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(12) United States Design Patent

Banes et al.

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(54) **APPARATUS FOR PATTERNING CELLS**

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

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Related U.S. Application Data

(63) Continuation of application No. 13/921,887, filed on Jun. 19, 2013, now abandoned.

(51) **LOC (12) Cl.** **24-02**

(52) **U.S. Cl.**
USPC **D24/224**

(58) **Field of Classification Search**
USPC D24/101, 103, 181, 224, 226, 229, 231; D7/672
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

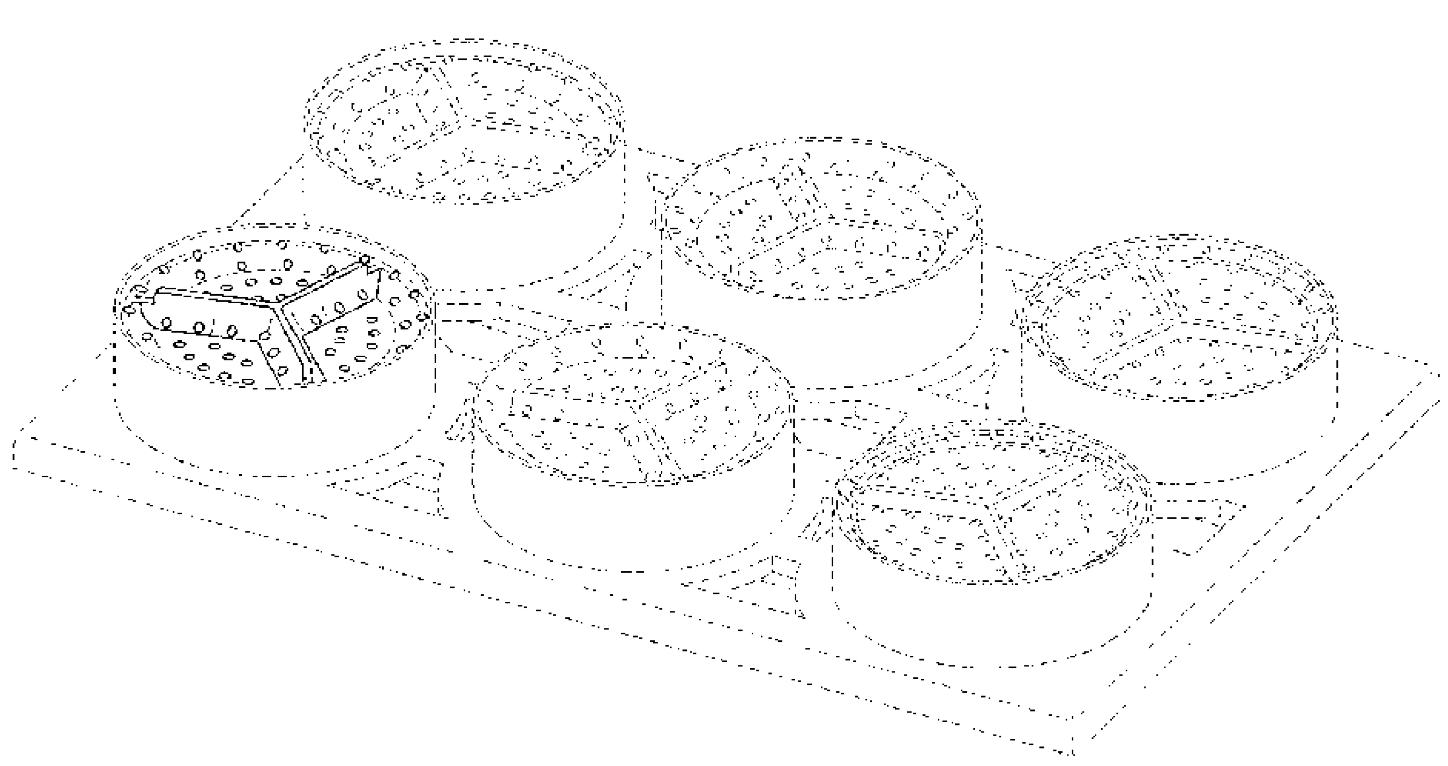
2,521,475 A 9/1950 Nickolas
4,087,327 A 5/1978 Feder et al.
4,228,243 A 10/1980 Iizuka
4,623,355 A 11/1986 Sawruk
4,642,220 A 2/1987 Bjorkman
4,695,547 A 9/1987 Hilliard et al.
4,831,869 A 5/1989 Fowler et al.
4,839,280 A 6/1989 Banes
4,839,292 A 6/1989 Cremonese
4,851,354 A 7/1989 Winston et al.
4,908,319 A 3/1990 Smyczek et al.
4,940,853 A 7/1990 Vandenburgh
4,974,952 A 12/1990 Focht
5,153,136 A 10/1992 Vandenburgh
5,240,854 A 8/1993 Berry et al.
5,273,905 A 12/1993 Muller et al.
5,348,879 A 9/1994 Shapiro et al.
5,414,556 A 5/1995 Focht
5,460,945 A 10/1995 Springer et al.
5,496,697 A 3/1996 Parce et al.
5,518,909 A 5/1996 Banes
5,686,303 A 11/1997 Korman
5,843,766 A 12/1998 Applegate et al.
D411,308 S * 6/1999 Pandey D24/216
5,958,760 A 9/1999 Freeman
6,015,590 A 1/2000 Suntola et al.
6,037,141 A 3/2000 Banes
6,048,723 A * 4/2000 Banes C12M 23/12 435/288.3
6,207,451 B1 3/2001 Dennis et al.
6,218,178 B1 4/2001 Banes
6,472,202 B1 10/2002 Banes
6,586,235 B1 7/2003 Banes
6,645,759 B2 11/2003 Banes
6,998,265 B2 2/2006 Banes
D522,145 S * 5/2006 Best D10/81
7,186,548 B2 3/2007 Li
7,738,682 B2 6/2010 Banes et al.
D632,386 S * 2/2011 Chang D24/101
D697,073 S * 1/2014 Andersson D14/485
D708,760 S * 7/2014 Smeja D24/229
D720,844 S * 1/2015 Wells D24/101
D736,403 S * 8/2015 Hudson D24/216
D754,840 S * 4/2016 Waldman D24/101
D767,163 S * 9/2016 Schimmel D24/226
D793,258 S * 8/2017 Buber D10/81
D828,122 S * 9/2018 Levine D7/675
2004/0142411 A1 7/2004 Kirk et al.
2005/0153273 A1 7/2005 Wikswo et al.
2006/0270023 A1 11/2006 LeDuc et al.
2007/0077653 A1 4/2007 Banes
2013/0337565 A1* 12/2013 Banes C12M 35/04 435/401

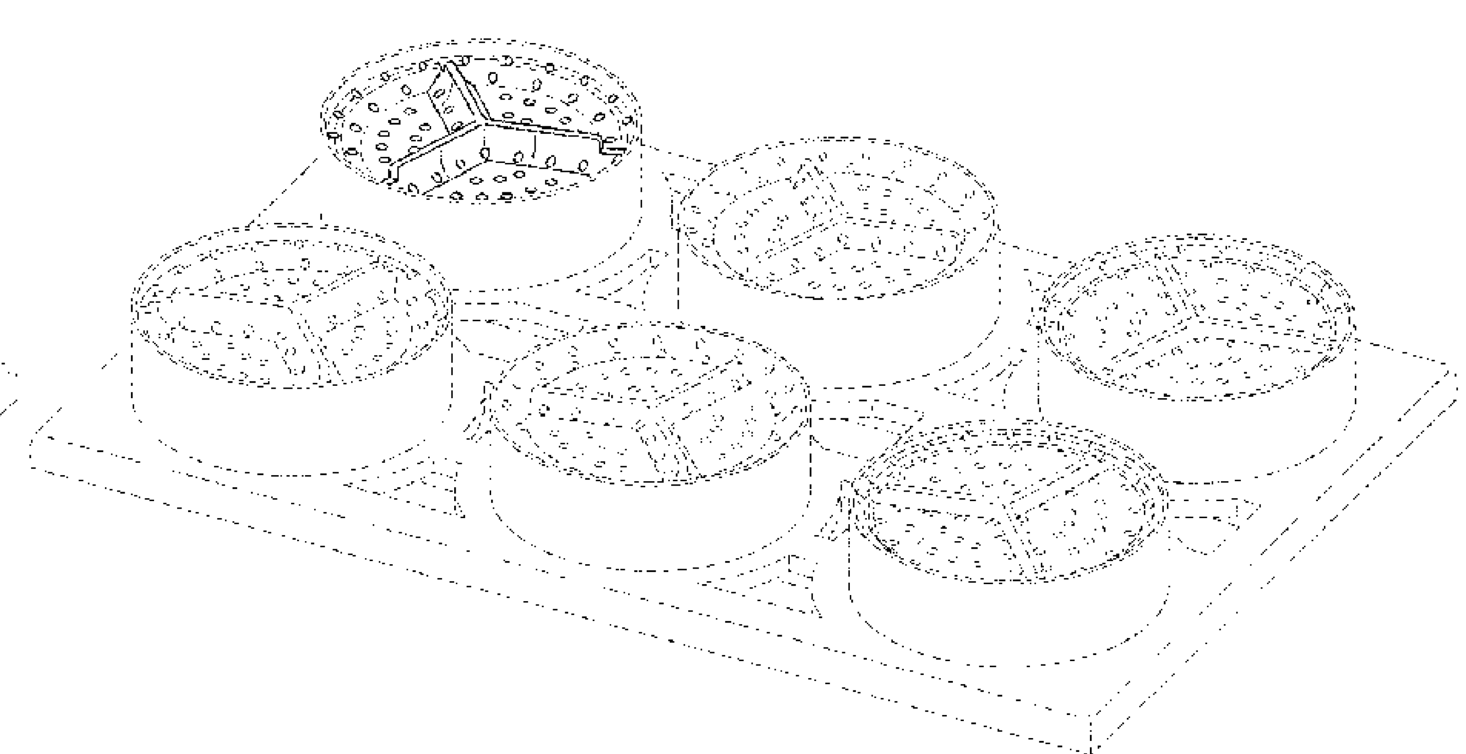
FOREIGN PATENT DOCUMENTS

GB 2155948 A 10/1985

OTHER PUBLICATIONS

Andarawis-Puri et al. “Rotator cuff tendon strain correlates with tear propagation,” J. Biomech, Jan. 9, 2009, pp. 158-163, vol. 42, No. 2.
Banes et al., “Mechanical forces and signaling in connective tissue cells: cellular mechanisms of detection, transduction, and responses





to mechanical deformation," Current Opinion in Orthopaedics, 2001, pp. 389-396, vol. 12.
Clark et al., "Integrins and signal transduction pathways: the road taken," Science, 1995, 6 pages, vol. 268.
Di Carlo et al. "Single-Cell Enzyme Concentrations, Kinetics, and Inhibition Analysis Using High-Density Hydrodynamic Cell Isolation Arrays," Anal. Chem. Jul. 15 2006, pp. 4925-4930, vol. 78, No. 14.
Discher et al., "Tissue Cells Feel and Respond to the Stiffness of Their Substrate," Science, Nov. 18 2005, pp. 1139-1143, vol. 310, No. 5751.
Duncan et al., "Mechanotransduction and the Functional Response of Bone to Mechanical Strain," Calcif Tissue Int, 1995, pp. 344-358, vol. 57.
Howard et al., "Mechanoelectrical Transduction by Hair Cells," Ann. Rev. Biophys. Biophys. Chem., 1988, pp. 99-124, vol. 17.
Hellmich et al., "Single cell manipulation, analytics and label-free protein detection in microfluidic devices for systems nanobiology," Electrophoresis, 2005, pp. 3689-3696, vol. 26.
Irimia et al. "Cell Handling using microstructured membranes," Lab Chip, 2006, pp. 345-352, vol. 6.
Irimia et al., "Single-Cell Chemical Lysis in Picoliter-Scale Closed Volumes Using a Microfabricated Device," Anal. Chem., Oct. 1, 2004, pp. 6137-6143, vol. 76, No. 20.
Li et al., "Biology on a chip: Microfabrication for Studying the Behavior of Cultured Cells," Critical Reviews in Biomedical Engineering, 2003, pp. 423-488, vol. 31, Nos. 5&6.
Long et al., "Low magnitude of tensile strain inhibits IL-1beta-dependent induction of pro-inflammatory cytokines and induces synthesis of IL-10 in human periodontal ligament cells in vitro," J Dent Res. 2001, pp. 1416-1420, vol. 80, No. 5.
Long et al., "Tumor Necrosis Factor alpha-dependent Proinflammatory Gene Induction Is Inhibited by Cyclic Tensile Strain in Articular Chondrocytes in Vitro." Arthritis & Rheumatism, Oct. 2001, pp. 2311-2319, vol. 44, No. 10.
Martini et al., "Systems Nanobiology: From Quantitative Single Molecule Biophysics to Microfluidic-based Single Cell Analysis," Subcellular Proteomics, 2007, Chapter 14, pp. 301-321.
McClain et al., "Microfluidic Devices for the High-Throughput Chemical Analysis of Cells," Anal. Chem., Nov. 1, 2003, pp. 5646-5655, vol. 75, No. 21.
Mijatovic et al., "Technologies for nanofluidic systems: top-down vs. bottom-up—a review," Lab Chip, 2005, 5, pp. 492-500.
Munce et al., "Microfabricated System for Parallel Single-Cell Capillary Electrophoresis," Anal Chem., Sep. 1, 2004, pp. 4983-4989, vol. 76, No. 17.
Munoz-Pinedo et al., "Confocal restricted-height imaging of suspension cells (CRISC) in a PDMS microdevice during apoptosis," Lab Chip, 2005, pp. 628-633, vol. 5.
Nevill et al. "Integrated microfluidic cell culture and lysis on a chip," Lab Chip, 2007, pp. 1689-1695, vol. 7, No. 12.
Ostuni et al., "Patterning Mammalian Cells Using Elastomeric Membranes," Langmuir, 2000, pp. 7811-7819, vol. 16.
Reyes et al., "Micro Total Analysis Systems. 1. Introduction, Theory, and Technology," Anal. Chem., Jun. 15, 2002, pp. 2623-2636, vol. 74, No. 12.
Riveline et al., "Focal Contacts as Mechanosensors: Externally applied Local Mechanical Force Induces Growth of Focal Contacts by an mDia1-dependent and Rock-independent Mechanism," Journal of Cell Biology, Jun. 11, 2001, pp. 1175-1185, vol. 153, No. 6.
Ros et al., "Bioanalysis in structured microfluidic systems," Electrophoresis, 2006, pp. 2651-2658, vol. 27.
Sims et al., "Analysis of single mammalian cells on-chip," Lab Chip, 2007, pp. 423-440, vol. 7.
Svahn et al., "Single cells or large populations?," Lab Chip, 2007, 544-546, vol. 7.
Tourovskaia et al., "Differentiation-on-a-chip: A microfluidic platform for long-term cell culture studies," Lab Chip, 2005, pp. 14-19, vol. 5.
Unger et al., "Monolithic Microfabricated Valves and Pumps by Multilayer Soft Lithography," Science, Apr. 7, 2000, pp. 113-116, vol. 288.
Voleti et al., "Tendon healing: repair and regeneration." Annu. Rev. Biomed. Eng., 2012, pp. 47-71, vol. 14.
Wall et al., "Comparison of cellular strain with applied substrate strain in vitro," Journal of Biomechanics, 2007, pp. 173-181, vol. 40.
Whitesides et al., "Soft Lithography in Biology and Biochemistry," Annu. Rev. Biomed. Eng., 2001, pp. 335-373, vol. 3.
Yang et al., "Hydrodynamic simulation of cell docking in microfluidic channels with different dam structures," Lab Chip, 2004, pp. 53-59, vol. 4.
Yang et al. "Cell Docking and On-Chip Monitoring of Cellular Reactions with a Controlled Concentration Gradient on a Microfluidic Device," Anal. Chem., Aug. 15, 2002, pp. 3991-4001, vol. 74 No. 16.

* cited by examiner

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(74) *Attorney, Agent, or Firm* — The Webb Law Firm

(57) CLAIM

The ornamental design for an apparatus for patterning cells, as shown and described.

DESCRIPTION

FIG. **1** shows a top view of an apparatus for patterning cells showing our new design, according to a first tricuspid embodiment of the present invention.
FIG. **2** shows a top perspective view thereof.
FIG. **3** shows a bottom view thereof.
FIG. **4** shows a bottom perspective view thereof.
FIG. **5** shows a top view of an apparatus for patterning cells showing our new design, according to a second tricuspid embodiment of the present invention.
FIG. **6** shows a top perspective view of a tricuspid embodiment of the present invention.
FIG. **7** shows a bottom view thereof.
FIG. **8** shows a bottom perspective view thereof.
FIG. **9** shows a top view of an apparatus for patterning cells showing our new design, according to a third tricuspid embodiment of the present invention.
FIG. **10** shows a top perspective view thereof.
FIG. **11** shows a bottom view thereof.
FIG. **12** shows a bottom perspective view thereof.
FIG. **13** shows a top view of an apparatus for patterning cells showing our new design, according to a fourth tricuspid embodiment of the present invention.
FIG. **14** shows a top perspective view thereof.
FIG. **15** shows a bottom view thereof.
FIG. **16** shows a bottom perspective view thereof.
FIG. **17** shows a top view of an apparatus for patterning cells showing our new design, according to a fifth tricuspid embodiment of the present invention.
FIG. **18** shows a top perspective view thereof.
FIG. **19** shows a bottom view thereof.
FIG. **20** shows a bottom perspective view thereof.
FIG. **21** shows a top view of a tricuspid embodiment of the present invention.
FIG. **22** shows a top perspective view of an apparatus for patterning cells showing our new design, according to a sixth tricuspid embodiment of the present invention.
FIG. **23** shows a bottom view thereof; and,
FIG. **24** shows a bottom perspective view thereof.
The broken lines in FIGS. **1-24** show portions of the invention which form no part of the claimed design. The

broken lines in FIGS. **1-24** are environmental only and are not part of the claimed design.

1 Claim, 12 Drawing Sheets

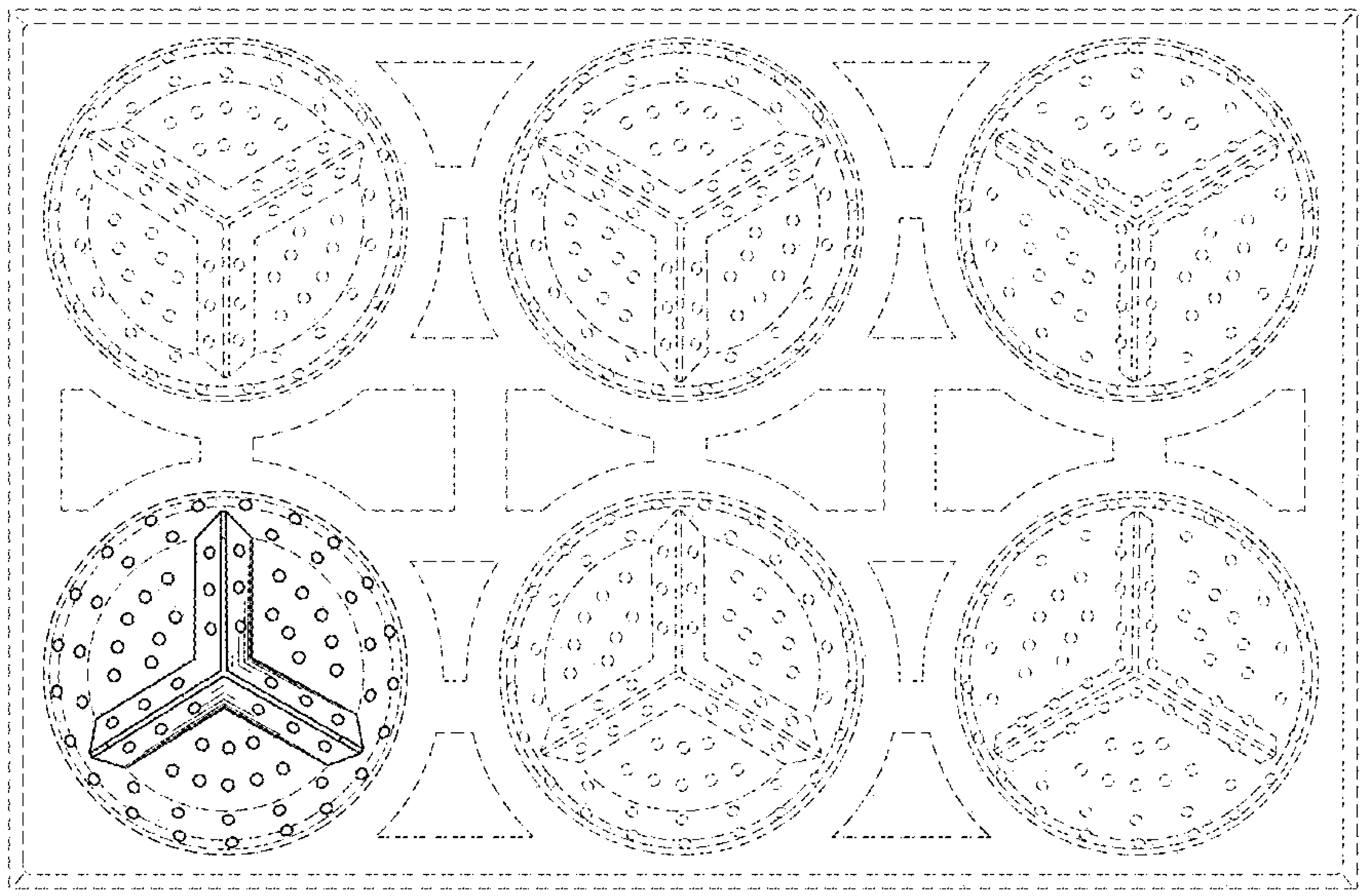


FIG. 1

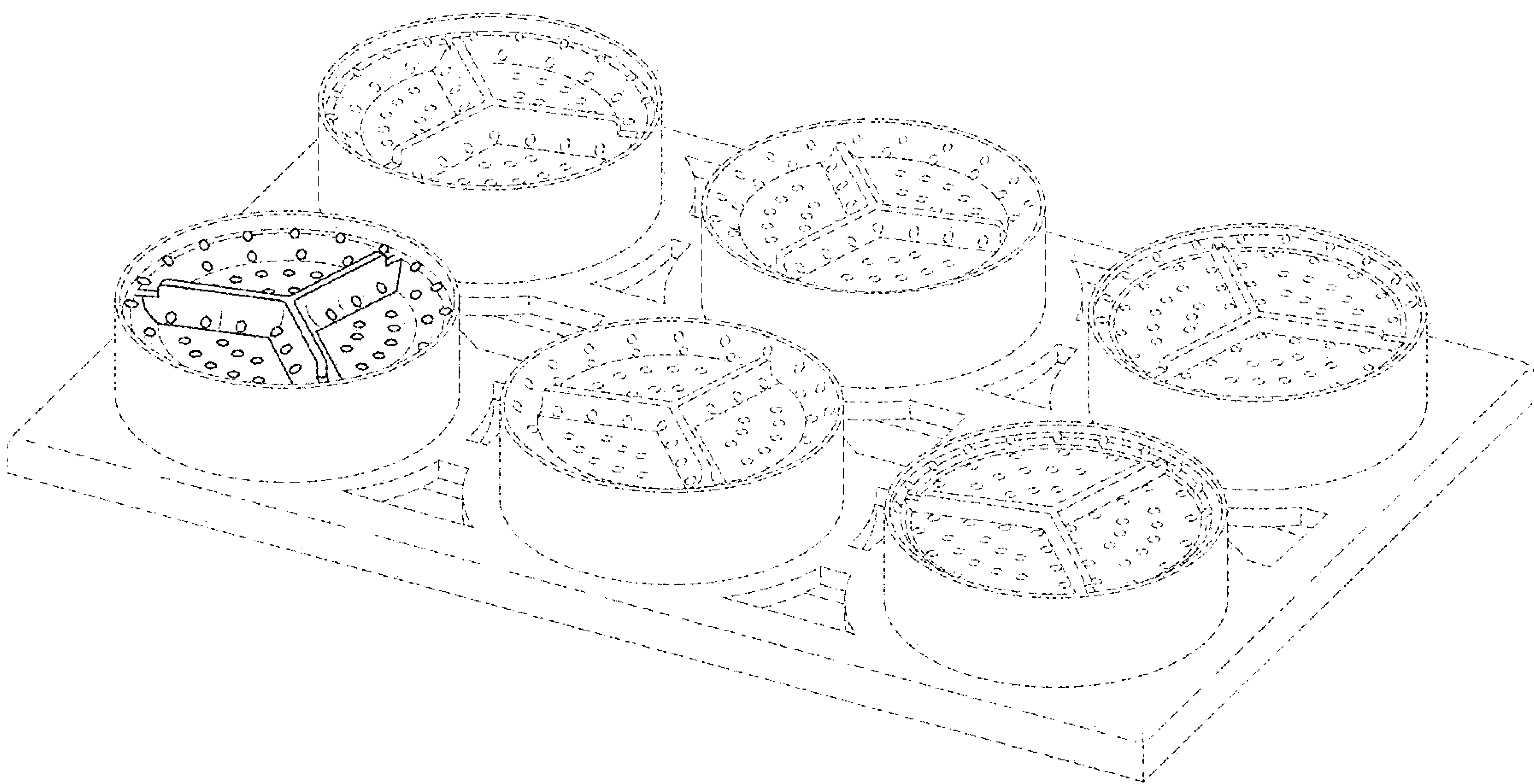


FIG. 2

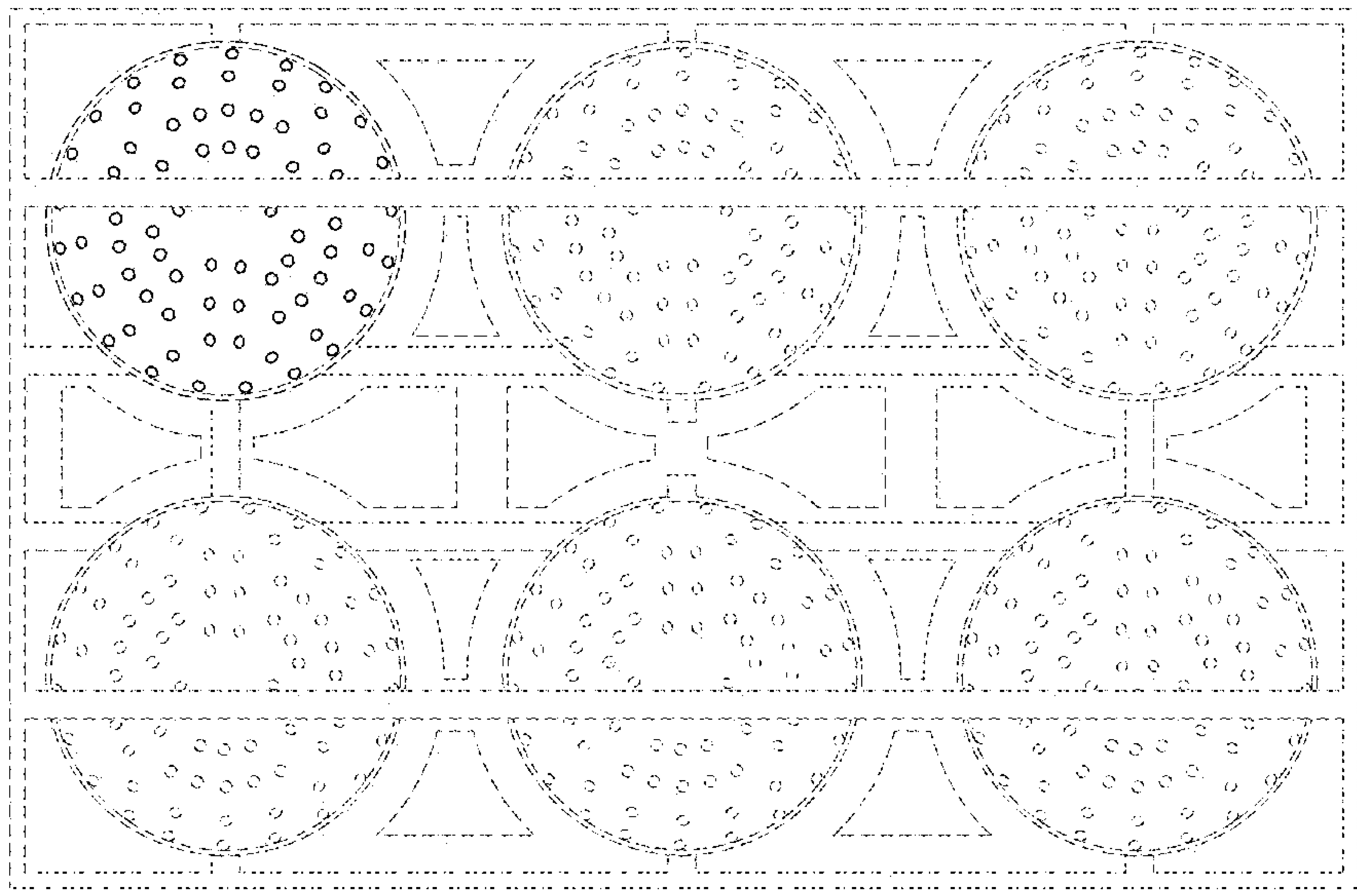
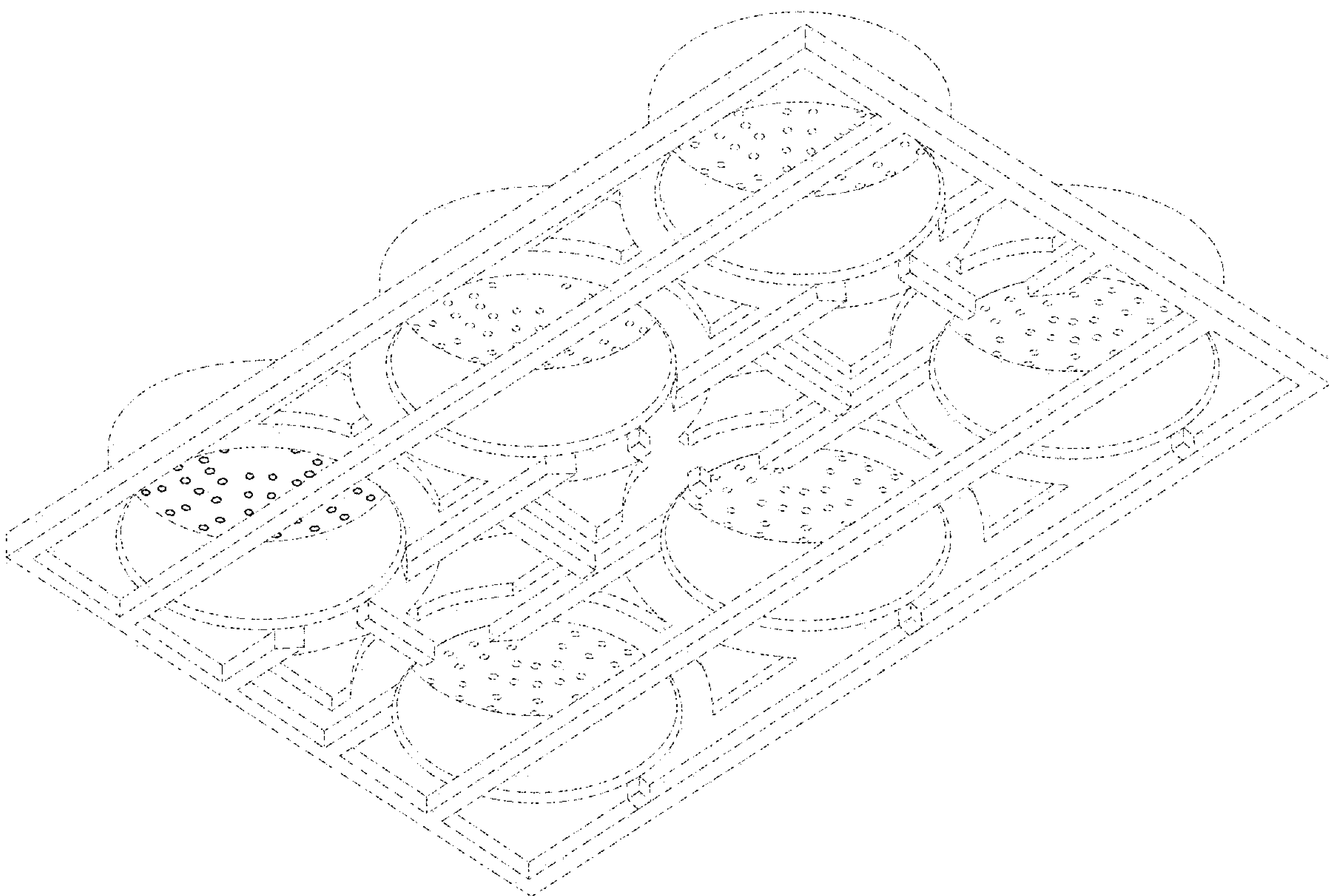


FIG. 3



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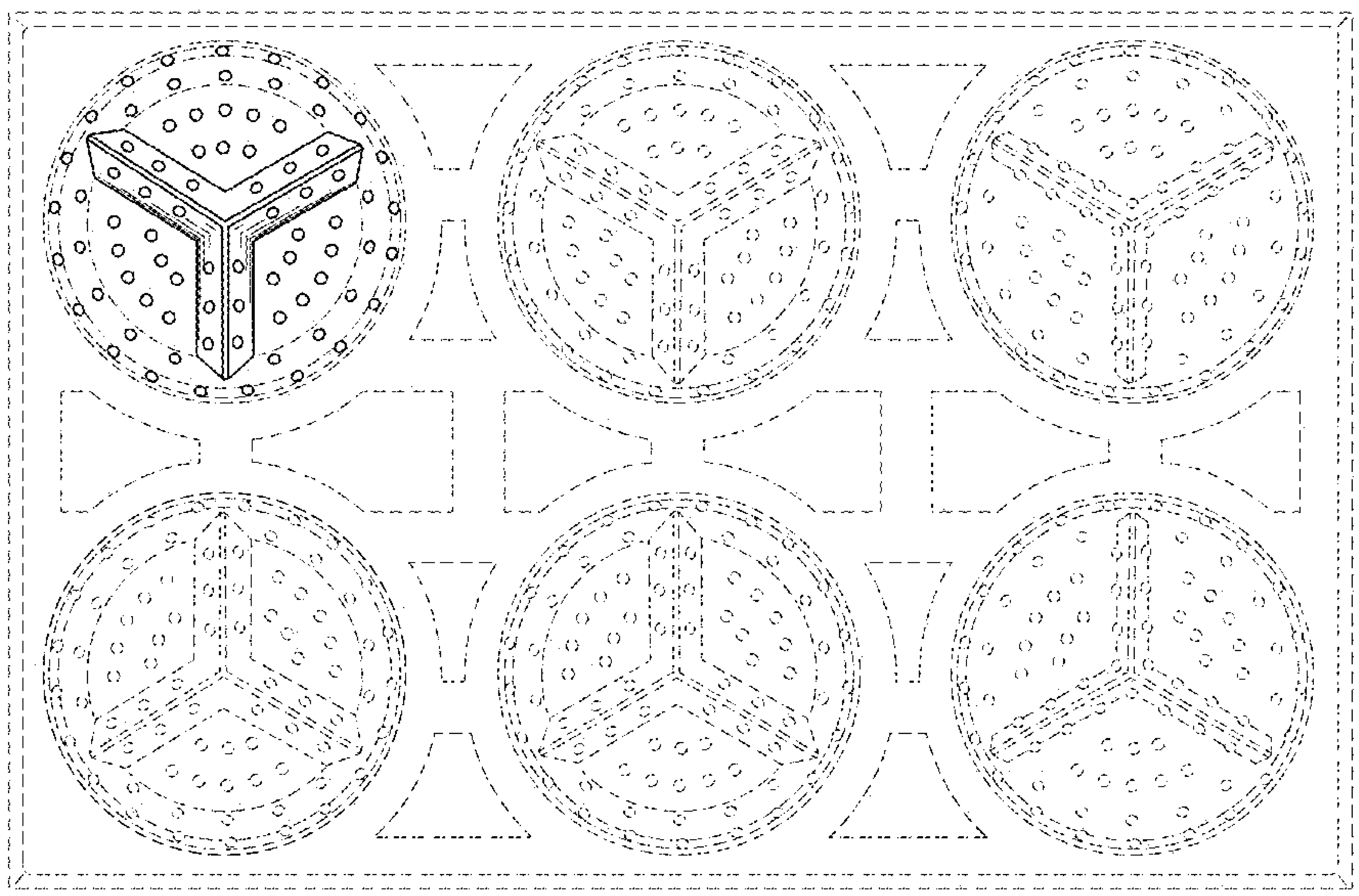


FIG. 5

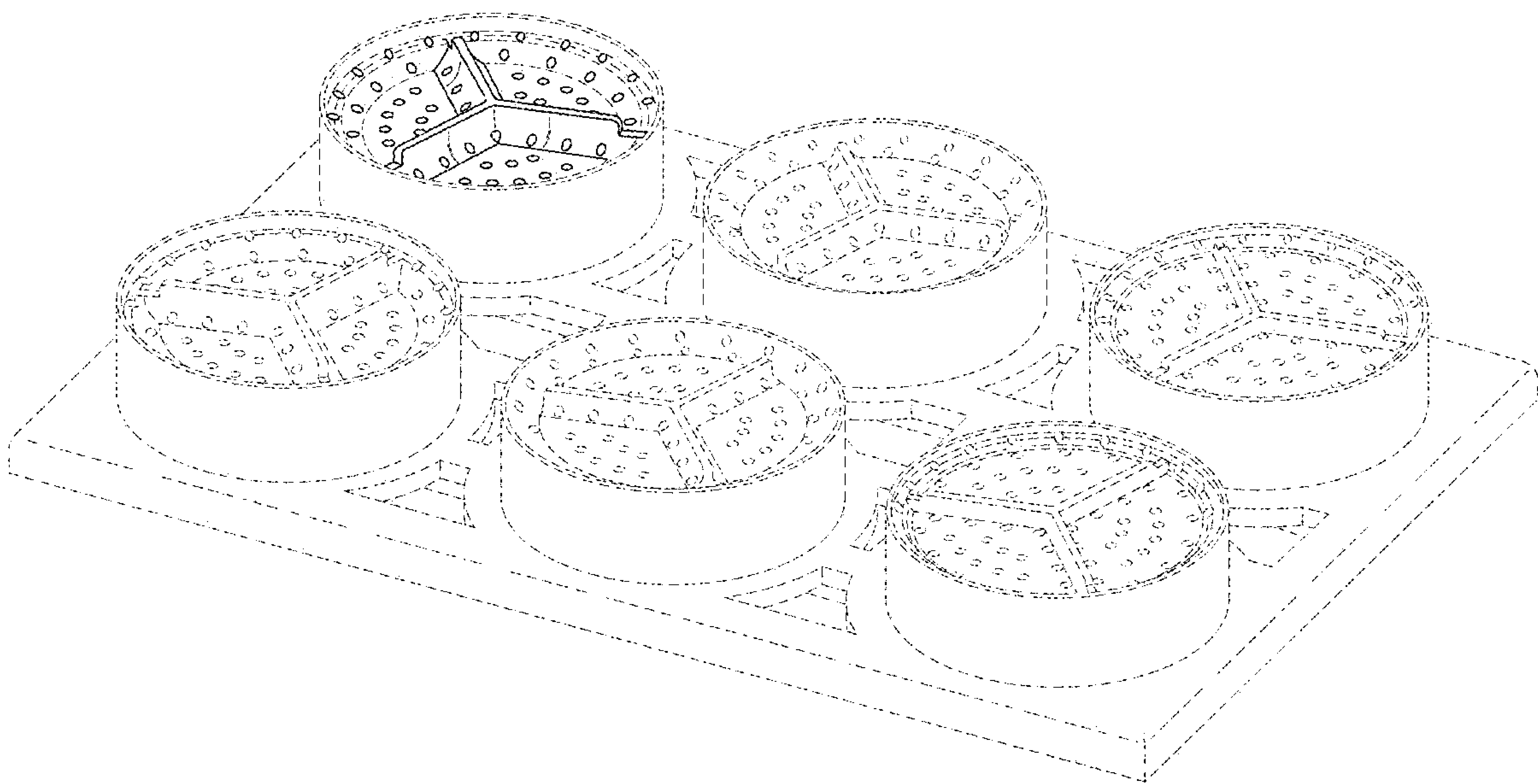
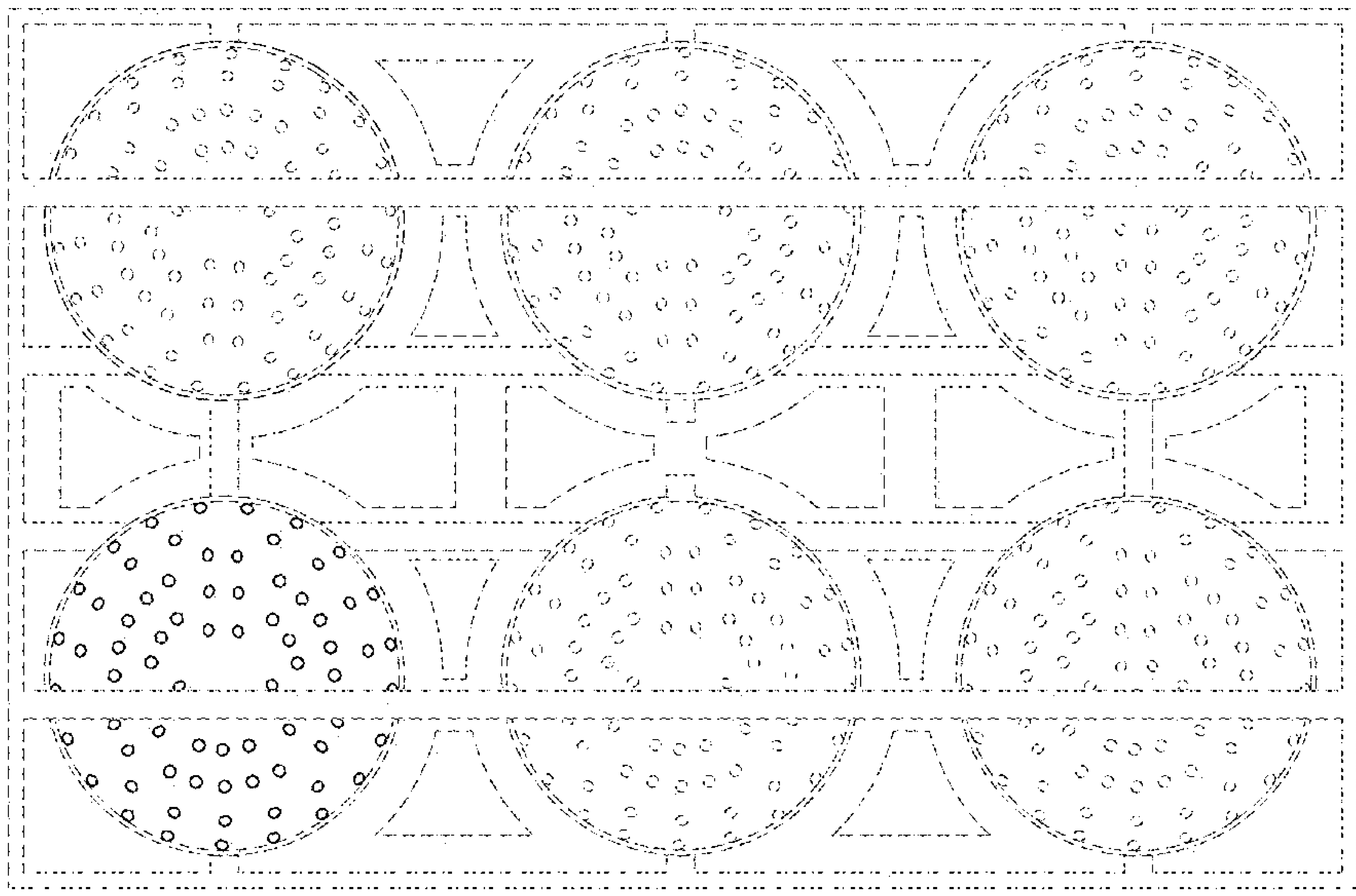


FIG. 6



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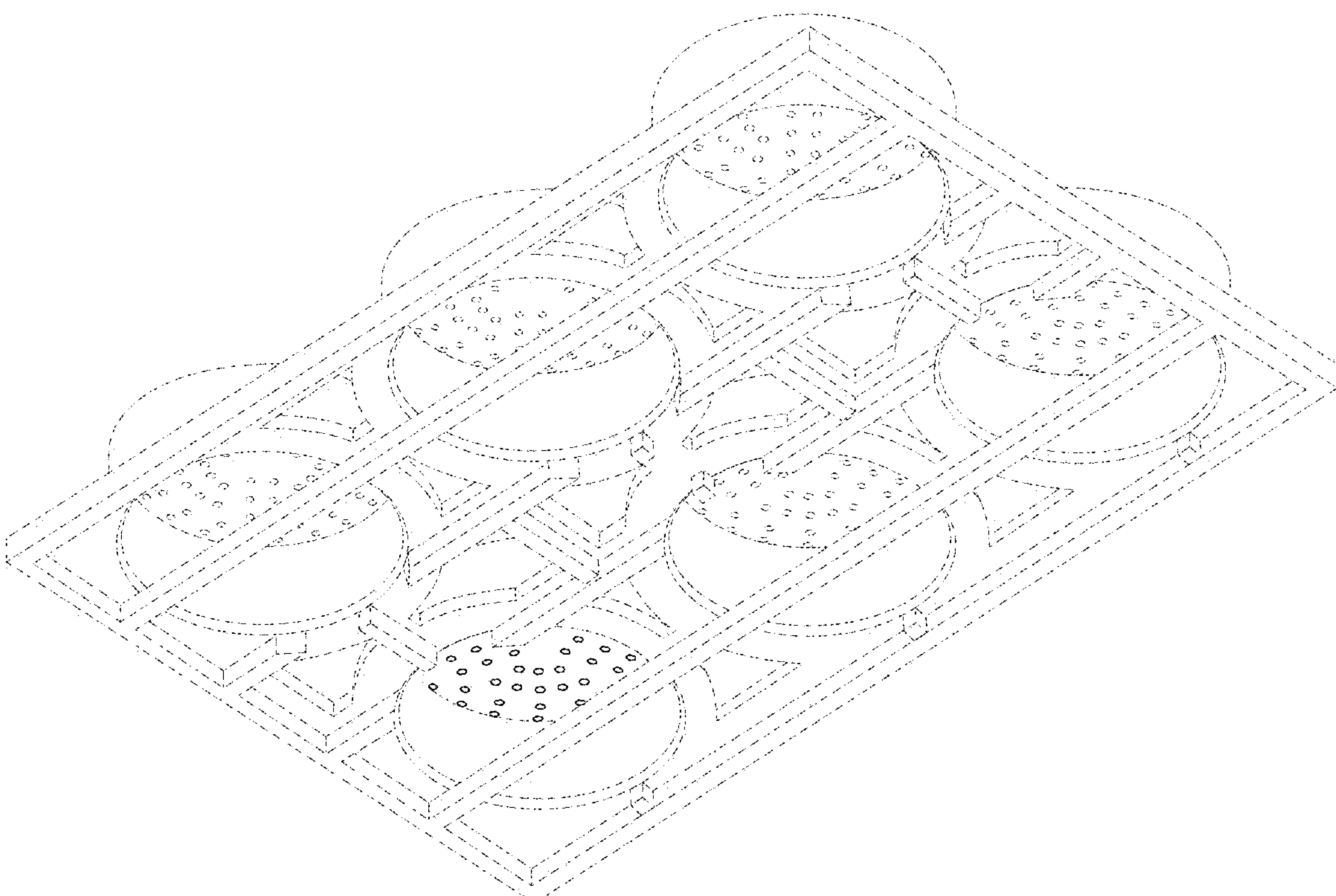

FIG. 8

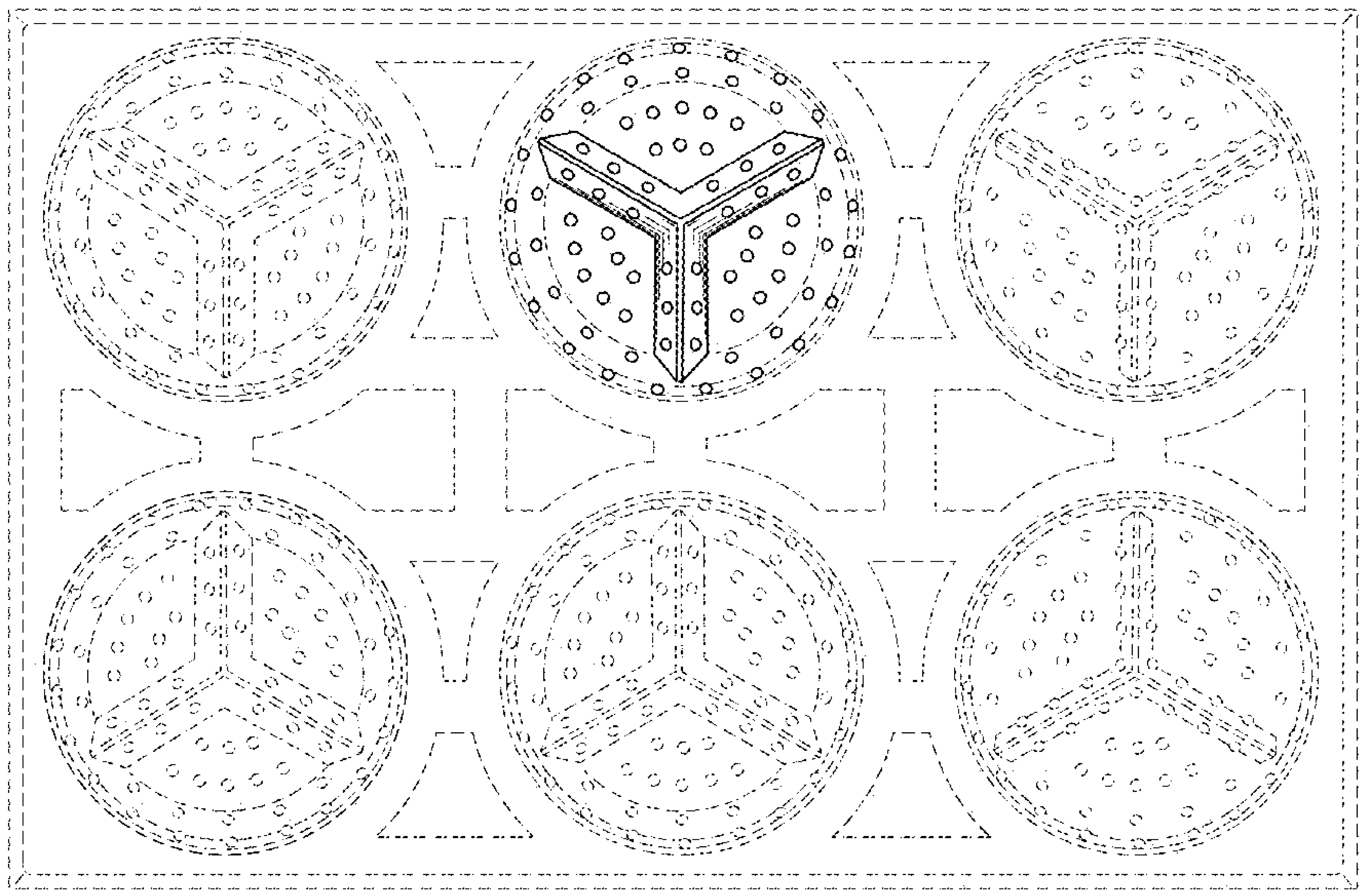

FIG. 9

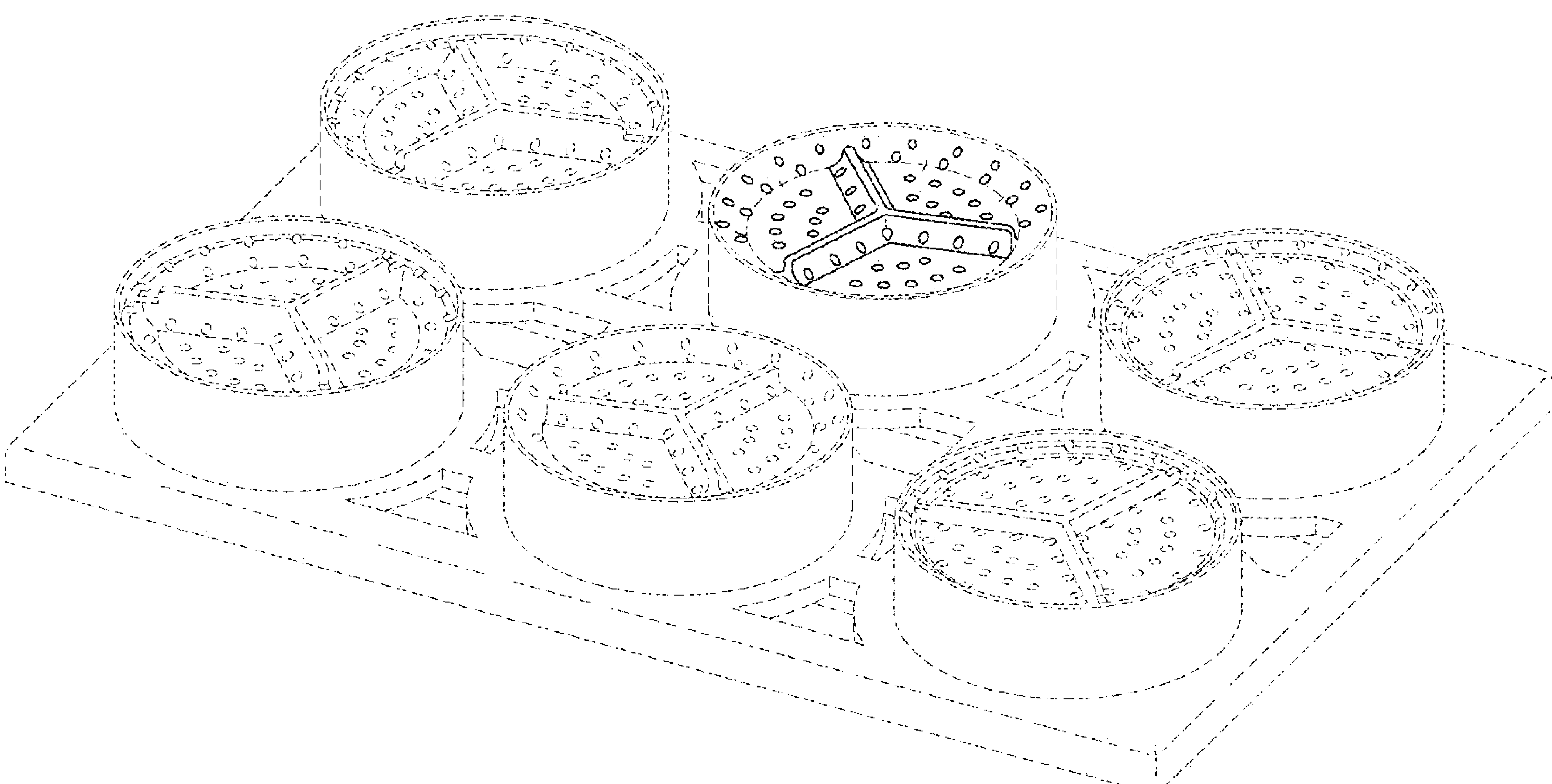

FIG. 10

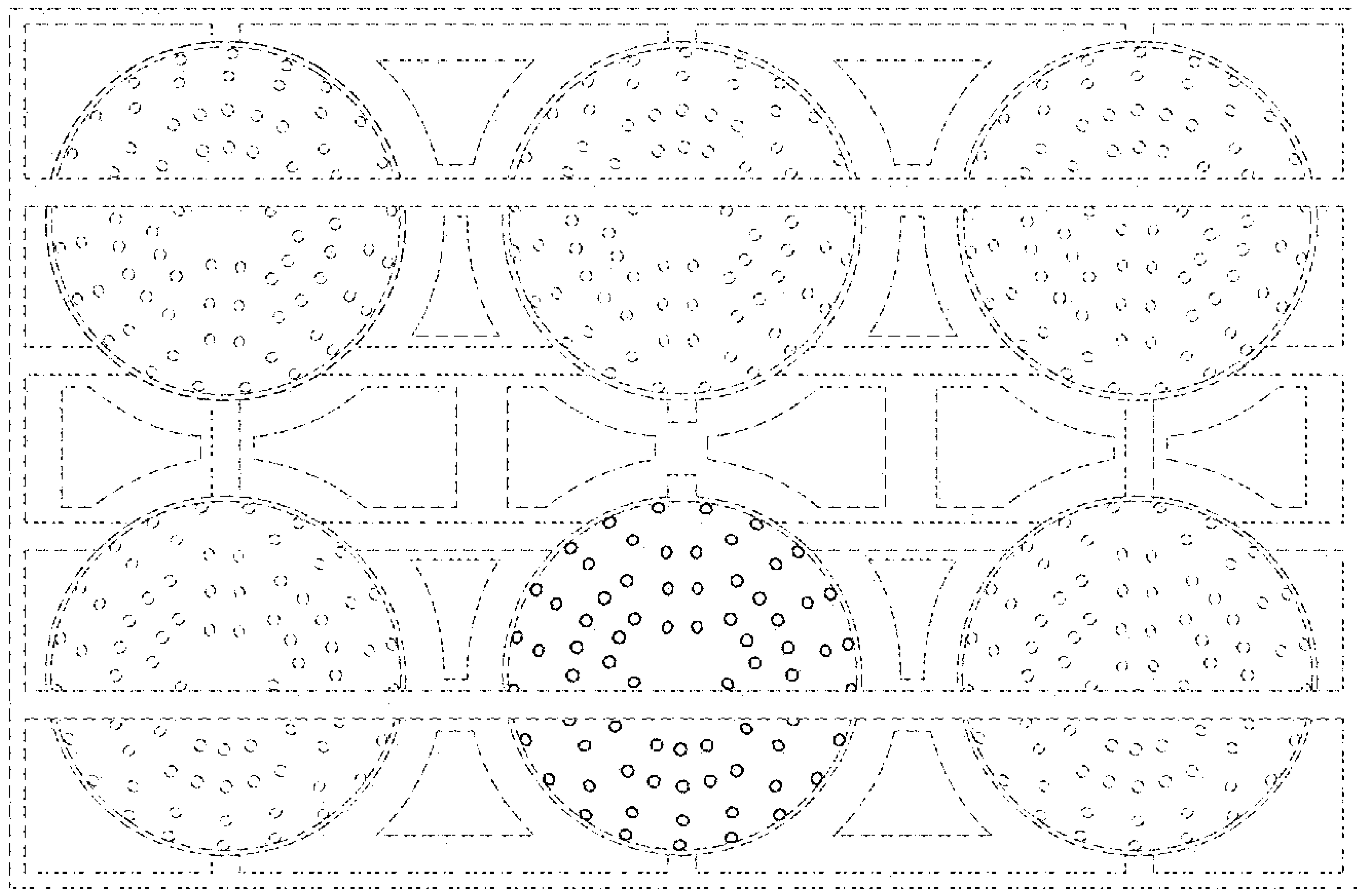

FIG. 11

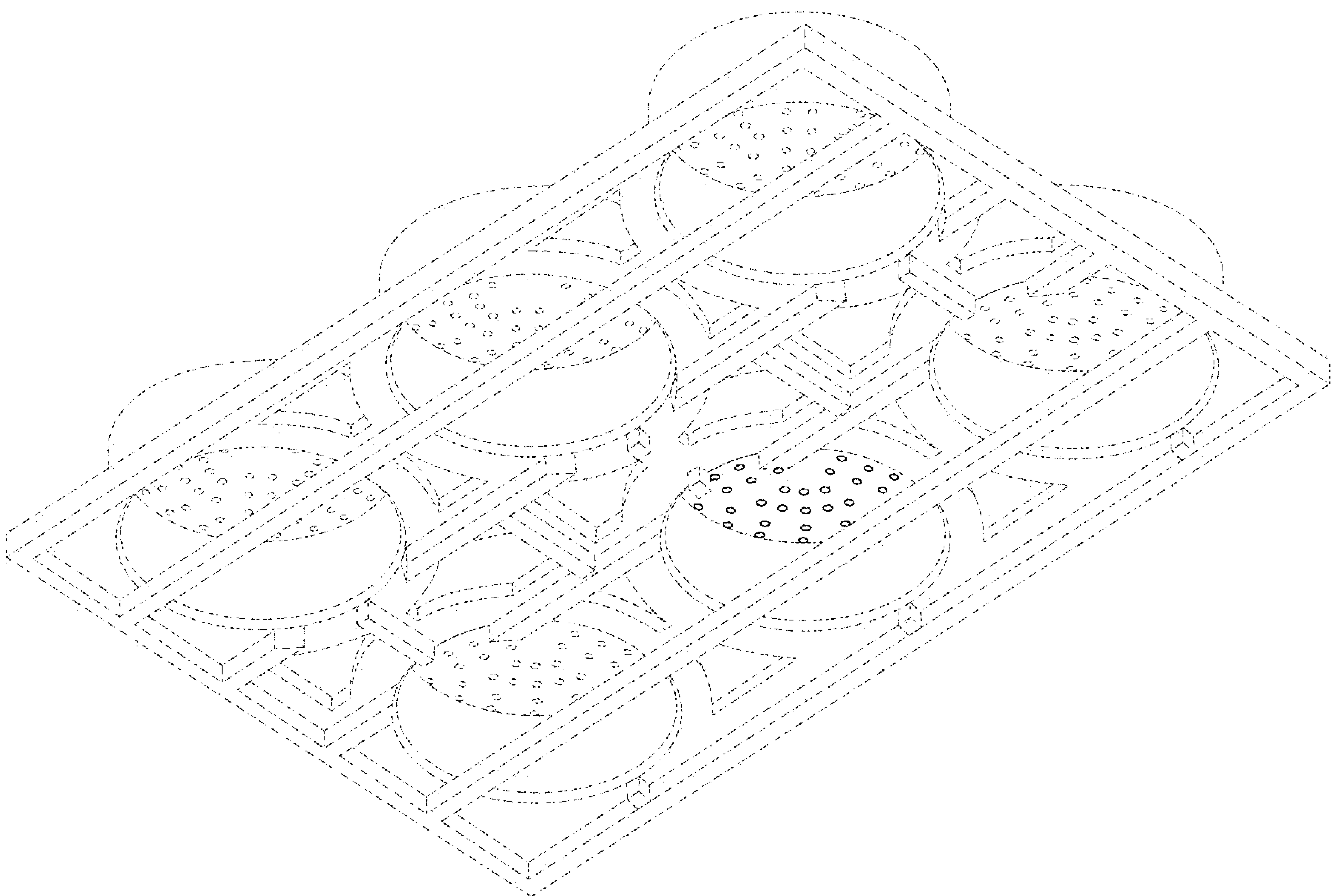

FIG. 12

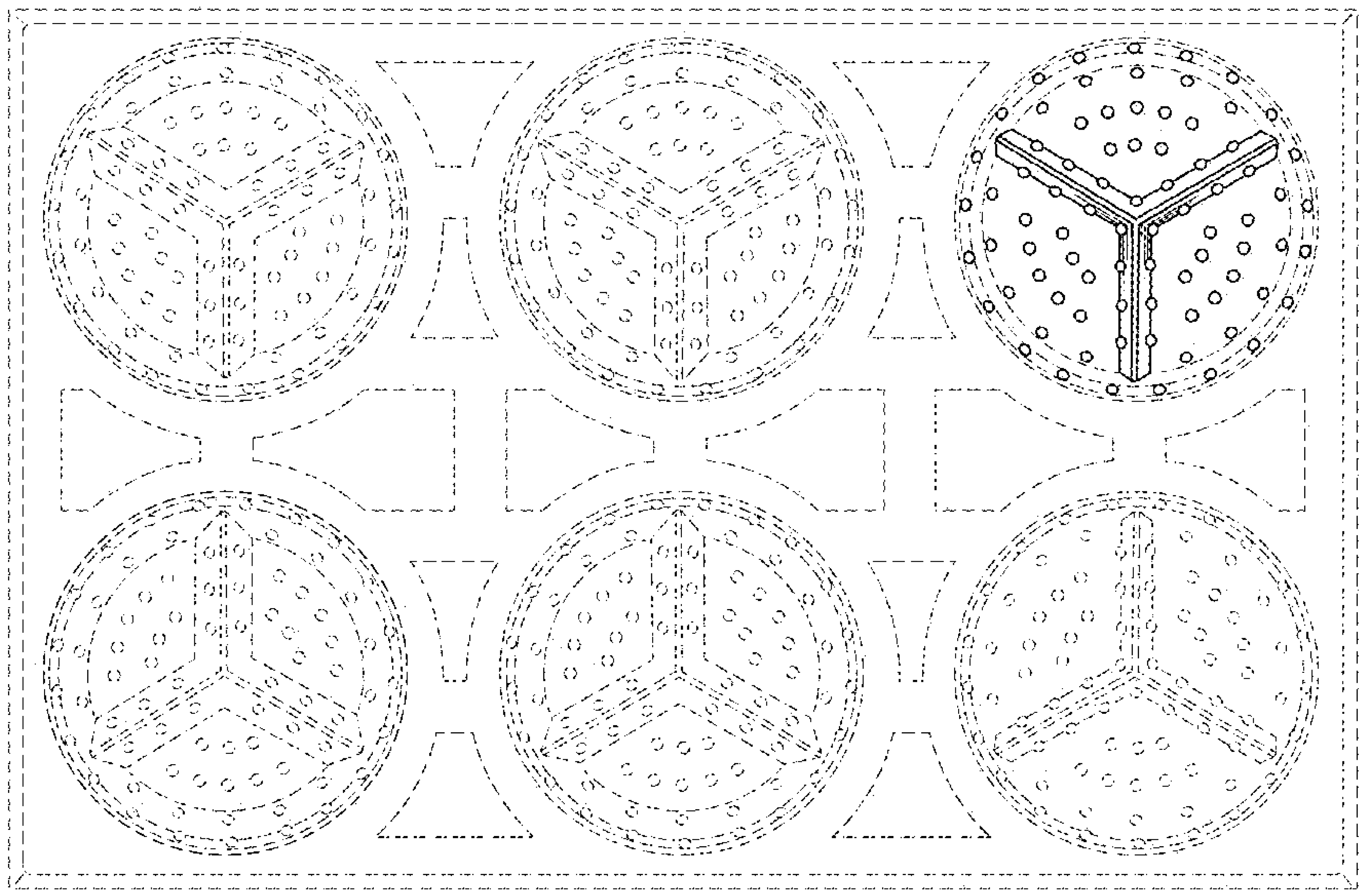

FIG. 13

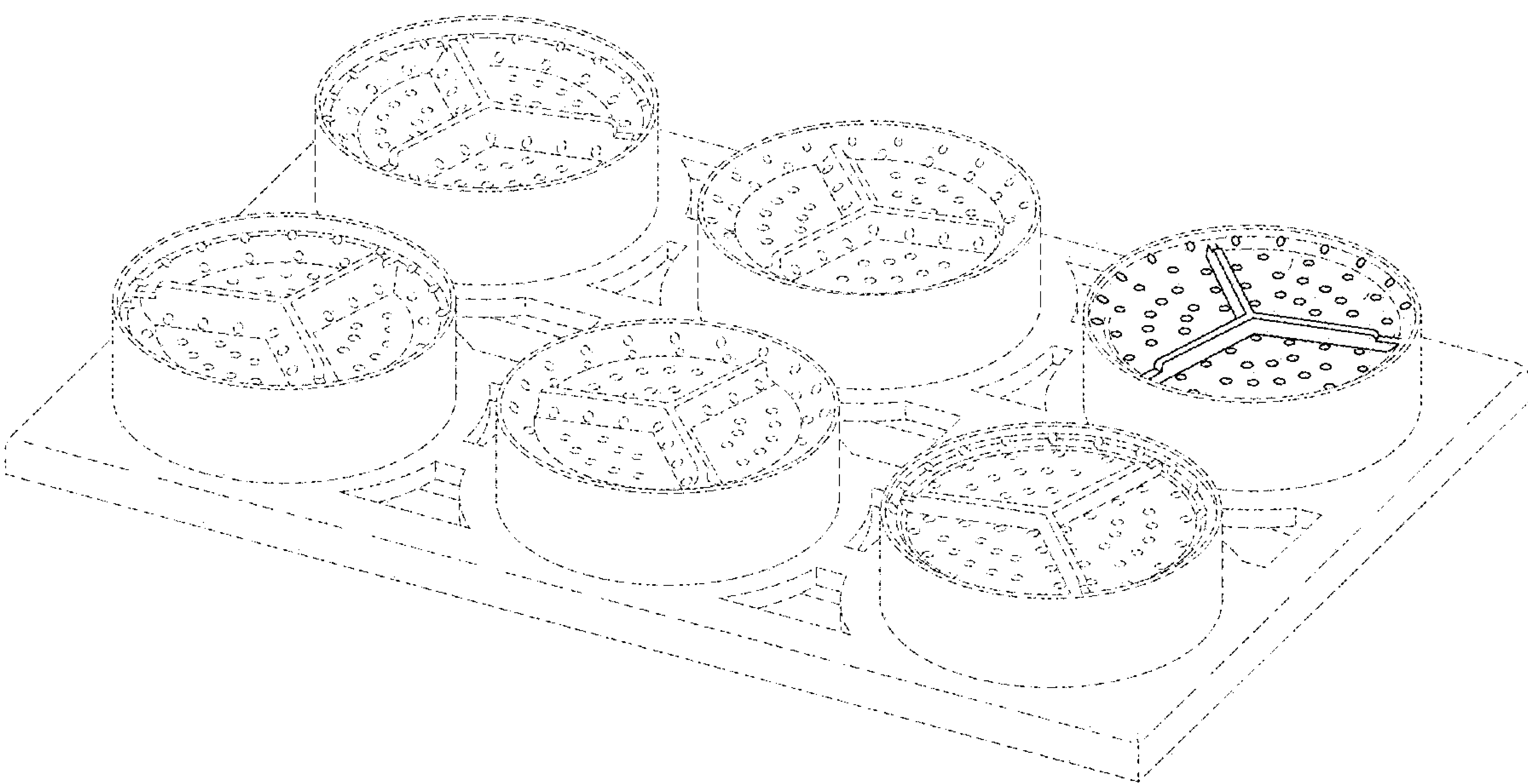

FIG. 14

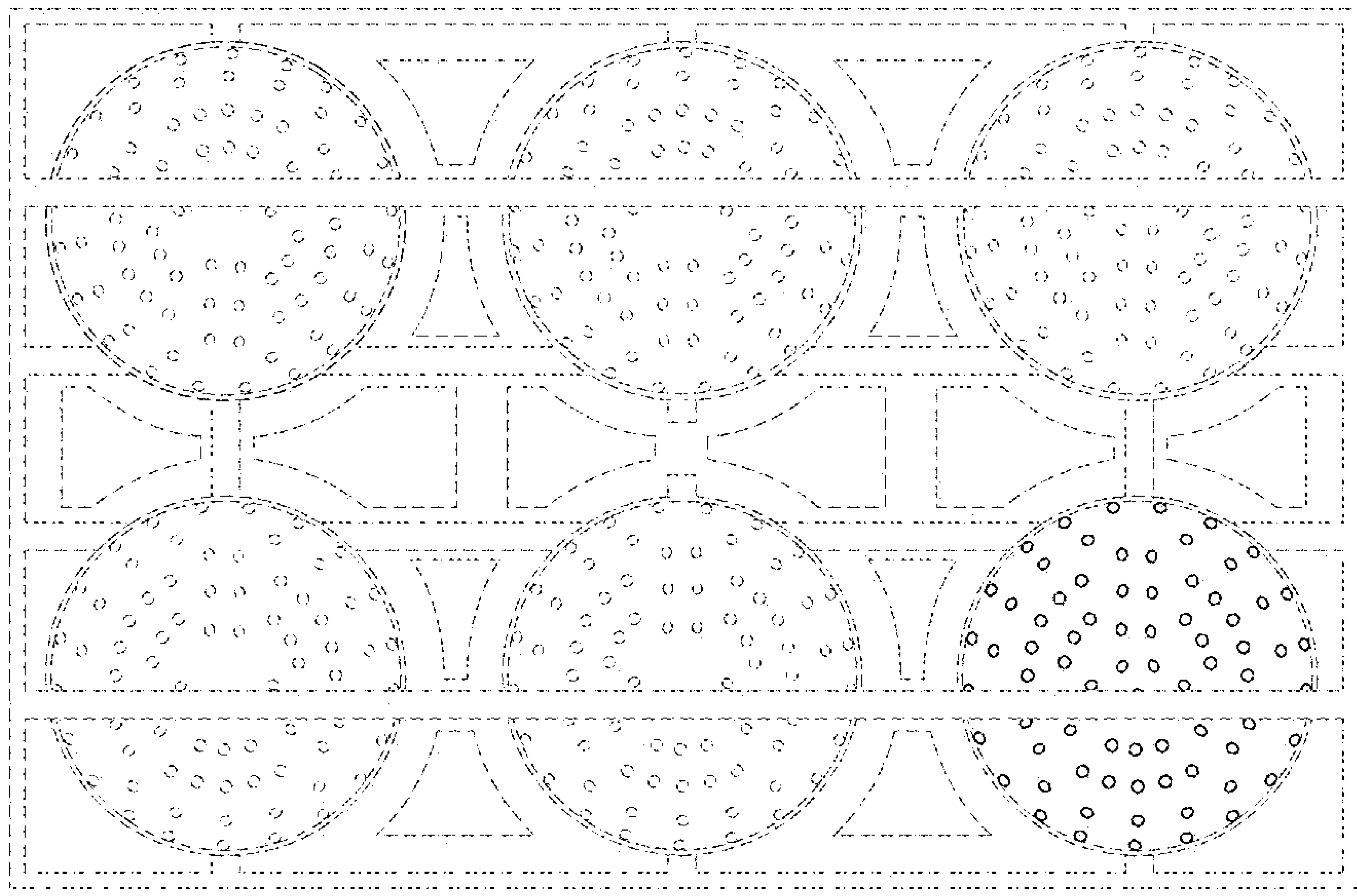

FIG. 15

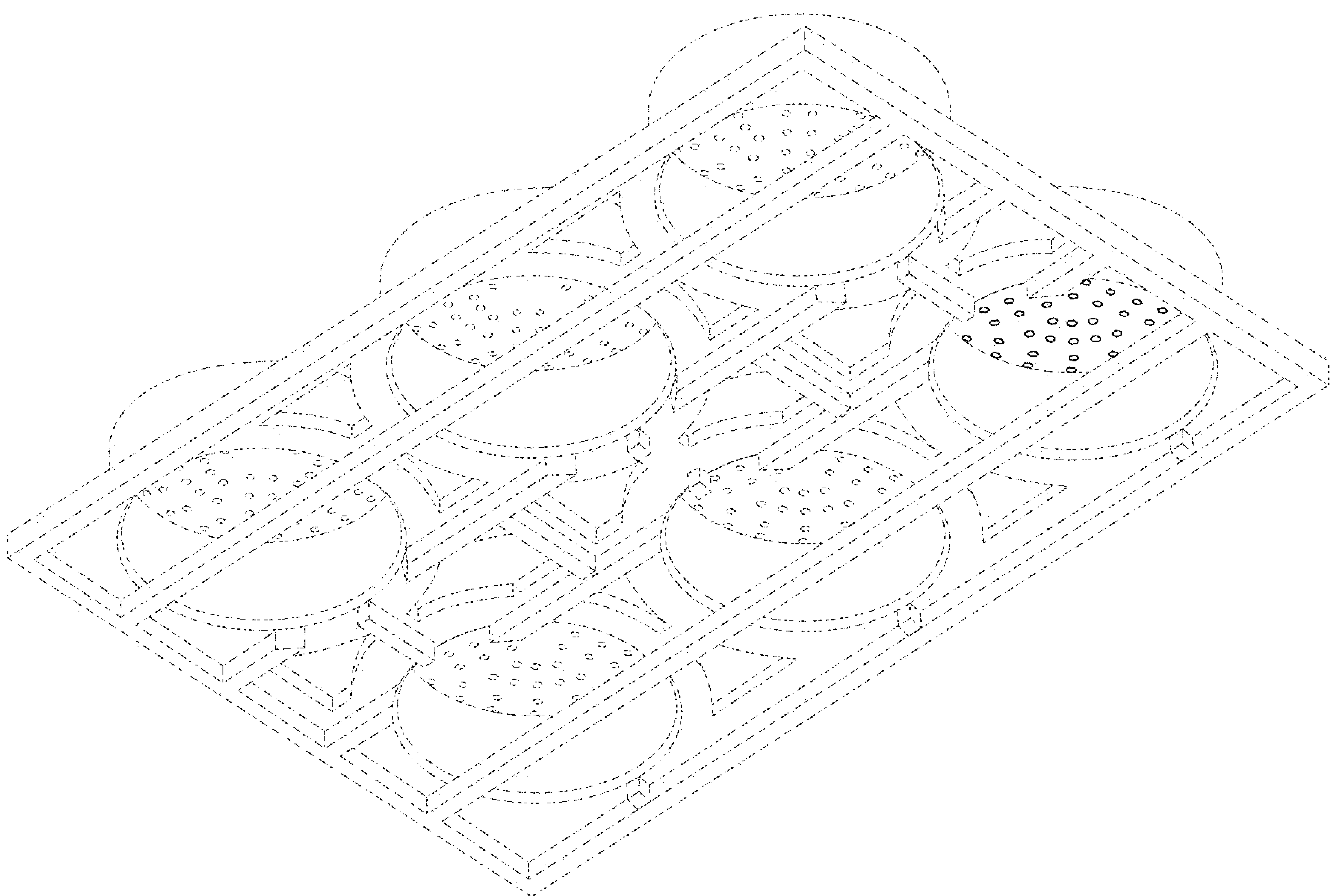

FIG. 16

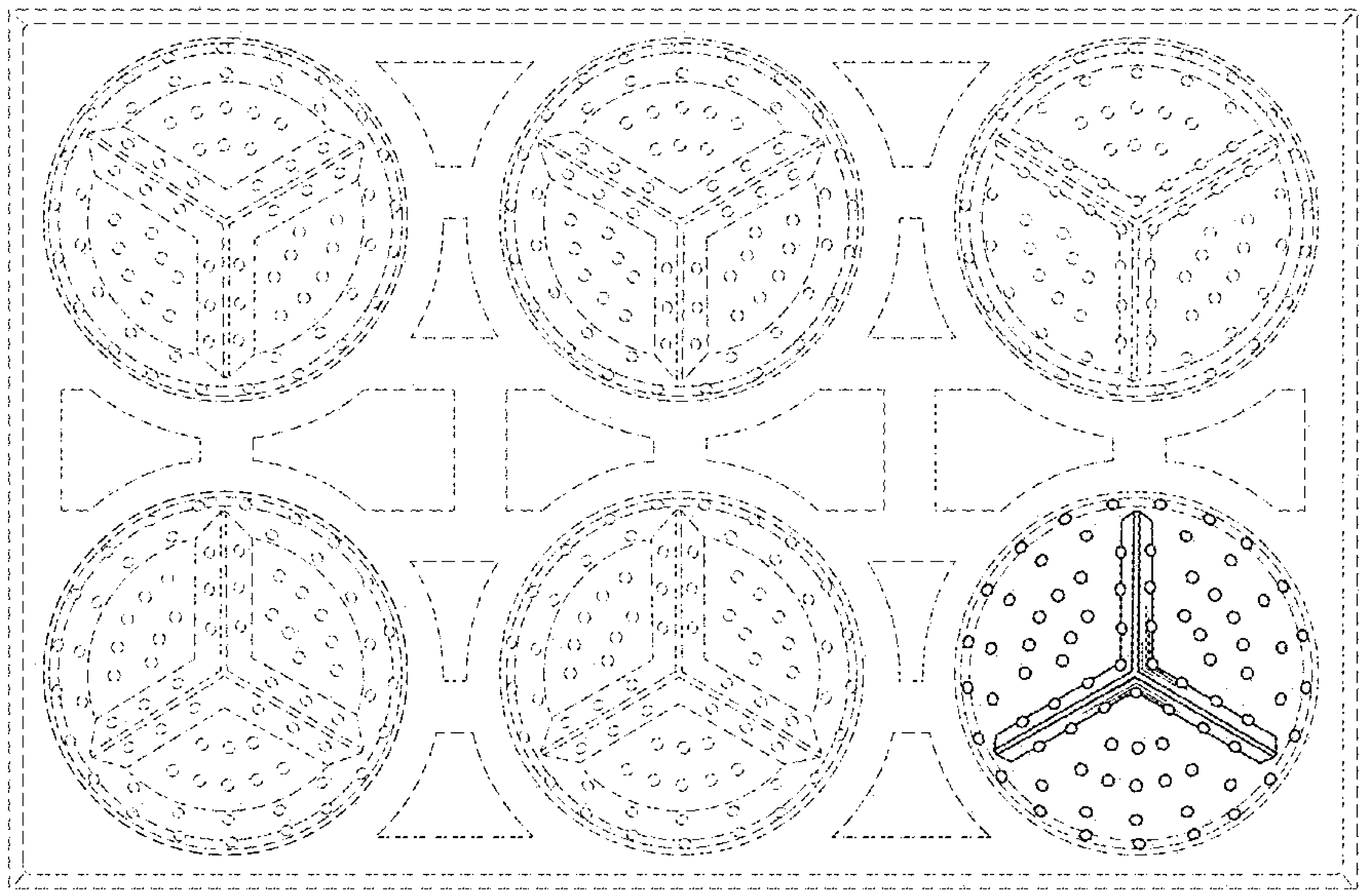

FIG. 17

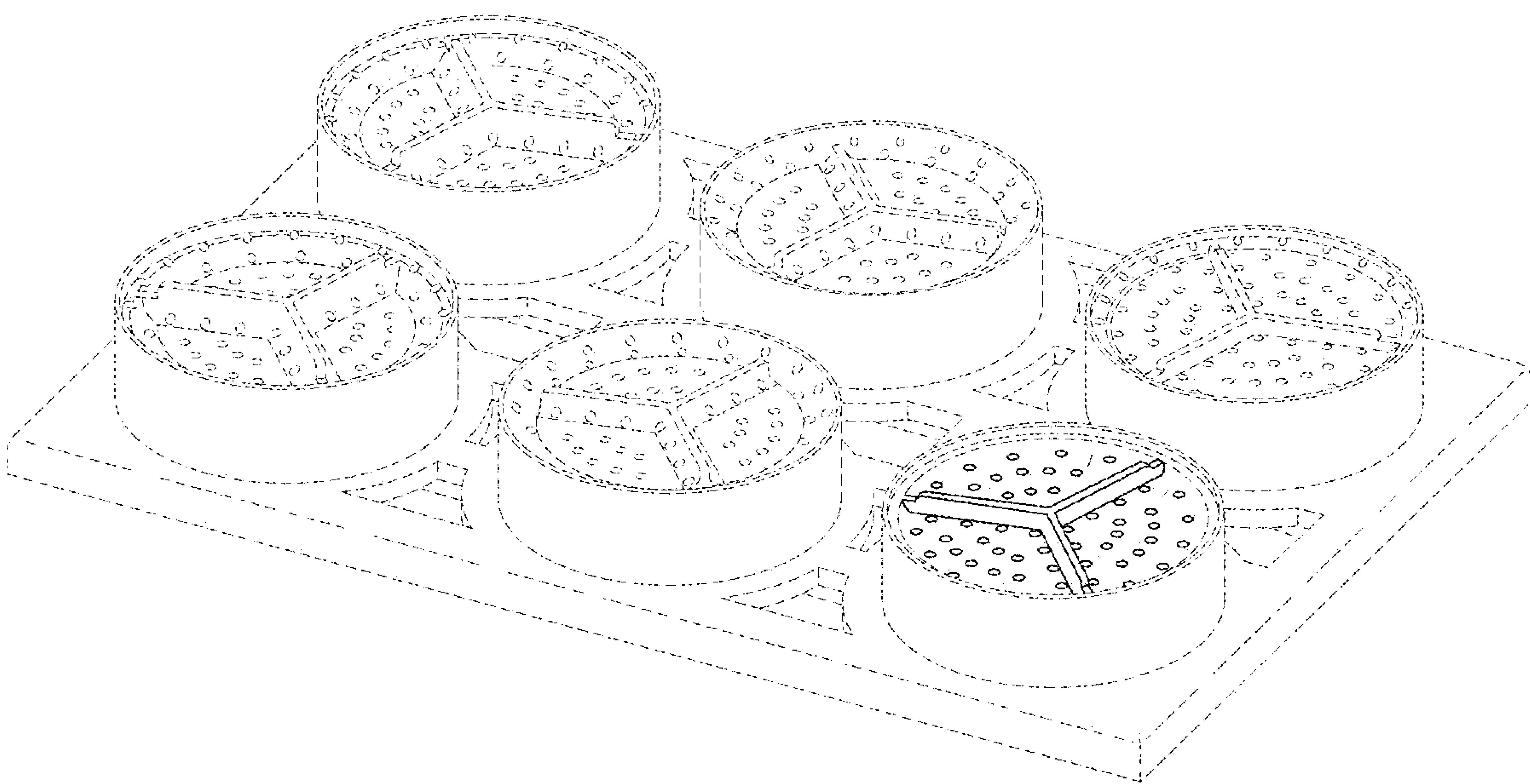

FIG. 18

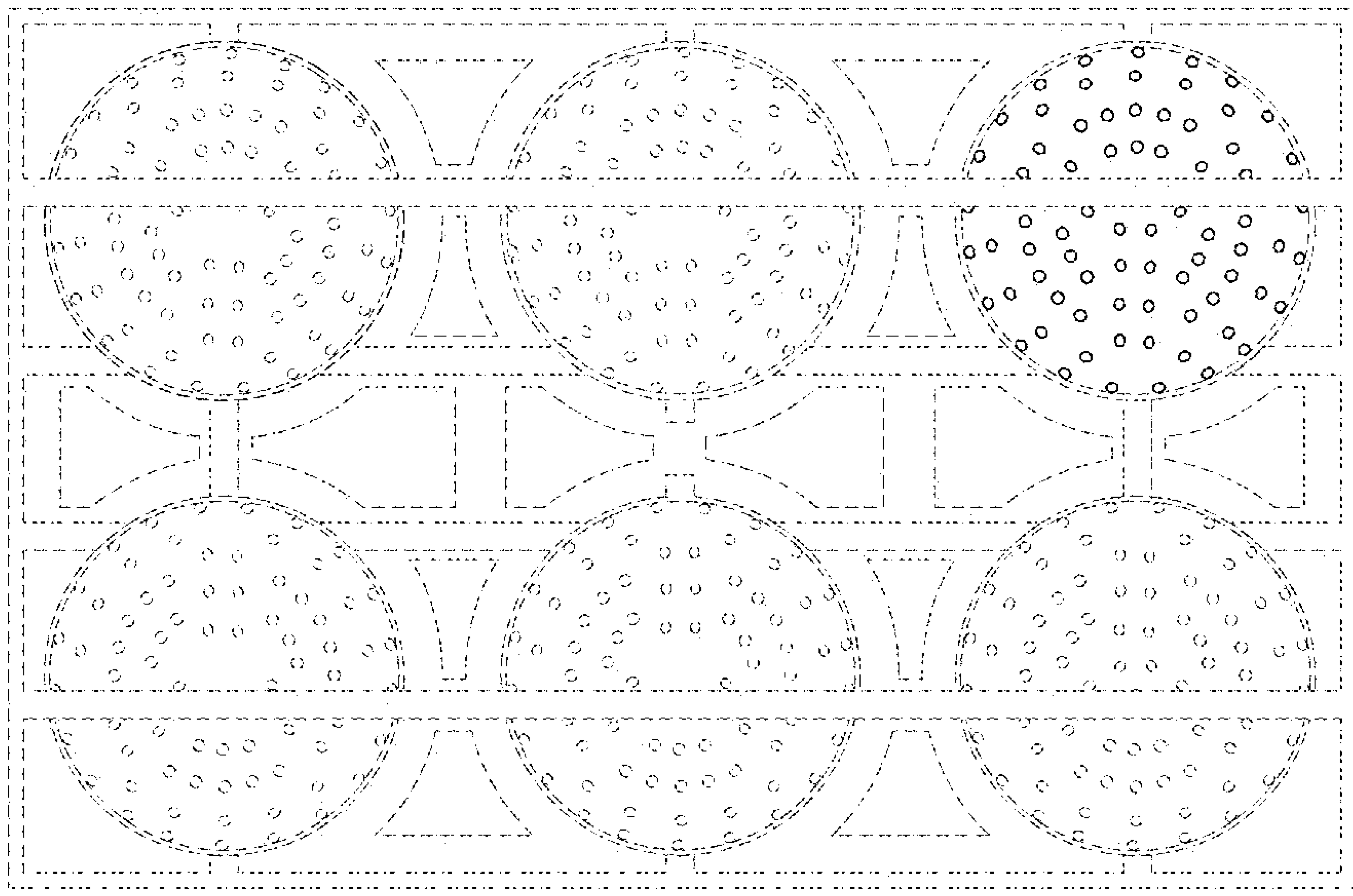

FIG. 19

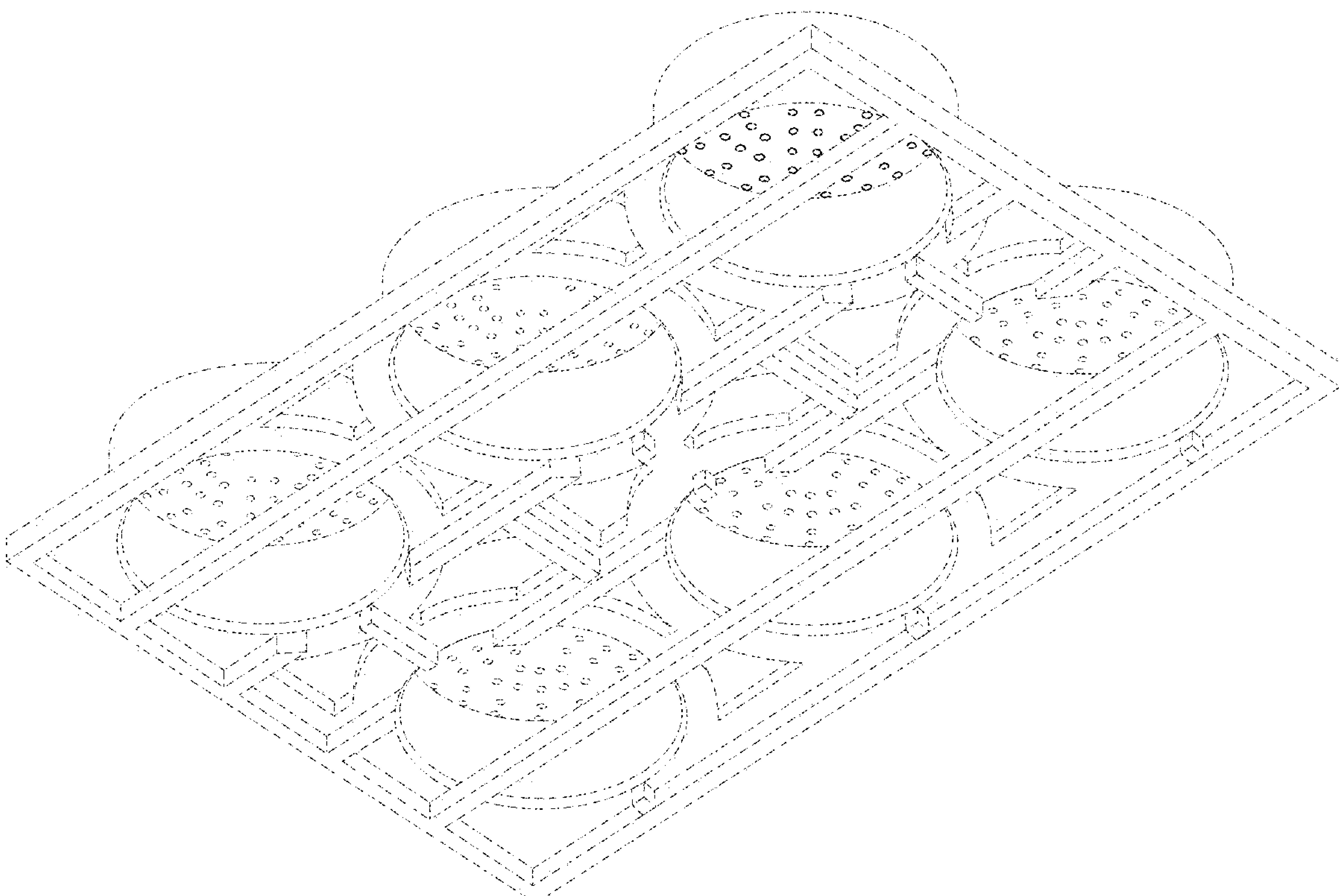

FIG. 20

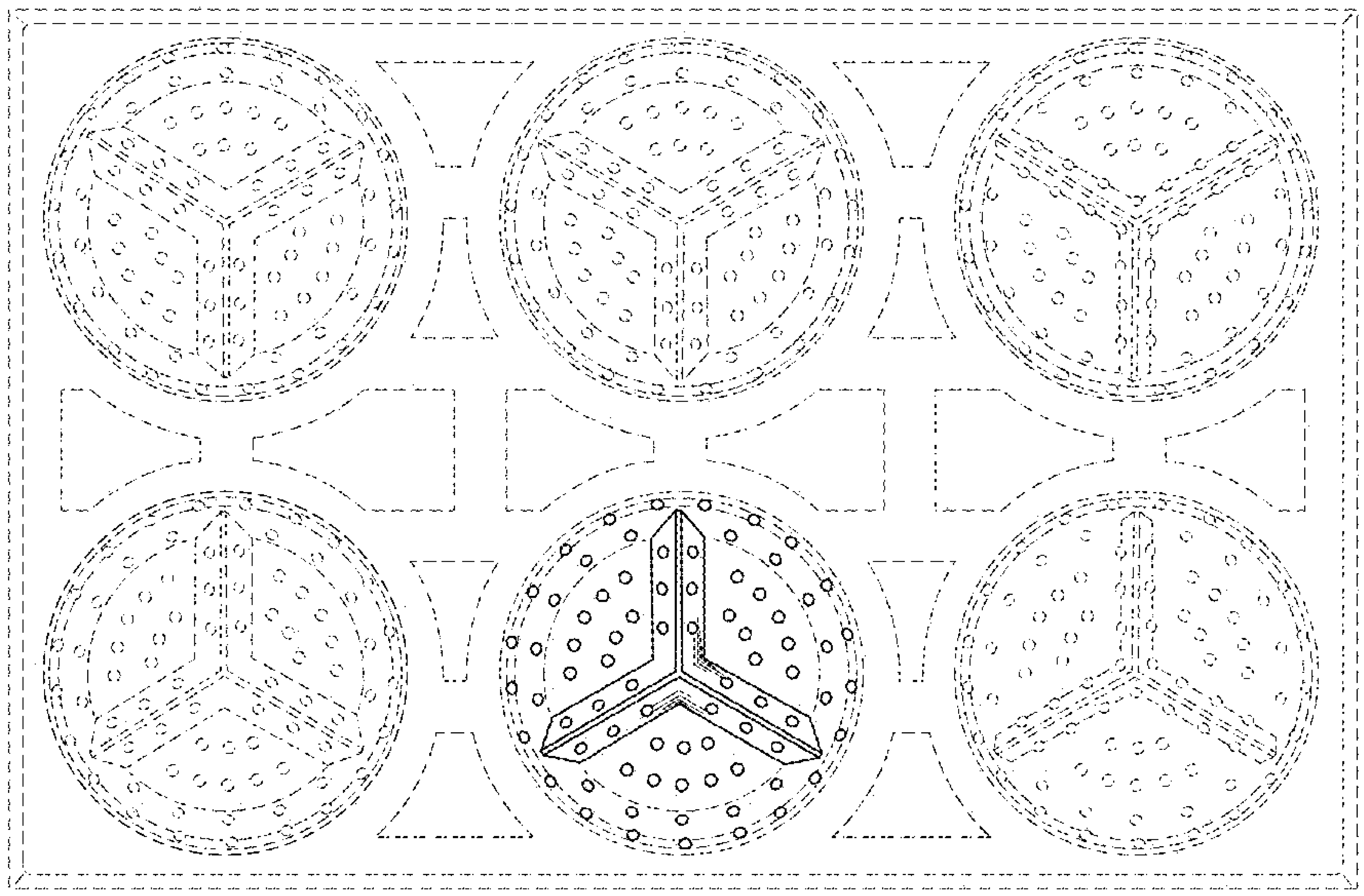

FIG. 21

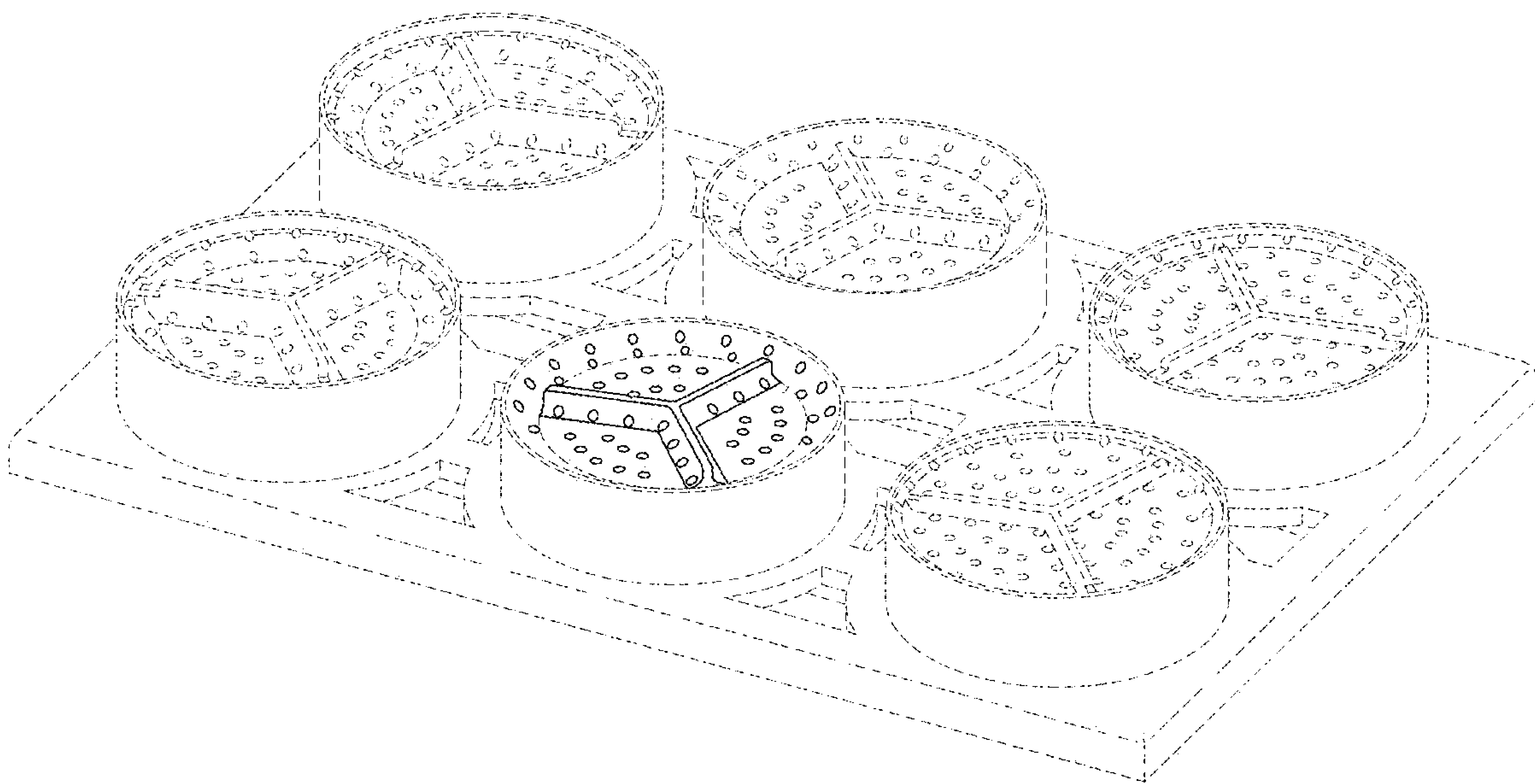

FIG. 22

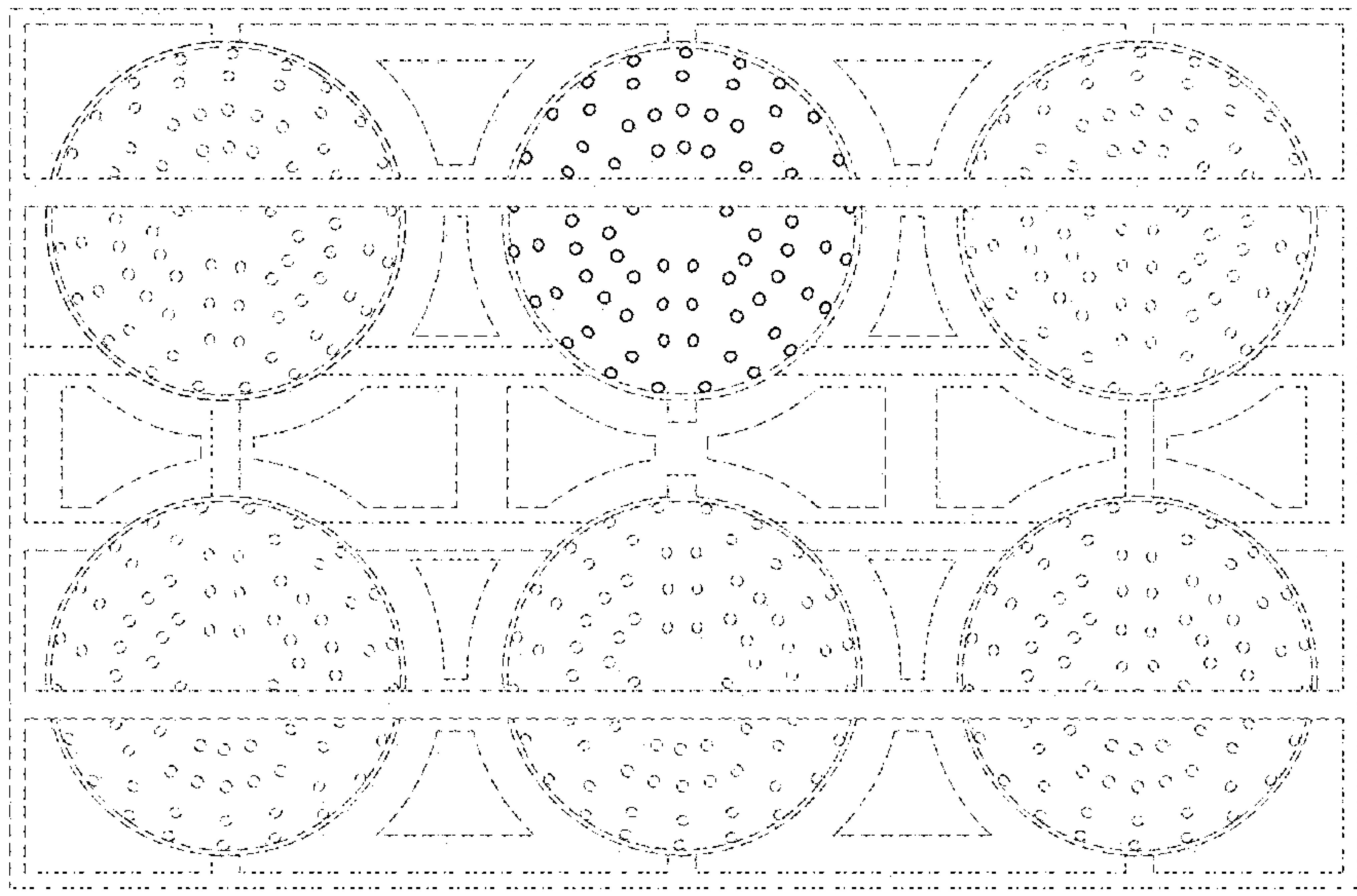

FIG. 23

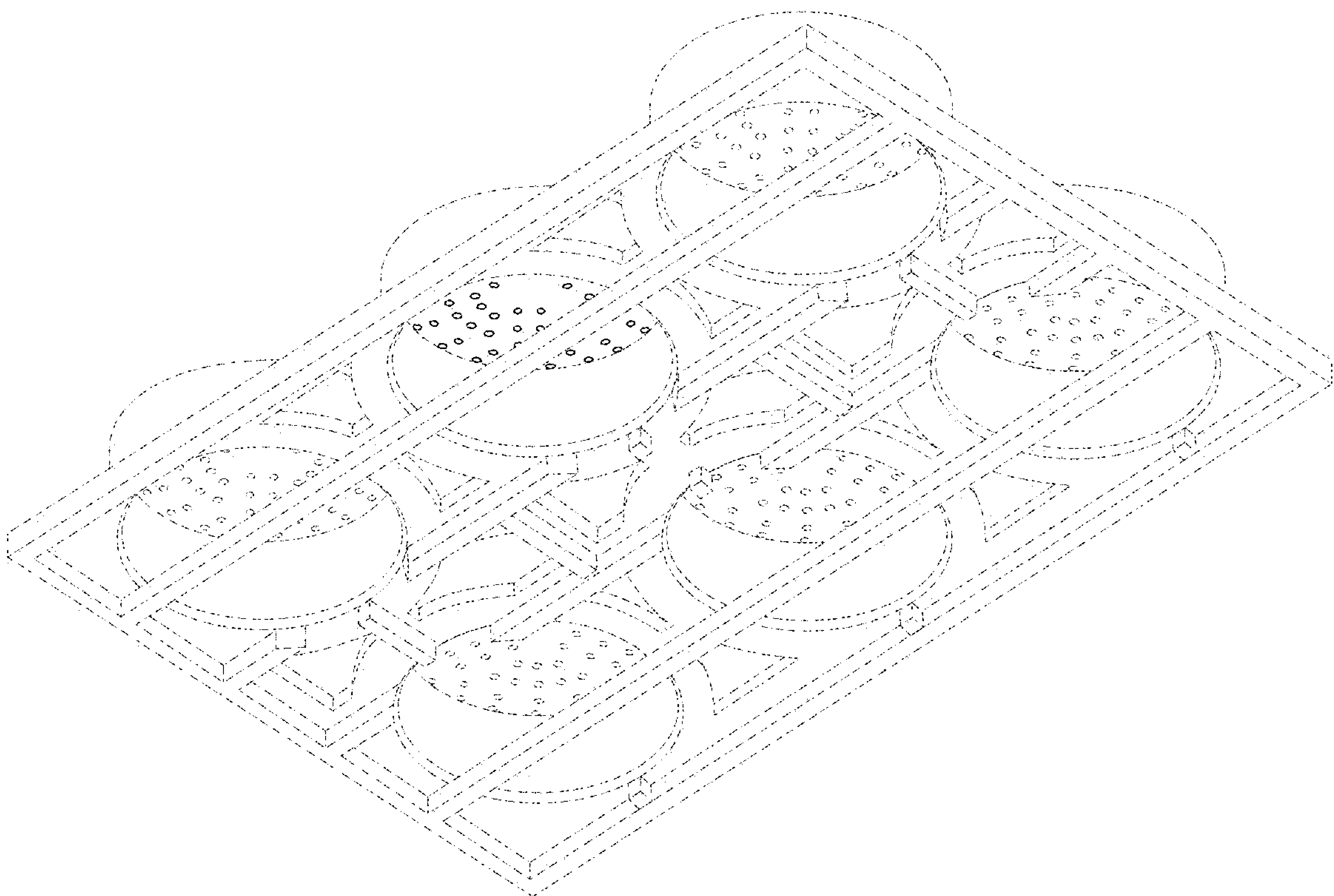

FIG. 24