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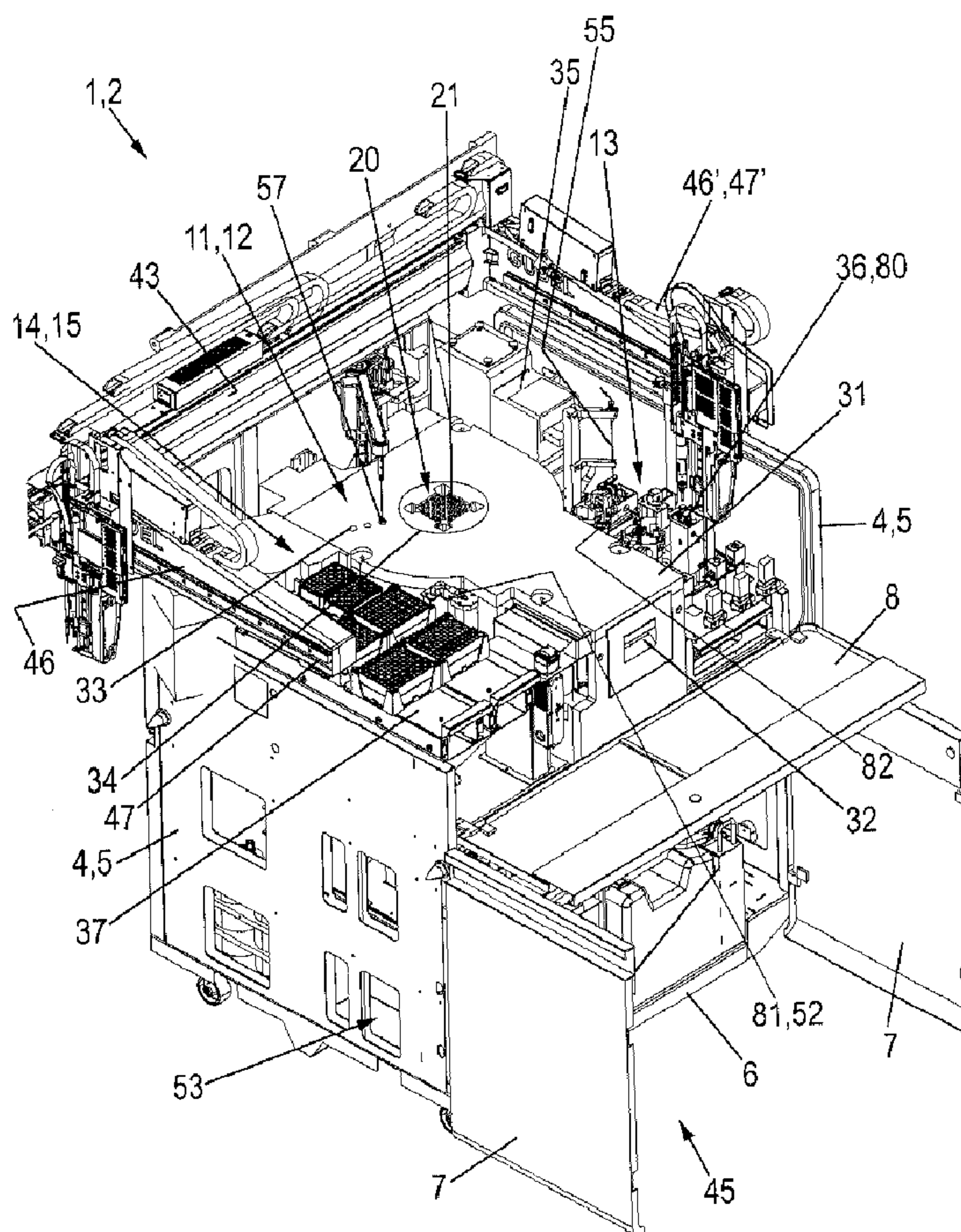
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(54) Titre : INSTRUMENT ET PROCEDE POUR LE TRAITEMENT AUTOMATISE D'ECHANTILLONS DE LIQUIDE

(54) Title: INSTRUMENT AND PROCESS FOR THE AUTOMATED PROCESSING OF LIQUID SAMPLES



(57) Abrégé/Abstract:

The present invention pertains to an automated instrument for processing samples, comprising: a sampling area for receiving said samples and reaction vessels; an analytical area provided with a first device resource comprising at least one analyzer for analyzing

(57) **Abrégé(suite)/Abstract(continued):**

said samples; a reaction area comprising a conveyor provided with a plurality of holders for storing reagent containers for containing reagents and an incubator configured for receiving said reaction vessels for incubating samples contained therein; a second device resource comprising first functional devices selected from at least one first gripper for gripping said reaction vessels and at least one first pipettor for pipetting liquids, said first functional devices being adapted to have access to said sampling area and said incubator so as to transfer reaction vessels from said sampling area to said incubator and/or to pipette samples and/or reagents into said reaction vessels; a third device resource comprising second functional devices selected from at least one second gripper for gripping said reaction vessels and at least one second pipettor for pipetting liquids, said second functional devices being adapted to have access to said incubator and said analytical area so as to transfer said reaction vessels from said incubator to said analytical area and/or to dispense liquids to or withdraw liquids from said reaction vessels. It further relates to an automated process for processing samples.

ABSTRACT

The present invention pertains to an automated instrument for processing samples, comprising: a sampling area for receiving said samples and reaction vessels; an analytical area provided with a first device resource comprising at least one analyzer for analyzing said samples; a reaction area comprising a conveyor provided with a plurality of holders for storing reagent containers for containing reagents and an incubator configured for receiving said reaction vessels for incubating samples contained therein; a second device resource comprising first functional devices selected from at least one first gripper for gripping said reaction vessels and at least one first pipettor for pipetting liquids, said first functional devices being adapted to have access to said sampling area and said incubator so as to transfer reaction vessels from said sampling area to said incubator and/or to pipette samples and/or reagents into said reaction vessels; a third device resource comprising second functional devices selected from at least one second gripper for gripping said reaction vessels and at least one second pipettor for pipetting liquids, said second functional devices being adapted to have access to said incubator and said analytical area so as to transfer said reaction vessels from said incubator to said analytical area and/or to dispense liquids to or withdraw liquids from said reaction vessels. It further relates to an automated process for processing samples.

**INSTRUMENT AND PROCESS FOR THE AUTOMATED PROCESSING
OF LIQUID SAMPLES**

5 TECHNICAL FIELD

The present invention is in the field of clinical analysis and medical diagnostics and more particularly relates to an instrument and process for the automated processing of liquid
10 samples.

BACKGROUND OF THE INVENTION

In recent years, a strong demand for the automated analysis of
15 liquid samples can be observed which is primarily due to the fact that there is an ongoing increase in the number of clinical analyses. Sample analysis most typically involves mixing of the samples with one or more reagents so as to determine the absence/presence and optionally concentration of one or more
20 analytes contained therein. Commercially available analyzers typically use pipetting robots for pipetting samples and reagents.

Many reagents have to be cooled and/or conditioned (e.g. mixed)
25 before their use. In daily practice, it is convenient to cool-store the reagent containers obtained from a supplier and to leave the reagents therein until the reagent is needed. Commercially available instruments for the automated processing of liquid samples often include a dedicated loading device for
30 loading the cooled reagent containers on a handling device such as a container carousel for withdrawing portions of the pre-cooled reagents contained therein by means of a pipette inserted through a container opening.

Due to the fact that reaction conditions can vary with temperatures, many reactions for analyzing liquid samples require that the sample/reagent mixtures are heated or incubated prior to transferring the reacted sample to an analyzer. Usually, the
5 temperature of the sample/reagent mixtures is raised and kept constant for at least one specific time interval to enable the desired reactions to run and to provide a generally controlled environment under which the reactions can be carried out. As a result, comparable analytical results can be obtained with high
10 reliability.

In light of the foregoing, it is an object of the invention to improve the automated process of analyzing samples involving the use of cooled reagents to prepare sample/reagent mixtures which
15 must be incubated to obtain the reacted sample. It is a further object of the invention to improve the workflow in processing the liquid samples. It is a yet further object to achieve a size reduction of the instrument especially with respect to the instrument's footprint.

20 These and further objects are met by an automated instrument and process for the processing of liquid samples according to the independent claims. Preferred embodiments of the invention are given by the features of the dependent claims.

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SUMMARY OF THE INVENTION

As used herein, the term "sample" generally relates to biological and non-biological (chemical) liquid fluids in which one or more
30 analytes of interest can be present. Examples of biological fluids are body fluids like blood, serum, urine, saliva and cerebrospinal fluid. Biological fluids can, e.g., be subject to analyses and assays in medical and pharmaceutical research and

clinical diagnosis, e.g., clinical-chemical or immunochemical analysis. Examples for non-biological fluids are samples of industrial waste water or environmental water drawn of lakes, rivers or springs. Non-biological fluids can, e.g., be subject to chemical analyses and assays, e.g., drug interaction screening, environmental analysis and identification of organic substances. Samples can also be pre-processed fluids such as extracts of body fluids, e.g., containing biological material in which nucleic acids can potentially be found. Samples can also be any other fluids or fluid extracts of interest such as, but not limited to, cells, tissues and micro-organisms as long as an automated analysis thereof involves the use of one or more reagents. As used herein, the term "sample" can also relate to sample combined with one or more reagents.

As used herein, the term "reagent" generally relates to any liquid fluid suitable to be combined with liquid sample. In the more strict sense of the term, a reagent is a liquid solution containing a reactant such as a compound or agent capable of binding to or transforming one or more analytes present in a sample. Specifically, reactants can be mixed with the liquid sample so as to obtain a detectable change such as an optical signal emitted in response to one or more analytes contained therein. Reagents can also be mixed with any other reagent(s). Accordingly, reagents may contain reactants for reaction with one or more analytes contained in the sample. Examples of reactants are enzymes, enzyme substrates, conjugated dyes, protein-binding molecules, nucleic acid binding molecules, antibodies, chelating agents, promoters, inhibitors, epitopes, antigens and catalysts. Reagents, however, can also be non-reacting fluids such as buffers, solvents and diluting fluids.

As used herein, the term "reagent container" generally relates to reservoirs for containing liquids, each of which comprising a container body provided with a container opening to be opened or closed by means of a cap, such as, but not limited to, a hinged cap pivotably fixed to the container body or a removable cap that can be taken away from the container body. Examples for reagent containers are sample tubes or sample cups provided with removable or hinged caps, single reagent containers and reagent cassettes comprising plural reagent containers, e.g., serially arranged with respect to each other.

As used herein, the term "reaction vessel" generally relates to any vessel which can be used to react the sample with one or more reagents.

As used herein, the term "sample vessel" generally relates to any vessel which can be used to store a liquid sample.

According to a first aspect of the invention, a new automated instrument for the processing of liquid samples is proposed. The instrument can, e.g., be adapted for the automated analysis of samples by performing tests or assays related to various immunochemical and/or clinical-chemical analysis items.

Specifically, the instrument of the invention comprises a sampling area for receiving the samples and reaction vessels. It further comprises an analytical area provided with a device resource, in the following denoted as "first device resource", comprising at least one analytical device for analyzing the samples. As used herein, the term "resource" relates to one or more devices which can be used to process liquid samples.

The instrument yet further comprises a reaction area which, e.g., can be arranged between the storing and analytical areas, comprising a conveyor such as, but not limited to, a driven carousel provided with a plurality of holders for storing reagent
5 containers for containing reagents and an incubator configured for receiving the reaction vessels for incubating samples contained therein. The sampling and analytical areas can, e.g., be disposed on different sides, e.g., on opposing sides, of the conveyor such as a carousel. As used herein, the term incubating
10 relates to subjecting a sample to a predefined temperature or temperature profile for at least one predefined time interval.

The instrument of the invention yet further comprises another device resource, in the following denoted as "second device
15 resource", comprising first functional devices selected from at least one first gripper for gripping the reaction vessels and at least one first pipettor for pipetting liquids such as samples and/or reagents. Specifically, the first functional devices can, e.g., be mounted to a driven first moving means. Furthermore,
20 the first functional devices are adapted to have exclusively access to the sampling area and the reaction area, and not to have access to the analytical area, so as to transfer reaction vessels from the sampling area to the incubator and to pipette samples and/or reagents into the reaction vessels transferred
25 to the incubator.

The instrument of the invention further comprises a yet another device resource, in the following denoted as "third device
resource", comprising second functional devices selected from
30 at least one second gripper for gripping the reaction vessels and at least one second pipettor for pipetting liquids such as reacted samples contained in the reaction vessels. Specifically, the second functional devices can, e.g., be mounted to a driven

second moving means. Furthermore, the second moving means are adapted to have exclusively access to the reaction area and the analytical area, and not to have access to the storing area, so as to transfer reaction vessels from the incubator to the analytical area and to dispense and/or withdraw one or more liquids to/from the reaction vessels transferred to the analytical area.

The automated instrument further comprises a controller (electronic logic device) for controlling the analysis of liquid samples configured for operating the first to third device resources for processing one sample wherein at least two of said device resources are at least temporarily operated in parallel for processing two or more samples. Stated more particularly, the controller can, e.g., be set up to operate one or more first functional devices of the second device resource, followed by operating one or more second functional devices of the third device resource and then followed by operating one or more analytical devices of the first device resource for processing one sample. The control can, e.g., be set up to successively (sequentially) operate the device resources in this order.

Furthermore, for processing two or more samples, the first to third device resources are at least temporarily (partially) operated in parallel to process liquid samples in a highly time- and cost-effective manner. Moreover, the first functional devices are operated in a manner to have exclusively access to the sampling area and the incubator and the second functional devices are operated in a manner to have exclusively access to the incubator and the analytical area. Hence, the above-mentioned configuration of the first and second functional devices to selectively have access to the storing area and reaction area and the reaction and analytical area, respec-

tively, can be reached by program-control. Furthermore, the controller controls operation of the first and second functional devices in a manner that the first and second functional devices have access to the incubator only one at a time, that is to say, 5 the first functional devices or, alternatively, the second functional devices have access to the incubator.

In the above-described instrument, the controller allows for program-control of the process of analyzing liquid samples, 10 e.g., implemented in a dedicated hardware and/or software component, in the following denoted as "scheduler", configured to generate and assign time slots for operating the various devices resources for processing two or more liquid samples. Hence, the controller controls operation of the devices re- 15 sources in a coordinated manner so as to avoid conflicts in processing liquid samples.

Due to the fact that the first to third device resources can at least temporarily be operated in parallel for processing two or 20 more liquid samples, e.g., by moving and/or operating the first and second functional devices simultaneously in different areas of the instrument (the reaction area being a commonly accessible area), the instrument of the invention advantageously allows a highly time- and cost-efficient analysis of several liquid 25 samples at a time involving mixing of the samples with one or more reagents, incubating the sample/reagent(s)-mixtures to obtain reacted samples and analyzing the reacted samples by at least one analyzer.

30 According to one embodiment of the invention, the plurality of holders of the conveyor surrounds a central region at least in part, wherein the incubator is being disposed in the central region. The conveyor can, e.g., be configured as driven carousel

wherein the holders are arranged in an annular row surrounding the central region. Specifically, it is preferred that the incubator is kept stationary with respect to the reaction area so that the conveyor can be moved, e.g., rotated, with respect to the incubator. By arranging the incubator in the central region, the instrument can be made particularly small and compact in shape so as to allow for an improved workflow, e.g. by having small distances to transport vessels and liquids, for analyzing the liquid samples.

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According to one embodiment of the invention, the instrument, e.g. the first moving means, includes a first transfer arm movable in a first direction and being provided with at least one first transfer head movable in a second direction perpendicular to the first direction for mounting the one or more first functional devices. Furthermore, the instrument, e.g. the second moving means, includes a second transfer arm movable in the first direction and being provided with at least one second transfer head movable in the second direction for mounting the one or more second functional devices. Hence, the first and second functional devices can be readily and quickly transferred to the various areas according to the control as implemented by the above-described scheduler. Furthermore, the instrument can be fabricated in a highly cost-efficient manner.

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According to one embodiment of the invention, the instrument comprises a cooling cell containing the conveyor such as a carousel for actively cooling the reagent containers stored by the holders, wherein the incubator is thermally isolated from the cooling cell. Hence, the instrument advantageously allows for actively cooling the reagent containers without providing for a dedicated cool-storing compartment so as to reduce the size and foot-print of the instrument. Furthermore, due to the fact

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that the reagent containers can be used without necessity of transfer from a dedicated cool-storage to the conveyor, the workflow for analyzing the liquid samples can be improved. Furthermore, reagents can also be cooled during their use so as to avoid an increased degradation thereof and to improve the reliability of the analytical results. Moreover, by thermally insulating the incubator from the reagent containers stored on the conveyor, the reagents can be effectively cooled.

10 According to one embodiment of the invention, the conveyor such as a carousel is operatively coupled to one or more of the following devices selected from:

1) a loader/unloader, arranged at the conveyor such as a carousel and being adapted for loading/unloading reagent containers to/from the holders. Stated more particularly, the loader/unloader can be used to load/unload reagent containers to/from the conveyor, e.g., during analysis of the liquid samples so as to advantageously improve the workflow in sample processing.

2) an opener/closer, arranged at the conveyor and being adapted for opening/closing caps of the reagent containers stored by the conveyor. Stated more particularly, the instrument can be configured for the use of reagent containers respectively comprising a cap that is pivotably fixed with respect to a container body so as to be bi-directionally pivoted in an opening or closing direction. Specifically, the instrument can be configured to simultaneously open/close plural fluid containers, e.g., provided in a fixed arrangement such as a cassette. Accordingly, the instrument of the invention advantageously enables one or a plurality of fluid containers to be (e.g. simultaneously) opened and optionally closed. For

instance, the opener/loader can be radially arranged with respect to the conveyor and can be provided with a carriage translatably movable towards and away from the carousel. Specifically, the carriage can, e.g., comprise a base portion and a pivoting portion pivotable with respect to the base portion so as to open and close, respectively, the reagent containers. Due to the fact that the carriage can be translated towards and away from the fluid containers to open/close the cap of each of the fluid containers by pivoting the pivoting portion thereof, the apparatus can advantageously be made small in vertical dimension thus leaving comparably large free space above the reagent containers enabling unhindered access to the reagent containers, e.g., by means of a pipettor or any other instrument used for manipulating liquids contained in the reagent containers such as, but not limited to, a liquid fluid mixer. In general, any device for manipulating the liquid fluids contained in the reagent containers can advantageously be arranged above the reagent containers.

3) a mixer, arranged at the conveyor and being adapted for mixing liquids contained in the reagent containers stored by the conveyor. Stated more specifically, the mixer can, e.g., comprise a stirrer having a bar provided with a paddle which can be lowered into a reagent container for mixing liquid contained therein by rotating the stirrer around a longitudinal axis. As above-detailed, due to the radial arrangement of the opener/closer, the mixer can advantageously be arranged above the reagent containers so as to make the instrument small in its vertical dimension.

4) an identifier, capable of identifying the reagent containers stored by the conveyor.

According to one embodiment, one or more of the above-captioned devices are contained in the cooling cell. Hence, in the instrument, while manipulation of reagent containers and/or reagents contained therein is possible, the reagent containers
5 can be cooled in a highly effective manner.

According to one embodiment of the invention, the sampling area is configured for storing disposable pipetting tips of the first pipetting means. Hence, the instrument advantageously allows for
10 the use of disposable pipetting tips to avoid sample carry-over which can readily be replaced after usage.

According to a second aspect of the invention, a new process for the automated processing of liquid samples is proposed. In one
15 embodiment, the steps described below are performed successively (sequentially) to process liquid samples but also be performed in a different order. Specifically, the process comprises a (e.g. first) step of providing a driven conveyor such as a rotatable carousel having plural holders for storing reagent containers
20 provided with one or more reagent containers, wherein said holders at least partly surround a central region containing an incubator for receiving one or more reaction vessels. The holders can, e.g., be arranged in an annular row surrounding the central region.

25 It comprises a further (e.g. second) step of transferring at least one of the reaction vessels from a sampling area to the incubator using a first gripper.

30 It comprises a yet further (e.g. third) step of moving the conveyor (e.g. rotating the carousel) with respect to the incubator so as to move (e.g. rotate) at least one reagent container in a dedicated position, in the following denoted as

"pipetting position", adapted for pipetting reagent contained therein.

It comprises a yet further (e.g. fourth) step of pipetting the
5 reagent contained in the at least one reagent container to the reaction vessel received in the incubator using a first pipettor.

It comprises a yet further (e.g. fifth) step of pipetting one
sample contained in the sampling area to the reaction vessel
10 received in the incubator containing the reagent using the first pipettor so as to obtain a sample-reagent mixture.

It comprises a yet further (e.g. sixth) step of incubating the
sample-reagent mixture so as to obtain a reacted sample.
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It comprises a yet further (e.g. seventh) step of transferring
the reaction vessel containing the reacted sample from the
incubator to an analytical area provided with at least one
analytical device for analyzing samples using a second gripper.
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It comprises a yet further (e.g. eighth) step of transferring
the reacted sample from the reaction vessel to the analytical
device for analysis thereof with respect to at least one analyte.

25 Accordingly, the process of the invention advantageously allows for a reliable, highly time- and cost-efficient processing of liquid samples with respect to one or more analytes contained therein.

30 According to one embodiment of the process of the invention, prior to incubating the sample-reagent mixture, the process comprises a step of pipetting another reagent to the reaction vessel received in the incubator containing the sample-reagent

5 mixture using the first pipettor. In one embodiment, the further reagent is taken from another reagent container already positioned in the pipetting position together with the first reagent container, e.g., as a reagent cassette comprising two or more reagent containers. In one embodiment, this step is combined with a step of moving the conveyor with respect to the incubator so as to move at least one further (other) reagent container in the pipetting position for pipetting reagent contained therein. This procedure can be performed once or
10 several times according to the number of reagents to be added to the samples.

According to one embodiment of the process of the invention, the process comprises a step of opening and optionally closing the
15 caps of one or more reagent containers prior to pipetting reagent contained therein. Accordingly, the reagent containers can be kept closed prior to their use and can optionally be closed after usage so as to avoid contamination and evaporation of reagents contained therein.

20 According to one embodiment of the process of the invention, the one or more reagent containers stored by the conveyor are actively cooled while being thermally isolated with respect to the incubator. Accordingly, the reagents can advantageously be
25 cooled prior to, during and after their use in a highly effective manner.

According to one embodiment of the process of the invention, one or more liquids are dispensed to and/or withdrawn from the
30 reacted sample contained in the reaction vessel using the second pipettor.

According to one embodiment of the process of the invention, a second device resource comprising the first gripper and the first pipettor, a third device resource comprising the second gripper and the second pipettor and a first device resources comprising the analytical device are sequentially operated for processing one sample wherein at least two of the device resources are at least temporarily (partially) operated in parallel for processing two or more samples so as to improve the workflow in sample processing in order to perform sample analysis in a highly efficient manner. Specifically, at least one device selected from the first gripper and the first pipettor is simultaneously moved and/or simultaneously operated with at least one device selected from the second gripper means and the second pipettor.

According to one embodiment of the process of the invention, the process comprises one or more of the following steps:

- a step of opening a cap of at least one reagent containers stored in the conveyor prior to pipetting reagent contained therein,
- a step of closing the cap of the reagent container stored in the conveyor after pipetting reagent,
- mixing reagent contained in the reagent container prior to pipetting reagent contained therein,
- identifying the reagent container stored by the conveyor prior to pipetting reagent.

The above-described various aspects and embodiments of the invention may be used alone or in any combination thereof without departing from the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Other and further objects, features and advantages of the invention will appear more fully from the following description. The accompanying drawings, together with the general description given above and the detailed description given below, serve to
5 explain the principles of the invention. In the figures,

FIG. 1 is a perspective view of a first part of an exemplary instrument according to the invention;

10 FIG. 2 is another perspective view of the first part of the exemplary instrument;

FIG. 3 is a top view of the first part of the exemplary instrument;

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FIG. 4 depicts an enlarged detail of FIG. 3;

FIG. 5 is a perspective view of a second part of the exemplary instrument;

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FIG. 6 is a top view of the second part of the exemplary instrument;

FIG. 7 is a perspective view of an opener/closer of the
25 exemplary instrument;

FIGS. 8A-8B are perspective views of an enlarged detail of the pivoting portion of the opener/closer of FIG. 7;

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FIGS. 9A-9B are perspective views of a variant of the pivoting portion of the opener/closer of FIG. 7;

FIG. 10 is a flow chart illustrating an exemplary embodiment of the process of the invention for analyzing liquid samples.

5 DETAILED DESCRIPTION OF THE INVENTION

By way of illustration, specific exemplary embodiments in which the invention may be practiced now are described. In this regard, terminology with respect to orientations and directions such as
10 "horizontal", "vertical", "upper" and "lower" is used with reference to the orientation of the figures being described. Because the components described can be positioned in a number of different orientations, this terminology is used for the purpose of illustration only and is in no way limiting.

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First, reference is made to FIGS. 1 and 5 illustrating a first part 2 and a second part 3 of an exemplary embodiment of the instrument of the invention for the automated processing of liquid samples generally referred to at reference numeral 1. The
20 instrument 1 usually is provided with a top cover which in the figures is removed for the sake of clarity. The instrument 1 may be used in (bio-)chemistry including in-vitro diagnostics and can be adapted to carry out various assays comprising mixing of samples and reagents as well as detecting the result of those
25 reactions. The instrument 1 is used for analyzing liquid samples with respect to various immunochemical analysis items, e.g., using diagnostic assays such as immunoassays. It will particularly be useful for performing heterogeneous immunoassays wherein reactants such as capturing antibodies are immobilized
30 on a solid support such as, but not limited to, magnetically responsive (i.e. magnetically attractable or magnetically repellable) particles. Such particles can, e.g., be embodied as magnetic beads or micro-spheres made of magnetically responsive

material provided with immobilized reactants, e.g., molecular binding elements such as antibodies adapted to specifically bind to at least one analyte contained in the sample.

5 Accordingly, the instrument 1 is comprised of the first or right part 2 depicted in FIG. 1 and the second or left part 3 depicted in FIG. 5 as seen from the front-side of the instrument 1 indicated by the reference numeral 45. While the first and second parts 2, 3 are shown to be separated for the purpose of ease of
10 illustration only, the two instrument parts are intended to be arranged side by side at the two mounting sides "A" to be secured to one another.

With particular reference to FIGS. 1 to 4, the first part 2 of
15 the instrument 1 includes a mount 4 provided with two side walls 5 and a base plate 6. At the front-side 45 of the instrument 1, two side doors 7 and a front cover 8 are hinged to the mount 4 so as to grant access to the interior of the instrument 1 and to close the lower part of the instrument's front-side 45. The
20 instrument 1 is sectioned into several vertical levels, each of which containing various components of the instrument 1 wherein the upper level 11 is being used as a processing or working zone for the analysis of liquid samples involving the transfer of reaction vessels and pipetting of fluids. In the following only
25 the upper level 11 of the instrument 1 is described in detail.

Accordingly, the working zone of the instrument 1 can be divided into several areas which are structurally and/or functionally different entities (units). Stated more particularly, the
30 instrument 1 includes a reaction area 12 arranged between an analytical area 13 and a sampling area 14, the sampling area 14 being disposed on the one side (left side as seen from the front-side 45) of the reaction area 12 and the analytical area

13 being disposed on the other side (right side as seen from the front-side 45) of the reaction area 12. The sampling area 14 is composed of two sub-areas, i.e., a disposables storing area 15 provided by the first part 2 of the instrument 1 and a sample receiving area 16 provided by the second part 3 of the instrument 1 to be put in juxtaposition to the first part 2 at the left side wall 5 as above-described.

Specifically, the reaction area 12 comprises a motor-driven rotatable carousel 17 provided with a plurality of holders 18 for storing reagent cassettes 19 which are circumferentially arranged with respect to each other surrounding a non-rotatable (stationary) central region 20 of the carousel 17. Hence, the holders 18 and reagent cassettes 19 stored thereon, respectively, can be rotated around the central region 20 that is stationary with respect to the instrument 1. While the carousel 17 is shown to be provided with a number of 28 holders 18, those of skill in the art will appreciate that any other number of holders 18 can be envisaged according to the specific demands of the user.

An incubator 21 is disposed in the central region 20 of the carousel 17 which is provided with a plurality of receptacles 9 for receiving reaction vessels 60. Analysis of samples typically requires the samples to be combined with one or more reagents to initiate chemical or immunochemical reactions with respect to specific substances contained therein. Specifically, analytes contained in the samples can be bound to magnetically responsive particles provided with molecular binding elements adapted to selectively bind to the analytes. Furthermore, the reaction vessels 60 can be used for labelling the particle-bound analytes with detectable labels such as fluorescence markers. The incubator 21 is configured for incubating the sample/reagent

mixtures contained in the reaction vessels 60, that is to say, to keep the temperature constant for predetermined time intervals so as to improve the reaction rates and to assure that reactions can be carried out in a generally controlled environment. The incubator 21 can, e.g., be configured to keep the temperature of the sample/reagent(s)-mixtures at about 37°C ($\pm 0.3^\circ\text{C}$).

The reaction area 12 further includes a loader/unloader 10 capable of loading/unloading reagent cassettes 19 to/from the holders 18 of the carousel 17. As can, e.g., be taken from FIG. 3, the loader/unloader 10 comprises two transport lines 22 which at least in part are in parallel alignment with respect to each other and are radially aligned with respect to the carousel 17. Stated more particularly, the transport lines 22 can commonly be brought in juxtaposition to two adjacent holders 18 so as to establish a transport connection between the transport lines 22 and the holders 18. By rotating the carousel 17, two adjacent holders 18 can selectively be brought in juxtaposition to the transport lines 22 to load/unload the holders 18 of the carousel 17. Hence, reagent cassettes 19 can be bidirectionally transported to/from holders 18 according to the specific demands of the user, e.g., for charging the carousel 17 with reagent cassettes 19 and replacing empty reagent cassettes 19. Furthermore, the reagent cassettes 19 can be manually or automatically placed on or removed from the transport lines 22, e.g., by means of a robotic arm provided with a gripper for gripping the reagent cassettes 19.

The transport of the reagent cassettes 19 on the transport lines 22 can, e.g., be effected by means of a movable (driven) gripping pin (not illustrated) configured to be brought in gripping engagement with one or both reagent cassettes 19, e.g., on a

bottom-side thereof, so as to push the reagent cassette(s) 19 onto the holder 18 or to draw it to the transport line 22. The loader/unloader 10 can be provided with one gripping pin for successively transporting reagent cassettes 19 by the two transport lines 22. Alternatively, each transport line 22 can be provided with an individual gripping pin allowing for a simultaneous transport of two reagent cassettes 19 on the two transport lines 22 in a same direction or in opposite directions. While the loader/unloader 10 is illustrated to include two transport lines 22, those of skill in the art will appreciate that more or less transport lines 22 can be envisaged according to the specific demands of the user. Due to the radial arrangement of the loader/unloader 10 with respect to the carousel 17, and, in light of the fact that the reagent vessels 60 contained in the incubator 21 and the reagent cassettes 19 stored by the carousel can be readily accessed from above, the loader/unloader 10 advantageously allows the reagent cassettes 19 to be loaded to or removed from the carousel 17 even during the process of analyzing liquid samples. Furthermore, since two transport lines 22 are available, two reagent cassettes 19 can simultaneously be transported either for simultaneous loading to the carousel 17 or for loading one reagent cassette 19 to the carousel 17 and for simultaneously unloading another reagent cassette 19 from the carousel 17.

The reaction area 12 yet further includes an opener/closer 23 capable of opening/closing caps 26 of individual reagent cassettes 19 stored by the holders 18 of the carousel 17. With particular reference to FIGS. 7, 8A-8B and 9A-9B, the opener/closer 23 comprises a mount 61 used to fix the opener/closer 23 in the upper level 11 of the instrument 1. The opener/closer 23 further comprises a carriage 62 movably supported by the mount 61 by means of a translating mechanism, e.g., configured as

rollers guided by linear guiding rails. Accordingly, the carriage 62 can be bidirectionally moved in an essentially horizontal plane with respect to the mount 61. Specifically, the carriage 62 can be reciprocally moved between two stop positions, i.e., a first translating position and a second translating position by translating the carriage 62 along first and second translating directions towards and away from the carousel 17.

As illustrated, in one embodiment, each reagent cassette 19 is comprised of a number of, e.g., three reagent containers 24 that are fixed in serial arrangement with respect to each other. Each reagent container 24 comprises a container body 25 for filling with reagent provided with an opening 63 closed by a cap 26 that is pivotably fixed (hinged) to the container body 25 so as to open the opening 63 by pivoting the cap 26 in the one pivoting direction (opening direction) and to close the opening 63 by pivoting the cap 26 in the other (reverse) pivoting direction (closing direction). Hence, each reagent container 24 can be repeatedly opened and closed according to the scheduler explained below.

In the specific embodiment illustrated with respect to the figures, each reagent container 24 comprises a cap closing mechanism (not further detailed) having a first cap closing position and a second cap closing position wherein in the first cap closing position ("hard close") the cap 26 is stronger fixed to the container body 25 with respect to the second cap closing position ("soft close"). For instance, in the first cap closing position, the cap 26 can be locked by means of a locking mechanism whereas the cap 26 is just plugged onto the opening 63 without securing the cap 26 to the container body 25 in the second cap closing position. Accordingly, while the first cap closing position will typically be used to transport or cool-store the reagent cassette 19, the second cap closing position mainly serves to prevent evaporation, spilling and contamination of fluids contained in the reagent containers 24 while in use. When

using the reagent containers 24 for the first time, the caps 26 typically are in the first cap closing position and, thus, have to be initially opened. Furthermore, as illustrated, each cap 26 is provided with two projecting portions 64, e.g., configured as cylindrical pins, laterally projecting from the cap 26 in an essentially horizontal plane on two opposing sides of the cap 26 for rotating the cap 26 in opening and closing directions.

Furthermore, the carriage 62 comprises a lower or base portion 65 and an upper or pivoting portion 66 pivotably supported by the base portion 65 and being comprised of a front part 17 and a rear part 18. The pivoting portion 66 is pivotably supported by the base portion 65 by means of a pivoting mechanism, e.g., configured as two horizontally arranged pairs of opposing pivot arms 67, each of which having an essentially S-like shape. Specifically, the pivoting mechanism includes a front pair and a rear pair wherein a lower end portion of each pivot arm 67 is rotatably linked to the base portion 65 so that the pivot arms 16 can be pivoted with respect to the base portion 65.

The opener/closer 23 further includes a driven spindle drive 68 operatively coupled to the pivoting portion 66 for both translating the carriage 62 towards and away from the carousel 17, that is to say, reagent cassette 19, and pivoting the pivoting portion 66 with respect to the base portion 65. Stated more particularly, the spindle drive 68 includes a frame 69 which rotatably supports an essentially horizontally aligned spindle 70. Hence, by rotating the spindle 70, a spindle nut 71 can be reciprocally translated along the spindle 70 wherein a driven shaft (not illustrated) of an electric motor 72 is rotatably coupled to the spindle 70 so as to rotate the spindle 70 in both rotating directions. In the spindle drive 68, the spindle nut 71 is connected to two vertically arranged pairs of opposing guiding rolls 73 so as to be entrained by the spindle nut 71 translated along the spindle 70. Furthermore, the guiding rolls 73 are accommodated in a vertical guiding cage 74 for guidance in vertical direction. The guiding cage 74 is connected to the

pivot arms 67. Accordingly, by rotating the spindle 70, the spindle nut 71 is translated along the spindle 70 entraining the guiding rolls 73 so as to pivot the pivot arms 67. Hence, driven by the spindle drive 68, the pivoting portion 66 can be

5 bidirectionally pivoted with respect to the base portion 65 so as to reciprocally move the pivoting portion 66 between two stop positions, i.e., a first pivoting position and a second pivoting position along first and second pivoting directions.

10 The opener/closer 23 can be used to open and optionally close the caps 26 of one reagent cassette 19 positioned in front of the thereof, i.e., in the translation path of the carriage 62. For pivoting the caps 26 in opening direction and optionally closing direction, the pivoting portion 66 is provided with at
15 least one pair of contact rods 75, 76 for contacting the projecting portions 64 of the caps 26 in the second translating position of the carriage 62.

Stated more particularly, as illustrated in FIGS. 8A and 8B, in
20 one embodiment, the pivoting portion 66 is provided with one pair of two opposing lower contact rods 75 arranged in a manner to contact the projecting portions 64 or to be brought in contact with the projecting portions 64 by pivoting the pivoting portion 66 when the carriage 62 is in the second translating position
25 with respect to the mount 61. As shown, each lower contact rod 75 is provided with a number of, e.g., three semi-circular recesses 77 serially arranged with respect to each other for inserting the projecting portions 64 of the caps 26. Hence, the lower contact rods 75 can be used to pivot the caps 26 in opening
30 direction to open the reagent containers 24, and, due to inserting the projecting portions 64 in the recesses 77, can also be used to pivot the caps 26 in closing direction. Furthermore, the base portion 65 is adapted to hold the reagent cassette 19 while pivoting the caps 26 in opening or closing directions to
35 open or close the openings 63. Stated more particularly, the base portion 65 is provided with two opposing interior struts 78 which, in the second translational position of the carriage 62

are placed in contact with upper shoulders 79 of the reagent containers 24.

As illustrated in FIGS. 9A, 9B, in a variant thereof, the pivoting
5 portion 66 can also be provided with one pair of two opposing
lower contact rods 75 and one pair of two opposing upper contact
rods 76 so that the projecting portions 64 can be positioned
in-between the upper and lower contact rods 75, 76. The lower
contact rods 75 can be used to pivot the caps 26 in opening
10 direction to open the reagent containers 24. Furthermore, the
upper contact rods 76 can be used to pivot the caps 26 in the
reverse or closing direction to close the reagent containers 24.

Hence, each reagent container 24 can be repeatedly opened and
15 closed according to the specific demands of the user to avoid
contamination and evaporation of reagents contained therein.
Since the opener/closer 23 is arranged in a radial direction with
respect to the carousel 17, individual reagent cassettes 19
stored by the holders 18 can be brought in juxtaposition to the
20 opener/closer 23 by rotating the carousel 17. Furthermore, due
to the radial arrangement of the opener/closer 23, the instrument
1 can be made highly compact in shape and the reagent cassettes
19 as well as the reaction vessels 60 contained in the incubator
21 can be readily accessed from above so as to continue sample
25 processing even during opening/closing reagent cassettes 19. A
detailed description of such opener/closer 23 and the reagent
cassettes 19 associated therewith can be taken from the un-
published European patent application EP 11167523.7, the
disclosure of which is incorporated herein by reference in its
30 entirety.

Some reagents such as suspensions of magnetic beads need to be
homogenized before use which most typically is done with a
stirrer having paddles on its free end which are lowered into
35 the reagents. Accordingly, the reaction area 12 yet further

includes a mixer 27 comprising a re-usable vertical stirrer 28 provided with an elongated rod 56 having a paddle 57 on its lower end adapted for stirring fluids when turning the rod 56 around its longitudinal axis. The stirrer 28 can be lowered into
5 individual reagent containers 24 stored by the holders 18 of the carousel 17. In order to avoid carry-over and cross-contamination, the stirrer 28 has to be washed in-between consecutive operations. Accordingly, the instrument 1 is provided with an open top wash station (not illustrated) for
10 washing the stirrer 28. Stated more particularly, the stirrer 28 can be moved over the wash station in a position right above an opening thereof then lowered into a cavity containing wash fluid. Furthermore, a fluid jet can be generated to wash the stirrer 28. While generating such fluid jet, the paddle 57 can
15 be turned so that all sides can be thoroughly washed. The stirrer 28 can then be moved upwards to perform the next stirring operation. As used herein, the term "wash fluid" refers to fluids commonly used with automated clinical analyzers, e.g., aqueous solutions to which specific substances such as detergents,
20 salts, preservatives and solubilizers have been added. Furthermore, deionized water can also be used for washing the stirrer 28. Due to the radial arrangement of the opener/closer 23 and loader/unloader 10, the stirrer 28 has access to the carousel 17 and can readily be placed over the reagent containers
25 24 to be lowered into the reagents contained therein for performing a mixing operation.

While not shown in the figures, the reaction area 12 yet further includes an identifier, capable of identifying individual
30 reagent cassettes 19 and/or individual reagent containers 24 disposed on the transport lines 22 and/or stored by the carousel 17. Stated more particularly, each reagent cassette 19 and/or each reagent container 24 can bear a machine-readable label such

as a barcode which can be automatically read by the identifier
such as a barcode reader. Furthermore, each reagent cassette 19
and/or each reagent container 24 can be provided with an RFID
tag (RFID = Radio-frequency identification) which can be read
5 by the identifier. The information presented in ma-
chine-readable form on the label or RFID tag identifies in-
dividual reagent cassettes 19 and/or reagent containers 24 and
can, for instance, code for a lot number or any other information
suitable for the identification thereof. It may also contain
10 additional information such as use-by date which may be relevant
for the use of the reagents. Advantageously, the reagent
cassettes 19 and/or reagent containers 24 can be identified,
e.g., prior to manipulating reagents contained therein so as to
improve the reliability of the sample processing.

15
With particular reference to FIG. 1, the reaction area 12 yet
further includes a box-like cooling cell 29 formed by plural
thick cell walls 31 made of thermally isolating material such
as foamed polystyrene forming an internal space 30 thermally
20 isolated from the surroundings. Specifically, the cooling cell
29 accommodates the carousel 17, the opener/closer 23 and the
loader/unloader device 10. As illustrated, a front portion of
the cooling cell 29 is provided with a first cell opening 32
opening into the internal space 30 of the cooling cell 29 and
25 being arranged in correspondence to the loader/unloader 10 so
that reagent cassettes 19 can advantageously be placed on the
transport lines 22 or removed therefrom via the first cell
opening 32 essentially without compromising the cooled interior
of the cooling cell 29 so as to allow for a highly efficient
30 cooling of the cooling cell 29.

Furthermore, an upper portion of the cooling cell 29 is provided
with three second cell openings 33 opening into the internal

space 30 of the cooling cell 29 and being arranged in correspondence to the reagent containers 24 of one reagent cassette 19 stored by the holder 18 in a dedicated rotating position allowing for the opening and optionally closing of the caps 26 by means of the opener/closer 23. The three second cell openings 33 allow for the manipulation of reagents contained in the opened reagent containers 24, e.g., for mixing reagents by the mixer 27 or for pipetting reagents contained therein. While the number of second cell openings 33 typically corresponds to the number of reagent containers 24 of one reagent cassette 19, those of skill in the art will appreciate that the number and arrangement thereof may vary according to the specific demands of the user. Hence, the second cell openings 33 advantageously allow the reagent containers 24 of one reagent cassette 19 to be accessed from above while being cooled in the cooling cell 29 so as to avoid deterioration of the reagents contained therein to improve the reliability of the test results.

Furthermore, the cooling cell 29 is provided with a central recess 34 thermally isolated against the cooled internal space 30 accommodating the incubator 21. Accordingly, the incubator 21 is disposed outside the cooling cell 29 thermally isolated against the cooled internal space 30 so as to allow for a highly efficient cooling of the cooling cell 29. Furthermore, placing the incubator 21 in the central region 20, the instrument 1 can be made particularly compact in shape.

As above-described, the internal space 30 of the cooling cell 29 can be actively cooled by means of a cooling device (not illustrated) such as, but not limited to, a thermoelectric (Peltier) device utilizing the Peltier effect. As known to the skilled persons, when passing electric current through the Peltier device, depending on the direction of the current

applied, the device functions as a heat sink which can absorb heat to thereby cool the internal space 30. Accordingly, the internal space 30 of the cooling cell 29 can be cooled for cooling reagent cassettes 19 thus (cool-)stored by the holders 18 of the carousel 17 or placed on the transport lines 22 of the loader/unloader 10 while (simultaneously) heating the incubator 21 thermally insulated against the internal space 30. The cooling cell 29 can, e.g., be adapted to cool-store the reagent cassettes 19 at a temperature in the range of from 6 to 10°C, preferably 6 to 8°C.

In the instrument 1, the analytical area 13 is provided with at least one analyzer 35 for analyzing the reacted samples. The analyzer 35 includes one or more detectors or sensors for detecting reaction products such as, but not limited to, an optical detector such as a photometer, a flow-through cell coupled to an ion-selective electrode (ISE), a biosensor such as an enzymatic-electrochemical detector and an electro-chemoluminescence (ECL) detector. As illustrated, in the present embodiment, the analyzer 35, e.g., includes an ECL-detector 54.

As illustrated in the figures, the analytical area 13 further includes a first reaction vessel receiving block 36 for receiving one or more reaction vessels 60 containing reacted sample. In the present embodiment, the first reaction vessel receiving block 36 can, e.g., be used to magnetically manipulate (e.g. attract) magnetically responsive particles contained in the reacted sample. Stated more particularly, the first reaction vessel receiving block 36 is provided with at least one magnet (not illustrated) for generating a magnetic field, adapted for magnetically manipulating the magnetically responsive particles contained in the reaction vessel 60, in particular, for retaining the magnetically responsive particles therein. The at

least one magnet can, e.g., be embodied as permanent magnet or electromagnet including a pole-shoe magnet, a switchable magnet or a toroidal magnet. Retaining the magnetically responsive particles, fluid can be removed from the reaction vessel 60, e.g., for washing out bound-free molecular detectable labels. The analytical area 13 yet further includes a second reaction vessel receiving block 82 for receiving one or more reaction vessels 60 from the first reaction vessel receiving block 36 for pipetting reacted sample into the analyzer 35 by means of a needle 55. Accordingly, in the analytical area 13, the needle 55 can be used for sucking the reacted sample from the reaction vessel 60 disposed in the second reaction vessel receiving block 82 into the ECL-detector 54 for detecting reaction products with respect to one or more analytes contained therein.

The ECL-detector 54 can be related to one or plural types of immunochemical methods different with respect to each other. Stated more particularly, the optical detection of reaction products by means of the ECL-detector 54 involves the production of electrochemically generated intermediates which undergo a highly exergonic reaction to produce an electronically excited state that emits light. Specifically, ECL advantageously allows traces of micro-organisms, hormones, viruses, antibodies, amines or proteins be measured.

As above-described, in the instrument 1, the sampling area 14 is composed of the disposables storing area 15 provided by the first part 2 of the instrument 1 and the sample receiving area 16 provided by the second part 3 of the instrument 1 to be put in juxtaposition to the first part 2 at the left side wall 5 thereof. Specifically, the disposables storing area 15 comprises two slidably mounted drawers 37, each of which being provided with plural recesses 44 for receiving tip racks 38 containing

disposable pipetting tips 39 for pipetting fluids and reaction vessel racks 83 containing disposable reaction vessels 60. The drawers 37 can be drawn out of the instrument 1 at the front-side 45 thereof to be charged with new (filled) tip racks 38 and
5 reaction vessel racks 83, respectively, or uncharged with used (empty) tip racks 38 and reaction vessel racks 83, respectively. While two drawers 37 respectively containing four tip racks 38 and four reaction vessel racks 83 are shown in FIGS. 1 and 2 for the purpose of illustration only, it is to be understood that
10 the instrument 1 can contain any other number and arrangement of drawers 37, tip racks 38 and reaction vessel racks 83 that would be compatible with the automated instrument 1 for analyzing liquid samples. By using disposable pipetting tips 39 and disposable reaction vessels 60 (cross-)contamination of liquid
15 samples and reagents can advantageously be avoided.

Furthermore, as illustrated in FIGS. 5 and 6, the sample receiving area 16 is provided with a plurality of slots 40, each of which being adapted for receiving one sample rack 41 for
20 carrying a number of open-top sample tubes 42 serially arranged with respect to each other for receiving samples to be analyzed. While five sample tubes 42 are shown to be contained in one sample rack 41 for the purpose of illustration only, each sample rack 41 can have any other number and arrangement of sample tubes 42
25 that would be compatible with the automated instrument 1 for analyzing liquid samples.

The instrument 1 yet further includes two separate two-rail translation systems 46, 46', i.e., a first translation system
30 46 and a second translation system 46', each of which comprising two rails comprised of a common back rail 43 and individual transfer head rails 47, 47', i.e., a first transfer head rail 47 and a second transfer head rail 47', arranged in orthogonal

relationship with respect to each other. The two two-rail translation systems 46, 46' are similar in construction. Stated more particularly, each two-rail translation system 46, 46' includes the (common) back rail 43 extending in one direction (x) slidably engaged with the transfer head rail 47, 47' extending in the orthogonal direction (y) thereof in a horizontal plane. Accordingly, each transfer head rail 47, 47' can be translatably moved along the back rail 43 in the one direction (x). Furthermore, the first and second transfer head rails 47, 47' respectively are provided with one transfer head 48, 48', i.e., the first transfer head rail 47 is provided with a first transfer head 48 and the second transfer head rail 48' is provided with a second transfer head 48' slidably mounted thereto so that the transfer heads 48, 48' can be translatably moved along the transfer head rail 47, 47', respectively, in the orthogonal direction (y). Accordingly, the transfer heads 48, 48' can be moved in two directions of travel over a horizontal plane. Furthermore, each transfer head 48, 48' is provided with one mounting block 49, 49', i.e., the first transfer head 48 is provided with a first mounting block 49 and the second transfer head 48' is provided with a second mounting block 49', slidably mounted to the transfer head 48, 48', respectively, so that the mounting blocks 49, 49' can be translatably moved in vertical direction (z). Accordingly, the mounting blocks 49, 49' can be moved in three orthogonal directions of travel. The translation of the mounting blocks 49, 49' can, e.g., be based on motor-driven spindle-drives not further elucidated herein.

Specifically, the first and second mounting blocks 49, 49' respectively are provided with one gripper 50, 50' for gripping one sample tube 42. Furthermore, the first mounting block 49 (the left as seen from the front-side 45) is provided with a first pipettor 51 for pipetting fluids configured for use with

disposable pipetting tips 39 stored in the disposable storing area 15. Due to being mounted to a same mounting block 49 the first gripper 50 is transferred together with the first pipettor 51. Furthermore, the second mounting block 49' (the right as seen from the front-side 45) is provided with a second pipettor 51' for pipetting fluids embodied as re-usable metallic needle. Due to being mounted to a same mounting block 49' the second gripper 50' is transferred together with the second pipettor 51'. For washing the metallic needle, the wash station described in connection with the stirrer 28 can be used. Alternatively, as illustrated, the instrument 1 can also be provided with a separate needle wash station 80 for washing the metallic needle 55 which may be of similar construction with respect to the wash station of the stirrer 28.

15

In the instrument 1, the first two-rail translation system 46 arranged on the left side thereof (as seen from the front-side 45) is being used for gripping reaction vessels 60 and pipetting liquids only in the reaction area 12 and the sampling area 14 but not in the analytical area 13. Stated more particularly, the first translation system 46 can, e.g., be used to transfer reaction vessels 60 from the sampling area 14 to the incubator 21, to pipette samples from the sample receiving area 16 into the reaction vessel 60 contained in the incubator 21 and to pipette reagent(s) from the reagent cassettes 19 stored by the carousel 17 to the reaction vessel 60 contained in the incubator 21. Furthermore, the second two-rail translation system 46' arranged on the right side of the instrument 1 (as seen from the front-side 45) is being used for gripping reaction vessels 60 and pipetting liquids only in the reaction area 12 and the analytical area 13 but not in the sampling area 14. Stated more particularly, the second translation system 46' can, e.g., be used to transfer reaction vessels 60 from the incubator 21 to

30

the first and second reaction vessel receiving blocks 36, 82 of the analytical area 13, to remove reaction vessels 60 from the second reaction vessel receiving block 83 to transfer the reaction vessels 60 into a waste container (not illustrated) and to pipette fluids with respect to reaction vessels 60 contained in first reaction vessel receiving block 36.

The two two-rail translation systems 46, 46' having only one (common) backrail 43 advantageously allow for a highly compact construction of the instrument 1 in which the first and second transfer head rails 47, 47' can be made comparably short. This especially applies to the specific arrangement of the reaction area 12 arranged in-between the sampling area 14 and the analytical area 13. Furthermore, since the loader/unloader 10 and the opener/closer 23 are radially arranged with respect to the carousel 17, the first and second transfer head rails 47, 47' can be readily moved to have (alternatively) free access to the incubator 21 and the carousel 17, respectively.

The instrument 1 further includes a controller 53 (not further illustrated) for controlling the operation of the instrument 1 for analyzing liquid samples. The controller 53 may, e.g., be embodied as programmable logic controller running a machine-readable program provided with instructions to perform operations in accordance with a predetermined process operation plan for processing samples by mixing samples with one or more reagents so as to obtain sample/reagent mixtures, incubating the sample/reagent mixtures to obtain reacted samples and analyzing the reacted samples by means of the analyzer 35. The controller 53 is electrically connected to the various instrument components requiring control so as to transmit control signals and check the result of such control by response signals. Particularly, the controller 53 includes a hardware and/or software

component related to as scheduler configured to generate and assign time slots for operating devices resources as detailed below of the instrument 1. A second device resource comprises the first gripper 50 and the first pipettor 51. A third device resource comprises the second gripper 50' and the second pipettor 51'. A first device resource comprises devices contained in the analytical area 13 comprising the analyzer 35 and the pipettor thereof comprising the needle 55. Stated more particularly, the scheduler of the controller 55 is set up to successively operate the various functional devices to process one sample. Furthermore, the scheduler is configured to operate the first to third device resources at least temporarily (partly) in parallel to process two or more liquid samples. Furthermore, the scheduler is set up in a manner that the devices connected to the first mounting block 49, i.e., the first gripper 50 and the first pipettor 51, have exclusively access to the reaction area 12 and the sampling area 14 (and not to the analytical area 13), and, that the devices connected to the second mounting block 49', i.e., the second gripper 50' and the second pipettor 51', have exclusively access to the reaction area 12 and the analytical area 13 (and not to the sampling area 14).

As above-detailed, in the instrument 1, the sampling area 14 is arranged on one side of the reaction area 12 and the analytical area 13 is arranged on the other side thereof. Combined with the two two-rail translation systems 46, 46', reaction vessels 60 and liquids contained therein can simultaneously be processed. Hence, e.g., a new reaction vessel 60 can be transferred from the sampling area 14 to the incubator 21 during processing of a reacted sample in the analytical area 13. Furthermore, the carousel 17 can, e.g. continuously, be loaded with or unloaded from reagent cassettes 19 while samples are processed. Furthermore, reagent cassettes 19 can be opened or closed by the

opener/closer 23 without hindering the operation of the two two-rail translation systems 46, 46' and the functional devices combined therewith. Accordingly, liquid samples can very quickly be processed. Furthermore, a major advantage is given by the fact
5 that sample/reagent mixtures can be incubated in thermal insulation to the cool-stored reagent cassettes 19 on the carousel 17 so that undesired condensation of water can largely be prevented.

10 Now referring to FIG. 10, which is a schematic flow diagram, an exemplary embodiment of the process for analyzing a liquid sample under control of the controller 53 is explained. The analysis of the sample is based on combining the sample with one or more reagents, one of which contains magnetically responsive particles embodied as magnetic beads made of magnetically re-
15 sponsive material provided with immobilized reactants such as antibodies adapted to specifically bind to at least one analyte contained in the sample.

20 The process starts (step A) with providing an instrument 1 as above-detailed provided with tip racks 38 containing pipetting tips 39 and empty reaction vessels 60 in the disposables storing area 15, sample racks 41 containing sample tubes 42 with liquid samples in the sample receiving area 16 and reagent cassettes
25 19 loaded onto the carousel 17 which are actively cooled within the cooling cell 29.

In the next step (step B), an empty reaction vessel 60 is transferred from the reaction vessel rack 83 of the disposables
30 storing area 15 to a receptacle 9 of the incubator 21 using the first gripper 50 of the left (first) translation system 46.

In the next step (step C), the carousel 17 is rotated to selectively move one reagent cassette 19 in a opening/pipetting position in juxtaposition to the opener/closer 23, followed by opening the reagent containers 24 thereof by the opener/closer
5 23.

In the next step (step D), the first pipettor 51 of the left (first) translation system 46 is lowered to an unused pipetting tip 39 contained in a tip rack 38 of the disposables storing area
10 15 so that the pipetting tip 39 is fixed thereto, followed by pipetting reagent from one or more reagent containers 24 of the reagent cassette 19 to the reaction vessel 60 in the incubator 21. For aspirating reagent into the pipetting tip 39, the first pipettor 51 is lowered and inserted into the desired reagent
15 container 24 through one of the second cell openings 33. In one embodiment, prior to pipetting, reagent (e.g. reagent containing magnetic beads) is mixed by the stirrer 28 by lowering the stirrer 28, inserting the paddle 57 into the reagent container 24 through the second cell opening 33 and rotating the rod 56 along its
20 longitudinal axis so as to mix the reagent by the paddle 57.

In the next step (step E), the used pipetting tip 39 of the first pipettor 51 of the left (first) translation system 46 is removed by lowering the first pipettor 51 into a tip waste container 81,
25 and, by contacting a projection 83 thereof while moving the first pipettor 51 upwards, stripping the pipetting tip 39 off the first pipettor 51. Hence, the used pipetting tip 39 can be discharged in the tip waste container 81. Then, the first pipettor 51 of the left (first) translation system 46 is lowered to an unused
30 pipetting tip 39 contained in a tip rack 38 of the disposables storing area 15 so that the pipetting tip 39 is fixed thereto.

In the next step (step F), one liquid sample is pipetted from the sample receiving area 16 to the reaction vessel 60 contained in the incubator 21 using the first pipettor 51 so as to obtain a sample-reagent mixture.

5

The above-detailed step E, followed by step D, can be repeated once or several times in case more than one reagent is to be pipetted to the reaction vessel 60 received in the incubator 21.

10 In the next step (step G), the sample/reagent(s) mixture is incubated for a predetermined time-interval so as to obtain a reacted sample. While incubating the sample/reagent(s) mixture contained in the reaction vessel 60 disposed in the incubator 21, the reagent cassettes 19 contained in the cooling cell 29
15 which are stored by the carousel 17 and placed on the transport lines 22 of the loader/unloader 10, respectively, are actively cooled in thermal insulation with respect to the incubator 21.

In the next step (step H), after incubation, the reaction vessel
20 60 containing the reacted sample is transferred from the incubator 21 to the first reaction vessel receiving block 36 of the analytical area 13 using the second gripper 50' of the right (second) translation system 46'.

25 In the next step (step I), the magnetic beads contained in the reaction vessel 60 are drawn to the inner side thereof so as to allow for withdrawal of fluid, e.g., for washing out bound-free molecular detectable labels using the second pipettor 51' embodied as re-usable metallic needle of the right (second)
30 translation system 46'. Furthermore, fluid(s) can be filled into the reaction vessel 60. Prior to or after pipetting fluid(s) with respect to the reaction vessel 60 disposed in the reaction vessel

receiving block 36, the second pipettor 51' can be washed to avoid carry-over.

In the next step (step J), the reaction vessel 60 containing the
5 reacted sample is transferred to the second reaction vessel receiving block 82 by means of the second gripper 50'.

In the next step (step K), the processed reacted sample is transferred from the reaction vessel 60 disposed in the second
10 reaction vessel receiving block 82 to the ECL-detector 54 for analysis with respect to one or more analytes contained therein using the metallic needle 55. Then, the reaction vessel 60 is removed from the second reaction vessel receiving block 82 using the second gripper 50' of the right (second) translation system
15 46' and transferred to a waste container (not illustrated).

In the above-detailed process, the two translation systems 46, 46' can be moved simultaneously and, furthermore, the first gripper 50 and first pipettor 51 of the left (first) translation
20 system 46 can be operated simultaneously with the second gripper 50' and second pipettor 51' of the right (second) translation system 46' so as to save time in processing liquid samples. Stated more particularly, while manipulating the reaction vessel 60 disposed in the first or second reaction vessel receiving blocks
25 36, 82 and/or manipulating reacted sample contained therein, another reaction vessel 60 and/or sample and/or reagent(s) can be transferred to the incubator 21. Furthermore, the reagent containers 24 can be opened for pipetting and/or mixing reagent(s) contained therein, and, can be closed in the remaining
30 time to avoid evaporation of reagents and contamination by small particles (particulate matter or dust) contained in the air. Specifically, the reagent containers 24 can be opened or closed while the two translation systems 46, 46' and the grippers 50,

50' and pipettors 51, 51' combined therewith are working to advantageously save time in analyzing the samples.

The above-detailed process may, e.g., include a further step of closing the caps 26 of the reagent containers 24 stored in the carousel 17 after pipetting reagent(s). It may include a yet further step of identifying reagent containers 24 stored by the carousel 17.

10 In one embodiment, in the above-described process, the various steps (A-K) are performed successively (sequentially). In another embodiment, at least two steps thereof are at least partially performed in parallel. In one embodiment, in the above-described process, the steps (A-K) are performed in the described alphabetical order but a different order may also be
15 considered.

From the former detailed description of exemplary embodiments of the invention, it becomes apparent that samples can be readily
20 processed and analyzed by the instrument 1 which can be made very small in height and compact in shape. Due to the central arrangement of the reaction area 12 in-between the sampling area 14 and the analytical area 13 combined with the loader/unloader 10 and opener/closer 23, both of which are radially arranged with
25 respect to the carousel 17, the instrument 1 can be made highly compact to have a comparably small footprint allowing for a quick and cost-efficient analysis of the samples in which the first and (alternatively) second transfer head rails 47, 47' can be readily moved over the incubator 21 and the carousel 17. Accordingly, the carousel 17 and the incubator 21 can be readily
30 accessed from above so that the opener/closer 23 and/or the loader/unloader 10 can be operated while performing other processing operations using the first and second pipettors 51,

51' and grippers 50, 50'. Furthermore, the two translation systems 46, 46', each including a pipettor 51, 51' and a gripper 50, 50', can be used to perform various simultaneous operations so as to save time in processing liquid samples. Specifically, loading/unloading of reagent cassettes 19 to/from the carousel 17, transfer of reaction vessels 60 to or alternatively from the incubator 21, pipetting of samples and/or reagents, incubation of sample/reagent(s) mixtures, opening and closing of caps 26 prior to or after performing a pipetting operation can simultaneously be performed. Furthermore, due to the compact shape of the instrument 1, the two translation systems 46, 46' can be operated to have a minimum drive range. The scheduler of the controller 53 is configured to sequentially (successively) operate the various device resources for processing one sample wherein at least two device resources are at least temporarily operated in parallel for processing two or more samples by generating and assigning time slots for operating the devices concerned. Hence, liquid samples can be processed in a highly time- and cost-effective manner.

20

Obviously many modifications and variations of the present invention are possible in light of the above description. It is therefore to be understood, that within the scope of appended claims, the invention may be practiced otherwise than as specifically devised.

25

Reference list

1	Instrument
2	First part
3	Second part
4	Mount
5	Side wall
6	Base plate
7	Side door
8	Front cover
9	Receptacle
10	Loader/unloader
11	Upper level
12	Reaction area
13	Analytical area
14	Sampling area
15	Disposables storing area
16	Sample receiving area
17	Carousel
18	Holder
19	Reagent cassette
20	Central region
21	Incubator
22	Transport line
23	Opener/closer
24	Reagent container
25	Container body
26	Cap
27	Mixer
28	Stirrer
29	Cooling cell
30	Internal space
31	Cell wall

32 First cell opening
33 Second cell opening
34 Recess
35 Analyzer
36 First reaction vessel receiving block
37 Drawer
38 Tip rack
39 Pipetting tip
40 Slot
41 Sample rack
42 Sample tube
43 Back rail
44 Recess
45 Front side
46 First translation system
46' Second translation system
47 First transfer head rail
47' Second transfer head rail
48 First transfer head
48' Second transfer head
49 First mounting block
49' Second mounting block
50 First gripper
50' Second gripper
51 First pipettor
51' Second pipettor
52 Projection
53 Controller
54 ECL-detector
55 Needle
56 Rod
57 Paddle
58 Sample vessel

59	Sample area
60	Reaction vessel
61	Mount
62	Carriage
63	Opening
64	Projecting portion
65	Base portion
66	Pivoting portion
67	Pivot arm
68	Spindle drive
69	Frame
70	Spindle
71	Spindle nut
72	Motor
73	Guiding roll
74	Guiding cage
75	Lower contact rod
76	Upper contact rod
77	Recess
78	Strut
79	Shoulder
80	Needle wash station
81	Tip waste container
82	Second reaction vessel receiving block
83	Reaction vessel rack

CLAIMS

1. An automated instrument (1) for processing liquid samples, comprising:

a sampling area (14) for receiving said samples and reaction vessels (60);

an analytical area (13) provided with a first device resource comprising at least one analytical device (35) for analyzing said samples;

a reaction area (12) comprising a conveyor (17) provided with a plurality of holders (18) for storing reagent containers (24) for containing reagents and an incubator (21) configured for receiving one or more of said reaction vessels (60) for incubating said samples contained therein;

a second device resource comprising first functional devices selected from at least one first gripper (50) for gripping said reaction vessels (60) and at least one first pipettor (51) for pipetting liquids, said first functional devices being adapted to have access to said sampling area (14) and said reaction area (12) so as to transfer said reaction vessels (60) from said sampling area (14) to said incubator (21) and to pipette samples and/or reagents into said reaction vessels (60);

a third device resource comprising second functional devices selected from at least one second gripper (50') for gripping said reaction vessels (60) and at least one second pipettor (51') for pipetting liquids, said second functional devices being adapted to have access to said reaction area (12) and said analytical area (13) so as to transfer reaction vessels (60) from said incubator (21) to said analytical area (13) and to dispense and/or withdraw one or more liquids to/from said reaction vessels (60) transferred to said analytical area (13);

a controller (53), configured for operating said first to third device resources for processing one sample wherein at least two of said device resources are at least temporarily operated in parallel for processing two or more samples.

2. The instrument (1) according to claim 1, wherein said plurality of holders (18) of said conveyor (17) are at least partly surrounding a central region (20) and wherein said incubator (21) is disposed in said central region (20).

3. The instrument (1) according to claim 2, wherein said incubator (21) is stationary with respect to said reaction area (12) so that said conveyor (17) can be moved with respect to said incubator (21).

4. The instrument (1) according to any one of claims 1 to 3, comprising a first transfer arm (47) movable in a first direction and being provided with at least one first transfer head (48) movable in a second direction perpendicular to the first direction for mounting said one or more first functional devices (50, 51), and a second transfer arm (47') movable in said first direction and being provided with at least one second transfer head (48') movable in said second direction for mounting said one or more second functional devices (50', 51').

5. The instrument (1) according to any one of claims 1 to 4, comprising a cooling cell (29) containing said conveyor (17) for actively cooling said reagent containers (24) stored by said holders (18) wherein said incubator (21) is thermally isolated from said cooling cell (29).

6. The instrument (1) according to any one of claims 1 to 5, wherein said conveyor (17) is operatively coupled to one or more of the following devices selected from

- a loader/unloader (10), capable of loading/unloading said reagent containers (24) to/from said holders (18),
- an opener/closer (23), capable of opening/closing caps (26) of said reagent containers (24) stored by said conveyor (17),
- a mixer (27), capable of mixing reagents contained in said reagent containers (24) stored by said conveyor (17);
- an identifier, capable of identifying said reagent containers (24) stored by said conveyor (17).

7. The instrument (1) according to claim 5 or 6, wherein one or more of said devices (10, 23) are at least partially contained in said cooling cell (29).

8. The instrument (1) according to any one of claims 1 to 7, wherein said sampling area (14) is configured for storing disposable pipetting tips (39) of said first pipettor (51).

9. The instrument (1) according to any one of claims 1 to 8, wherein said reaction area (12) is located between said sampling area (14) and said analytical area (13).

10. A process for the automated processing of liquid samples, comprising the following steps of:

- a step of providing a conveyor (17) having plural holders (18) for storing reagent containers (24) provided with one or more reagent containers, said holders (18) at least partly surrounding a central region (20) containing an incubator (21) for receiving one or more reaction vessels (60),

- a step of transferring at least one of said reaction vessels (60) from a sampling area (14) to said incubator (21) with a first gripper (50),
- a step of moving said conveyor (17) with respect to said incubator (21) so as to move at least one reagent container (24) in a pipetting position for pipetting reagent contained therein,
- a step of pipetting said reagent to said reaction vessel (60) received in said incubator (21) with a first pipettor (51),
- a step of pipetting sample contained in said sampling area (14) to said reaction vessel (60) received in said incubator (21) containing said sample with said first pipettor (51),
- a step of incubating said sample-reagent mixture so as to obtain a reacted sample,
- a step of transferring said reaction vessel (60) containing said reacted sample from said incubator (21) to an analytical area (13) provided with at least one analytical device (35) for analyzing samples with a second gripper (50'),
- a step of transferring said reacted sample from said reaction vessel (60) to said analytical device (35) for analysis thereof with respect to at least one analyte.

11. The process according to claim 10, wherein, prior to incubating said sample-reagent mixture, a step of pipetting another reagent to said reaction vessel (60) received in said incubator (21) containing said sample-reagent mixture with said first pipettor (51) is performed at least once.

12. The process according to claim 10 or 11, wherein said one or more reagent containers (24) stored by said conveyor (17) are actively cooled while being thermally isolated with respect to said incubator (21).

13. The process according to any one of claims 10 to 12, wherein one or more liquids are dispensed to and/or withdrawn from said reacted sample contained in said reaction vessel (60) with said second pipettor (51').

14. The process according to any one of claims 10 to 13, wherein a second device resource comprising said first gripper (50) and said first pipettor (51), a third device resource comprising said second gripper (50') and said second pipettor (51') and a first device resources comprising said analytical device (35) are sequentially operated for processing one sample, and wherein at least two of said device resources are at least temporarily operated in parallel for processing two or more samples.

15. The process according to any one of claims 10 to 14, further comprising one or more of the following steps:

- a step of opening a cap (26) of at least one reagent container (24) stored in said conveyor (17) prior to pipetting reagent contained therein,
- a step of closing said cap (26) of said reagent container (24) stored in said conveyor (17) after pipetting reagent contained therein,
- mixing reagent contained in said reagent container (24) prior to pipetting thereof,
- identifying said at least one reagent container (24) stored by said conveyor (17) prior to pipetting.

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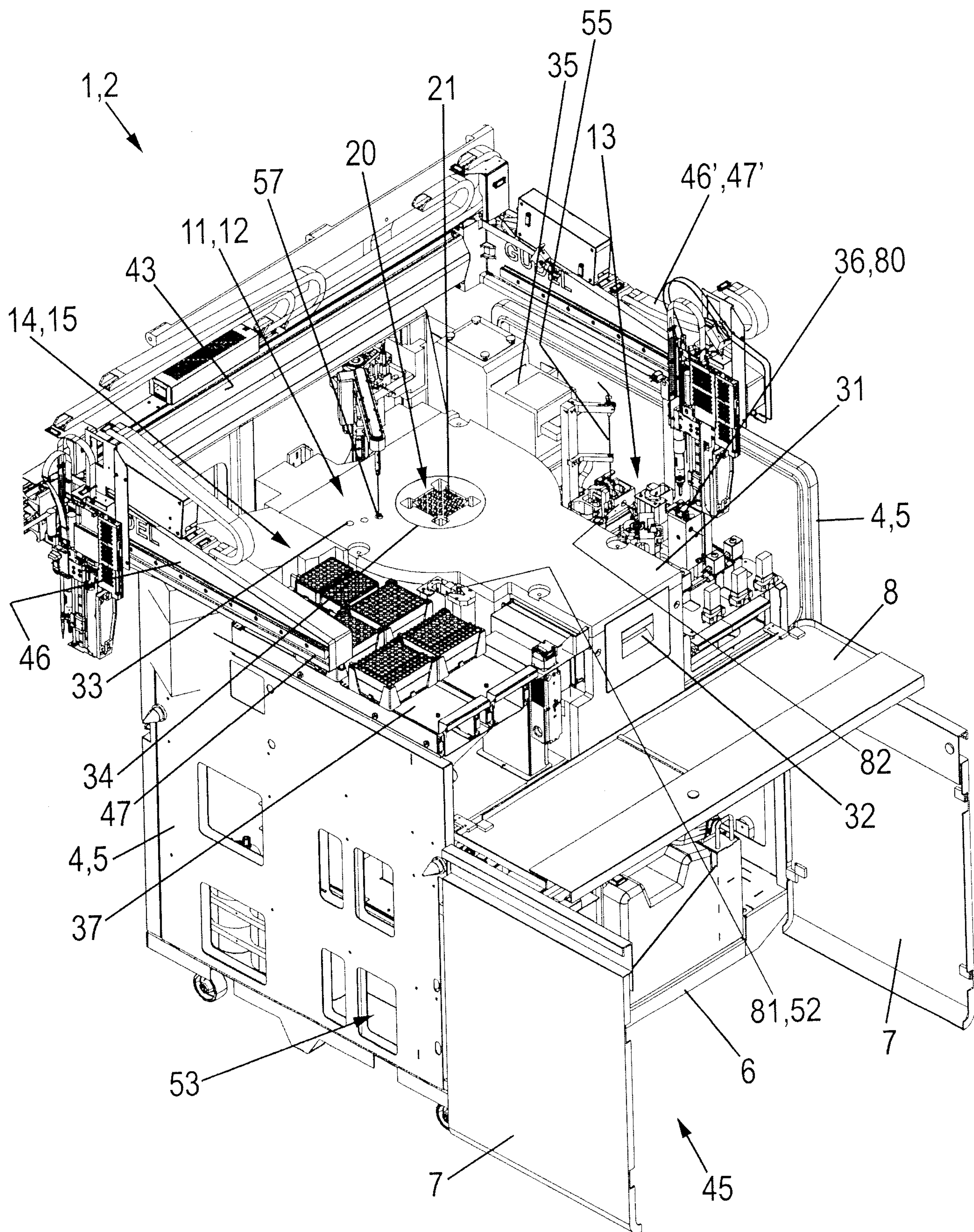


FIG. 1

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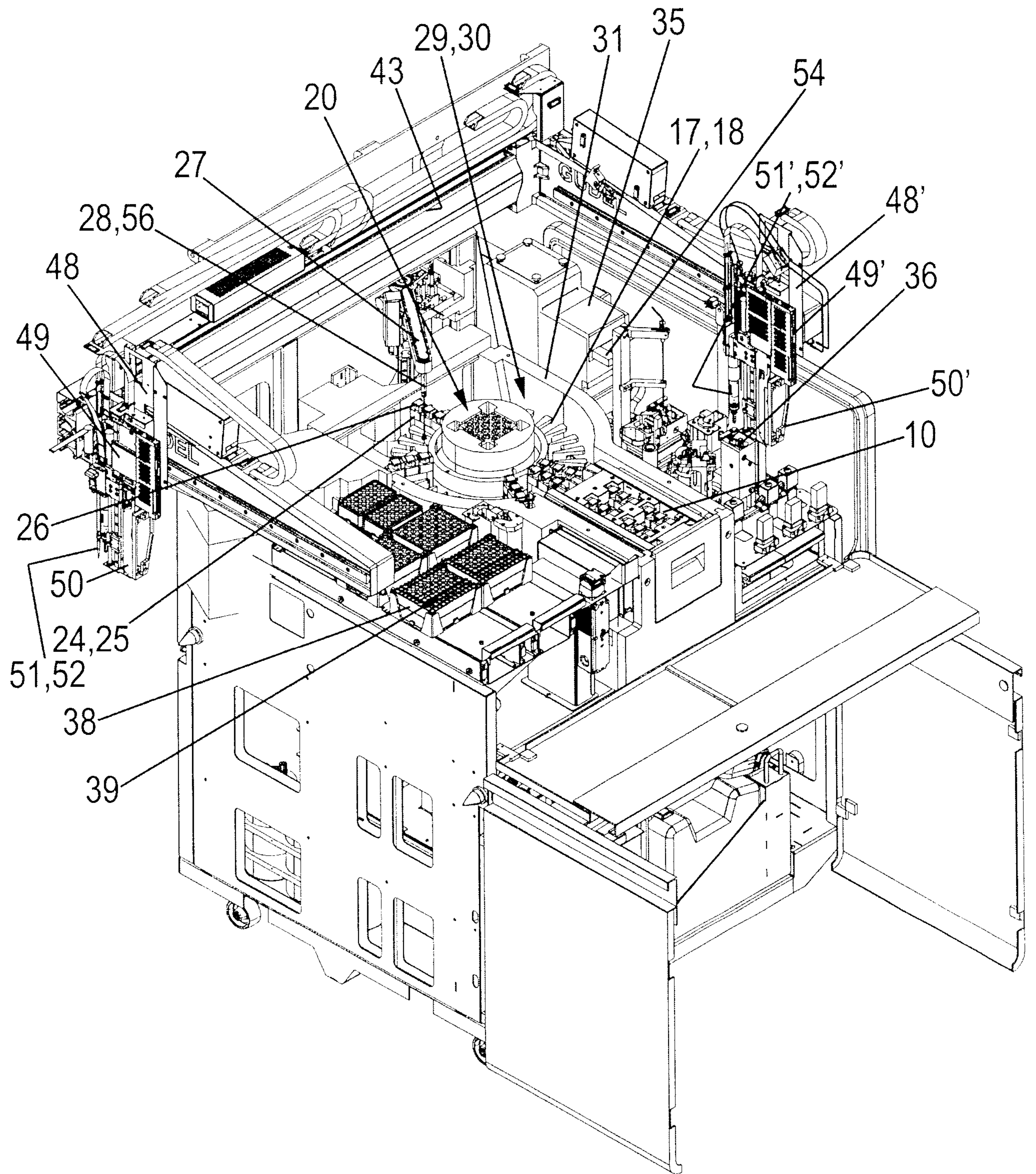


FIG. 2

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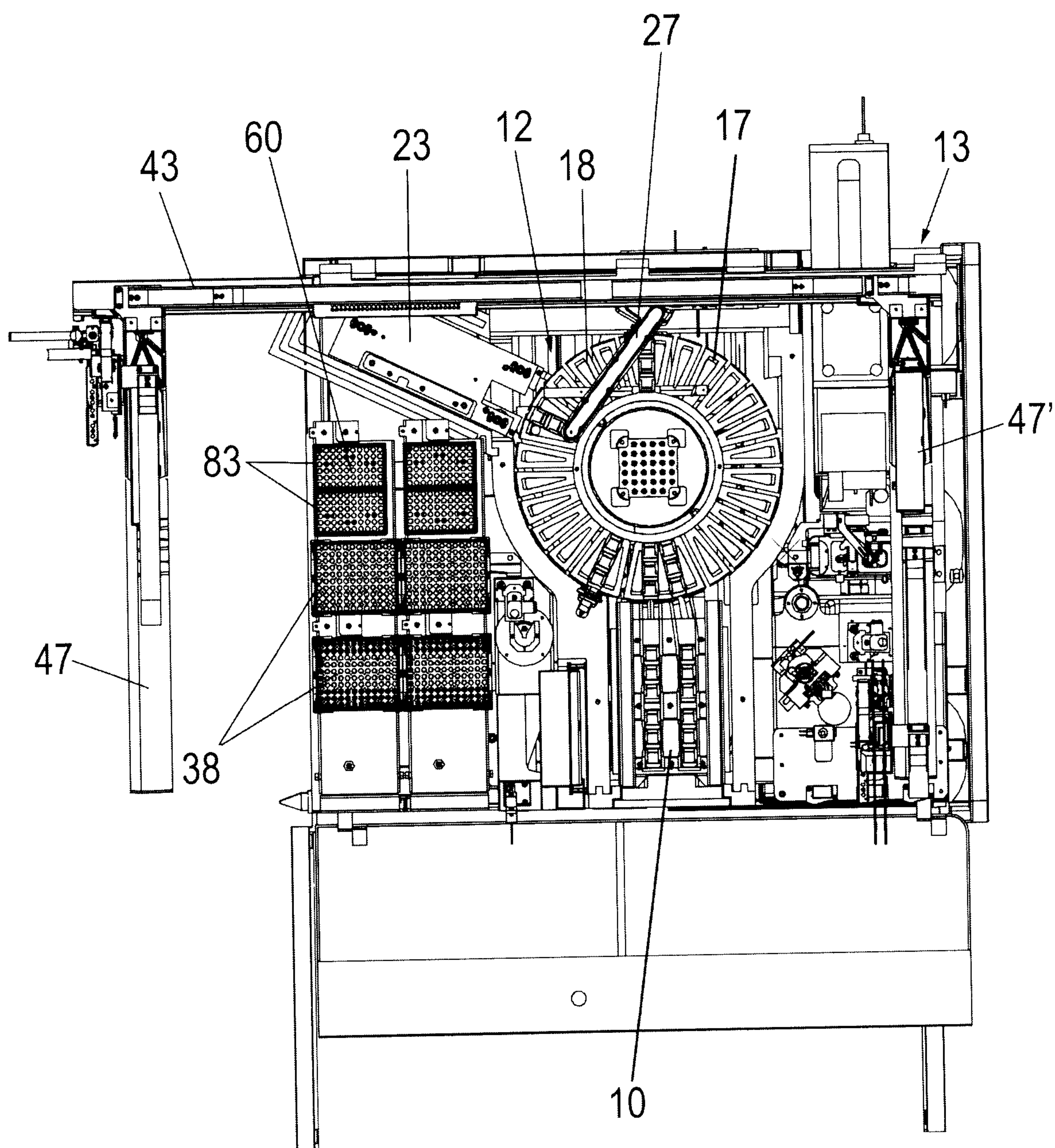


FIG. 3

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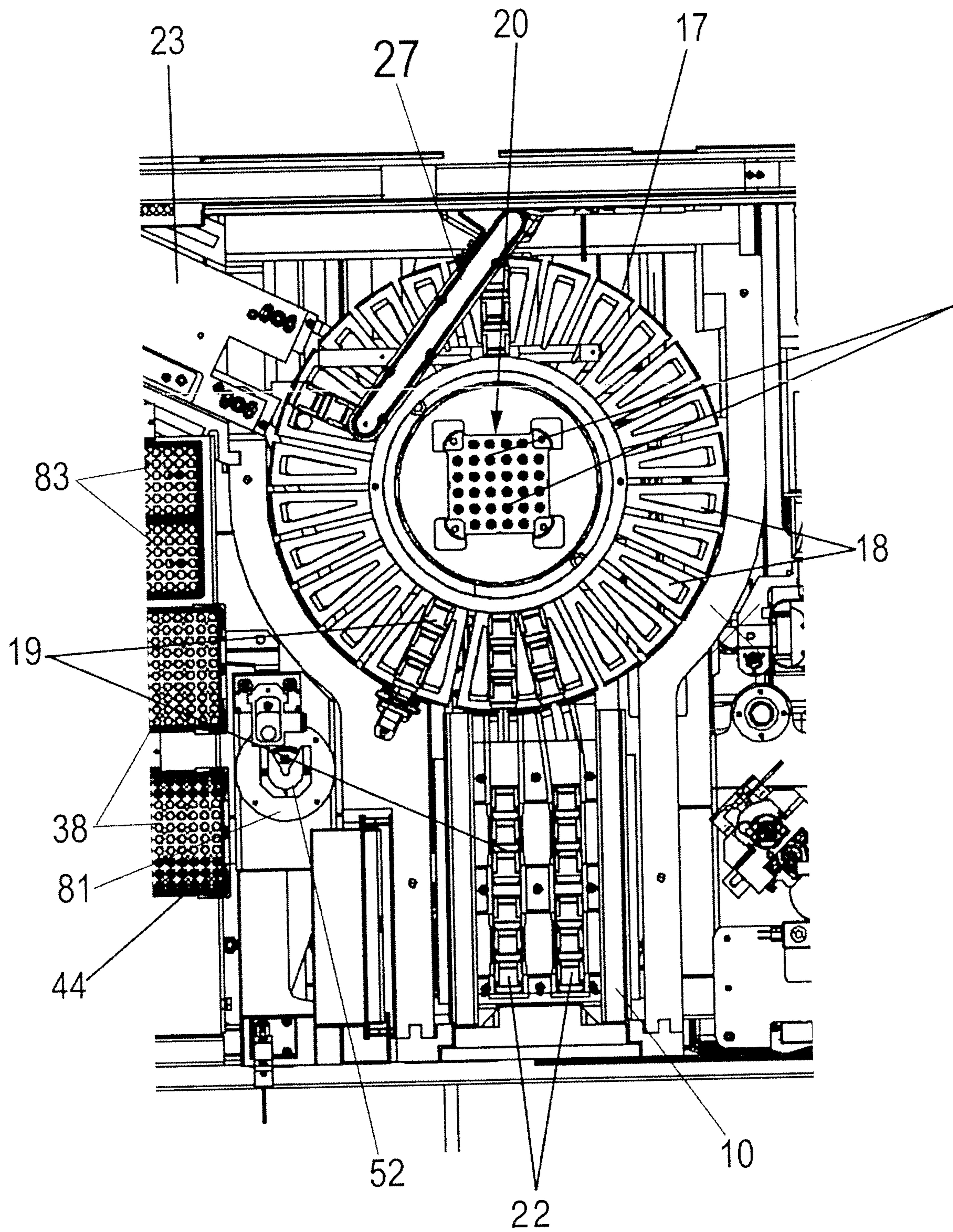


FIG. 4

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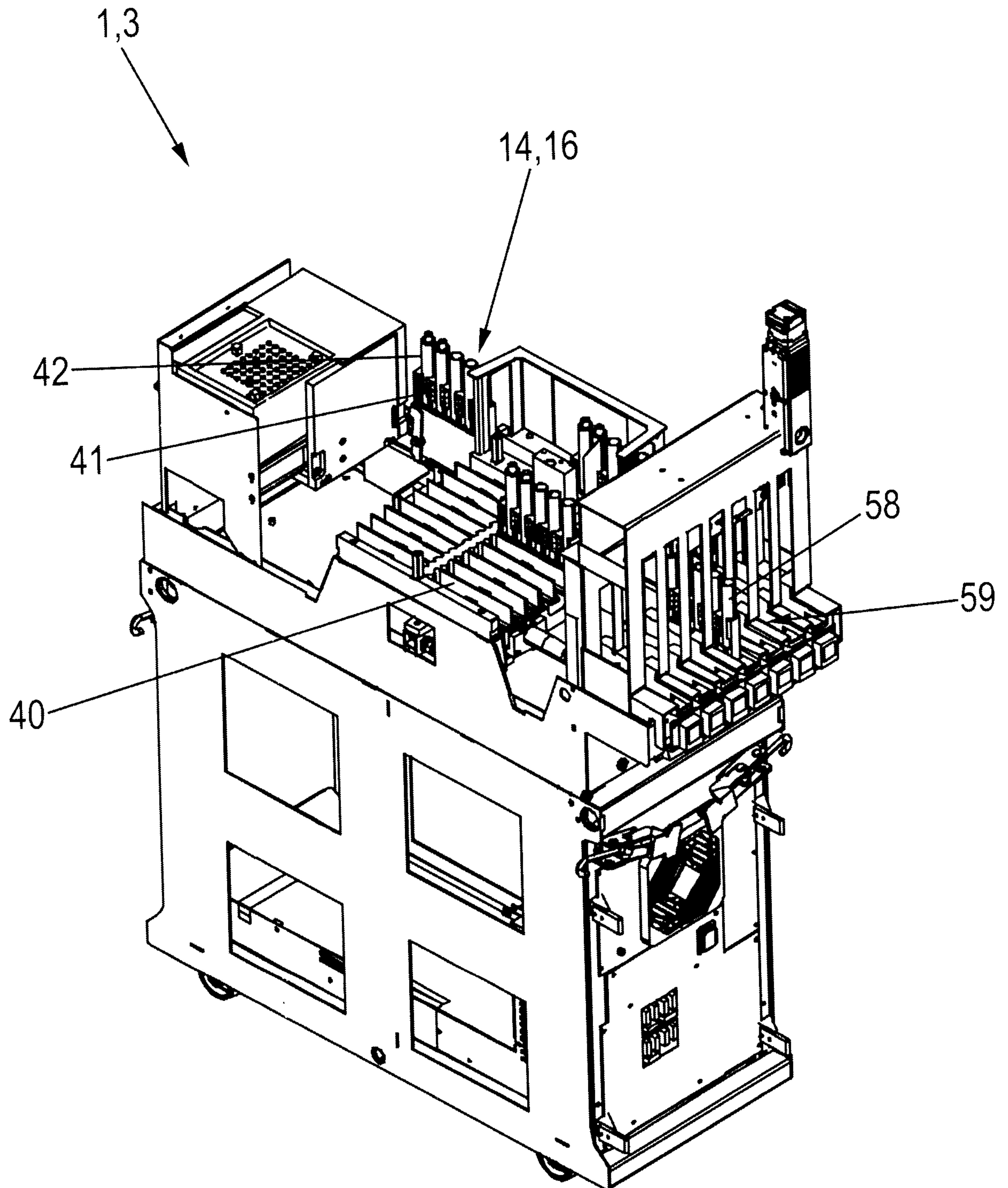


FIG. 5

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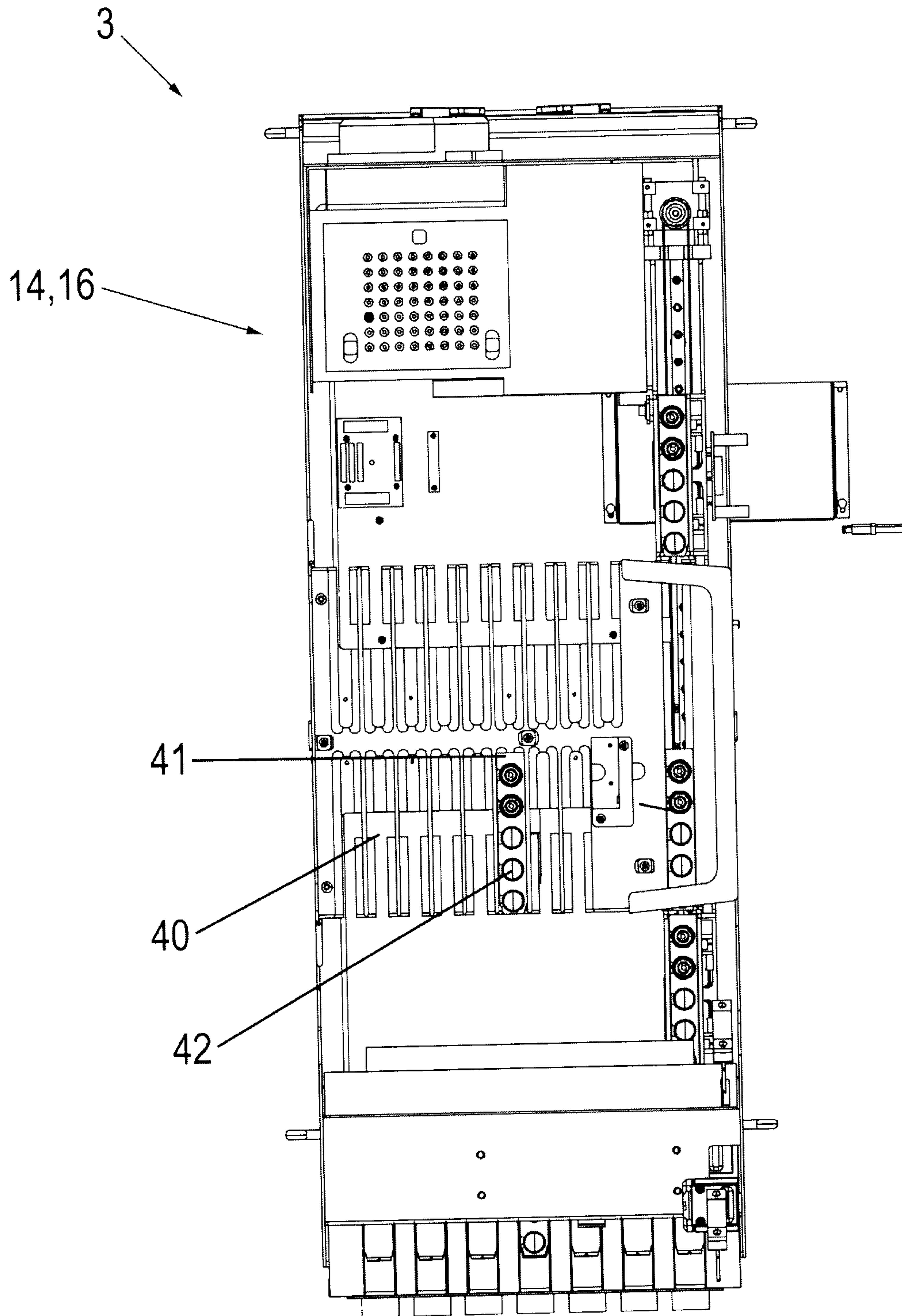


FIG. 6

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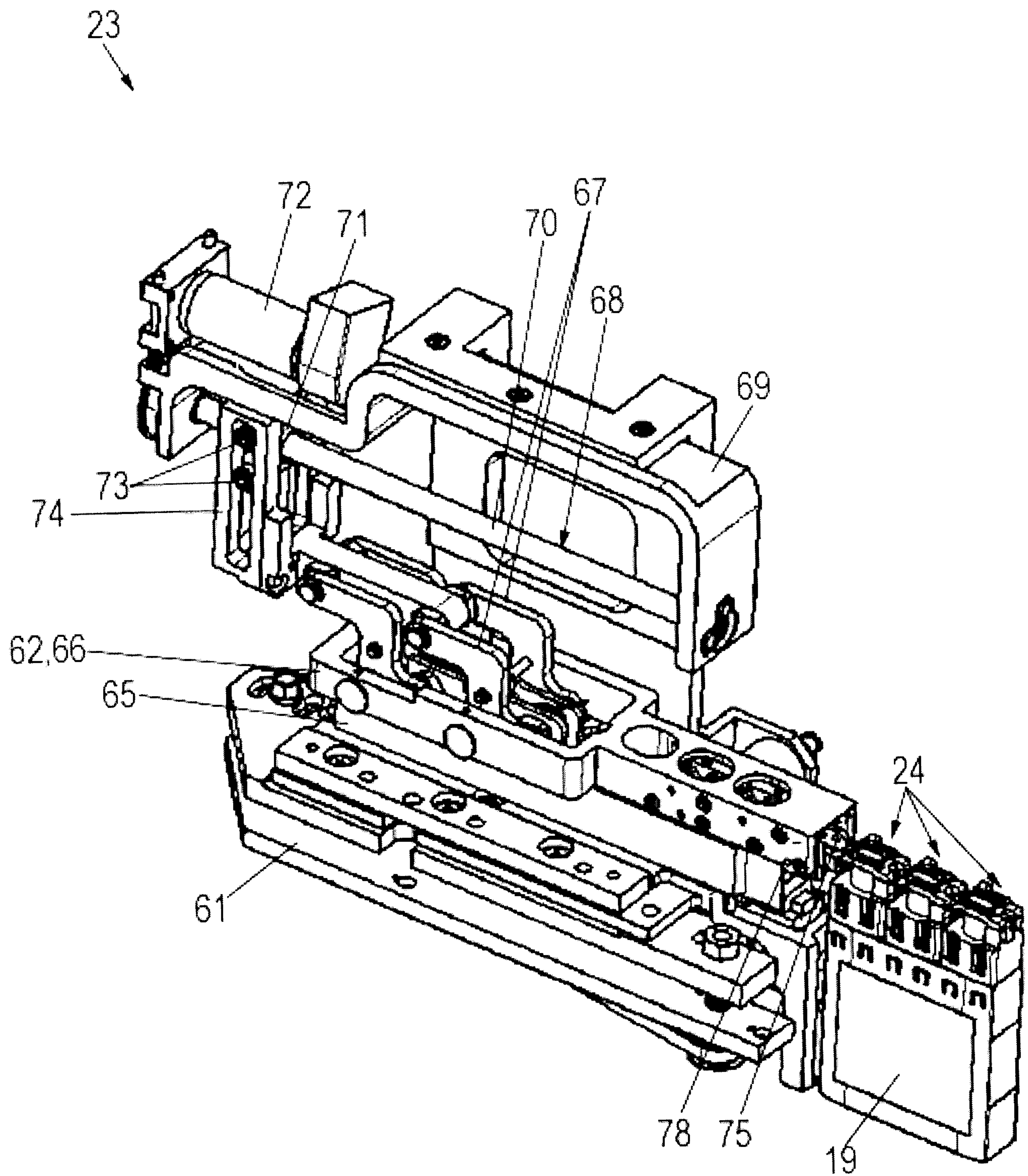


FIG. 7

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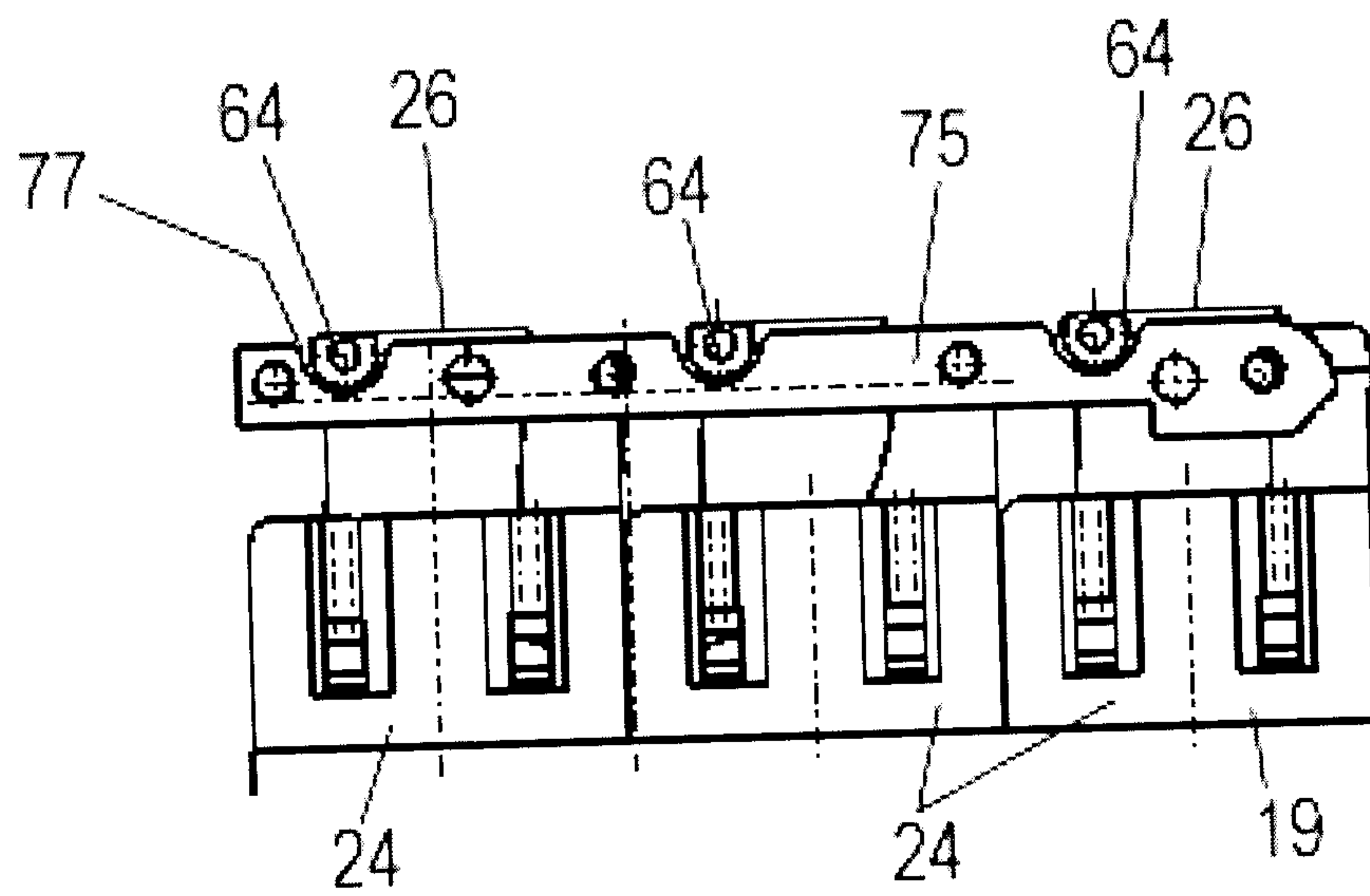


FIG. 8A

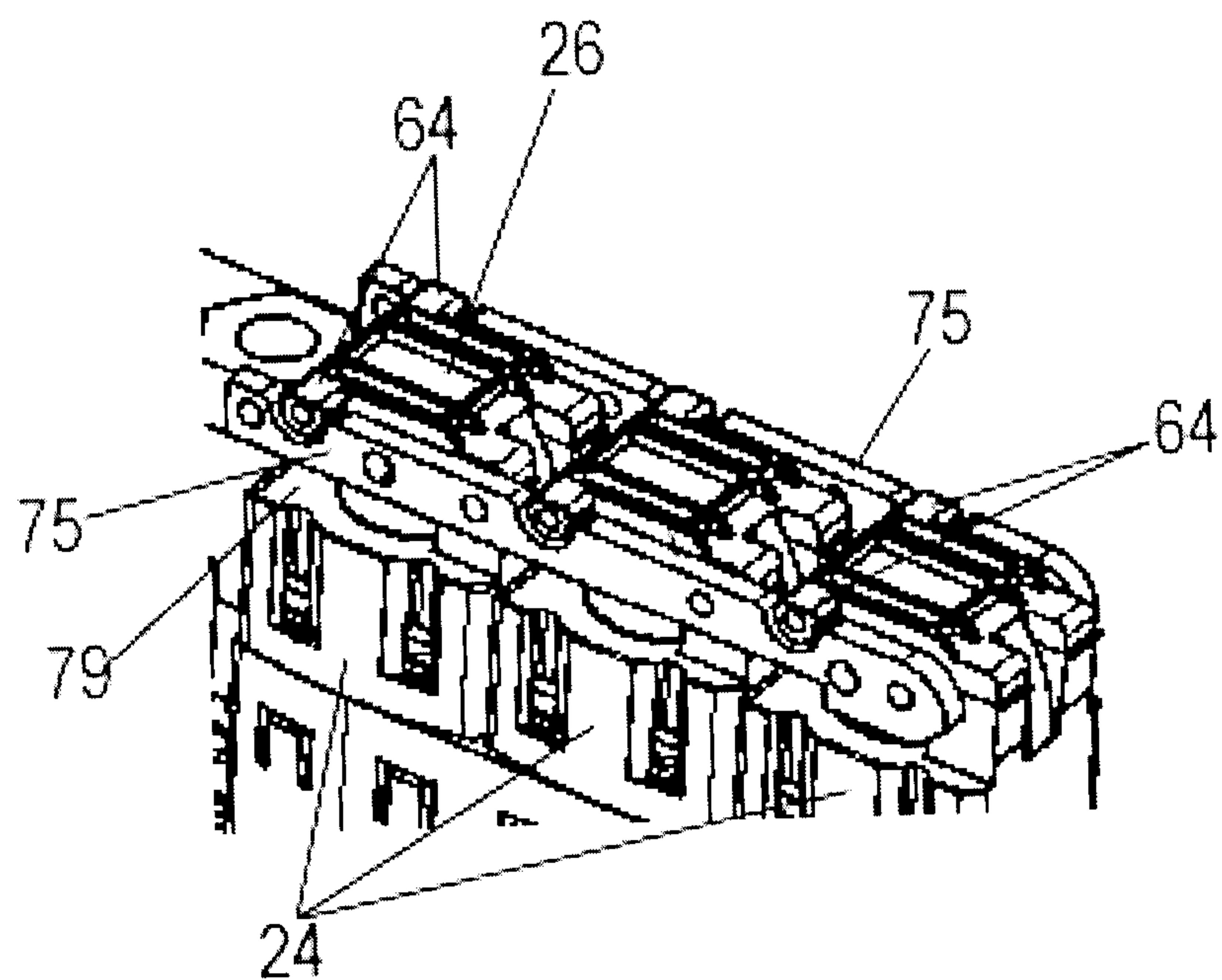


FIG. 8B

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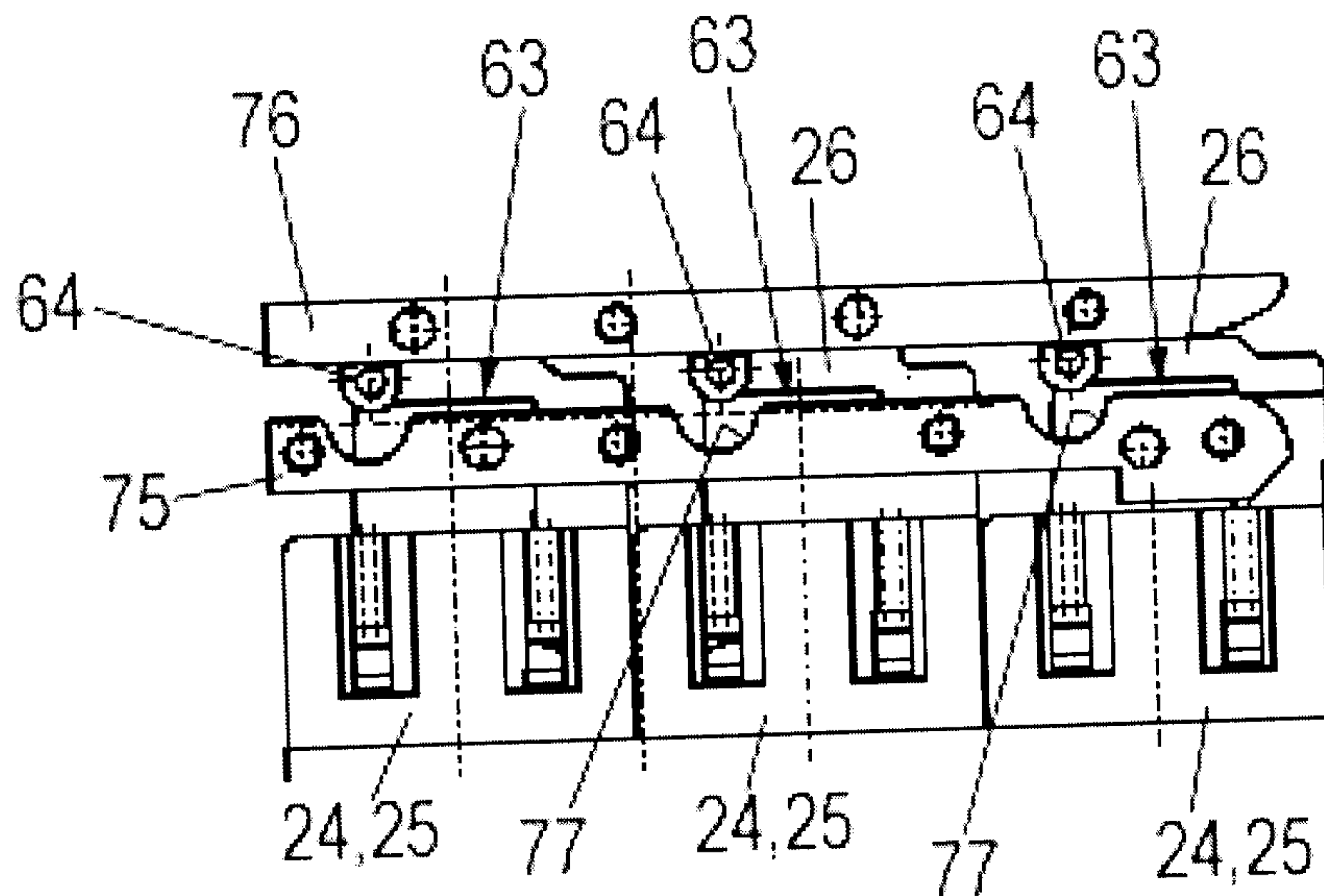


FIG. 9A

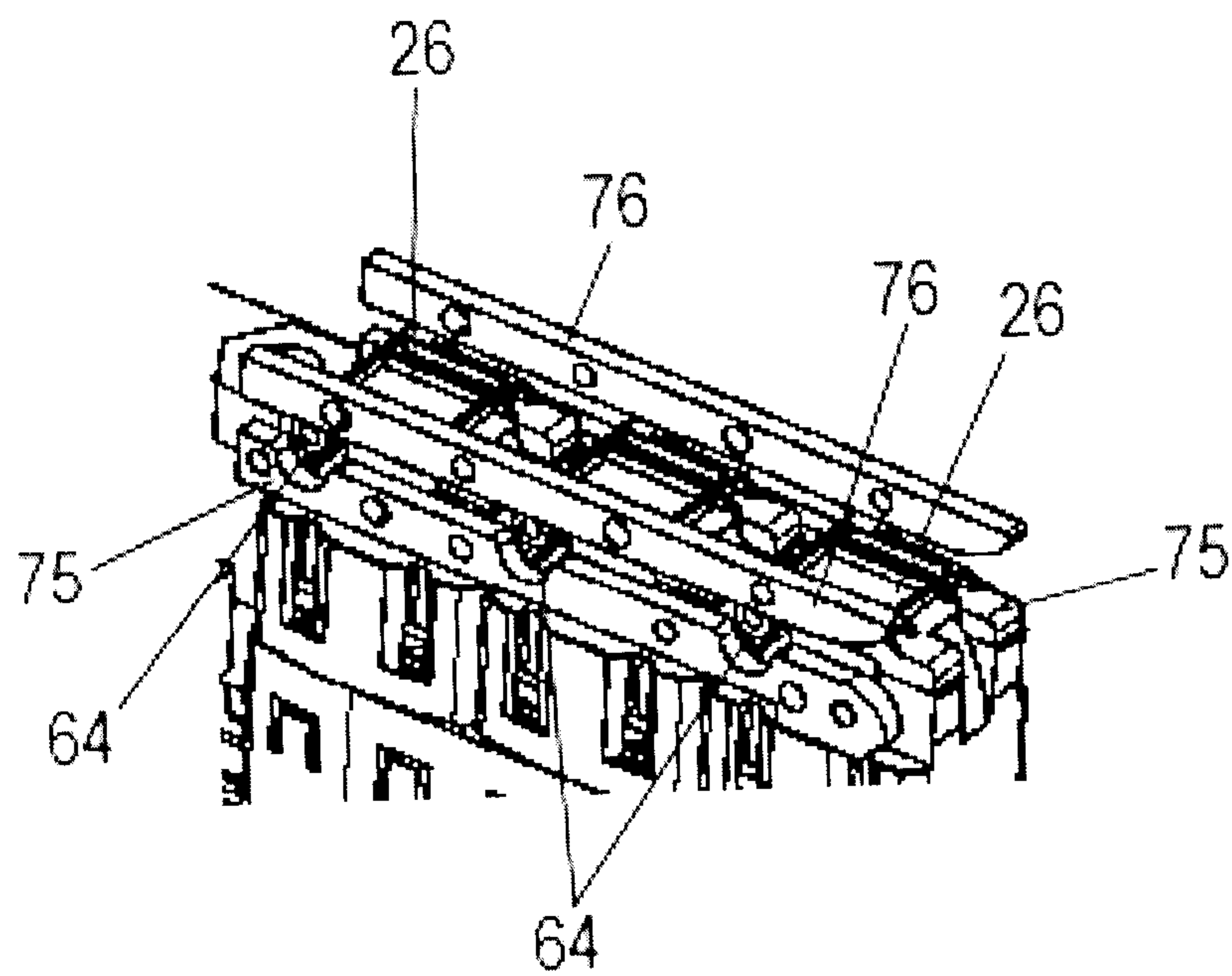


FIG. 9B

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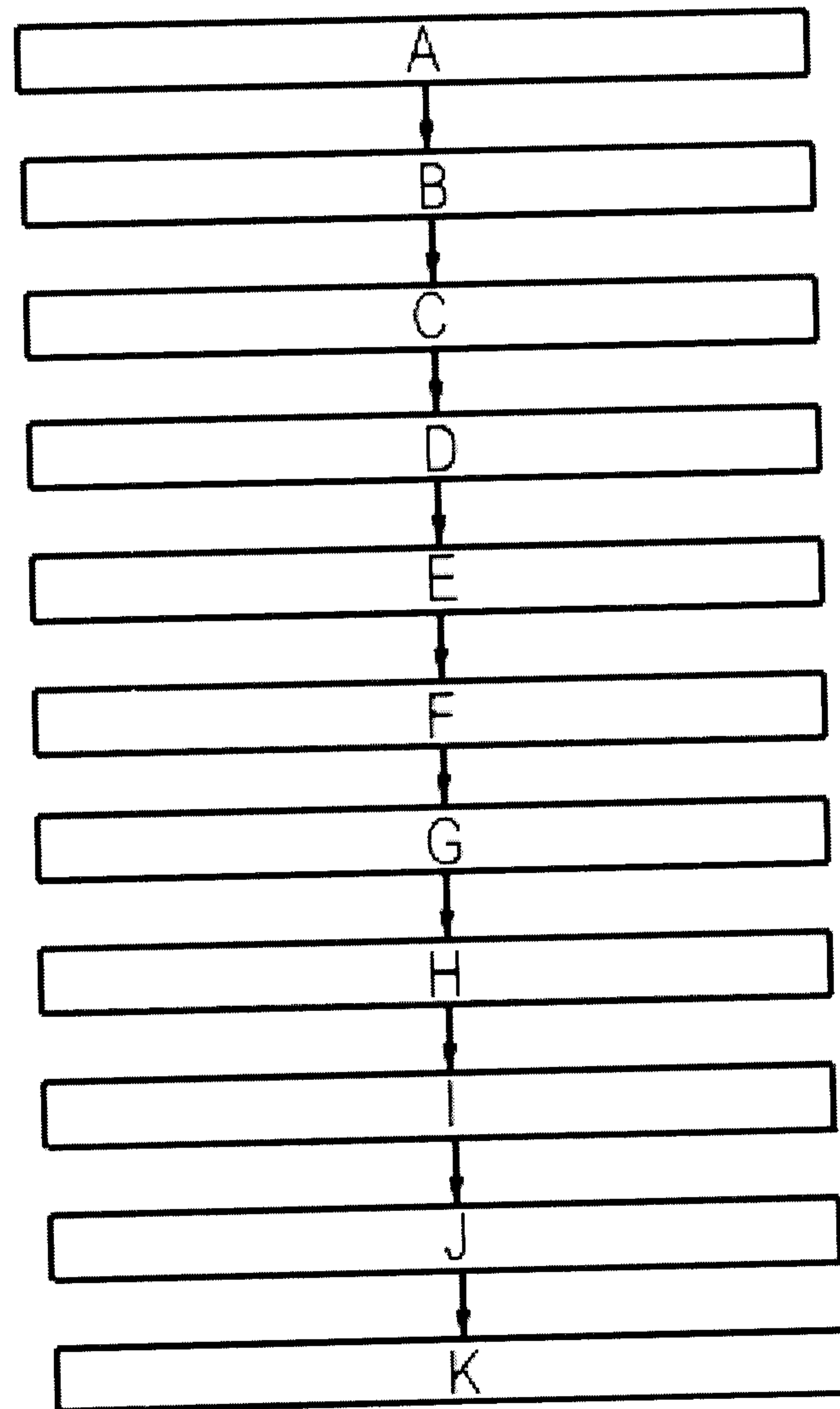


FIG. 10

