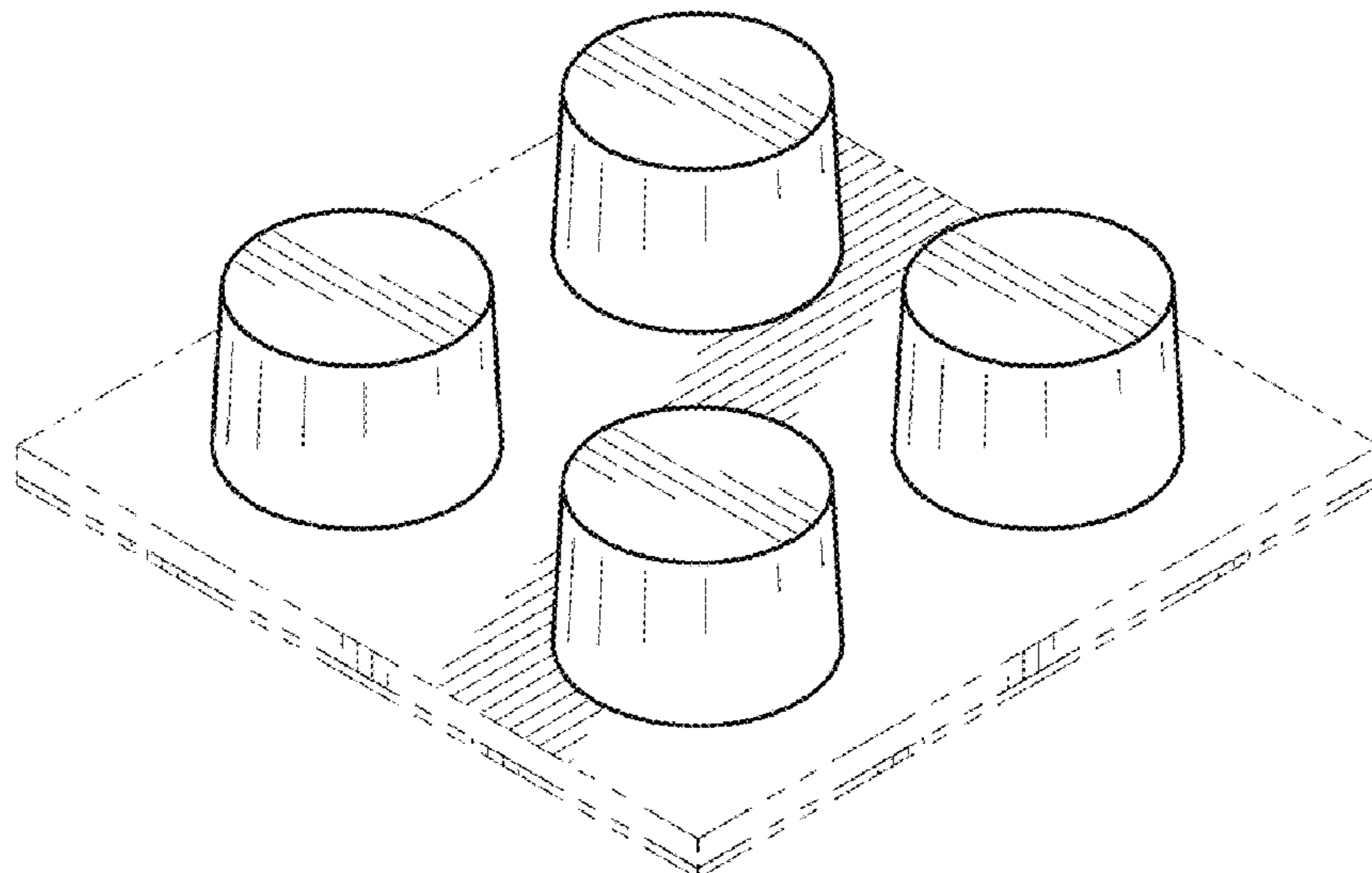
(56) **References Cited**

U.S. PATENT DOCUMENTS

2,243,979 A 6/1941 Reynolds
3,234,683 A * 2/1966 Christiansen A63H 33/086
446/103
3,640,017 A * 2/1972 Christiansen A63H 33/088
446/102
D244,632 S * 6/1977 Christiansen D21/491

(Continued)

1 Claim, 2 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

4,064,300 A * 12/1977 Bhangu F28F 3/04
428/120

5,057,903 A 10/1991 Olla

5,102,829 A 4/1992 Cohn

D327,185 S * 6/1992 Ryaa D30/161

5,369,301 A * 11/1994 Hayashi H01L 21/4882
165/80.3

5,763,296 A 6/1998 Casati

D398,295 S * 9/1998 Chang D13/179

5,912,805 A * 6/1999 Freuler H01L 23/4275
156/346

5,991,155 A 11/1999 Kobayashi

6,142,847 A * 11/2000 Rudy A63H 33/082
446/122

6,221,463 B1 * 4/2001 White F28F 3/04
428/174

6,250,127 B1 6/2001 Polese

6,367,541 B2 4/2002 McCullough

D487,544 S * 3/2004 Jessen D3/326

6,724,071 B2 4/2004 Combs

6,800,932 B2 10/2004 Lam

6,919,504 B2 7/2005 McCutcheon

6,921,462 B2 7/2005 Montgomery

6,965,513 B2 11/2005 Montgomery

7,056,566 B2 * 6/2006 Freuler B32B 7/06
165/104.19

7,086,451 B2 8/2006 Leu

7,173,823 B1 * 2/2007 Rinehart F28F 3/04
165/80.4

7,399,919 B2 * 7/2008 McCutcheon F28D 15/0241
174/16.3

D576,185 S * 9/2008 Park D15/126

7,443,678 B2 * 10/2008 Han F21K 9/00
361/704

7,465,605 B2 12/2008 Raravikar

7,828,827 B2 * 11/2010 Gartstein A61M 37/0015
606/290

D647,959 S * 11/2011 Takaghi D19/26

8,093,715 B2 1/2012 Xu

8,220,530 B2 7/2012 Cola

8,226,625 B2 7/2012 Turner

8,377,364 B2 * 2/2013 Shiomitsu A61M 37/0015
216/11

D694,226 S * 11/2013 Thompson D14/250

D694,703 S * 12/2013 Faro D13/103

9,097,468 B2 8/2015 Chen

D792,183 S * 7/2017 Miller D8/71

D822,625 S * 7/2018 Tamura D13/179

10,037,930 B2 * 7/2018 Kume H01L 23/3675

D839,253 S * 1/2019 Su D14/250

10,287,471 B2 * 5/2019 Zhang C09K 5/14

10,297,523 B2 5/2019 Hong

D865,876 S * 11/2019 Webber D21/500

2002/0140336 A1 10/2002 Stoner

2003/0183379 A1 10/2003 Krassowski

2004/0027816 A1 * 2/2004 Ice H05K 7/20418
361/797

2004/0065717 A1 4/2004 Saijo

2004/0105807 A1 6/2004 Fan

2004/0118579 A1 * 6/2004 McCutcheon F28F 3/022
174/16.3

2004/0125266 A1 * 7/2004 Miyauchi G02B 1/111
349/57

2004/0184981 A1 9/2004 Liu

2004/0261987 A1 12/2004 Zhang

2005/0214197 A1 9/2005 Gu

2005/0228097 A1 10/2005 Zhong

2006/0073089 A1 4/2006 Ajayan

2006/0231970 A1 10/2006 Hua

2007/0091565 A1 * 4/2007 Malone H05K 7/20145
361/695

2007/0253889 A1 11/2007 Awano

2008/0095695 A1 4/2008 Shanov

2008/0149166 A1 6/2008 Beeson

2008/0160866 A1 7/2008 Zhang

2008/0236804 A1 10/2008 Cola

2008/0241755 A1 10/2008 Franklin

2008/0292840 A1 11/2008 Majumdar

2009/0032496 A1 2/2009 Yuan

2009/0246507 A1 10/2009 Graham

2010/0006272 A1 * 1/2010 Braun F28F 3/022
165/121

2010/0027221 A1 2/2010 Iwai

2010/0053892 A1 * 3/2010 Wang H01L 23/3677
361/692

2011/0020593 A1 1/2011 Winkler

2011/0067841 A1 * 3/2011 Doo H05K 7/20254
165/104.19

2011/0086464 A1 4/2011 Kim

2011/0103021 A1 5/2011 Janssen

2012/0018134 A1 * 1/2012 Polk, Jr. F28F 3/04
165/170

2012/0090563 A1 * 4/2012 Thijssen F28F 3/022
122/367.1

2012/0128880 A1 5/2012 Talapatra

2012/0132410 A1 * 5/2012 Gu H01L 23/3672
165/185

2012/0217257 A1 * 8/2012 Ting G06F 1/1628
220/660

2012/0325430 A1 * 12/2012 Chen H01L 23/3672
165/67

2013/0153189 A1 * 6/2013 Lin F28F 3/022
165/185

2013/0234313 A1 9/2013 Wainerdi

2013/0256868 A1 10/2013 Aliyev

2013/0284404 A1 * 10/2013 Matsushima F28F 3/022
165/104.19

2014/0015158 A1 1/2014 Baratunde

2014/0083671 A1 * 3/2014 Ideguchi H01L 23/3677
165/185

2015/0047822 A1 * 2/2015 Lin H01L 23/3677
165/185

2015/0245523 A1 * 8/2015 Takagi H01L 23/051
361/715

2015/0338176 A1 * 11/2015 Chen F28F 3/022
165/185

2016/0069622 A1 * 3/2016 Alexiou F21V 29/81
165/146

2016/0091260 A1 * 3/2016 Schultz F28F 3/022
165/185

2016/0158825 A1 * 6/2016 Inoshita H01L 23/3677
29/890.03

2016/0234976 A1 * 8/2016 Shimura H02M 7/003

2017/0018478 A1 * 1/2017 Maple H01L 23/367

2017/0280588 A1 * 9/2017 Wu H01L 23/3677

2017/0363375 A1 * 12/2017 Mayor F28F 3/022

2018/0087846 A1 * 3/2018 Remsburg F28F 3/022

2018/0149436 A1 * 5/2018 Lee F28F 3/022

2018/0151472 A1 5/2018 Chen

2018/0317342 A1 * 11/2018 Gong H01L 23/473

2018/0359886 A1 * 12/2018 Lin H01L 23/49838

2018/0363893 A1 12/2018 Cheng

2019/0139863 A1 5/2019 Tamura

2019/0219313 A1 * 7/2019 Draenkov F28F 3/046

2019/0221501 A1 * 7/2019 Tamura H05K 7/20254

2019/0237382 A1 * 8/2019 Kim H01L 23/3677

2019/0302325 A1 * 10/2019 Sorbel G02B 1/111

2019/0369294 A1 * 12/2019 Chang G02B 1/111

FOREIGN PATENT DOCUMENTS

CN 302015674 8/2015

EM 001318182-003 * 3/2012

EP 0662244 7/1995

EP 2251302 11/2010

JP 34324772 8/2003

JP D1465458 * 2/2013

JP 2013115094 6/2013

JP 2015041768 3/2015

KR 3008331680000 1/2016

KR 3009927820000 2/2019

(56)

References Cited

FOREIGN PATENT DOCUMENTS

WO	1996/006321	2/1996
WO	1996006321	2/1996
WO	2013/007645	1/2013
WO	2013007645	1/2013
WO	2017/087136	5/2017
WO	2017087136	5/2017

OTHER PUBLICATIONS

Research Micro Stamps, “shop”, Cached on May 18, 2017. (<https://researchmicrostamps.com/shop-online/>) (Year: 2017).*

Toshiba Machine, “Micro-Pattern Imprinting Machine ST Series”, Cached on Feb. 28, 2015. (<http://www.toshiba-machine.co.jp/en/product/nano/lineup/st/imprint.html>) (Year: 2015).*

MIT News, “Better surfaces could help dissipate heat”, Published Jun. 26, 2012. (<http://news.mit.edu/2012/better-heat-transfer-0626>) (Year: 2012).*

13th IEEE IThERM Conference, “Microfabrication of Short Pin Fins on Heat Sink Surfaces to Augment Heat Transfer Performance”, Congshun Wang, Youmin Yu, Terrence Simon, and Tianhong Cui. 2012 (Year: 2012).*

Youtube, “TCP3D Flexible 3D Printed Composite Heat Sink for SSD, LEDs, CPUs, etc.”, Uploaded by TCPoly on Jan. 25, 2018. (<https://www.youtube.com/watch?v=ta2vwQrOqI4>) (Year: 2018).*

Amazon, “Easycargo Raspberry Pi 4 Heatsink Copper Kit.”, First on sale May 29, 2018. (<https://www.amazon.com/Easycargo-Raspberry-Heatsink-Conductive-Adhesive/dp/B07D4BWK6G>) (Year: 2018).*

Embedded, “Hybrid heat sinks provide optimal cooling for embedded systems”, Posted May 20, 2009. (<https://www.embedded.com/hybrid-heat-sinks-provide-optimal-cooling-for-embedded-systems/>) (Year: 2009).*

Youtube, “Thermal Interface Material Explanation”, uploaded by user Advanced Thermal Solutions, Inc. on Jan. 23, 2018. (<https://www.youtube.com/watch?v=MAdTWlPnzBA>) (Year: 2018).*

YGmetal, “Substrate & Heat sinks”, Posted Dec. 6, 2018. (<https://www.ygmetal.com/info/substrate-heat-sinks-30971008.html>) (Year: 2018).*

U.S. Appl. No. 16/021,562, filed Jun. 28, 2018, Cola.

140 mm Pin Din Heatsink Square Shapes, https://www.alibaba.com/product-detail/140mm-Pin-Fin-Heatsink-Square-Shapes_60775112298.html, accessed Oct. 2, 2019.

Bayer, et al., Support-Catalyst-Gas interactions during carbon nanotube growth on metallic ta films, *J. Phys. Chem.*, 115:4359-69 (2011).

Cola, et al., “Contact mechanics and thermal conductance of carbon nanotube array interfaces”, *Int. J. Heat Mass Trans.*, 52:3490-3503 (2009).

Cu/Al Pin Fin Heat Sink_Heat_Sink Jacarlos Industries Co. Ltd., www.jacarlosworld.com/view/asp?id=159, 1-2, accessed Oct. 2, 2019.

Dagan, et al., “Hybrid heat sinks provide optimal cooling for embedded systems”, <https://www.embedded.com/print/4027004>, 1-5, (2009).

Dai, et al., “Controlled growth and modification of vertically-aligned carbon nanotubes for multifunctional applications”, *Mater. Sci. Eng.*, 70:63-91 (2010).

Hildreth, et al., “Conformally coating vertically aligned carbon nanotube arrays using thermal decomposition of iron pentacarbonyl”, *J. Vac. Sci. Technol. B*, 30(3):03D1011-03D1013 (2012).

Kim, et al., “Evolution in catalyst morphology leads to carbon nanotube growth termination”, *J Phys. Chem. Lett.*, 1:918-22 (2010).

Learn How AlSiC substrates Offer CTE matching for Thermal Dissipation, <https://www.indium.com/blog/learn-how-alsic-substrates-offer-cte-matching-for-thermal-dissipation.php>, 1-4, (2010).

Sleasman, et al., “Cool Running Autos”, <https://powersystemsdesign.com/articles/cool-running-autos/22/5339>, 1-6, (2010).

Learn How AlSiC substrates Offer CTE matching for Thermal Dissipation, <https://www.indium.com/blog/learn-how-alsic-substrates-offer-cte-matching-for-thermal-dissipation.php>, 1-4, (2010).

U.S. Appl. No. 16/021,562, filed Jun. 28, 2018. (unpublished application).

Thermocool, “Copper base bonded fin heatsink”, first accessed on 07/06/201, (<https://thermocoolcorp.com/project/copper-base-bonded-fin-heatsink/>) (2017).

* cited by examiner

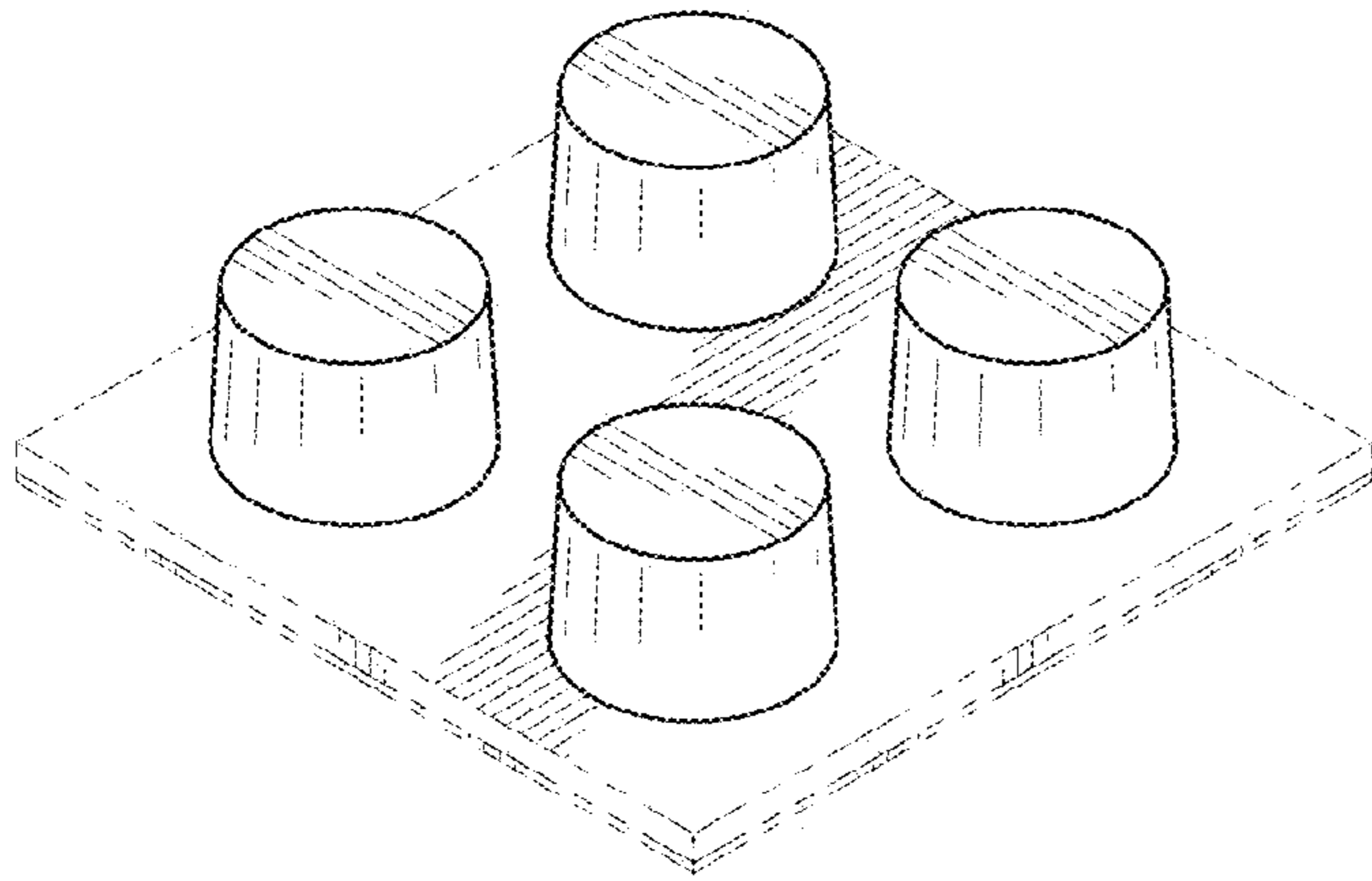


FIG. 1

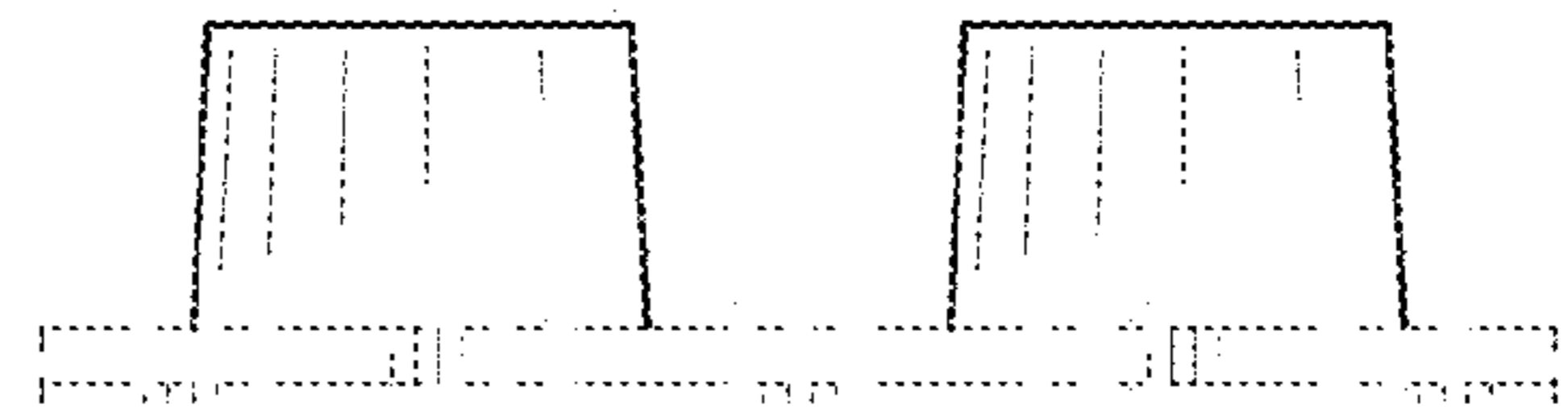


FIG. 2

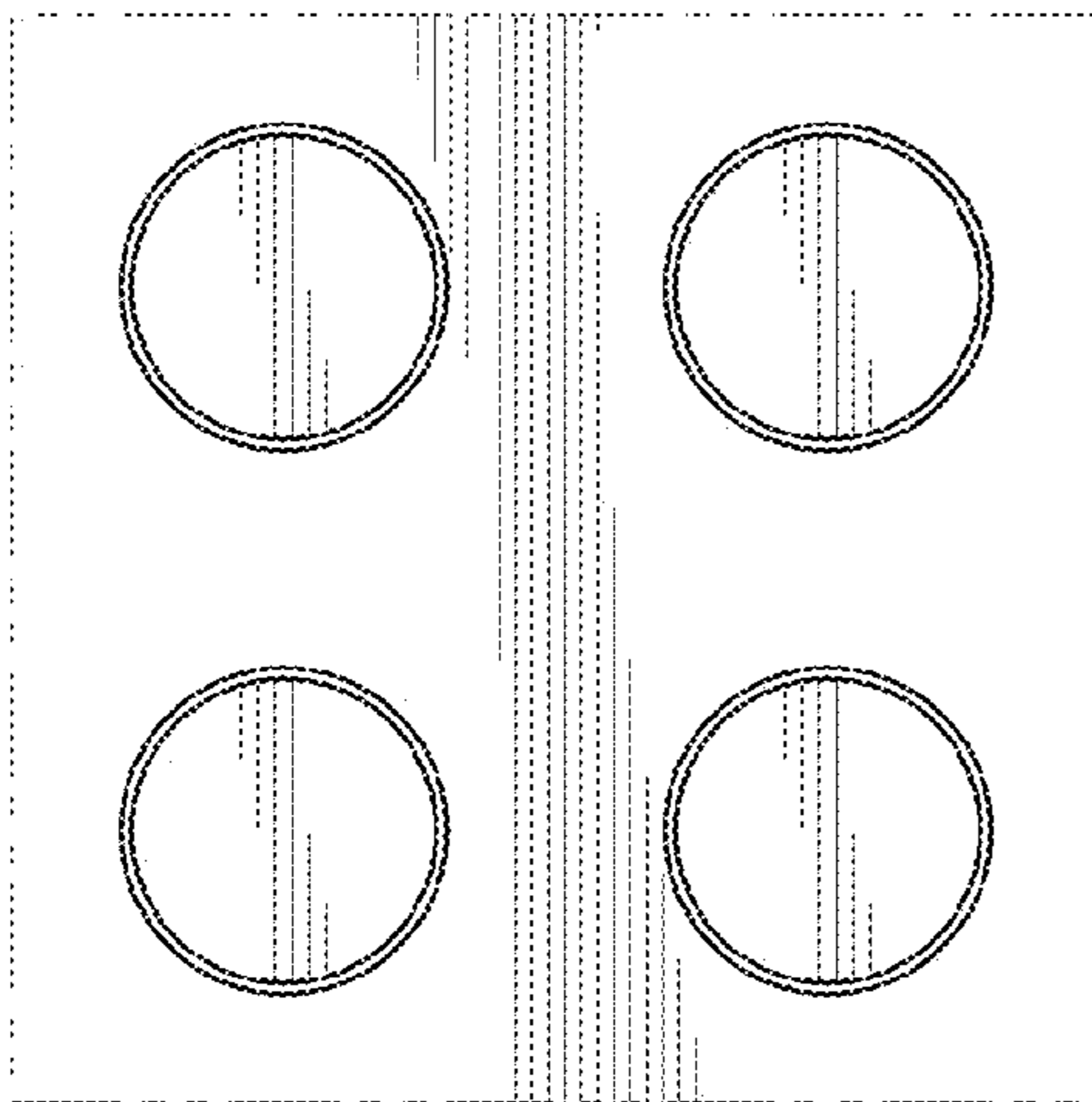


FIG. 3

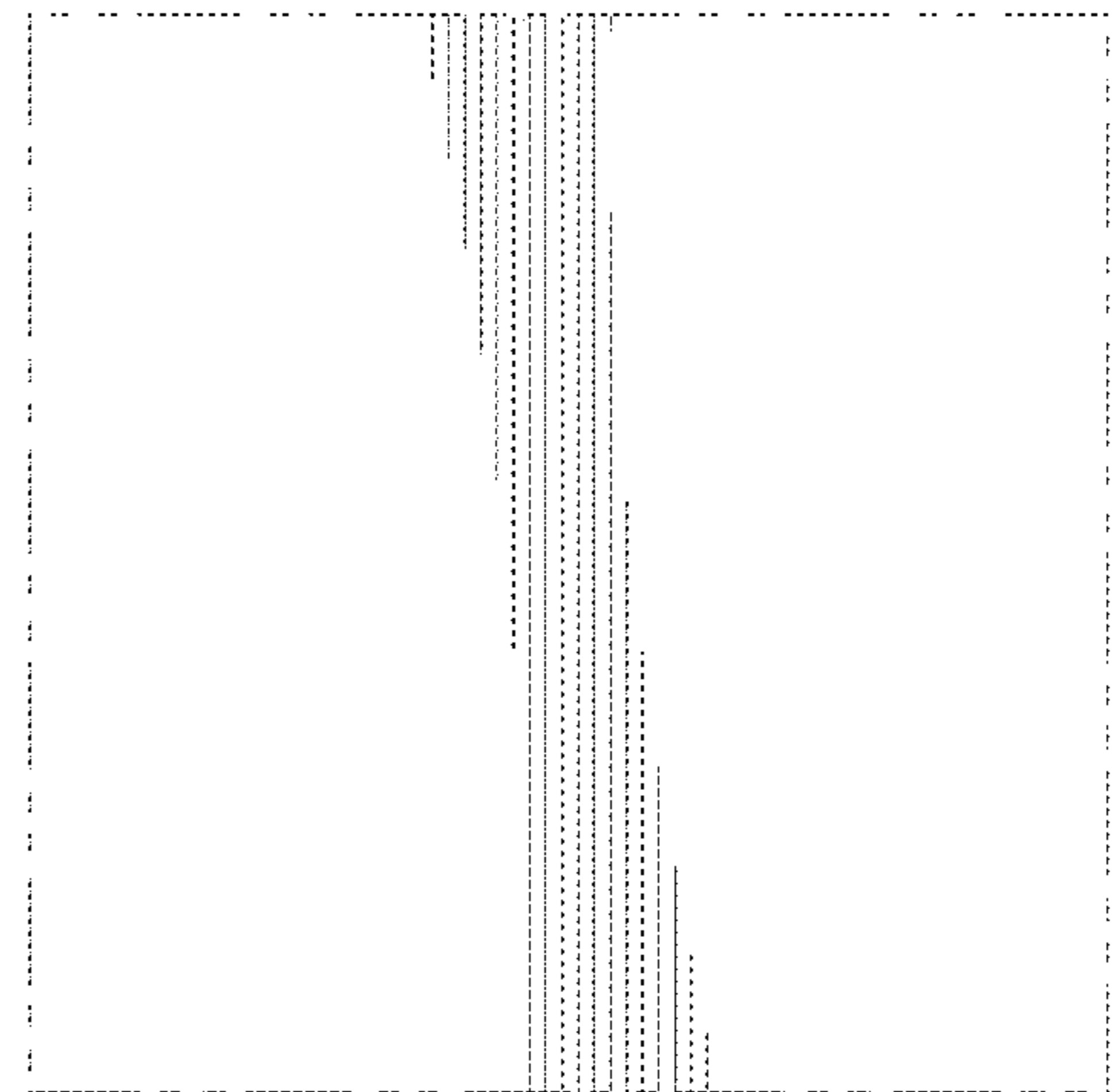


FIG. 4

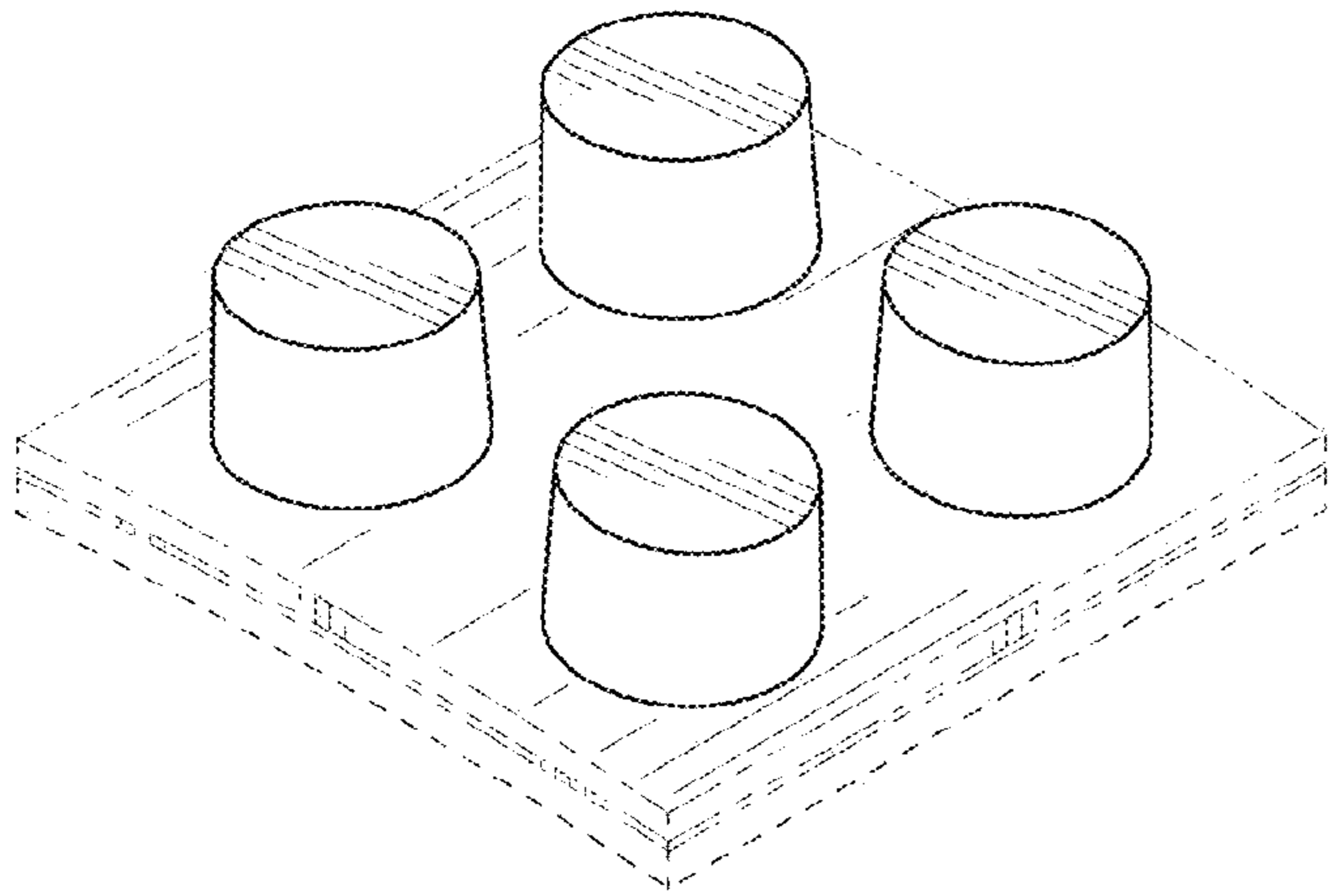


FIG. 5

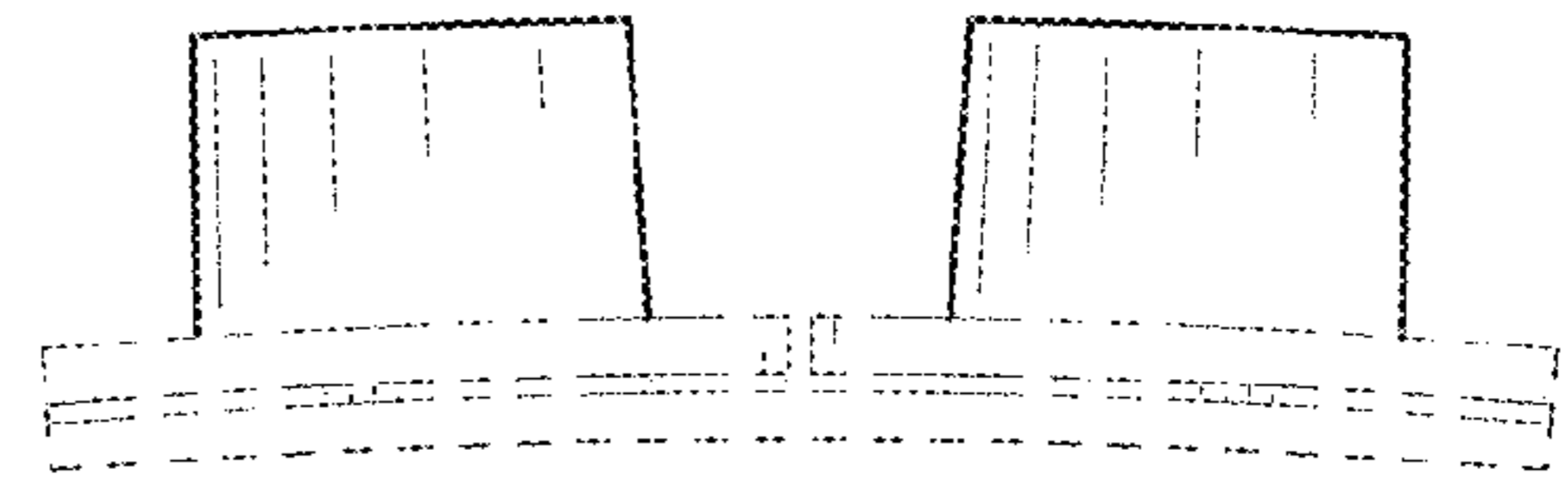


FIG. 6

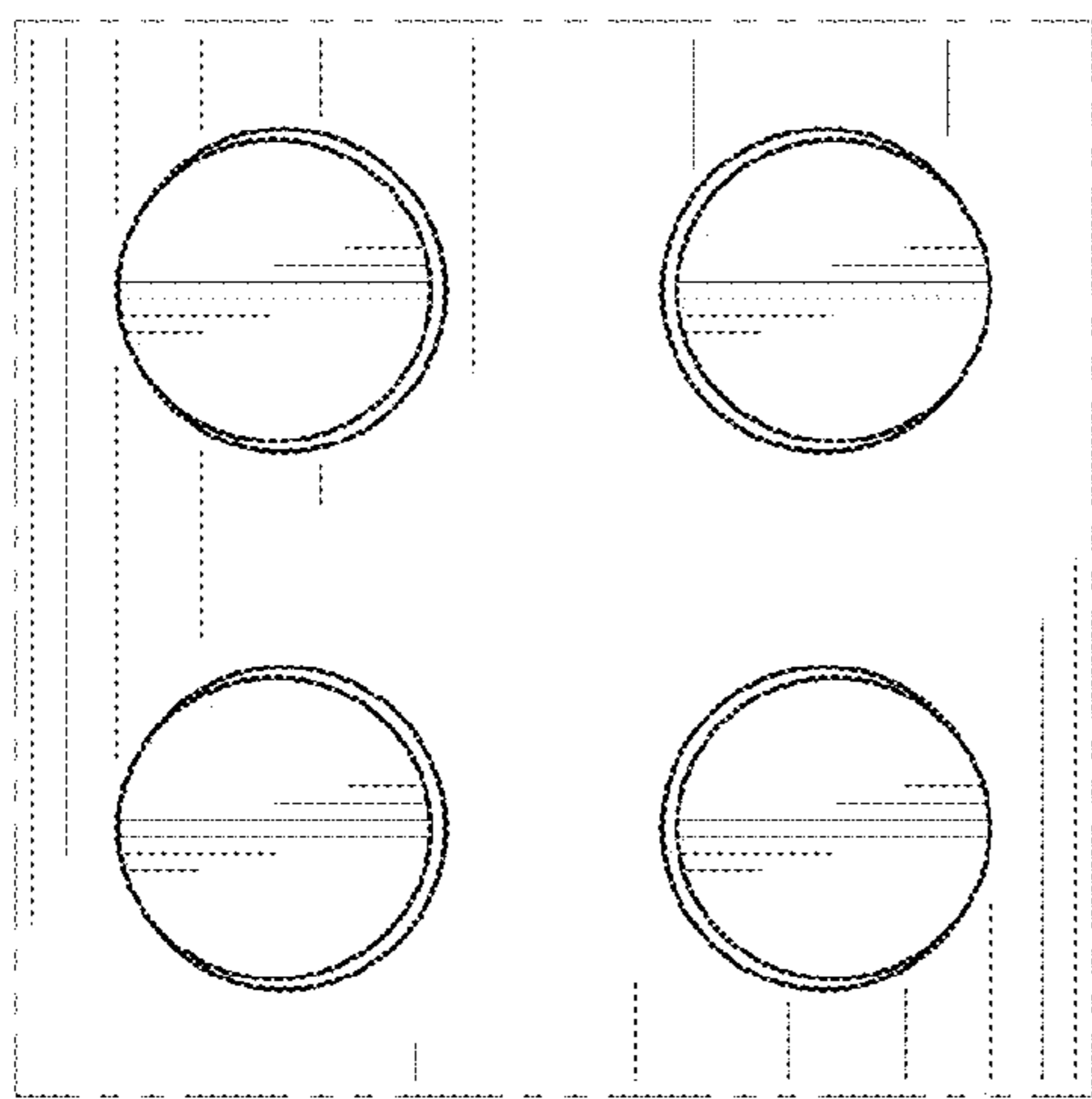


FIG. 7

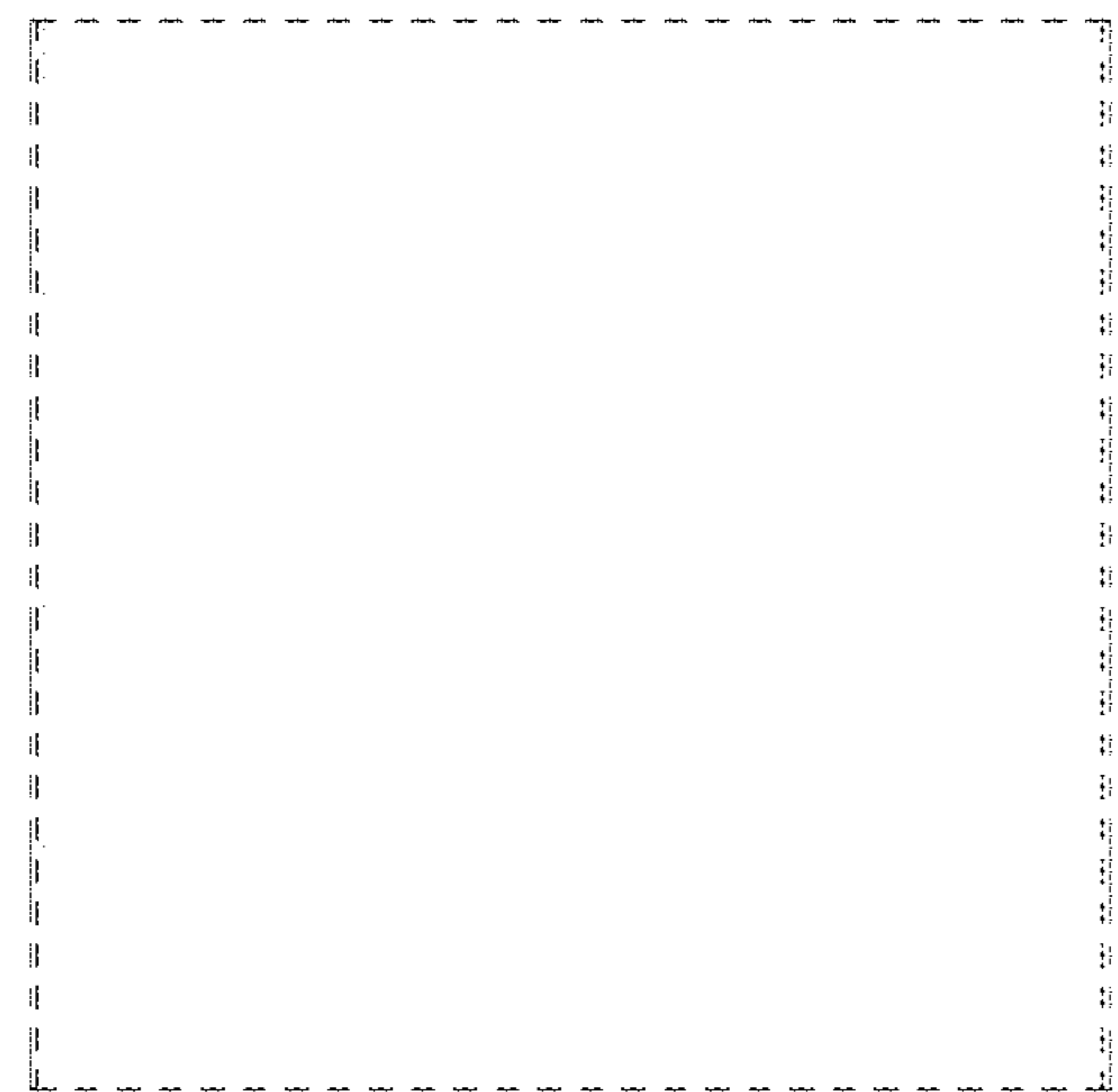


FIG. 8