(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 May 2023 (19.05.2023)

WIPO | PCT

(10) International Publication Number
WO 2023/081995 A1

(51) International Patent Classification:
B29C 45/17 (2006.01)

(21) International Application Number:
PCT/CA2022/051577

(22) International Filing Date:
26 October 2022 (26.10.2022)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
63/263,910 11 November 2021 (11.11.2021) US

(71) Applicant: HUSKY INJECTION MOLDING SYSTEMS LTD. [CA/CA]; 500 QUEEN STREET SOUTH, BOLTON, Ontario L7E 5S5 (CA).

(72) Inventors: NIEWELS, Joachim Johannes; 7155 9th Line, R. R. #3, Thornton, Ontario L0L 2N0 (CA). DEUTSH, Menny; 75 Tamarack Drive, Thornhill, Ontario L3T 4W2 (CA). NOGUEIRA, Joaquim Martins; 25 Moore Avenue, Everett, Ontario L0M 1J0 (CA). KARNER, Richard; 30 Blackstone Court, Holland Landing, Ontario L9N 1C2 (CA). YANKOV, Peter; 30 Loontail Street, Bolton, Ontario L7E 2X1 (CA). ULEMEK, Adam Christopher; 1611 Liveoak Drive, Mississauga, Ontario L5E 2X8 (CA).

(74) Agent: GOW, Geoffrey; c/o Husky Injection Molding Systems Ltd., 500 Queen Street South, BOLTON, L7E 5S5 (CA).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,

(54) Title: CONFIGURABLE PLASTIC MOLDING SYSTEMS AND METHODS

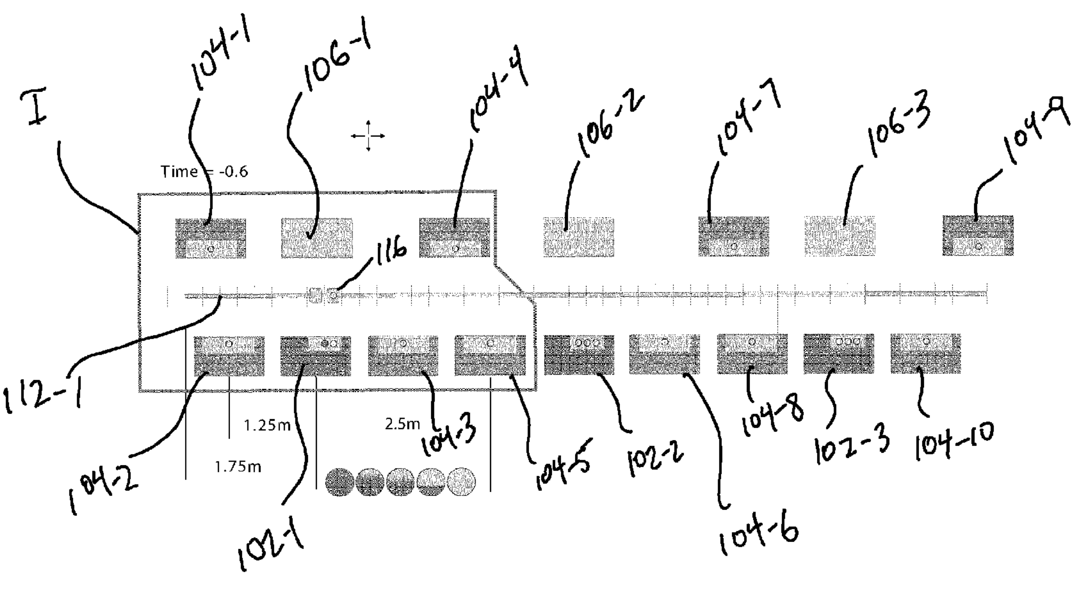


FIG. 8

(57) Abstract: A plastic molding system comprises dispensing stations for dispensing molding material into vessels and shaping stations configured to receive molding material from the dispensing stations. A conveying path extends proximate each of the dispensing and shaping stations, and vessels are movable along the path. A controller is operable to direct movement of the vessels along the path and to define partitions dividing the system into zones, each zone comprising dispensing and shaping stations, the shaping stations of each zone for configured for receiving molding material from the dispensing station of the respective zone. The stations of each zone are positioned along respective contiguous sections of the conveying path.

WO 2023/081995 A1

[Continued on next page]

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*
— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

CONFIGURABLE PLASTIC MOLDING SYSTEMS AND METHODS

TECHNICAL FIELD

This relates to plastic molding, and more particularly, to systems and methods for producing multiple types of articles.

BACKGROUND

Many plastic molding facilities are optimized for production of products of a single type in very large quantities.

Molding operations require customized tooling. For example, plastic beverage containers are often produced using multiple molding steps. Blanks, often referred to as preforms, may be produced by injection molding, using molds customized for each possible blank size and configuration. Blanks may then be reshaped by blow molding, using molds customized for each possible size and configuration of final molded article.

Such facilities and equipment are generally very large and require extensive setup. Production space and resources cannot easily be configured or reconfigured for production of specific products.

SUMMARY

An example plastic molding system comprises: a first set of dispensing stations for dispensing molding material into vessels; a second set of dispensing stations for dispensing molding material into vessels; a plurality of shaping stations, each selectively configurable to define a first set of the shaping stations configured to receive molding material from the first set of dispensing stations and a second set of shaping stations configured to receive molding material from the second set of dispensing stations; a conveying path proximate each one of the dispensing units and the shaping stations a plurality of vessels movable along the conveying path; a controller operable to direct movement of the vessels along the conveying path to transport the molding material from the dispensing stations to the shaping stations, the controller operable to partition said system corresponding to configuration of the shaping stations, such that the first dispensing unit and the first set of shaping stations are positioned along a first contiguous section of the conveying path and the second dispensing station and the second set of shaping stations are positioned along a second contiguous section of conveying path.

In some embodiments, the first set of dispensing stations comprises a single dispensing station.

In some embodiments, the second set of dispensing stations comprises a single dispensing station.

In some embodiments, the controller is operable to partition the system by defining a virtual partition.

In some embodiments, the controller is operable to direct movement of the vessels such that the vessels do not cross the virtual partition.

In some embodiments, each shaping station is configurable by installation of a mold.

In some embodiments, the controller is operable to partition the system in response to installation of a mold at a shaping station.

In some embodiments, installation of a mold at a shaping station comprises installation of a mold at a shaping station of the first set, in order to add that shaping station to the second set.

In some embodiments, the system comprises a plurality of secondary shaping stations for re-shaping articles from the shaping stations and a secondary conveying path extending along a path proximate to the plurality of shaping stations and the plurality of secondary shaping stations for transporting the articles.

In some embodiments, the secondary conveying path is parallel to the conveying path.

In some embodiments, the plurality of secondary shaping stations comprises a first set of the secondary shaping stations configured to re-shape articles from the first set of shaping stations, and a second set of the secondary shaping stations configured to re-shape articles from the second set of the shaping stations.

In some embodiments, the controller is operable to define a secondary partition along the secondary conveying path such that the first the of the shaping stations and the first set of the secondary shaping stations are positioned along a first contiguous section of the secondary conveying path and the second set of the shaping stations and the second set of the secondary shaping stations are positioned along a second contiguous section of the secondary conveying path.

In some embodiments, the secondary partition corresponds to the partition.

In some embodiments, the shaping stations are injection molding stations and the secondary shaping stations are blow molding stations.

In some embodiments, the secondary conveying path comprises a track.

In some embodiments, the conveying path comprises a track.

Example molding systems may include the above features in any operable combination.

An example plastic molding method for a molding system comprising a plurality of mold material dispensing stations, a plurality of shaping stations, and a conveying path for moving articles between the stations, comprises: configuring the shaping stations and the material dispensing stations to define a first set of the shaping stations for receiving molding material from a first set of the material dispensing stations and a second set of shaping stations for receiving molding material from a second set of the material dispensing stations; based on the configuring, partitioning the system so that the first dispensing station and the first set of shaping stations are positioned along a first contiguous section of the path and the second dispensing station and the second set of shaping stations are positioned along a second contiguous section of the path.

In some embodiments, the first set of the material dispensing stations comprises a single material dispensing station.

In some embodiments, the second set of the material dispensing stations comprises a single material dispensing station.

In some embodiments, the partitioning comprises defining a partition in a controller.

In some embodiments, the configuring comprises installing a mold.

In some embodiments, the method comprises re-configuring a shaping station of the first set to receive molding material from the second dispensing station, thereby adding that shaping station to the second set.

In some embodiments, the method comprises re-defining the partition based on the re-configuring.

In some embodiments, the molding system comprises a plurality of secondary shaping stations along a secondary conveying path.

In some embodiments, the method comprises partitioning the secondary conveying path so that a first set of the secondary shaping stations is along a first contiguous section of the secondary conveying path with the first set of the shaping stations, and a second set of the secondary shaping stations is along a second contiguous portion of the secondary conveying path with the second set of the shaping stations.

In some embodiments, the first and second contiguous sections of the secondary conveying path correspond to the first and second contiguous sections of the conveying path.

In some embodiments, the shaping stations comprise injection molding stations and the secondary shaping stations comprise blow molding stations.

In some embodiments, the secondary conveying path comprises a track.

In some embodiments, the conveying path comprises a track.

Example methods may include the above features in any operable combination.

An example plastic molding system comprises: a plurality of fabrication blocks, each fabrication block comprising: at least one dispensing station for dispensing a molding material; a plurality of shaping stations for forming molded articles from the molding material; the plurality of fabrication blocks arranged end-to-end along a conveying path, with shaping stations of adjacent fabrication blocks are positioned intermediate the dispensing stations of those adjacent fabrication blocks.

Other aspects and features will be apparent from the following description.

DESCRIPTION OF THE DRAWINGS

In the drawings, which depict example embodiments:

FIG. 1 is a schematic diagram of a molding system;

FIG. 2 is an isometric view of a molding system;

FIG. 3 is a top view of the molding system of FIG. 2

FIG. 4 is a top view of the molding system of FIG. 2;

FIG. 5 is a side view of the molding system of FIG. 2;

FIG. 6 is a schematic view of a control system of the molding system of FIG. 2;

FIGS. 7A, 7B and 7C are top views of the control system of FIG. 2, showing partitioning of the system;

FIGS. 7D, 7E and 7F are top views of the control system of FIG. 2, showing re-allocation of a station;

FIG. 8 is a top view of a molding system showing a carrier within a zone of the system;

FIGS 9A, 9B, 9C and 9D are top views of a zone of the molding system of FIG. 8, showing movement of a carrier;

FIGS 10A, 10B, 10C and 10D are top views of a zone of the molding system of FIG. 8, showing movement of another carrier.

DETAILED DESCRIPTION OF THE NON-LIMITING EMBODIMENT(S)

FIG. 1 schematically depicts an example plastic molding system 100 for producing plastic molded articles. As described in further detail below, plastic molding system 100 is capable of molding articles through a sequence of processing operations.

Plastic molding system 100 includes a plurality of process stations. The stations include groups of stations that are each operable to perform the same type of processing operation. Specifically, the depicted embodiment comprises a plurality of dispensing stations 102, a plurality of shaping stations 104, a plurality of secondary shaping stations 106, and a plurality of conditioning stations 108.

Each of the dispensing stations 102 is operable to perform a dispensing operation, namely, producing an output of molding material for use in subsequent operations. Each of the shaping stations 104 is operable to perform a primary shaping operation. For example, each station 104 may include an injection mold for performing an injection molding operation. Each one of shaping stations 106 is operable to perform a secondary shaping operation. For example, each one of shaping stations 106 include a blow mold for re-shaping an injection molded article into a finished shape.

Each station is operable to receive an input unit, and perform a process operation on the input unit to produce an output unit (collectively, "parts"). Input parts to dispensing stations 102 are empty vessels for receiving molding material. Output parts from dispensing stations 102 are vessels filled with molding material. Input parts to shaping stations 104 are filled vessels from dispensing stations 102 and output parts from shaping stations 104 are parts molded into an intermediate shape. Input parts to shaping stations 106 are the intermediate-shaped parts output from shaping stations 104, and output parts from shaping stations 106 are re-shaped into finished articles. Intermediate-shaped parts from shaping stations may be processed at conditioning stations 108 prior to re-shaping at shaping stations 106. Conditioning stations 108 may, for example, add heat to the intermediate-shaped parts, to create desired conditions for reshaping.

In an example, dispensing stations 102 comprise extruders for producing a flow of molten plastic molding material such as PET from a solid (e.g. pelletized) feedstock; shaping stations 104 are injection molding stations for producing blanks known as preforms to be subsequently re-shaped into containers such as beverage containers; and shaping stations 106 are blow molding stations for re-shaping the preforms.

In some embodiments, dispensing stations 102 are operable to dispense a range of possible molding materials. For example, the dispensing stations may output molding materials having different colours, compositions, or other properties. Dispensing stations 102 may be configured to output molding material in discrete quantities, which may be referred to as doses. Likewise, different shaping stations 104 and different shaping stations 106 may include molds of different sizes or shapes. Collectively, system 100 may be capable of concurrently producing molded articles of a number of different types, with each specific type of article corresponding to a combination of a type and quantity of molding material from a dispensing station 102, a shape and size of an injection molded article from a shaping station 104, and a shape and size of a finished article from a shaping station 106. Different types of articles would be processed at different combinations of stations.

Other embodiments may include more or fewer stations and carry out molding processes with more or fewer process steps. For example, some molding processes may include only a single molding step, or may include more than two molding steps. Alternatively or additionally, plastic molding system 100 may include stations for other operations. For example, plastic molding system 100 may include stations for post-molding operations such as container filling, labelling or capping.

The process stations of plastic molding system 100 are connected by a transport subsystem 110.

Transport subsystem 110 is configurable to move molding material and in-progress or finished parts between stations of molding system 100. As depicted, transport subsystem defines a longitudinal axis of molding system 100.

FIGS. 2, 3, 4 and 5 depict an example physical layout of plastic molding system 100. As depicted, the transport system defines a conveying path which passes proximate dispensing stations 102 and shaping stations 104, 106. That is, each of dispensing stations 102 and shaping stations 104, 106 is positioned along the conveying path so that material may be transferred between the conveying path and the stations. In the depicted embodiment, the conveying path includes a track 112. Additionally or alternatively, the transport system may include other devices, such as conveyor belts. The transport system may further include a plurality of carriers that are individually movable along track 112. Carriers are configured to receive and carry in-progress parts along the length of track 112. For example, carriers may be used to transport molten molding material from a dispensing station 102 to a shaping station 104, or to transport molded parts from a shaping station 104 to a shaping station 106.

In some embodiments, the conveying path may include multiple parallel sections. For example, in the depicted embodiment, track 112 includes a first conveying path section, i.e. upper track section 112-1 and a second conveying path section, i.e. lower track section 112-2 which is parallel to and vertically offset from the upper track section. In the depicted embodiment, shaping stations 106 are positioned along the track to be accessible from upper track section 112-1, dispensing stations 102 are positioned along the track to be accessible from lower track section 112-2 and shaping stations 104 are positioned along the track to be accessible from both of lower track section 112-2 and upper track section 112-1

The transport system 110 is operable to move each individual carrier to any desired position along track 112. For example, the track 112 may include an array of electromagnets extending along its length. The track may be arranged in segments, each having an encoder output sensor.

The track 112 may comprise an array of electromagnets extending along its length. The track may be arranged in segments, each having a scale and an encoder output sensor extending along its length. The controller provides control voltages to the electromagnets of the track segments and is connected to the encoder output sensor.

Transport subsystem 110 includes carriers operable to hold parts for movement along track 112. In the depicted embodiment, the carriers include molding material carriers 116 and preform carriers 118. Preform carriers 118 travel along upper track section 112-1 and molding material carriers travel along lower track section 116.

In some embodiments, track 112 may include multiple parallel track sections.

Carriers 116, 118 are movable along the length of track 112 by selective operation of the electromagnets in the track. In addition, the encoder at each track segment is able to precisely detect the position of the carriers along the track. Accordingly, the position of each individual carrier 116, 118 may be monitored and a carrier 116, 118 may be accurately sent to any arbitrary position along track 112.

Track 112 and carriers 116, 118 may be those manufactured by Beckhoff Automation GmbH & Co. KG under the trademark XTS.

Molding material carriers 116 are operable to transport molding material to be used at shaping stations 104. Specifically, as depicted, at dispensing stations 102, molding material is melted and transferred in molten form to vessels 120, also referred to as material transport units. Molding material carriers 116 are designed to selectively receive and retain (e.g. interlock with) vessels 120.

Preform carriers 118 are designed to selectively receive and retain in-progress parts for transport to subsequent stations. Specifically, as depicted, molten molding material is molded into an intermediate shape at shaping stations 104. The preform carriers are shaped correspondingly to the intermediate shape. A plurality of intermediate shapes may be possible and the preform carriers may be configured to accommodate all of the possible intermediate shapes. In an example, the intermediate shapes are preforms for being formed in a secondary shaping operation into a bottle or other container. Possible intermediate shapes may correspond to final bottle specifications, such as physical size and shape, wall thickness or the like.

Transport subsystem 110 may further include transfer devices (not shown) for moving parts between individual stations and track 112. For example, robotic devices may be positioned proximate shaping stations 104 for moving vessels 120 onto and off of track section 112, for transferring parts that have been formed into an intermediate shape from shaping stations 104 to preform carriers 118. Likewise, robotic devices may be positioned proximate shaping stations 106 for transferring parts in an intermediate shape into the shaping stations 106 for re-shaping. The robotic devices may be single-axis or multi-axis robotic arms with end effectors operable to selectively grasp an intermediate shape.

Details of a suitable example transport subsystem are disclosed in patent cooperation treaty application no. Patent Co-operation Treaty (PCT) application no. PCT/CA2019/051205.

FIG. 6 is a block diagram depicting physical organization of an example control system 200 for operating molding system 100. As shown, the control system 200 includes a supervisory controller 204 and a plurality of station control modules, each of which generally controls operation of a single station of a molding system. For example, the depicted control modules 207-1, 207-2,…207-16 are responsible for controlling the dispensing stations 102, shaping stations 104 and shaping stations 106 of molding system 100. A further control module 207-17 controls operation of transport subsystem 110.

Each control module may include one or more programmable logic controllers (PLCs) coupled to individual actuators and sensors within the station. For example, actuators controlled by a PLC at a dispensing station 102 may include actuators for extruder screw rotation; barrel heating; gate opening and closing, and the like. Actuators controlled by a PLC at a shaping station 104 may include mold opening and closing, core movement, mold material injection, gate opening and closing, and the like.

In the depicted embodiment, the PLCs are implemented as virtualized PLCs running on industrial computers. Suitable industrial computers are Beckhoff GmbH series C6930 PCs based on multi-core intel CPUs and Microsoft Windows 10 operating system. Virtualized PLCs may be implemented in the Beckhoff TwinCAT 3 PLC runtime.

As noted, molding system 100 may simultaneously produce molded parts of multiple types. Supervisory controller 204 may allocate stations of molding system 100 for the various types of parts under production. For example, if parts of two different types are concurrently produced, supervisory controller 204 may allocate a first subset of each of dispensing stations 102, shaping stations 104 and shaping stations 106 for production of parts of the first type, and a second subset of each of dispensing stations 102, shaping stations 104 and shaping stations 106 for production of parts of the second type.

During operation of molding system 100, supervisory controller 204 may further select a sequence of stations to process each part. For example, for a given dose of molding material dispensed from a dispensing station 102, supervisory controller 204 selects which one of shaping stations 104 and which one of shaping stations 106 will be used to process that part.

An example of a suitable technique for such allocation and selection is described in Patent Co-operation Treaty application no. PCT/CA2021/050671.

Based on the selected sequence of stations, supervisory controller 204 may provide instructions to control module 207-17 for moving specific carriers 116, 118 to locations along track 112 corresponding to stations in the sequence. That is, once a carrier 116 has received molding material from a dispensing station 102, supervisory controller 204 may send an instruction to control module 207-17, causing the carrier 116 to be moved to a position corresponding to the shaping station 104 at which the molding material is to be processed. Subsequently, once the molding material has been formed into an intermediate shape and transferred to a carrier 118, control module 207-17 causes the carrier to be moved to a position corresponding to the shaping station 106 at which it is to be processed next.

Molding system 100 may be capable of operation in multiple possible configurations. For example, the three dispensing stations 102 may be configured to dispense any combination of one, two or three different molding materials. Likewise, the ten shaping stations 104 may be configured to with molds in any combination of up to ten different sizes or shapes, and the three shaping stations 106 may be configured with molds in any combination of up to three different sizes and shapes.

FIGS. 7A, 7B, 7C and 7D depict example configurations of molding system 100.

FIG. 7A represents a configuration of molding system 100 for producing parts of a single type, e.g. parts of a single stock keeping unit (SKU). Each of dispensing stations 102 is configured to dispense the same type of molding material. Each of shaping stations 104 is configured with a mold in the same shape, and each of shaping stations 106 is configured with a mold in the same shape. Accordingly, a given dose of molding material dispensed from any of dispensing stations 102 could be sent to any one of shaping stations 104-1 through 104-10. Likewise, any part in an intermediate shape from a shaping station 104 could be sent to any one of shaping stations 106-1 through 106-3 for subsequent shaping.

Conversely, when molding system 100 is configured to concurrently produce parts of multiple types (e.g. multiple SKUs), only a subset of shaping stations 104 may be suitable for processing parts from any given one of dispensing stations 102. Likewise, only a subset of shaping stations 106 may be suitable for processing parts from any given one of shaping stations 104.

Thus, the combined configurations of dispensing stations 102, shaping stations 104 and shaping stations 106 define capabilities of molding system 100, e.g. what types of molded articles can be produced by molding system 100, and in what quantities and proportions.

The configuration of each station, and thus, of molding system 100 may be modified. For example, components at dispensing stations 102 may be interchanged to change molding materials, and molds at shaping stations 104, 106 may be interchanged to change sizes or shapes of articles being produced. Such changes of configuration may be partially or fully automated. An example of a suitable system for automated configuration changes is disclosed in pending United States provisional patent application no. 63/211,175 filed June 17, 2021.

FIG. 7A reflects a configuration in which all resources of molding system 100 are dedicated to a single SKU, in order to produce that SKU in the highest possible volume. However, molding system 100 may be reconfigured according to production requirements, e.g. according to orders received from customers.

For example, FIG. 7B reflects a configuration for production of two SKUs concurrently. A majority of resources within system 100 are allocated to production of a first SKU. Specifically, dispensing stations 102-1, 102-2, shaping stations 104-1 through 104-8 and shaping stations 106-1, 106-2 are dedicated to production of the first SKU. A smaller set of resources, namely, dispensing station 102-3, shaping stations 104-9, 104-10 and shaping station 106-3 are dedicated to production of a second SKU. Accordingly, the configuration of FIG. 7B allows for mixed production, with one SKU being produced in a large volume. The configuration of FIG. 7A could be converted to that of FIG. 7B by re-allocating shaping stations 104-9, 104-10 and 106-3, and dispensing station 102-3 and installing different tools at some or all of those stations.

As depicted in FIG. 7B, the stations 102, 104, 106 dedicated to the first SKU are within a first physical zone I of molding system 100. The stations dedicated to the second SKU are within a second physical zone.

FIG. 7C depicts a configuration of system 100 for concurrently producing three types of parts, e.g. three SKUs. Dispensing station 102-1, shaping stations 104-1 through 104-3, and shaping station 106-1 are dedicated to a first SKU. Dispensing station 102-3, shaping stations 104-8 through 104-10 and shaping station 106-3 are dedicated to the second SKU. Dispensing station 102-2, shaping stations 104-4 through 104-7 and shaping station 106-2 are dedicated to a third SKU. The configuration of FIG. 7B could be changed to that of FIG. 7C by re-allocating shaping station 104-8 for production of the second SKU and re-allocating dispensing station 102-2, shaping stations 104-4 through 104-7 and shaping station 106-2 for production of a new, third SKU. New tooling may be installed at shaping station 104-8 that matches that at shaping stations 104-9, 104-10, and different tooling for the new SKU may be installed at one or more of dispensing station 102-2, shaping stations 104-4 through 104-7, and shaping station 106-2. Stations dedicated to the three SKUs lie within three discrete physical zones I, II, III of molding system 100.

Each dispensing station 102, shaping station 104 and shaping station 106 has a particular cycle time. The cycle times define the rate at which the stations can process parts. In the depicted example, the cycle time of a shaping station 104, i.e. the time required to perform an injection molding operation, is approximately three times as long as the cycle time of a dispensing station 102, i.e. the time required to dispense a dose of molding material. The cycle time of a shaping station 106, i.e., the time required to perform a blow molding operation, is approximately the same as that of a dispensing station 102. Accordingly, a dispensing station 102 or shaping station 106 is capable of processing parts at approximately triple the rate of a shaping station 104.

Utilization of stations 102, 104, 106 and efficiency of molding system 100 are generally maximized when the rate at which a particular station outputs parts is the same as the rate at which stations supplied by that station are able to receive inputs (also referred to as the takt time). For example, maximum utilization occurs when the rate at which a particular dispensing station 102 outputs parts corresponds to the rate at which the associated shaping stations 104 can collectively receive parts for processing. Likewise, maximum utilization occurs when the rate at which the shaping stations 104 can output parts corresponds to the rate at which the associated shaping station or stations 106 can receive parts for processing.

Molding system 100 is therefore designed so that configuration of stations 102, 104, 106 and allocation of those stations can be adjusted, while maintaining desired ratios of stations producing each SKU. For example, in the configuration of FIG. 7A, three dispensing stations are dedicated to production of the first SKU, along with ten shaping stations 104 and three shaping stations 106. Thus, dispensing stations 102 and shaping stations 106 are in a ratio of about 1:1, whereas dispensing stations 102 are in a ratio of about 1:3.3 with shaping stations 104. In the configurations of FIGS. 7B and 7C, in each zone I, II, III, dispensing stations 102 and shaping stations 106 are in a ratio of 1:1, and dispensing stations 102 and shaping stations 104 are in a ratio of between 1:2 and 1:4.

Allocation of stations may be done based at least on the desired production rate of each SKU, and on the relative cycle times of dispensing stations 102, shaping stations 104 and shaping stations 106, as configured for production of each SKU. For example, for production of a first SKU, the cycle time of shaping stations 104 may be triple that of dispensing stations 102. Thus, shaping stations and dispensing stations may be allocated for production of that SKU in a ratio of 3:1. For production of a second SKU, the cycle time of shaping stations 104 may be longer, such that the ratio of shaping stations 104 to dispensing stations 102 is higher (e.g. 5:1).

Conveniently, as depicted in FIGS. 7A-7C, in each configuration, stations 102, 104, 106 that are dedicated to production of a particular SKU are located along a contiguous section of track 112. For example, in the configuration of FIG. 7C, the stations 102, 104, 106 within zone I are dedicated to a first SKU and are positioned alongside a contiguous section of track 112. Likewise, stations 102, 104, 106 within zone II are dedicated to a second SKU and are positioned alongside a second contiguous section of track 112, and stations 102, 104, 106 within zone III are dedicated to a third SKU and are positioned alongside a third contiguous section of track 112.

Accordingly, each station 102, 104, 106 and all of the stations from which it receives input parts and to which it sends output parts, are positioned on the same section of track, without any stations dedicated to another SKU interposed.

Supervisory controller 204 and controller 207-17 may define partitions within molding system 100 corresponding to the zones and the associated sections of track 112. Each partition may include a primary partition along upper track 112-1 and a corresponding secondary partition along lower track 112-2. Defining of such partitions may be responsive to allocation and configuration of the dispensing stations 102 and shaping stations 104, 106. For example, partitions may be defined corresponding to the configuration of the stations, and partitions may be updated or redefined in response to re-allocation and reconfiguration of one or more dispensing stations 102 or shaping stations 104, 106. In some embodiments, supervisory controller 204 and controller 207-17 may automatically define partitions upon installation of tooling at any station of system 100. As depicted in FIGS. 7B-7F, partition P-1 is a partition corresponding to a boundary of zone I and partition P-2 is a partition corresponding to a boundary of zone II

For example, supervisory controller 204 and controller 207-17 may define virtual boundaries within molding system, 100, and prevent any of carriers 116, 118 from crossing such boundaries. Accordingly, each specific carrier 116, 118 travels only along the contiguous section of track 112 within a single zone of the molding system. With such travel limits, the section of track 112 traversed by carriers 116, 118 in one zone does overlap with any track section traversed by carriers 116, 118 in any other zone. Such partitioning does not require mechanical barriers, and may be adjusted at any time in response to reconfiguration of the molding system 100. Such virtual boundaries may be defined implicitly by supervisory controller 204 and controller 207-17. For example, the controllers may include data structures identifying those stations and carriers 116, 118 in each zone, and rules prescribing that each carrier 116, 118 is only moved to stations within the same zone. Such constraints may prevent the carriers from crossing between zones. Additionally or alternatively, such boundaries may be defined explicitly. For example, supervisory controller 204 and controller 207-17 may maintain data structures defining the locations of such boundaries, e.g. by coordinates along track 112, and may maintain logic for preventing movement of carriers 116, 118 across those boundaries.

In the depicted configurations, each one of dispensing stations 102-1, 102-2, 102-3 is consistently paired with a corresponding shaping station 106-1, 106-2, 106-3. That is, dispensing station 102-1 and shaping station 106-1 are dedicated to production of the same SKU and lie in the same zone. Similarly, dispensing station 102-2 and shaping station 106-2 are dedicated to production of the same SKU and lie in the same zone, and dispensing station 102-3 and shaping station 106-3 are dedicated to production of the same SKU and lie in the same zone.

In contrast, some or all of shaping stations 104 have multiple possible dispensing stations 102 with which they can be grouped. For example, in the configuration of FIG. 7B, shaping station 104-8 is grouped with dispensing station 102-2 and lies in the same zone, while in the configuration of FIG. 7C, shaping station 104-8 is grouped with dispensing station 102-3 and lies in the same zone.

Stations 102, 104, 106 of molding system 100 are physically arranged to allow flexibility of allocation of at least some stations to multiple possible zones. For example, as noted, in the depicted embodiment, shaping stations 104-3, 104-4 and 104-5 can be allocated to a zone with dispensing station 102-1, or to a zone with dispensing station 102-2. Similarly, shaping stations 104-6, 104-7, 104-8 can be allocated to a zone with dispensing station 102-2 or with dispensing station 102-3.

Allocation of stations and defining zones and partitions may be done during operation of system 100. For example, FIGS. 7D-7F depict re-allocation of shaping station 104-8 from a first zone I for production of a first SKU, as shown in FIG. 7D, to a second zone II for production of a second SKU, as shown in FIG. 7E.

To re-allocate a station, supervisory controller 204 and controller 207-17 stop routing parts for processing at that station. In the case of a shaping station 104, supervisory controller 204 and controller 204-17 stop routing carriers 116 with molding material to that station. The supervisory controller 204 sends an instruction to the station to stop. The station does not stop immediately, but rather completes processing any in-progress part and then stops. Specifically, in the case of a shaping station 104, if molding of a part is underway, the station completes molding and then stops.

Once the station has stopped, controllers 204, 207-17 remove the station from its current zone. For example, as shown in FIG. 7E, shaping station 104-8 is removed from zone I and partitions between zones change accordingly. Accordingly, carriers are no longer sent to shaping station 104-8.

If necessary, tooling may be removed from shaping station 104-8 and new tooling installed. For example, if a shaping station 104 or 106 is re-allocated for production of parts of a different shape or size, a new mold may be installed.

The station may then be allocated to the appropriate zone. For example, as shown in FIG. 7F, shaping station 104-8 is allocated to zone II. Partitions between zones are changed accordingly. Once station 104-8 is added to zone II, parts may be sent to that station for processing.

Conveniently, this approach may allow for reconfiguration of system 100 with limited interruption of operation. For example, removal of station 104-8 from zone I in the depicted manner may allow for the remaining stations of zone I to continue operating while a tool change occurs. Likewise, station 104-8 may be added to zone II without requiring the other stations of zone II to stop operating.

As shown, dispensing stations 102 and shaping stations are arranged in fabrication units, arranged end-to-end along track 112. Zones I, II, III depicted in FIG. 7C correspond to fabrication units. Each fabrication units includes the stations required for production of finished molded parts. That is, each fabrication unit includes at least one each of a dispensing station 102, shaping station 104 and shaping station 106. Accordingly, each fabrication unit may operate independently to produce parts.

The layout and end-to-end positioning of the fabrication units allows some stations of each fabrication unit to be re-allocated to work with the stations of another fabrication unit. Each fabrication unit includes a dispensing station 102 located centrally within the fabrication unit, and shaping stations 104 located peripherally within the fabrication unit. Thus, when multiple fabrication units are positioned end-to-end, some shaping stations 104 are located between the dispensing stations 102 of adjacent fabrication units and can be allocated to receive and process molding material from either one of those dispensing stations 102. For example, dispensing station 102-1, shaping stations 104-1, 104-2, 104-3 and shaping station 106-1 form a fabrication unit. However, shaping station 104-3 is positioned between dispensing station 102-1 and dispensing station 102-2, and could be configured to receive and process molding material with either one of those dispensing stations. Because of the position of shaping station 104-3, a partition could be defined between shaping station 104-3 and dispensing station 102-2 such that dispensing station 102-1 and shaping station 104-3 lie along a contiguous section of track 112. Alternatively, a partition could be defined between dispensing station 102-1 and shaping station 104-3 such that dispensing station 102-2 and shaping station 104-3 lie along a contiguous section of track 112.

In the depicted embodiment, each zone I, II, III has its own preform carriers 118 and molding material carriers 116. That is, some of the preform carriers 118 within system 100 move only along the section of upper track 112-1 that lies within zone I. Likewise, some of the molding material carriers 116 move only along the section of lower track 112-2 that lies within zone I. Similarly, other preform carriers 118 and molding material carriers 116 move only along the sections of upper track 112-1 and lower track 112-2 that lie within zone II, and only along the sections of upper track 112-1 and lower track 112-2 that lie within zone II.

In an example, each zone has a single preform carrier 118 on upper track 112-1 and a single molding material carrier 116 on lower track 112-2.

Each preform carrier 118 travels back-and-forth along the section of upper track 112-1 within its zone. Likewise, each molding material carrier travels back-and-forth along the section of lower track 112-2 within its zone. The sections of track do not overlap one another. Accordingly, the paths of preform carriers 118 do not overlap one another and the paths of molding material carriers 116 do not overlap one another.

FIG. 8 schematically depicts carriers 116 within a zone I of system 100. FIGS. 9A-9T schematically depict movement of a carrier 112 along lower track 112-2 within zone I.

In the depicted embodiment, each carrier 116 has capacity to carry multiple vessels holding molding material. For example, each carrier 116 may have two side-by-side nests, each for receiving a vessel. One such next may be left vacant while carrier 116 moves between stations, so that the carrier 116 can receive a vessel upon arriving at a station.

As shown in FIG. 9A, a carrier 116 is positioned on upper track 112-1 proximate dispensing station 102-1. An empty vessel 120 is positioned on carrier 116. Two vessels 120 are positioned at dispensing station 102-1. One vessel 120 is filled with molding material, and a second vessel 120 is empty and queued for filling.

As indicated by the arrows in FIG. 9A, the filled vessel 120 is transferred from dispensing station 102-1 to carrier 116, and an empty vessel 120 is transferred from carrier 116 to dispensing station 102-1. Filling of the next vessel 120 at dispensing station 102-1 begins.

As shown in FIG. 9B, once vessels 120 have been transferred, carrier 116 holds a filled vessel 120 and two vessels 120 are positioned at dispensing station 102-1, one of which is empty, and one of which is in the process of being filled. Carrier 116 then moves towards a shaping station 104.

FIGS. 9C-9D depict carrier 116 at shaping station 104-3. As shown in FIG. 9C, the carrier 116 arrives at shaping station 104-3 with a filled vessel 120. Another vessel 120 is positioned at shaping station 104-3, and is empty after having ejected molding material into a mold at shaping station 104-3.

As indicated by the arrows in FIG. 9C, the empty vessel 120 is transferred from the shaping station 104-3 to an empty position at carrier 116. The filled vessel 120 is transferred from carrier 116 to shaping station 104-3, and positioned for ejection of molding material into a mold at the shaping station. Carrier 116 then returns to dispensing station 102-1 with the empty vessel 120 as indicated in FIG. 9D.

The motions depicted in FIGS. 9A-9D may be repeated to move carrier 116 to transport filled vessels 120 to each of shaping stations 104-1 through 104-5, and to transport empty vessels 120 from the shaping stations to dispensing station 102-1 for re-filling. Carrier 116 can move between dispensing station 102-1 and any of shaping stations 104-1 through 104-5 by linear back-and-forth motion along upper track 112-1. Because only a single carrier 106 is present on track 112-1 within zone I, the carrier can be freely moved between dispensing station 102-1 and any of shaping stations 104-1 through 104-5 without any interference from other carriers.

Concurrently with movement of carrier 116 along track 112-1, carrier 118 moves along track 112-2 as depicted in FIGS. 10A-10D.

As shown in FIG. 10A, each carrier 118 may include a pair of movers which cooperatively define a nest for receiving a molded part from a shaping station 104. As noted, the molded parts from shaping stations 104 may be blanks for producing containers (e.g. bottles) using a blow molding process. Such blanks may be referred to as preforms 119.

As shown in FIG. 10A, carrier 118 is positioned on track 112-2 opposite shaping station 104-3. A preform 119 is located within a mold (not shown) at the shaping station after molding, and is ready to be removed.

Preform 119 is de-molded at shaping station 104-3 and transferred to carrier 118. Example methods and apparatus for such de-molding and transfer are described in patent cooperation treaty application no. Patent Co-operation Treaty (PCT) application no. PCT/CA2019/051205. The preform 119 is received by carrier 118, which then moves towards shaping station 106-1, as indicated by the arrow in FIG. 10B

As shown in FIG. 10C, carrier 118 is positioned opposite shaping station 106-1. As indicated by the arrow in FIG. 10C, and as shown in FIGS. 10C-10D, preform 119 is transferred to shaping station 106, e.g., placed inside a blow mold. Re-shaping of the preform then occurs at shaping station 106.

Carrier 118 may move in turn to each of shaping stations 104-1 through 104-5, and after moving to each shaping station 104, return to shaping station 106-1 with a preform.

Carrier 116 may move along track 112-1 at a fixed, known speed, such that the amount of time required for carrier 116 to move between two points can be determined from the corresponding distance along track 112-1. The system 100 may be configured such that the total round-trip transit time is less than or equal to the system takt time. Such configuration may ensure that transit time does not delay operations at the stations or increase the overall system takt time.

As described above with reference to FIGS. 9A-9D and FIGS. 10-10D, carriers 116, 118 can move to all of the dispensing stations 102 and shaping stations 104, 106 within the zone I to which they are assigned, while travelling on a single contiguous track section. The carriers 116, 118 need not cross any partition between zone 1 and an adjacent zone. Likewise, other carriers 116, 118 may move along other sections of track 112 that lie in other zones of system 100.

Accordingly, the partitioning of system 100 in this manner allows parallel operation of sub-systems of system 100 in discrete zones, without interference with one another. The zones may be easily re-sized or re-configured according to production requirements.

In addition, control of the movement of carriers 116, 118 may be relatively simple. For example, with system 100 partitioned, supervisory controller 204 and controller 207-17 need not manage physical sequencing of carriers 116, 118 along track 112. Conversely, if multiple types of parts were produced concurrently without partitioning of system 100, carriers 116, 118 could obstruct one another along track 112, in which case the complexity of routing and sequencing logic at supervisory controller 204 and controller 207-17 may increase substantially.

Of course, the above described embodiments are intended to be illustrative only and in no way limiting. The described embodiments are susceptible to many modifications of form, arrangement of parts, details and order of operation. The invention is intended to encompass all such modification within its scope, as defined by the claims.

WHAT IS CLAIMED IS:

1. A plastic molding system, comprising:

a first set of dispensing stations for dispensing molding material into vessels;

a second set of dispensing stations for dispensing molding material into vessels;

a plurality of shaping stations, each selectively configurable to define a first set of said shaping stations configured to receive molding material from said first set of dispensing stations and a second set of shaping stations configured to receive molding material from said second set of dispensing stations;

a conveying path proximate each one of said dispensing units and said shaping stations

a plurality of vessels movable along said conveying path;

a controller operable to direct movement of said vessels along said conveying path to transport said molding material from said dispensing stations to said shaping stations, said controller operable partition said system corresponding to configuration of said shaping stations, such that said first dispensing unit and said first set of shaping stations are positioned along a first contiguous section of said conveying path and said second dispensing station and said second set of shaping stations are positioned along a second contiguous section of conveying path.

2. The system of claim 1, wherein said first set of dispensing stations comprises a single dispensing station.

3. The system of claim 1 or claim 2, wherein said second set of dispensing stations comprises a single dispensing station.

4. The system of any one of claims 1 to 3, wherein said controller is operable to partition said system by defining a virtual partition.

5. The system of claim 4, wherein said controller is operable to direct movement of said vessels such that said vessels do not cross said virtual partition.

6. The system of any one of claims 1 to 5, wherein each said shaping station is configurable by installation of a mold.

7. The system of claim 6, wherein said controller is operable to partition said system in response to installation of a mold at a shaping station.

8. The system of claim 7, wherein said installation of a mold at a shaping station comprises installation of a mold at a shaping station of said first set, in order to add that shaping station to said second set.

9. The system of any one of claims 1 to 8, comprising a plurality of secondary shaping stations for re-shaping articles from said shaping stations and a secondary conveying path extending along a path proximate to said plurality of shaping stations and said plurality of secondary shaping stations for transporting said articles.

10. The system of claim 9, wherein said secondary conveying path is parallel to said conveying path.

11. The system of claim 9 or claim 10, wherein said plurality of secondary shaping stations comprises a first set of said secondary shaping stations configured to re-shape articles from said first set of shaping stations, and a second set of said secondary shaping stations configured to re-shape articles from said second set of said shaping stations.

12. The system of claim 11, wherein said controller is operable to define a secondary partition along said secondary conveying path such that said first said of said shaping stations and said first set of said secondary shaping stations are positioned along a first contiguous section of said secondary conveying path and said second set of said shaping stations and said second set of said secondary shaping stations are positioned along a second contiguous section of said secondary conveying path.

13. The system of claim 12, wherein said secondary partition corresponds to a partition along said primary conveying path.

14. The system of any one of claims 9 to 13, wherein said shaping stations are injection molding stations and said secondary shaping stations are blow molding stations.

15. The system of any one of claims 9 to 14, wherein said secondary conveying path comprises a track.

16. The system of any one of claims 1 to 15, wherein said conveying path comprises a track.

17. A plastic molding method for a molding system comprising a plurality of mold material dispensing stations, a plurality of shaping stations, and a conveying path for moving articles between said stations, the method comprising:

configuring said shaping stations and said material dispensing stations to define a first set of said shaping stations for receiving molding material from a first set of said material dispensing stations and a second set of shaping stations for receiving molding material from a second set of said material dispensing stations;

based on said configuring, partitioning said system so that said first dispensing station and said first set of shaping stations are positioned along a first contiguous section of said path and said second dispensing station and said second set of shaping stations are positioned along a second contiguous section of said path.

18. The plastic molding method of claim 17, wherein said first set of said material dispensing stations comprises a single material dispensing station.

19. The plastic molding method of claim 17 or claim 18, wherein said second set of said material dispensing stations comprises a single material dispensing station.

20. The method of any one of claims 17 to 19, wherein said partitioning comprises defining a partition in a controller.

21. The method of any one of claims 17 to 20, wherein said configuring comprises installing a mold.

22. The method of any one of claims 17 to 21, comprising re-configuring a shaping station of said first set to receive molding material from said second dispensing station, thereby adding that shaping station to said second set.

23. The method of claim 22, comprising re-defining said partition based on said re-configuring.

24. The method of any one of claims 17 to 23, wherein said molding system comprises a plurality of secondary shaping stations along a secondary conveying path.

25. The method of claim 24, comprising partitioning said secondary conveying path so that a first set of said secondary shaping stations is along a first contiguous section of said secondary conveying path with said first set of said shaping stations, and a second set of said secondary shaping stations is along a second contiguous portion of said secondary conveying path with said second set of said shaping stations.

26. The method of claim 25, wherein said first and second contiguous sections of said secondary conveying path correspond to said first and second contiguous sections of said conveying path.

27. The method of any one of claims 24 to 26, wherein said shaping stations comprise injection molding stations and said secondary shaping stations comprise blow molding stations.

28. The method of any one of claims 24 to 27, wherein said secondary conveying path comprises a track.

29. The method of any one of claims 17 to 28, wherein said conveying path comprises a track.

30. A plastic molding system comprising:

a plurality of fabrication blocks, each fabrication block comprising:

at least one dispensing station for dispensing a molding material;

a plurality of shaping stations for forming molded articles from said molding material;

said plurality of fabrication blocks arranged end-to-end along a conveying path, with shaping stations of adjacent fabrication blocks are positioned intermediate said dispensing stations of those adjacent fabrication blocks.

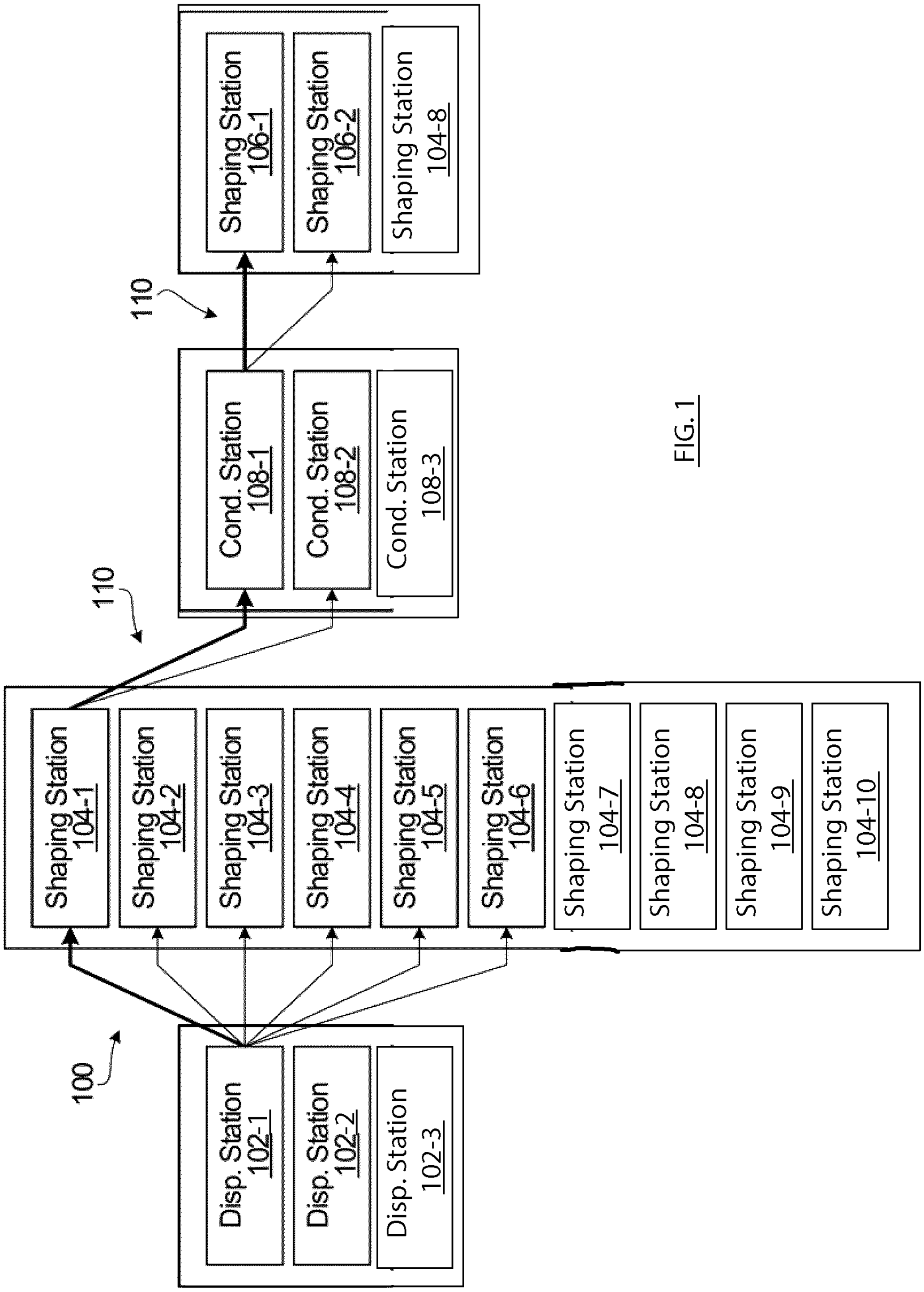

Disp. Station 102-1
Disp. Station 102-2
Disp. Station 102-3
100
Shaping Station 104-1
Shaping Station 104-2
Shaping Station 104-3
Shaping Station 104-4
Shaping Station 104-5
Shaping Station 104-6
Shaping Station 104-7
Shaping Station 104-8
Shaping Station 104-9
Shaping Station 104-10
110
Cond. Station 108-1
Cond. Station 108-2
Cond. Station 108-3
110
Shaping Station 106-1
Shaping Station 106-2
Shaping Station 104-8

FIG. 1

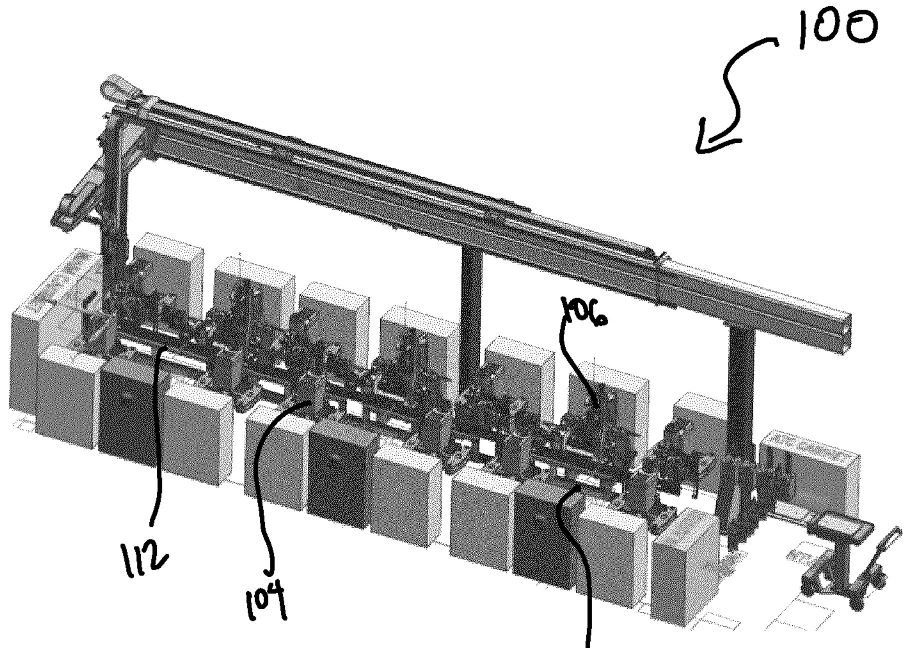

100
106
ATC CABINET
112
104
102

FIG. 2

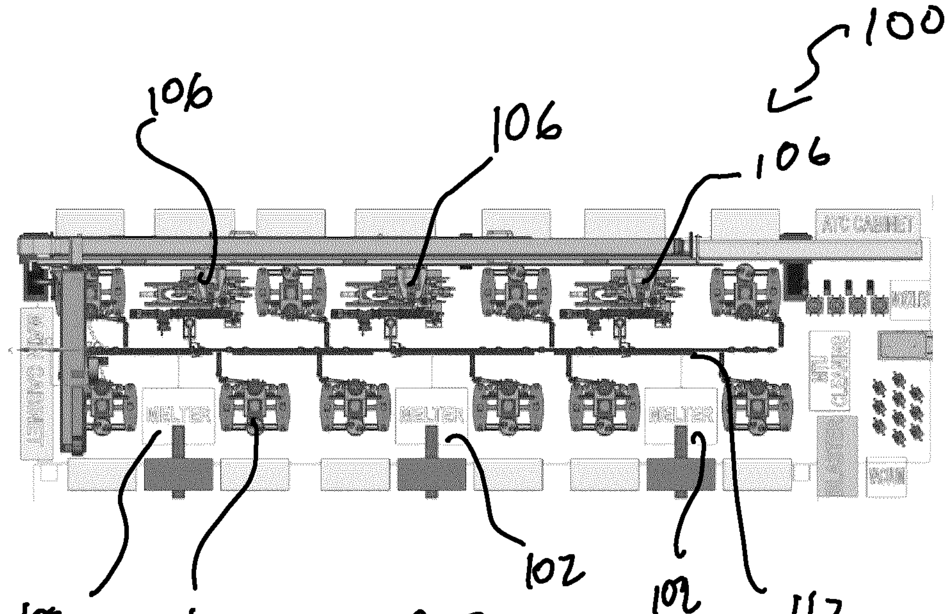

100
106
106
106
ATC CABINET
MELTER
MELTER
MELTER
102
104
102
102
112

FIG. 3

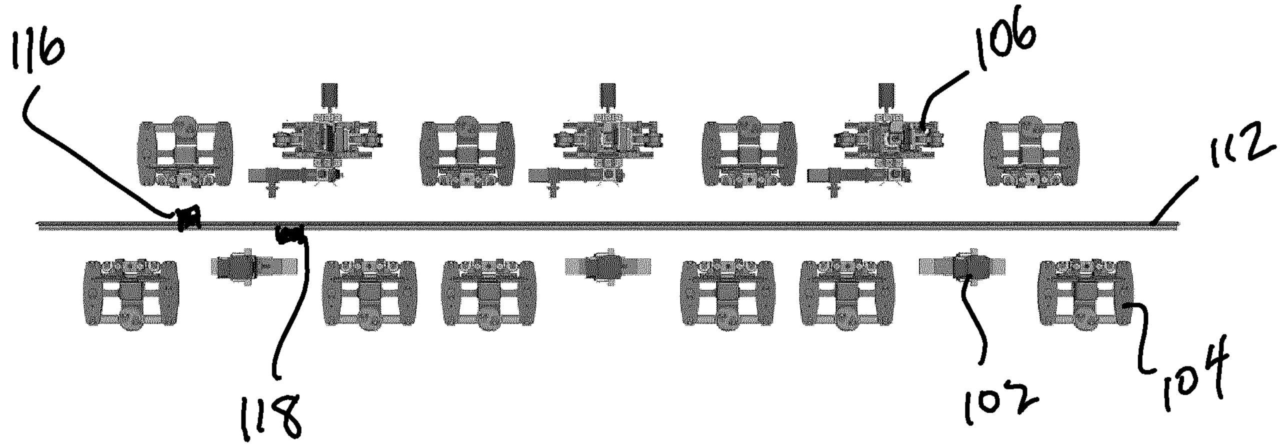

116
106
112
118
102
104

FIG. 4

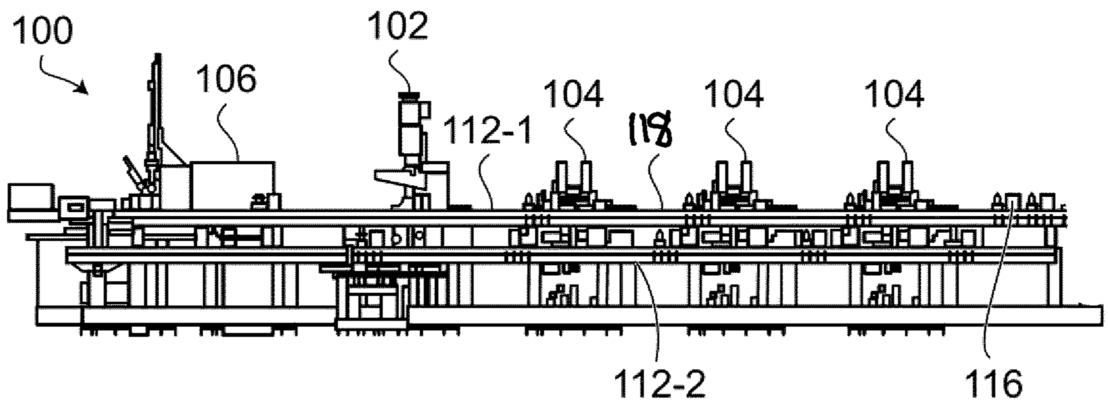

100
106
102
104
112-1
118
104
104
112-2
116

FIG. 5

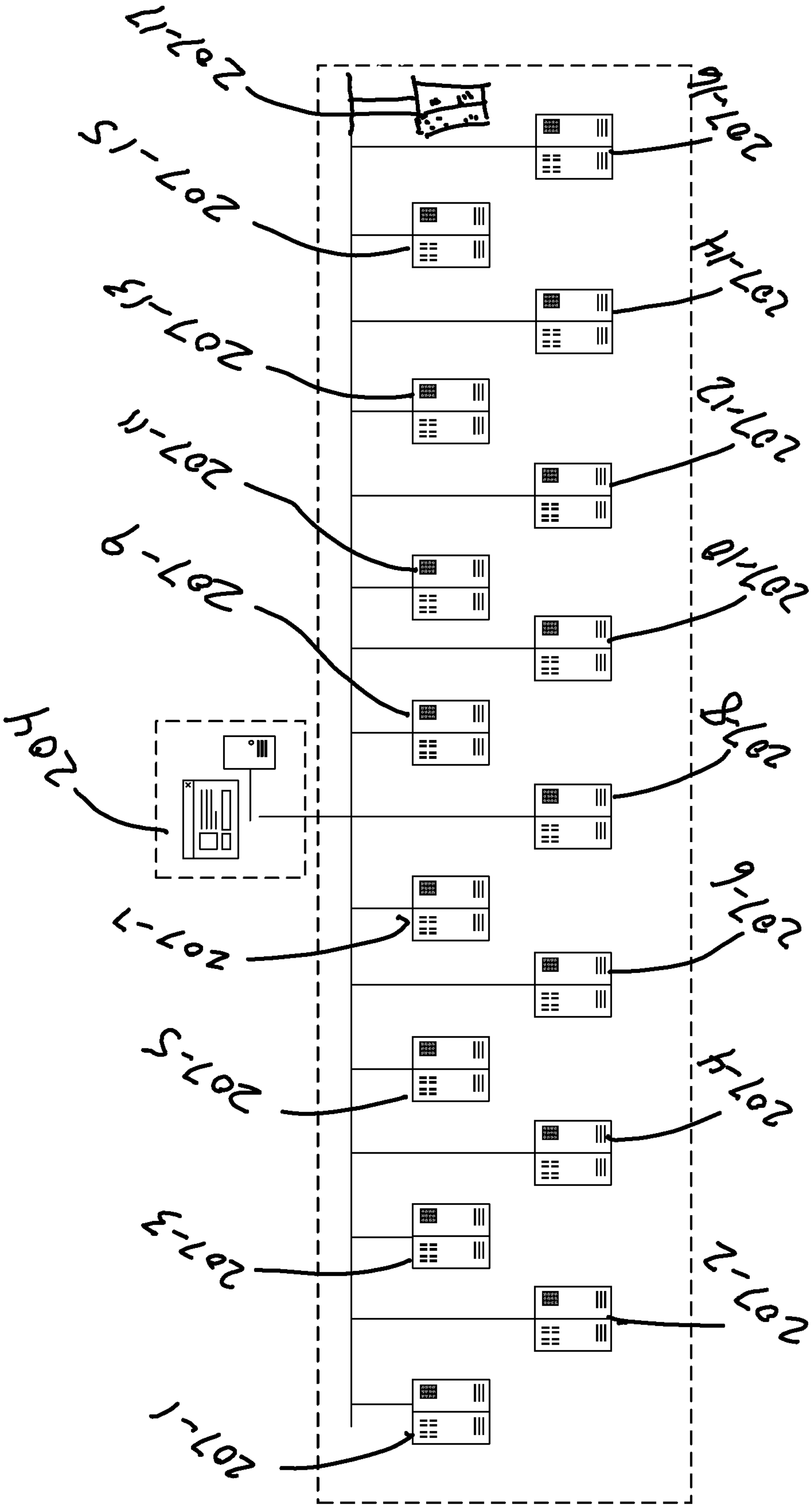

207-17
207-16
207-15
207-14
207-13
207-12
207-11
207-10
207-9
207-8
204
207-7
207-6
207-5
207-4
207-3
207-2
207-1

Fig. 6

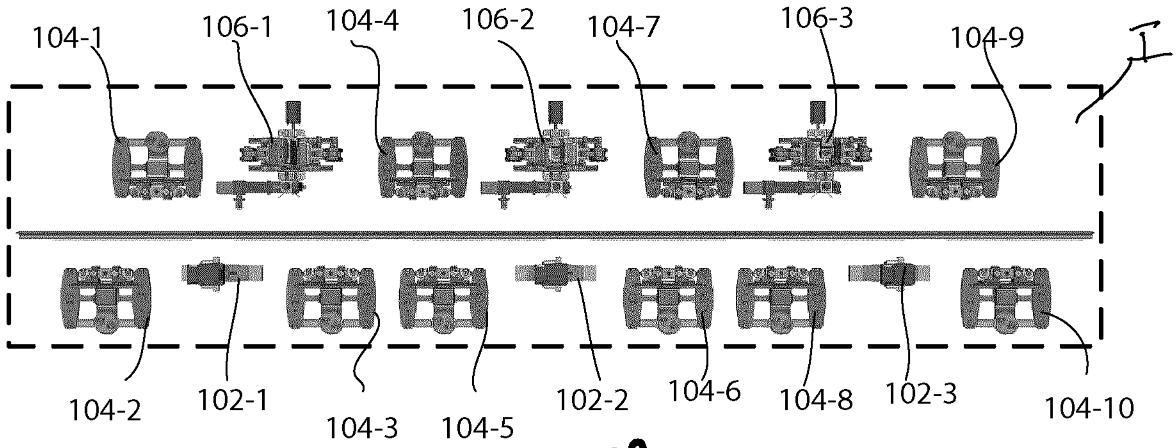


FIG. 7A

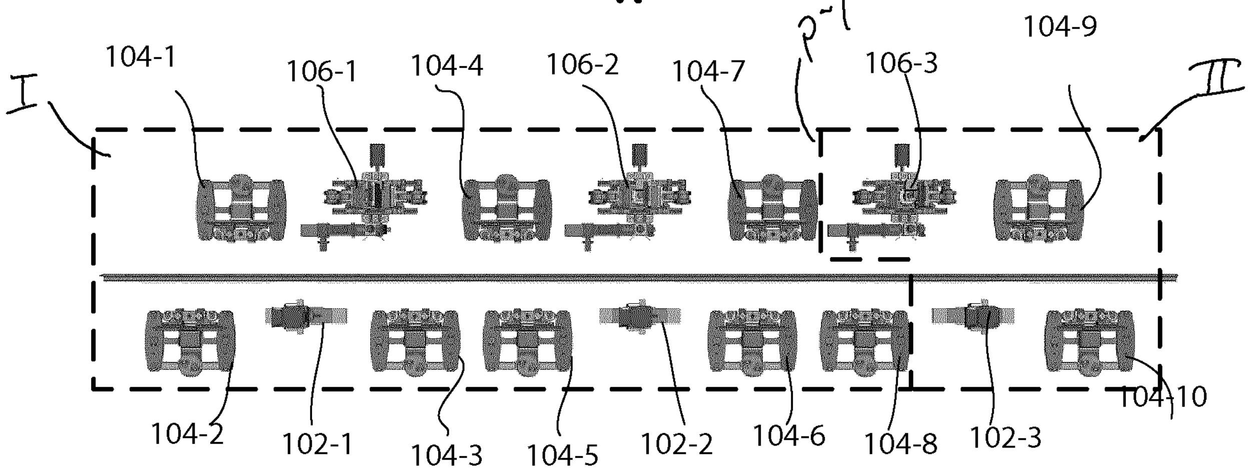


FIG. 7B

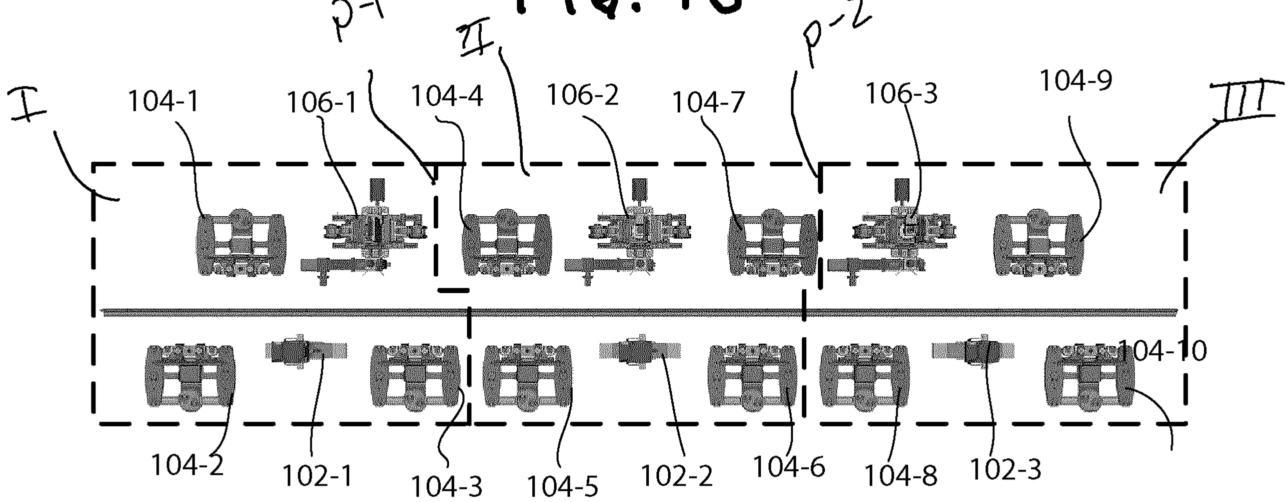


FIG. 7C

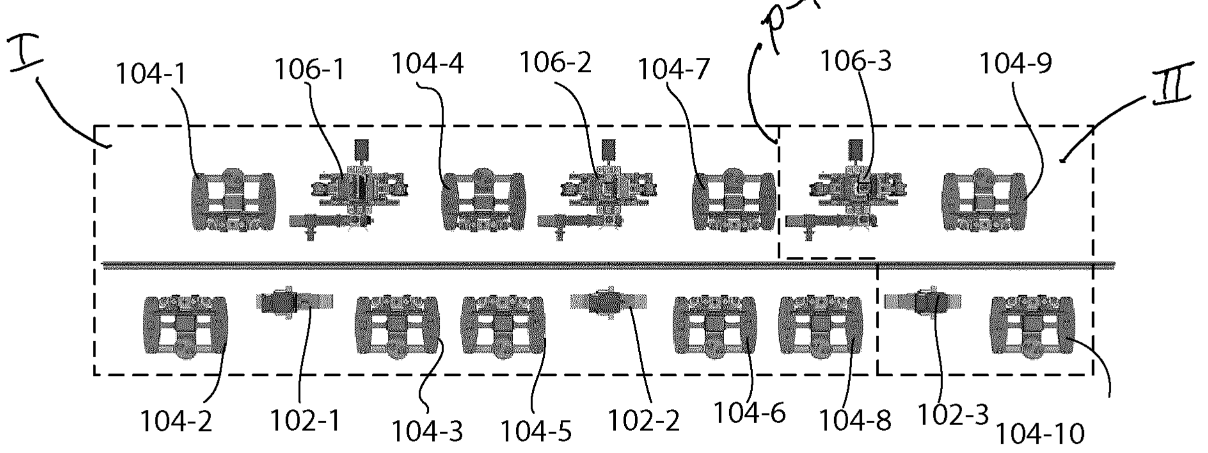


FIG. 7D

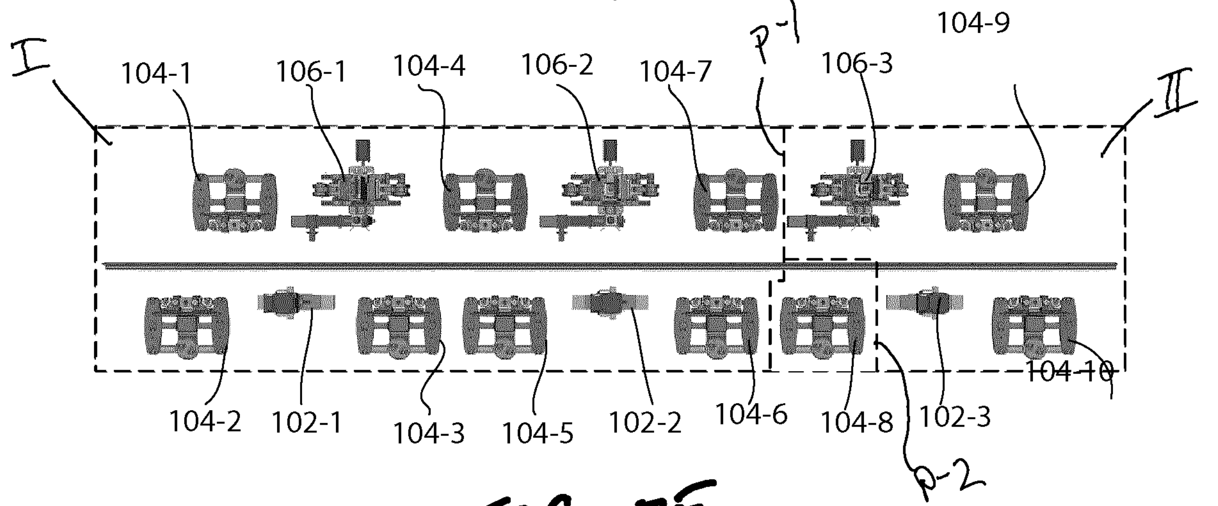


FIG. 7E

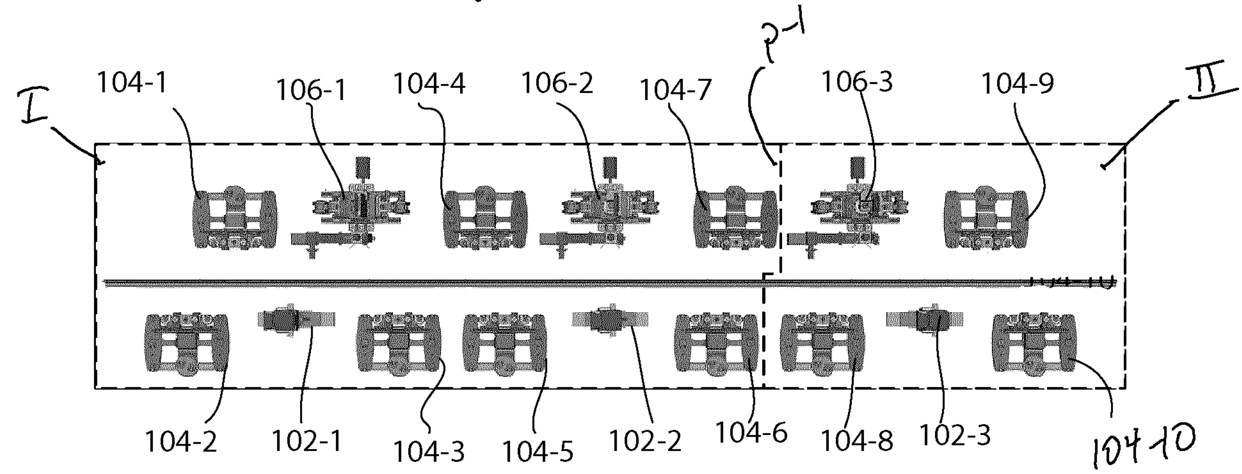


FIG. 7F

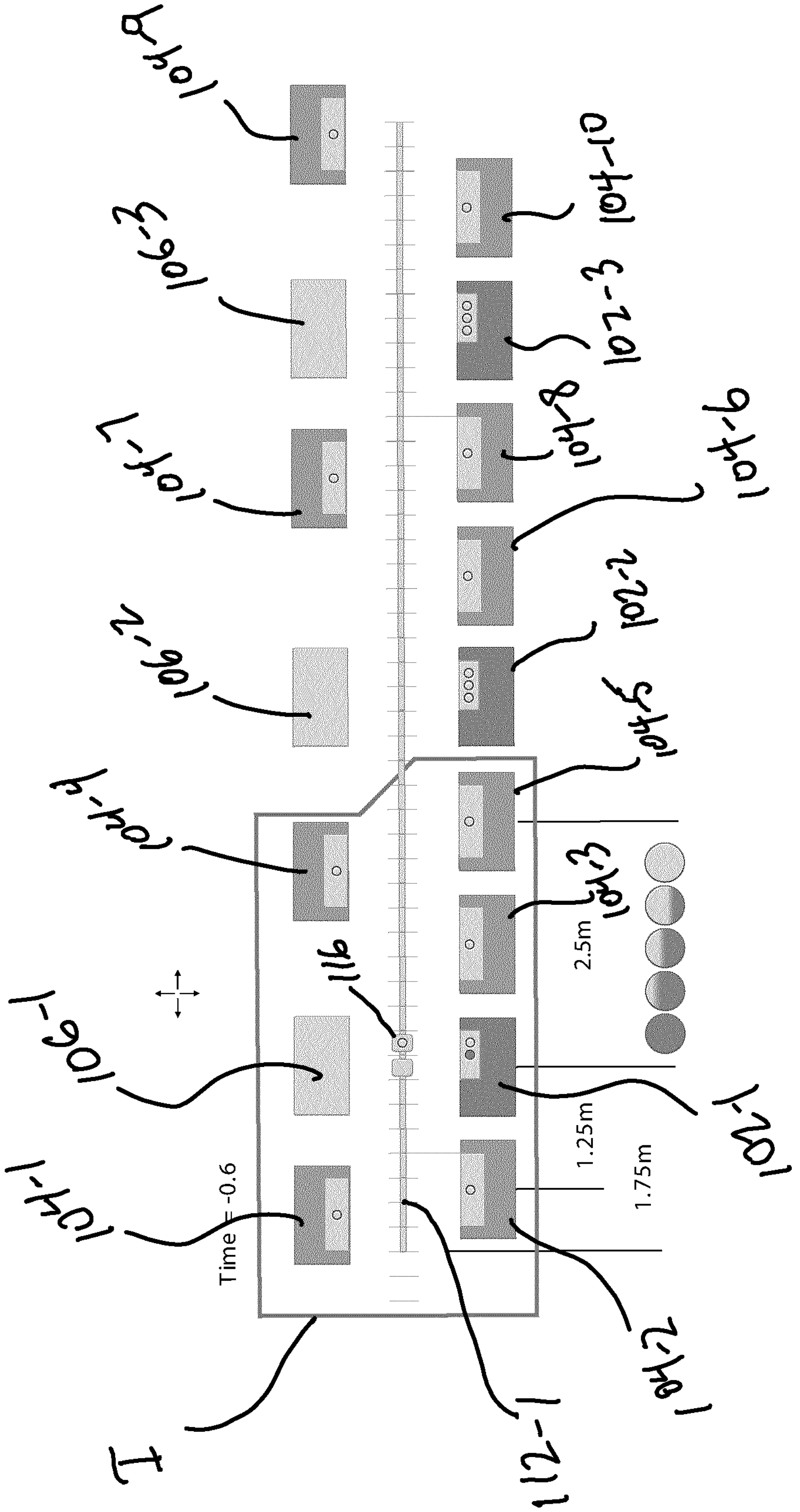
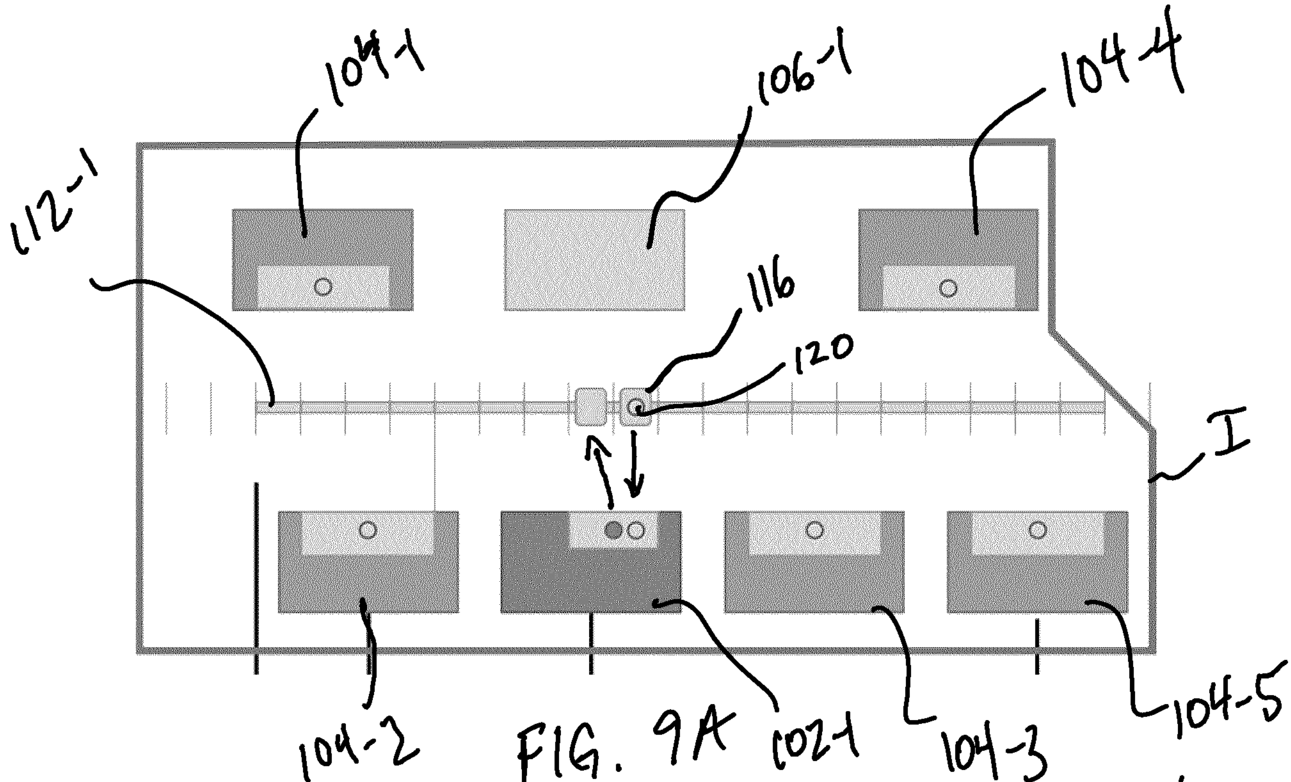
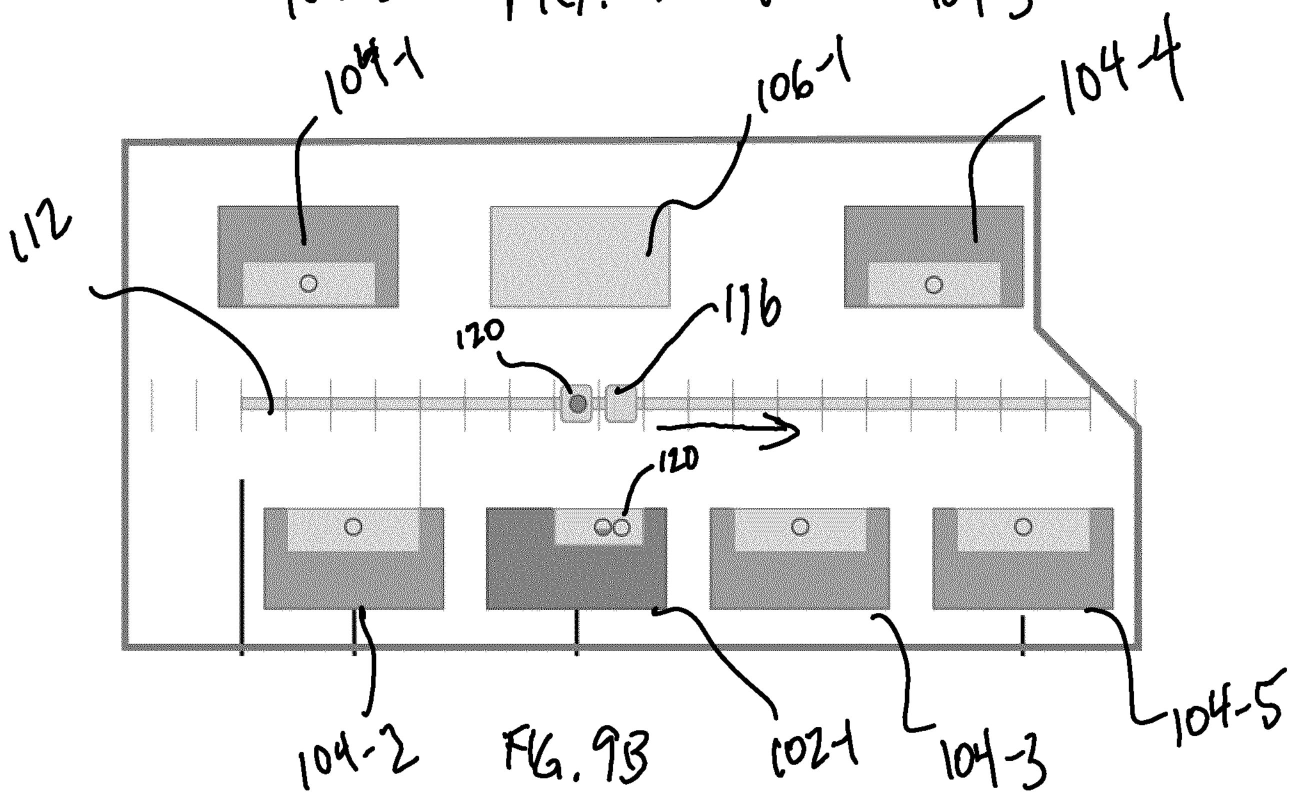


FIG. 8



104-1
106-1
104-4
112-1
116
120
I
104-2
102-1
104-3
104-5

FIG. 9A



104-1
106-1
104-4
112
120
116
120
104-2
102-1
104-3
104-5

FIG. 9B

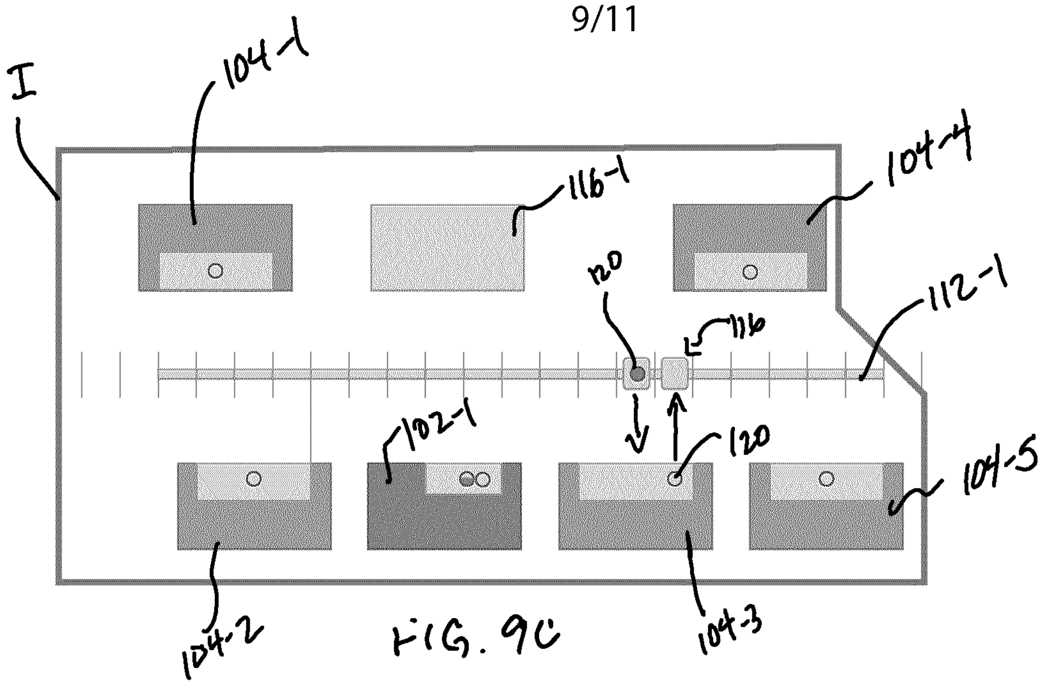

I
104-1
116-1
104-4
120
116
112-1
102-1
120
104-5
104-2
104-3

FIG. 9C

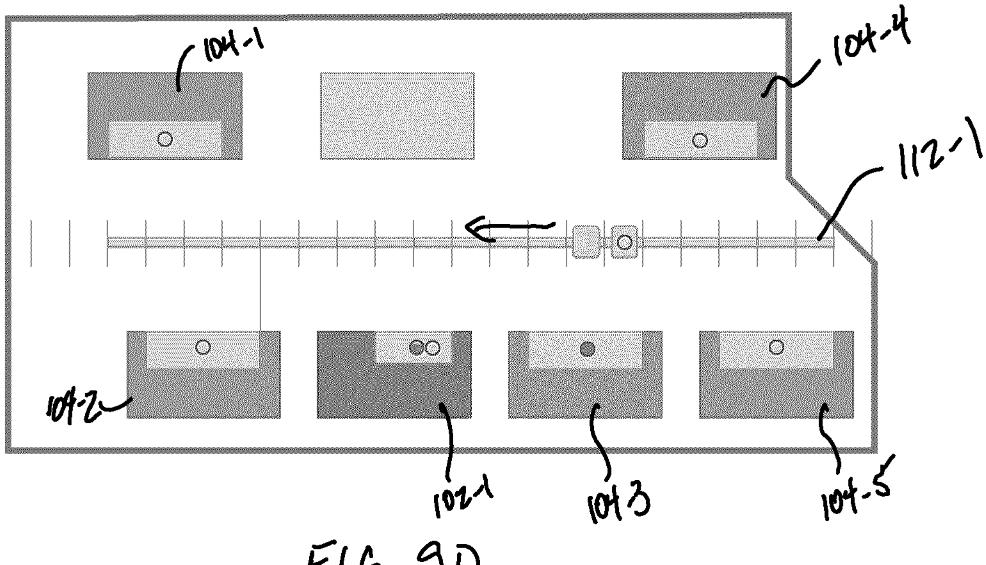

104-1
104-4
112-1
104-2
102-1
104-3
104-5

FIG. 9D

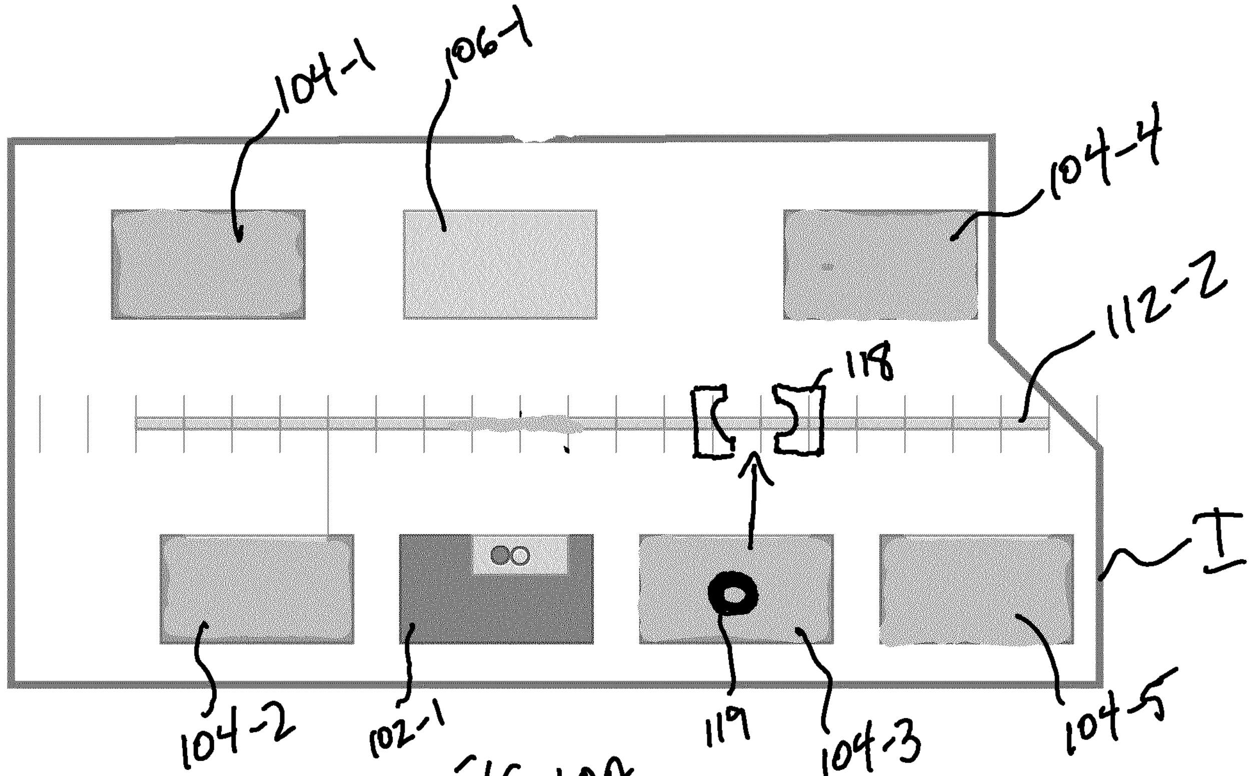


FIG. 10A

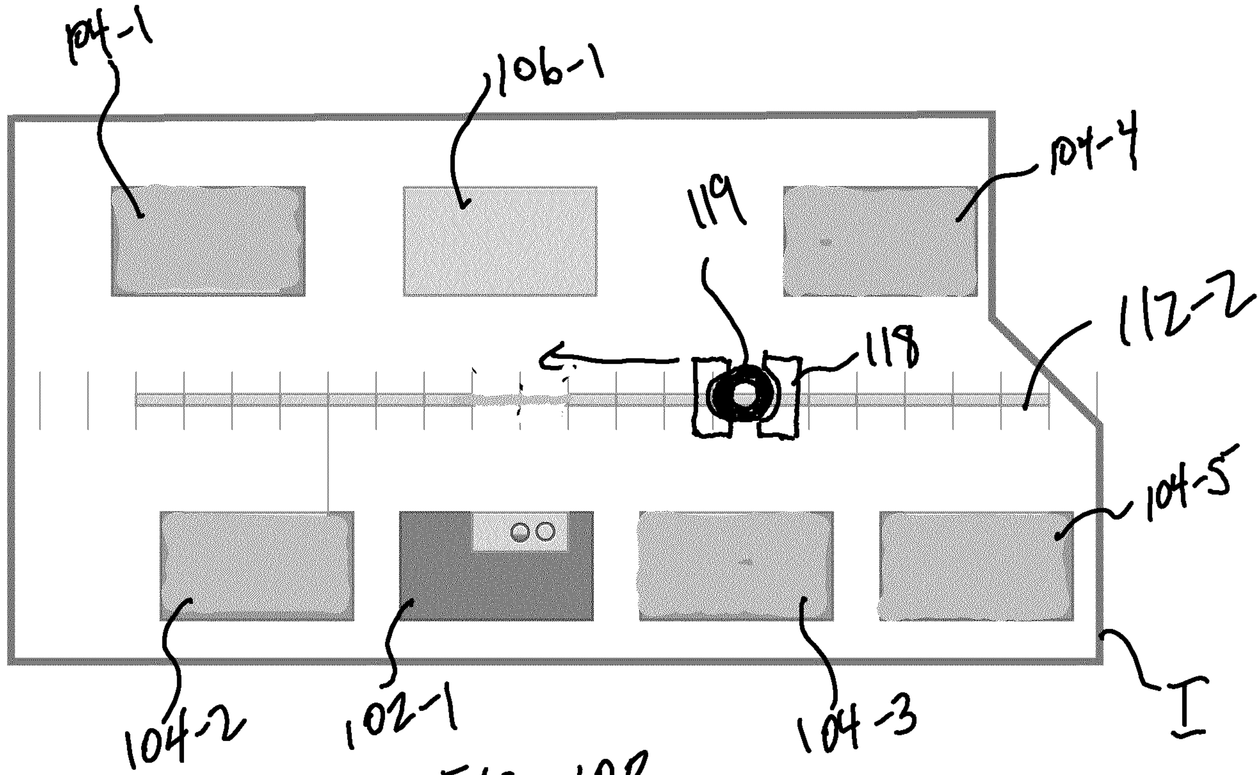


FIG. 10B

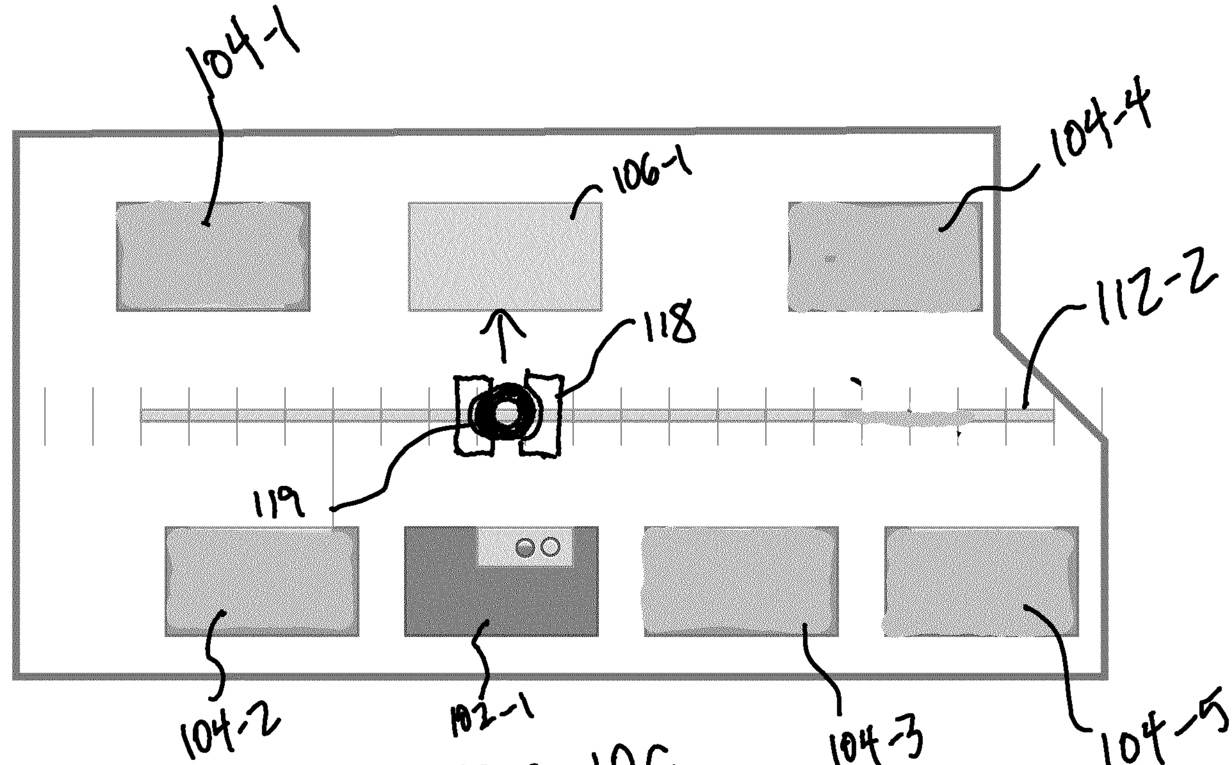


FIG. 10C

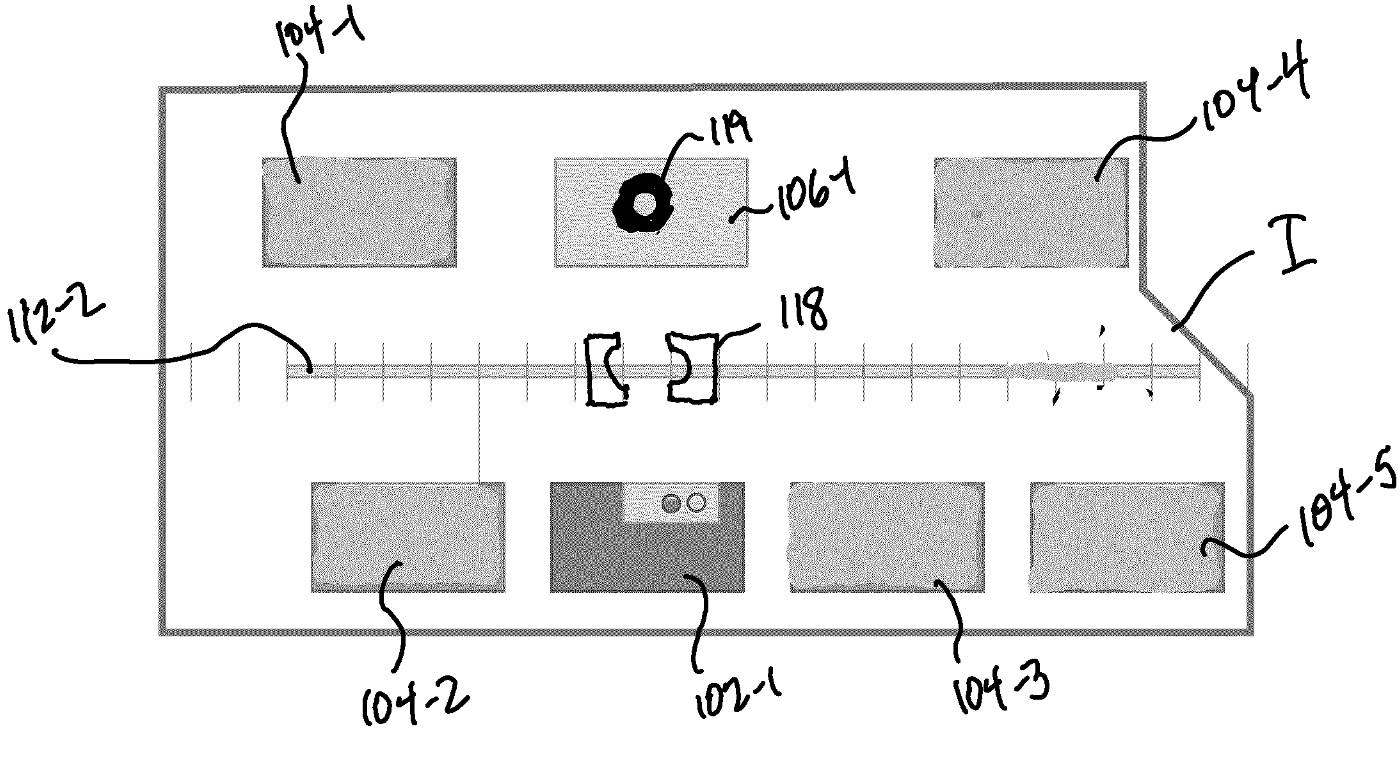


FIG. 10D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2022/051577

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***B29C 45/17*** (2006.01)

CPC: **B29C 45/17** (2020.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC (2006.01): B29C 45/17
CPC (2020.01): B29C 45/18, b29c 45/1858, B29C 31/00, B29C 31/02, B29C 31/008

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel Orbit, Scopus
Search Terms: control+, automat+, vessel, partition, mold+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO2020/041889A1 (NIEWELS, J., et al.) 5 March 2020 (05-03-2020) *Figures 53, 56, 58; pages 108-116* *Same Applicant*	1, 17, 30
A	US4880372A (KEIDA, Y.) 14 November 1989 (14-11-1989) *Figure 1; column 2, lines 40-57; column 4, lines 34-37*	1, 17, 30
P, A	WO2021/237339A1 (NIEWELS, J., et al.) 2 December 2021 (02-12-2021) *Figure 2; pages 19, 20, 27* *Same Applicant*	1, 17, 30
A	JP06182767A (USHIBA, K) 5 July 1994 (05-07-1994) *Abstract; Figures*	1, 17, 30

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 18 January 2023 (18-01-2023)	Date of mailing of the international search report 15 February 2023 (15-02-2023)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Kurtis Ulicny (819) 639-7918

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
WO2020041889A1	05 March 2020 (05-03-2020)	BR112021003657A2	18 May 2021 (18-05-2021)
		BR112021003661A2	18 May 2021 (18-05-2021)
		BR112021003663A2	18 May 2021 (18-05-2021)
		BR112021003664A2	18 May 2021 (18-05-2021)
		CA3109880A1	05 March 2020 (05-03-2020)
		CA3109895A1	05 March 2020 (05-03-2020)
		CA3110107A1	05 March 2020 (05-03-2020)
		CA3110120A1	05 March 2020 (05-03-2020)
		CN112839790A	25 May 2021 (25-05-2021)
		CN113015609A	22 June 2021 (22-06-2021)
		CN113195195A	30 July 2021 (30-07-2021)
		CN113811432A	17 December 2021 (17-12-2021)
		EP3843970A1	07 July 2021 (07-07-2021)
		EP3843970A4	29 June 2022 (29-06-2022)
		EP3843971A1	07 July 2021 (07-07-2021)
		EP3843971A4	22 June 2022 (22-06-2022)
		EP3846994A1	14 July 2021 (14-07-2021)
		EP3846994A4	16 November 2022 (16-11-2022)
		EP3846995A1	14 July 2021 (14-07-2021)
		EP3846995A4	18 May 2022 (18-05-2022)
		EP3928949A1	29 December 2021 (29-12-2021)
		EP3932648A1	05 January 2022 (05-01-2022)
		EP3950265A1	09 February 2022 (09-02-2022)
		JP2022000340A	04 January 2022 (04-01-2022)
		JP7149373B2	06 October 2022 (06-10-2022)
		JP2021525668A	27 September 2021 (27-09-2021)
		JP7149411B2	06 October 2022 (06-10-2022)
		JP2021535011A	16 December 2021 (16-12-2021)
		JP7171897B2	15 November 2022 (15-11-2022)
		JP2022036897A	08 March 2022 (08-03-2022)
		JP7182658B2	02 December 2022 (02-12-2022)
		JP2021535012A	16 December 2021 (16-12-2021)
		JP7198913B2	04 January 2023 (04-01-2023)
		JP2022140728A	27 September 2022 (27-09-2022)
		JP2022145914A	04 October 2022 (04-10-2022)
		JP2022168012A	04 November 2022 (04-11-2022)
		JP2022501214A	06 January 2022 (06-01-2022)
		US2021308918A1	07 October 2021 (07-10-2021)
		US11518077B2	06 December 2022 (06-12-2022)
		US2020407084A1	31 December 2020 (31-12-2020)
		US2021331361A1	28 October 2021 (28-10-2021)
		US2021339442A1	04 November 2021 (04-11-2021)
		US2021394415A1	23 December 2021 (23-12-2021)
		US2022332028A1	20 October 2022 (20-10-2022)
		WO2020041886A1	05 March 2020 (05-03-2020)
		WO2020041887A1	05 March 2020 (05-03-2020)
		WO2020041888A1	05 March 2020 (05-03-2020)
US4880372A	14 November 1989 (14-11-1989)	AT76802T	15 June 1992 (15-06-1992)
		DE3779589D1	09 July 1992 (09-07-1992)
		DE3779589T2	28 January 1993 (28-01-1993)
		EP0272335A1	29 June 1988 (29-06-1988)
		EP0272335A4	07 November 1989 (07-11-1989)
		EP0272335B1	03 June 1992 (03-06-1992)
		JPS63147621A	20 June 1988 (20-06-1988)
		JPH0535661B2	27 May 1993 (27-05-1993)
		KR880701625A	04 November 1988 (04-11-1988)

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
		KR950010637B1 WO8800118A1	21 September 1995 (21-09-1995) 14 January 1988 (14-01-1988)
WO2021237339A1	02 December 2021 (02-12-2021)	CN114829103A	29 July 2022 (29-07-2022)
JP06182767A	05 July 1994 (05-07-1994)	JP3228359B2	12 November 2001 (12-11-2001)