



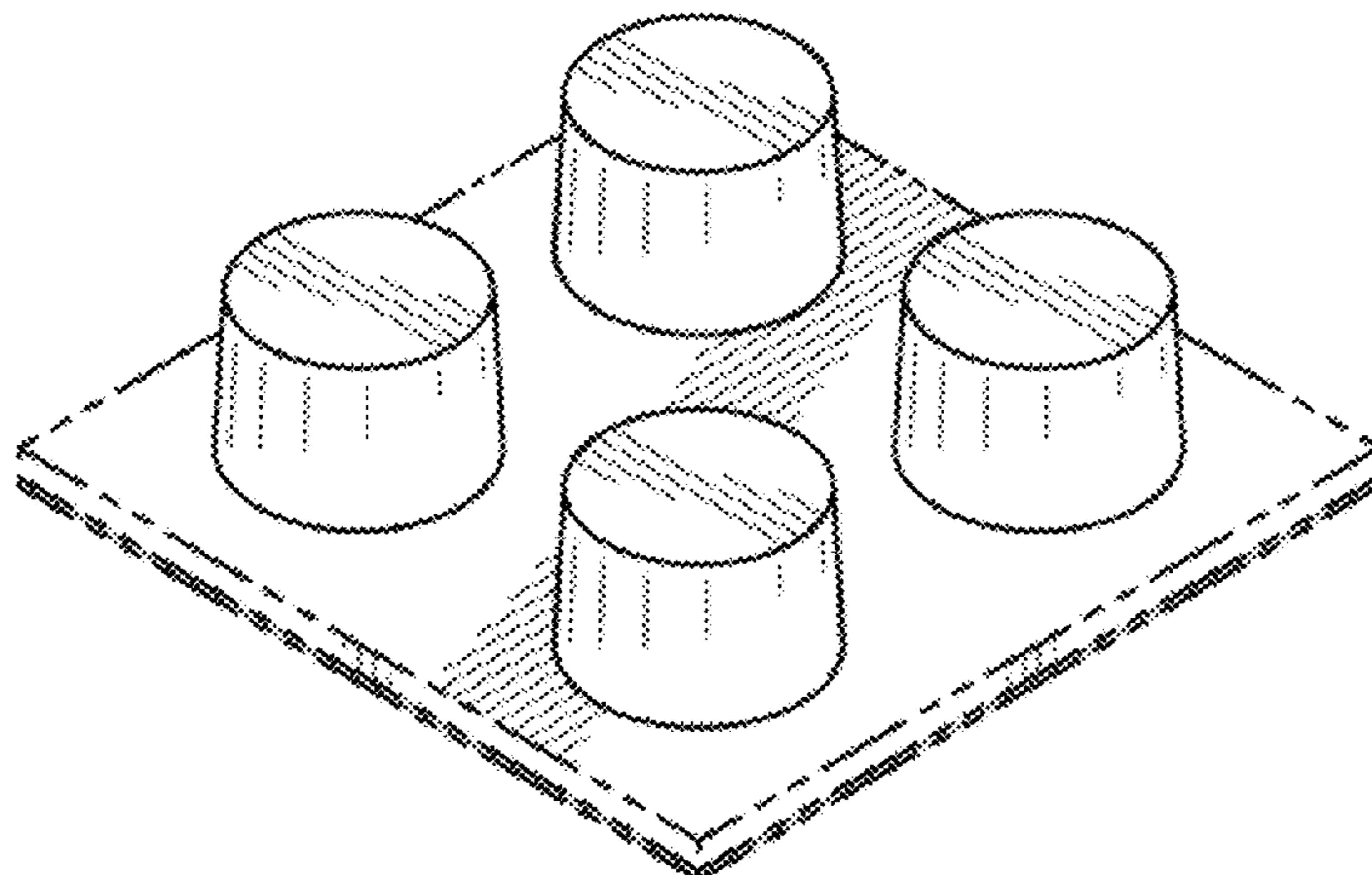
US00D903610S

(12) **United States Design Patent** (10) **Patent No.:** **US D903,610 S**
Cola et al. (45) **Date of Patent:** **** *Dec. 1, 2020**

- (54) **FLEXIBLE HEAT SINK** 5,369,301 A * 11/1994 Hayashi H01L 21/4882
165/80.3
- (71) Applicant: **Carbice Corporation**, Atlanta, GA 5,763,296 A 6/1998 Casati
(US) D398,295 S * 9/1998 Chang D13/179
5,912,805 A * 6/1999 Freuler H01L 23/4275
156/346
- (72) Inventors: **Baratunde Cola**, Atlanta, GA (US); 5,991,155 A 11/1999 Kobayashi
Craig Green, Atlanta, GA (US) 6,142,847 A * 11/2000 Rudy A63H 33/082
446/122
- (73) Assignee: **CARBICE CORPORATION**, Atlanta, 6,221,463 B1 * 4/2001 White F28F 3/04
GA (US) 428/174
- (*) Notice: This patent is subject to a terminal dis- 6,250,127 B1 6/2001 Polese
claimer. 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
- (**) Term: **15 Years**
- (21) Appl. No.: **29/703,632**
- (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
See application file for complete search history.

(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 |
| 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 |
| 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 |



US D903,610 S

Page 2

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 Huang
 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 Yao
 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 Cola
 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 Draenkow 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	303114809	2/2015
CN	303114811	* 2/2015
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
WO	1996006321	2/1996
WO	2013007645	1/2013
WO	2017087136	5/2017

OTHER PUBLICATIONS

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).*

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=ta2vwQrOq14>) (Year: 2018).*

Thermocool, "Copper base bonded fin heatsink", first cached on Jul. 6, 2017. (<https://thermocoolcorp.com/project/copper-base-bonded-fin-heatsink/>) (Year: 2017).*

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).*

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).

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 (unpublished application).

* cited by examiner

Primary Examiner — April Rivas

(74) *Attorney, Agent, or Firm* — Pabst Patent Group LLP

(57) **CLAIM**

We claim the ornamental design for a flexible heat sink, as follows.

DESCRIPTION

The patent or application file contains at least one drawing executed in color. Copies of this patent or patent application publication with color drawing(s) will be provided by the Office upon request and payment of the necessary fee.

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

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 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;

FIG. 8 is a bottom view thereof; and

FIG. 9 is a top isometric view of a heat sink showing our new design in color;

FIG. 10 is a front elevation view thereof, each of the right elevation, left elevation, and rear elevation views being a mirror image thereof;

FIG. 11 is a top view thereof;

FIG. 12 is a bottom view thereof;

FIG. 13 is a top isometric view of the heat sink illustrated in FIGS. 10 to 13 on a curved surface;

FIG. 14 is a front elevation view thereof, the rear elevation view being a mirror image thereof;

FIG. 15 is a top view thereof;

FIG. 16 is a bottom view thereof; and

FIG. 17 is a top isometric view of a heat sink showing our new design in color;

FIG. 18 is a front elevation view thereof, each of the right elevation, left elevation, and rear elevation views being a mirror image thereof;

FIG. 19 is a top view thereof;

FIG. 20 is a bottom view thereof;

FIG. 21 is a top isometric view of the heat sink illustrated in FIGS. 17 to 20 on a curved surface;

FIG. 22 is a front elevation view thereof, the rear elevation view being a mirror image thereof;

FIG. 23 is a top view thereof; and,

FIG. 24 is a bottom view thereof.

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

The white and black broken dash-dot-dot lines in the views define boundary lines and 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.

1 Claim, 6 Drawing Sheets
(2 of 6 Drawing Sheet(s) Filed in Color)

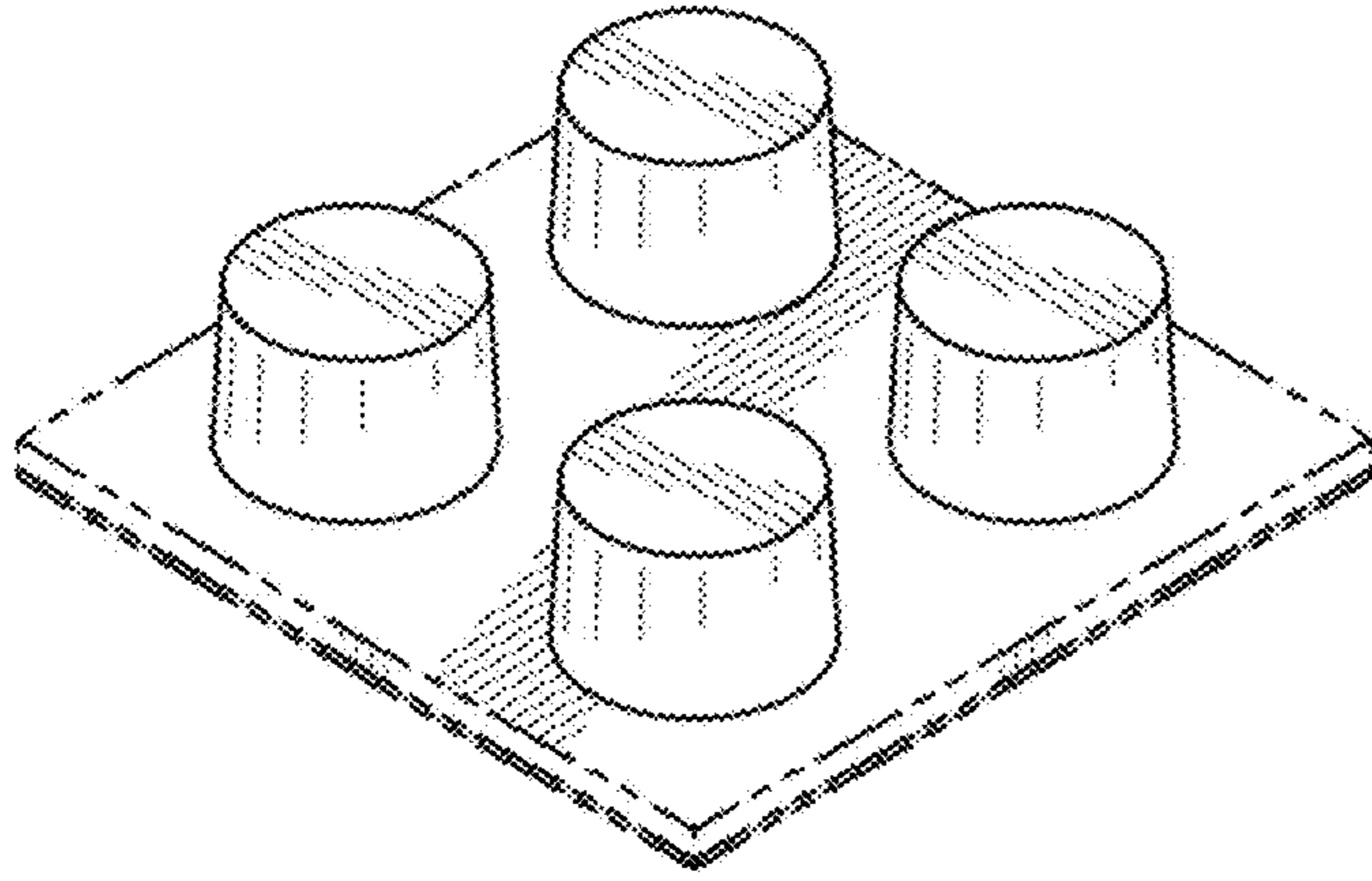


FIG. 1

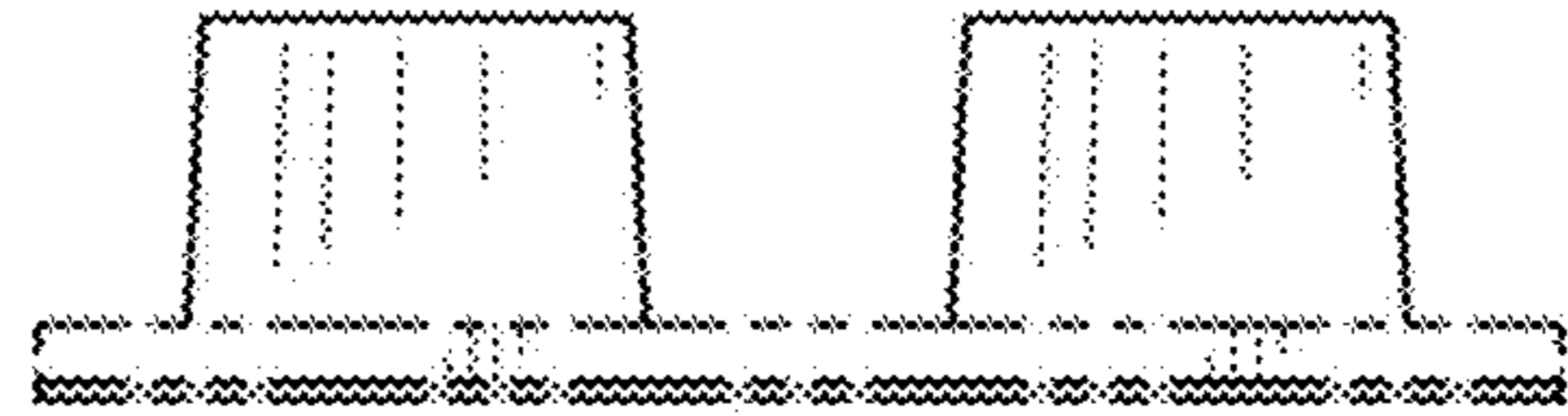


FIG. 2

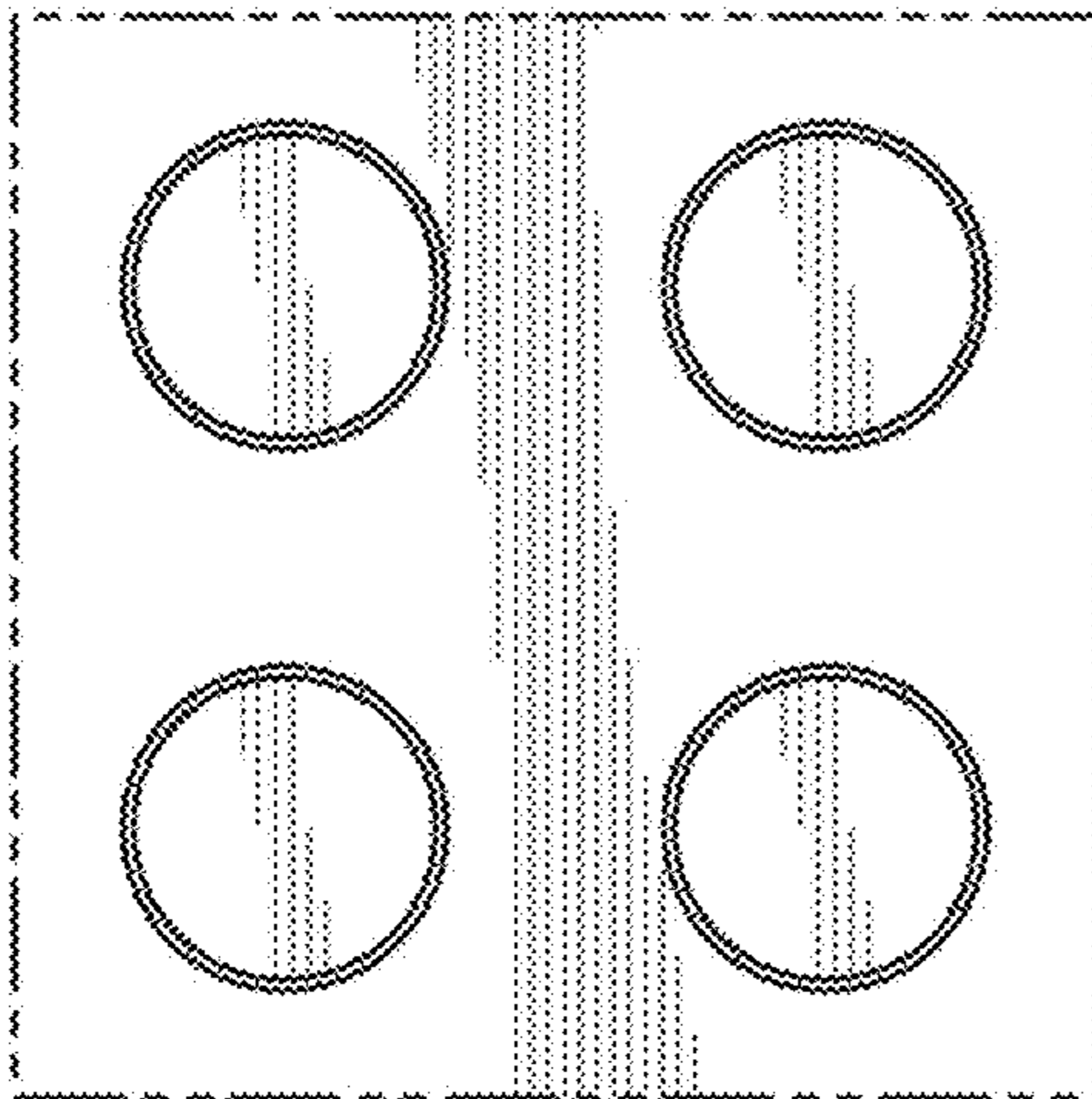


FIG. 3

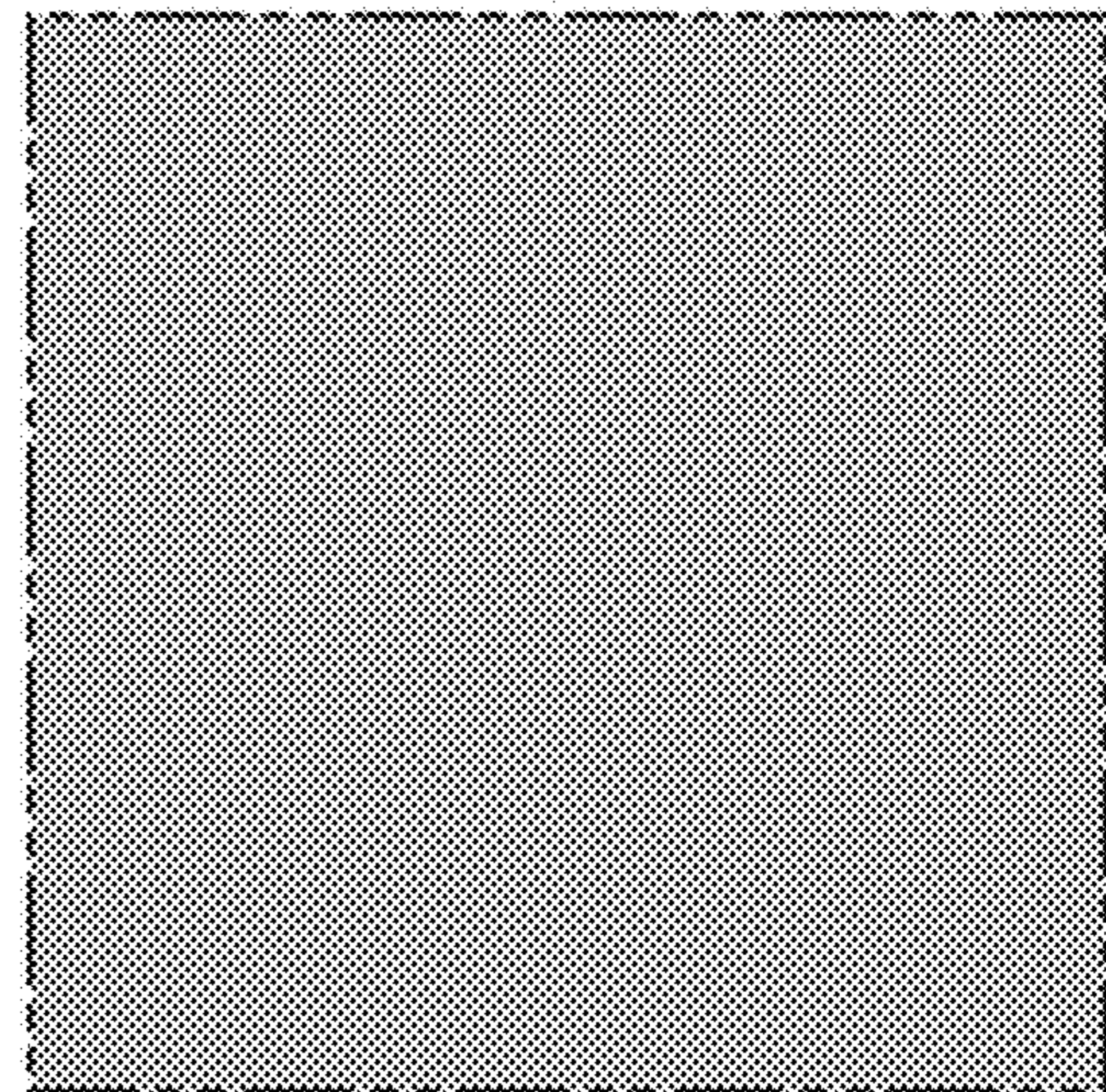


FIG. 4

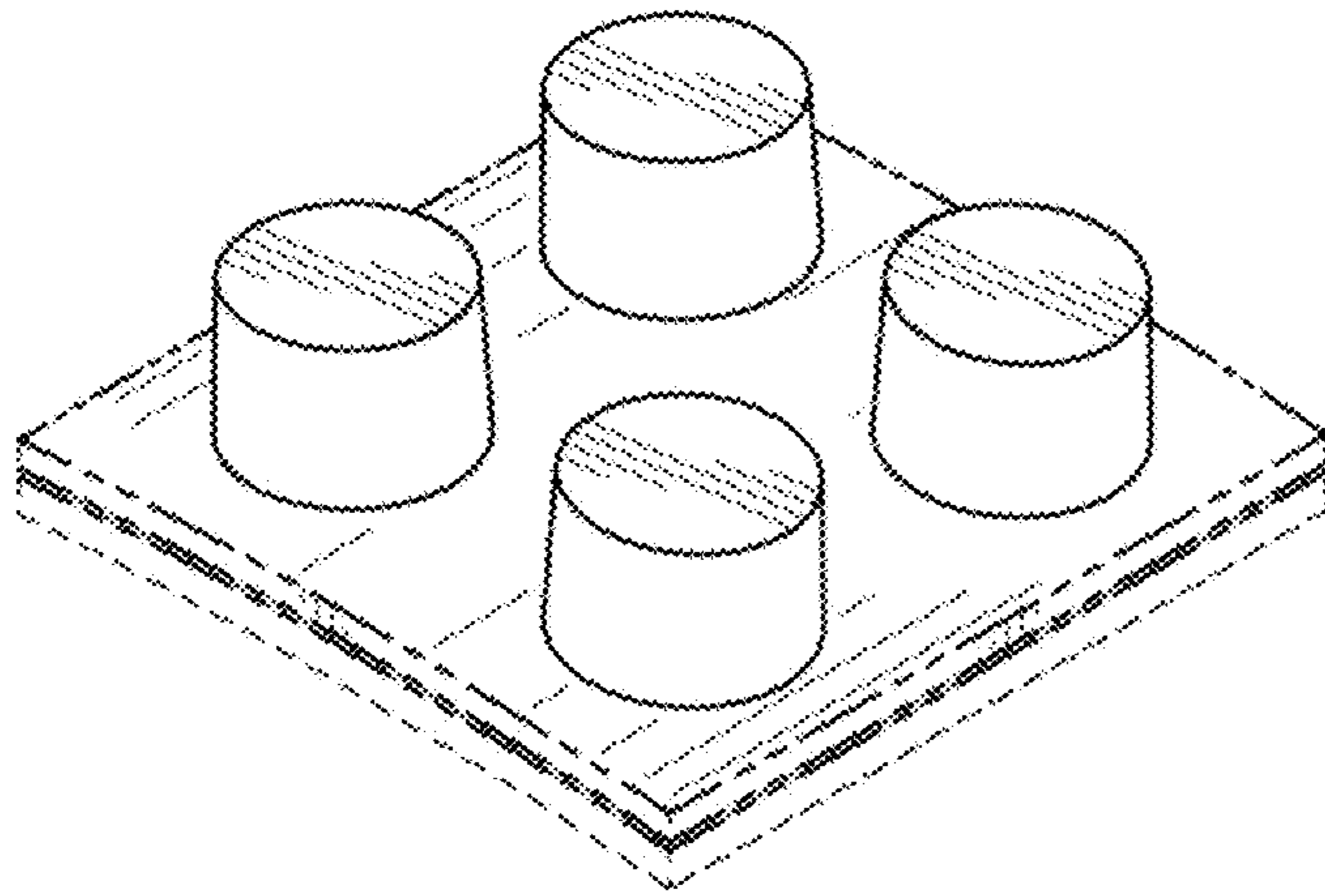


FIG. 5



FIG. 6

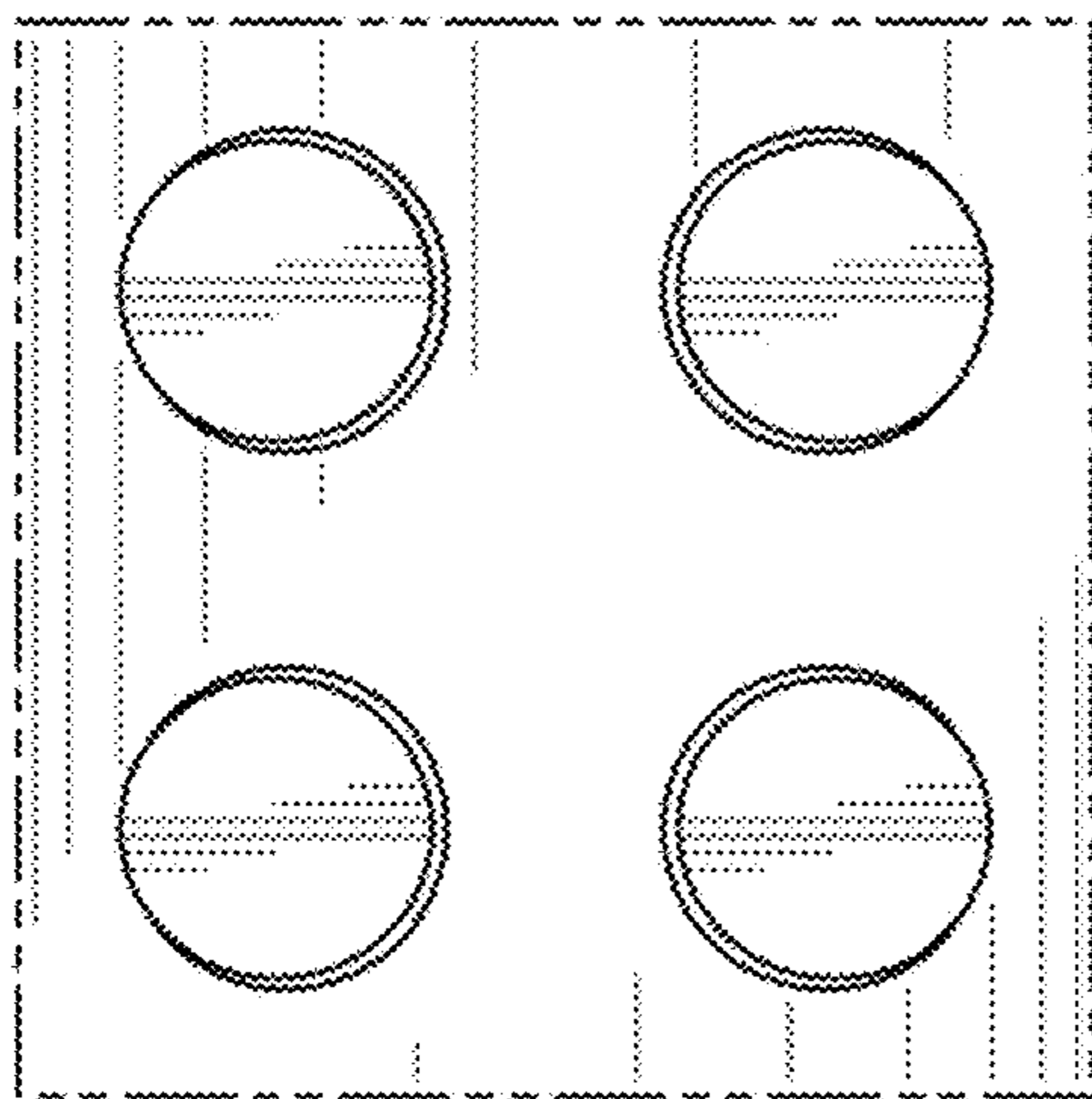


FIG. 7

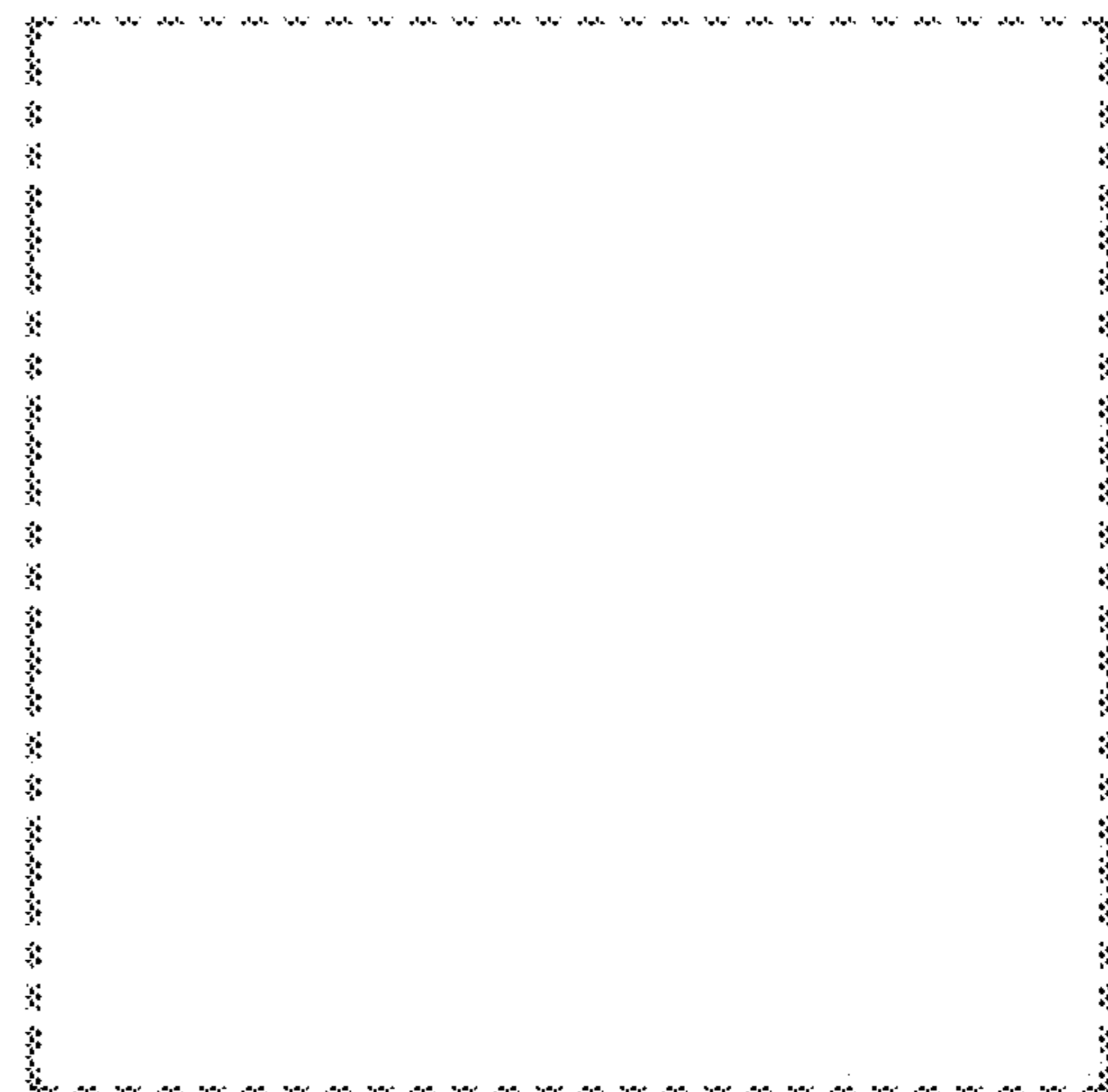


FIG. 8

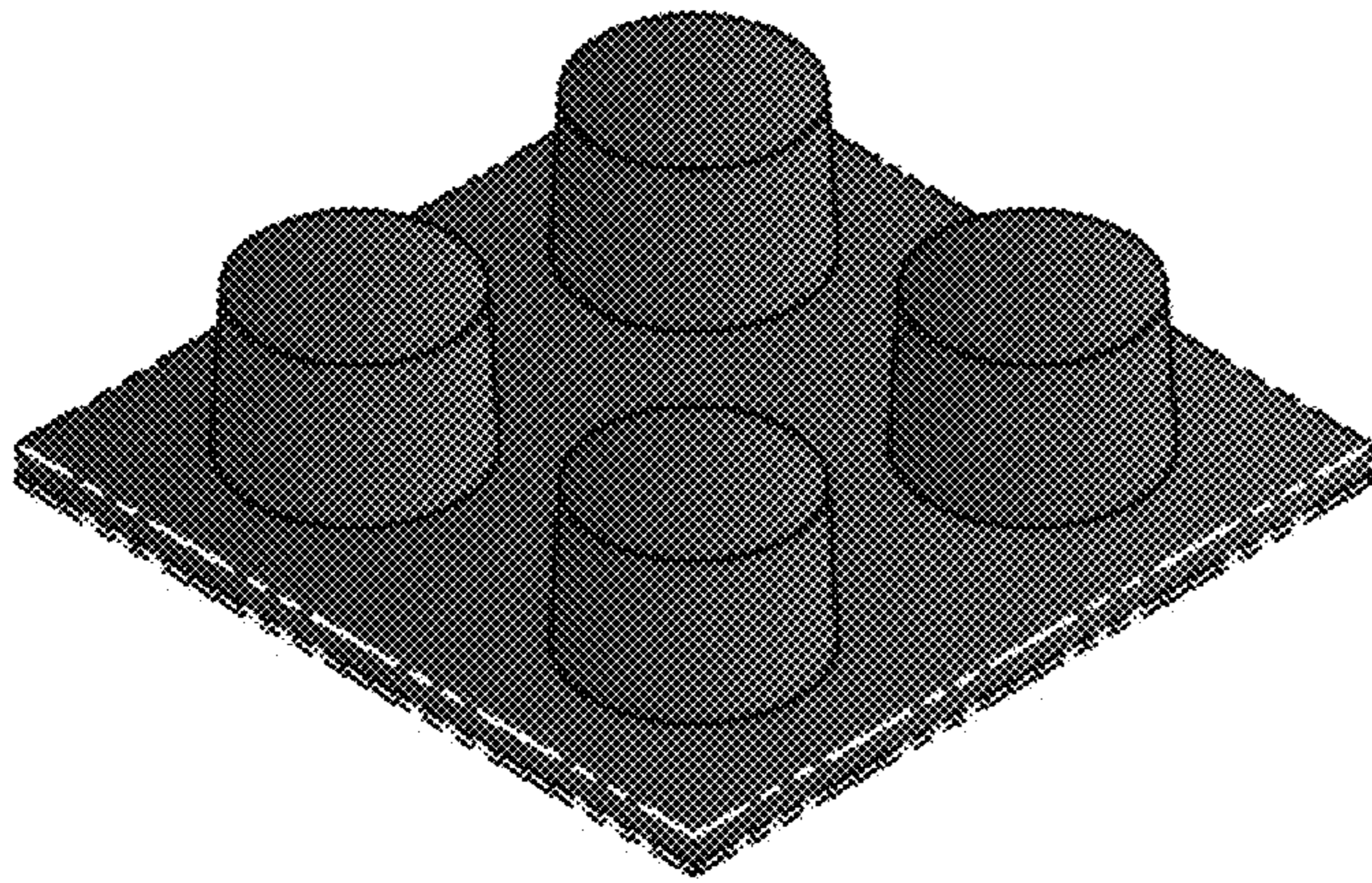


FIG. 9

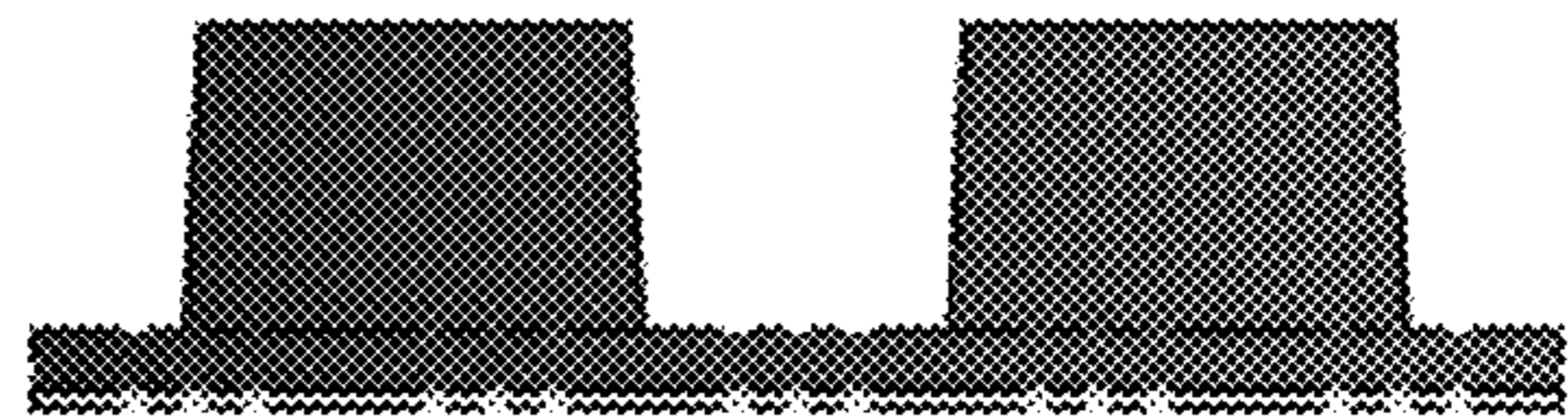


FIG. 10

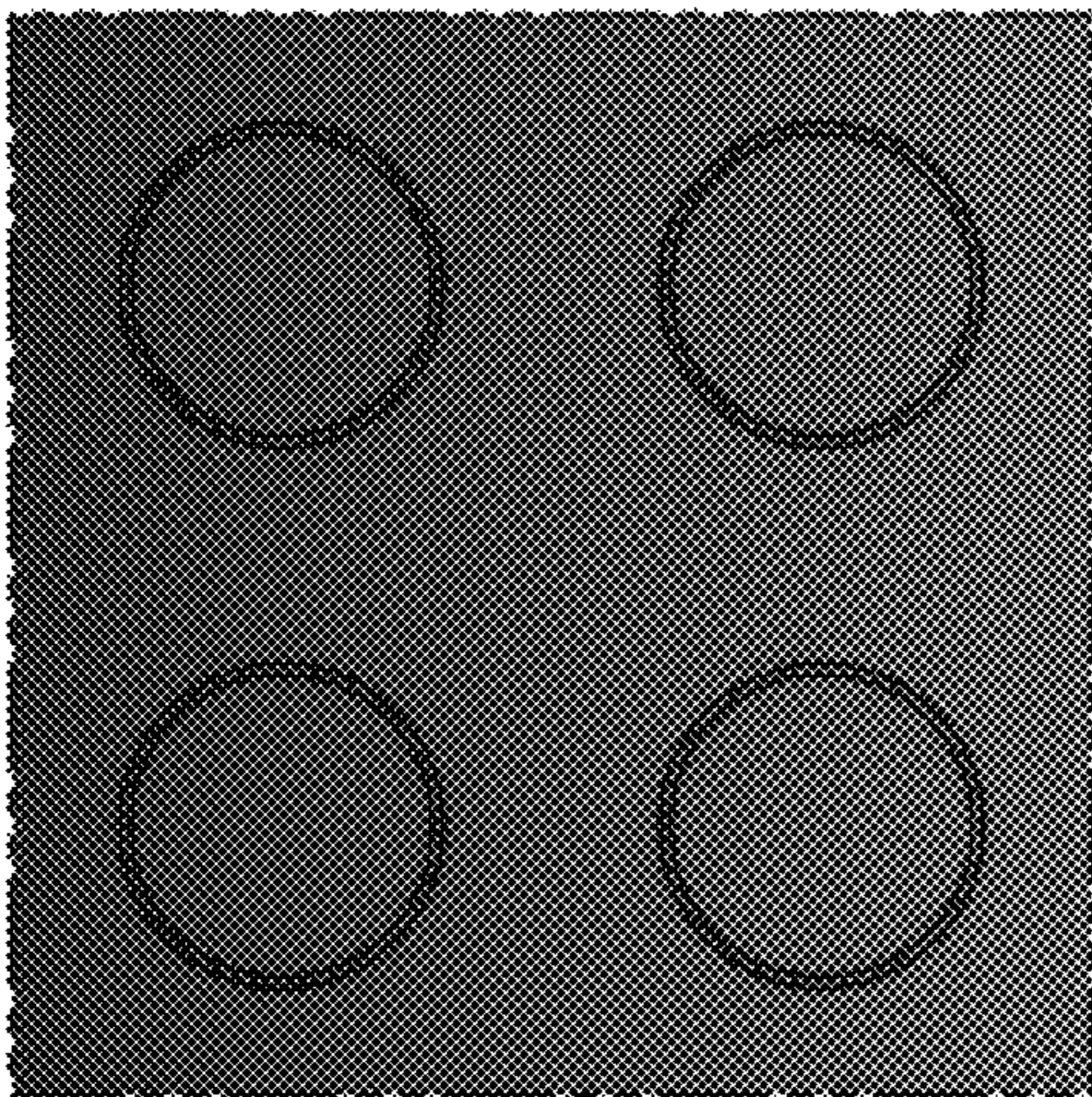


FIG. 11

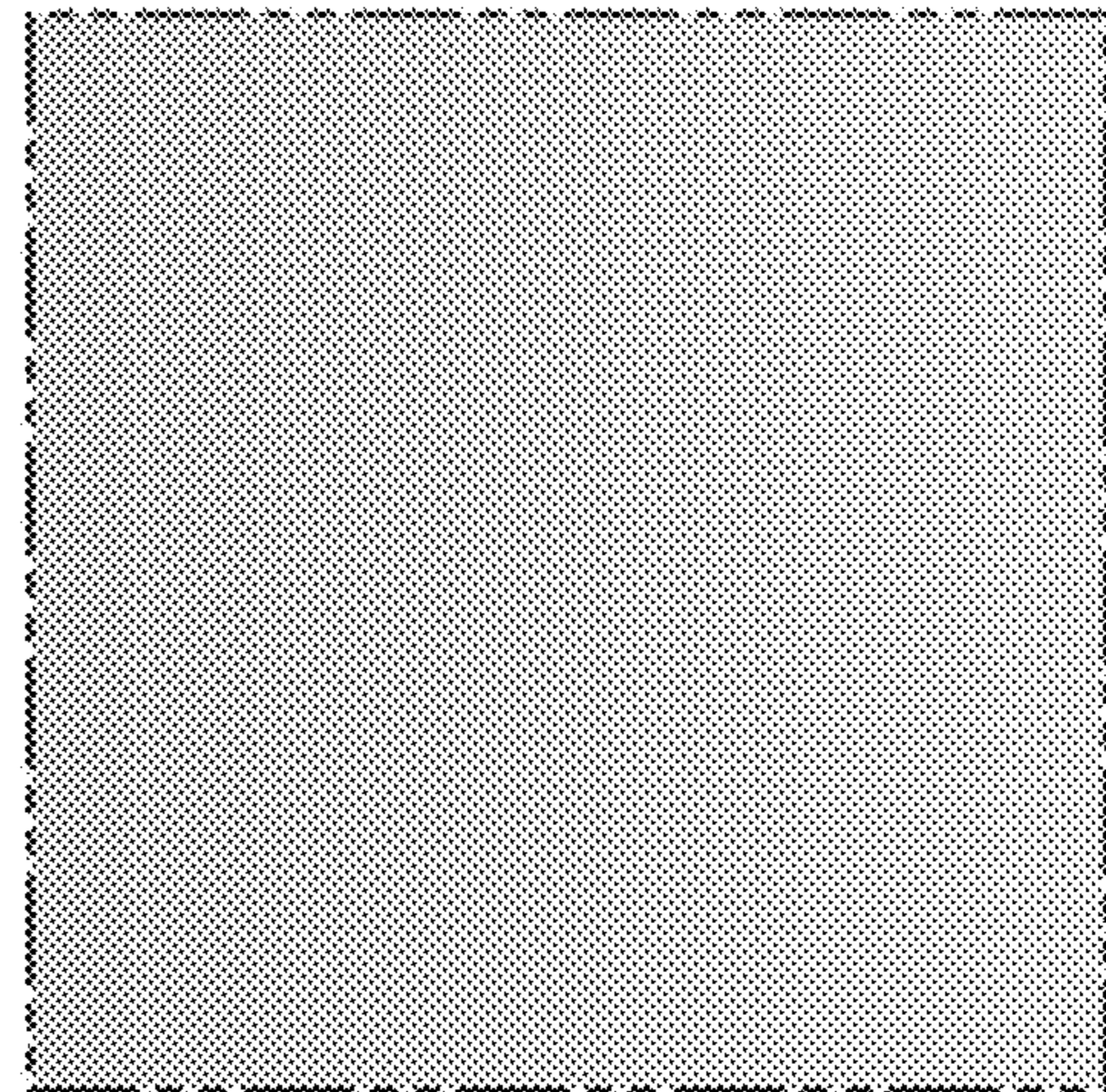


FIG. 12

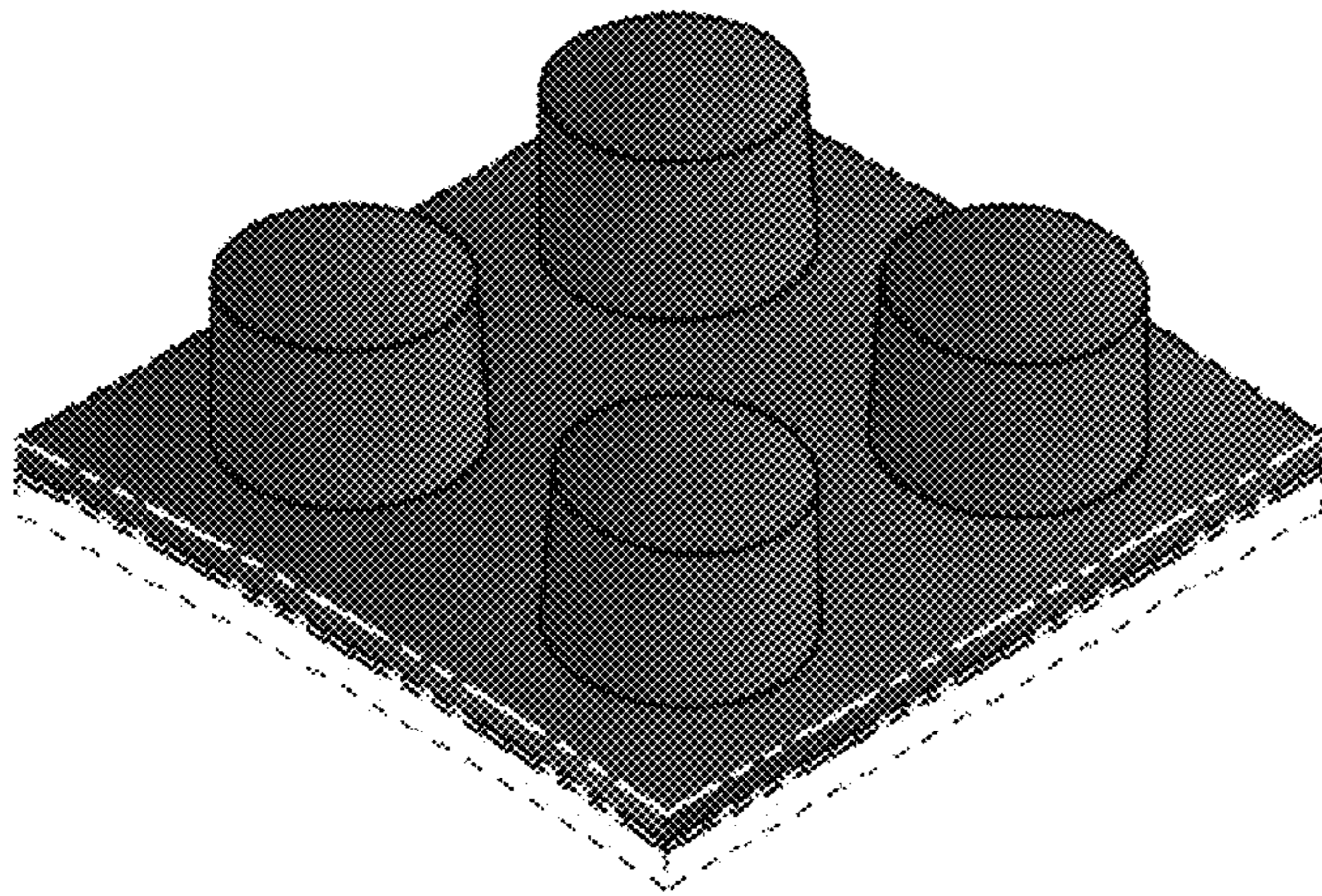


FIG. 13

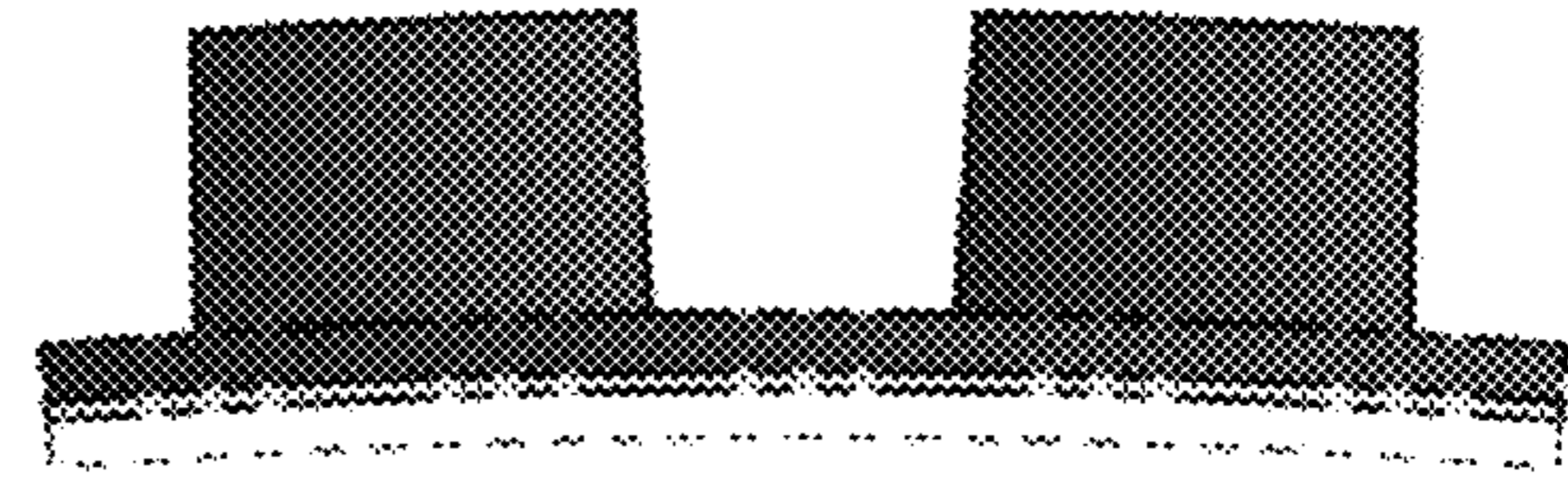


FIG. 14

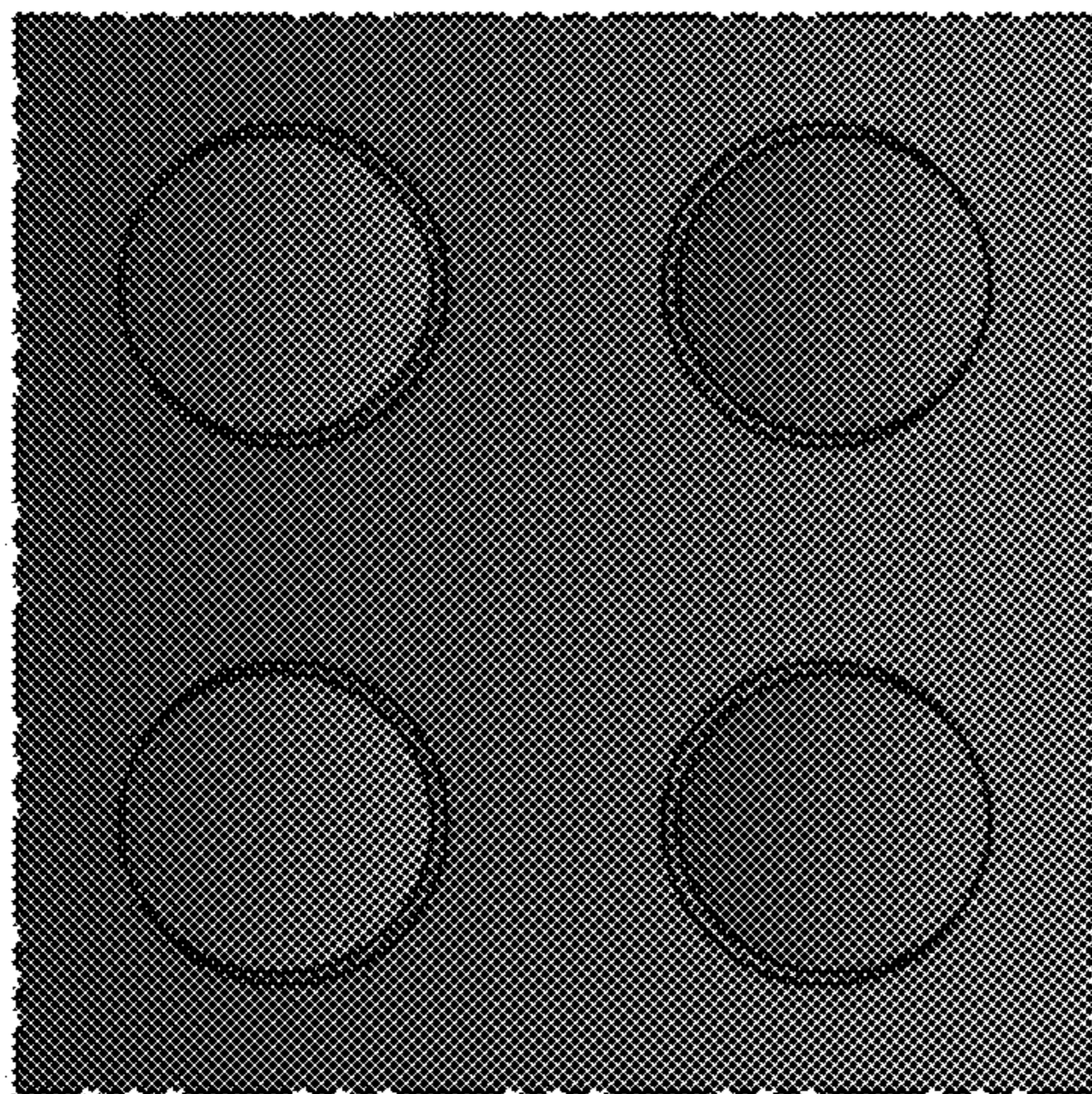


FIG. 15

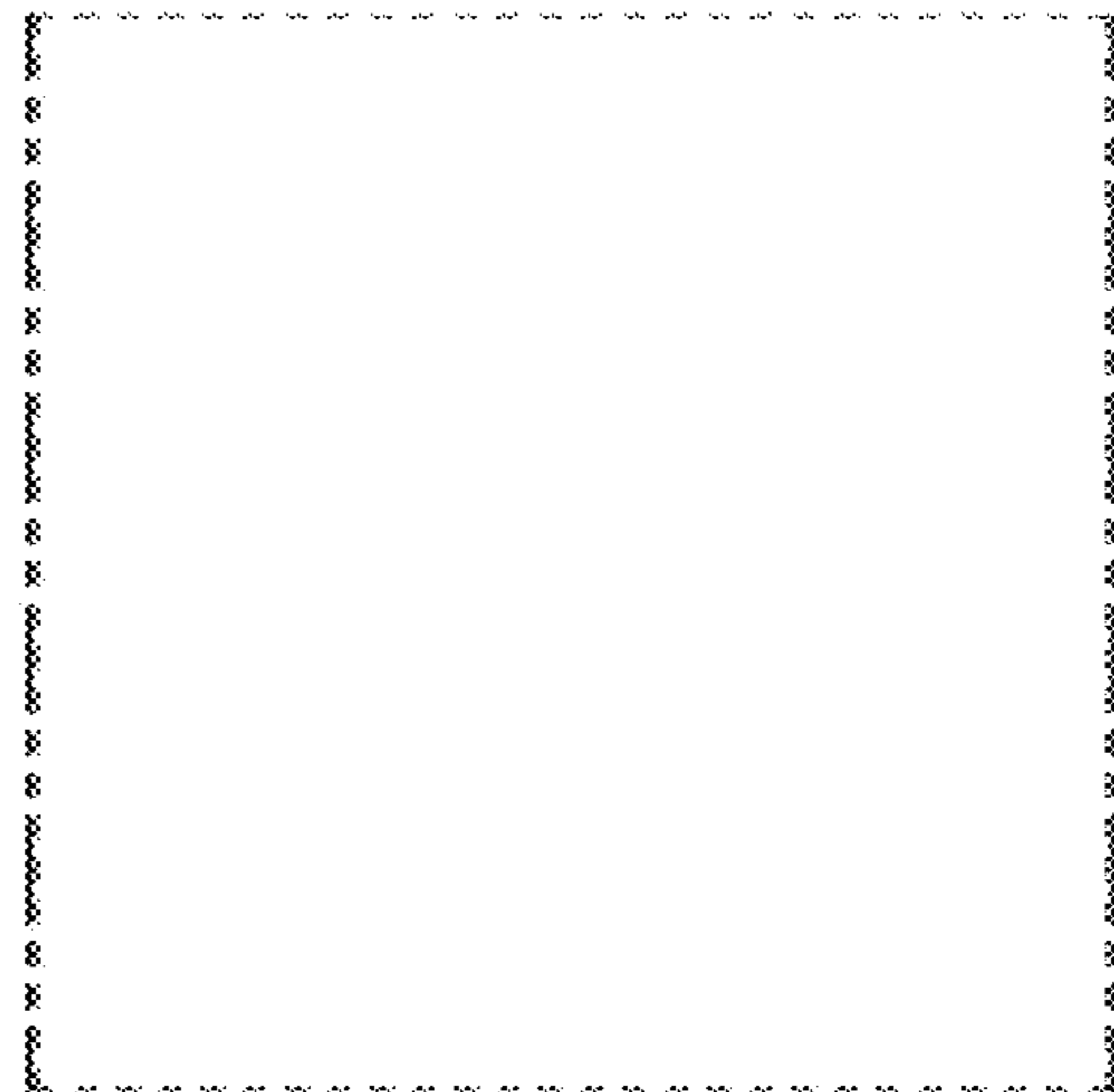


FIG. 16

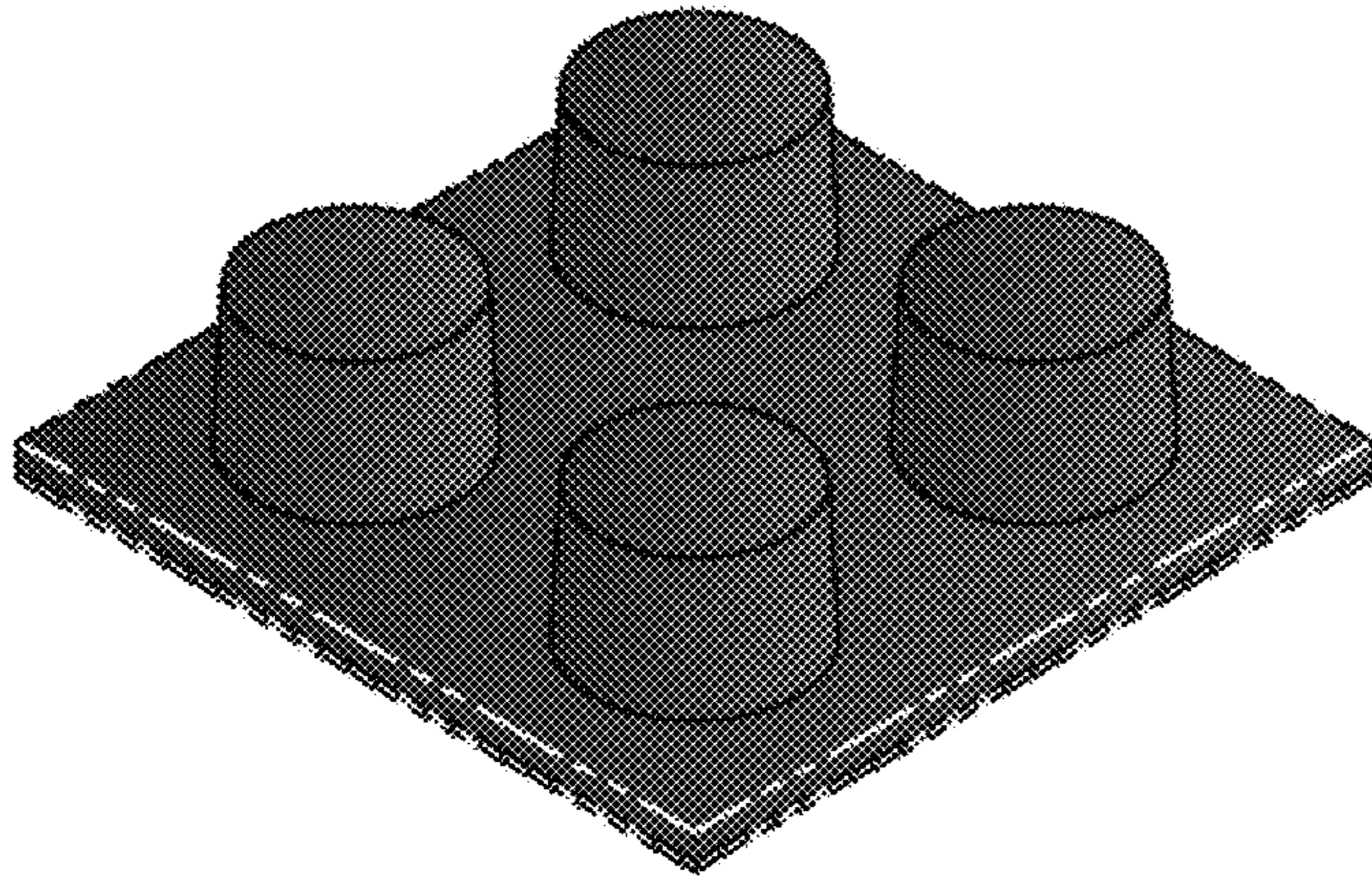


FIG. 17

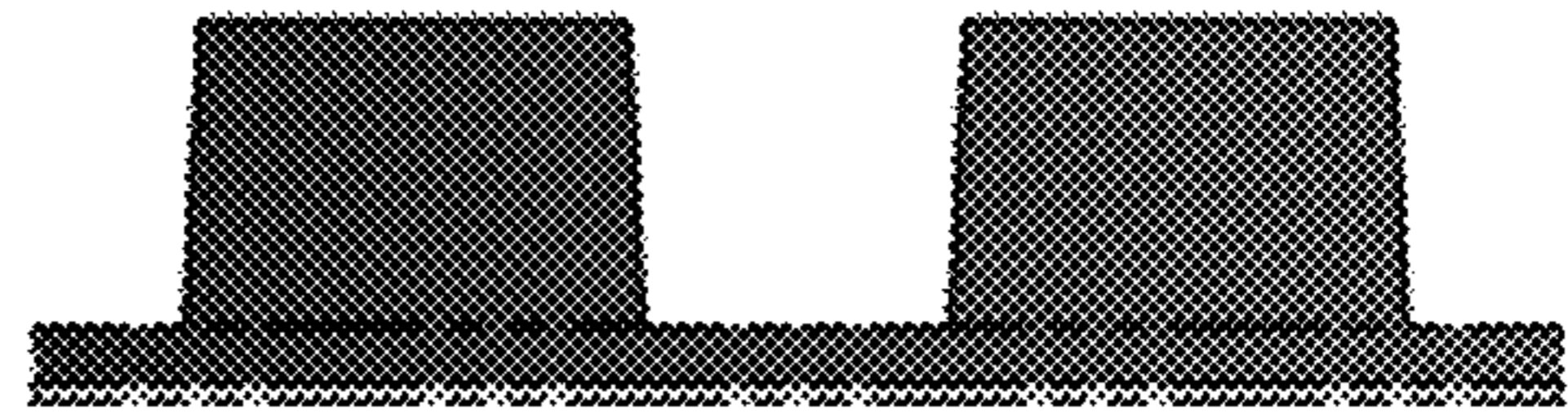


FIG. 18

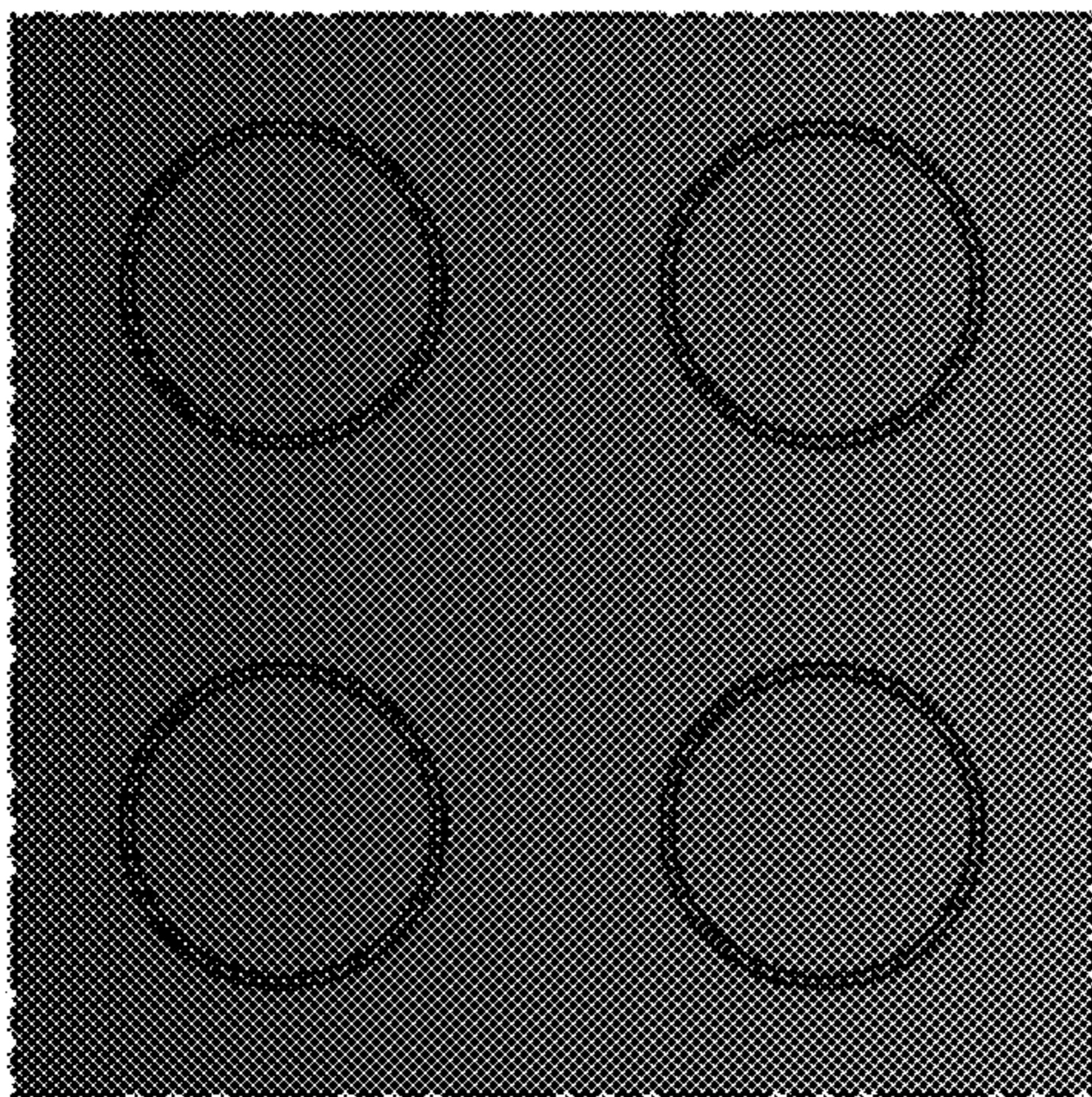


FIG. 19

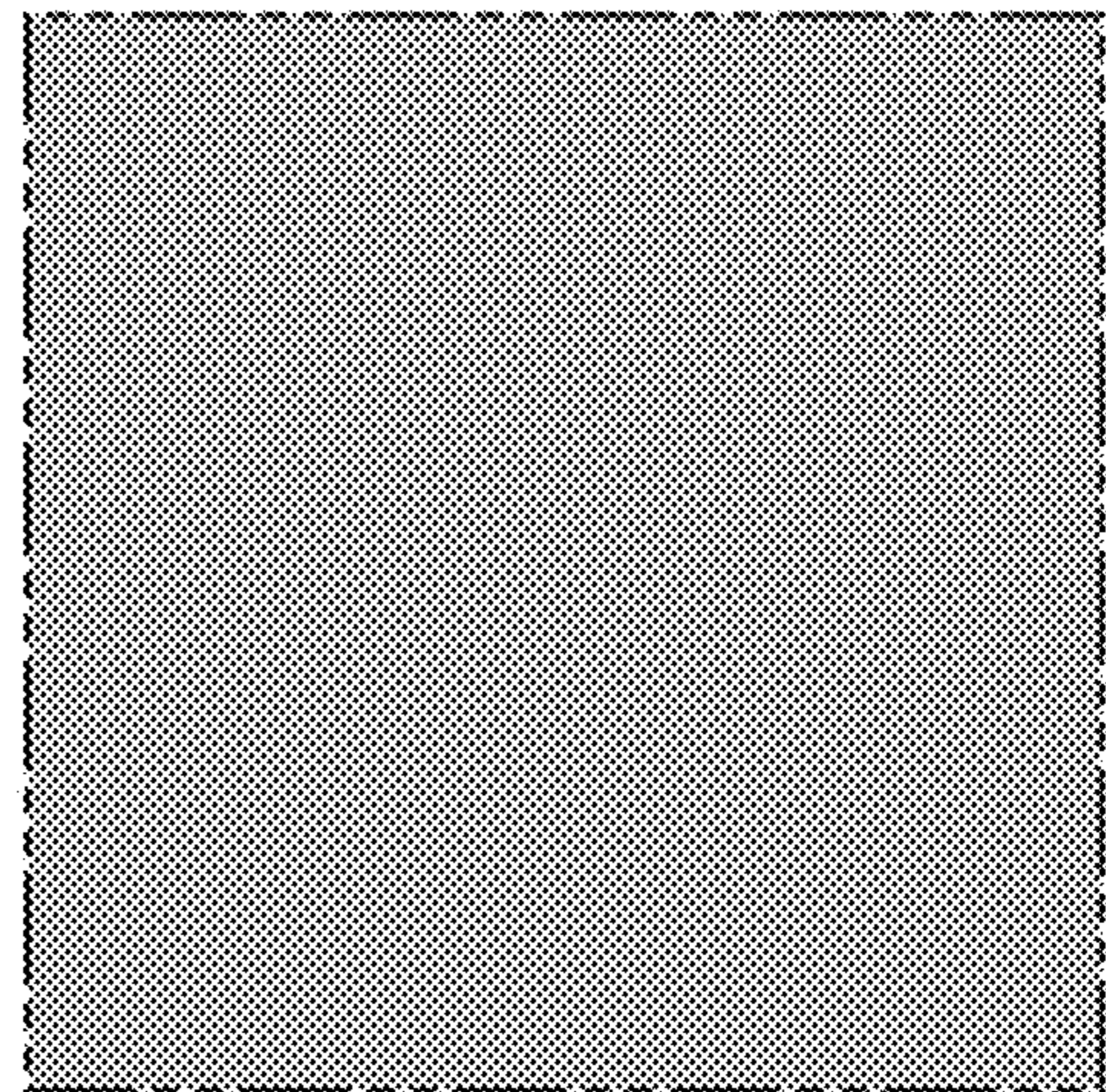


FIG. 20

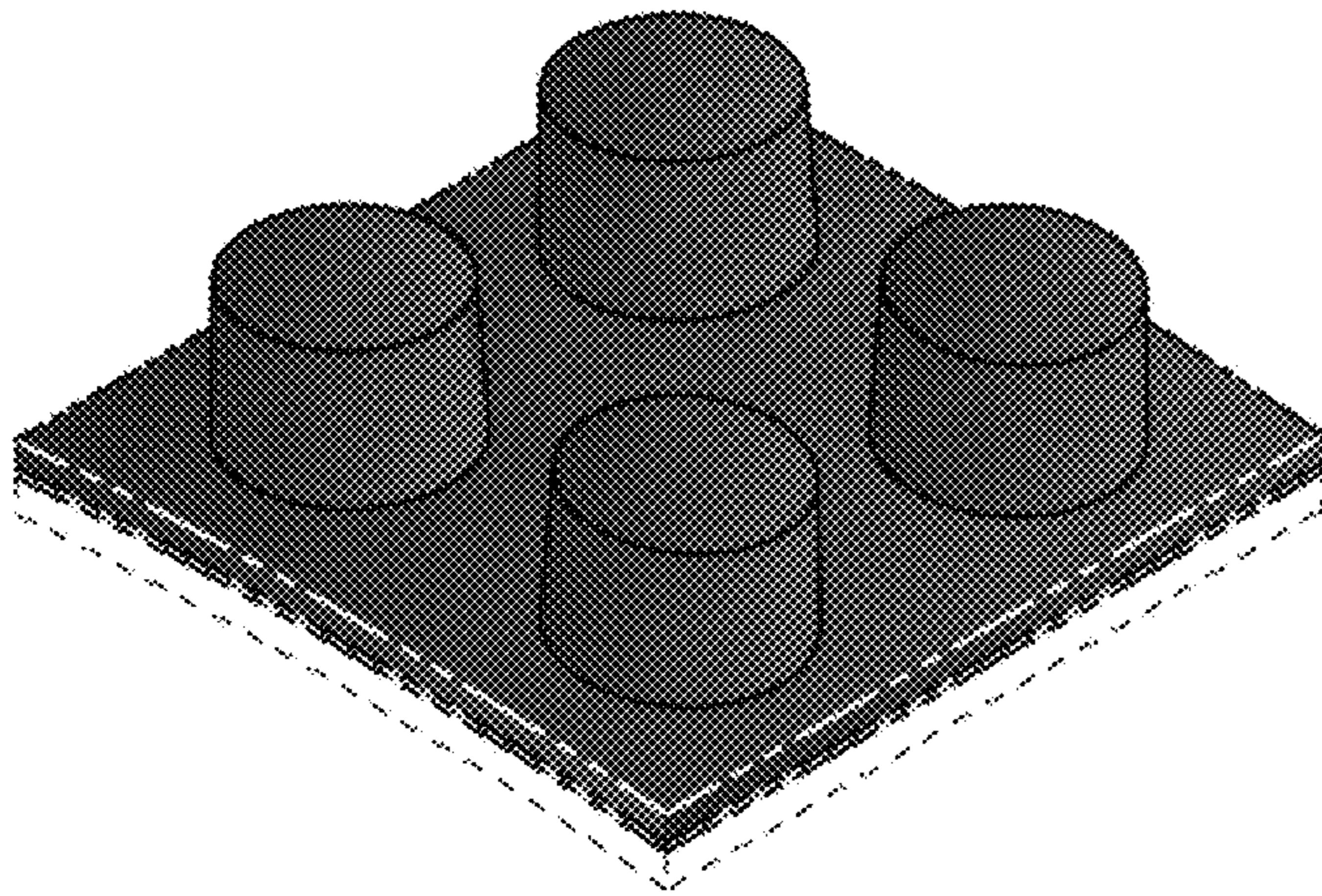


FIG. 21

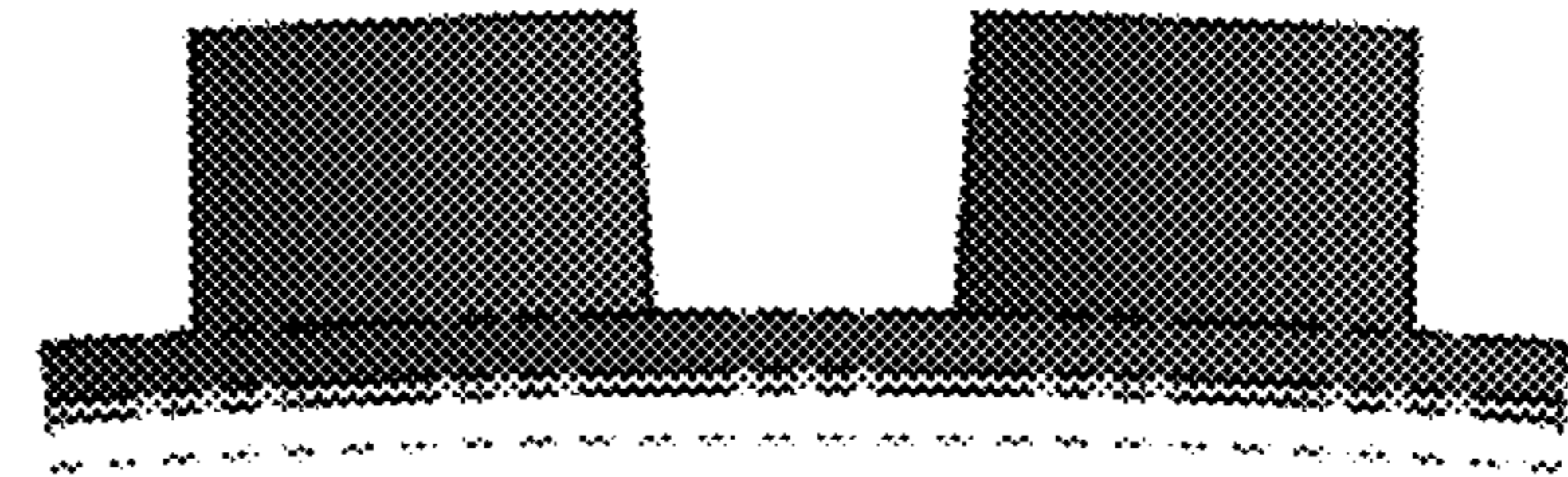


FIG. 22

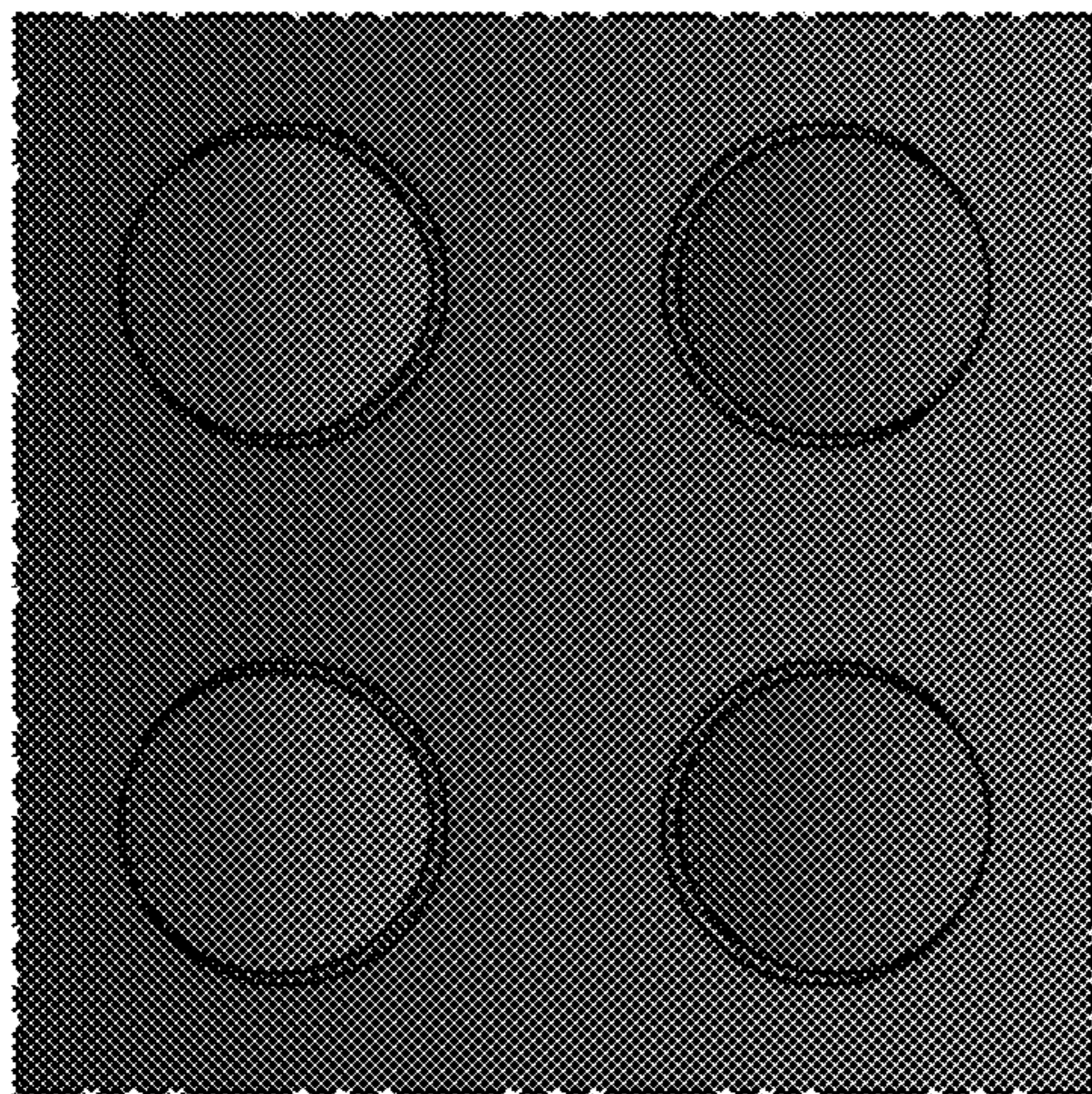


FIG. 23

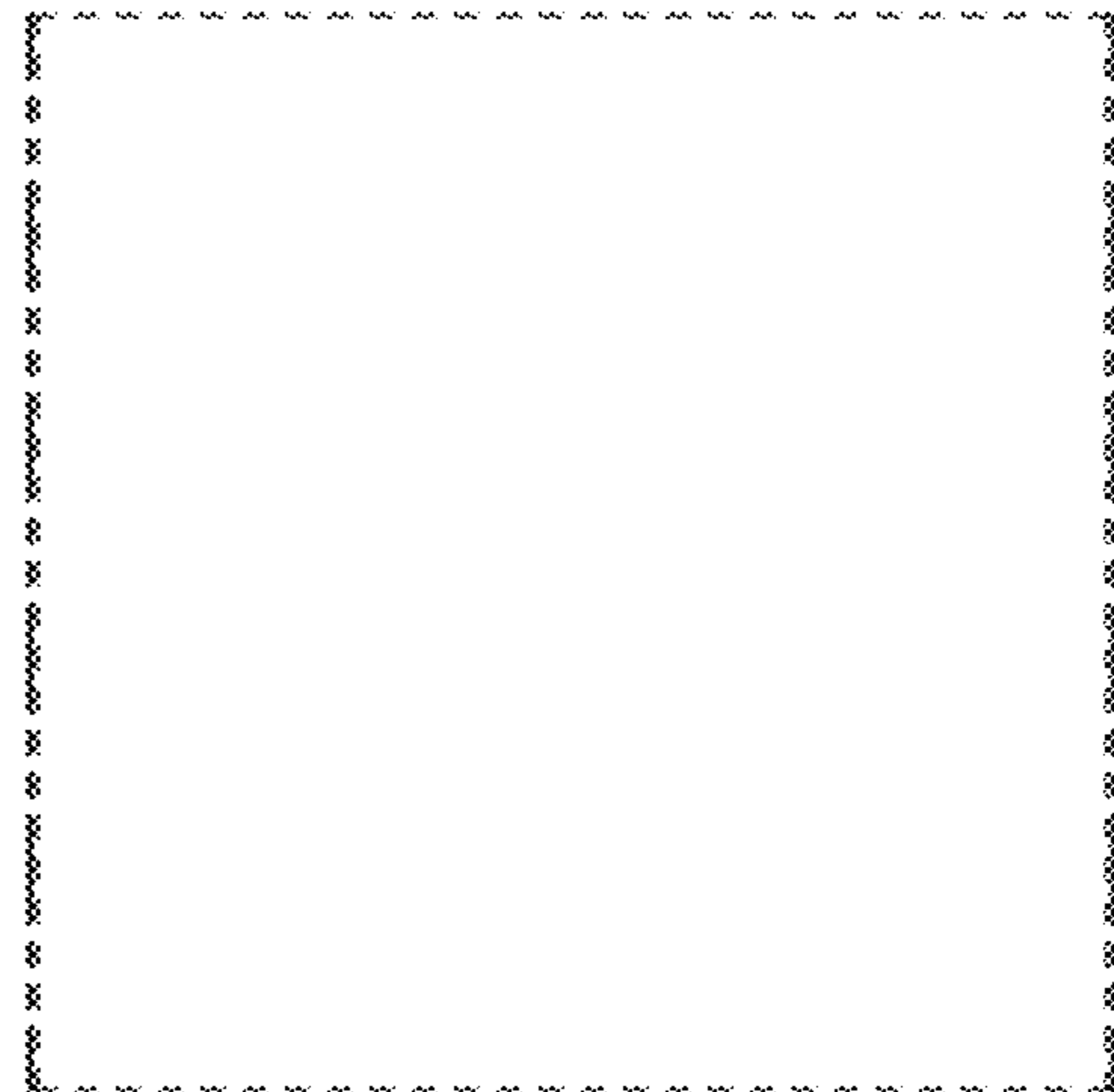


FIG. 24